- The approach roads for all alignments will require the relocation of houses, small businesses and the taking of agricultural lands, including paddy fields, orchards and mixed market garden areas. The minimization of such resettlement is both environmentally and economically prudent and needs to be weighed against the engineering costs of such mitigation measures.

- Given that this bridge may become a main thoroughfare for the E-W traffic from Thailand, Laos, and Vietnam, and will see primarily truck and bus use for the foreseeable future, significant increases in noise, vibration and air pollution in an impact zone at least 100 m to either side of the alignment is highly likely. Therefore, selection of route alignment was carried out taking into account considerations of the trade-offs between, increasing negative health effects (air, noise and vibration) and engineering costs.

- Bridge pier spacing near the river bank was defined considering the 10 m-25 m band from the riverbank within most of the small boat river traffic takes place. In fact the traffic is significantly large and blockages or the introduction of dangerous currents or eddies in this nearshore travel corridor during the rainy season, forcing small boats to move into the main river current, should be avoided.

- At present, logging, in Champasak Province, is probably effectively limited by restricted access of large haulage vehicles from Thailand, since the only way across the river is by small, limited tonnage ferries. The new bridge may stimulate significant increases in logging of woods such a teak and rosewood, resulting in an accelerated and uncontrolled deforestation and commensurate habitat loss in the region.

6.4.2 Environmental Considerations of Each Alternative Routes

6.4.2.1 Impacts on the Environment

1) Route A

- The East approach road would traverse some 1,040 m across almost exclusively paddy lands. Water, Fisheries and Terrestrial Resource components will be minimally affected by this alignment. The 2020 air emission estimates indicate that air quality within the 200 m zone would be significantly degraded (i.e., being in relation to existing background conditions), particularly for SO_2 and THC. The noise levels will obviously increase significantly since this area was 100 percent farming land with an ambient noise environment, 15-25 dBA below what would be with a new approach road. (Refer to Annexes)
- Natural vegetation is limited to a number of mature trees, including teak and Ficus sp., plus introduced eucalyptus (Refer to Annexes). Bamboo stands were also observed within the zone of influence, although none were recorded as being in the 40m-wide clearing zone.. Drainage in this area is controlled by the paddy

irrigation system but generally flows north and south to the two small streams which eventually flow into the Mekong. A small road to the south and paralleling the alignment has incurred settlement and has a number of small businesses located on it and meets the approach road 100 m or so from the river bank. Wat Lau is located at that point and is within the 200 m impact zone of the approach road. At least 12 houses would be affected, removed within the ROW and 41 are within the impact zone where they would be exposed to such effects as noise and air pollution.

- However, the impact on landuse is of greatest significance, particularly rice farming on both sides, especially on the Muang Kao side, since the approach roads on both sides would cut across much productive paddy lands, effectively changing access patterns, damaging the gravity-fed irrigation systems and requiring farmers to cross a high speed roadway to bring in their livestock, their harvest and simply to tend their fields.
- The Pakse airport improvement plan include the lengthened of runway with work starting as early as 1997.
- On the Pakse side, the vertical alignment is more than 5 meters thus noise will be broadcast and the visual intrusion will be dramatic for local farmers.

2) Route B

- The proposed East-side approach road would run for about 780 m from the intersection with National Highway 13, approximately 1.8 km south of the old Sedon River bridge in Pakse to the Mekong River bank approximately 140 m upstream of the existing Pakse water supply pumping station. Starting at the NR 13 intersection, the road would pass through a densely populated residential area sloping toward a low lying (as much as 10 m-15 m below the level of NR 13) wet depression, possibly a former wetland, then pass up towards the West past small wooden houses and disturbed areas, some with serious erosion problems. Drainage in this area is generally from the SE to the NW, nearly perpendicular to the approach road. Small garden operations for personal consumption as well as small dry goods and food stalls are found within the zone of influence within 100 m to the river bank.
- Effects felt by the Water, Fisheries and Terrestrial environment will be minimal. However, given the significant vertical elevation, the noise environment will be significantly degraded within the 200 m impact zone.
- Natural vegetation is limited to a few mature teak trees, some bamboo stands and other grasses. Near the Mekong, on the East side, a few mature trees will need to be removed.

  The low lying area is heavily polluted with sewage and other wastes. The river bank is relatively highly eroded in some spots but has considerable vegetative ground cover.

- The West approach road first traverses the of Mount Salao (exposed bed-rock formation) and then turns toward the West and North passing through agricultural lands. The approach road must pass over two streams near the towns of Houayphek and Khan-Gneng. Both these streams are considered to be spawning streams for several locally important fish species (Refer to Table 6.3-1) and therefore bridge or culvert design and construction will have to consider this important function. These streams, which, during the dry season, are nearly dry and have major flows of 300-400 m^3/sec during the monsoon period.
- As well, several important fish migrations are said to take place along the western shore of the river at various times of the year (both up and downstream). It is not likely that they would be seriously affected by the project.
- On the Pakse side, Alternative B will require the removal of 38 buildings (mostly houses) and quite a bit of rice paddy (Refer to Table 6.4-1). Within the 200 m wide impact zone are two Wats and a School, which will require careful examination to establish the best mitigation measures should this alternative be chosen.

The following three important potentially limiting factors were considered in designing a bridge along alignment of Alternative B:

(i) Approximately 140 m downstream of the East end of the bridge section is the Pakse water supply pumping station. Although probably small, the risk of an accidental spill of hazardous materials on the bridge contaminating the water supply could lead to very serious health-related consequences for a large number of people.

(ii) Chronic contamination from storm water runoff from the road and bridge so close to the water intake could also contribute to increased contaminant levels in the water supply (particularly since the water treatment is only for suspended materials and pathogens).

(iii) Storm water retention and runoff control will be essential for this location.

3) Route C

- Alternative C has the shortest bridge span but the longest approach roads on both sides of the Mekong.
- The East approach road alignment is about 1,700 m long and intersects NR 13 about 3 km South from the old Sedon River bridge in Pakse and reaches the Mekong at a point about 30 m upstream (North) of the power transmission line tower on the East bank of the river. No significant natural environment was observed during two site visits. There is a considerable wet area (about 200 m) that the road would have to pass through. There are no significant water courses or wildlife habitats in the East approach road alignment since most of it has been severely disturbed by human habitation. For about the first 150 m inland from the river bank, land use is dominated by small wooden houses, private gardens and small farm animal operations. We were informed that much of this land is owned by the state, thus residents in this area have been given use rights only. Further

along the alignment there are large residential houses as well as small clusters of dwellings. In its present alignment, Alt C will require the removal of 51 structures, of which 35 are on the Pakse side (Refer to Annexes). The Wat Kang Yang and Kang Yang School will be well within the 200 m impact zone.

- The entire length of the West approach road was surveyed and, although much more natural then the East side, it was essentially stripped of natural habitat, aside from some areas where the alignment crosses the foot of Mt Salao. This section of the study area is wooded, has a variety of trees including acacias, teak, fig and palms, but within the ROW has primarily scrub brush cover, as the alignment passes over a great deal of exposed bedrock outcrops as it leads down to the rice fields just after the village of Khan-Gneng. A few meters in from the West bank the topography begins to slope steeply upward.
- Considerable small scale agriculture takes place in this area even though there is no usable road connection. In that regard this new road will be a major benefit for local area farmers, so long as access is permitted and reasonably safe.

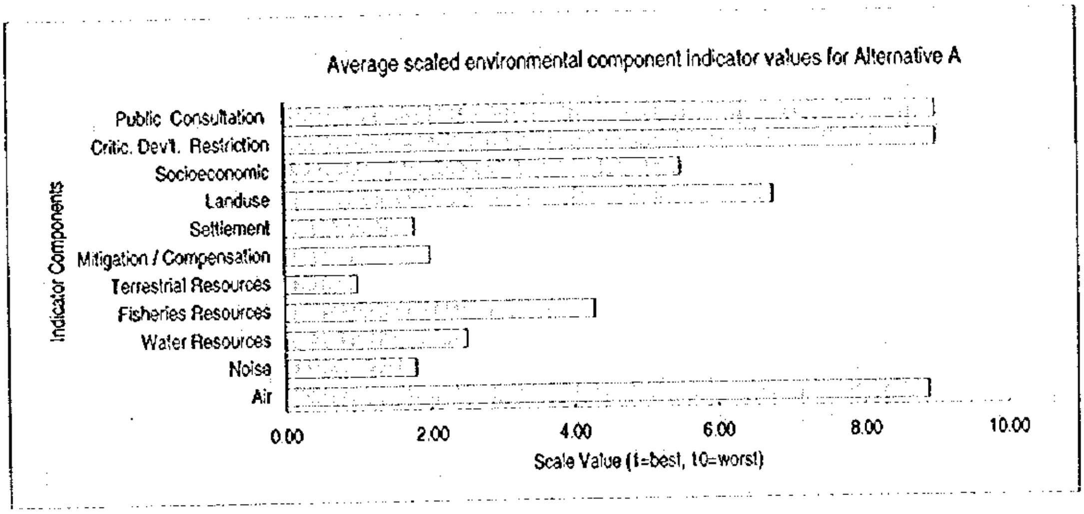
6.4.2.2 Comparison of Alternatives

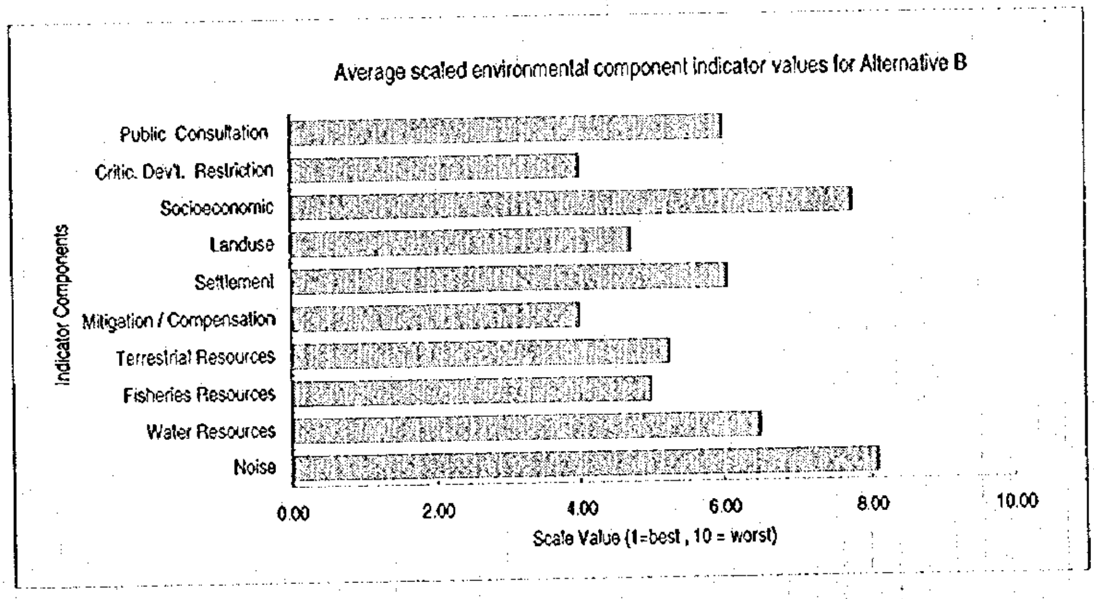
The impact of the Project will come from the approach roads, not the bridge, since the conditions in the river are such that only shoddy construction practices, e.g. fuel spills, major construction erosion, etc. would significantly endanger the water or the local aquatic ecosystem. The Environmental Impact Assessment will contain an environmental construction guideline, defining the environmentally sensitive construction practices to be followed by the constructors. From the perspective of the local residents and officials, the bridge will be visually pleasing; a daily reminder of the area's development. A bridge, located to the East and downstream of the town, will afford a better view of the bridge and also travelers coming to Pakse, will see the town as they pass on the West shore and must come across the river at a height several meters above the elevation of Pakse.

The one exception is bridge storm water runoff management. Ideally the storm water running off the bridge should be controlled, in that in the event of a spill, all runoff can be contained in a holding basin. The ADB, in their bridge projects, now regularly install such systems, which collect all storm water prior to releasing it into receiving waters.

Given the similarity of the three locations in terms of measurable biophysical and human/built environmental factors, it is not surprising that the total scores for the three alternatives were as close as they were (Figure 6.4-1 and Table 6.4-2).

The major differences among the alternatives were in the area of local acceptance, urban planning and induced traffic congestion, given the dynamic and unpredictable growth and development of Pakse.





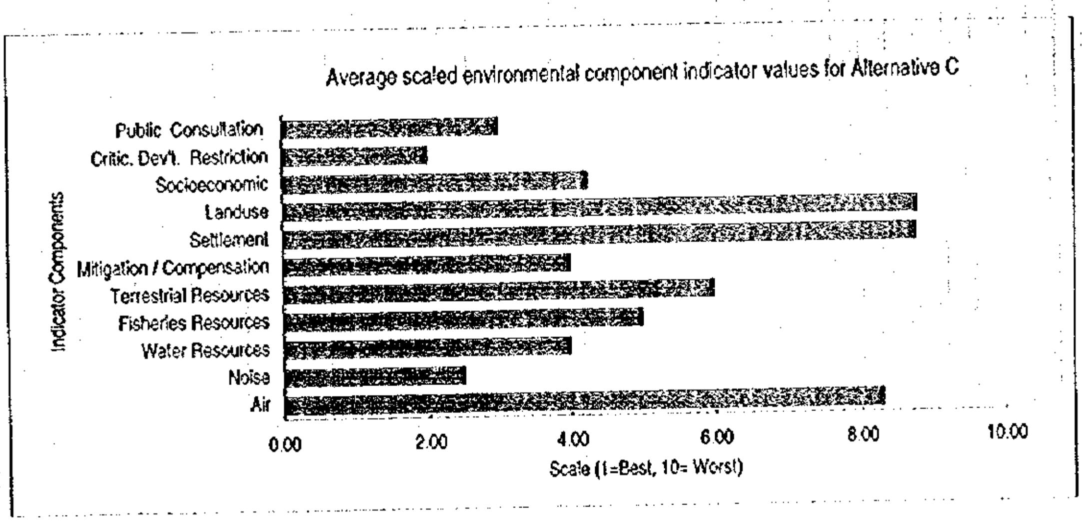


FIGURE 6.4-1 AVERAGE SCALE VALUES PER ENVIRONMENTAL COMPONENTS

TABLE6.4-1 SUMMARY OF SCORES OF ENVIRONMENTAL COMPONENTS

(26 indicators obtained for Route alignments A, B and C, Refer to Annexes)

Environmental Components	Weighting Scale (1-10)	Total of Weighted Component Indicators (0 = least intrusive, 10 = most intrusive - least desirable)		
Route Alternative		A	B	C
Air	5	8.90	5.96	8.31
Noise	6	1.80	8.10	2.50
Water Resources	7	2.50	6.50	4.00
Fisheries Resource	7	4.30	5.00	5.00
Terrestrial Resources	3	1.00	5.25	6.00
Mitigation/ Compensation	6	2.00	4.00	4.00
Settlement	10	1.79	6.07	8.77
Landuse	8	6.75	4.72	8.78
Socioeconomic	9	5.50	7.75	4.25
Critic. Devt. Restriction	10	9.00	4.00	2.00
Public Consultation	9	9.00	6.00	3.00
Weighted Average Score per Alt..		5.22	5.73	5.11

Nearly all of the study area (except Alt B-East side), through which the approach roads are planned, is rural and even subsistence farming area. In other words an area, without significant air emissions, low L_{90} noise levels and no access restrictions. For this reason even the relatively minor impacts will have profound impacts on the local people's lives. Introducing a new road into an urban setting has not considerable effect compared to building a roadway in an area that is substance farming with trails and motorized paths passable only during the dry season.

CHAPTER 7

ENGINEERING SITE SURVEYS

7. ENGINEERING SITE SURVEYS

7.1 General

Topographic, bathymetric and geological surveys of the Study Area were conducted covering the sites of the proposed routes and bridge sites. The summary of surveys and their results are shown below.

7.2 Topographic and Bathymetric Surveys

The topographic and bathymetric surveys for the three proposed bridge crossings and topographic survey of all road approaches were carried out from September to October 1995.

7.2.1 Topographic Survey

1) Survey Works

The topographic survey was composed of the following works:

- Road Center Line Survey and Profile Survey: Setting up of the road center line at an interval of about 50 m along the proposed routes. Profile survey along the center line.
- Road Cross Sectional Survey: Taking cross sections at about 50 m intervals and with a width of 50 m from either side of the center line.
- Topographic Survey: Survey carried out along the center line of each proposed route to the extend of 50 m each side.
- Topographic Mapping: Topographic maps were prepared by using the results of the profile survey, the cross sectional survey, and the topographic survey (contours are shown at interval of 1.0 m and thicked every 5.0 m).
- Drawings: Plotting of the survey results. The center line of the proposed bridge and approach roads were plotted at a scale of 1:1000, and its respective profile section at a scale of 1:1000 horizontal and 1:100 vertical; while the cross sections were plotted at a scale of 1:1000 horizontal and 1:100 vertical, and the maps at a scale of 1:1000.

Quantities of the topographic survey works for the proposed bridge routes are summarized in Table 7.2-1.

TABLE 7.2-1 QUANTITIES OF THE SURVEYS WORKS

ROUTE	TOPOGRAPHIC SURVEY			BATHYMETRIC SURVEY
	Road Center Line and Profile Survey (m)	Road Cross Sectional Survey (No. of Sections)	Road Cross Sectional Survey (No. of Sections)	River Cross Sectional Survey (m)
ROUTE A	3,700	75	37	4,500
ROUTE B	2,900	58	29	4,500
ROUTE C	3,000	60	30	2,700
TOTAL	9,600	193	96	11,700

2) Horizontal and Vertical Control

The location map of horizontal and vertical controls are shown in Figure 7.2-1.

- *Horizontal Control*

The horizontal control was done by electronic traversing, connecting to existing survey monuments from Highway NR 13S improvement project, Champasack Road Improvement Project (ADB 7th.).

The coordinates of existing monuments used as horizontal control are shown in Table 7.2-2.

TABLE 7.2-2 HORIZONTAL CONTROL POINTS

STATION	COORDINATE(*)		REMARKS
	North	East	
C025	1,670,377.689	8,584,924.237	Concrete
C024	1,670,405.713	8,584,709.234	Concrete
C001	1,670,617.825	8,583,660.454	Concrete
C028	1,670,649.815	8,583,662.962	Concrete

(*) Data about elevation of coordinates are not available. The whole elevations are referred to BM 0154 which elevation is of 103.216 m above M.S.L. South China Sea Datum.

The coordinates belong to the National Survey Control Network for Lao P.D.R.

- Spheroid: Krasobsky
- Projection: Gauss-Kruger
- Equatorial Semi Axis: a = 6,378.245
- Flattening: f = 1:298.3
- Scale Factor at CM: = 1.0000

The traverse was run from existing monument C024 and C025 on NR 10 (Phonthong Side) across the Mekong River to NR 13S, along the road and across the Mekong River again to closed at another pair of existing monument C001 and C028.

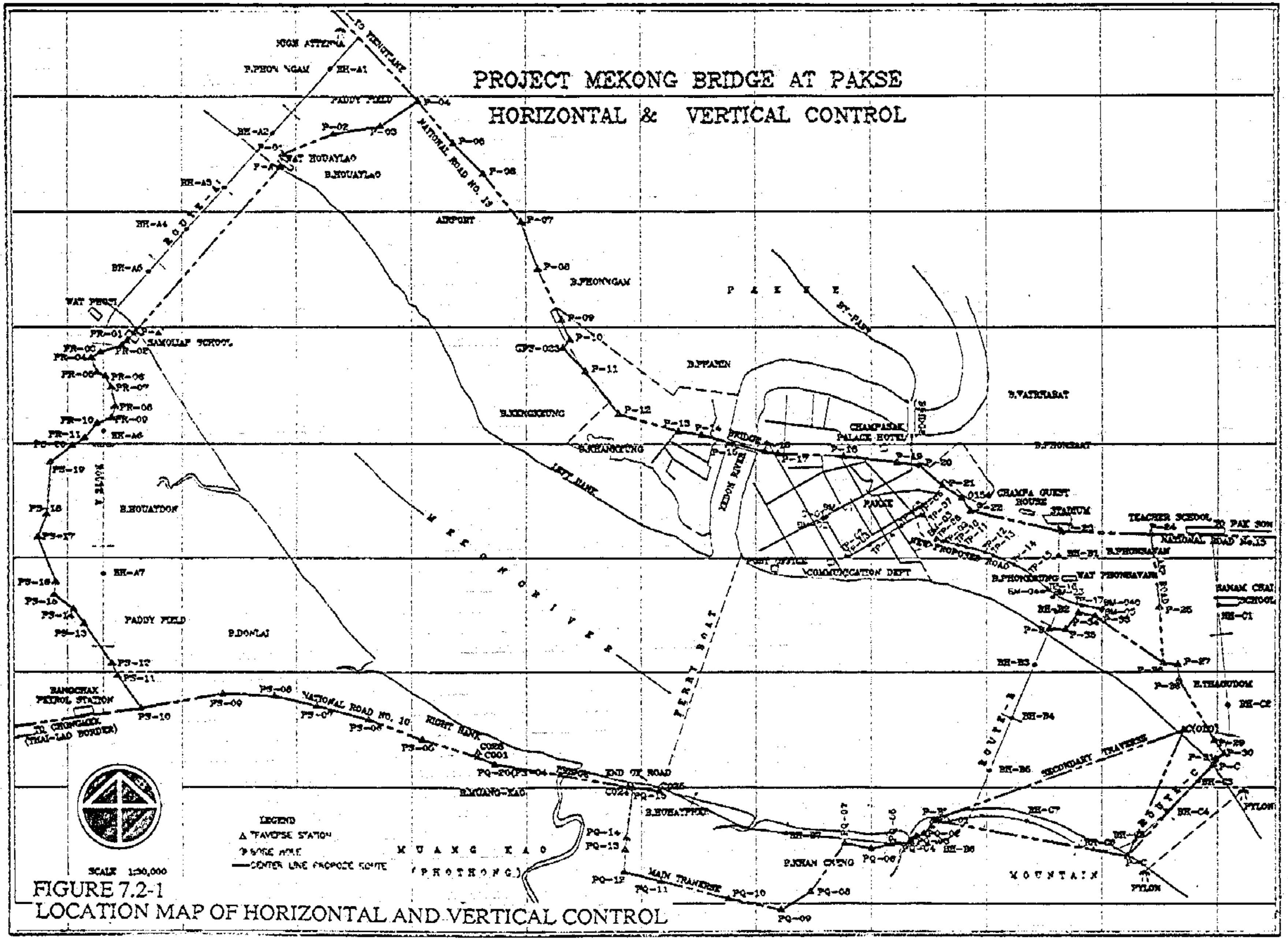


FIGURE 7.2-1
LOCATION MAP OF HORIZONTAL AND VERTICAL CONTROL

The angles were measured by theodolite, and the distance by Electronic Distance Meter (EDM). The main traverse accuracy was achieved to 1:140,244.

The secondary traverse loops had started from the main traverse monuments to distribute the survey control monuments cover the entire area.

There were 88 concrete monuments had been installed. The description of survey monuments is shown in the Annexes.

- *Vertical Control*

The vertical control was started from the existing bench mark BM 0154 which elevation is of 103.216 m above m.s.l. South China Sea Datum. This bench mark was established beside NR 13S by the National Geographic Department (NGD).

The spirit leveling was run forward and backward between established monuments. Hence these monuments can be utilized as horizontal and vertical controls.

The reciprocal trigonometric leveling method was applied for transferring the elevation across the Mekong River.

It is necessary to remark that Mean Sea Level South China Sea Datum is approximate below Mean Sea Level Ko Lak Datum by 0.140 m.

7.2.2 Bathymetric Survey

The bathymetric survey was carried out during end of August 1995. According the data from gauging station at Pakse, during this period, the Mekong river has recorded some of its highest level.

1) Survey Works

The bathymetric survey was composed of the following works:

- River Cross Sectional Survey: Survey carried out along each proposed bridge route, three sections having an interval of 100 m in both directions of each center line (i.e., upstream and down stream). The river depth was measured every at an interval of 50 m along the proposed bridge center line.
- Drawings: Plotting of the river cross sections were plotted at a scale of 1:1000 horizontal and 1:100 vertical.

Quantity of the bathymetric survey works for the proposed bridge routes are summarized in Table 7.2-1.

