around 30:1. Discharge at the gauging stations along the Mekong River are summarized in Table 6.4.

Table 6.4 Summary of River Discharge

(Unit : m^3/sec)

Station	Maximum Recorded	Minimum Recorded	Average
Kratie	66,700 (1939)	1,250 (1960)	13,970 (1924-68)
Kompong Cham	57,000 (1966)	1,310 (1970)	13,660 (1964-73)
Phnom Penh	49,700 (1961)	1,250 (1960)	13,131 (1960-73)
Neak Loeung	31,700 (1966)	-	-

Source : National Mekong Committee

The Mekong River causes flood inundation in the areas downstream from Kompong Cham every rainy season. Riverbank overflow may occur when the water level rises to around 13 m above MSL at Kompong Cham (west bank), 8 m above MSL at Phnom Penh (west bank), and 7 m above MSL at Neak Loeung (east bank).

The particular hydrological characteristic of the Mekong River is the reverse flow to the Great Lake through the Sap River. When the flow of the Mekong River increases, the reverse flow of the Sap River begins. The reverse flow generally continues from May to September. During this period, the water surface area of the Great Lake varies from 3,000 km^2 to 10,000 km^2 with the corresponding lake water level from 3 m to 12 m above MSL, approximately.

6.2 Hyrological Study for Alternative Bridge Site

6.2.1 Water Level Analysis

(1) High Water Level

Probable high water levels were analyzed using the available gauge height records from year 1960 to 1994 at the gauging stations listed in Table 6.2. At first, probability analysis was made for the gauging stations of the Mekong River at Kratie and the Bassac River at Phnom Penh in consideration of the availability of records (Appendix 6.1 to Appendix 6.7). The probability distribution of Log Pearson Type III was applied for analysis of the annual highest water level records (Appendix 6.8).

Probable high water levels at the other gauging stations such as Kompong Cham, Phnom Penh (Mekong), and Neak Loeung were obtained by correlation with the annual highest water level at Kratie or Phnom Penh (Bassac) as shown Appendix 6.10. The estimated probable high water levels at the gauging stations are shown in Table 6.5.

Table 6.5 Probable High Water Levels at Gauging Stations

Return Period (years)	Water Level (above MSL)				
	Kratie	Kompong Cham	Phnom Penh (Mekong)	Phnom Penh (Bassac)	Neak Loeung
2	19.92	13.72	8.87	8.86	6.67
5	20.89	14.35	9.40	9.39	7.14
10	21.33	14.64	9.66	9.64	7.36
25	21.75	14.92	9.91	9.90	7.59
50	21.99	15.07	10.07	10.06	7.73
100	22.19	15.20	10.21	10.20	7.85

Source : JICA Study Team

For the alternative bridge sites, probable high water levels were estimated from the results above and water surface gradients between the gauging stations with reference to the daily gauge height records during the past major flood periods (Appendix 6.12). Table 6.6 provides the estimated probable flood level at each alternative bridge site.

Table 6.6 Probable Flood Water Levels at Alternative Bridge Sites

Return Period (years)	Water Level (above MSL)					
	Kompong Cham (C-1)	Kompong Cham (C-2)	Prek Tamak (B-1)	Prek Tamak /Svay Chrum (B-2)	Neak Loeung (A-1)	Neak Loeung (A-2)
2	13.72	13.66	10.02	8.87	6.75	6.71
5	14.35	14.29	10.57	9.40	7.22	7.18
10	14.64	14.58	10.84	9.66	7.45	7.40
25	14.92	14.85	11.10	9.91	7.68	7.63
50	15.07	15.00	11.26	10.07	7.81	7.77
100	15.20	15.13	11.39	10.21	7.93	7.89

Source : JICA Study Team

(2) Low Water Level

An analysis of low water levels was made by the following procedure, which is similar to the analysis of high water levels discussed in the above section.

1) Probability analysis of annual lowest water level at Kratie and Phnom Penh (Bassac) were made using the probability distribution of Log Pearson Type III (Appendix 6.9).

2) For the other gauging stations, probable low water levels were estimated from the results of (1) by correlation of water surface gradient during low water periods (Appendix 6.11 and Appendix 6.13).

3) For the alternative bridge sites, probable low water levels were estimated from the low water levels at the gauging stations and the water surface gradients (Appendix 6.13).

Results of the analysis are shown in Table 6.7 for the gauging stations and Table 6.8 for the alternative bridge sites.

Table 6.7 Probable Low Water Levels at Gauging Stations

Return Period (years)	Water Level (above MSL)				
	Kratie	Kompong Cham	Phnom Penh (Mekong)	Phnom Penh (Bassac)	Neak Loeung
2	4.44	0.98	0.66	0.67	0.54
5	4.12	0.82	0.59	0.62	0.48
10	3.94	0.73	0.56	0.51	0.45
20	3.79	0.66	0.53	0.56	0.43

Source : JICA Study Team

Table 6.8 Probable Low Water Levels at Alternative Bridge Sites

Return Period (years)	Water Level (above MSL)					
	Kompong Cham (C-1)	Kompong Cham (C-2)	Prek Tamak (B-1)	Prek Tamak /Svay Chrum (B-2)	Neak Loeung (A-1)	Neak Loeung (A-2)
2	0.98	0.98	0.78	0.66	0.54	0.53
5	0.82	0.82	0.69	0.59	0.49	0.48
10	0.73	0.73	0.64	0.56	0.46	0.45
20	0.66	0.66	0.60	0.53	0.43	0.43

Source : JICA Study Team

6.2.2 Flow Velocity

(1) Measurement of Flow Velocity

Measurement of flow velocity was carried out for each alternative bridge site during the following periods.

1) 29th May - 4 th June (in the end of low flow season)

2) 27 th July - 1st August (in the beginning of high flow season)

Results of the measurement are attached in Appendix 6.14 to 6.24. The results show that the average flow velocity by site varies from 0.1 m/sec to 0.3 m/sec in the end of low flow season and from 1.2 m/sec to 1.7 m/sec in the beginning of high flow season, respectively.

(2) Estimation of Flow Velocity during Flood

Flood flow velocities at the alternative bridge sites were estimated by Manning's equation as follows :

$$Q = AV \qquad \text{(eq. 1)}$$
$$V = (1/n) I^{1/2} R^{2/3} \qquad \text{(eq. 2)}$$

where: Q = Discharge (m^3/sec)

A	=	Discharge Area (m^2)
V	=	Flow Velocity (m/sec)
n	=	Coefficient of Roughness
I	=	Hydraulic Gradient
R	=	Hydraulic Mean Depth (m)

Since no discharge record is available for recent years, the annual maximum discharge records from the 1960s to 1970s were used. A relationship between water level and discharge area was obtained from the bathymetric survey data. When the alternative bridge site is located at a close location to the gauging station, flow velocity can be calculated by eq. 1. For the other cases, eq. 2 can be used on the assumption that the hydraulic gradient is equal to water surface gradient at the corresponding date of occurrence of the annual maximum discharge at the closest gauging station, and that the coefficient of roughness at the closest gauging station can be applied to the bridge site. The maximum flow velocity estimated from the available discharge records is shown in Table 6.9.

Table 6.9 Flood Flow Velocities at Alternative Bridge Sites

Site	Kompong Cham (C-1)	Kompong Cham (C-2)	Prek Tamak (B-1)	Prek Tamak/ Svay Chrum (B-2)	Neak Loeung (A-1)	Neak Loeung (A-2)
Flow Velocity (m/sec)	2.84	2.53	2.78	2.26	1.96	1.96

Source : JICA Study Team

6.2.3 Required Minimum River Width

Since the Mekong is a natural river and riverbank overflow and inundation frequently occur along the river, the channel width of the river is determined not only by the width of water surface. The definition of river width depends on the existence of a river structure to be provided properly against river flow. In this study, river width is defined as the distance between bridge abutments at opposite sides of the river, which would not be seriously affected by river flow.

The channel of the Mekong River has the following characteristics:

1) The river channel is rather deep and wide.

2) The difference between the low water channel and high water channel is not clear, and the river stage generally varies within the channel except in the case of extremely high water level.

3) The elevation of the top of the riverbank is higher than the hinterland; this indicates that a natural levee is formed along the river channel.

According to the above, if a bridge abutment is placed on the hinterland of a natural levee, the bridge abutment is not seriously affected by flow because flow velocity becomes quite low in the inundation area in comparison with channel flow velocity. Consequently, the minimum required river width can be defined as the distance between the tops of the riverbanks on both sides of the river channel. Table 6.10 shows the river widths for each bridge route.

Table 6.10 River Width

Route	Kompong Cham (C-1)	Kompong Cham (C-2)	Prek Tamak (B-1)	Prek Tamak/ Svay Chrum (B-2)	Neak Loeung (A-1)	Neak Loeung (A-2)
River Width (m)	819	1,280	915	1,035	1,800	1,084

Source : JICA Study Team

Besides the river width, the following considerations are required:

1) At least a 2 m flood clearance above the 100-year flood level should be provided at the abutment.

2) When inundation depth is significantly deep around the abutment and approach road, a viaduct bridge should be provided.

6.3 River Morphology

6.3.1 River Channel Conditions

(1) Kompong Cham (C-1)

Around the City of Kompong Cham, the width of the river becomes rather narrow while large meanderings are observed both upstream and downstream. The site is located in the section where the river behavior changes rapidly. On the west side, the foundation rock outcrops on the riverbank and bed are due to scouring from the river flow. The lowest riverbed elevation is around 47 m below MSL. Riverbank overflow does not occur on the west riverbank with the highest elevation of around 16 m above MSL. On the other hand, sediment deposit is observed on the east riverbank with a relatively gentle slope. The area along the east riverbank frequently suffers from flooding because the elevation of the top of the riverbank is around 13.5 m above MSL, which is lower than the estimated 2-year flood level of 13.72 m. The river channel is stable at the proposed bridge centerline because the scouring on the west riverbank already reaches the foundation rock, while significant erosion is observed around 1 km upstream; the riverbank just downstream of the bridge site has a shape similar to that of a bay which may have been formed by disturbance of flow.

(2) Kompong Cham (C-2)

The C-2 site is located 1 km downstream from the C-1 site. The river channel shows a similar tendency to that of the C-1 site: erosion and scouring on the west riverbank and sediment deposit on the east riverbank, but the flow effects are relatively minor because the channel width is wider than the C-1 site. The lowest riverbed elevation is 26 m below MSL. The highest elevation of the riverbank is around 15.7 m above MSL on both sides, which is higher than the estimated 50-year flood level of 15.20 m above MSL so that the proposed bridge route should not be seriously affected by riverbank overflow.

(3) Prek Tamak (B-1)

The river channel becomes almost straight with a narrow width after the bending section upstream from Prek Tamak. The lowest riverbed elevation is 26 m below MSL. The elevation of the top of the riverbank is around 10.5 m above MSL, which almost corresponds with the estimated 5-year flood level. Along the west riverbank, sediment deposit has proceeded in the upstream bending section and some erosion is observed at the proposed bridge route.

(4) Prek Tamak/Svay Chrum (B-2)

The two branches divided by an island join into one channel just upstream of the B-2 site. On the east side, the lowland, which may be trace of the old river, extends for a distance of 500 m from the current riverbank. The elevation of the lowland is around 3 m lower than the top of the riverbank. East of the lowland, lakes and swamps are widely distributed. The lowest elevation of the riverbed is 23 m below MSL. The river channel seems to be almost stable at the bridge route, while the upstream east branch tends to move eastward around the junction.

(5) Neak Loeung (A-1)

Around the bridge route, the Phnum Khnong island is formed with a 4 km length and 1 km width. On the proposed bridge centerline, the highest elevation of the island is around 7.2 m above MSL and most of locations are lower than the normal high water level of 6.75 m above MSL. This indicates that the island is almost entirely submerged during floods. The channel east of the island is a main water course with the lowest riverbed elevation at 22 m below MSL. The channel west of the island is shallow with the lowest riverbed elevation at 0.6 m below MSL, and it is subject to sediment buildup. A sand bar has extended to the west and around the southern end of the island. Riverbank overflow may not be frequent around this route because the top of the riverbanks on both sides are higher than the estimated 25-year flood level of 7.59 m above MSL.

(6) Neak Loeung (A-2)

The proposed bridge route is located 1 km downstream of the ferry. Both riverbanks seem to be in stable condition; notable erosion and deposits are not observed. Since the top of the riverbank on the west side has almost the same elevation as the normal high water level of 6.67 m above MSL, flood inundation may occur once every two years on this side. The lowest riverbed elevation is 21 m below MSL.

6.3.2 Study of Flood Area

The Mekong River flows through Kratie, Kompong Cham, Kandal, and Prey Veng provinces before heading into Vietnam. The lowlands of these provinces are subject to flooding during the peak flow season, specifically July to September causing widespread damage to crops and property. Further, the flooding is significant on the left bank of the Sap River north of Phnom Penh. Comprehensive studies of viable transportation plans and regional development programs should give proper consideration to the inundation and consequences of floods.

The historical records and published maps of flooding areas are obsolete or not yet completed. The Landuse Map prepared by the Remote Sensing and Mapping Unit of the Mekong Secretariat in 1991 is the best source of information available for land cover in the present study area. The areas delineated as swampy vegetation and grass lands susceptible to flooding could be considered as the flood inundation areas, but the generalization of source data and the presented scale may have diminished the accuracy of the flood hazard land area.

In the present study, it was decided that the inundated area should be investigated just after a flood using satellite remote sensing data. Considering the spectral properties of commercially available satellite sensors, extent of coverage, ground resolution, and the availability of data, it was decided that this study should be carried out using the Landsat Thematic Mapper (TM) system. The ground resolution of the TM sensor is 30 m, and it observes the earth's surface in seven different spectral regions of the electromagnetic spectrum, referred to as *bands*. The principal application of each of the TM spectral bands is summarized and shown in the Table 6.11. It is visibly noticeable that TM bands 1, 4, and 7 are specifically good for discernment of water bodies, and bands 3, 4, and 5 can well identify vegetation.

Comparing the available rainfall data and flood information with the cloud-free Landsat TM data, the images produced on 5 November 1994 and 5 February 1995 were procured for analysis, the former representing the state of 1994 monsoon floods and the latter depicting the area during the dry season. Acquisition of the two data sets may facilitate delineating standing water, rivers and streams, and water-logged areas after the monsoon rains.

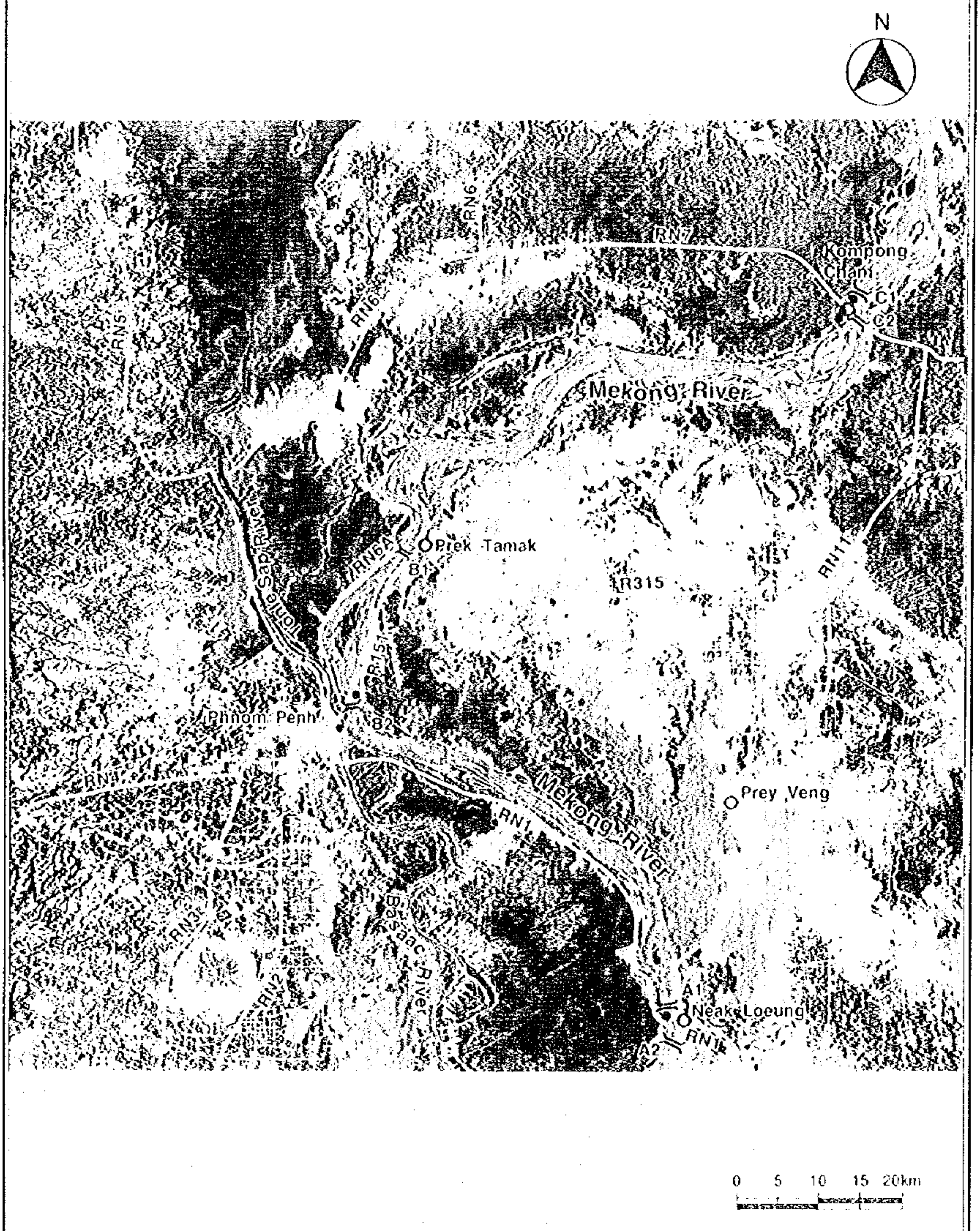
Geographical rectification and image processing was carried out before digital analysis for flood area interpretation. Both Landsat TM data sets were rectified and transformed into the Universal Transverse Mercator coordinate system using ground control points acquired from available topographical maps. Best suitable bands were investigated and image enhancement was carried out to increase visual interpretability. The Enhanced False color image of the area after the flood is shown in Figure 6.4. After investigating spectral response patterns of different bands and their ratios, it was found that the ratio of bands 3 and 4 and the ratio of bands 4 and 5 could be utilized satisfactorily in delineating water bodies and inundated areas. Comparing these two ratios for the two dates of TM data, the area was classified into water bodies, flood-affected areas, and unaffected areas (see Figure 6.5). The same interpretation was integrated with road network available in the 1:250,000 scale topographical map series published in 1967 and reproduced in Appendix 6.25.

The area denominated as flood-affected in Figure 6.5 represents the actual inundated area at the time of the satellite pass. It is important to note that because the flooding had actually taken place a few months prior to the satellite observation, the designated inundated area may represent an underestimate of the maximum annual flood area. Therefore, the actual flood-affected area may be larger than the present estimation.