2) Survey Method

- Sounding of riverbed was carried out by echo sounder Raytheon 719 Cm operating at single frequency 208 KHz. The traducer was mounted on board of survey boat. The standard bar check was carried out to calibrate the equipment before using every day. The sounding lines run across the Mekong river at 100 m interval. Depths were recorded on the echo sounding chart. Location of the sounding are shown in the Annexes.
- Position fixing of survey boat was done by intersection from 2 theodolites on the river bank at Pakse side. The intersects angles were planed to given the good intersecting angle (30 - 150 degrees). The position was fixed simultaneously to the fix mark on the echo sounder chart.
- The staff gauge was installed at the column of water pump tower near line B. The leveling was run to transferred the elevation to top of staff gauge. The tidal observations were recorded every 30 min. during the bathymetric survey.
- The cross sections were run from river bank to the riverbed where the sounding can not be performed due to survey boat can not access. The data were combined to the sounding data to cover the entire area for both sides of the river.
- Co-ordinates and elevations were computed for all the survey points of bathymetric survey by combining of data from echo sounding chart, tidal observation, intersection points and river bank sections.

7.2.3 Data Processing

The survey computation and automatic contour interpolation were processed by using Survey Software Package GEOCOMP Ver.8.07.

7.3 Water Flow Velocity Survey

The flow velocity survey was carried out by surveying 5 points along each proposed bridge route. The measuring of water flow velocity in depth direction was carried out at an interval of 1.5 m.

Results of the survey show that the water flow velocity ranges from a minimum of 0.825 m/sec, 0.753 m/sec and 0.763 m/sec to a maximum of 1.657 m/sec, 1.760 m/sec and 2.561 m/sec for the proposed bridge routes A, B and C respectively.

Water velocity cross sections for the three alternative routes are shown in the Annexes.

7.4 Geology and Subsoil Investigation

7.4.1 Regional Geology

The geological location of the Project area is in the central part of Indochina sub-continent (Figure 7.4-1). In this region geological formations, from Precambrian to Cenozoic Quaternary layer (Figure 7.4-2), are existing as the following description is shown:

(1) Basal Metamorphic Rocks (Precambrian)

These rocks are distributed in the east border mountain region (2,000 m above m.s.l.) between Laos and Vietnam. The region is a craton called Kontum Massif which is equivalent to the South-China Platform located in the north of Laos. The geological age of this rock is estimated to be around 530 million years (Hurley & Fairbairn 1972). Main litho-facies are composed of gneisses, granites and migmatites in which gem stones such as supphia and ruby are concealed.

(2) Paleozoic Formations (Devonian to Carboniferous)

This stratum is located in the Hercinian orogenic belt, about 1,000 m above m.s.l., in the high land region of Savannakhet and Kham Mouan Provinces. Major rock type consists of sandstone mudstone associated with coal and of limestone. It is worthy to note especially the limestone known as Bacson series, on the scale of outcrop which extensively appears in an area of about 500 km^2 near Thakeky city.

(3) Mesozoic formations (Triassic to Jurassic)

There are main layers along the Project area that were brought by the Indosinian orogenic cycle. This orogenic area was converted into stable block (kraton) peneplane and a series of table mountains were formed. The peneplane, 100 m to 150 m above m.s.l., spreads out at both banks of the Mekong river, and 900 m to 1,000 m high table mountains come in sight with an echelon row (line of flying wild geese). The Mt. Bachiang with an elevation of 904 m above m.s.l. at left bank, and Mt. Malong, 1,304 m above m.s.l., are representative of those mountain. Typical rock facies of these rocks are: sandstone, mudstone and tuff, associated with volcanic breccia.

(4) Cenozoic Formations (Terting to Quaternary)

The basalt lava flow is a notable layer among these formations of what the Plateam is composed. A large scale area, with about 400 km^2, is located in around 500 m to 800 m above m.s.l. high land of Salavan Province, where rock quarry site is developed.

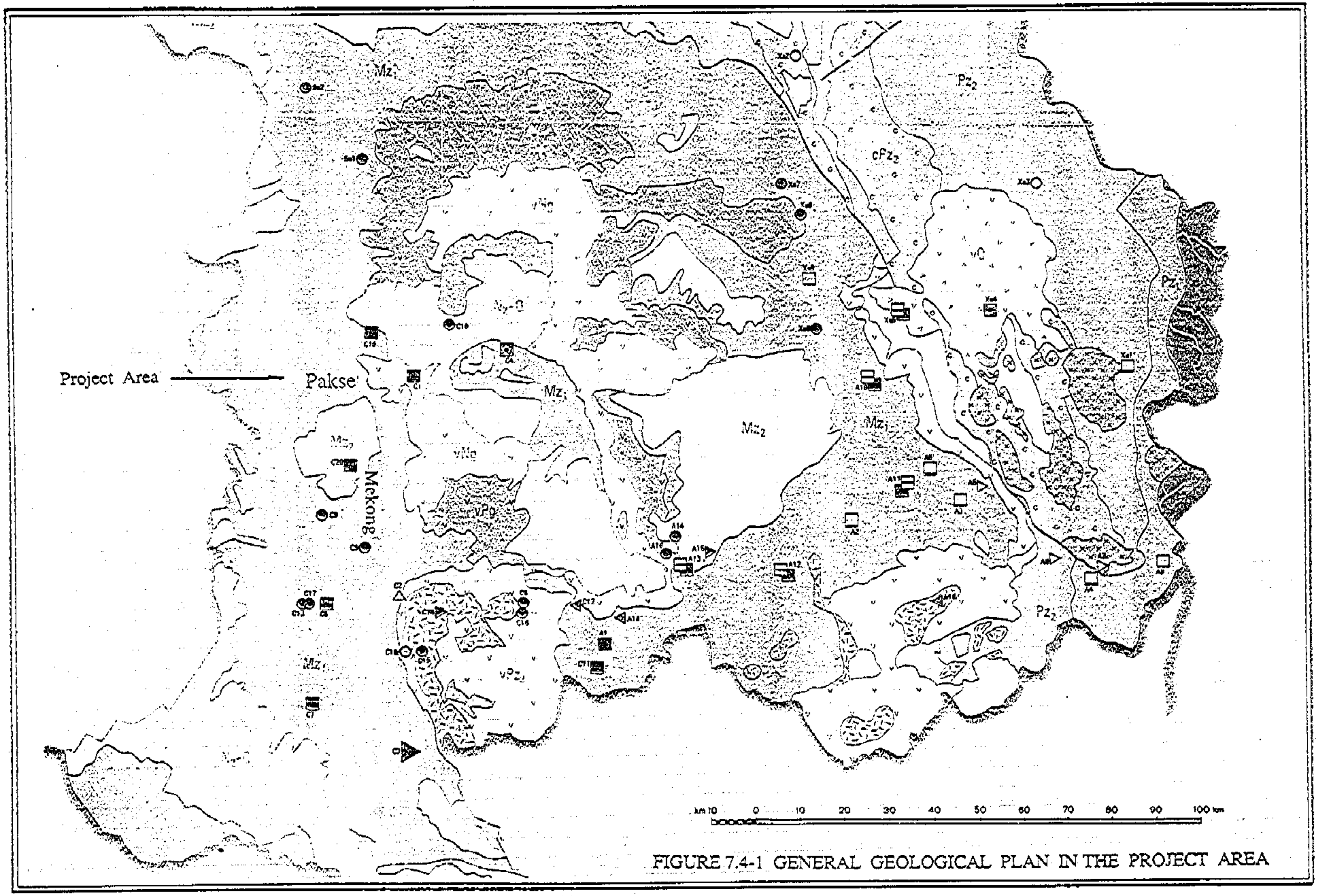


FIGURE 7.4-1 GENERAL GEOLOGICAL PLAN IN THE PROJECT AREA

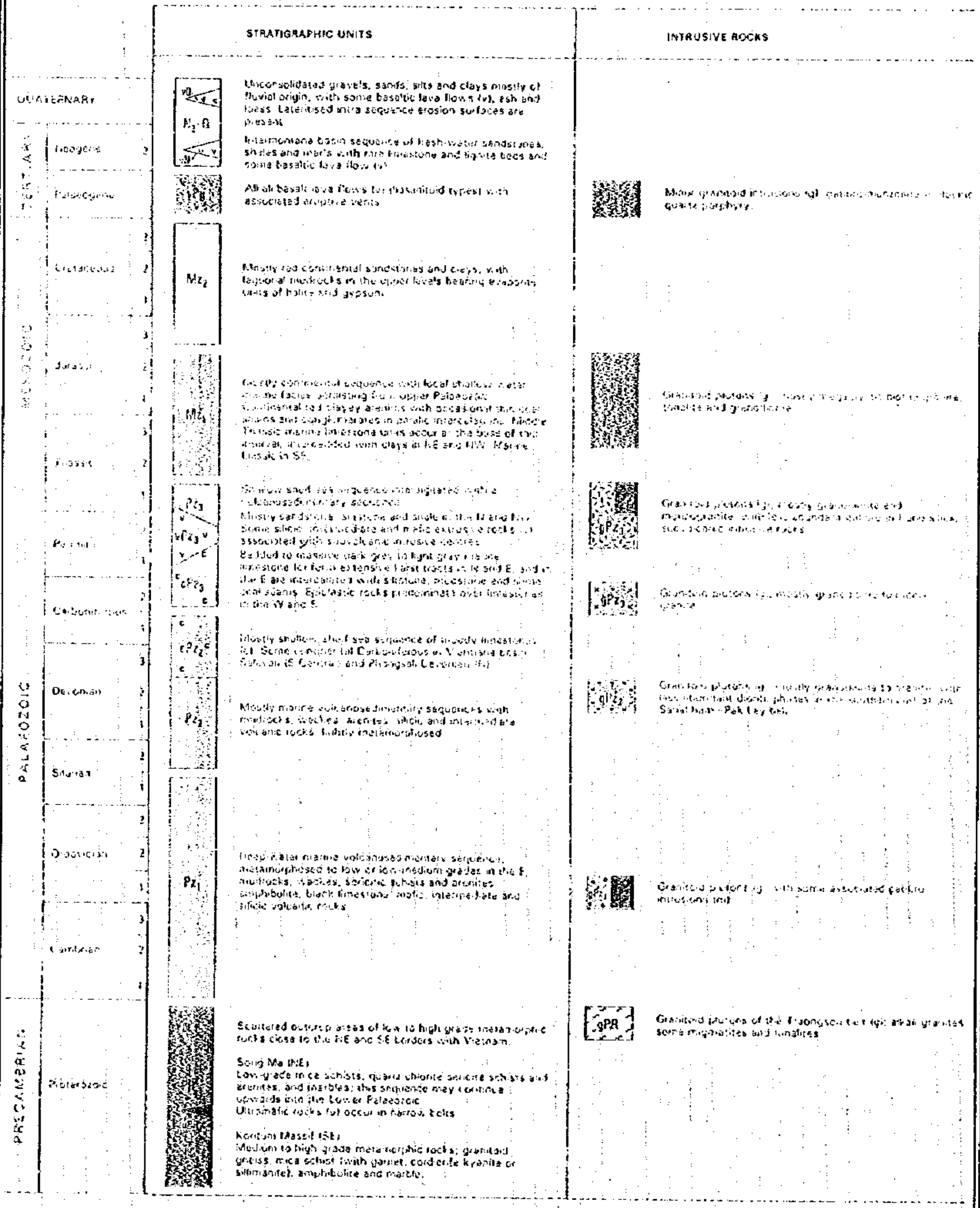


FIGURE 7.4-2 STRATIGRAPHY IN THE PROJECT AREA

The existing basalt layer of the left bank of Mekong river, covers the ground in a shape of a flat hill with an elevation of approximately 110 m to 120 m above m.s.l., slightly higher than alluvial terrace plane below described. It is assumed that the age of this basalt ranges from Neogene Tertiary to old Quaternary. Other main layer of Cenozoic formations, is the Quaternary alluvial deposit of terrace, back marsh and recent river bed. Terrace and back marsh deposit are found out in the flat plane at 90 m to 100 m above m.s.l. at both river banks of the Mekong. The main soil type of this formation is clay and/or silty clay. Moreover, in the river bed of the Mekong, sand and gravel are extensively deposited. These are well sorted and fairly well distributed in grain size, which are used for various kinds of civil works.

7.4.2 Subsoil Investigation

1) Boring Test

In this study three alternative routes (A, B and C) were investigated, therefore a total of 21 bore holes (7 holes per route) were drilled. The hole locations were arranged so that 2 holes for the left bank approach road, 3 holes in the river, and 2 holes for the right bank approach road were investigated for every route. In order to observe the quality of soil and rock, core drilling was carried out and the existence of fresh rocks was confirmed underlying the soil layer.

Standard Penetration Tests (S.P.T) were executed for soil layer investigation at 1.0 m depth interval.

Figure 7.4-3 is shown the geological profiles of the approach roads at left and right beds, and at the river cross section of each proposed bridge alignments.

2) Laboratory Test

Core samples and S.P.T. samples were tested in laboratory. Test Items are shown as follows.

i) Specific gravity,
ii) Grain size analysis,
iii) Natural water content,
iv) Unit weight,
v) Atterberg limits,
vi) Uniaxial compressive strength with static modulus, and
vii) Triaxial compressive strength.

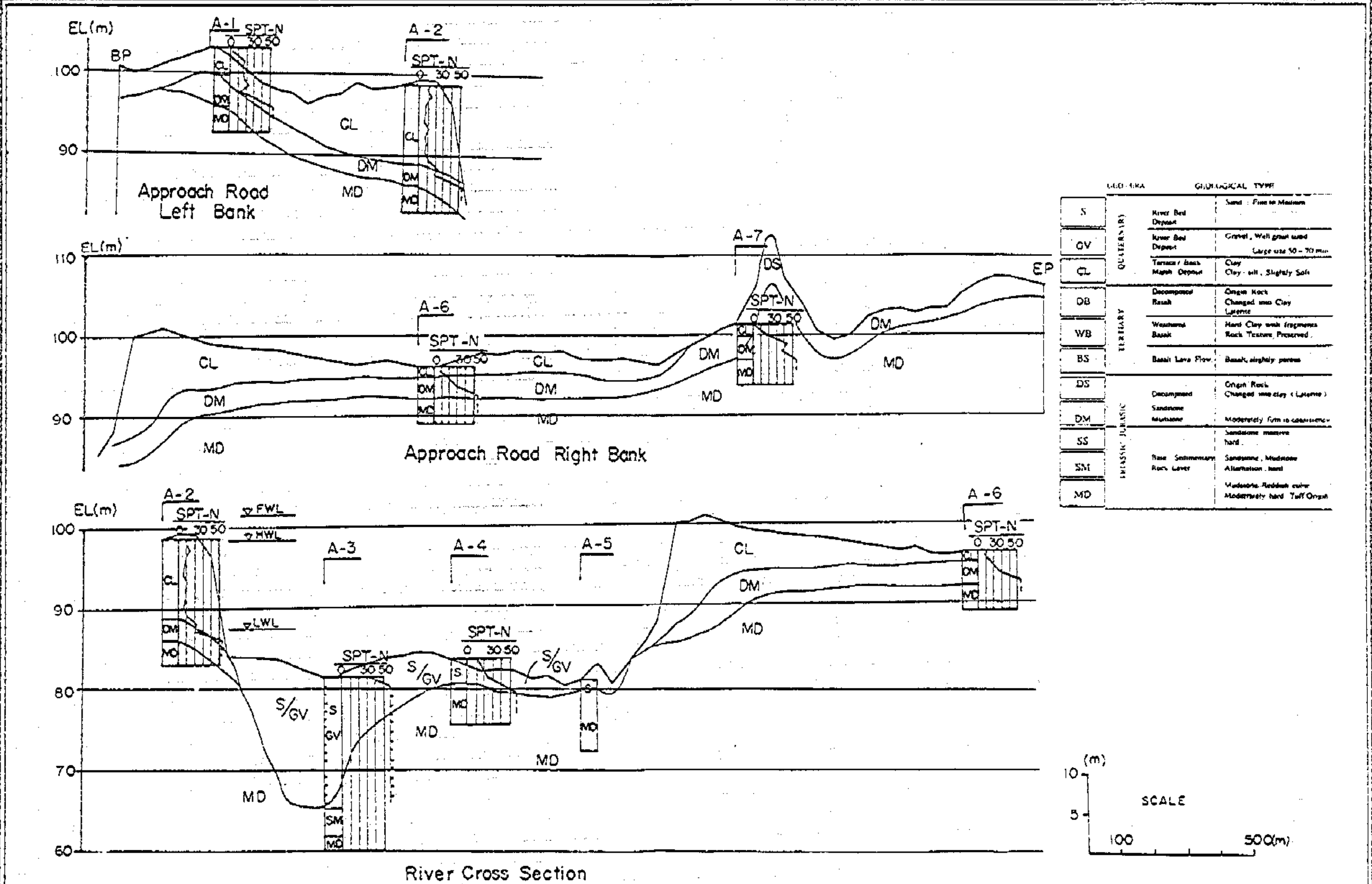
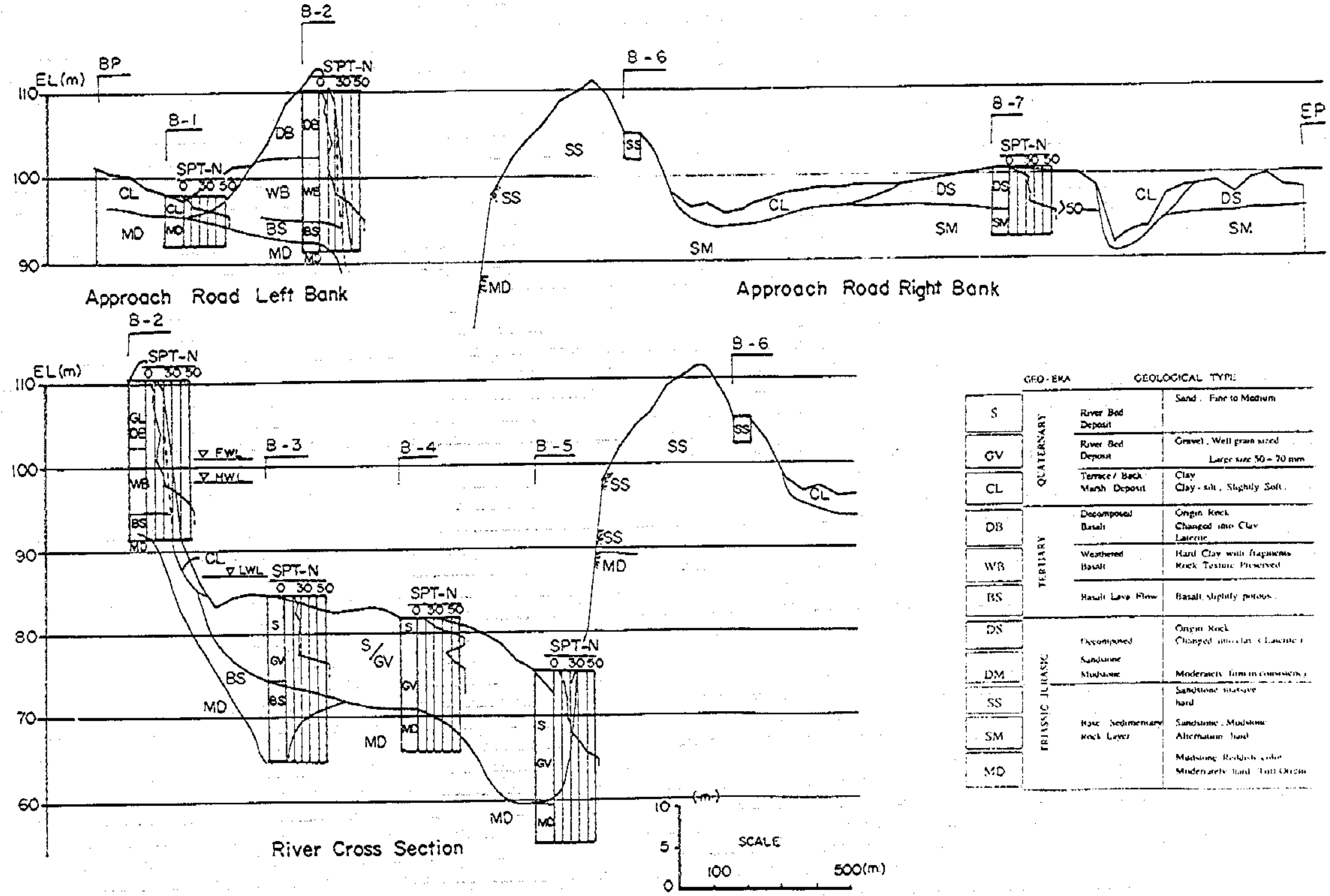


FIGURE 7.4-3 GEOLOGICAL PROFILE (1/3) : ROUTE - A



	GEO-ERA		GEOLOGICAL TYPE
S	QUATERNARY	River Bed Deposit	Sand, Fine to Medium
GV	QUATERNARY	River Bed Deposit	Gravel, Well grain sized Large size 50 ~ 70 mm
CL	QUATERNARY	Terrace / Back Marsh Deposit	Clay Clay - silt, Slightly Soft.
DB	TERTIARY	Decomposed Basalt	Origin Rock Changed into Clay Laterite
WB	TERTIARY	Weathered Basalt	Hard Clay with fragments Rock Texture Preserved
BS	TERTIARY	Basalt Lava Flow	Basalt slightly porous.
DS	TRIASSIC JURASSIC	Decomposed	Origin Rock Changed into clay (Laterite)
DM	TRIASSIC JURASSIC	Sandstone Mudstone	Moderately firm in consistency
SS	TRIASSIC JURASSIC	Base Sedimentary Rock Layer	Sandstone massive hard
SM	TRIASSIC JURASSIC	Base Sedimentary Rock Layer	Sandstone, Mudstone Alternation hard
MD	TRIASSIC JURASSIC	Base Sedimentary Rock Layer	Mudstone Reddish color Moderately hard Tuff Origin

FIGURE 7.4-3 GEOLOGICAL PROFILE (2/3) : ROUTE - B

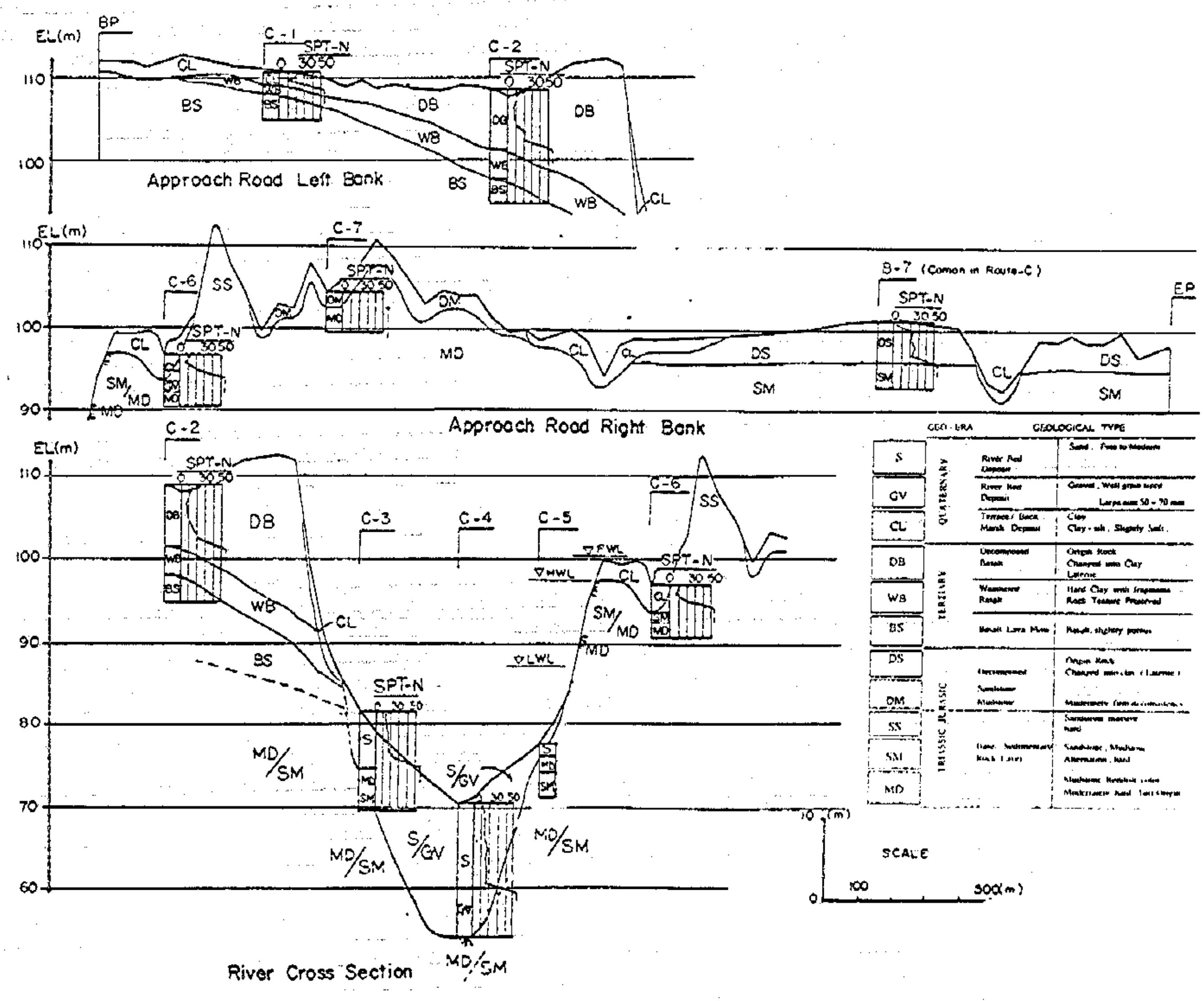


FIGURE 7.4-3 GEOLOGICAL PROFILE (3/3) : ROUTE - C

7.4.3 Geology in the Site

Geological conditions of the site in each route are described on the basis of the results of sub-surface investigation and geological mapping as follows:

1) Route A

Flat plane of terrace is formed at both banks, and the river cross section shows a reverse trapezoid shape. Geological type in the land consists of clay which is separated into 2 facies: terrace deposit clay, and decomposed rock origin.