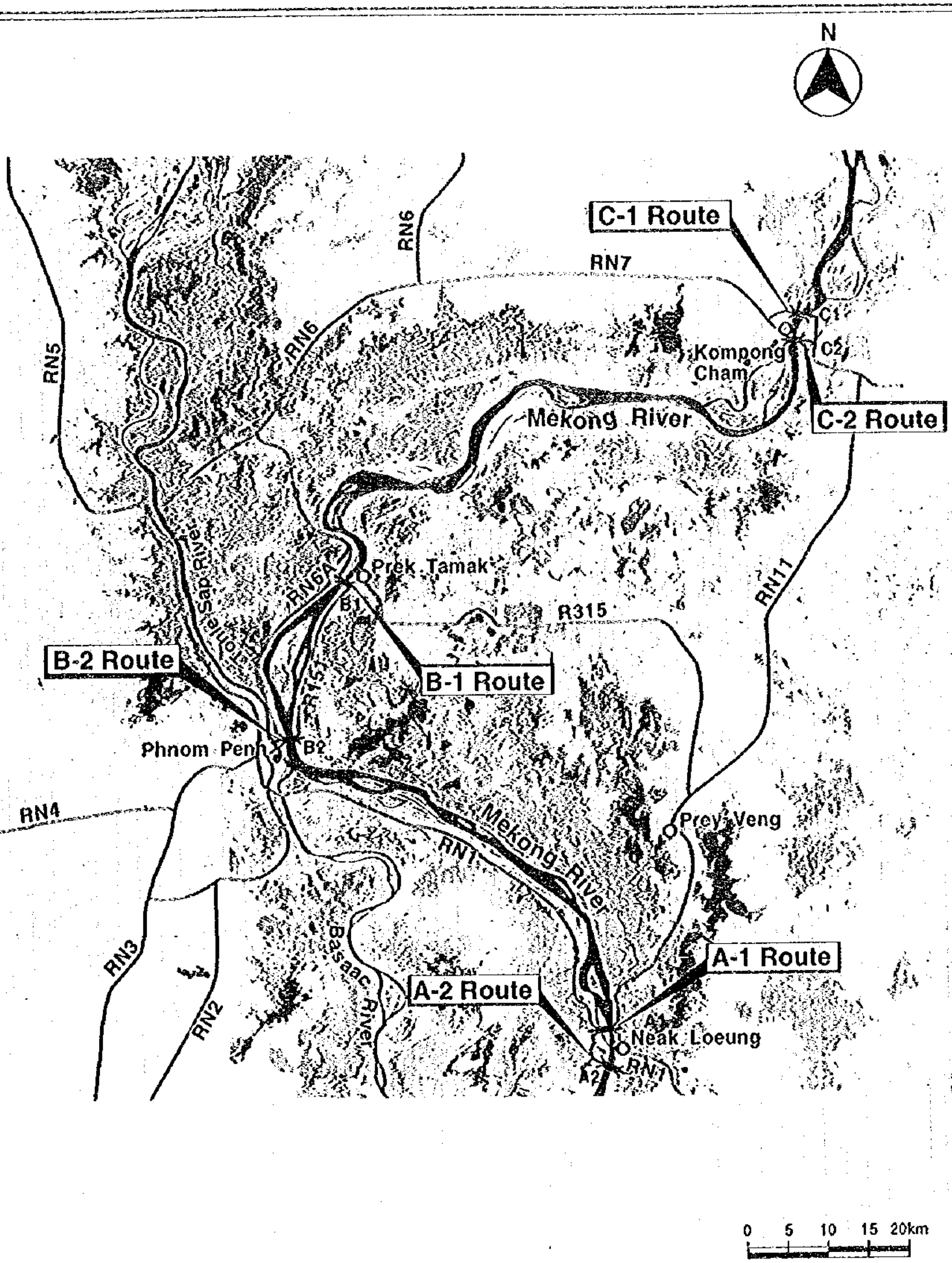
Table 6.11 Principal Fields of Application of Landsat TM Spectral Bands

Band	Wavelength	Nominal Spectral Location	Principal Application
1	0.45 - 0.52	Blue	Water body/coastal water mapping Soil vegetation discernment
2	0.52 -0.60	Green	Vegetation discernment Vigor assessment
3	0.63 - 0.69	Red	Plant species discernment Cultural feature delineation
4	0.76 - 0.90	Near Infrared	Biomass assessment Land/water discernment
5	1.55 - 1.75	Mid-Infrared	Vegetation and soil moisture
6	10.4 - 12.5	Thermal Infrared	Vegetation stress Soil moisture, Thermal mapping
7	2.08 - 2.35	Mid-Infrared	Mineral and rock type discernment Geological and land/water discernment

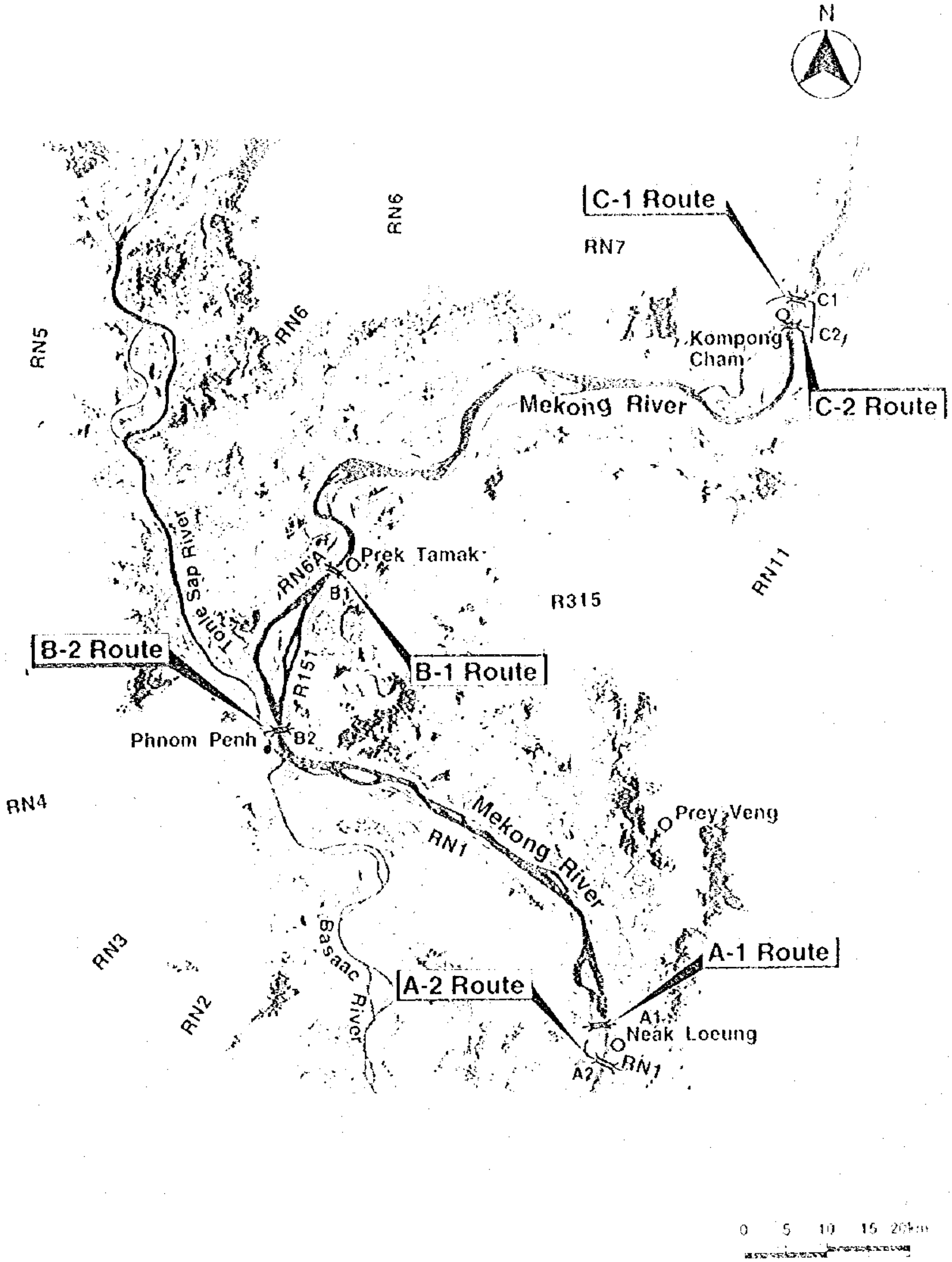
THE FEASIBILITY STUDY ON CONSTRUCTION OF THE MEKONG BRIDGE IN KINGDOM OF CAMBODIA	Figure 6.4 Landsat TM False Color Image (1994.11.05)
	JAPAN INTERNATIONAL COOPERATION AGENCY



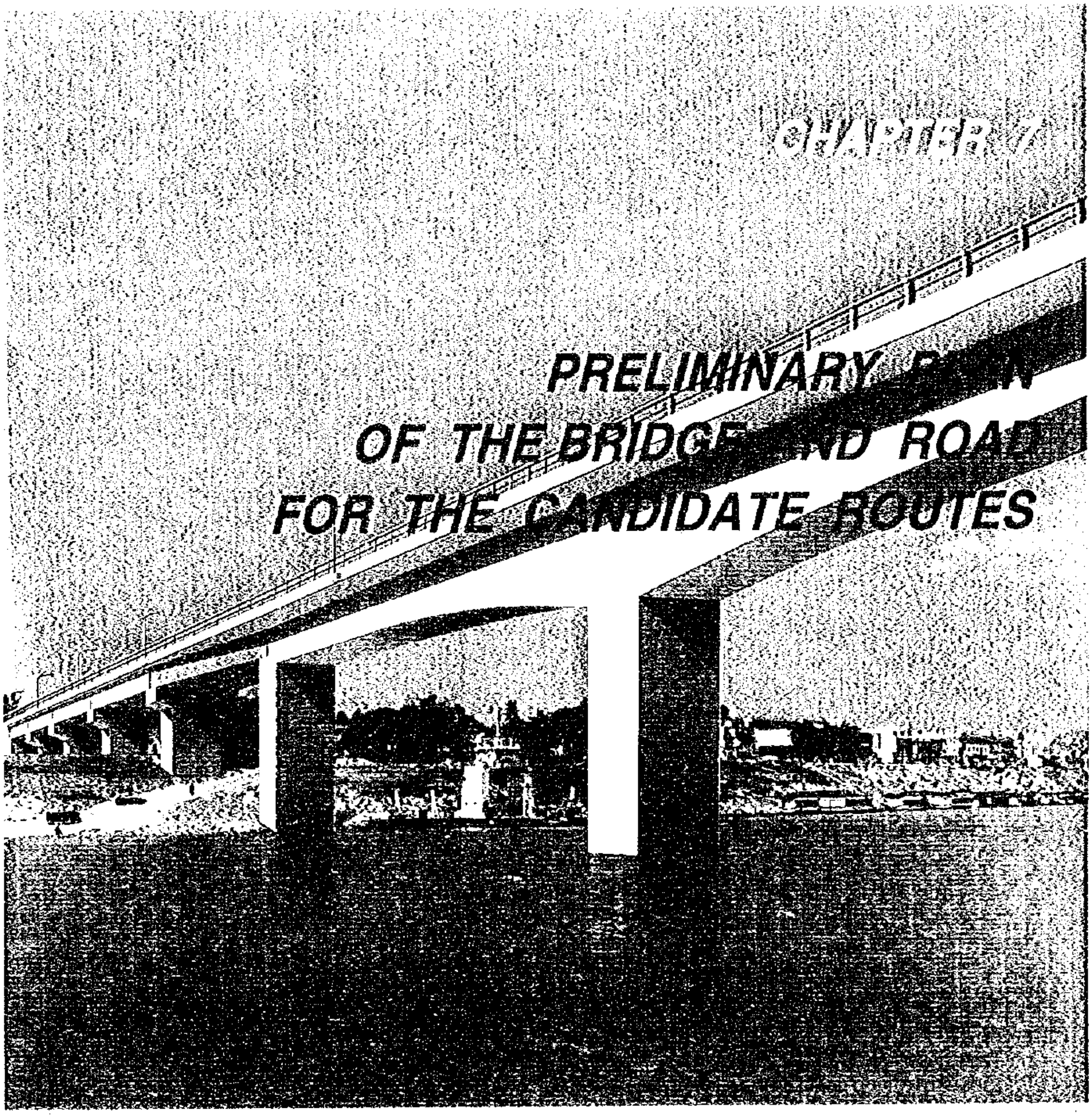
THE FEASIBILITY STUDY ON CONSTRUCTION OF THE MEKONG BRIDGE IN KINGDOM OF CAMBODIA	Figure 6.4 Landsat TM False Color Image (1994.11.05) JAPAN INTERNATIONAL COOPERATION AGENCY



THE FEASIBILITY STUDY ON CONSTRUCTION OF THE MEKONG BRIDGE IN KINGDOM OF CAMBODIA	Figure 3.1 Location Map of Alternative Routes
	JAPAN INTERNATIONAL COOPERATION AGENCY



THE FEASIBILITY STUDY ON CONSTRUCTION OF THE MEKONG BRIDGE IN KINGDOM OF CAMBODIA	Figure 3.1 Location Map of Alternative Routes JAPAN INTERNATIONAL COOPERATION AGENCY


CHAPTER 7
PRELIMINARY
OF THE BRIDGE
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CHAPTER 7 PRELIMINARY PLAN OF THE BRIDGE AND ROAD FOR CANDIDATE ROUTES

7.1 Bridge Plan Comparisons

7.1.1 General

The three main candidate locations subject to bridge plan comparisons are the Neak Loeung bridge route, the Prek Tamak bridge route, and the Kompong Cham bridge route. Each candidate location has two alternatives; therefore, there are six routes in total. In this study, the Neak Loeung routes are named A-1 and A-2, the Prek Tamak routes are B-1 and B-2, and the Kompong Cham routes are C-1 and C-2. The routes of these six alternatives were shown earlier in section 3.2.

Bathymetric, geological, and river hydrological surveys were conducted for the six routes during the first field work in Cambodia, and the results of these surveys were applied to this bridge plan comparison study.

7.1.2 Bridge Plan Conditions

(1) Navigation Clearance

Several navigation-related issues concerning the Mekong River are provided in the "Mekong Basin Navigation Strategy Review" of 1994, and they are summarized below:

a) Between Phnom Penh and the South China Sea, the Mekong River is navigable by sea-going vessels with sizes of up to 3,000 DWT. The Bassac River is also navigable by such vessels between the Vam Nao Pass in Vietnam and the South China Sea; however, the Bassac River north of the Vam Nao Pass is not navigable by such vessels.

b) The Mekong River upstream from Phnom Penh to Kratie is navigable by boats with a maximum 400 DWT.

c) The Mekong Secretariat commissioned a draft paper on transport policy in 1992, which includes recommendations to:

- improve navigation to Kratie such that vessels of 1,000 DWT can be used; and
- improve the channel of the Mekong River to permit the passage of vessels of 6,000 DWT between Phnom Penh and the South China Sea.

d) In 1972, Cambodia and Vietnam agreed that a vertical clearance of the My Thuan Bridge (to be built in Vietnam) should be 37.5 m from the high water level, which would permit the passage of vessels of 10,000 DWT.

e) Contrary to this agreement, in 1991 a vertical clearance of approximately 20 m was proposed by a consulting team for the (yet-to-be-constructed) My Thuan Bridge; the reason being that vessel traffic to/from this part of Vietnam does not require such a high clearance. Consequently, necessary dredging was proposed for the Bassac River such that it could serve as an alternative international waterway for vessels of 5,000 DWT between Phnom Penh and the South China Sea.

In general, navigational clearance, which is closely related to future development plans such as port projects and shipping transport plans, is one of the most significant factors in determining the size of a bridge.

The Mekong River Commission, whose members represent the countries surrounding the Mekong River (e.g., Vietnam, Cambodia, Lao PDR, Thailand) stipulated that the vertical clearance of any Mekong River bridge constructed between Phnom Penh and the South China Sea should be 37.5 m.

When drafting preliminary plans for the Mekong River Bridge, the Study Team held discussions with the Ministry of Public Works and Transport regarding the vertical clearance requirements at each of the proposed routes. Based on these discussions, the Study Team fixed the vertical clearances for the three candidate locations (see Table 7.1) with approval from the Steering Committee of this Feasibility Study.

Table 7.1 Assumed Navigational Clearances in the Bridge Plans

location	Vertical Clearance (m)	Horizontal Clearance (m)
Neak Loeung	37.5	175
Prek Tamak	15.0	90
Kompong Cham	15.0	90

(2) Typical Cross Section

During the first meeting between the Study Team and the Steering Committee on 6 April 1995, it was agreed that the total width of bridge should be 13.5 m with two lanes (carriageways) as for fundamental bridge plan. Based on the basic conditions, the Study Team proposed the typical cross sections for bridge and road considering the following;

a) Typical width of one lane (carriageway) is 3.5 meters from viewpoint of Japanese Standard.

b) Motorcycle ways with a width of 1.9 m (2.5 m for road) are to be provided on both sides of the carriageways to separate light and heavy traffic.

c) Sidewalks are to be provided on both sides with widths of 1.1 m for pedestrianway and 0.25 m for railings in order to secure the security of increasing pedestrian volumes.

d) Shoulders with a width of 0.75 m are to be provided on both sides of the road to protect the edges of embankment.

The typical cross sections for bridge and road proposed by the Study Team are shown in Figure 7.1.

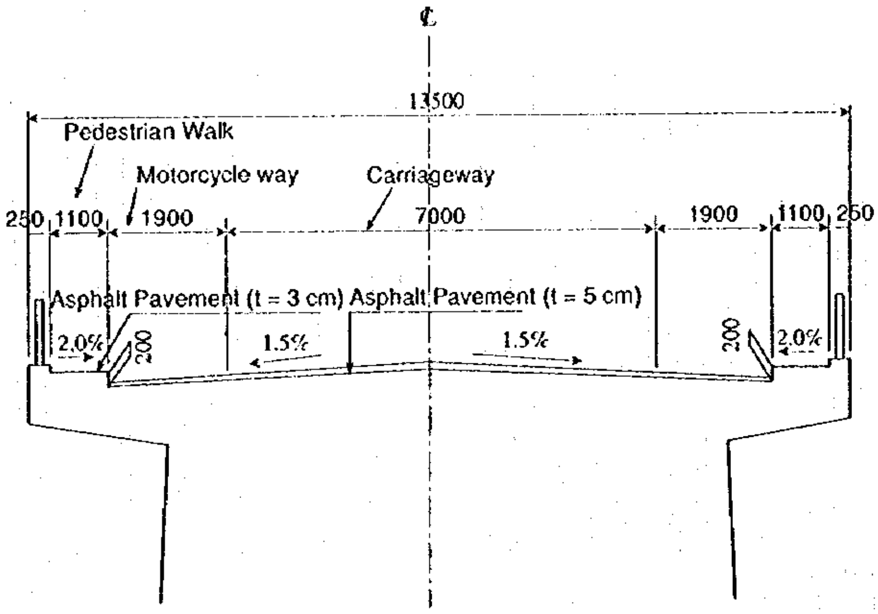


Figure 7.1 Typical Cross Section of Bridge

7.1.3 Superstructure

There are three common types of classifications regarding bridge superstructures:

a) classification according to material type (e.g., steel, Prestressed Concrete (PC)), depending on the materials used for the main components of the bridge;

b) classification according to structural type (e.g., slab bridge, continuous bridge, cantilever bridge, girder bridge, truss bridge, arch bridge, cable-stayed bridge, suspension bridge); and

c) classification according to main girder type (e.g., slab bridge, I-beam bridge , T-girder bridge, box-girder bridge).