River bed is composed by an approximately 5.0 m thick sand gravel layer. Rock layer (Mudstone) underlies elevation 85 m above m.s.l. at banks, and 80 m in the river. Traces of scoring/erosion scatter along the slope of banks. According to a hearing investigation carried out in the site, it is presumed that erosion of riverbanks by water wearing effect advances at the rate of 1.0 m annually.

2) Route B

Flat hill of basalt flow continues through the left bank, while a mountain slope of sandstone approaches to the right riverbank. The river cross section declines slightly toward the right bank where riverbed is deeper and river section turns to a V-shape section.

Geological type in the lane surface of left bank consists of back marsh clay and laterite originated from decomposed basalt, while at the right bank, a rock layer (sandstone) out crops on the surface near the bridge abutment, and a terrace deposit and decomposed sandstone on the approach road. Moreover, the thickness of deposits of sand and/or gravel existing in the riverbed was estimated as about 10 m to 20 m.

Rock line (basalt, sandstone, mudstone) undulates lying about an elevation of 95 m and 105 m above m.s.l. at left and right bank respectively, while in the river its height changes from elevation 70 m to 55 m.

Weathering of the basalt layer increase in the land of left bank therefore comparatively thick laterite, 10 m to 15 m thick, is brought about there.

Small erosion hollows come out in some places along the slope of left bank. According to a hearing investigation carried out in the site, it is presumed that erosion of riverbanks by water wearing effect advances at the rate of 1.0 m annually.

3) Route C

The left bank is composed of flat hill of basalt flow same as route B, while the right river bank is basically composed by mountain slope of mudstone, however near the site of the proposed bridge a terrace and back marsh (flood plane) appears. River cross section shows a shape of convex lens.

Geologically, the type of left bank consists of laterite (decomposed basalt), weathered basalt and rock layer (basalt). In the right bank, rock layer (mudstone) underlies below terrace/back marsh clay (15 m thick) near the bridge site. Moreover, around the approach road area, the ground surface is covered by a clay of terrace and decompose rock. Average of thickness of river bed deposits (sand gravel) is estimated as 5.0 m.

The level of rock line is shown as follows, elevation 95m at banks (rock type basalt and mudstone), elevation 75 to 65m in the river (rock type mudstone).

Weathering and erosion circumstances are same as the Route B, consequently erosion increases in about 1.0 m per year each side.

A general geological plan in the project site is shown in the Annexes.

7.5 Soil and Rock Materials

Around the Project site there are 3 rock quarry sites and a few borrow areas of natural sand gravel along the Mekong. Table 7.5-1 is shown a description of those areas. The location maps of soil and rock materials are shown in the Annexes.

TABLE 7.5-1 LOCATION OF SOIL AND ROCK MATERIALS

Type of Material	Location Name	Distance from Pakse
1 Basalt (Rock Quarry)	Latbok	55 Km
2 Basalt (Rock Quarry)	Black 18, NR 13 km 18	20 km
3 Sandstone (Rock Quarry)	Keng Rang	40 km
4 Sand, Gravel (River Bed Deposit)	Keng Rang	4 km

Characteristics of each material type can be described as follows:

(1) Basalt (Rock Quarry) Latbok

Consists of hard basalt which is currently used for macadam road, and available for prestressed concrete judging from hardness. In this quarry site, 4 kinds of crushing stone are produced, those are 5 mm under 5 to 10 mm, 10 to 20 mm and 20 to 40 mm (maximum size 40 mm). Daily capacity of production is 500 m^3.

(2) Basalt (Rock Quarry) Black 18

This basalt is also used for macadam road. It is slightly porous in quality, and its rate of abrasion loss is comparatively high. Therefore, detailed examination should be carried out for prestressed concrete. 500m^3 daily production of crushing stone 40 mm under size is possible.

(3) Sandstone (Rock Quarry) Keng Rang

According to its producer this is used for base/sub base course material in Thailand. Inferior in hardness, it is not available for Prestressed concrete.

4) Sand Gravel Mekong Phonsikhai

It is a natural river sand gravel which is widely distributed in the Mekong. It is very well sorted and flat shaped stone is conspicuous. Regarding the grain size, it ranges from medium sand to pebble and cobble. The maximum size is around 10 cm. However, according to a visual inspection of materials components carried out at the site, the granular size of coarse sand is estimated as small (2 to 5 mm). As each gravel (sandstone, schert, basalt, granite etc.) is hard, sufficient strength can be expected for prestressed concrete. The total daily production capacity of sand and gravel is approximately of 500 m^3.

Besides the above mentioned material, the laterite used for embankment material will be obtained from random places along each national road. According to previous report, 4 places (NR 13 km 15, 22, 28 and 29.5) are marked as a source location of it. (LAO Seventh Road Improvement Project Final Report By ADB). Moreover at left bank of the route B and C good embankment material (decomposed basalt origin laterite) will be obtained.

CHAPTER 8

DESIGN STANDARDS AND CRITERIA

8. DESIGN STANDARDS AND CRITERIA

8.1 Design Standards

The existing design standards and design criteria, Road Design Manual compiled by MCTPC in 1994 (hereinafter called as "LAO Standards"), will be advantageously applied to the Project. However the international standards including Japanese standards also will be supplementary applied since the LAO Standards isn't yet completely finalized. Especially Road Bridge Specifications recompiled by Japan Road Association in 1992 (hereinafter called as "JRA Standards") will be applied for bridge design to the purpose.

8.2 Design Criteria for Road

8.2.1 General

The Project roads are categorized as national roads in the road classification according to the LAO Standards referred above. The national roads are graded at the road standard III in "the Geometric Design Standards for Rural Road, Road design Manual Part I, MCTPC". Therefore, the design criteria are mainly derived from the prescriptions referred to the road standard III for the road design.

8.2.2 Geometric Criteria

• Design Speed

According to the Geometric Standard prescribing the road standard III, a design speed of 80 km/hr is applicable for flat terrain and 60 km/hr for rolling terrain. The geography of the Project site is classified in terrain. The design speed of 80 Km/hr is employed for the Project.

• Minimum Radius of Curve

According to the latest version of the Road Design Standard in Lao, for Road Design Class III with design speed of 80 km/hr, the curve radius of 250 m is required minimally when the curve has 10 percents gradient for super elevation. For the Project, the larger radius of 300 m against the prescription of 250 m for 80 km/hr design speed is proposed.

• Maximum Gradient

As aforementioned, design speed has an influence over maximuni gradients. In the Lao Standard, 6 percents is to be used for Road Design Class III.

In accordance with the actual observations, heavy truck with full load runs with speed of 20-30 km/hr on approximately 5 to 6 percents up-hill gradient along NR 10 and NR 13.

Because of the difficulty of overtaking slow moving vehicles by high speed one, steep gradient causes disturbance to the smooth traffic flow. The four percents maximum gradient on 80 km/hr design speed will be proposed in the Project.

Based on the above findings, the geometric criteria for road design are summarized as follows.

Item	Figure
Design Class	Grade III
Design Speed (km/hr)	80
Carriageway Width (m)	3.5
Shoulder Width (m)	2.0
Minimum Radius (m)	300
Maximum Gradient (%)	4.0
Super-elevation (%)	10.0

8.2.3 Standard Cross Section

• Width of Carriageway

Capacity of traffic volume on the road mainly depends on the width of carriageway and the number of lanes. Carriageway widths in several design standards vary between 2.75 m and 3.5 m for one lane, corresponding to the estimated volume of future traffic.

Road Design Class III for Rural Road in flat terrain requires a carriageway width of 3.5 m for one lane.

Carriageway for the project road will be of double lane. The calculated capacity with the above mentioned carriageway width will be sufficient of the project road.

• Shoulder

Width of shoulder, as before-mentioned, has an influence on traffic capacity of road as lateral clearance. There are three kind of shoulders, in the classifications with regards to shoulder width, i.e.:

- full-width shoulder;
  2.5 to 3.25 m width, which can accommodate any type of vehicles
- half-width shoulder;
  1.25 to 1.75 m width, which can accommodate passenger cars
- narrow-width shoulder;
  0.5 to 0.75 m width, which is minimum lateral clearance.

Usually for the same kind of project road as rural road, 1.0 m to 1.5 m is applied as shoulder width. And Road Design Class III for Rural Road in flat terrain requires a shoulder width of 1.5 m . However the approach roads of the Project pass through some villages and Pakse urban area. In addition, ADB 7th Project adopted 2.0 m as shoulder width of connected section of NR10 on Phonthong Side. Therefore, the Project requires 2.0 m as shoulder width.

The standard cross sections of roads and bridge are determined as shown in Figure 8.2-1 based on the above findings and through discussions with MCTPC counterparts in the course of study.

8.3 Design Criteria for Bridge

8.3.1 Design Loads

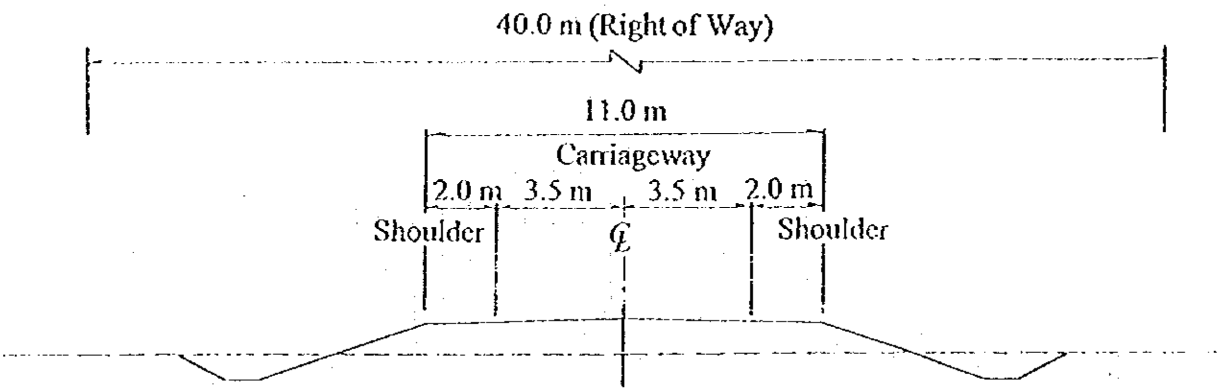
8.3.1.1 Live Loads

The live load shall consist of vehicle load for carriageway and pedestrian load for sidewalk. HS 25-44 (Standard Specification for Highway Bridges, AASHTO) will be applied for carriageway live loading according to the LAO Standard. The impact fraction incidental to carriageway live loading also shall meet to AASHTO Standard. For the sidewalk loading the uniform load as specified in Article 2.1.2 of JRA Standard Part I will be applied.

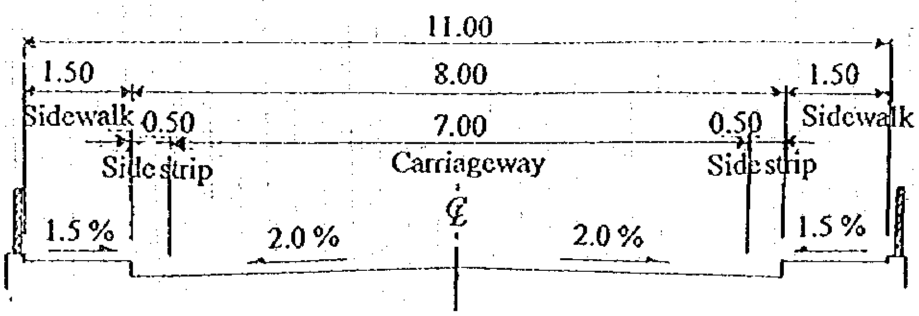
8.3.1.2 Dead Loads

The dead load shall consist of the weight of bridge structure including incidental bridge facilities and future services. The dead load computation will be based on the unit weights as specified in Article 2.1.3 of JRA Standard Part I. The dead loads for future services installed under sidewalks will be considered. Main unit weights and load intensity for future installation are as follows:

Steel material:	7.850 tf/m^3
Reinforced concrete:	2.500 tf/m^3
Prestressed concrete:	2.500 tf/m^3
Plain concrete:	2.350 tf/m^3
Asphalt concrete:	2.300 tf/m^3
Handrail:	0.050 tf/l.m each side
Future services:	0.050 tf/l.m each side



TYPICAL CROSS SECTION FOR ROADS



TYPICAL CROSS SECTION FOR BRIDGE

FIGURE 8.2 -1 STANDARD CROSS SECTION

8.3.1.3 Handrail Loading

Lateral force of 250 kg/l.m acting at the top of handrail will be applied for handrail loading as specified in Article 4.2.1 of JRA Standard Part I.

8.3.1.4 Kerb Loading

For Kerb loading the lateral force of 750 kg/l.m as specified in Article 3.14.2 of AASHTO Standard will be applied.

8.3.1.5 Thermal Effect

As described in the subsection 3.2.2 of this report the highest and lowest air temperatures at Pakse were recorded 40.0°C and 10.1°C respectively, while mean monthly air temperature was 27.2°C for the years 1960 to 1994. According to these data temperature variations considering thermal effect will be proposed as follows:

For concrete structure:	+10 to +40 °C
For steel structure:	+10 to +55 °C

8.3.1.6 Dry Shrinkage and Creep

JRA Standard will be employed for design calculation on the effect of dry shrinkage and creep. As described in the subsection 3.2.4 of this report the annual mean relative humidity computed for past 30 years at Pakse is around 72%. According to this data a mean value of 70% relative humidity will be proposed for the design.

8.3.1.7 Wind Loading

The probable maximum wind velocity in 50-years return period at Pakse is estimated at 40.6m/sec and in 100-years return period 45.5m/sec as shown in the subsection 3.2.5 of this report. The values of wind load for bridge structure specified by JRA Standard Part I are based on the basic wind velocity of 40m/sec as 50-years return period probability. The wind velocity condition of the site is in similar level to the basic data of JRA Standard. It is so proposed that JRA Standard will be used for the wind loading to this Project.

8.3.1.8 Earthquake Forces

There is no record on earthquake effect in and around the Project site and no epicenter observed in the past within 300 km from the Project site. Assumed an earthquake of 8.0 magnitude in Richter scale at 300 km distance, the ground acceleration at the Project site is estimated at 45 gal adopting the super revolve formula proposed in JRA Standard, Part V. Under this seismic environment it is recommended that the seismic coefficient of 0.05 for earthquake resistance design will be employed as an minimum requirement to horizontal force.

8.3.1.9 Hydrodynamic Force

The hydrodynamic Force to be applied to the piers due to river current will be calculated by the following formula:

P = K * V2 * A

where,

P : Pressure intensity in kg/m^2

K : Resistant coefficient of pier specified in Article 2.1.8 of JAR Standard Part I.

V : Velocity of river water in m/sec

A : Vertical projection area of pier in square meter

The probable maximum velocity in 100-years return period was estimated at 1.8 m/sec as described in the subsection 3.3.3 of this report. This value of velocity will be used in the calculation of hydrodynamic force due to water flow.

The hydrodynamic force due to earthquake effect also will be considered. JRA Standard Part V will be applied in the calculation.

8.3.1.10 Ship Collision Force

The ship collision force to piers is considered as the equivalent impact force that would be consequential from the collision of 300 DWT ship at a velocity of 5 m/sec. The calculation formula is as follows:

F = W * V * V / (4 * g * D)

where,

F : Ship collision force in metric ton

W : Dead weight ton of ship

V : Velocity of ship at the time of collision in m/sec

D : Stopping distance of ship in meter

g : Acceleration of gravity in m/sec

The acting location of the collision force to pier is 1.0 m above the water level.

8.3.2 Material Properties

The following material properties will be assumed for the preliminary design.

1) Steel

Structural steel plate : 2,100 kgf/cm^2 (allowable stress)

Reinforcing bar :	1,800 kgf/cm^2 (allowable stress)
Strand cable for prestressing :	SWPR 7 A according to JRA Specification
Steel bar for prestressing :	SBPR 95/110 according to JRA Specification

2) Concrete

Compressive strengths of concrete by structure are as follows:

Prestressed concrete structure :	350 kgf/cm^2
Deck slab for steel bridge :	240 kgf/cm^2
Deck slab for composite girder :	300 kgf/cm^2
Pier shaft, footing, pile cap and abutment :	240 kgf/cm^2
Cast-in-situ RC pile :	300 kgf/cm^2

The strength specified is the compressive strength of a cylinder at age of 28 days.

8.3.3 Navigation Clearance

The navigation clearances under bridge girder secured for ship traffic in the Mekong river were determined through discussions with MCTPC as follows:

a) Vertical navigation clearance

For 2 spans around the longitudinal center of bridge:	Not less than 10.0 m
For the side spans excluding extreme side spans:	Not less than 5.5 m

These clearances shall be measured on H.W.L of the river.

b) Horizontal navigation clearance

For all spans excluding extreme side spans:	Not less than 60.0 m

8.3.4 Design Water Levels

Design water levels were determined from the results of the hydraulic analysis of water level and water flow velocity at each proposed bridge site. This analysis was carried out by the input of the bathymetric survey data, water flow velocity survey data, available hydrological records, and the results of calculation of discharge and water level, into a computation program prepared for this purpose.

Table 8.3-1 and Figure 8.3-1 are shown a summary of the computation results for water level at each proposed bridge site and the Pakse gauging station.

TABLE 8.3-1 DESIGN WATER LEVELS AT PROPOSED BRIDGE SITES

Condition at Gauging Station→	Q = 54,070 m3/sec Gage Height = 15.00 m	Q = 36,291 m3/sec Gage Height = 11.51 m	Q = 1,692 m3/sec Gage Height = 0.62 m
SECTION ↓	F.W.L. (m)	H.W.L. (m)	L.W.L. (m)
SITE A	101.69 (101.55)	98.19 (98.05)	87.14 (87.00)
Gauging Station	101.49 (101.35)	98.01 (97.87)	87.11 (86.97)
SITE B	101.38 (101.24)	97.92 (97.78)	87.10 (86.96)
SITE C	101.12 (100.98)	97.75 (97.61)	87.10 (86.96)

Note: Water levels are expressed in meters above the mean sea level of Ko Lak Datum and meters above the mean sea level of South China Sea Datum (figures in brackets). Mean sea level of South China Sea Datum is approximate below the mean sea level of Ko Lak Datum by 0.140 m.

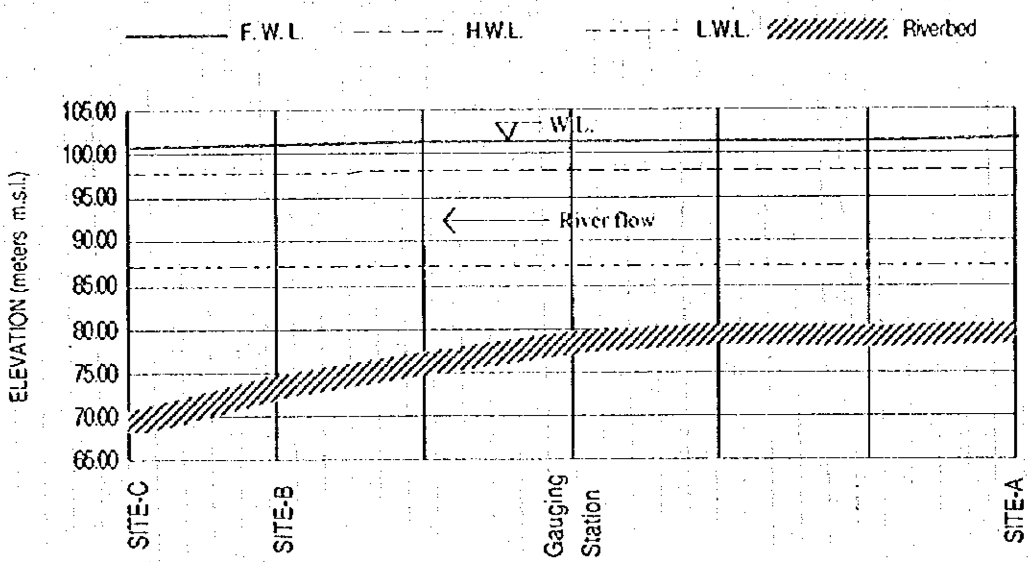


FIGURE 8.3-1 FLOW WATER LEVEL AT PROPOSED BRIDGE SITES

CHAPTER 9

PRELIMINARY DESIGN OF ALTERNATIVE ROUTES

9. PRELIMINARY DESIGN OF ALTERNATIVE ROUTES

9.1 General

This chapter addresses the planning conditions and the results as well as the way of solution on the preliminary design of bridges and approach roads along the alternative routes selected in Chapter 4 on the basis of the results of engineering site surveys to provide substantial data for the selection of optimal bridge route and to obtain the Project features preliminary throughout the Proposed route.

9.2 Preliminary Design of Bridge

9.2.1 Bridge Length

In the site, any route of Alternatives, there is no existing road network and no concrete scheme for land use in the vicinity of the river banks. The bridge length, therefore, will be determined so as to reduce the length as much as possible considering the geomorphologic conditions around the river shores since the bridge length affects the construction cost of the route.

The river widths corresponding to water levels by route vary as shown in Table 9.2-1.

TABLE 9.2-1 RIVER WIDTHS DEPEND ON WATER LEVELS

Route	Water Level	Elevation of Water Level (m MSL)	River Width depend on Water Level (m)
Route-A	L.W.L	87.00	1,370
	H.W.L	98.05	1,460
	F.W.L	101.55	Not identified due to over flow
Route-B	L.W.L	86.96	1,180
	H.W.L	97.78	1,260
	F.W.L	101.24	1,330
Route-C	L.W.L	86.96	565
	H.W.L	97.61	860
	F.W.L	100.98	1,060

The proposed location of abutment in order to determine bridge length will be selected on each route taking the following requirements and site conditions into consideration:

a) Any abutment should be set back from the shore line of H.W.L not to block the river flow

b) On the route crossing the narrow section of the river, i.e. Route-B and Route-C, the shore line defined in the above a) will be considered as of F.W.L

c) River bank erosion should be taken into consideration at the left bank of each Route and the right bank of Route-A. The bank erosion will be at a rate of 1.0 meter a year as mentioned in the subsection of 3.3.5 of this report. The shore line at the time of taking into account bank erosion will be considered as of H.W.L.

d) The stability of abutments and approach road embankments should be maintained on the occurrence of the bank erosion estimated

It is proposed that the estimation of quantity of river bank erosion will be counted for 50 years equivalent to a design life of the bridge. Consequently the Proposed location of abutment at each river bank by alternative route will be mainly determined with the following factors confoming to the requirements and conditions mentioned above:

- Route-A	Right bank:	Bank erosion of 50 m
	Left bank:	Bank erosion of 50 m
- Route-B	Right Bank:	Shore line of F.W.H
	Left bank:	Bank erosion of 50 m
- Route-C	Right Bank:	Shore line of F.W.H
	Left Bank:	Bank erosion of 50 m

As a result, the bridge length by route will be estimated at as follows:

Route-A:	1,560 m
Route-B:	1,380 m
Route-C:	1,100 m

9.2.2 Proposed Height Formation

The proposed formation heights of road center throughout each route are assessed in subsection 9.3.1.