Clearly, many different types of bridges can be constructed due to the many classification combinations possible. Nevertheless, the objective of bridge design planning is to propose a bridge that will have a long lifetime of at least 50 years, will be economical, will function appropriately in terms of meeting traffic demand, and will harmonize with its surroundings.

Because of the many recent advancements in structural materials and construction equipment, the span lengths of newly constructed bridges have been gradually becoming longer and longer. These technological improvements have, in turn, led to reduced construction costs.

The Mekong River Bridge in Cambodia will actually consist of at least three bridges, i.e., the main bridge and two approach bridges. The main bridge is the section that provides the required navigational clearance as well as the adjacent bridge sections of similar form. The approach bridges are the remaining sections of the bridge at both edges of the river, and they connect the main bridge with the bank structure. Sometimes additional bridge sections are placed between the main bridge and the approach bridges.

The suitability of the various bridge types is governed primarily by the lengths of individual spans. Figure 7.2 shows the applicable ranges of span lengths for different types of concrete and steel bridges. Applying this information and data presented earlier in this report, preliminary bridge design types were determined for each of the six alternative bridge routes.

(1) Approach Bridge Sections

Concerning the approach bridges, either concrete T-girders or steel I-beams (i.e., steel I-beam stringers with prestressed-concrete girders) can be considered for span lengths between 20 and 50 m. Taking into account the economical advantages of using locally obtainable materials, post-tensioned prestressed-concrete T-girders with lengths of 40 m are recommended for the approach bridge sections.

(2) Main Bridge Sections

(a) Neak Loeung

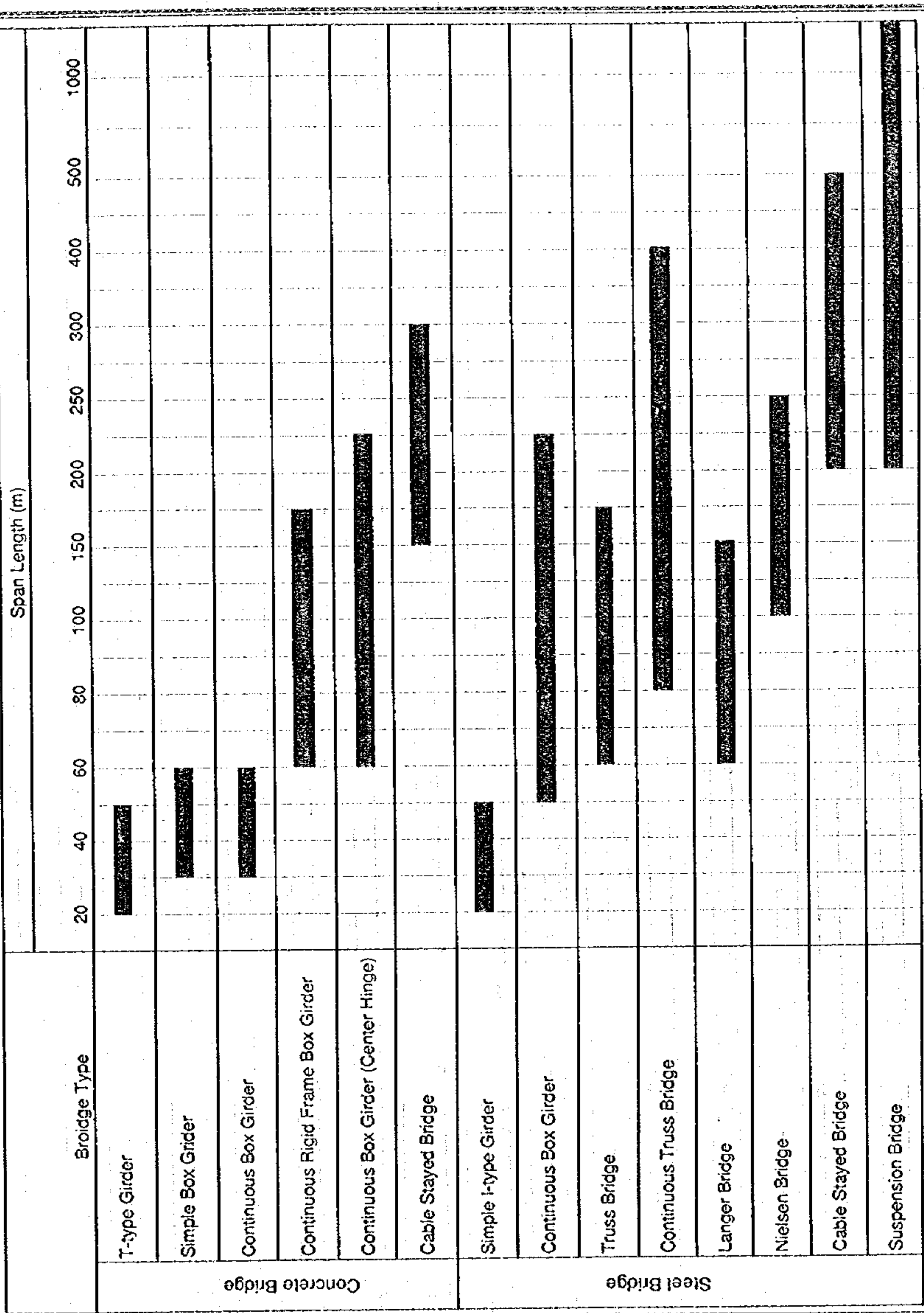
A-1 Route

Although the Mekong River is divided into two channels at this bridge point by an island formed from river sedimentation, the left side of river (i.e., east channel) is navigable. At this east river channel, two bridge options could be recommended (see Table 7.2):

- a symmetrical multiple-harp prestressed-concrete cable-stayed bridge with two 105 m side spans and a center span length of 210 m; or
- a steel continuous truss bridge with the same side and center span lengths as those of the cable-stayed bridge.

A-2 Route

A bridge at this location would need to be designed to cross the 850 m width of the Mekong. In this case, as with most of the other routes, there are two fundamental planning bridge concepts that are utilized: (1) superstructures with short spans; or (2) superstructures with long spans.



THE FEASIBILITY STUDY ON CONSTRUCTION OF THE MEKONG BRIDGE IN KINGDOM OF CAMBODIA	Figure 7.2 Applicable Ranges of Span Length by Bridge Type JAPAN INTERNATIONAL COOPERATION AGENCY

Because the main characteristics of the Mekong River are the large difference in water level between the rainy and dry seasons (i.e., 10-14 m) and the rather deep depth of the river, it would be advantageous to adopt relatively long spans for the bridge. This design would facilitate construction work on the substructure and reduce the number of foundations required.

For these reasons, the following two options are suggested (see Table 7.3):

- a symmetrical multiple-harp prestressed-concrete cable-stayed bridge with two 105 m side spans and a 220 m center span, and two sets of prestressed-concrete box-girders with 80 m outer side spans, 150 m center spans, and 100 m inner side spans; or

- a bridge with three sets of continuous steel trusses: two two-span sets (i.e., outer spans) with each span having a length of 100 m, and one three-span set with two 105 m side spans and a 220 m center span.

(b) Prek Tamak

B-1 Route

The B-1 route is associated with a river width of approximately 700 m. Consequently, the following two bridge options were selected (see Table 7.4).

- a prestressed-concrete box-girder bridge with two 90 m side spans and three 150 m central spans; or

- a steel box-girder bridge with the same number and length of spans as for the prestressed-concrete box-girder bridge.

B-2 Route

The river width is approximately 950 m at the B-2 route (see Table 7.5); the two alternatives chosen are listed below:

- a prestressed-concrete box-girder bridge with two 90 m side spans and five 150 m central spans; or

- a bridge consisting of two sets of three-span steel box-girders (outer and inner spans of 100 m, central span of 165 m) and a Nielsen-type single-span bridge with a length of 200 m.

route B-2, although the approach bridges differ in length.)

(c) Kompong Cham

C-1 Route

The width of the Mekong River narrows suddenly around this location to approximately 550 m. The depth of the river at this location, however, is very deep at approximately 50 m. This condition has been brought about due to the hard basalt rock on the right side of the river (i.e., west bank); the gradient of riverbed slope at this right side in the direction of the bridge axis is extremely steep. Because of these natural conditions, installation of bridge foundations would be technically difficult. Consequently, a long-span bridge was adopted for this route as shown in Table 7.6. The two alternatives are:

- a steel suspension bridge with 500 m center span; or
- a symmetrical multiple-harp steel cable-stayed bridge with two 150 m side spans and a 500 m center span.

C-2 Route

Although the C-2 route is located only 800 m downstream from route C-1, the river conditions are significantly different. First, the Mekong River widens to approximately 1000 m. Second, the tertiary basalt layer is no longer found at this location. Third, the gradient of riverbed slope in the direction of the bridge axis is not as steep as that of C-1. Therefore, placing the bridge foundation would not be technically difficult. Based on these observations, the following bridges are proposed for this route as shown in Table 7.7:

- a prestressed-concrete box-girder bridge with two 90 m side spans and five 150 m central spans; or
- a bridge consisting of two sets of three-span steel box-girders (outer and inner spans of 100 m, central span of 165 m) and a Nielsen-type single-span bridge with a length of 200 m.

(Note that these superstructure configurations are the same as those for Table 7.6 Evaluation of Superstructure between one candidate route

(3) Evaluation of Main Bridge Superstructures between the Two Alternatives for Each Route

This subsection presents the results of an evaluation to determine which of the two superstructure alternatives (shown above) is more appropriate. The evaluation criteria used are as follows:

- Procurement of Materials and Equipment
- Design Span
- Structural Characteristics
- Construction Method
- Construction Workability
- Structural Aesthetics
- Maintenance Aspect
- Construction Period
- Construction Cost

Provided that the Mekong River Bridge will be constructed in Cambodia, the following additional items should also be considered: availability of skilled workers, means of transport for imported materials (from origin country to Cambodia) at a reasonable cost, worker productivity, domestic and foreign labor costs, etc.

These criteria are tabulated for each potential bridge location in Tables 7.2 to 7.7. Based on the results of this qualitative yet systematic evaluation, the recommended superstructures for each bridge route are shown below in Table 7.8.

Table 7.8 Selected Type of Superstructure for Each Route

Route	Type of Superstructure
A-1	Prestressed-Concrete Cable-Stayed Bridge
A-2	Prestressed-Concrete Cable-Stayed Bridge
B-1	Prestressed-Concrete Box-Girder Bridge
B-2	Prestressed-Concrete Box-Girder Bridge
C-1	Suspension Bridge
C-2	Prestressed-Concrete Box-Girder Bridge

7.1.4 Foundation and Substructure

(1) Foundation

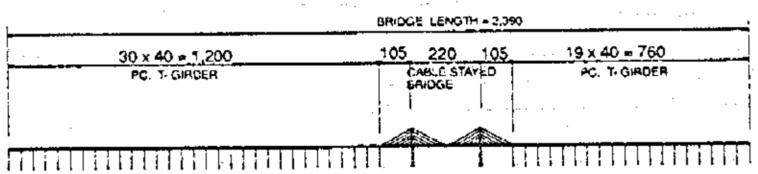
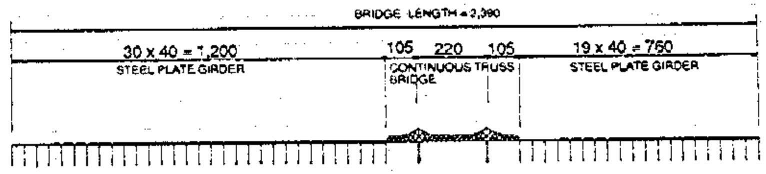
The preliminary foundation planning for the Mekong River Bridge is based on the following conditions:

- It is proposed that the foundations be constructed in the 6 months during the dry season (January to June). The water depth at the low water level is approximately 20-40 m at Kompong Cham, 20 m at Prek Tamak, and 18 m at Neak Loeung.

- The variation between the highest and lowest water level is approximately 14.5 m at Kompong Cham, 10.5 m at Prek Tamak, and 7.5 m at Neak Loeung.

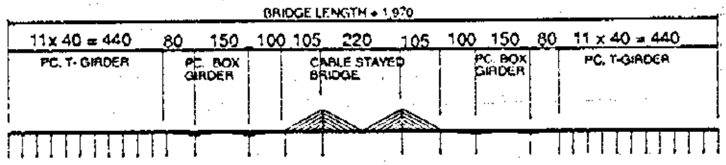
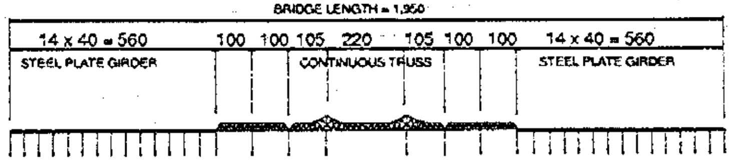
- It is assumed that the rock line in the river is found at approximately -20 m to -30 m. The rock is overlaid by alluvial deposits, which cannot be relied upon

Table-7.2 Evaluation of Superstructure between Two Alternatives A-1 Route

Item \ Route	A-1 Route	
	Alternatives A	Alternatives B
Side View and Span Arrangement		
Type of Superstructure	Prestressed Concrete Cable Stayed Bridge	Continuous Steel Truss Bridge
Principal Materials	High early strength cement/PC tendon or high tension wire Cable: high tension steel wire	Girder--steel
Procurement of Materials and Equipment	Early strength cement/PC tendon/cable imported Large-scale & special construction equipment are required	All structural steel member imported Large-scale & special construction equipment are required
Appreciable Span	150m~300m(center span)	60m~175m(center span)
Design Span	220m	220m
Structural Characteristics	Because of statically indeterminate structure, adjustment of cable tension is sophisticated. Required the check of aero- dynamic stability	Rigidity of cross-section is considerably high, so dead load of bridge is heavy as steel structure
Construction Method	Girder to be normally erected by 3m length.	Two options; erected by panel or block
Construction Workability	As mentioned in structural characteristic, erection of cable should be treated carefully.	It depends upon planned construction equipment.
Structural Aesthetics	○	△
Maintenance Aspect	Except that adjustment of cable is required in due course, no works is necessary for concrete structure.	Because of steel structure, repaint works is periodically essential
Construction Period	○	○
Construction Cost	○	△
Total Evaluation	○	△

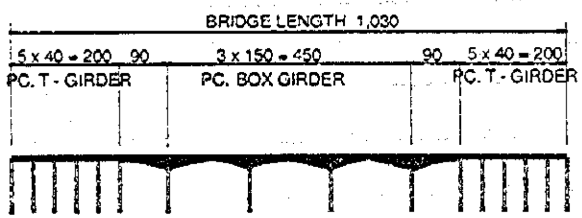
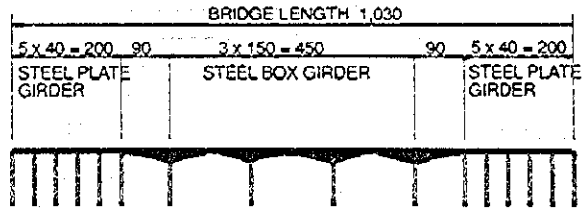
○:Good △:Fair ×:Bad

Table-7.3 Evaluation of Superstructure between Two Alternatives A-2 Route

Item \ Route	A-2 Route	
	Alternatives A	Alternatives B
Side View and Span Arrangement		
Type of Superstructure	Prestressed Concrete Cable Stayed Bridge	Continuous Steel Truss Bridge
Principal Materials	High early strength cement/PC tendon or high tension wire	Girder/Truss-high tension steel
Procurement of Materials and Equipment	Early strength cement/PC tendon/cable imported Large-scale & special construction equipment are required	All structural steel member imported Large-scale & special construction equipment are required
Appreciable Span	150m~300m(center span)	60m~175m(center span)
Design Span	220m	220m
Structural Characteristics	Because of satirically indeterminate structure, adjustment of cable tension is sophisticated. Required the check of aero- dynamic stability	Rigidity of cross-section is considerably high, so dead load of bridge is heavy as steel structure
Construction Method	Girder to be normally erected by 3m length.	Two options; erected by panel or block
Construction Workability	As mentioned in structural characteristic, erection of cable should be treated carefully.	It depends upon planned construction equipment.
Structural Aesthetics	○	△
Maintenance Aspect	Except that adjustment of cable is required in due course, no works is necessary for concrete structure.	Because of steel structure, repaint works is periodically essential
Construction Period	○	○
Construction Cost	○	△
Total Evaluation	○	△

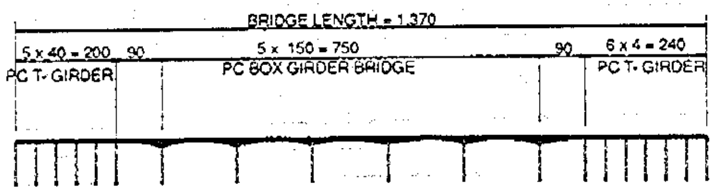
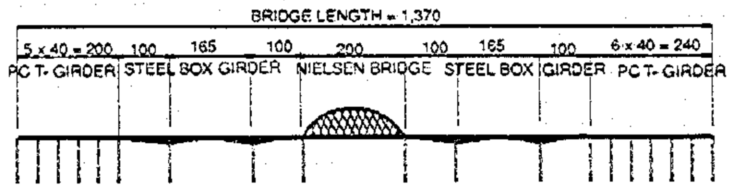
○:Good △:Fair ×:Bad

Table-7.4 Evaluation of Superstructure between Two Alternatives B-1 Route

Route / Item	B-1 Route: Alternatives A	B-1 Route: Alternatives B
Side View and Span Arrangement		
Type of Superstructure	Prestressed Concrete Box Girder	Continuous Steel Box Girder
Principal Materials	High early strength cement/PC tendon or high tension wire	Girder--steel
Procurement of Materials and Equipment	Early strength cement/PC tendon/cable imported For extension of girder, traveling forms are to be provided.	All structural steel member imported Large-scale & special construction equipment are required
Appreciable Span	60m~225m	50m~250m
Design Span	150m(center span)	150m(center span)
Structural Characteristics	Rigidity of cross-section is high. There are two options: hinged at middle span and continuos type without hinge.	Reducing the weight of superstructure eases the design of substructure, comparing to alternatives A.
Construction Method	By traveling form box girder casted in site is erected.	Steel box girders fabricated in foreign country are erected by each panel or blocks using crane with deck barge.
Construction Workability	As concrete girder is constructed by cast in site, careful quality control is required under limited construction period.	As fabricated at bridge factory, quality control is easier except portion field welding.
Structural Aesthetics	○	○
Maintenance Aspect	Maintenance works is almost free.	Because of steel structure, repaint works is periodically essential
Construction Period	△	○
Construction Cost	○	△
Total Evaluation	○	△