In the bridge section of route the elevation of road center will be determined considering the clearances required above water level. The requirement for the vertical clearances will be proposed pertaining to bridge structure as follows:

a) The navigation clearances are considered from H.W.L as conditioned in subsection 8.2.3

b) The clearance of 1.5 m from F.W.L to the bottom of bridge girder will be secured for drifts in the river

c) The elevation of bridge shoe bed should be 0.5 m over higher than F.W.L

9.2.3 Bridge Type

9.2.3.1 Span Length Range and Bridge Type

In order to select the bridge types the scale range of span length will be aimed considering the following requirements and information.

a) Horizontal navigation clearance:

The requirement of horizontal clearance of 60 m for ship navigation forces the bridge to have span length of at least 65 - 70 m depend on the dimensions of substructure.

b) Impediment rate of river flow area:

The concept on the impediment rate of river flow area to the structure in the river should be imported for the river stability after the bridge construction for this Project. The rate of not exceeding 5 % would be proposed for this bridge according to the basic value legislated by the Ministry of Construction in Japan. Assumed the pier dimension of 4.0 m along bridge axis, the span length satisfied the blocking rate would be not less than 80.0 m as a minimum requirement. In case the pile caps with piles or footings project in the river water such dimensions shall be counted for impediment areas.

c) Economic span length:

The economic span length should be pursued unless it will be restricted by the requirements mentioned above. The economic span length is looked for in case the construction cost summed superstructure cost and substructure cost would be minimized.

d) Span length of existing bridge:

The span length, 105 m, of the Mittaphab (friendship) bridge crossing over the Mekong river completed in 1990 gives a useful information to this project, although the river site conditions and bridge length are not always similar to this Project.

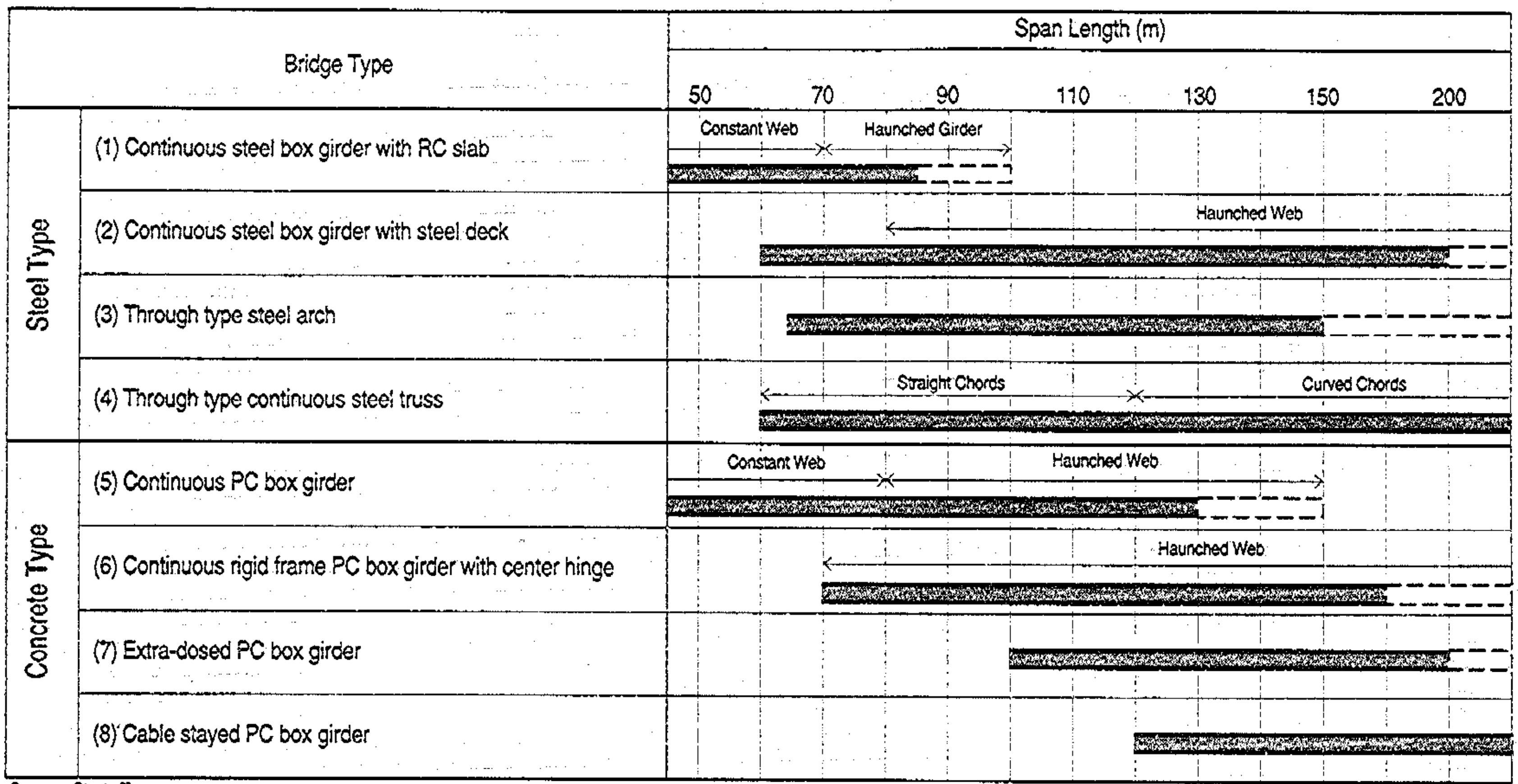
From the above requirements and information the span lengths in a range of 60 m to 150 m, extreme maximum 200 m are to be examined. Applicable bridge types corresponding to these span lengths are selected as follows:

- Steel type:
  - (1) Continuous steel box girder with RC slab
  - (2) Continuous steel box girder with steel deck
  - (3) Through type steel arch
  - (4) Through type continuous steel truss

- Concrete Type:
  - (5) Continuous PC box girder
  - (6) Continuous rigid frame PC box girder
  - (7) Extra-dosed PC box girder
  - (8) Cable stayed PC Box girder

The feasible span ranges of above bridge types are shown in Figure 9.2-1.

FIGURE 9.2-1 FEASIBLE SPAN LENGTH OF BRIDGE TYPES



Source: Study Team

LEGEND

: Feasible

: Possible

9.2.3.2 Foundation Structure

According to the results of site surveys in Chapter 7, the soil conditions and water depths of each alternative route are summarized are follows:

- Route-A:

The mean water depth of L.W.L is estimated at around 4.0 m while varied 3.0 m to 6.0 m along the river cross section. The soils of river bed are alluvial deposit of 3 - 9 m depth. Under the river deposit mud stone slightly weathered lays as a bed rock. This bed rock is reliable as a bearing stratum for the foundation structure of bridge.

- Route-B:

The water depth of L.W.L is widely varied from 2.0 m to 15.0 m along the river cross section, however the deeper section being of more than 10 m depth is less than 200 m in sectional length. The river bed deposit layered alternately sand and gravel sediments in the thickness of 10 - 15 m along the whole section. N Values are observed 10 - 30 at the sand layer and more than 50 at the gravel layer. The bed rocks under the river deposit are found of basalt in the left bank side and mud stone in the right bank side from the center of the river cross section. These are also reliable to be bearing stratum for foundation structure although weathered.

- Route-C:

This river section has evenly deep water flow throughout the section. The mean water depth of L.W.L is estimated at around 11.0 m. The deepest is of 18.0 m from L.W.L. The river deposit of 5 - 12 m depth covers bed rock. The bed rock is mainly mud stone which is reliable to be bearing stratum for foundation structure.

Considering the span length range of superstructure aimed in previous subsection, the foundation types applicable to above site conditions are nominated as follows and shown conceptually in Figure 9.2-2.

(1)	Cast-in-situ pile (protrusion type)	: for all site
(2)	Direct foundation	: for Route-A only
(3)	Open caisson	: for Route-A and a part of B
(4)	Inter-locking steel pipe pile well	: for all site

The bases of above nomination to foundation type are as follows:

(1) Cast-in-situ Pile (Protrusion type)

The protrusion type of cast-in-situ pile foundation is selected as a foundation method to enable the construction of pile cap and/or footing of pier shaft above water level and to enable the construction of deep foundation.

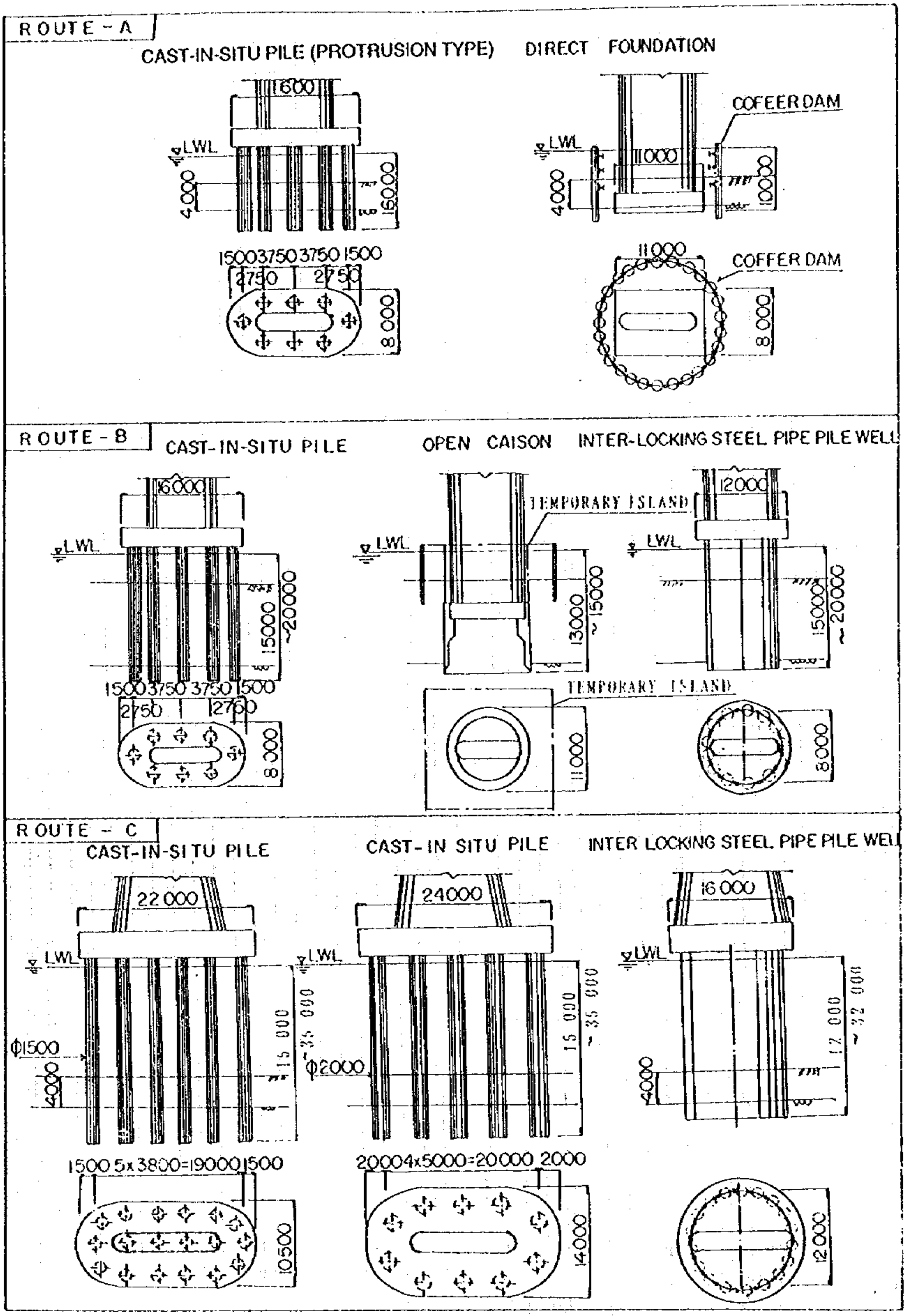


FIGURE 9.2-2 APPLICABLE FOUNDATION TYPES

This type is applicable for all alternative routes. The pile diameter of 1.0-2.0 m will be employed corresponding to supporting capacity required for superstructure load. To construct piles using boring machine a temporally staging or floating vessel would be used for Route-A and Route-B in common way, but SEP(Self Elevated Platform) should be used to secure the sure works for Route-C .

(2) Direct Foundation

Direct foundation method in the river needs to accompany with a shuttering or coffer dam works. The feasible construction depth of shuttering or cofferdam method is normally within around 10 m. This foundation method becomes so feasible in cost as the construction depth is as less as deep. In this point this method is limited in Route-A as an alternative.

(3) Open Caisson

This foundation type enables the deep and stable foundation structure although costly and retarded in construction progress. As a preparatory work to commence the construction of caisson foundation the temporally island in the river should be constructed above the water level. For the necessity of this island method in the site of more than 5 m water depth this foundation type is tend to be unfeasible. Therefore, for Route-A and a half section of Route-B this type is selected as alternative.

(4) Inter-locking Steel Pipe Pile Well

This foundation method is to form well type foundation by steel pipes of 1.0 - 1.5 m diameter inter-locked with joint pipes of small diameter slitted. The stiffness of the foundation is larger than multi-pile foundation type and less than concrete caisson type. This type also enables deep foundation as far as the driving of pile in soil stratum possible.

For the selection and determination of foundation type the followings will be considered in addition to above site conditions:

a) As water level varies largely more than 10 m between in dry season and in rainy season, the construction works of foundations and pier shafts should be limited in dry season only.

b) It will be not allowed to use more than 2 dry seasons for the construction period of substructure to economize the total construction cost.

c) It is considered that there is a river bed fluctuation of at least 5 m in depth, including local scouring around pier or foundation, caused by river hydrological phenomena and/or artificial extraction of river deposit.

d) The safety and sure construction under water should be claimed especially.

According to above conditions and requirements, the nominated foundation types are evaluated by each alternative route as shown in Table 9.2-2. (The details of cost data are shown in "Volume II: Annexes").

As a result of the evaluation, the cast-in-situ pile (protrusion type) foundation is proposed for all foundations of each alternative Route in the advantages of economy and workability.

9.2.3.3 Proposed Bridge Type and Span Length Range

The combinations of super structure and substructure with foundation selected in above sections give the cost curves corresponding to span lengths of superstructures as shown in Figure 9.2-3, Figure 9.2-4 and Figure 9.2-5 by alternative route respectively. The bases of these figures are shown in "Volume II: Annexes". According to these figures the continuous rigid frame PC box girders give the lowest cost among others for all alternative Route.

Accordingly, it is proposed that the continuous rigid frame PC box girder is optimal bridge type for each alternative route. The span lengths giving the bottom of cost curve are found in a range of around 80 m - 120 m for Route-A and Route-B, and around 100 m–160 m for Route-C and their spans satisfy the planning conditions described in subsection 9.2.3.1.

For a section of Route-B having deep foundations the span length of more than 100 m which is given as the economic span for Route-C will be applied since the foundation conditions of Route-B around this section are similar to Route-C.

In these economic spans each optimal span length is generally determined in a manner of making less the quantity of piers in number, since their constructions in the river might be tend to be trouble to bring delay on it consequently. On the other hand it should be considered from the side of structural characteristics of superstructure. As a continuous rigid frame PC box girder type is applied for long bridge section, non-continuous section such as center-hinged sections are required intermittently along spans to release a longitudinal force action due to elongation or contraction of bridge girder. For the spans having such section their length is preferable to be shorter to make less deflection deformations mainly due to creep of concrete. The detailed study for the optimal span length remains in later chapter as well as the detailed structural study after the selection of optimal bridge route. At this preliminary design stage the span of 100 m long is basically used for Route-A and Route-C and the span of 150 m long for Route-C as the optimal span length.

TABLE 9.2-2 FOUNDATION TYPE COMPARISON BY ALTERNATIVE ROUTE

Alternative Routes	Foundation Type (1) - (4)	Construction Depth from L.W.L	Construction Materials	Construction Method	Aimed Issues	Construction period of foundation (Month)	Construction Cost (Ratio)	Overall Evaluation	Selection
Route-A	(2) Direct Foundation	10 m	Reinforced concrete, Inter-locking steel pipe for coffer dam	Temporally shattering or coffer dam shall be constructed. Mainly temporally staging is used for access.	Stability of shattering	4.0	1.0	Fair	Abandoned
	(1) Protrusion Type Cast-in-situ Pile	15 m	Reinforced concrete, Steel casing pipe	Up to bed rock steel casing pipes are driven from floating vessel. Bore holes are made by using drilling bucket for river deposits stratum and percussion drill for bed rock. To Construct pile cap platform is built at pile tops.	Workability of rock drilling	3.5	1.4	Good	Selected
Route-B	(1) Protrusion Type Cast-in-situ Pile (D=1.50 m)	15 m - 20 m	Reinforced concrete, Steel casing pipe	Same as Route-A but to boring for pile the drilling bucket only will be used.	Gravel size in the river deposit stratum	3.5	1.0	Good	Selected
	(3) Open Caisson	13 m - 15 m	Reinforced concrete, Steel sheet pile for temporally island	Firstly make temporally island up to above water level. On the island concrete body of caisson is built. By excavating inside the caisson is settled.	Trouble in the sinking of caisson	5.0	1.7	bad	Abandoned
	(4) Inter-locking Steel Pipe Pile Well	15 m - 20 m	Steel pile with joint pipe	Make well shape foundation using inter-locking steel pile. Driving of pile is made by vibro-hammer from floating vessel.	Driving capability for pipe pile in the river deposits stratum of more than 50 N value	3.5	1.8	Fair	Abandoned
Route-C	(1) Protrusion Type Cast-in-situ Pile (D=1.50 m)	15 m- 35 m	Reinforced concrete, Steel casing pipe	Same as Route-A, B but for the construction SEP should be used. To make bore hole mainly percussion drilling rig is used.	Workability of rock drilling	4.0	1.0	Better	Selected
	(1) Protrusion type Cast-in-situ Pile (D=2.00 m)	15 m- 35 m	Reinforced concrete, Steel casing pipe	Same as the above row, but high torque capacity and heavy weight should be needed for pile construction.	Handling of heavy boring machine	4.5	1.04	Good	Abandoned
	(4) Inter-locking Steel pipe pile well	12 m - 32 m	Steel pile with joint pipe	Same as Route-B but SEP should be used.	Difficulty of Socketting of steel pile	4.0	1.6	Bad	Abandoned

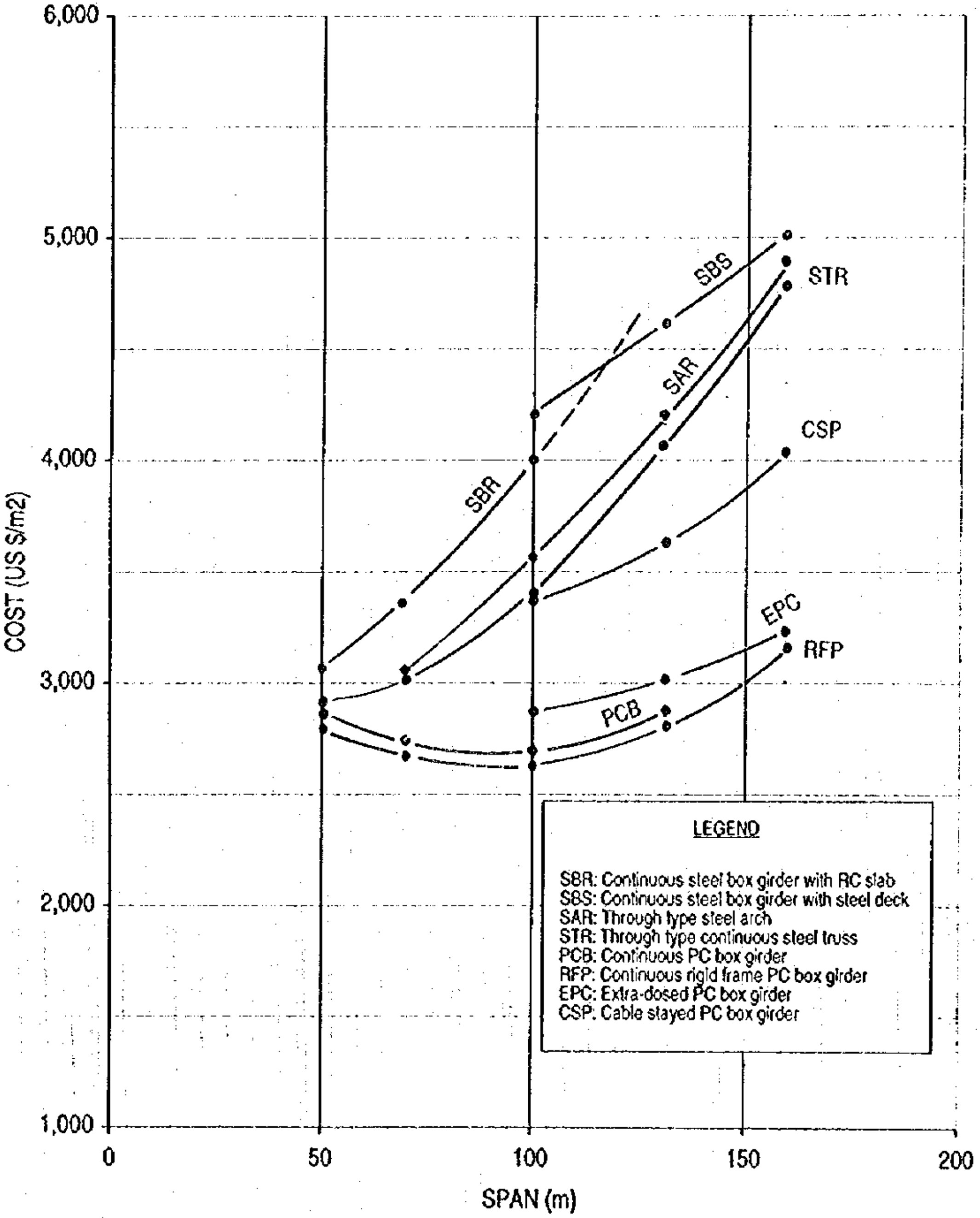


FIGURE 9.2-3 BRIDGES TYPES AND SPAN LENGTH RANGE OF ROUTE-A

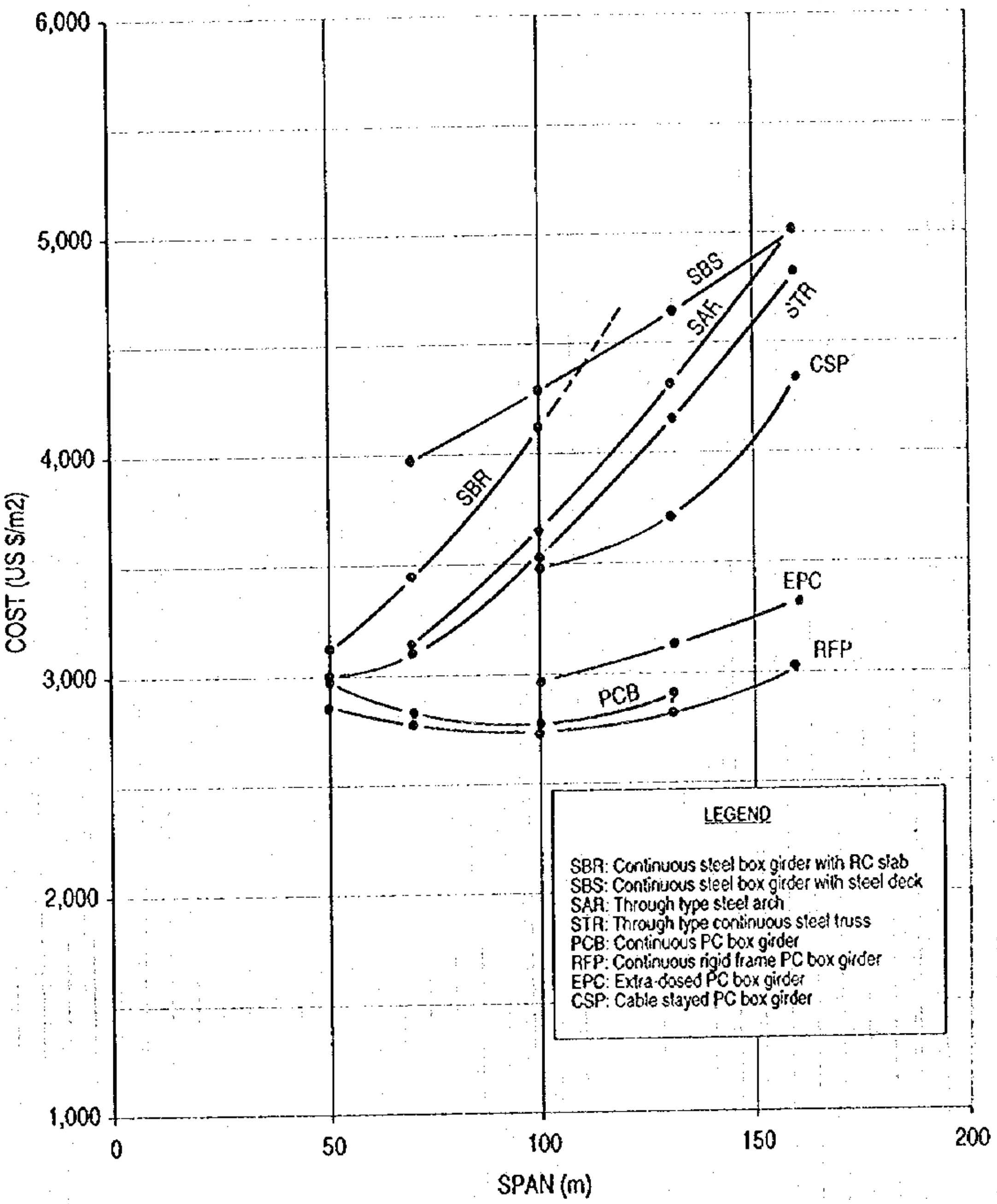


FIGURE 9.2-4 BRIDGES TYPES AND SPAN LENGTH RANGE OF ROUTE-B

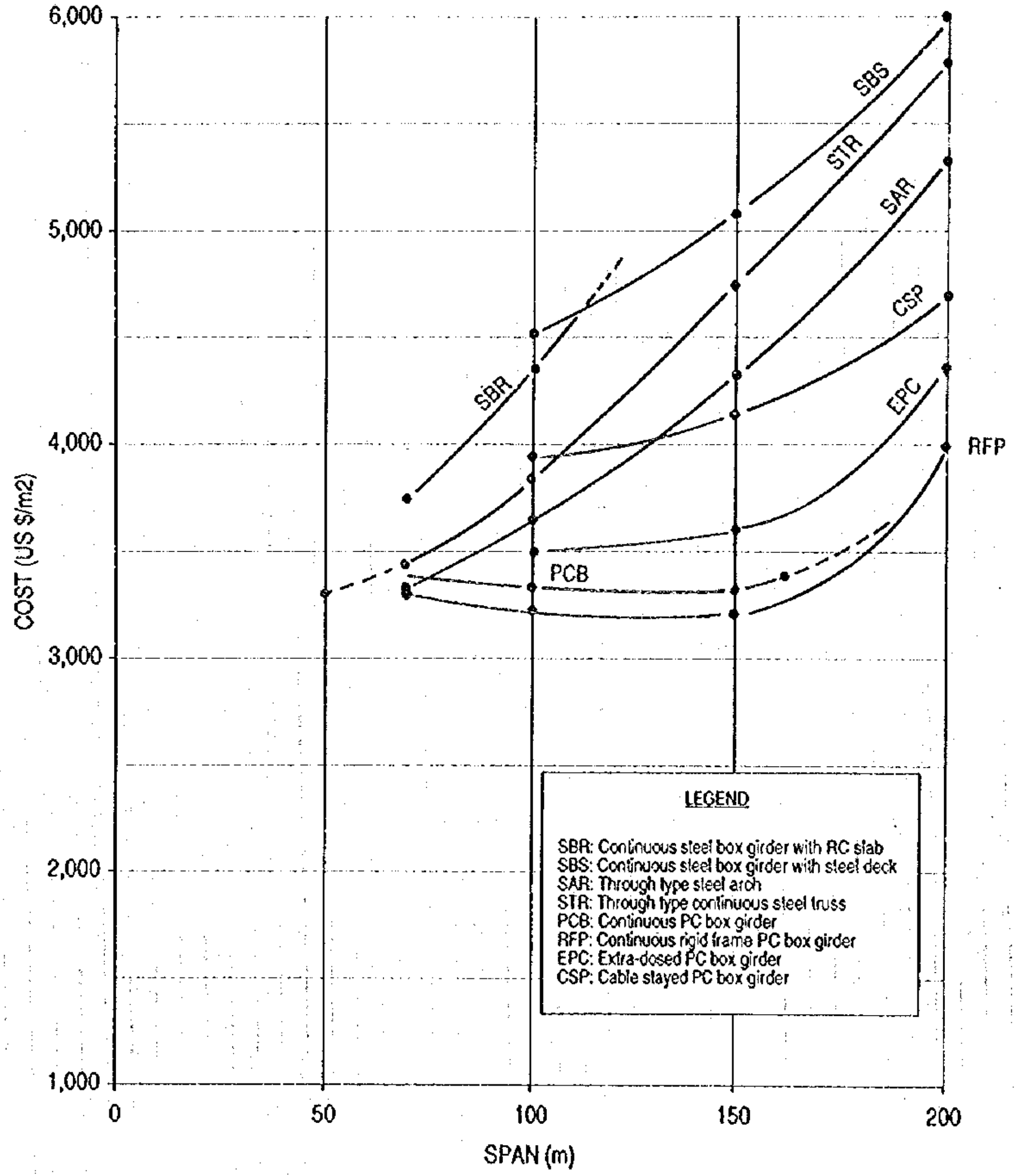


FIGURE 9.2-5 BRIDGE TYPES AND SPAN LENGTH RANGE OF ROUTE-C

9.2.4 Preliminary Bridge Configurations

Being applied optimal spans looked for in the above section to the main sections of bridge routes, the bridge configurations throughout whole bridge sections are shown in Figure 9.2-6, Figure 9.2-7 and Figure 9.2-8 for Route-A, Route-B and Route-C respectively.

These bridge configurations are made based on the following conditions and dimensions:

- Common:
  - The locations of abutments are determined conforming to the conditions of bridge length determination described in subsection 9.2.1.
  - The location of the first pier from each bank in the river is away at least 30 m from the shore line of H.W.L.
  - The navigation clearances are secured in the section between the first piers mentioned above.

- Route-A:

Bridge length:	1,560 m
Bridge type:	Continuous rigid frame PC box girder with center-hinge
Main span:	100 m
Foundation:	Protrusion type cast-in-situ concrete pile
Diameter of pile:	1.5 m
Length of pile:	13 - 20 m (Socketting depth into the bed rock of 6.0 m)
Number of pile:	8 nos.

- Route-B:

Bridge length:	1,380 m
Bridge type:	Continuous rigid frame PC box girder with center-hinge and 3-span continuous extra-dosed PC box girder
Main span:	100 m to 150 m
Foundation:	Protrusion type cast-in-situ concrete pile
Diameter of pile:	1.5 m
Length of pile:	12 - 20 m (Socketting depth into the bed rock of 1.5 m)
Number of pile:	8 nos.

- Route-C:

Bridge length:	1,100 m
Bridge type:	Continuous rigid frame PC box girder with center-hinge (including partially curved span) and 4-span continuous PC box curved girder
Main span:	150 m
Side spans:	37.5 m
Foundation:	Protrusion type cast-in-situ concrete pile
Diameter of pile:	1.5 m
Length of pile:	15 - 40 m (Socketting depth into the bed rock of 7.0 m)
Number of pile:	18 nos.

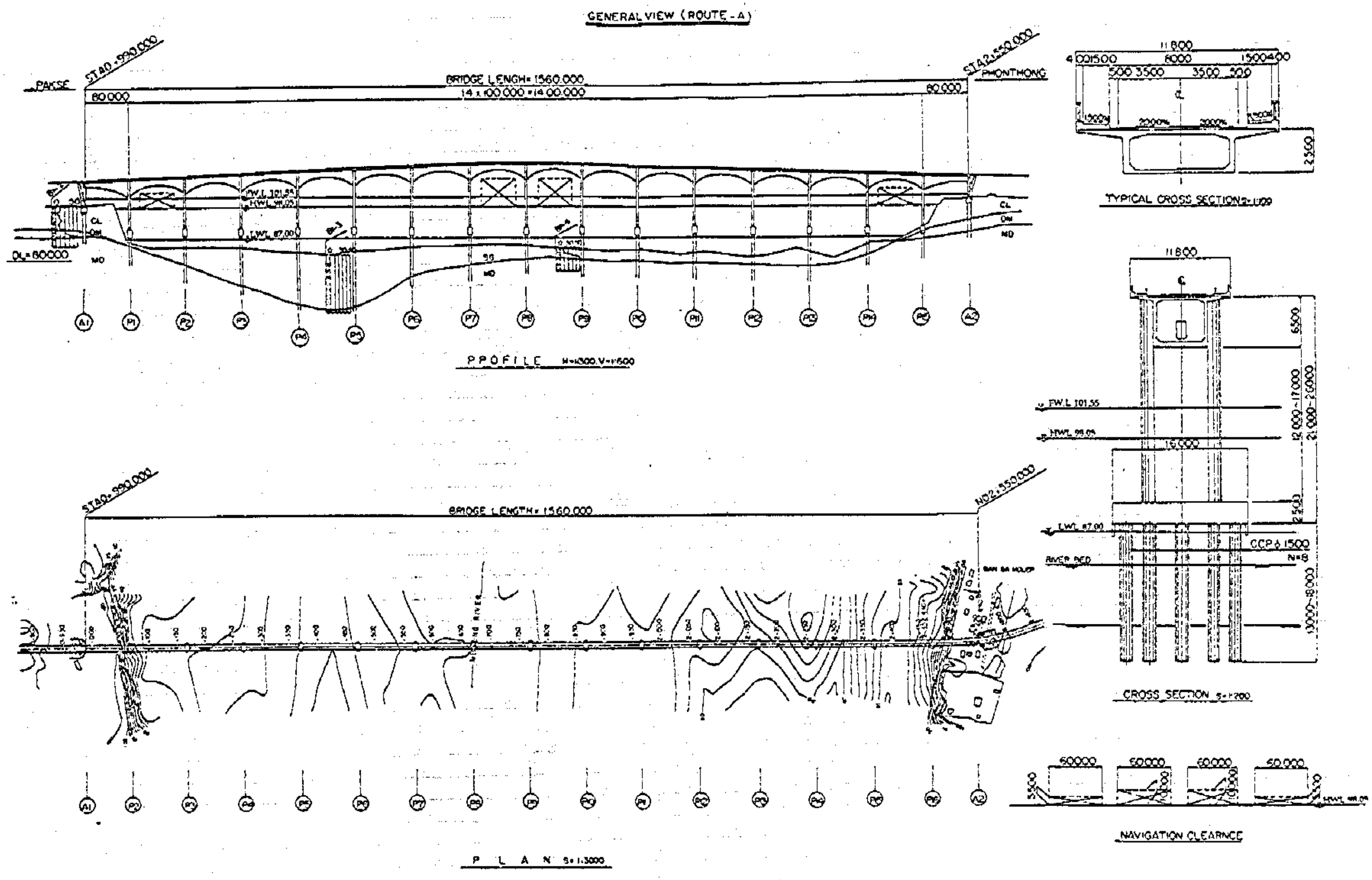


FIGURE 9.2-6 BRIDGE CONFIGURATION FOR ROUTE - A

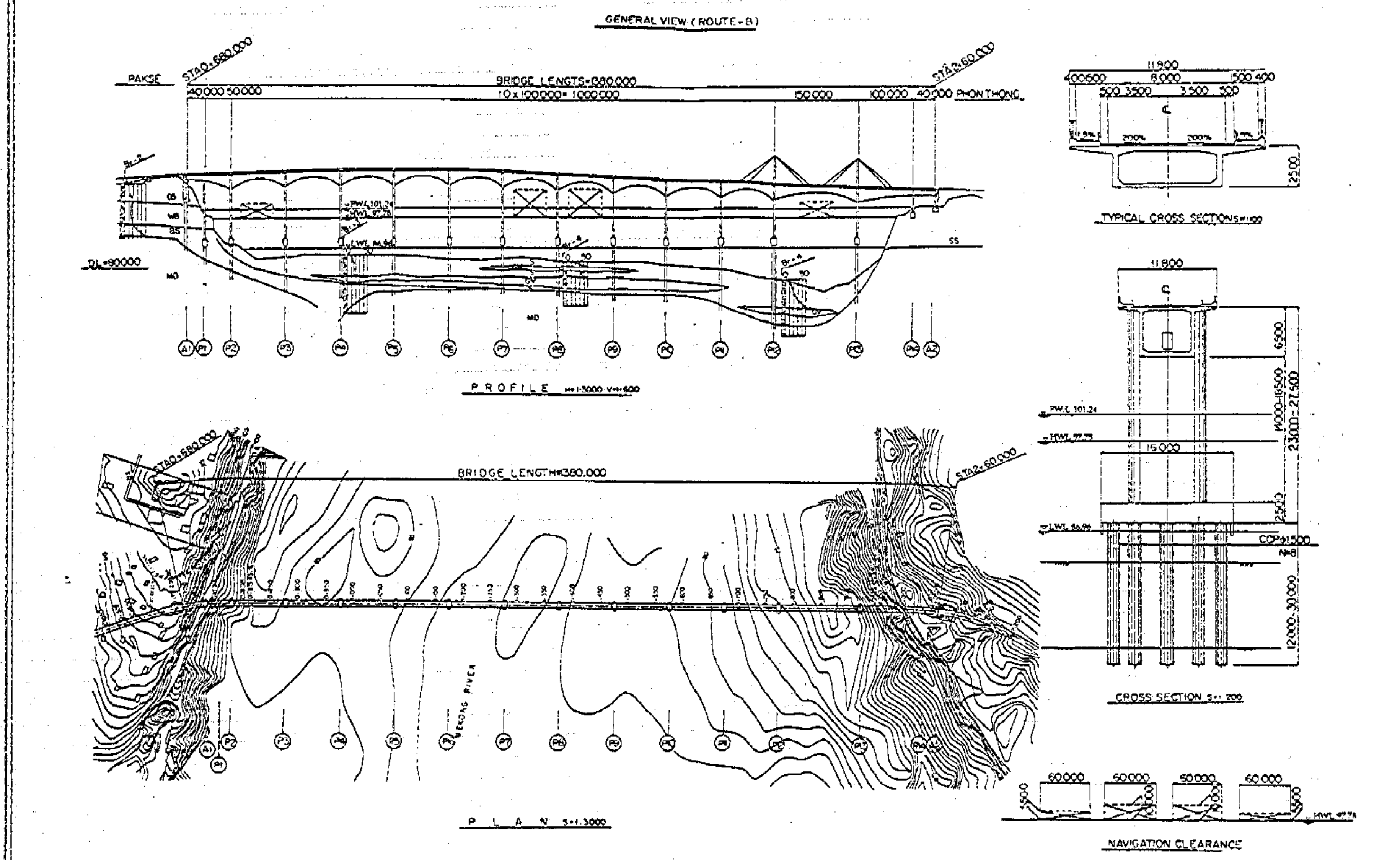


FIGURE 9.2-7 BRIDGE CONFIGURATION FOR ROUTE - B

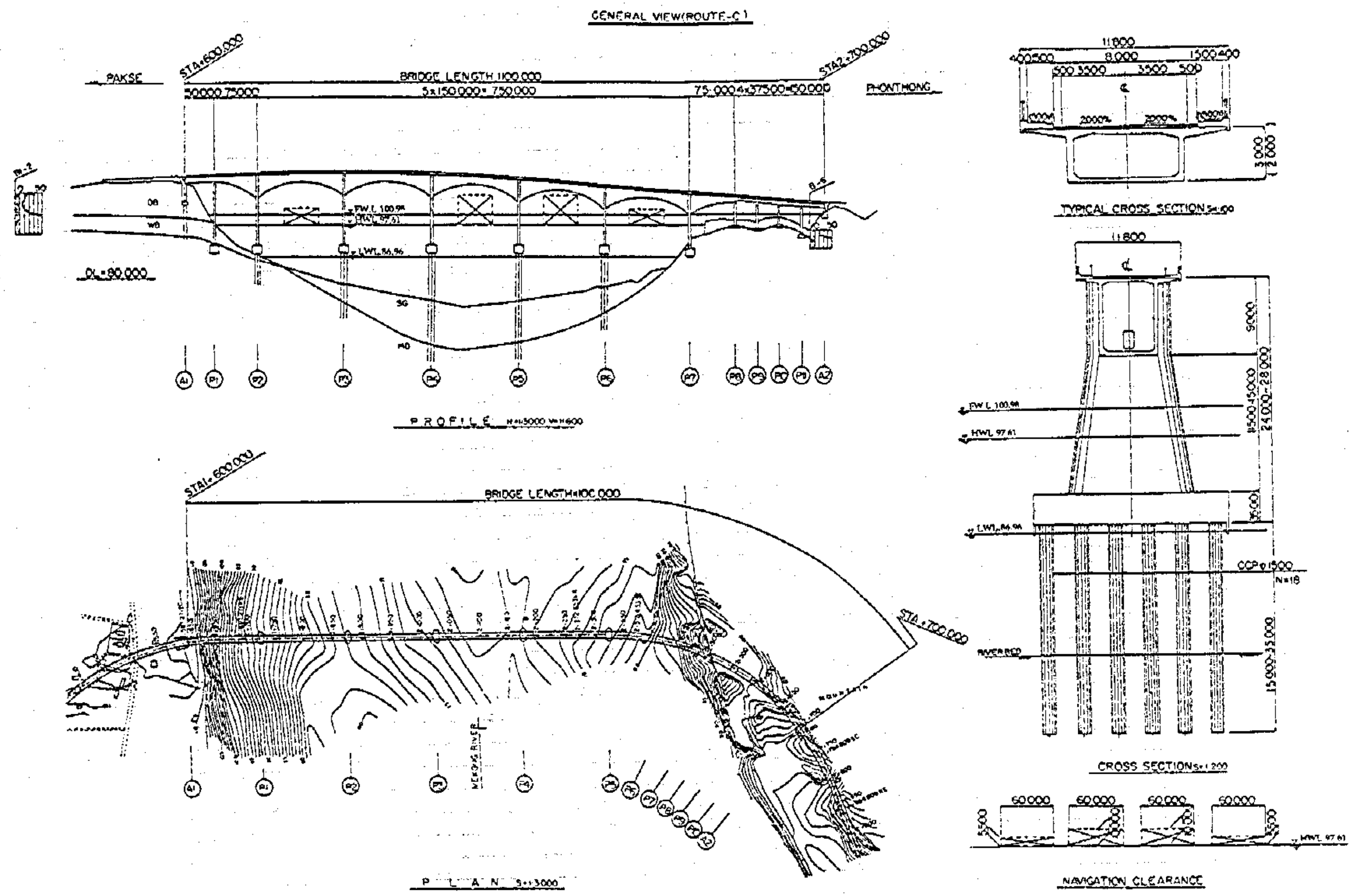


FIGURE 9.2-8 BRIDGE CONFIGURATION FOR ROUTE - C

9.3 Preliminary Design of Approach Roads

9.3.1 Geometric Design

The alignments of the alternative routes were studied on the topographic map at a scale of 1:20,000 and designed on the topographic map at a scale of 1:1000 which was prepared from the topographic survey carried out in a manner as described in subsection 7.2. The preliminary design of approach roads was made by taking into consideration the following basic requirement:

- To keep sufficient allowance in the designs of the horizontal and vertical alignments so that minor probable deviations would be made during the final design;
- To maintain the smooth traffic flow between the proposed roads and existing road network; and
- To minimize the environmental affect around the road sites.

1) Horizontal Alignment

The location of bridge section of each alternative route was selected as studied in section 4 and subsection 9.2. The horizontal alignment of approach roads is determined taking into the following factors throughout the route:

- To avoid curve section in the bridge section as much as possible;
- To avoid small radius horizontal curves and short curve length between long tangent length; and
- To avoid sharp curves.

Accordingly, the minimum curve radius of the horizontal alignment is set at 400 meters and clothoidal transition curves are applied for smooth alignment.

The final alignment is shown by alternative route in "Volume III: Drawings".

2) Vertical Alignment

The vertical alignment along the center line is mainly controlled by flood water level, the formation heights of bridge section around river banks and the designed elevations of NR 13S and NR 10 in the ADB 7th Project. Other factors controlling the vertical alignment design taken into account are:

- To keep generous gradient (maximum 4.00 %, minimum 0.30 %);
- To select vertical curve length which match with coincidental horizontal curves; and
- To make formation between the proposed roads and the existing roads and/or planning roads otherwise which intersect each other.

The vertical alignment prepared on the longitudinal profile sheets at 1:200 vertical scale and 1:2,000 horizontal scale is shown by alternative route in "Volume III: Drawings".

3) Description of Alignment

Route - A:

The starting point of Route - A is a place of 2 km on NR 13S from the north junction of Pakse Bypass . This route passes in a straight line at the elevation of 102 - 108 m in the paddy field around 500 m apart from Pakse Airport and crosses the Mekong river with right angle. After crossing the river it leads to NR 10 selecting the shortest distance with a curve of 400 m radius. The junction with NR 10 is located at KM 35 of NR 10 which is EL 105.93.

Route - B:

The junction with NR 13S of this route is located at KM 2+100 of NR 13S which is EL 101.75. This Pakse side approach extends in the residential area, which is not so congested, to the left river bank. It passes the west of Wat Phongsavat at a distance of around 100 m. The beginning point of the bridge at Pakse side is located at around 200 m upstream from Pakse Water Supply Station. The horizontal alignment of this section shifts the direction by an angle of 20 ° to cross the river at the shortest distance. The elevation of the bridge section varies EL 115.60 at the left bank to 107.87 at the right bank. The bridge section and the Phonthong side approach road are connected with the horizontal curvature of 400 m radius. This Phonthong side road passes behind the residential belt area located along the right river bank and connects the end point of NR 10.

Route - C:

The starting point of this route is located at KM 3+200 of NR 13S. The Pakse side approach road extends in a straight line and nearly at ground level toward the bridge section. It has a few crossing points with the existing paths. The route shifts the direction by an angle of 51° to cross the river and again by an angle of 69° to be connected with NR 10. For this horizontal alignment the bridge section around left bank side is forced to have a curve alignment. The approach road of Phonthong side leads along the river bank to NR 10 in similar alignment with alternative Route - B.

9.3.2 Cross Section

The basic cross elements and their dimensions of approach roads have been determined as described in the section 8.2.3.

At this preliminary design stage the typical cross section of approach roads integrating pavement structure, drainage system and cut and embank sections is proposed in proportion as the design of the ADB 7th Project as shown in Figure 9.3-1.

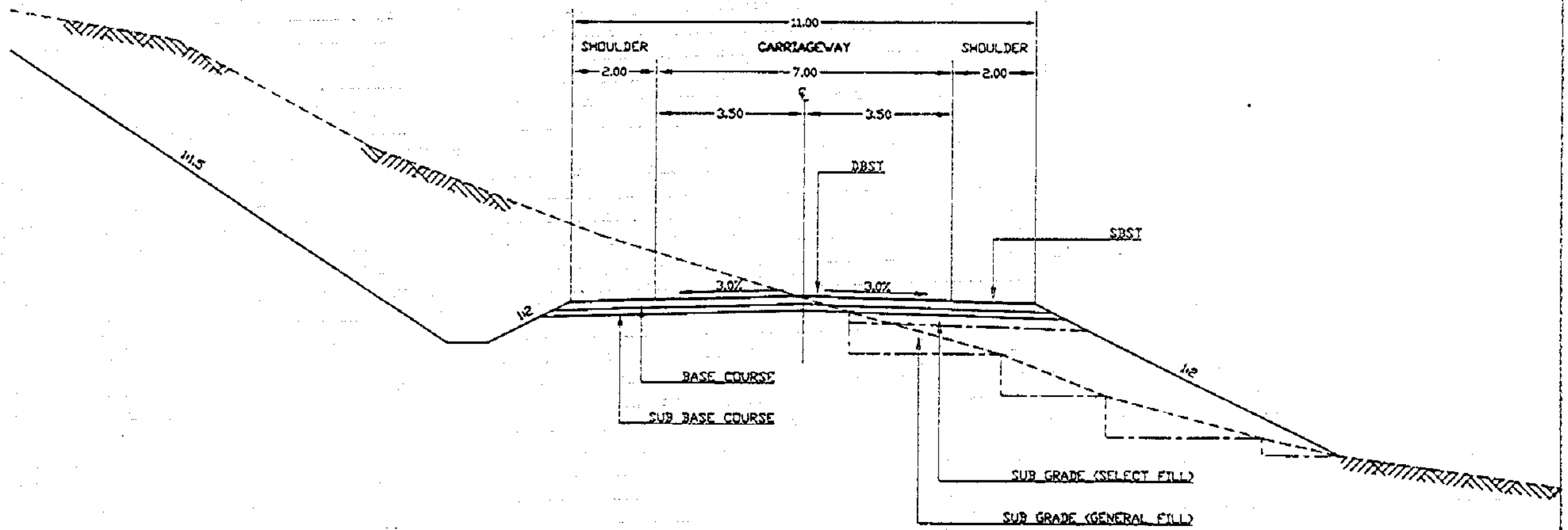


FIGURE 9.3-1 TYPICAL CROSS SECTION OF APPROACH ROAD

9.4 Construction Plan and Cost estimate

9.4.1 Construction Method

1) Foundation and Substructure

Cast-in- situ pile of protrusion type has been selected for foundation structure. To construct this foundation type the working stage above river water should be prepared. The systems of working stage for each alternative route are selected applicable to each site conditions as mentioned in subsection 9.2.3.2 as follows:

Route - A:	Floating vessels and temporary jetty for partial section
Route - B:	Floating vessels and temporary jetty for partial section
Route - C:	SEP and temporary jetty for partial section

The construction order after the preparation of working stage are follows:

Step 1	Driving of steel casing into river deposit layer up to bed rock surface
Step 2	Excavating of inside of casing
Step 3	Boring of bed rock for pile socketting without casing up to required depth
Step 4	Placing of reinforced bar cage into bored hole
Step 5	Casting of concrete

The steel casings for concrete piles are driven from the stage using a vibro-hammer together with water jet. For the excavation of inside of casing crab bucket or RCD (Reverse circulation drill) is used. For the drilling of bed rock heavy rock auger is used. To pore concrete into bored hole Tremee duct is used.