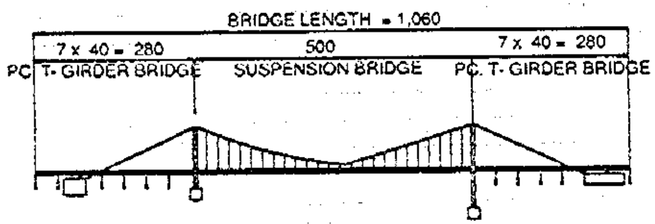
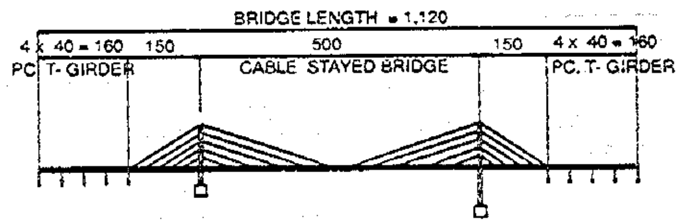
○:Good △:Fair ×:Bad

Table-7.5 Evaluation of Superstructure between Two Alternatives B-2 Route

Item \ Route	B-2 Route	
	Alternatives A	Alternatives B
Side View and Span Arrangement		
Type of Superstructure	Prestressed Concrete Box Girder	Nielsen Type Bridge (compared to main bridge)
Principal Materials	High early strength cement/PC tendon or high tension wire	Girder/Arch: high tension steel Cable--high tension wire
Procurement of Materials and Equipment	Early strength cement/PC tendon/cable imported For extension of girder, traveling forms are to be provided.	All structural steel member imported Special construction equipment required
Applicable Span	60m~225m	100m~250m(center span)
Design Span	150m(center span)	220m
Structural Characteristics	Rigidity of cross-section is high. There are two options: hinged at middle span and continuos type without hinge.	Reducing the weight of superstructure eases the design of substructure, comparing to alternatives A.
Construction Method	By travelling form box girder casted in site is erected.	Normally erected by panel for girder and by piece member for arch code with crane
Construction Workability	As concrete girder is constructed by cast in site, careful quality control is required under limited construction period.	As far as erection equipment is provided adequately, there will not occur any problem.
Structural Aesthetics	○	○
Maintenance Aspect	Maintenance works is almost free.	Because of steel structure, repaint works is periodically essential
Construction Period	△	○
Construction Cost	○	△
Total Evaluation	○	△

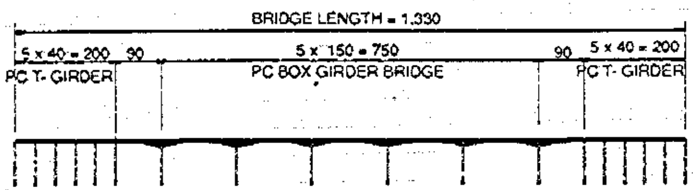
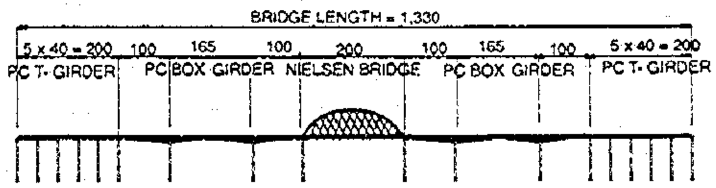
○: Good △: Fair ×: Bad

Table-7.6 Evaluation of Superstructure between Two Alternatives C-1 Route

Item \ Route	C-1 Route	
	Alternatives A	Alternatives B
Side View and Span Arrangement		
Type of Superstructure	Suspension Bridge with single span	Steel Cable Stayed Bridge
Principal Materials	Stiffening girder steel Cable high tension wire	Stiffening girder steel Cable high tension wire
Procurement of Materials and Equipment	All structural steel member imported Large-scale & special construction equipment are required	All structural steel member imported Large-scale & special construction equipment are required
Appreciable Span	250m~1800m(center span)	250m~500m(center span)
Design Span	500m	500m
Structural Characteristics	As this type of structure is flexible , check of aerodynamic stability is required. Tower or anchorage at east side should be treated carefully in design and const- ruction.	As this type of structure is flexible, check of aerodynamic stability is required. Span ratio (Center span/Side span) is not balanced due to site condition.
Construction Method	Normally erected by one panel for stiffening girder	Normally erected by one panel for stiffening girder
Construction Workability	Because of sophisticated structure it may arise some problems on construction workability	Because of sophisticated structure it may arise some problems on construction workability
Structural Aesthetics	○	○
Maintenance Aspect	Because of steel structure, repaint works is periodically essential	Because of steel structure, repaint works is periodically essential
Construction Period	△	△
Construction Cost	△	△
Total Evaluation	○	△

○:Good △:Fair ×:Bad

Table-7.7 Evaluation of Superstructure between Two Alternatives C-2 Route

Item \ Route	C-2 Route	
	Alternatives A	Alternatives B
Side View and Span Arrangement		
Type of Superstructure	Prestressed Concrete Box Girder	Nielsen Type Bridge (compared to main bridge)
Principal Materials	High early strength cement/PC tendon or high tension wire	Girder/Arch: high tension steel Cable high tension wire
Procurement of Materials and Equipment	Early strength cement/PC tendon/cable imported For extension of girder, traveling forms are to be provided.	All structural steel member imported Special construction equipment required
Appreciable Span	60m~225m	100m~250m(center span)
Design Span	150m(center span)	220m
Structural Characteristics	Rigidity of cross-section is high. There are two options: hinged at middle span and continuos type without hinge.	Reducing the weight of superstructure eases the design of substructure, comparing to alternatives A.
Construction Method	By traveling form box girder casted in site is erected.	Normally erected by panel for girder and by piece member for arch code with crane
Construction Workability	As concrete girder is constructed by cast in site, careful quality contr control is required under limited construction period.	As far as erection equipment is provided adequately, there will not occur any problem.
Structural Aesthetics	○	○
Maintenance Aspect	Maintenance works is almost free.	Because of steel structure, repaint works is periodically essential
Construction Period	△	○
Construction Cost	○	△
Total Evaluation	○	△

○:Good △:Fair ×:Bad

as a bearing layer for the bridge piers. All the piers must, therefore, be placed deeper than the rock surface.

- The foundation works should be completed within 2 or 3 dry seasons.

- The depth of local scour, which can be estimated at the piers due to the obstruction caused by the pier foundation, is approximately 20 m.

Considering the above conditions, four relevant foundation concepts have been envisaged:

- Multi-Column Pile Foundation
- Open Caisson/Pneumatic Caisson
- Steel Pipe Sheet Caisson
- Steel Caisson with Steel Pipe Pile (Bell-type foundation)

(2) Selection of Optimum Foundation

Stability of foundation and constructibility were examined for each alternative; construction costs were then estimated. The results are shown in Table 7.9. Comparing procurement of materials and equipment, construction aspects, and construction costs, an evaluation was made at the alternative routes as shown in Table 7.9.

Based on this evaluation, a multi-column pile foundation is recommended for all of the alternative routes. A pile diameter of 2.0 m is recommended at this stage based on the lifting capacity of conventional crawler cranes; floating cranes are not recommended due to their high cost.

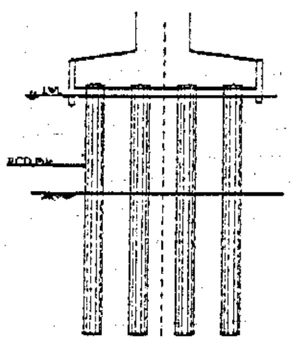
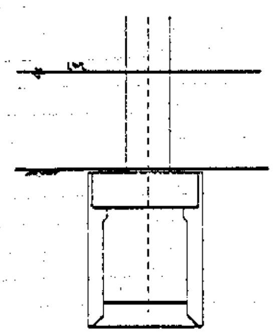
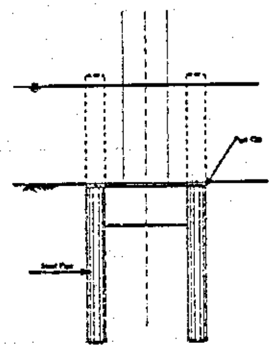
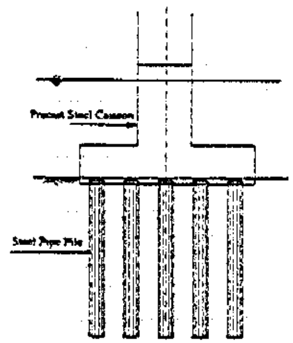
(3) Substructure

A T-shaped pier on the pile cap is selected as the support of the superstructure. The T-shaped pier could be either reinforced concrete or a composite of reinforced concrete and structure steel. For the Mekong River Bridge, a reinforced concrete pier is recommended for the multi-column pile foundation. The abutment must be safe from overturning and sliding on the footing. The maximum height of abutment is, therefore, assumed to be 10 m from the existing ground level.

7.1.5 Preliminary Selection by Route

As mentioned previously, the Study Team conducted several types of surveys during the first field works in Cambodia (e.g., topographic, bathymetric, geological, and river hydrological studies). Applying these data to the bridge planning process, a preliminary selection of bridge type and design for each route was carried out with the aim to eventually recommend one route among the six for final selection.

Table 7.9 Alternative Foundations

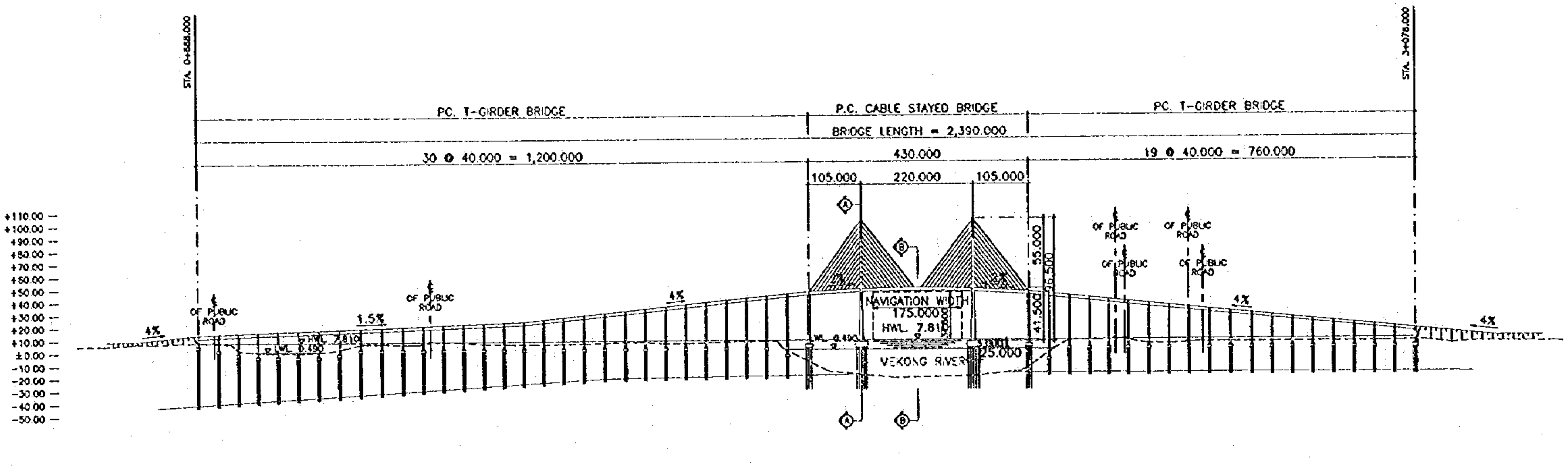
		Multi-Column Pile Foundation (Cast-in-place R.C. Pile)	Open Caisson	Steel Pipe Sheet Caisson	Steel Caisson with Steel Pipe Pile (Bell-Type Foundation)
Foundation Type		Multi-Column Pile Foundation (Cast-in-place R.C. Pile)	Open Caisson	Steel Pipe Sheet Caisson	Steel Caisson with Steel Pipe Pile (Bell-Type Foundation)
Configuration of Foundation					
Principal Materials of Foundation		Concrete, Reinforcing Bar, and Steel Casing Pipe	Concrete, Reinforcing Bar	Steel Pipe, Concrete, Reinforcing Bar	Steel Pipe Pile, Steel Caisson, Concrete Reinforcing Bar
Procurement of Materials and Equipment and Transpotation		Steel casing pipes are imported. Self-elevated platform (SEP) and large capacity crane are required.	Floating crane (FC) with capacity 1500~2000ton is required.	Large capacity pile driver is required.	Pile driver, floating crane (FC) is required. Steel caisson is manufactured in and transported from another country.
Construction Aspect	Applicable Span	80 ~ 250 m	80 ~ 150 m	up to 150m	150 ~ 300 m
	Construction Method	Steel casing pipes are driven by vibro-hammer. Bore holes are made by using reverse-circulation drill. Concrete is placed up to top of a casing pipe. Pile cap is supported on the multi-column.	Open caisson of 15~20 m height is cast on land and transported to the site and set on the river bed by floating crane; then, excavation in the caisson, sinking and placing of concrete are repeated.	Driving steel pipe sheet pile with both functions of foundation and cofferdam. After dried up in the caisson, pile cap is connected to steel pipes with re-bar. Steel pipes are cut at top of the pile cap.	Driving steel pipe piles by a pile driver. Steel caisson is manufactured in and transported from another country and set on steel pipes by floating crane. Then, concrete is placed in the steel caisson.
	Difficult Points of Construction	Scouring depth is large. Protection work is necessary.	Sinking difficulty in stratum of rock boulder.	Connection method between steel pipe piles and pile cap is not reliable	No factory manufacturing precast steel caissons in Cambodia
	Construction Period	6 months/pier	5 ~ 6 months	5~ 6 months	4 ~ 5 months
	Construction Cost (Ratio)	1.00	1.05	1.20	1.45
Overall Evaluation	Route A-1	O	×	×	△
	Route A2	O	×	×	△
	Route B-1	O	△	△	×
	Route B-2	O	△	△	×
	Route C-1	O	△	△	×
	Route C-2	O	×	×	×

O : Good △ : Fair × : Bad

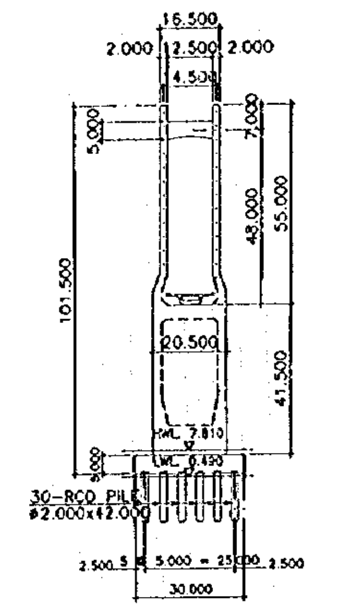
Prior to the study of preliminary selection by route, the bridge conditions are summarized below:

- Navigational clearance is to be adopted as described in section 7.1.2;
- Estimated high water levels corresponding to the level of a 100 year return period were applied;
- The type of superstructure according to section 7.1.3 was selected; and
- Multi-column pile foundation is applied to the substructure of each selected superstructure except for both the anchorage and west side tower foundation of the suspension bridge at the C-1 route.

According to these conditions, preliminary bridge plans for the Mekong River Bridge were prepared, and they are shown in Figures 7.3 to 7.8.