The forming and concreting of pile caps for pier footings are done to be supported by beams and brackets connected with piles constructed. After the completion of pile cap, pier shafts are constructed on it using floating vessels. The above works should be carried out during the water level is low.

2) Superstructure

Continuous rigid frame PC box girder has been selected for the structural system of superstructure in the subsection 9.2.3.3. This structural type also has been selected for the construction to be available to employ the increasing cantilever erection method since any supporting system is not useful.

The first block of box girder is constructed on the pier top using bracket staging anchored on pier shaft. This girder block and pier shaft are connected rigidly with reinforcing bars and PC bars. After completion of pier top block the cantilever blocks of 2.5 - 3.5 m length are casted extending toward opposite direction each other along the bridge axis taking the balance of weight. For this cantilever erection works the vorbau wagen is used. The connection of blocks at center span is carried out on the suspension stage.

9.4.2 Construction Schedule

The construction schedules for 3 alternative routes were prepared in consideration with annual workable days, construction methods and work items and quantities estimated through preliminary design on the bridge and approach roads.

To provide the special heavy construction equipment for foundation works and execute effectively the foundation works of piers of the bridge in the dry and drought (low river water level) season, the time of commencement of the construction works is assumed at the beginning of August.

Figure 9.4-1 shows construction schedule for 3 alternative routes under the following conditions.

Workable Days and Workable Hours:

The annual workable days are estimated assuming that the works will be suspended on Sunday, national holidays, rainy days and due to flood. The average annual workable days are approximately 210 to 220 days for earth work, and 230 to 240 days for structural works.

The actual daily workable hours are assumed to be 8 hours including 1.5 hour overtime. Two shifts of actual working hour of 6.5 hours each will be adopted for foundation works of the piers in the first dry season.

Work Party:

For the substructure construction two work parties are organized to start the work at same time. The foundation constructions including pile cap construction for all piers are scheduled to be completed in one dry season.

The erection works of superstructure starts at almost same time on the piers of half the number in any alternative route. For this scheme the set number of vorbau wagen prepared by alternative route are follows:

Route - A	7 sets at the first stage and 8 sets at the second stage
Route - B	6 sets at the first stage and 7 sets at the second stage
Route - C	3 set at each stage

where, one set means 2 units of the vorbau wagen. These construction units have at least time differences of 2 weeks in progress each other.

Labour Force:

Semi-skilled and common labours for the works will be recruited from the surrounding area of Pakse.

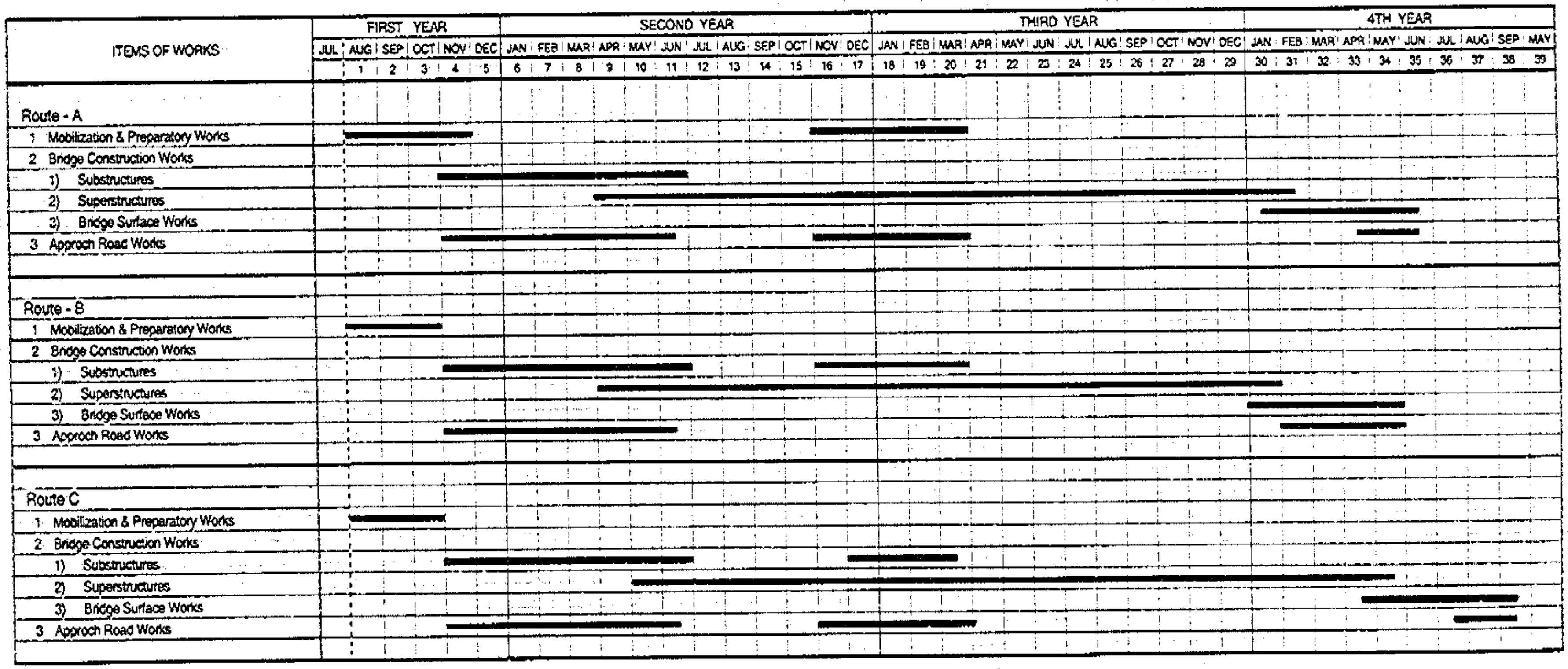


FIGURE 9.4-1 CONSTRUCTION SCHEDULE FOR THE PROPOSED ROUTES

9.4.3 Cost Estimate

Conditions of Cost Estimate:

The construction costs for the bridge and approach roads were estimated under the following conditions.

1) Project Execution Method

All the works will be executed on contract basis. The construction equipment, materials and labours required for the works will be provided by contractor to be selected through bidding.

2) Construction Cost

The cost estimate in this section includes construction cost only and is not including the costs such as land acquisition and compensation costs, engineering services and administration costs, and price escalation and physical contingency.

3) Unit Price

The unit construction costs for major work items were prepared by referring the prevailing unit price for construction cost for contractor system including direct cost and indirect cost , profit, etc. employed by similar project in South-East Asian countries.

The costs, including cost of construction equipment, materials and labor, both for the foreign and local currency portions were estimated in terms of US$.

4) Price Level

All the direct construction cost were estimated at the price level of September 1995. The exchange rate applied for the cost estimate is as follows:

US$1.00 =JY100 = Kip 920 = Thai B 24

The construction costs for 3 alternative routes are estimated as shown in Table 9.4-1. (Refer to "Volume II: Annexes").

TABLE 9.4-1 CONSTRUCTION COST OF ALTERNATIVE ROUTES

(Unit: US$1,000)

Item of Works	Route - A		Route - B		Route - C	
	Quantity	Amount	Quantity	Amount	Quantity	Amount
Construction Cost						
1. Bridge Construction		50,430		44,150		43,680
1) Substructure	A2, P15	13,860	A2, P15	11,870	A2, P11	14,370
2) Superstructure	17,160 m^2	36,570	15,180 m^2	32,280	12,100 m^2	29,310
2. Approch Road Construction	3,800 m	12,510	3,030 m	8,520	4,690 m	8,480
Total		62,940		52,670		52,160

CHAPTER 10

OPTIMAL BRIDGE ROUTE

10. OPTIMAL BRIDGE ROUTE

10.1 Preliminary Economic Analysis by Route

10.1.1 General

The main purpose of preliminary economic analysis is to provide a bit of basic information for selection of the optimal route from the three alternative routes. The analysis focuses on the "comparative study" of the alternatives. A detailed economic evaluation for the selected optimum plan will be carried out at the next step of the design work based on more elaborated cost estimates.

10.1.2 Methodology

(1) Economic Benefits of New Bridge Construction

It is broadly recognized that the main advantages of construction of a new bridge are the savings in time costs of traffic crossing over a river through realization of non-stopping, no-waiting continuous flows. The following types of benefit are calculated in this study:

1) Savings in time cost of vehicles crossing over the Mekong river on the ferries.
2) Savings in crew cost of commercial vehicles (buses and trucks)
3) Savings in future additional investment, operation, maintenance, repair cost for ferry boats and for ferry terminal facilities.
4) Savings in time costs of passengers in vehicles.

In addition to the above benefits, it is necessary to take into account the distance-related Vehicle Operating Costs (VOC) such as fuel, oil, tire consumption and repair cost of vehicles. In case of the Pakse bridge project, however, the locations of alternative routes are planned at the outskirts of Pakse town to avoid environmental problems. As the existing ferry route connects directly the center of Pakse with the NR10 on the opposite bank, future network conditions with the new bridge will result in longer running distances to cross the Mekong river than the existing ferry route for a lot of traffic which have origins/destinations from/to the town center. Therefore, not only the benefits of time savings but also losses in distance-related VOCs should be estimated as well.

(2) "With" and "Without" Comparison Method

The project benefits are calculated based on the "With project" and "Without project" comparison method. The definitions of "With" and "Without" cases are given in Table 10.1-1.

TABLE 10.1-1 DEFINITIONS OF "WITH" AND "WITHOUT" PROJECT CASES

Situation	Ferry/ New Bridge	Year 2000	2010	2020
Without Project	Ferry Services	Improvement	Improvement	Improvement
	New Bridge	--	--	--
With Project	Ferry Services	--	--	--
	New Bridge	With bridge	With Bridge	With Bridge

Above definitions indicate that the "Without project" case does not mean "Do nothing" case. Future river crossing traffic will continue to increase even in "without project" case and hence will reach the capacity of ferry services if do nothing. Under these situations, additional investments in ferry services (such as procurement of additional boats and expansion of terminals) will be required to cope with over capacity traffic. If these investments are not realized or "do nothing", waiting time at the ferry terminals will be increased to a level not born by almost all vehicles. That is not a realistic situation. The future operation costs and investment costs for ferry services will be estimated and treated as a part of benefits in the case of "With project" case.

(2) Benefits of Induced (Generated) Traffic

As analyzed in the traffic forecasting stage, there are three types of traffic demands which were defined as "Normal Traffic", "Development Traffic" and "Induced Traffic". Benefits of normal traffic and development traffic can be estimated based on the "with" and "without" comparison method. Benefits of induced traffic, however, are not estimated by the same way and hence so-called "Consumers' Surplus" procedure (applying the half of unit benefit of normal traffic) is adopted for benefit calculation.

10.1.3 Economic Project Costs

(1) Construction Cost

The project costs by alternative bridge route presented in the previous Chapter are the values in which transfer items such as taxes and duties are not included. Therefore, those costs will be applicable to the economic analysis. The physical contingency cost is estimated at 10 % of direct cost and administration costs are estimated at 3 % of local currency portion (assuming 50 % of total direct cost). No shadow prices are applied to this preliminary analysis.

(2) Land Acquisition and Compensation Costs

Land acquisition and compensation costs were preliminary estimated based on the environmental examinations.

TABLE 10.1-2 ECONOMIC COSTS (1995 PRICES)

(US$1,000)

ROUTE	ITEM / YEAR	Total ('96-2000) (1995 prices)	1996	1997	1998	1999	2000
ROUTE-A	- Direct Cost	62,940	0	21,085	19,826	17,623	4,406
	- Physical Contingency	6,294	0	2,108	1,983	1,762	441
	Subtotal	69,234	0	23,193	21,809	19,386	4,846
	- Engineering	4,406	1,386	800	971	971	278
	- Administration	944	0	316	297	264	66
	- Land Acquisition	104	0	104	0	0	0
	Total	74,688	1,386	24,413	23,078	20,621	5,190
ROUTE-B	- Direct Cost	52,670	0	17,644	17,539	14,748	2,739
	- Physical Contingency	5,267	0	1,764	1,754	1,475	274
	Subtotal	57,937	0	19,409	19,293	16,222	3,013
	- Engineering	3,687	1,160	669	813	813	232
	- Administration	790	0	265	263	221	41
	- Land Acquisition	275	0	275	0	0	0
	Total	62,689	1,160	20,618	20,369	17,257	3,286
ROUTE-C	- Direct Cost	52,160	0	17,474	17,369	14,605	2,712
	- Physical Contingency	5,216	0	1,747	1,737	1,460	271
	Subtotal	57,376	0	19,221	19,106	16,065	2,984
	- Engineering	3,651	1,148	663	805	805	230
	- Administration	782	0	262	261	219	41
	- Land Acquisition	647	0	647	0	0	0
	Total	62,456	1,148	20,793	20,172	17,089	3,254

(3) Annual Operation and Maintenance Costs (O & M Costs)

The annual economic operation and maintenance costs after opening year are estimated tentatively at US$ 4 per m per year for the approach roads. O & M costs by each alternative route are summarized as follows:

1) Route - A US$ 15,200 (3,800 m)
2) Route - B US$ 12,120 (3,030 m)
3) Route - C US$ 18,760 (4,690 m)

The economic project costs are summarized in the above Table 10.1-2.

10.1.4 Economic Benefits

(1) Vehicle Operating Costs (VOC)

1) Bases for Establishment of Vehicle Operating Costs

Since the National Transport Study (NTS) and ADB 1st - 8th projects, VOCs adopted in the Lao PDR have been conventionally based on the RTIM model (Road Transport Investment Model) which was developed by the Transport and Road Research Laboratory (TRRL) of the UK. NTS has considered originally to use another VOC model i.e. HDM model (Highway Design and Maintenance Standard Model) developed by the World Bank. However, HDM model is most appropriate for improvement or maintenance projects of existing roads and is quite complex to apply to new road/new bridge construction projects. NTS has thus preferred to develop individual spreadsheet models for each new construction project. Recently, however, the Transportation

Planning Unit (TPU) in MCTPC started to develop the HDM model for road maintenance projects in Laos. For this preliminary economic analysis of the new bridge construction project, it was decided to apply basically the same method adopted in the NTS after updating price components and adding some adjustments in calculation process. The basic input data were obtained referring to the ongoing studies of "ADB 8th Xieng Khouang Road Improvement Project (ADB 8th)" and "East - West Transport Corridor Study, ADB and Mekong River Commission (EWTCS)".

2) Vehicle Types and Representative Vehicles

The following five vehicle types and representative vehicles were adopted for VOC estimation:

1) Passenger Car (PC) :	Toyota Corolla
2) Pickup	Mitsubishi L200
3) Medium Truck	MAZ (8t)
4) Heavy Truck	KAMAZ (10t)
5) Very Heavy Truck	Hino (15t)
6) Bus (Micro bus)	Toyota Coaster (30 persons)

The relationship between vehicle categories used in the traffic forecast and above vehicle types is as follows:

Traffic forecast	Vehicle Types in VOC
- Motorcycle (MC)	Motorcycle
- Light Vehicle (LV)	PC and Pickup
- Bus	Micro bus
- Truck	Medium, Heavy and Very heavy truck

Motorcycles are not included in the NTS and HDM models. Therefore, the VOCs of motorcycles are roughly estimated to be at 20% of those of light vehicles. The characteristics of representative vehicles are presented in Table 10.1-3.

3) Road Surface Roughness and VOCs

Most components of unit VOCs (such as fuel, oil and tire consumption, the need for repair and maintenance) depend more or less strongly on the road type, mainly on surface roughness. Some other items of VOCs as well as the passenger time costs also depend on the average travel speed.

The NTS estimated VOCs by the level of road surface roughness; IRI (International Roughness Index) and set those values according to the following road types:

Road Type	IRI	Roughness
- Good Paved Road	4.5	3000mm/km
- Fair Paved Road	6.0	4500mm/km
- Average Paved Road	6.5	5000mm/km
- Poor Paved Road	7.5	6000mm/km

- Very Bad Paved Road 9.0 7500mm/km

In case of the Pakse bridge construction project, however, future main road network conditions in the study area are assumed to be improved by the ADB road rehabilitation projects regardless of "With" and "Without" bridge cases (Bridge *versus* Ferry). Therefore, VOCs of "Good Paved Roads" are applied to the both cases in this study.

TABLE 10.1-3 CHARACTERISTICS OF REPRESENTATIVE VEHICLES

(Basic Data for an Average Bitumen Road, R=5000, IRI 6.5 (dL=1.28)

(1995 prices)

	Vehicle Characteristics / Vehicle Type / Make	1	2	3	4	5	6
	Vehicle Type	PC	Pickup	Medium Truck	Heavy Truck	Very Heavy Truck	Microbus
	Make	Toyota Corolla	Mitsubishi L 200	MAZ (8t)	Kamaz (10t)	Hino (15t)	Toyota Coaster (30 pers)
1	Market Price new (US$)	26500	36260	26999	55440	70001	62640
2	Assumed average value (US$)	13250	18130	13500	27720	35000	31320
3	Import duty (%)	80%	30%	20%	20%	20%	20%
4	Assumed life length (years)	10	10	10	10	10	8
5	Gross Vehicle Weight (GVW) (kg)	1000	2465	15000	16000	22000	5180
6	Capacity - passengers	5	14	-	-	-	30
7	Capacity - goods (kg)	-	1200	8000	10000	15000	-
8	Type of fuel	Petrol	Petrol	Diesel	Diesel	Diesel	Diesel
9	Fuel price - financial (USc/l)	25.3	25.3	23.1	23.1	23.1	23.1
10	Fuel price - economic (USc/l)	17.7	17.7	18.5	18.5	18.5	18.5
11	Fuel consumption (l/km)	0.12	0.22	0.35	0.40	0.40	0.40
12	Oil consumption (l/100km)	0.15	0.20	0.40	0.40	0.30	0.40
13	No. of axles	2	2	2	3	3	2
14	No. of tyres (excl.spares)	4	4	6	10	10	6
15	Typical tyre size	645*13	650*14	1200*20	900*20	1200*20	650*14
16	Price per tyre - financial (US$)	57	59	304	149	304	59
17	Estimated tyre life (km)	30000	20000	40000	40000	40000	30000
18	No. of crew	1.0	1.0	1.2	1.2	1.2	1.2
19	Crew wages (US$/month)	60	60	72	72	72	72
20	Productive time (hours/year)	400	400	800	800	1200	1600
21	Average mileage (km/year)	15000	15000	20000	20000	30000	40000

4) Components of Vehicle Operating Costs

VOCs consist of the following components:

- Fixed costs (Time-related costs)
    - Capital costs of vehicles (a half of total depreciation cost and Interest)
    - Crew costs
    - Insurance cost
    - Overhead cost

- Variable costs (Distance-related costs)
    - Depreciation cost (a half of total depreciation cost)
    - Fuel cost

- Oil cost
- Tire cost
- Services and Repair cost

The costs of new and average vehicles, tire prices and fuel prices are shown in Table 10.1-4 to Table 10.1-6.

The NTS has combined the time-related VOCs with the distance-related VOCs and expressed those values as cost per km. However, separate estimates and separate application of time-related VOCs and distance-related VOCs are essential for this project because the main benefits which will be gained from this project are the savings in time-related costs but not from the savings in distance-related VOCs.

TABLE 10.1-4 NEW VEHICLE PRICES (US$, DECEMBER 1995)

Vehicle Type / Make / Price components	1 PC Toyota Corolla	2 Pickup Mitsubishi L 200	3 Medium Truck MAZ (8t)	4 Heavy Truck Kamaz (10t)	5 Very Heavy Truck Hino (15t)	6 Microbus Toyota Coaster (30 pers)
CIF	13384	26564	21428	44000	55556	49714
Import duty	10707	7969	4286	8800	11111	9943
Subtotal (CIF+Import Duty)	24091	34533	25714	52800	66667	59657
TVA Rate (%)	10%	5%	5%	5%	5%	5%
TVA Amount	2409	1727	1286	2640	3333	2983
Subtotal (CIF,Import Duty, TVA)	26500	36260	26999	55440	70001	62640
Total financial cost	26500	36260	26999	55440	70001	62640
Total economic cost (Average Value)	6692	13282	10714	22000	27778	24857

TABLE 10.1-5 TYRE PRICES (US$, DECEMBER 1995)

Vehicle Type / Make / Cost items	1 PC Toyota Corolla	2 Pickup Mitsubishi L 200	3 Medium Truck MAZ (8t)	4 Heavy Truck Kamaz (10t)	5 Very Heavy Truck Hino (15t)	6 Microbus Toyota Coaster (30 pers)
Tyre size	645*13	650*14	1200*20	900*20	1200*20	650*14
CIF	54	56	271	137	271	56
Import duty (%)	5%	5%	12%	9%	12%	5%
Import duty (US$)	2.7	2.8	33.1	12.3	33.1	2.8
Local sales cost & profit						
Total, financial cost	57	59	304	149	304	59
Total, economic cost	54	56	271	137	271	56

TABLE 10.1-6 FUEL PRICES (DECEMBER 1995)

Price Components	Super	Regular	Diesel
CIF (USc/litre)	19.3	17.7	18.5
CIF (Kip/litre)	179.607	176.329	171.446
Import Duty (%)	20%	15%	5%
Import Duty (Kip/l)	35.921	26.449	8.572
Contribution Tax (Kip/l)	53	36	18
Sub-total	268.528	238.778	198.018
Dealer Margin (Kip/l)	35.0	35.0	35.0
Sub-total	303.528	273.778	233.018
Tax on chiffre de affaires (%)	5.0%	5.0%	5.0%
Tax on chiffre de affaires (Stamp Duty) (Kip/l)	15.176	13.689	11.651
Grand Total	318.705	287.467	244.669
Pump Price (Market Price Kip/l)	275	235	215
Market Price (USc/l)	29.570	25.269	23.118
Implied Subsidy	43.705	52.467	29.669
Financial prices (USc/l)	29.6	25.3	23.1
Economic Price (USc/l)	19.3	17.7	18.5

5) Revised VOCs

The fixed economic VOCs (time-related costs excluding crew costs) and variable economic VOCs are presented in Table 10.1-7 and Table 10.1-8.

(2) Time Costs of Passengers

The valuation of time for vehicle occupants forms an another major part of benefits although the opportunity cost of time has been estimated so far at a low level in various studies. In order to calculate the passenger time values per vehicle, the following factors have to be taken into account:

- Average time value per person (i.e., a trip taker)
- Number of passengers per vehicle (excluding crew in commercial vehicles)
- Hourly utilization ratio

1) Average Time Value per Person

According to the household survey(*) conducted by the National Statistical Centre (NSC) in 1992/93, average monthly expenditure per household in the whole country of Laos was estimated at 84,920 Kip/month. Based on this information and together with other supplemental data, an average time value per vehicle in 1995 can be obtained through the following calculation:

a) Average monthly income per household in 1995 = (84,920 Kip) x 1.39 (= growth rate of per Capita GDP in current price 1992/93 - 1995) = 118,039 Kip

b) Average number of working persons per household = Household size (6.1 persons) x Independency Ratio (51.7% : percentage of age group 15-64 years old: population census) = 3.2 persons/household.
c) Average income per person in 1995 = (a)/(b) = 36,887 Kip/person (= US40/person/month: 1 US$ = 920Kip).
d) Average income per person per hour = (c) / 160 hours = 230 Kip/hour (=US$ 0.25/hour).

Note (*) : "Expenditure and Consumption Survey and Social Indicator Survey (1992-1993)", Committee for Planning and Co-operation, National Statistical Centre, 1995.

2) Number of Passengers per Vehicle

Information on average number of passengers by each vehicle type was provided by the "East - West Transport Corridor Stduy, ADB (EWTCS) and shown in Table 10.1-9.

3) Hourly Utilization Ratio

The evaluation of possibility of using a saved time for another productive activities is another problem. The EWTCS has applied the "Hourly Utilization Ratio" in order to take into account the opportunity cost of time by vehicle type (i.e. higher factors for commercial vehicles) as shown in Table 10.1-8. Different adjustment factors should be applied to passengers. In this analysis, 50% of saved time is assumed to be input to another economic activities.

Results of estimation of passenger time values are presented in Table 10.1-9 in which the future values escalated with the growth rates of per Capita GDP are also included.

TABLE 10.1-7 VEHICLE OPERATING COSTS ON A PAVED ROAD

(R = 5000 mm/km, IRI 6.5) 1995

	1	2	3	4	5	6
Vehicle Type	PC	Pickup	Medium Truck	Heavy Truck	Very Heavy Truck	Microbus
Make	Toyota Corolla	Mitsubishi L 200	MAZ (8t)	Kamaz (10t)	Hino (15t)	Toyota Coaster (30 pers)
Cost Items						
Fixed financial costs, US$/year						
Depreciation	1325	1813	1350	2772	3500	3132
Interest on capital (12%)	1590	2176	1620	3326	4200	3758
Crew	720	720	1296	1296	1296	1296
Insurance	508	682	517	1024	1283	1152
Overheads	0	539	478	842	1028	934
Time related financial costs US$/year (excl. crew cost)	3423	5210	3965	7964	10011	8976
Variable financial costs, US c/km						
Depreciation	8.83	12.09	6.75	13.86	11.67	7.83
Fuel	3.03	5.56	8.09	9.25	9.25	9.25
Oil	0.21	0.28	0.56	0.56	0.42	0.56
Tyres	0.76	1.18	4.56	3.73	7.60	1.18
Service & Repairs	1.33	1.33	1.00	1.00	2.57	2.57
Running costs, financial, USc/km	14.2	20.4	21.0	28.4	31.5	21.4
Fixed economic costs, US$/year						
Depreciation	335	664	536	1100	1389	1243
Interest on capital (12%)	402	797	643	1320	1667	1491
Crew	720	720	1296	1296	1296	1296
Insurance	94	150	128	225	274	249
Overheads	0	233	260	394	463	428
Time related economic costs US$/year (excl.crew cost)	830	1844	1567	3039	3792	3411
Variable economic costs, US c/km						
Depreciation	2.23	4.43	2.68	5.50	4.63	3.11
Fuel	2.12	3.89	6.48	7.40	7.40	7.40
Oil	0.18	0.24	0.48	0.48	0.36	0.48
Tyres	0.72	1.12	4.07	3.43	6.78	1.12
Service & Repairs	0.60	1.00	0.75	0.83	1.93	1.93
Running costs, economic, USc/km	5.9	10.7	14.5	17.6	21.1	14.0
Total economic costs, US c/km						
Hourly Utilization Rate (%)	75%	85%	85%	85%	85%	90%
Average speed, km/h	70	60	40	40	40	40
- running costs	5.9	10.7	14.5	17.6	21.1	14.0
- time related costs (excl. crew cost)	2.2	6.5	4.2	8.1	6.7	4.8

TABLE 10.1-8 ECONOMIC VEHICLE OPERATING COSTS BY ROAD STANDARD

(1995 prices)

Cost Items	1	2	3	4	5	6
VehicleType / Make	PC Toyota Corolla	Pickup Mitsubishi L 200	Medium Truck MAZ (8t)	Heavy Truck Kamaz (10t)	Very Heavy Truck Hino (15t)	Microbus Toyota Coaster (30 pers)
GOOD PAVED ROAD (R=3000 mm/km, IRI 4.5)						
Hourly Utilization Rate (%)	75%	85%	85%	85%	85%	90%
Average speed, km/h	90	75	55	45	45	65
- dL factor	1.0	1.0	1.0	1.0	1.0	1.0
- running costs, c/km	4.6	8.3	11.3	13.8	16.5	11.0
- time related costs, c/km (excl. crew cost)	1.7	5.2	3.0	7.2	6.0	3.0
Total Economic Costs, c/km	6.3	13.6	14.3	21.0	22.4	13.9
FAIR PAVED ROAD (R=4500 mm/km, IRI 6.0)						
Hourly Utilization Rate (%)	75%	85%	85%	85%	85%	90%
Average speed, km/h	75	65	45	40	40	55
- dL factor	1.2	1.2	1.2	1.2	1.2	1.2
- running costs, c/km	5.5	10.0	13.5	16.5	19.8	13.2
- time related costs, c/km (excl. crew costs)	2.1	6.0	3.7	8.1	6.7	3.5
Total Economic Costs, c/km	7.6	16.0	17.2	24.6	26.5	16.6
AVERAGE PAVED ROAD (R=5000 mm/km, IRI 6.5)						
Hourly Utilization Rate (%)	75%	85%	85%	85%	85%	90%
Average speed, km/h	70	60	40	40	40	50
- dL factor	1.28	1.28	1.28	1.28	1.28	1.28
- running costs, c/km	5.9	10.7	14.5	17.6	21.1	14.0
- time related costs, c/km (excl. crew cost)	2.2	6.5	4.2	8.1	6.7	4.8
Total Economic Costs, c/km	8.1	17.2	18.6	25.7	27.8	18.8
POOR PAVED ROAD (R=6000 mm/km, IRI 7.5)						
Hourly Utilization Rate (%)	75%	85%	85%	85%	85%	90%
Average speed, km/h	60	55	35	30	30	45
- dL factor	1.5	1.5	1.5	1.5	1.5	1.4
- running costs, c/km	6.9	12.5	16.9	20.7	24.7	15.4
- time related costs, c/km (excl. capital cost & crew cost)	2.6	7.1	4.8	10.8	9.0	4.3
Total Economic Costs, c/km	9.5	19.6	21.7	31.4	33.7	19.6
VERY BAD PAVED ROAD (R=7500 mm/km, IRI 9.0)						
Hourly Utilization Rate (%)	75%	85%	85%	85%	85%	90%
Average speed, km/h	45	45	30	25	25	35
- dL factor	1.7	1.7	1.8	1.8	1.8	1.8
- running costs, c/km	7.8	14.2	20.3	24.8	29.7	19.7
- time related costs, c/km (excl. capital cost & crew costs)	3.5	8.7	5.5	12.9	10.7	5.5
Total Economic Costs, c/km	11.2	22.9	25.9	37.7	40.4	25.2

TABLE 10.1-9 ADOPTED TIME-RELATED AND DISTANCE RELATED COSTS

Items \ Vehicle Type	VEHICLE TYPE: Light Vehicle		Truck			Bus	
Items	PC	Pickup	Medium	Heavy	Very Heavy		
River Crossing Traffic (1995)	25	55	45	54		14	
TIME-RELATED VOC							
US$/year	830	1844	1567	3039	3792	3411	
(US$/hour)	2.07	4.61	1.96	3.80	3.16	2.13	
Hourly Utilization Ratio (= Fleet reduction factor)	75%	85%	85%	85%	85%	90%	
Economic Time-Related Cost (US$/h)	1.56	3.92	1.66	3.23	2.69	1.92	
Weighted Average Time Cost of Vehicles (US$/hour)	**3.18**			**2.37**		**1.92**	
RUNNING COSTS OF VEHICLES							
Economic Variable VOC (USc/km)	4.6	8.3	11.3	13.8	16.5	11.0	
Weighted Average Running Cost of Vehicles (USc/km)	**7.17**			**13.38**		**11.0**	
TIME COSTS OF CREW							
(A) Monthly Crew Costs (US$)	60	60	72	72	72	72	
(B) Hourly Crew Costs (US$/hour)	1.80	1.80	1.62	1.62	1.08	0.81	
(C) Hourly Utilization Ratio (= Fleet reduction factor)	75%	85%	85%	85%	85%	90%	
(D) Time Cost of Crew (US$/hour)	1.35	1.53	1.38	1.38	0.92	0.73	
(E) Average Time Cost of Crew (US$/hour)	**1.47**			**1.25**		**0.73**	
	Light Vehicle		Truck				
TIME COSTS OF PASSENGERS	PC	Pickup	Medium	Heavy	Very Heavy	Bus	Motorcycle
(1) Number of Passengers (excl. crew in commercial vehicles)	2.8	2.8	2.7	2.7	2.7	22.4	1.5
(2) Average Time Costs per Person (US$/hour) 1995*	0.25	0.25	0.25	0.25	0.25	0.25	0.25
(3) Passenger Time Cost per Vehicle	0.70	0.70	0.68	0.68	0.68	5.60	0.38
(4) Hourly Utilization Ratio of passenger time	50%	50%	50%	50%	50%	50%	50%
(5) Economic Time Cost (US$/hour)	0.35	0.35	0.34	0.34	0.34	2.80	0.19
Weighted Average Time Cost of Passengers (US$/hour) 1995	**0.35**			**0.34**		**2.80**	**0.19**
TOTAL TIME COSTS (US$/hour)							
(CREW + PASSENGERS) 1995		1.82		1.59		3.53	0.19
(CREW + PASSENGERS) 2000**		2.17		1.89		4.19	0.22
(CREW + PASSENGERS) 2010**		3.15		2.74		6.09	0.32
(CREW + PASSENGERS) 2020**		4.75		4.14		9.19	0.49

Note: * Material source was monthly expenditure per household based on "Expenditure and Consumption Survey and Social Indicator Survey (1992-1993), CPC, NSC, July 1995

** Increased with the same growth of future per Capita GDP.

TOTAL TIME COSTS	YEAR	LV	Truck	Bus	MC
	1995	5.00	3.96	5.45	0.82
	2000	5.35	4.26	6.11	0.86
	2010	6.33	5.11	8.01	0.96
	2020	7.93	6.51	11.10	1.12

(3) Ferry Operations and Improvement Costs

1) Present Ferry Operating Costs

The information on annual expenditures for the existing ferry operations was obtained through interviewing the ferry company and DCTPC as shown in Table 10.1-10. Those costs were converted to economic costs by deducting taxes and duties and by applying the economic unit cost of fuel. It is assumed that those operation costs will be increased with the same rate of future traffic growth.

TABLE 10.1-10 PAKSE FERRY ANNUAL OPERATION COSTS (1995)

COST ITEMS	UNITS	ECONOMIC COSTS (in US$1,000/year)	US$/ferry trip
(1) Direct Ferry Operation Costs (for 5 boats)		119.9	13.1
- Ferry crew wages (20 persons)	100,000 Kip/person/month	26.1	2.9
- Fuel cost (for existing 5 boats)	22,500 litre/month	59.9	6.6
- Lubricant Oil	750litre/month	13.1	1.4
- Ferry boat maintenance costs	2,000,000 Kip/month	20.9	2.3
(2) Ferry Terminal Operation Costs		69.3	
- Terminal worker wages (54 persons)	86,000 Kip/person/month	60.6	6.6
- Jetty and approach road maintenance	10,000,000 Kip/year	8.7	1.0
(3) Annual capital costs		374.3	
- Depreciation costs	296,329,100Kip/year	322.1	35.3
- Interest costs	48,000,000 Kip/year	52.2	5.7
(4) General administration costs	6,000,000 Kip/month	77.4	8.5
TOTAL ECONOMIC OPERATION COSTS		640.9	70.2

Source: "Boat Association" and DCTPC.

It is anticipated that the ferry services (at least vehicle ferries) would cease its operations if the bridge were constructed. Therefore, future operation costs and future investment costs of ferry services after the new bridge is opened would be saved and those saved costs may be counted as benefits of the project from a point of view of national economy.

2) Future Improvement Program of Ferry Operations

- Ferry Boats

Table 10.1-11 indicates a future procurement plan of additional ferry boats in accordance with the future river crossing traffic demands.

TABLE 10.1-11 PAKSE FERRY INVESTMENT PROJECTION

Year	River Crossing Traffic M/C	L/V	BUS	TRUCK	TOTAL	TOTAL In Truck	Traffic Increase	Additional ferry trips	Daily Capacity	Ferry trips/day	No. of ferries	Additional boats required	Oneway trips per boat	Q/C TRU/(3)	Economic Cost for Additional Boats
	0.20	0.40	0.80	1.00		Unit(TRU)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(US$1,000)
1995	388	95	14	99	596	226			240	50	5		10	0.94	0
1996	448	110	16	123	697	269	43	9	283	59	5	0	12	0.95	0
1997	517	127	18	152	815	321	52	11	335	70	5	0	14	0.96	0
1998	598	148	20	189	955	384	63	13	398	83	5	0	17	0.96	0
1999	690	171	23	235	1119	459	75	16	474	99	5	0	20	0.97	0
2000	797	198	26	291	1312	550	91	11	565	110	6	1	20	0.97	215
2001	868	214	28	319	1429	601	50	6	615	116	6	0	20	0.98	0
2002	945	232	30	350	1557	656	55	7	670	123	6	0	20	0.98	0
2003	1029	251	32	383	1696	716	60	7	730	131	7	1	20	0.98	215
2004	1120	272	35	420	1847	781	65	8	795	139	7	0	20	0.98	0
2005	1220	295	37	461	2012	852	71	9	867	148	7	0	20	0.98	0
2006	1328	319	40	505	2192	930	78	10	945	158	8	1	20	0.98	215
2007	1446	346	43	554	2388	1016	85	11	1030	168	8	0	20	0.99	0
2008	1574	374	46	607	2602	1109	93	12	1123	180	9	1	20	0.99	215
2009	1714	405	49	666	2834	1210	102	13	1224	193	10	1	20	0.99	215
2010	1866	439	53	730	3088	1321	111	14	1335	206	10	0	20	0.99	0
2011	1973	465	56	754	3249	1380	58	7	1394	214	11	1	20	0.99	215
2012	2086	493	60	779	3418	1441	61	8	1455	221	11	0	20	0.99	0
2013	2206	523	64	804	3596	1505	64	8	1519	229	12	1	20	0.99	215
2014	2333	554	68	830	3784	1573	67	8	1587	238	12	0	20	0.99	0
2015	2466	587	72	857	3983	1643	71	9	1657	247	12	0	20	0.99	0
2016	2608	622	77	885	4192	1717	74	9	1731	256	13	1	20	0.99	215
2017	2758	659	81	914	4413	1795	78	10	1809	266	13	0	20	0.99	0
2018	2916	699	87	944	4646	1876	81	10	1890	276	14	1	20	0.99	215
2019	3083	741	92	975	4891	1962	85	11	1976	286	14	0	20	0.99	0
2020	3260	785	98	1007	5150	2051	90	11	2066	298	15	1	20	0.99	215
2021	3447	832	104	1040	5423	2145	94	12	2160	309	16	1	20	0.99	215
2022	3645	882	111	1074	5711	2244	99	12	2258	322	16	0	20	0.99	0
2023	3854	935	118	1109	6015	2348	104	13	2362	335	17	1	20	0.99	215
2024	4075	990	125	1145	6336	2457	109	14	2471	348	17	0	20	0.99	0
2025	4309	1050	133	1183	6675	2571	114	14	2585	363	18	1	20	0.99	215
2026	4556	1113	142	1221	7032	2691	120	15	2705	378	19	1	20	0.99	215
2027	4818	1179	151	1261	7409	2817	126	16	2831	393	20	1	20	0.99	215
2028	5094	1250	160	1303	7807	2949	132	17	2964	410	21	1	20	1.00	215
2029	5386	1324	170	1345	8226	3089	139	17	3103	427	21	0	20	1.00	0
2030	5695	1404	181	1389	8669	3235	146	18	3249	446	22	1	20	1.00	215

Source : JICA Study Team

Present river crossing traffic volume surveyed by the study team is 596 vehicles per day (traffic mixed). Those volume is equivalent to 226 TRUs (Truck Unit) per day.

On the other hand, the capacity of present ferry services is calculated as follows:

5 boats x 5 trips/one-way x 2 ways x 4.8 TRUs (average capacity /boat) = 240 TRUs

Therefore, volume/capacity ratio is 0.94 (= 226/240) and the present ferry services are seemed to be handling the demands in almost full capacity. According to the ferry company, however, present 5 boats can be increased their trips up to maximum 10 round trips (= 20 times crossing) per day per boat. This means a total potential capacity of the present ferry services is estimated as follow:

5 boats x 10 trips/one-way x 2 ways x 4.8 TRUs = 480 TRUs per day

Under these conditions, it is appear that no additional boats are necessary until the year 2000 as shown in Table 10.1-11. The increased traffic demands will be handled by the present 5 boats by increasing number of ferry trips. The procurement of additional boats will starts from 2000 so as to keep maximum number of trips per boat at 20 time crossings and keeping the total capacity at the level enough to cover the excessive demands.

Regarding the additional boats, a boat with a capacity of 8 TRUs is planned to be introduced in this study and the cost per boat is estimated at 250 million Kip (= US$ 269,000 in financial cost and US$ 215,000 in economic cost).

- Ferry Terminal Facilities

The present parking area at Pakse side terminal has enough space for future parking demands. No parking areas exist at Muang Kao side at present. Vehicles make a queue on the NR 10. It is difficult to expand present approach roads/slipways/landing facilities. According to DCTPC, relocation or construction of new ferry routes at other locations are also difficult because of dredging problems. Under these circumstances, only the costs of additional ferry boats are included in this preliminary analysis.

(4) Vehicle Waiting Time

The study team conducted a river crossing time survey at the ferry terminals on 15 November 1995 (Wednesday) in order to estimate the average crossing time including waiting time of vehicles. This was one day survey (12 hours; 7:00 am - 7:00 pm) and the survey form is illustrated in Table 10.1-12.

TABLE 10.1-12 MEKONG RIVER CROSSING TIME SURVEY FORM

STUDY ON CONSTRUCTION OF THE MEKONG BRIDGE AT PAKSE
(JAPAN INTERNATIONAL COOPERATION AGENCY & MCTPC)

CROSSING TIME SURVEY FORM (One sheet for one vehicle)

To ferry boat users
Please hand this survey sheet to a surveyor when you get off the boat

Site : 1. Pakse 2. Muang Kao

Surveyor's name ______________

SURVEY ITEMS	ENTRY SPACE		CODING SPACE
PLATE No.			
Arriving time to the terminal	AM PM		
Vehicle Type (Circle the appropriate No.)	1. Motorcycle 3. Bus 2. Car, Jeep, Pickup, Samlor 4. Truck		
Landing time	AM PM		

The results of the survey are summarized as follows:

Vehicle Type	No. of Samples	Crossing Time	Average
Motorcycle	89	20min. - 90min.	35min.
Car, Pickup	61	20min. - 95min.	39min.
Bus	3	22min. - 55min.	37min.
Truck	52	20min. - 115min.	42min.
All Vehicles	205	20min - 115min.	38min.

Above results indicate that the average crossing time is around 40-45 minutes and waiting time is about 30 minutes considering the observed actual crossing time on the river is 15 minutes. This estimated crossing time (45 minutes) is used for the calculation of time saving benefits of bridge users.

(5) Direct Benefits by Alternative Route

Total vehicle-km and vehicle-hours by alternative network (including "without project" case) were calculated from the results of traffic assignments. Traffic costs on the alternative network are estimated applying the unit VOCs (US$/km) and unit time values (US$/hour) to those vehicle-km and vehicle-hours. Direct benefits are calculated as the differences (savings) of traffic costs between without project case and with project case.

Results of calculations are presented in Table 10.1-13 (for normal traffic) and Table 10.1-14 (for induced traffic).

TABLE 10.1-13 BENEFITS OF NORMAL TRAFFIC

UNIT VOC AND UNIT TIME COST

	Unit VOC (US$/km)				Unit time cost (US$/hour)			
Year	MC	LV	Bus	Truck	MC	LV	Bus	Truck
1995	0.01434	0.0717	0.1100	0.1338	0.82	5.00	5.45	3.96
2000	0.01434	0.0717	0.1100	0.1338	0.86	5.35	6.11	4.26
2010	0.01434	0.0717	0.1100	0.1338	0.96	6.33	8.01	5.11
2020	0.01434	0.0717	0.1100	0.1338	1.12	7.93	11.10	6.51

ESTIMATED VEHICLE OPERATING COST (VOC) AND TIME COST (US$1,000/Year) (NORMAL TRAFFIC)

		VOC (1,000 US$ per annum)					Time cost (1,000 US$ per annum)				
Year	Route	MC	LV	Bus	Truck	Total	MC	LV	Bus	Truck	Total
2000	Without	348	899	295	1458	3001	502	1277	292	1043	3115
	A	367	922	300	1523	3111	329	1010	252	729	2320
	B	364	918	299	1496	3077	326	1004	250	717	2296
	C	374	930	302	1519	3125	335	1017	252	726	2331
2010	Without	736	1887	535	3575	6733	1251	3265	713	3161	8391
	A	781	1937	544	3737	6999	802	2572	608	2223	6205
	B	773	1930	542	3657	6902	794	2553	602	2171	6120
	C	798	1957	548	3705	7007	817	2588	608	2192	6205
2020	Without	1279	3311	866	5129	10585	2592	7375	1669	5831	17468
	A	1357	3404	885	5355	11001	1685	5844	1402	4196	13127
	B	1343	3387	881	5248	10859	1657	5777	1390	4094	12918
	C	1386	3435	890	5319	11031	1717	5870	1406	4149	13141

BENEFIT CALCULATION (US$1,000/year) (NORMAL TRAFFIC)

		VOC Savings (1,000US$/year)					Time savings (1,000US$/year)					Total
Year	Route	MC	LV	Bus	Truck	Total	MC	LV	Bus	Truck	Total	Benefits
2000	A	-19	-23	-5	-64	-110	173	268	40	314	795	684
	B	-16	-19	-4	-38	-76	176	273	42	327	818	742
	C	-26	-31	-6	-60	-124	167	260	40	317	784	660
2010	A	-44	-50	-10	-162	-266	450	693	105	938	2186	1920
	B	-37	-42	-8	-82	-169	457	712	111	990	2270	2101
	C	-61	-70	-13	-130	-274	434	677	105	970	2186	1912
2020	A	-78	-93	-19	-226	-416	907	1531	267	1635	4340	3924
	B	-65	-76	-15	-120	-274	935	1598	280	1737	4550	4275
	C	-107	-124	-24	-191	-446	876	1505	263	1682	4326	3880

TABLE 10.1-14 BENEFITS OF INDUCED TRAFFIC

UNIT VOC AND UNIT TIME COST

Year	Unit VOC (US$/km)				Unit time cost (US$/hour)			
	MC	LV	Bus	Truck	MC	LV	Bus	Truck
1995	0.00717	0.03585	0.0550	0.0669	0.410	2.500	2.725	1.980
2000	0.00717	0.03585	0.0550	0.0669	0.430	2.675	3.055	2.130
2010	0.00717	0.03585	0.0550	0.0669	0.480	3.165	4.005	2.555
2020	0.00717	0.03585	0.0550	0.0669	0.560	3.965	5.550	3.255

ESTIMATED VEHICLE OPERATING COST (VOC) AND TIME COST (US$1,000/year) (INDUCED TRAFFIC)

Route	VOC (1,000 US$ per annum)					Time cost (1,000 US$ per annum)				
	MC	LV	Bus	Truck	Total	MC	LV	Bus	Truck	Total
Without	8	10	2	11	31	19	29	3	20	72
A	9	11	2	14	36	8	12	1	6	27
B	9	11	2	14	36	8	12	1	6	27
C	8	12	2	15	38	7	13	1	7	28
Without	23	30	4	21	78	59	103	10	45	217
A	26	34	5	26	91	27	44	4	15	90
B	25	34	4	26	89	26	44	4	15	89
C	24	36	5	29	93	25	46	4	17	92
Without	38	49	7	33	127	115	214	24	83	437
A	43	55	8	40	146	54	96	12	31	193
B	40	55	8	39	142	51	94	12	30	187
C	40	58	9	43	149	50	101	14	33	199

BENEFIT CALCULATION (US$1,000/year) (INDUCED TRAFFIC)

Route	VOC Savings (1,000US$/year)					Time savings (1,000US$/year)					Total
	MC	LV	Bus	Truck	Total	MC	LV	Bus	Truck	Total	Benefits
A	-1	-1	0	-3	-6	11	18	2	14	45	39
B	-1	-1	0	-3	-5	11	18	2	14	45	40
C	0	-2	0	-4	-7	12	17	2	13	44	37
A	-3	-4	0	-5	-12	32	59	6	30	126	114
B	-2	-4	0	-5	-10	33	59	6	30	128	118
C	-1	-6	-1	-8	-15	34	57	6	28	124	109
A	-5	-6	-1	-7	-19	61	119	12	52	244	225
B	-3	-6	-1	-6	-15	64	120	12	53	250	234
C	-2	-10	-1	-10	-23	65	113	10	50	238	215

(6) Summary of Benefit Estimation

Estimated benefits by each benchmark year are summarized in Table 10.1-15. Benefits accruing from the route B show the highest amount among the alternatives.