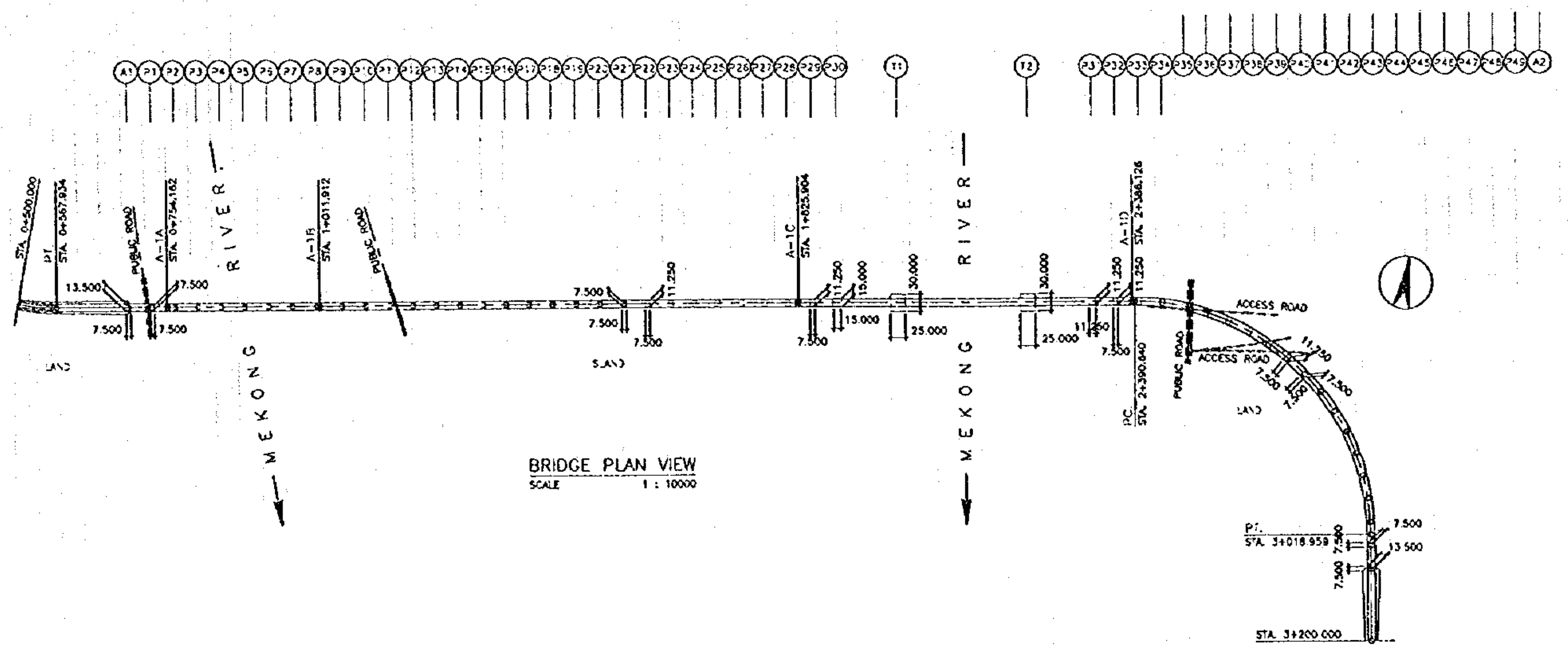


BRIDGE ELEVATION VIEW



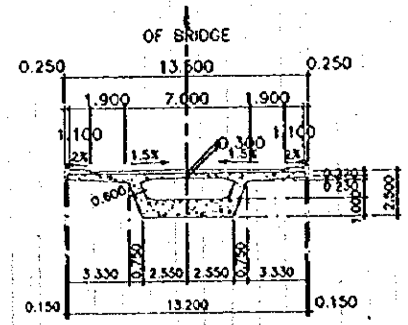
BRIDGE CROSS SECTION A-A

SCALE 1 : 2000



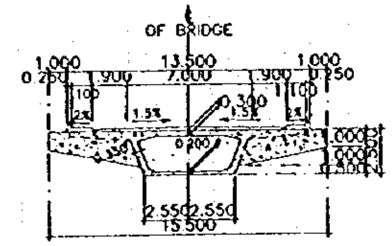
BRIDGE PLAN VIEW

SCALE 1 : 10000



BRIDGE SECTION A-A

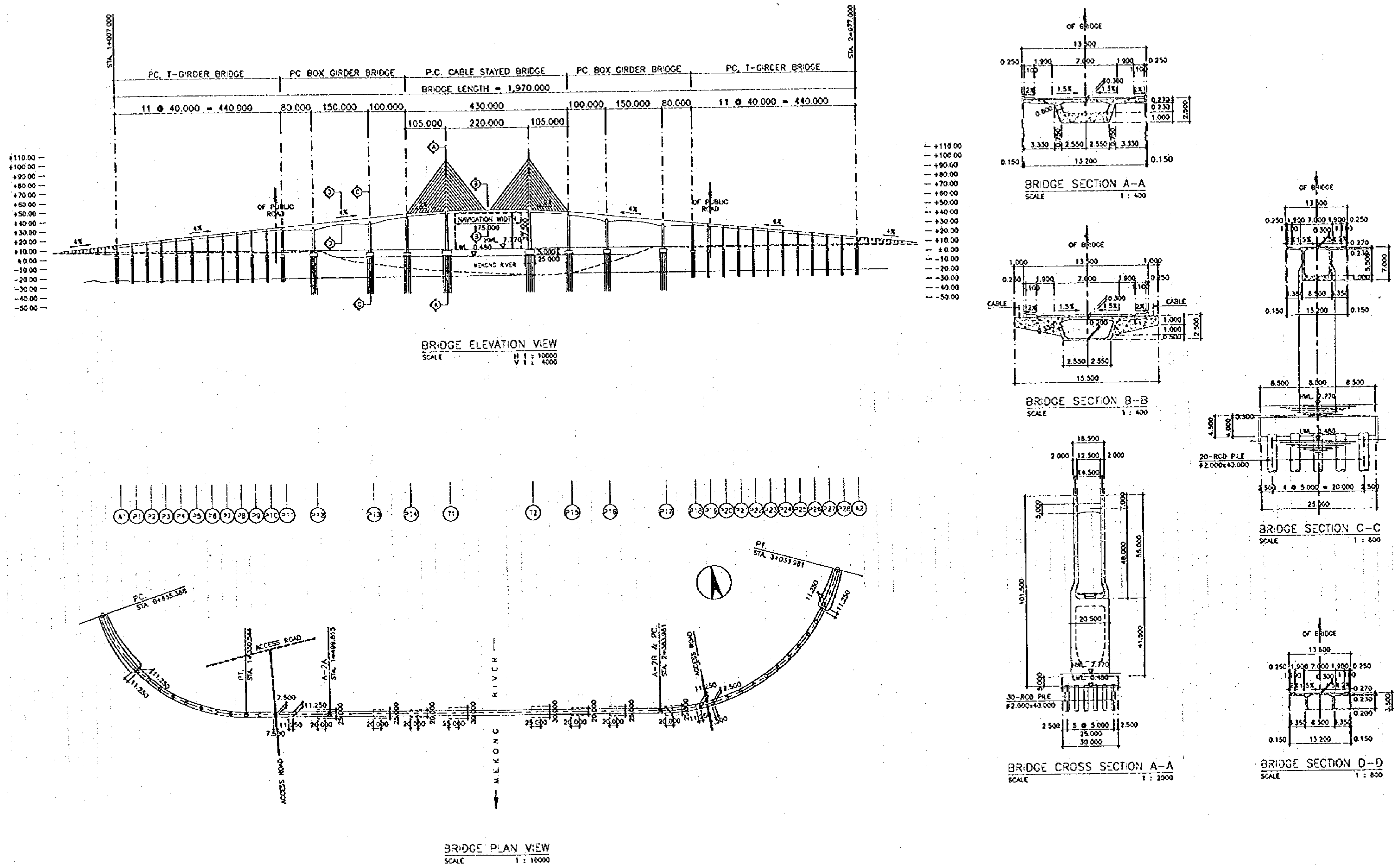
SCALE 1 : 400



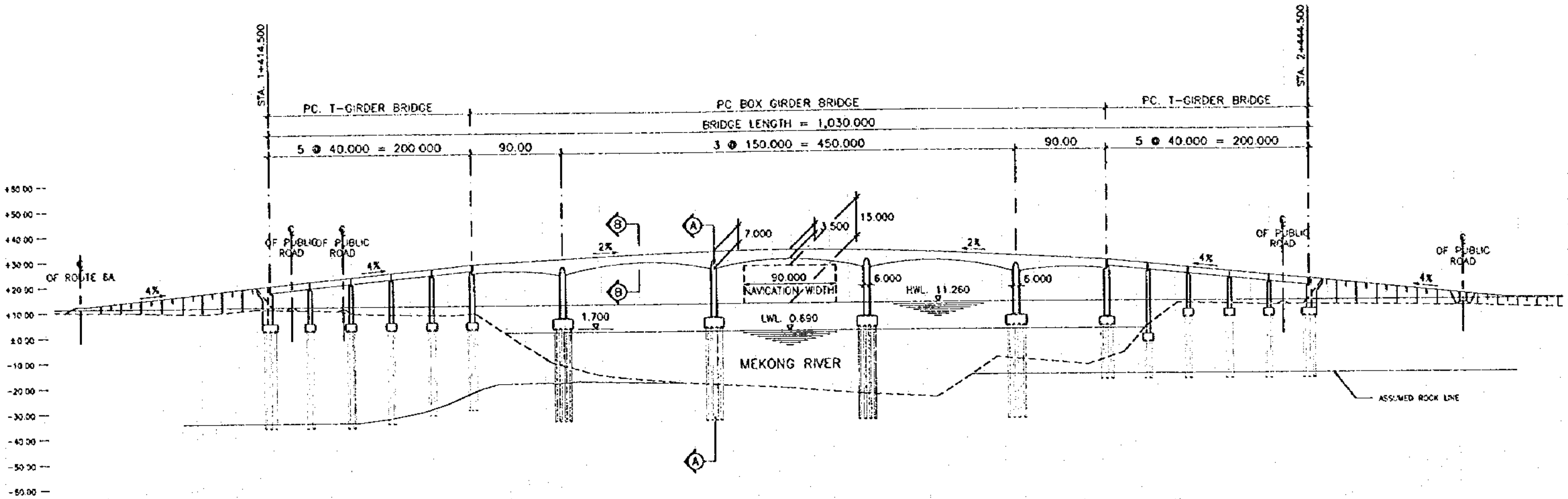
BRIDGE SECTION B-B

SCALE 1 : 400

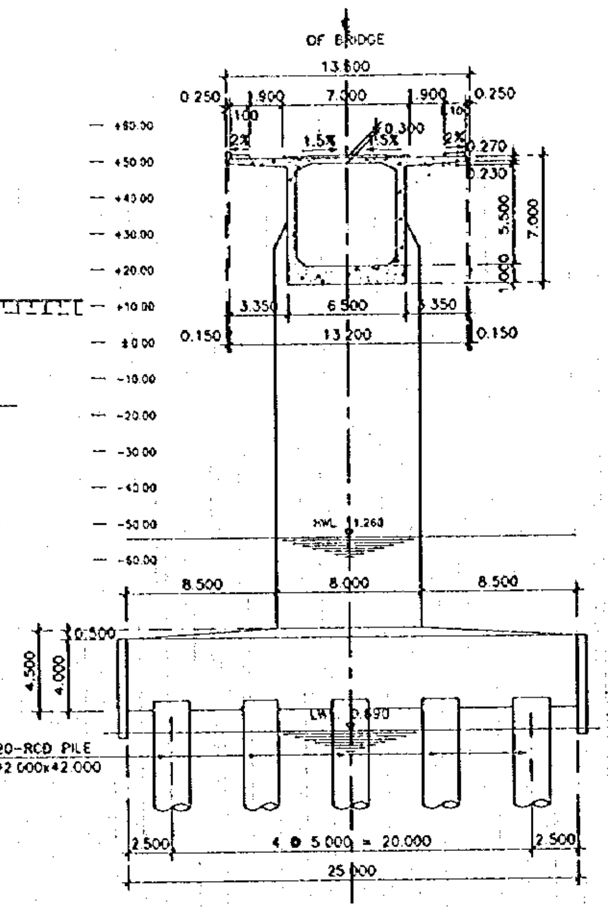
THE FEASIBILITY STUDY ON CONSTRUCTION OF THE MEKONG BRIDGE IN KINGDOM OF CAMBODIA	Figure 7.3 Preliminary Bridge Plan for A-1 Route
	JAPAN INTERNATIONAL COOPERATION AGENCY



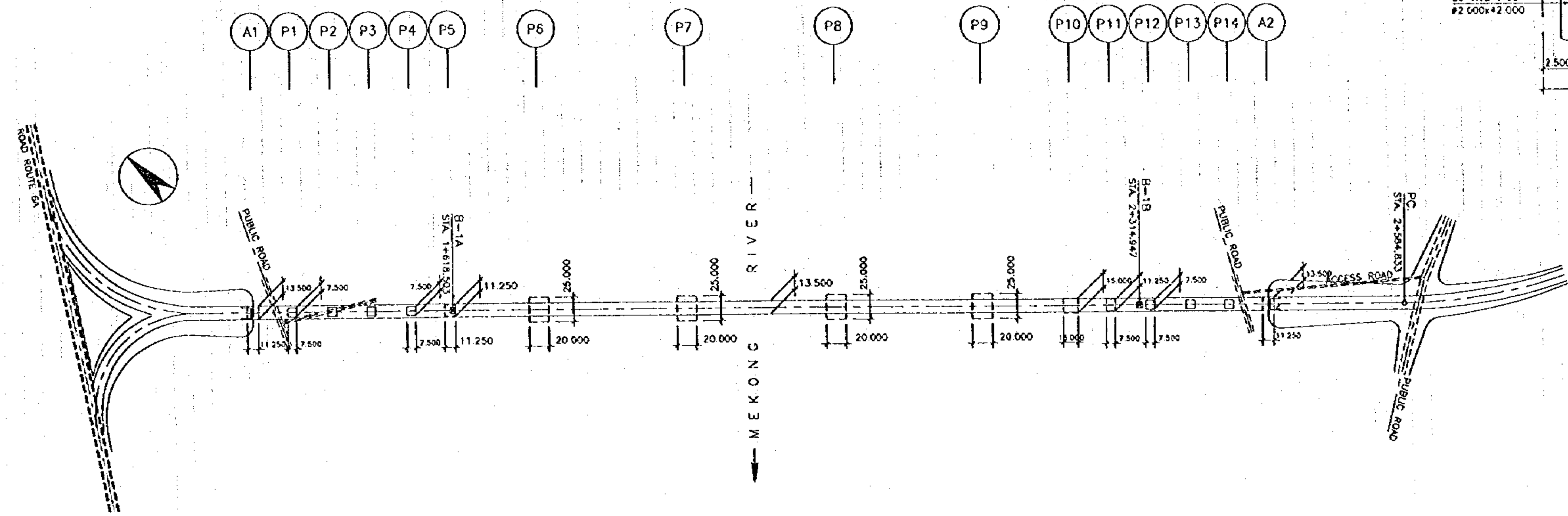
THE FEASIBILITY STUDY ON CONSTRUCTION OF THE MEKONG BRIDGE IN KINGDOM OF CAMBODIA	Figure 7.4 Preliminary Bridge Plan for A-2 Route
	JAPAN INTERNATIONAL COOPERATION AGENCY



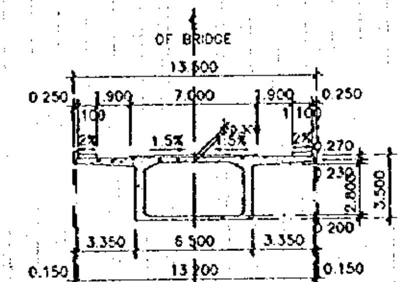
BRIDGE ELEVATION VIEW
SCALE H 1 : 5000 V 1 : 2000



BRIDGE SECTION A–A
SCALE 1 : 400

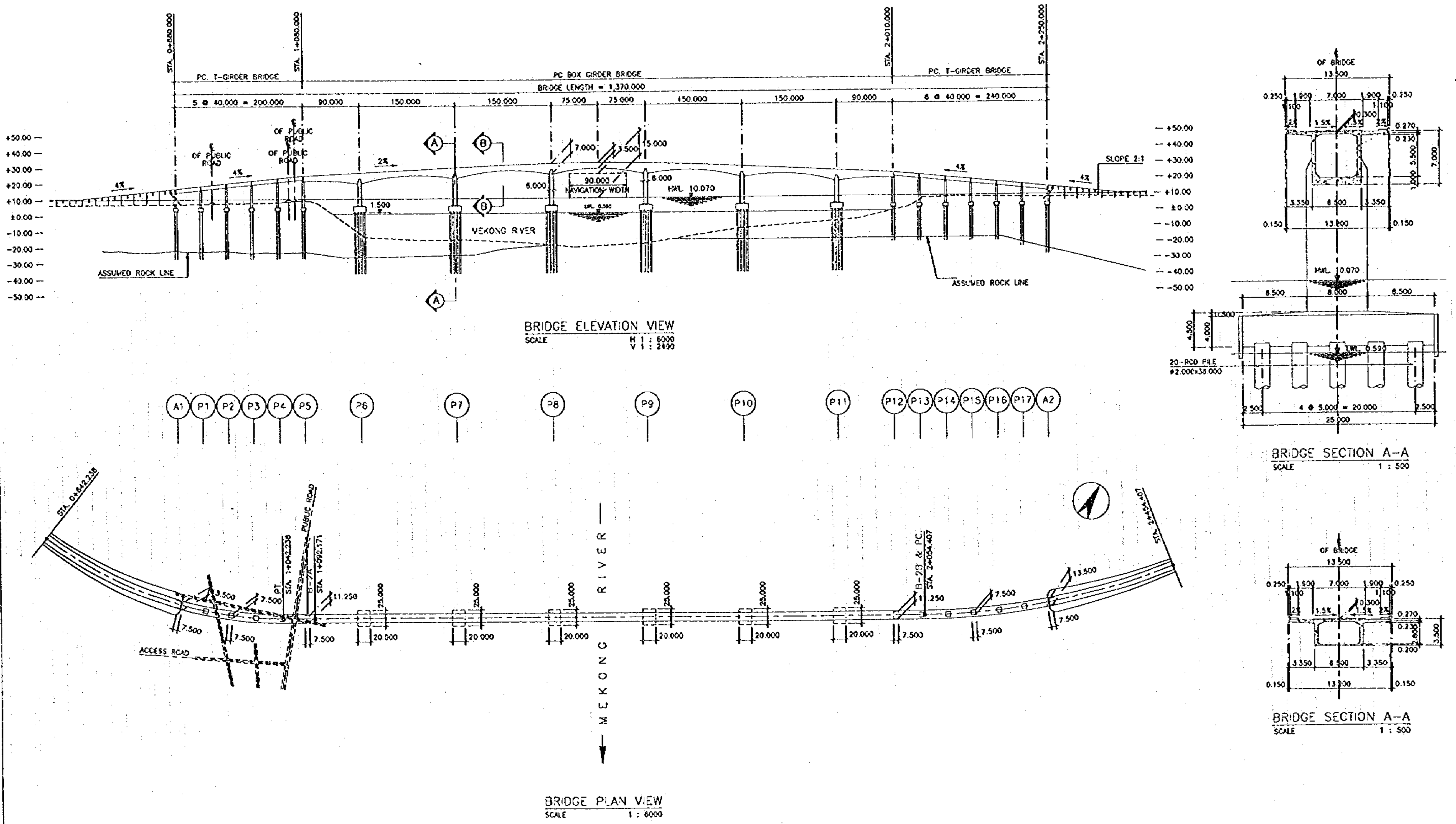


BRIDGE PLAN VIEW
SCALE 1 : 5000

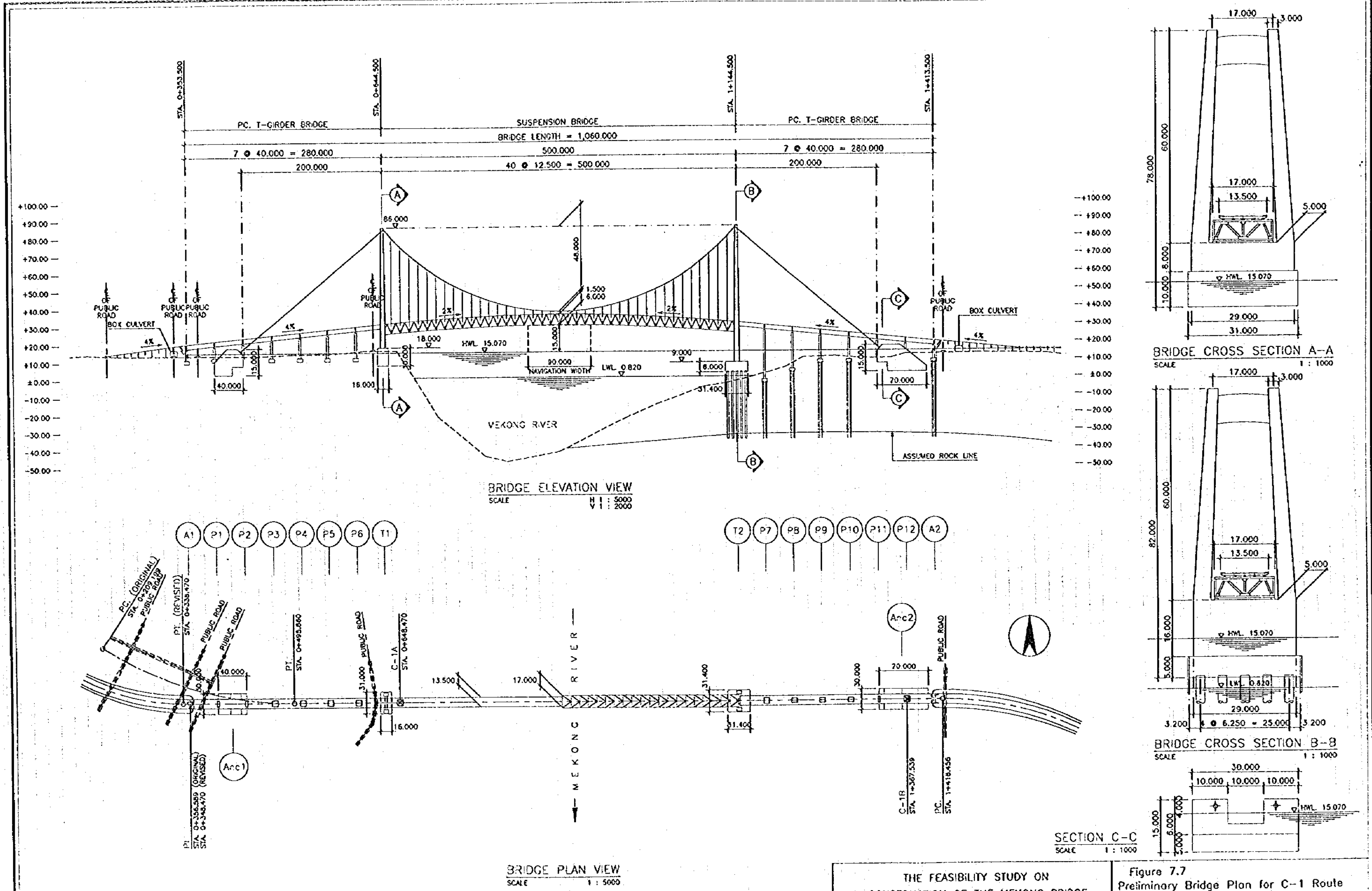


BRIDGE SECTION B–B
SCALE 1 : 400

THE FEASIBILITY STUDY ON CONSTRUCTION OF THE MEKONG BRIDGE IN KINGDOM OF CAMBODIA	Figure 7.5 Preliminary Bridge Plan for B–1 Route
	JAPAN INTERNATIONAL COOPERATION AGENCY