TABLE 10.1-15 SUMMARY OF BENEFIT ESTIMATION

(US$1,000)

BENEFIT	ROUTE	TRAFFIC	2000	2010	2020
Users Cost Savings (VOC) (Time Costs)	A	Normal Traffic	(*) 684/2=342	1920	3924
		Induced Traffic	39/2=20	114	225
		Total	362	2034	4149
	B	Normal Traffic	(*) 742/2=371	2101	4275
		Induced Traffic	40/2=20	118	234
		Total	391	2219	4509
	C	Normal Traffic	(*) 660/2=330	1912	3880
		Induced Traffic	37/2=19	109	215
		Total	349	2021	4095
Savings in Ferry Service Costs	Operations		1562/2=781	3750	5823
	Investment		215	0	215
	Total		996	3750	6038

Note: (*) Opening timing of the Bridge is scheduled to be at the middle of 2000.
A half of yearly benefits is reckoned.

10.1.5 Economic Evaluation

(1) Assumptions for Economic Evaluation

Economic evaluation of the project bridge is made with so-called "Cost Benefit Analysis". The following conditions were assumed for the evaluation :

1) The opening timing of the Pakse bridge (regardless of alternatives) is scheduled to be in the middle of the year 2000 in accordance with the implementation plan.

2) Benefit streams between each benchmark year (2000, 2010 and 2020) are estimated by means of interpolation. Benefits after 2020 to 2030 are assumed to grow with the same trend of 2010 - 2020.

3) The evaluation period of the project bridge is assumed as 30 years after opening year.

4) Benefits are counted for up to the year 2030, while the bridge and approach roads will remain serviceable. Hence, the initial investment amount is not fully depreciated by that year. Assuming that the durable life of the bridge is 50 years, the residual value 30 years after opening, is calculated to be at 40 % (=20/50) of the total direct construction cost. This amount is refunded in 2030, as a negative amount in cost flow. In addition, 100 % of land acquisition costs are also counted as residual value because a land is not depreciable and will remain as it is even after

a long project life.

(2) Results of Economic Evaluation

Combining the annual investment schedule together with the annual benefits, the cost benefit cash flows were tabulated in order to calculate a evaluation indicator : Internal Rate of Return (IRR) by each alternative and shown in Table A.10-2 to A.10-4 ("Volume II: Annexes").

Consequently, the IRRs were as follows:

Route	IRR
Route - A :	6.8 %
Route - B :	8.0 %
Route - C :	7.8 %

The above results provide enough information to judge the priorities among the alternatives in this preliminary comparative study. In conclusion, the route B is the optimum route from an economic point of view if the IRR criterion is strictly applied.

10.2 Engineering Evaluation

This subsection addresses the relative assessment in engineering aspect to the alternative routes as a results of preliminary design.

Route Alignment:

There is no disadvantage on each route in the geometric design, but in viewpoint of road network efficiency Route-C located far from existing ferry route has an disadvantage comparing with Route-B and C since the major traffics originate at around center of Pakse urban area as being found in the data of O-D pattern of traffic flow between NR-10 and NR-13 (Refer to Fig 5.2-4 and 5.2-5). This has been reflected in the traffic benefits in above subsection.

River Hydrology:

The preferable bridge location shouldn't be to be on the narrowest section of river in viewpoint of the river hydrology and the stability of wet heritage, particularly for the river having no river training. At this aspect, Route-C is assessed in negative and Route-A in positive.

Foundation Structure:

The work conditions to construct pile foundations of Route-B is better than the other Route. The boring for piles is not so difficult to work for river deposit stratum of Rout-B. The foundation piles of Route-A and Route-B should be socketed deeply into bearing stratum of bed rock. For these socketting works the heavy and high torque capacity boring machine will be needed and operated on the river. Especially as the water depth of Route-C is deeper than the other Route, the stable and stiff platform should be prepared on the river for the work staging. Route-A and Route-B, particularly Route-C, are disadvantageous on the construction of foundation structures.

Superstructure:

As the structural type of main superstructure of each Route is selected in same type of PC box girder, there is no significant difference among alternative Routes. But, Route-C has longer spans and curved girder in partial section, the workability and selection of erection method will be restricted.

Construction Period:

Although there is no prominent difference in the construction periods, Rout-C takes about 3 months more than Route-A and Route-B of around 34 months. This factor also has been reflected in the construction cost.

Future Maintenance:

The concrete bridges of each Route are seemed to be free from maintenance works except bridge surface portions. For the approach roads the regular and periodic maintenance services will be required. Route-C having longer approach roads is disadvantageous in this aspect.

10.3 Environmental Evaluation

The analysis completed to date has been documented in detail in Section 6, where a summary of the analytical results obtained for 26 indicators within 11 components is shown. Each of the components was given a weighting according to the relevance and sensitivity of the component in relation to the project and the study area. This approach was used since components were not of equal importance. Since the overall impact of a bridge project is low the scales (aside from the social components) were on the low side. As expected, when combining the biophysical with the socioeconomic factors, the three alternatives had very similar scores. Using this scaling and weighting scheme, the numerical results, based on a scale of 1-10 with 10 being the least desirable, were that Alternative A had a score of 5.22, Alternative B had a score of 5.73, and Alternative C had a score of 5.11. In other words on purely environmental grounds Alternative C is the preferable alignment.

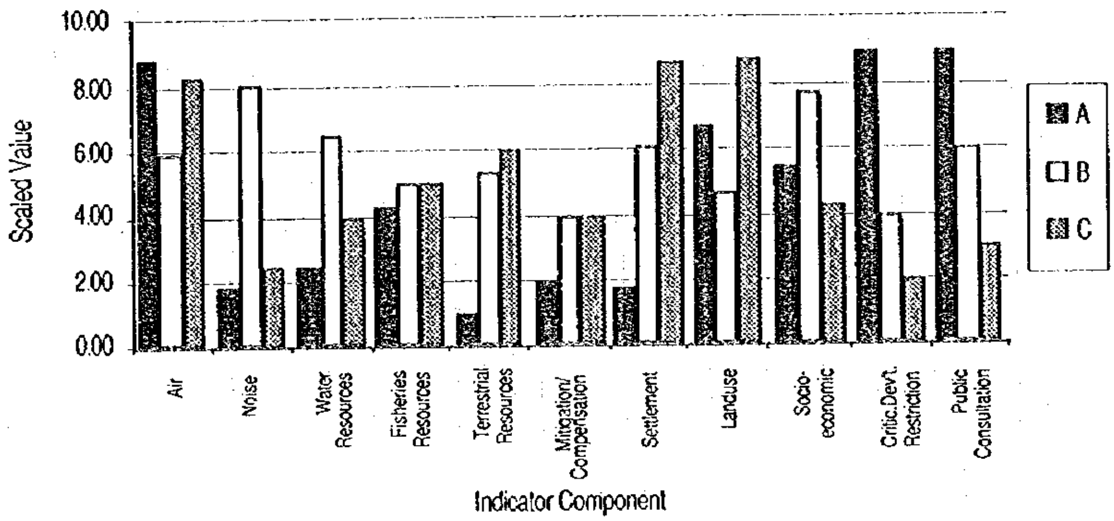


FIGURE 10.3-1 COMPARISON OF AVERAGE SCALED VALUES FOR 11 INDICATOR COMPONENTS
(based on 26 measured environmental indicators)

Where they differed (Figure 10.3.1) more significantly is in the social components. If we look at only the only the Human /Built, Critical Devít. Restrictions and Public Consultation components we find that Alternative A is the least desirable whereas B and C are only 0.41 points apart. Figure 10.3.1 also shows, graphically, that noise and water resources scores were quite variable.

With the exception of bridge runoff catchment facility, no mitigation was assumed for this analysis. No construction period effects and impacts associated with each alternative were addressed in this analysis (these details will be documented in the EIS).

Overall, biophysical impacts will be minimal, provided that construction methods are carefully controlled and that bridge runoff, during operation is collected (e.g., in a catchment pond) and allowed to settle, before discharged into the Mekong.

10.3.1 The Alternatives

(1) Alternative A

The major advantage of Alt. A is that it is located away from the urban area, with few homes and buildings to be taken. However it has a number of key negative characteristics, namely that it traverses, on both sides of the river, large areas of rice paddies, resulting in a much expanded impact since access and drainage in a large area, particularly on the Muang Kao (West) side of the river, would be irreparably affected. Secondly, this alignment is inside the no build zone of the airport (which has plans to expand its runway). If anything, the overall score for this components is conservative, given the potential long terms impacts of local farming.

The vertical elevation will be higher than 5.0 m in the East side thus creating a very significant access restriction and a major visual intrusion from ground or house level. If anything, the overall score for this components is conservative, given potential long terms impacts of local farming.

(2) Alternative B

Major advantages of Alt. B are that the approach road on the Pakse side is that it is shorter and will require the least number of dwellings/buildings to be taken from within the 40-m wide ROW.

Disadvantages are that the East approach road will have to be built in the urban residential part of what is now eastern Pakse, an area said, by the provincial government during consultation sessions, to be slated for steady residential development, incompatible with a 5-7 m elevated roadway. Their perception is that the proposed intersection of the approach road with the existing NR-13 will create congestion in the future, as the use- intensive facilities, crowded around this junction, expand.

Given the vertical profile of this approach road, noise will be broadcast over a wide area (with existing low level noise environment), extending at least 100m in either direction of the ROW.

Visually, the proposed Pakse side alignment will be highly intrusive and will block all direct contact with the other side and will drastically change local travel patterns. On the West side this will be far less severe.

Alignment B, on the West side must cross two streams which during the rainy season have flows in excess of 300 m^3/sec and which are spawning streams for at least two locally important fish species. Environmental acceptable crossings, which do not restrict flows or create downstream "plunge pools" or obstructions will be need to be part of the road design if important local impacts are to be avoided.

Finally, the Pakse-side approach road is only 140-m upstream of the towns water supply intake, creating a significant risk that if there is a bridge spill, the water supply may be fouled.

(3) Alternative C

Alternative C's advantages are that its Eastern approach road is located about 1.5 km away from the high use area along NR 13 and is in an area where vertical alignment will be more than 1 m thus keeping this more than 1 km long approach road reasonably intrusive. Given that the road is at or near ground level, natural noise attenuation approaches such as tree plantings would be easily established.

The same biophysical constraints apply here as for Alternative B, since the West side approach road would link into the starting section of Alt. B alignment, near the West side bridge abutment. In terms of fisheries, the potential impact may be higher since, just downstream of the bridge, there exists an important fishing community at Ban Salao, where artisanal fishermen fish the waters along the West half of the river Northward past Alt. C bridge crossing.

Disadvantages are that this alignment would require the taking of the greatest number of dwellings, the removal of the greatest number of trees (17 mature trees), as well as the use of greatest area of rice fields.

10.3.2 Considerations

For this project, and based purely on environmental grounds, it is difficult to determine clearly which alternative is the preferred one. The overall measurable impact is low, not withstanding that the new bridge, facilitating a future international road through Pakse, will bring profound longer term changes to the economic growth and social makeup of the town, and mitigation could be quite effective. Once environmental mitigation costs such as noise attenuation, provision of access under the approach road, establishment and maintenance of haul roads for the fill materials, rehabilitation of borrow areas, and other construction mitigation measures are added to the evaluation plus the inclusion of critical economic and engineering factors, a more decisive "preferred" alignment will emerge.

10.4 Optimal Bridge Route

The optimal bridge route is selected grading the appraised points on the evaluation items which consist of economic evaluation, engineering evaluation and environmental evaluation taking into consideration the results obtained from the previous subsections.

<u>The examination method for evaluation</u>:

(1) Evaluation components and Weighting

The weightings for the evaluation items are assigned attaching importance to economic component first and environment component second as follows:

Economic component	65 %
Engineering component	15 %
Environment component	20 %

(2) Sub-components

Each component has sub-components which are also allotted weighting. The appraisal score of component comes from the summation of sub-component scores.

(3) Score

Each score of sub component is given in inverse proportion to the appraisal ranking among 3 alternatives as follows:

Rank	Score
1	3
2	2
3	1

(4) Total score

The total score of each alternative route firstly is expressed in a range of the full mark of 3 as a summation of component scores. Finally the total scores are expressed in a range of the full mark of 100 as equivalent to raw scores.

The marking table is summarized as shown in Table 10.4-1. According to the evaluation result, it is concluded that Route-B should be selected for the optimal bridge route of this Project.

TABLE 10.4-1 EVALUATION TABLE FOR THE ALTERNATIVE ROUTES

		Alternatives		
		Route-A	Route-B	Route-C
Project Length (m)		5,360	4,410	5,790
Bridge Length (m)		1,560	1,380	1,100
Evaluation Items	Component and Sub component Weighting			
(1) Economic Evaluation	**0.65**	**0.65**	**1.69**	**1.56**
Economic Internal Rate of Return (EIRR %)	0.60	1 (6.8%)	3 (8.0%)	2 (7.8%)
Initial Capital Cost	0.40	1	2	3
(2) Engineering Evaluation	**0.15**	**0.32**	**0.44**	**0.15**
Alignment / Road Network	0.35	2	3	1
River Hydrology	0.10	3	2	1
Superstructure	0.05	2	3	1
Foundation	0.20	2	3	1
Construction Period	0.05	2	3	1
Future Maintenance	0.25	2	3	1
(3) Environmental Evaluation	**0.20**	**0.46**	**0.35**	**0.39**
Biophysical Environment	0.25	3	1	2
Human/Built Environment	0.40	3	2	1
Critical Development Restriction	0.15	1	2	3
Public Consultation Outcome	0.20	1	2	3
Summation		**1.43**	**2.48**	**2.1**
Score Out of the Full Marks of 100		**48**	**83**	**70**
Evaluated Priority Rank		**3**	**1**	**2**

(*) Note on the weighting rates of evaluation components:

Three major evaluation components composed of economy, engineering and environment are set for the project evaluation, and economic components is given the highest weighting rate among three components because economic benefit should be attached importance for the development Project. The engineering component is given the lowest weighting rate in the viewpoint that most of the effects might be automatically reflected in the economic benefit. On the other hand, as no crucial issues are found in the aspect of environmental impact assessment, the lower weighting rate is given to environment evaluation than economic component.

By way of experiment, should three components have given the same weight, the appraised scores of the alternatives are follows:

Route-A	Route-B	Route-C
53	81	59

This case also gives the first priority to Route B.

CHAPTER 11

ENGINEERING STUDY ON PROPOSED ROUTE

11. ENGINEERING STUDY ON PROPOSED ROUTE

11.1 General

The proposed route selected in previous chapter as the optimal route of the Project is the alternative Route-B. In this chapter the further engineering study on the proposed route following the preliminary design presented in Chapter 9 is carried out to clarify the Project features and to facilitate the data for the project evaluation and to establish the implementation plan of the Project.

11.2 Main bridge

11.2.1 Span Arrangement

The bridge length of 1380 m proposed in chapter 9 is determined as a bridge length of the proposed route. As for the span lengths around 100 m in the river section of shallow water depth and around 150 m in deeper section are employed as the economic span length respectively as studied in chapter 9.

The span arrangement which decides a number of pier was reconsidered on the preliminary plan so that the first pier located on the left river bank slope is deleted by making the extreme side span length longer, and as a result the bridge has 14 spans supported with 12 piers in the river and one pier on land, which is consisted of 70 m span, ten 102 m spans, 150 m span, 100 m span and 40 m span as shown in Fig. 11.1-1. This span arrangement was made based on not only employing economic span length but aiming at the pier to locate away from the deepest section of the river and also aiming at planning an even-numbered piers in the river considering the most effective appropriation of erection equipment when the increasing cantilever erection method is employed.

11.2.2 Superstructure

The structural type selected is a 14-span continuous rigid frame PC box girder with center hinges having the main span length of 100 - 102 m and 150 m. The geometric main dimensions of box girder structure are determined for the span of 102 m length. The shape of girder cross section is employed single box type with canti-lever slab decks as bridge width is 11.8 m. The section of 150 m span length is reinforced with the extradosed cables not to vary the main dimensions of box girder determined for the section of 102 m span length. The towers supporting extradosed cables at piers and the anchoring of extradosed cables into main girder are installed in the area between carriageway and sidewalk. For these spaces the bridge width is extended by 1.5 m at both side to 14.8 m in the section installed the towers or the anchors.

The girder depth of 6.5 m at pier was employed aiming at 1/16 of span length. The depth of 3 m at span center was determined due to the minimum requirement for the space installing center hinge shoes and the effective section properties against the section forces.

As a center hinge system transmits shear forces the structural analysis was carried out on the entire system of 14-span rigid frame. In the structural analysis the foundation structures were modeled as the spring fulcrum boundary conditions to the entire system for the structural analysis. The structural analyses and design calculations were carried out based on the design criteria and conditions established in Chapter 8. The loading combination for structural analysis on the entire bridge skeleton is considered as follows:

Case-1	Dead load + Dry shrinkage + Creep
Case-2	Dead load + Dry shrinkage + Creep + Live load
Case-3	Case-1 + Case-2 + Thermal force
Case-4	Case-1 + Thermal force + Seismic force
Case-5	Case-2 + Water flow pressure

The results of structural analysis are shown in ANNEX A.11.1.

The prestressing steel materials employed in the design are as follows:

Multi-strands 12T12.7	:For longitudinal prestressing
Multi-cable 12Ø8	:For lateral prestressing
PC bar Ø26	:For vertical prestressing
Multi-strand 27T15.2	:For extradosed diagonal cable

11.2.3 Substructure

Since the pier shafts, except one pier supporting superstructure with movable shoes, constitute the members of rigid frame structural system for bridge as mentioned above, the working forces for design mainly are come out from the results of the said analysis on superstructure. The member property of pier shaft was determined in the manner that the bending stiffness of pier shaft in the direction of longitudinal bridge axis becomes low. The thickness of pier shaft determined is of 3.0 m and the effective width is selected as same dimension as the lower flange width of box girder. As the sides of pier shaft to face to river flow direction should be made in a semicircular shape the entire width of pier shaft including the flare portions becomes 11 m. The entire width of both piers supporting 150 m span was estimated at 14 m to support the towers for extradosed cables.

The pier shaft also was checked against the working force of unbalanced moment which is anticipated to occur during erection works of superstructure.

The concrete of 350 kgf/cm2 strength was used for the pier top portion of 6 m prestressed to connect rigidly main girder with pier shaft while the pier shaft is designed as a reinforced concrete structure used the concrete of 240 kgf/cm2 strength for the other portions.

11.2.4 Foundation

About diameter of pile and the location of pile cap, the following conclusions were established based on the results of studies on comparison of construction cost, construction period, availability of piling equipment;

[Diameter of Pile]

- Availability of Piling Machine,
  Piling Machine(Rock Drilling Machine) for Dia. 1.00 m. has advantage on market availability comparing to Dia. 1.50 m. machine.

- Engineering Stability,
  Considering effects of river current to pier and piles), driftwood etc., Dia. 1.50 m. pile would be most appropriate.

- Construction cost and construction period
  In these two subjects, Dia. 1.50 m. of pile has some advantages to Dia. 1.20/1.00 m. as follows;

  * Shorter construction period due to less number of piles and similar piling speed comparing to the ones of smaller diameter pile types.
  * More effective stability to external forces, like river current, driftwood and other lateral and vertical loading conditions.

[Pile Cap]

The most appropriate type and location of pile cap were selected based on the following studies;

- How to reduce works below water level, such as scaffolding work, form work and concerning work,
- Considerations for stability and durability of pile foundation considering soil conditions of river bed, little covered soils on bed rock and not so fast current velocity and expected less effect of scoring for bed rock.

Major layout of pile foundation;

[Pile Foundation]

- Cast-in-situ reinforced concrete pile of 1.50 meter diameter covered by steel pipe in river water portion and constructed by rock drilling machine on floating barge or SEP, self elevating platform,
- Embedded length in river bed rock is about 5 meters depend on properties of bed rock,
- Reinforced concrete pile cap is allocated at the top of multiple piles to support rectangular shaped reinforced concrete column (pier) for supporting super structure, was selected as most appropriate layout,
- Pile cap has reinforced concrete skirt to cover the gap between bottom of pile cap

and LLWL, lowest low water level, as to protect accident due to small boat during dry season.

(3) Abutment and Foundation

Both abutments of Main Bridge are located on land pile foundation of large diameter cast-in-situ reinforced concrete piles and major layout of abutment and foundation are as follows;

- Cantilevered reinforced concrete wall type abutments were selected as most appropriate type of the abutments for the Main Bridge based on the engineering and economical reasons,
- Considering lighter loading condition due to the Main Bridge and different soil conditions comparing with the sub-structures in river area, off-shore, less number of piles with higher elevation of pile bottom are designed.

(Refer to Figure 11.1.1 ~ 11.1.3)

11.3 Approach Road

(1) Right of Way

In accordance with Lao PDR's regulations, there are two standards for Right of Way. A 30 meter Right of Way is used for Provincial Roads, and 40 meter for National Roads.

A 40 meters Right of Way is applied for this Project as well as the NR 10 and NR 13S.

(2) Pavement Design

The pavement design has been carried out in accordance with "Pavement Design, Road Design Manual Part III, Lao PDR". The Pavement shall consist of Subbase Course, Base Course and Surface Course. Subbase Course having a 15 cm thickness shall be constructed with lateritic soil. On the other hand, the Base Course shall be a mixture of gravel with lateritic soil. It should have a thickness of 20 cm. Refer to Figure 11.2-4

The Road surface of the carriageway will be paved by DBST(Double Bituminous Surface Treatment) using screened gravel.

(3) Miscellaneous Road Structures and Facilities

- Guard Post
  Some parts of the Approach Road have guard posts for protection against traffic accidents especially, sections of high banking and outer curvature.

- Guardrail
  Steel guardrails are installed in the sections of the approaches of each 200 m long to the main bridge.

- Centerline Mark
  In order to ensure safe driving, it is necessary to provide a painted centerline on the Road.

- Lighting
  Lighting facilities are installed on Main Bridge section only.

(4) Intersection with NR 13S at Beginning Point

Regarding the connection of the Approach Road with NR13S, a T-shape junction will be adopted. At the point of the junction, the traffic flows north and south in both directions on NR13S. Therefore, the carriageway shall be allowed sufficient width to additional lanes for a Left-turn lane and a Right-turn channel.

In future, when the traffic volume passing over the bridge increases the intersection shall be improved to a "major junction", refer to Figure 11.2-5.

(5) Drainage

Surface water on the new road will be directed to major drains through side ditches and/or pipe culverts. These facilities shall have sufficient capacity for the design flow. As for rainfall intensity, the analysis is shown in Table A.3-9 of Annexes.

(6) Settlement of High Bank at Fill Section

Settlement and consolidation in the section of high bank shall be studied for the soft ground area. There are some sections where the embankment is over 8m. The study by circular slip analysis will be considered for a typical cross section near a small river. (refer to Annexes)

Boring tests show that an approximately one meter thick layer of clayey silty fine sand overlies the lateritic clay layer. The consolidation of soft ground will not be a problem in this condition, because the layer is thin and the construction of the embankment will not be carried out rapidly.

(7) Slope Protection

Long slopes occur in the cuts in several places on the Phonthong side at the foot of Mt. Salat and in the high fill embankments in agricultural areas. Slope protection is very important to prevent soil erosion and slope failure especially in the high embankments.

Sodding is the generally preferred method in view of construction cost and aesthetic appearance. In the case of this Project, Sodding will be employed for slope protection on the section of embankment.