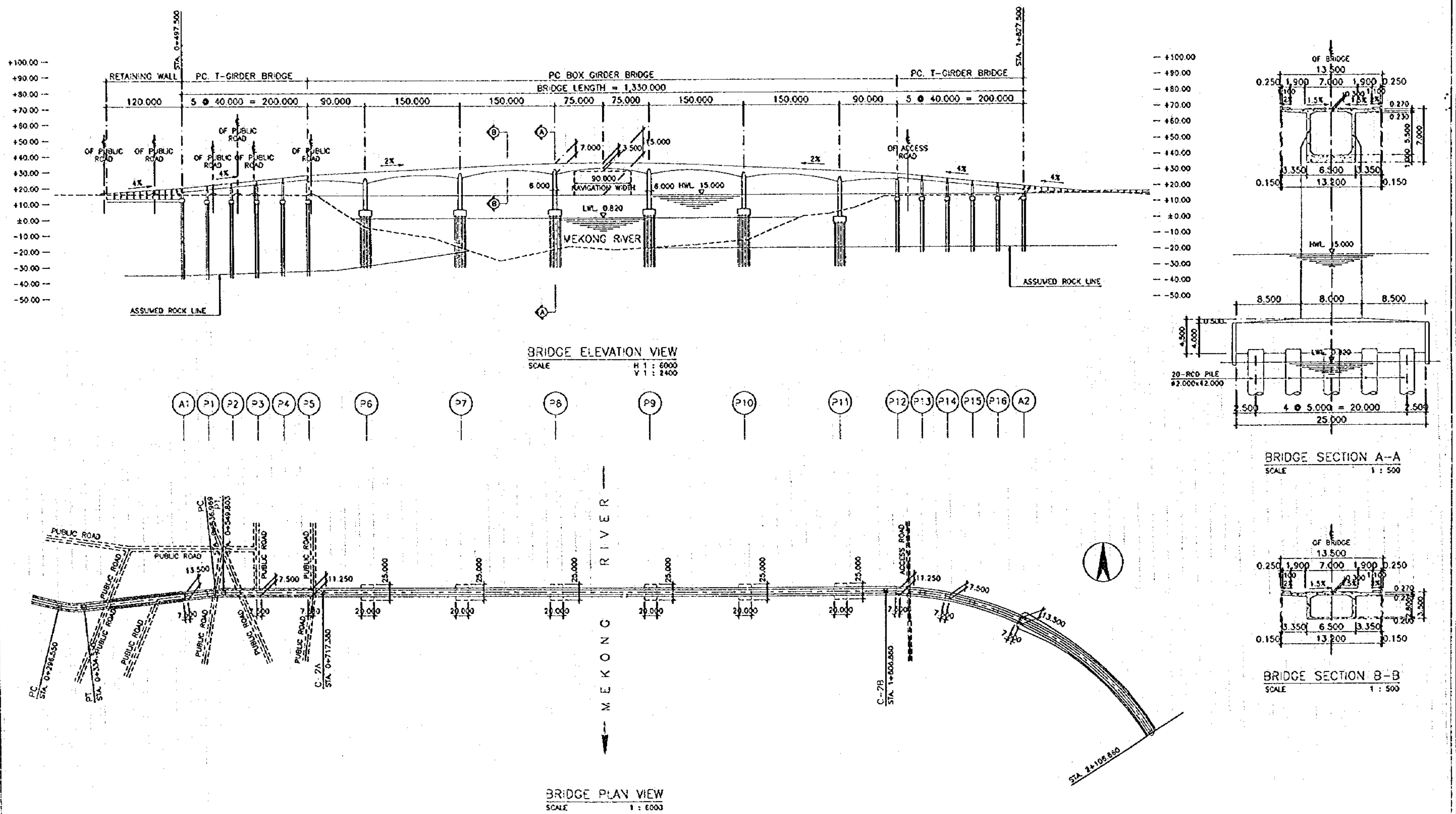
THE FEASIBILITY STUDY ON CONSTRUCTION OF THE MEKONG BRIDGE IN KINGDOM OF CAMBODIA	Figure 7.6 Preliminary Bridge Plan for B-2 Route
	JAPAN INTERNATIONAL COOPERATION AGENCY



THE FEASIBILITY STUDY ON
CONSTRUCTION OF THE MEKONG BRIDGE
IN KINGDOM OF CAMBODIA

Figure 7.7
Preliminary Bridge Plan for C–1 Route

JAPAN INTERNATIONAL COOPERATION AGENCY



THE FEASIBILITY STUDY ON CONSTRUCTION OF THE MEKONG BRIDGE IN KINGDOM OF CAMBODIA	Figure 7.8 Preliminary Bridge Plan for C-2 Route
	JAPAN INTERNATIONAL COOPERATION AGENCY

7.2 Approach and Connecting Road Studies

This section reviews road standards and practices in Cambodia, and presents preliminary standards and plans for road approaches to alternative Mekong Bridge sites and for the rehabilitation and upgrading of Route 315 connecting a bridge at Prek Tamak (B-1 or B-2) with Route 11 near Svay Antor. Traffic accident issues are also discussed.

7.2.1 Design Standards

Preliminary geometric and pavement design standards for approach and connecting roads have been developed based on a review of existing road standards and practices in Cambodia, anticipated levels of traffic, the need to provide a smooth transition from main roads to the bridge, and the quality and availability of materials for road construction.

(1) Review of Road Standards and Practices

In general, standards for major roads in Cambodia call for a 6.00 to 7.00 m paved roadway and two 1.50 to 2.00 m shoulders.

The standards recommended for Asian Highways (i.e., connecting country capitals), primary roads (i.e., connecting provincial centers with the respective capital), and secondary roads (i.e., linking district centers with provincial capitals, primary roads, or other districts) are shown in Table 7.10. These standards were proposed in the Cambodia Transport Rehabilitation Study, sponsored by the Asian Development Bank.

The standards for upgrading Route 1 as recommended in the Feasibility Study of the Ho Chi Minh City - Phnom Penh - Bangkok Road Project, and the standards used in the ongoing reconstruction of Route 6A and Route 4 (from Phnom Penh to Sihanoukville) are summarized in Table 7.11.

Ongoing rehabilitation works for sections of Routes 1, 2, 3, 5, 6, and 11 provide for a 6.00 m wide roadway with a double bituminous surface treatment (DBST) and two 1.50 m shoulders. Basecourse would consist of a crushed rock layer 200 mm thick, and subbase course of select material at least 230 mm thick unless existing base and subbase courses are adequate.

An April 6, 1995 agreement between the Cambodian Ministry of Public Works and Transport (MPWT) and the Japan International Cooperation Agency (JICA) adopted a road width of 13.50 m for the Mekong Bridge approach road, consisting of a 7.00 m roadway, two 2.50 m motorcycle/NMV/pedestrian ways, and two 0.75 m shoulders. The agreed road width is similar to the bridge cross-section also stipulated in the above agreement, which provides for a 7.00 m wide roadway (carriageway), two 1.90 m wide motorcycle/NMV ways, and two 1.10 m wide pedestrian sidewalks, with two 0.25 m wide edges for installing guardrails.

In general, approach roads would pass over intersecting local roads or streets via a box or deck type structure when their difference in elevation provides a clearance of more than 4.0 m; otherwise, the approach roads would intersect local roads at grade, which would require raising the level of the local roads since most of them are built at or near ground level. In cases where overpasses cannot be provided and at grade intersections would be unsafe, local roads or streets would be rerouted or ended.

Small irrigation canals would be traversed by box culverts, with bridges provided over larger water crossings or wide swamps. Crossing of ponds would normally be done over an embankment.

Preliminary plans and particular design features of each approach road are outlined in the sections that follow.

Table 7.10 Standards Proposed in the Cambodia Transport Rehabilitation Study

	Asian Highway	Primary Road	Primary/Secondary Road
Average Daily Traffic (excl. motorcycles)	5,000 - 10,000	1,500 - 5,000	500 - 1,500
Roadway (m)	7.00	7.00	6.00
Shoulders (m)[1]	3.00 x 2	1.50 x 2	1.50 x 2
Total Width (m)[1]	13.00	10.00	9.00
Surface	Bituminous	Bituminous	Bituminous
Max. Gradient (%)	8	8	10
Design Speed (km/h)			
- Mountainous Terrain	85	70	60
- Rolling Terrain	100	85	85
- Flat Terrain	120	100	85

Note: [1]The shoulder width would be less for ADT < 5,000.
Source: Cambodia Transport Rehabilitation Study, Final Report, prepared for the Asian Development Bank.

Table 7.11 Standards for Ongoing/Planned Reconstruction Projects

	Route 1[1]	Route 1[2]	Route 6A	Route 4
Roadway (m)	7.00	6.00	7.00	7.00
Shoulders (m)	2.00 x 2	1.50 x 2	1.50 x 2	2.00 x 2
Total Width (m)	11.00	11.00[3]	10.00	11.00
Surface	DBST[4]	DBST[4]	AC	AC
Base (mm)	175	325	100	100
Subbase (mm)	175	275	100 or exist.	existing

Notes: [1]From Phnom Penh to Neak Loeung.
[2]From Neak Loeung to the Vietnamese border.
[3]A road formation width of 11.00 m instead of 9.00 m was recommended to facilitate future widening of roadway and shoulders.
[4]The minimum requirements call for DBST surfacing initially, followed by AC overlays in future years when roughness reaches an IRI of 6 or more.

Sources: Route 1: PADECO Co., Ltd., Feasibility Study of the *Ho Chi Minh-Phnom Penh-Bangkok Road Project, Final Report - Main Text*, prepared for the Asian Development Bank, April 1995, pp. 4-7.
Route 6A: Final design drawings, construction contractor.
Route 4: Final design drawings, supervising consultant.

(2) Design Standards for Approach Roads

Approach roads start at the viaduct edges and end with a connection to a main road. Preliminary design standards for the approach roads were developed based on the April 6, 1995 agreement between MPWT and JICA, a review of existing standards and practices in Cambodia, traffic considerations, the need to provide a smooth transition between the bridge and connecting roads, the availability and quality of construction materials, and other appropriate considerations.

The recommended design width for the approach roads is 13.50 m from the viaduct edges for a distance of 200 m, and 9.00 m to 11.00 m beyond that point. The width beyond 200 m being gradually reduced so that it matched the width of the main road to which the approach road connects. The transition from 13.50 m to a narrower road width being achieved by tapering off the motorcycle/NMV ways while increasing shoulder widths.

Narrowing of the approach road width for the section located 200 m from the viaduct start/end point is recommended in order to reduce construction costs, as some approach roads were about 3.7 km long.

Recommended approach road standards are shown in Table 7.12, and typical sections are shown in Figure 7.9. Base and subbase courses are full-width, i.e., they extend across the entire road formation width (including shoulders) to provide better drainage and to facilitate potential future roadway widening.

Table 7.12 Approach Road Design Standards

Standards for Approach Road Type I
(Within 200 m from the Viaduct Edge):

Main roadway	7.00 m wide, AC paved, 70 mm thick
Motorcycle/NMV/pedestrian ways	2.50 m wide, both sides, AC paved, 50 mm thick
Shoulders	0.75 m wide, both sides
Total Width	13.50 m
Base	Crushed gravel, 150 mm thick
Subbase	Select laterite gravel, 200 mm thick
Embankment	Slope 1:2, protected with sodding

Standards for Approach Road Type II
(200 m from the Viaduct Edge to the Connection with a Main Road):

Roadway	7.00 m wide, AC paved, 70 mm thick
Shoulders	1.00 - 2.00 m wide, both sides
Total Width	9.00 - 11.00 m
Base	Crushed gravel, 150 mm thick
Subbase	Select material, 200 mm thick
Embankment	Slope 1:2, protected with sodding

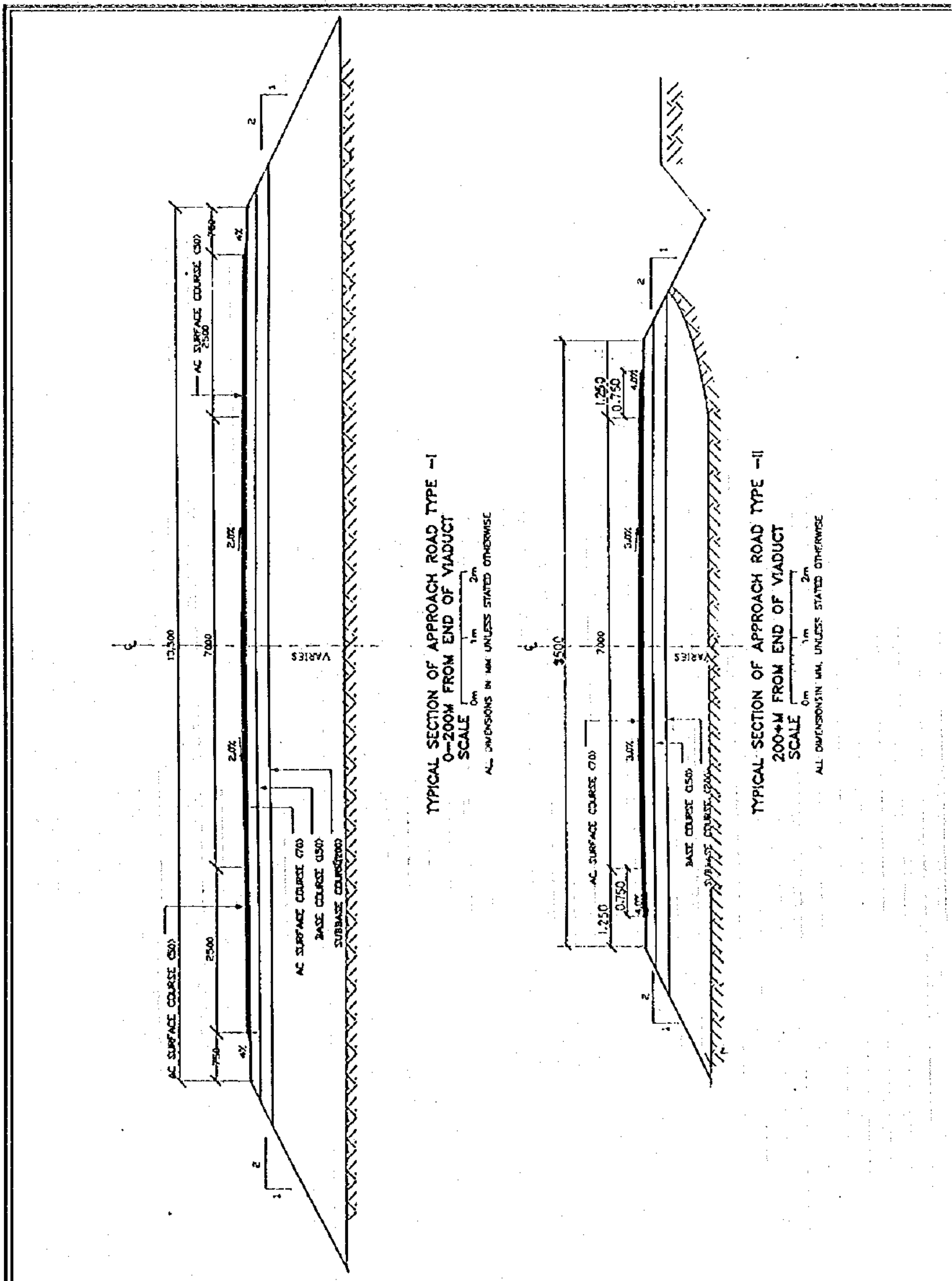
(3) Design Standards for Connecting Roads

Design standards for Route 315 or other roads connecting a B-1 or B-2 bridge with Route 11 were based on a review of existing standards and practices, traffic considerations, availability and quality of construction materials, construction cost, and maintenance considerations. A 6.00 m wide roadway with two 1.50 m shoulders is recommended, as shown in Table 7.13.

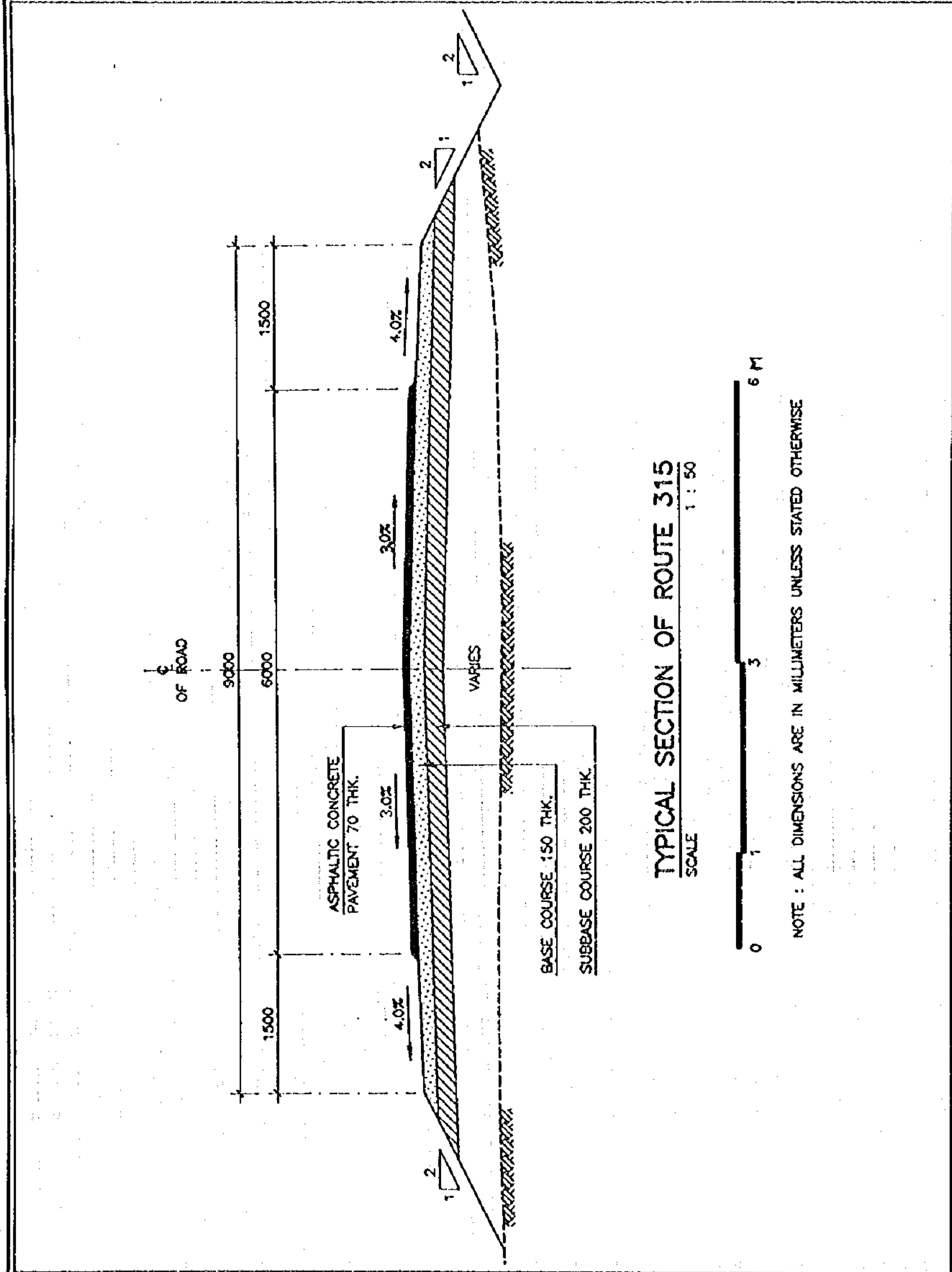
Table 7.13 Design Standards for Connecting Roads (Route 315)

Roadway	6.00 m wide, AC paved, 70 mm thick
Shoulders	1.50 m wide, both sides
Base	Crushed gravel, 150 mm thick
Subbase	Select material, 200 mm thick
Embankment	Slope 1:2, protected with sodding

A typical section for Route 315 is shown in Figure 7.10. As with the case for approach roads, base and subbase courses are full-width to provide to ensure drainage and to facilitate future roadway widening, if necessary.



THE FEASIBILITY STUDY ON CONSTRUCTION OF THE MEKONG BRIDGE IN KINGDOM OF CAMBODIA	Figure 7.9 Typical Road sections JAPAN INTERNATIONAL COOPERATION AGENCY



THE FEASIBILITY STUDY ON CONSTRUCTION OF THE MEKONG BRIDGE IN KINGDOM OF CAMBODIA	Figure 7.10 Typical Road section of Route 315
	JAPAN INTERNATIONAL COOPERATION AGENCY

7.2.2 Preliminary Design of Approach Roads

The various approach roads, which connect the bridge to the existing road network, range in total length, from 1,755 m for the Prek Tamak B-1 route, to 3,715 m for the Kompong Cham C-1 route. The estimated preliminary lengths of alternative bridges and road approaches and the main features within their immediate vicinities are summarized in Table 7.14 and are discussed, in more detail below.

Viaduct bridge sections typically extend from the main bridge structure either in a straight horizontal line or with curves having a minimum radius of 300 m. Horizontal curves along the main section of approach roads have a minimum radius of 250 m, thus providing a design speed of at leaast 85 km/h. Junction curves, on the other hand have a minimum radius of about 100 m thus providing a design turning speed of 60 km/h.

The centerline elevation of approach roads typically start at about 8 m above ground level, where they meet the viaduct bridge section; at which point the roads run in a downward grade of 4% to the level of the connecting road or street, or to the minimum level required for adequate flood protection.

Minimum road elevations were based on the requirement that the top edge of subgrade (i.e., bottom edge of subbase course) should be at least 1 m above the floodwater level or level of water covering adjacent rice fields to protect the pavement layers from water infiltration.

(1) Neak Loeung A-1 Route Approach Roads

The preliminary design plan for approach roads to a bridge at the Neak Loeung A1 site is shown in Appendix 7.1.

For the purposes of this study, Route 1, which is currently undergoing reconstruction, has been assumed to be 10.00 m wide (7.00 m roadway, with two 1.50 m shoulders). The width of approach road sections located more than 200 m from the viaduct edges was therefore also assumed to be 10.00 m; the width of approach road sections within 200 m from the viaduct edges was 13.50 m.

The starting centerline elevations at the viaduct edges was about 14.3 m for the western approach road and 15.9 m for the eastern one. The average minimum centerline elevation was about 8.4 m to the junctions with Route 1, where elevations of the approach roads matches those of Route 1.

A box culvert was assumed for the small canal crossing the eastern approach road.

(2) Neak Loeung A-2 Route Approach Roads

Appendix 7.2 shows the proposed alignment for approach roads to a bridge at the Neak Loeung A-2 route.

Table 7.14 Bridges and Road Approaches

Bridge and Road Approach[1]	Length (m)	Connects Bridge to:	Main Features of the Immediate Vicinity
Neak Loeung A-1			
Bridge	2,300		
Western Approach	910	Route 1	Farmland, houses, temple
Eastern Approach	2,510	Route 1	Farmland, houses, temple, swamps
Total	5,810		
Neak Loeung A-2			
Bridge	1,970		
Western Approach	1,270	Route 1	Farmland, houses
Eastern Approach	1,470	Route 1	Farmland, houses
Total	4,710		
Prek Tamak B-1			
Bridge	1,030		
Western Approach	450	Route 6A	Farmland
Eastern Approach	1,305	Route 315	Farmland, houses, temple
Total	2,785		
Connecting Road[2]	59,000	Route 11	Farmland, houses, swamps
Prek Tamak (Svay Chrum) B-2			
Bridge	1,370		
Western Approach	1,300	Route 6A	Farmland, swamps, houses
Eastern Approach	1,440	Route 315	Swamp, houses, temple
Total	4,110		
Connecting Road[3]	65,500	Route 11	Farmland, houses, swamps
Kompong Cham C-1			
Bridge	1,060		
Western Approach	380	Street	Houses, temple
Eastern Approach	3,335	Route 7	Farmland, houses, swamps
Total	4,775		
Connecting Road[4]	1,250	Route 7	Houses, military camp
Kompong Cham C-2			
Bridge	1,330		
Western Approach	500	Street/Route 7	Houses, commercial bldgs
Eastern Approach	2,600	Route 7	Farmland, houses, swamps
Total	4,430		

Notes: [1]Road approach lengths include both branches of Y junctions. Some road lengths differ from surveyed lengths due to office design modifications.

[2]Route 315 from the B-1 eastern approach to Route 11 is 59 km long.

[3]The road from the B-2 eastern approach to Route 11 is 65.5 km long.

[4]The street from the end of the C-1 western approach to Route 7 at its entrance into Kompong Cham is 1,250 m long.

The approach road width was 13.50 m from the viaduct edges to a distance of 200 m. Beyond 200 meters the approach road width was 10.00 m, the same as the assumed width of Route 1.

The starting centerline elevations at the viaduct edges was about 15.4 m for both the western and eastern approach roads. The average minimum centerline elevation was about 8.3 m to the junctions with Route 1, where elevations would then coincide.

(3) Prek Tamak B-1 Route Approach Roads

The proposed alignment for approach roads to a bridge at the Prek Tamak B1 site is illustrated in Appendix 7.3.

The main section of the western approach road and its southern branch, which joins Route 6A in the direction of Phnom Penh, had a width of 13.50 m, tapering to 10.00 m at the junction with Route 6A. The northern branch, which also connects with Route 6A, had a width of 10.00 m, the same as that of Route 6A.

The eastern approach road had a width of 13.50 m, within 200 m of the viaduct edge, and 9.00 m thereafter, corresponding to the proposed 9.00 m width of Route 315 (see section 7.2.3).

The starting centerline elevations at the viaduct edges was about 19.9 m for both the western and eastern approach roads. The average minimum centerline elevation was about 11.4 m to the junctions with Routes 6A and 315, where elevations of the approach roads matches those of the two routes, respectively.

(4) Prek Tamak (Svay Chrum) B-2 Route Approach Roads

The proposed alignment for approach roads to a bridge at the Prek Tamak (Svay Chrum) B-2 route is shown in Appendix 7.4.

The approach roads had a width of 13.50 m, from viaduct edge for a distance of 200 m. Thereafter, the western approach had a width of 10.00 m, corresponding to the width of Route 6A; the eastern approach had a width of 9.00 m, the same as the proposed width of Route 151 (see section 7.2.3).

The starting centerline elevations at the viaduct edges is about 17.7 m for the western approach road and 16.1 m for the eastern one. The average minimum elevation is about 10.5 m to the junctions with Routes 6A and 151, where elevations then coincide.

A bridge about 50 m long had been assumed over part of the swamp crossing the eastern approach; the remaining swamp section being traversed by an embankment.

(5) Kompong Cham C-1 Route Approach Roads

Appendix 7.5 illustrates the proposed alignment for approach roads to a bridge at the Kompong Cham C-1 route. A roundabout needed to be provided at the intersection of the western approach road with four Kompong Cham city streets, as shown in more detail in Appendix 7.6.

The western approach road had a width of 13.50 m over the first 200 m from the viaduct edge, and thereafter a width of 10.00 m, to the roundabout. Sidewalks were provided in lieu of shoulders, since the road served as an urban street.

The 1,250 m long street connecting the proposed roundabout to Route 7, at its entrance into Kompong Cham was also assumed to be reproved, as it was in poor condition.

The eastern approach road had a width of 13.50 m within 200 m from the viaduct edge, and 10.00 m thereafter, matching the assumed 10.00 m width of a reconstructed Route 7.

The starting centerline elevations at the viaduct edges was about 22.4 m for both the western and eastern approach roads. The average minimum centerline elevation was about 15.8 m to the junction of the western approach with the roundabout, and to the junction of the eastern approach with Route 7, where the elevations of the approach roads matched those of the roundabout and Route 7, respectively.

Retaining walls were provided along the first section of the western approach road in order to reduce embankment width. An alternative option was to extend the western viaduct until its elevation is close to the existing ground elevation.

It was also proposed that box structures be provided for the two streets crossing this approach. A bridge about 30 m long was also provided over the stream at station 2+980 on the eastern approach.

(6) Kompong Cham C-2 Route Approach Roads

The proposed alignment for approach roads to the Kompong Cham C-2 route is shown in Appendix 7.7. The centerline of the western approach road coincides with that of Route 7 within Kompong Cham.

Retaining walls were assumed along the first section of the western approach road to contain the embankment, as shown in Appendix 7.8. Another option considered was the extension of the western viaduct.

The western approach road had a width of 13.50 m over the initial section until its elevation corresponds to that of the existing street (Route 7). Sidewalks were also provided, in lieu of shoulders, since this road is an urban street. For the remainder of its length, the approach road cross-section coincided with that of the existing street.

The eastern approach road had a width of 13.50 m within 200 m from the viaduct edge, and 10.00 m thereafter, matching the assumed 10.00 m width of a reconstructed Route 7.

The centerline elevation at the viaduct edge was about 21.9 m for both the western and eastern approach roads. The centerline elevation of the western approach road then descended at a grade of 4% until it met the level of the existing street (Route 7), at an elevation of about 15.8 m. The average minimum centerline elevation of the eastern approach was about 15.8 m to its junction with Route 7, where the elevations then matched.

A bridge about 30 m long was assumed over the stream at station 2+660 (station 2+980 on the C1 eastern approach road).

7.2.3 Preliminary Design of Connecting Roads

The design of the two connecting roads referred to above, namely those joining the eastern approach road of the B-1 or B-2 bridges with Route 11, are discussed below.

In the case of a B1 bridge, the connecting road consisted of Route 315, from Prek Tamak near its junction with the eastern approach road, to its junction with Route 11, at Svay Antor, a length of 59.5 km.

In the case of a B2 bridge, the connecting road was made up of the following sections totalling 65.5 km: (1) 7.5 km of Route 151 from its junction with the eastern approach road at Svay Chrum to Taval; (2) 10 km of a new road from Taval to Thmei on Route 315; (3) and 48 km of Route 315 from Thmei to the junction with Route 11. The last section of the B2 connecting road is the same as the last 48 km of a B1 connecting road. For ease of reference, the 65.5 km B2 connecting road is referred to as Route 315/B2.

Conceptual designs for the two roads were based on road reconnaissance surveys and reviews of existing topographic maps (1:50,000 scale) and aerial photographs (1:10,000 scale, enlarged from 1:25,000 scale prints). No specific topographic surveys were carried out.

(1) Route 315 Design

The first 32.0 km, from Prek Tamak, of the existing Route 315 has a total average width (laterite roadway and shoulders) of about 7.0 m; from km 32.0 to km 51.5 the total average width is about 5.3 m; and for the last 8.5 km currently there is no road, just seasonal trails about 3 m wide. For most of the initial 51.5 km, the existing road is built on low embankment or is at ground level, and consequently it has experienced substantial erosion and damage due to saturation by floodwaters and/or adjoining rice fields.

The proposed new Route 315, as outlined in section 7.2.1 (3) of this report, had a roadway width of 6.00 m and two 1.50 m shoulders. The road pavement consisted of 70 mm of asphaltic concrete over 150 mm of crushed rock basecourse and 200 mm of subbase; the base and subbase courses extended for the full-width of the embankment. Embankment slopes of 1:2, protected by sodding, were also assumed in the design.

The proposed new Route 315, for the first 51.5 km from Prek Tamak, was to generally follow the alignment of the existing road, with some realignments to improve curves and water crossings. The last 8.0 km to the junction with Route 11 was to consist of a new, straight alignment, about 0.5 km shorter than the existing 8.5 km winding trail. A schematic plan of Route 315 is shown in Appendix 7.9 to Appendix 7.11.

The embankment of the new road was to be constructed at an average height of 2.0 m above the natural surface, to protect it from severe water damage and safeguard the investment in its construction. Table 7.15 shows estimated existing road levels and proposed embankment heights, and road levels of Route 315.

Table 7.15 Existing and Proposed New Roadway Levels of Route 315

Section[1]		Average	Average New	Average New
From (km)	To (km)	Existing Road Level (m)	Embankment Height (m)[2]	Road Level (m)
0.0	2.0	0.0	0.5	1.0
2.0	6.0	2.0	4.0	4.5
6.0	9.5	1.0	2.5	3.0
9.5	11.5	0.0	0.5	1.0
11.5	15.0	0.0	1.0	1.5
15.0	16.0	0.5	2.0	2.5
16.0	18.0	0.0	0.5	1.0
18.0	19.0	2.0	3.0	3.5
19.0	22.0	0.7	2.0	2.5
22.0	27.5	0.7	2.0	2.5
27.5	28.5	0.0	0.5	1.0
28.5	30.5	0.5	2.5	3.0
30.5	31.5	0.0	0.5	1.0
31.5	34.5	0.0	1.5	2.0
34.5	45.0	0.3	2.5	3.0
45.0	47.0	0.3	0.5	1.0
47.0	51.0	0.3	2.0	2.5
51.0	52.0	1.5	3.5	4.0
52.0	59.5	0.0	2.0	2.5

Notes: [1]Stations indicate distance from Prek Tamak (km 0.0).

[2]Embankment heights at the top edge of subgrade (i.e., the bottom edge of subbase) were set at about 1.0 m above the estimated floodwater level or water level of adjoining rice fields. In areas not normally subjected to flooding (such as villages), a minimum embankment height of 0.5 m was provided for rainwater drainage purposes. The top 0.5 m of embankment was also to consist of select fill.

There are 15 bridges along the existing road, of which 13 are in poor condition or are temporary bridges that have to be replaced. The two bridges in fair condition were to be retained.

New bridges were to have a width of 9.00 m and be constructed at an elevation that would ensure that they, and the approach roadworks were clear of floodwaters. The two existing bridges, to be retained have widths of 9.80 m and 5.05 m, respectively. Table 7.16 lists the existing and proposed bridges along Route 315.

Table 7.16 Existing and Proposed New Bridges along Route 315

	Existing Bridges			Proposed New Bridges		
Section[1] (km)	Length (m)	Width (m)	Condition	Length (m)	Width (m)	Area (m2)
3.3	15.24	4.20	Poor	17.00	8.00	153.00
4.5	84.00	5.05	Fair	Retain Existing		
7.6	18.30	4.40	Poor	21.00	9.00	189.00
8.1	15.24	4.40	Poor	17.00	9.00	153.00
9.5	18.28	4.30	Poor	22.00	9.00	198.00
18.6	22.80	3.65	Poor	24.00	9.00	216.00
18.7	10.50	4.20	Poor	14.00	9.00	126.00
20.1	10.20	4.30	Poor	13.00	9.00	117.00
21.4	100.00	9.80	Fair	Retain Existing		
22.9	18.00	2.70	Poor	22.00	9.00	198.00
26.0	90.00	2.80	Poor	90.00	9.00	810.00
30.6	126.00	3.40	Poor	126.00	9.00	1,134.00
35.7	10.00	8.70	Poor	15.00	9.00	135.00
41.9	11.80	4.00	Poor	16.00	9.00	144.00
51.5	14.60	4.00	Poor	18.00	9.00	162.00
Total Proposed New Bridges				415.00		3,735.00

Note: [1]Stations indicate the distance from Prek Tamak (km 0.0).

Box and pipe culverts were to be provided along the road for cross drainage and for equalization of water levels at both sides of high embankments. For purposes of preliminary planning, it was proposed that one pipe culvert be installed every 1.25 km and that one box culvert be constructed every 5 km.

(3) Route 315/B2 Design

Route 315/B2 connecting the B-2 bridge site to Route 11 at Svay Antor had a length of about 65.5 km, of which the last 48 km coincided with the last 48 km of Route 315, described above.

A schematic plan of the first 17.5 km of Route 315/B2, from the end of the B-2 eastern approach road to its junction with Route 315, at Thmei is shown in

Appendix 7.12. Thmei is located on Route 315 at a distance of 11.5 km from Prek Tamak.

The geometric and pavement design of Route 315/B2 was the same as that adopted for Route 315. This applied equally to the bridges.

The first 7.5 km of Route 315/B2 followed the alignment of Route 151 from its junction with the B2 eastern approach road to Taval. The total road width (roadway and shoulders) of this earth road was about 8.0 m, built mainly at ground level. Since this road section did not normally flood, an embankment height of 0.5 m was deemed to be sufficient for the new road.

There are 6 existing bridges along this 7.5 km section of road, of which 4 are in poor condition and needed to be replaced. The two bridges considered to be in fair condition, and to be retained; had widths of 5.60 m and 6.20 m, respectively. Where necessary, the replacement bridges and approach roadworks were to be constructed well above normal flood levels.

There is currently no road between Taval and Thmei, the route consisting primarily of a few short and scattered dry season trails, near the two towns, but not connecting the two. This area is low lying, has several large swamps and water crossings, and is subjected to heavy flooding.

Preliminary estimates indicated that a 10 km road section from Taval to Thmei would have to be built on an average embankment height of 4 to 5 m over much of its length. At least three large drainage structures would be required: one bridge about 100 m long; one bridge about 150 m long; and a viaduct about 1,400 m long. (The viaduct could conceivably be replaced by a series of bridges on high embankment.)

Table 7.17 shows estimated existing road levels and proposed embankment heights and road levels for Route 315/B2. Table 7.18 lists the existing and proposed bridges along Route 315/B2.

Box and pipe culverts were assumed along the road, for cross drainage and for equalization of water levels on both sides of high embankments. For purposes of preliminary planning, it was assumed that it would be necessary to install one pipe culvert every 1.25 km and one box culvert every 5 km.

Table 7.17 Existing and Proposed New Roadway Levelsof Route 315/B2

Section From (km)	Section To (km)	Average Existing Road Level (m)	Avg. Existing Embankment Height (m)	Average New Road Level (m)[1]
From B2 Eastern Approach Road to Thmei[2]				
0.0	7.5	0.0	0.5	1.0
7.5	9.0	0.0	2.5	3.0
9.0	13.3	0.0	5.0	5.5
13.3	14.7	0.0	Viaduct	Viaduct
14.7	16.0	0.0	4.0	4.5
16.0	17.0	0.0	1.5	2.0
17.0	17.5	0.0	0.5	1.0
From Thmei (Km 11.5 of Route 315) to Km 59.5 of Route 315[3]				
11.5	15.0	0.0	1.0	1.5
15.0	16.0	0.5	2.0	2.5
16.0	18.0	0.0	0.5	1.0
18.0	19.0	2.0	3.0	3.5
19.0	22.0	0.7	2.0	2.5
22.0	27.5	0.7	2.0	2.5
27.5	28.5	0.0	0.5	1.0
28.5	30.5	0.5	2.5	3.0
30.5	31.5	0.0	0.5	1.0
31.5	34.5	0.0	1.5	2.0
34.5	45.0	0.3	2.5	3.0
45.0	47.0	0.3	0.5	1.0
47.0	51.0	0.3	2.0	2.5
47.0	51.0	0.3	2.0	2.5
51.0	52.0	1.5	3.5	4.0
52.0	59.5	0.0	2.0	2.5

Notes: [1]Embankment heights at the top edge of subgrade (i.e., the bottom edge of subbase) were set at about 1.0 m above the estimated floodwater level or water level of adjoining rice field. In areas not normally subjected to flooding (such as villages), a minimum embankment height of 0.5 m was provided for rainwater drainage purposes. The top 0.5 m of embankment would consist of special fill.

[2]Stations 0.0 to 17.5 indicate the distance from the junction with the B2 bridge eastern approach road.

[3]Stations 11.5 to 59.5 indicate the distance from Prek Tamak (km 0.0).

Table 7.18 Existing and Proposed New Bridges along Route 315/B2

Station (km)	Existing Bridges Length (m)	Width (m)	Condition	Proposed New Bridges Length (m)	Width (m)	Area (m2)
From B2 Eastern Approach Road to Thmei[1]						
2.5	22.60	5.60	Fair		Retain Existing	
3.5	17.10	6.20	Fair		Retain Existing	
4.3	14.00	4.50	Poor	17.00	9.00	153.00
5.2	32.80	5.70	Poor	33.00	9.00	297.00
7.0	10.40	3.50	Poor	14.00	9.00	126.00
7.4	4.70	3.50	Poor	6.00	9.00	54.00
8.6	NA	NA	NA	100.00	9.00	900.00
12.9	NA	NA	NA	150.00	9.00	1,350.00
13.3 - 14.7	NA	NA	NA	1,400.00	9.00	12,600.00[2]
From Thmei (Km 11.5 of Route 315) to Km 59.5 of Route 315[3]						
18.6	22.80	3.65	Poor	24.00	9.00	216.00
18.7	10.50	4.20	Poor	14.00	9.00	126.00
20.1	10.20	4.30	Poor	13.00	9.00	117.00
21.4	100.00	9.80	Fair		Retain Existing	
22.9	18.00	2.70	Poor	22.00	9.00	198.00
26.0	90.00	2.80	Poor	90.00	9.00	810.00
30.6	126.00	3.40	Poor	126.00	9.00	1134.00
35.7	10.00	8.70	Poor	15.00	9.00	135.00
41.9	11.80	4.00	Poor	16.00	9.00	144.00
51.5	14.60	4.00	Poor	18.00	9.00	162.00
Total Proposed New Bridges				2,058.00		18,522.00

Notes: [1]Stations indicate the distance from the junction with the B2 bridge eastern approach road.

[2]Stations indicate the distance from Prek Tamak (km 0.0).

[3]Viaduct.

7.2.4 Traffic Accident Considerations

The accident statistics in Cambodia, like those in other developing countries are generally poor with a high level of road accidents given the generally low vehicle population. This is caused by a number of factors, including the mix of traffic (slow (pedestrians, cyclists and animal drawn vehicles) and fast traffic share the same road space), encroachment of roadside activity onto the shoulders of the road, poor vehicle maintenance, poor driving habits, poor road conditions (pot-holes and inadequate shoulder maintenance) and inadequate signs. All of these apply to Cambodia and the study roads, as most will involve high embankments in areas with mixed traffic.

While the available data did not give any indication of the type of accident that commonly occurs in Cambodia, evidence from other countries would suggest that a high percentage, in rural areas, would involve vehicles leaving the road; in urban or semi urban areas the higher percentage of non-motorised traffic (pedestrians, cyclists and animal drawn vehicles) typically found there, combined with the encroachment of roadside activities, usually results in more collision type accident, with pedestrians and cyclists being the main casualties. The accident prevention and minimisation measures required to address the accident problem are therefore different. These are discussed below.

Locations of particular concern for the study roads include intersections with crossroads, T-junctions, crossings of or entries into villages or urban areas, sections with sharp horizontal curves, changes in road width, connections of bridges and approach roads, and road sections on high embankments.

(1) Intersections and T-Junctions

The design approach has assumed that where the approach road embankment was high enough (4 m clearance) the local road would pass under the bridge approach, through a box or deck type structure. Where this was not possible the intersection would be constructed at grade, with the local road/street being raised to match the level of the approach road level, or being rerouted.

All at-grade intersections would to be provided with adequate signs and line/pavement markings, including stop signs for the traffic on the minor roads and warning signs for the traffic on the approach roads. Intersection areas would also be clear of trees, fences, houses, and other obstructions to improve sight distance.

The western approach of the C-1 route in Kompong Cham intersects three city streets, ending at a junction with four other streets. A five-arm roundabout was proposed at the junction with the four streets. Underpasses were also to be provided for two of the crossing streets, while an at-grade intersection was to be provided for the third one.

The western approach of the C-2 route in Kompong Cham coincides with an existing main street (a continuation of Route 7). Because this main street carries high traffic volumes, stop signs were to be placed for incoming traffic on the intersecting side streets, and warning signs for traffic on the approach road.

T-junctions of approach roads and main roads occur at the beginning and end of all approach roads, except the western approaches of the C-1 and C-2 routes. Curves with a radius of 100 m or greater were proposed for such junctions. Yield or stop signs were be placed for incoming traffic from approach roads and warning signs for traffic along the main roads. Junction areas were also to be clear of trees, fences, houses, and other obstructions to improve sight distance.

(2) Crossings/Entries into Residential Areas

There are houses along most local roads intersecting approach roads and along the main approach roads. The most densely populated areas are at the western approaches of the C-1 and C-2 routes (Kompong Cham), and at the eastern approaches of the B-1 route (Prek Tamak village) and B-2 route (Svay Chrum village).

Traffic safety in these areas was enhanced by providing pedestrian crossings at designated locations. Wider shoulders and slow traffic lanes were also adopted for those sections adjacent to residential areas with significant roadside activity or which catered for pedestrian and bicycle traffic.

(3) Points of Change in Road Width and Bridge and Road Connections

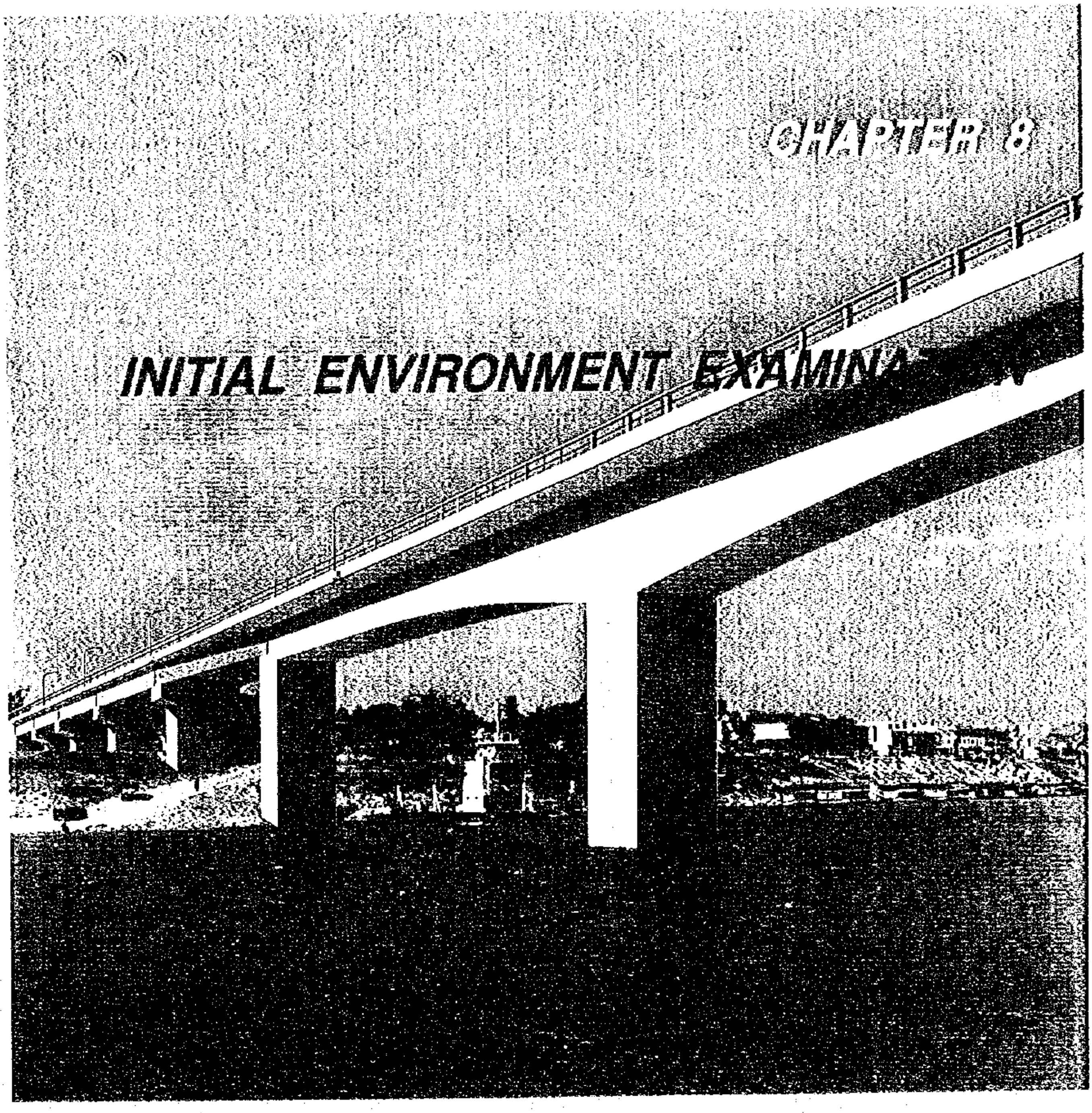
Changes in road width occur on all approach roads about 200 m from the edge of viaducts, from a 13.50 m width to a 9.00 m or 10.00 m width.

Appropriate taper lengths were adopted, and allowance made in the estimate for the provision of road markings and warning signs.

Proper taper lengths were also adopted for the transition from bridge cross-section to road cross-section.

(4) Roads on High Embankments

Approach roads are generally on high embankments, both where they descend from viaducts and elsewhere for flood protection reasons. When embankments are higher than about 3 or 4 m, road traffic safety barriers were assumed.


CHAPTER 8
INITIAL ENVIRONMENT EXAMINA

CHAPTER 8 INITIAL ENVIRONMENTAL EXAMINATION (IEE)

8.1 Introduction

The prime objective of an Initial Environmental Examination (IEE) is to reach a decision on whether a full-scale examination of environmental impacts, i.e., an Environmental Impact Assessment (EIA), is required. The purpose of conducting an IEE for this bridge construction project is to identify various environmental parameters affected by project implementation and to evaluate the magnitude of impact on these parameters for the six alternative routes, namely A-1 and A-2 at Neak Loeung, B-1 and B-2 at Prek Tamak, and C-1 and C-2 at Kompong Cham. The results of the examination are also utilized for the selection of an optimum site from these alternatives. The impact on these specific environmental parameters for the selected optimum site will be reviewed and carefully examined in the EIA stage.

This IEE was prepared at the middle stage of the feasibility study, based mostly on preliminary information on hand or on information which was readily available, such as topographic maps with a scale of 1:50,000, land use maps, and an initial field observation conducted in May 1995.

This chapter also presents legal and administrative aspects of environmental protection.

8.2 Legal and Administration Aspects of Environmental Protection

Legal and administrative issues on environmental protection were studied based on a series of interviews with officials of the Ministry of Environment and materials released by the agency.

8.2.1 Current Status of Environmental Laws and Environmental Protection Policies

At present, there are no specific laws or regulations on natural resources conservation and environmental protection in Cambodia. The Ministry of Environment is currently drafting an environmental law and the law is expected to be enacted in 1995. The Kingdom is yet equipped with environment monitoring systems, e.g., an Environmental Impact Assessment (EIA). The lack of qualified personnel and equipment is bottleneck of the establishment of the monitoring systems. No standards on ambient air quality, water quality, and noise level have yet set up.

Besides the drafting of the environmental law, the government, assisted with expatriates from international aid organizations, has been drafting subdecree of various types of environmental protection. This includes management and use of pesticide, watershed management, solid waste management, and an EIA.

8.2.2 Major Governmental Agencies In Charge of Environmental Protection

The Ministry of Environment, replacing the State Secretariat for Environment (SSE), was newly established in December 1993 and launched its activities in April 1994. The Ministry has six department in Phnom Penh headquarters and 18 regional offices nationwide. The headquarters comprises the following six departments:

- Department of Environmental Planning, Water Management, and Land Use;
- Department of Natural Resources Conservation and Protection;
- Department of Pollution Control and Prevention;
- Department of Environmental Laws;
- Department of Environmental Education and Environmental Quality Promotion; and
- Department of Administration and Finance.

The Phnom Penh headquarters has 336 staff, while 18 regional offices staffed with 225 officials, totaling 561 personnel in the ministry.

Other governmental bodies relating to the environmental protection include the Ministry of Agriculture, Forestry and Fishery, the Ministry of Public Works and Transport, the Ministry of Industry, Mines and Energy, and National Mekong Committee (NMC).[1]

8.3 Identification of Environmental Parameters for IEE

Probable environmental impacts caused by large scale bridge construction can be expected in various forms. Based on the Preliminary Environmental Survey (PES) conducted in May 1995, the following environmental parameters are selected as screening parameters and brief explanations on these parameters are presented below. It should be noted that items 12.1.1 to 12.1.8 are common to all alternatives, while Item 12.1.9 is unique to the specific alternative, i.e., B-2.

8.3.1 Pollution Levels of Air and Noise

The levels of air and noise pollution are expected to increase considerably with project implementation. The magnitude of pollution varies with construction methods and pollutant receptors, i.e., local inhabitants near the bridge construction site. Particular attention should be given to sensitive receptors, such as schools, hospitals and temples.

[1] NMC is national level organization established in the Mekong riparian countries under the United Nation-Managed Mekong Secretariat having its headquarters in Bangkok, Thailand.

Existence of sensitive receptors, i.e., schools, hospitals and temples, and affected residential areas were examined based on the field survey.

8.3.2 Riverine Terrestrial Ecology

Forest and wildlife resources will be adversely affected in the form of tree cutting, habitat alternation, and disturbance from air and noise and pollution.

8.3.3 Water Quality and Aquatic Ecology

Bridge construction activities along the river banks and in the water body may create some adverse impacts on the existing environment, e.g., sedimentary volume changes on riverbeds or waterway alterations. Aquatic resources are likely to be affected by such physical condition changes.

Some local inhabitants along the Mekong River are considered to rely on fish resources for their staple, and partially for the source of cash incomes.

8.3.4 Cultural/Historical Properties

Buddhist temples and monasteries are the most important parameters in this category, because people throughout the Kingdom rely spiritually on these cultural heritages. Therefore, careful consideration to minimizing adverse impacts should be given. Other cultural properties, such as churches, historical architectures and archaeological properties, will also be studied on a selected optimum site in the EIA stage.

8.3.5 Soil Erosion and Siltation

Bridge construction works may affect the river bank erosion if vulnerable site is selected. Eroded soils are subject to increase sedimentation volume, resulting in an increase of riverbed level and turbidity of water.

8.3.6 Environmental Aesthetics

Environmental aesthetics is generally considered to be disturbed by the appearance of new structures, which may destroy the harmony of the existing scenery or simply shut it out. Preliminary field survey is utilized for the evaluation on this parameter in the IEE stage.

8.3.7 Human Resettlement

The construction of new large-scale bridge will induce both positive and negative impacts on the communities. Typical adverse impacts concerning this matter are human resettlement. Affected commercial facilities and households to be removed are critical criteria for evaluating this parameter. Adjacent agricultural lands belonging to the households nearby are also examined during the preliminary field survey. Forthcoming EIA will study in depth on the impacts on this parameter for the selected site.

8.3.8 Transportation Systems

Interactive effects between the new bridge and existing roads with respect to traffic volume increase, subject to the congestion, and the impact of these changes on regional economies are expected.

This parameter will be analyzed further in the EIA stage.

8.3.9 Other Issues Concerning the Natural Environment

This item includes other environmental parameters that are not common to all alternative routes, but in fact affects only alternative B-2. The B-2 route would potentially have adverse impacts on wetland/marsh area, as reflected in Table 8.2.

8.4 Probable Environmental Impacts on the Candidate Locations

Environmental parameters that will be adversely affected by this bridge project and brief descriptions of these parameters are presented in the previous section. Evaluation criteria for these parameters are summarized in Table 8.1 below. Based on the criteria and the results of the preliminary field survey, adverse impacts on the alternatives are examined, and the magnitude of probable impacts are shown in Table 8.2, Checklist of Environmental Parameters for the Candidate Sites, in the following page.

Table 8.1 Evaluation Criteria for the Environmental Parameters

Environmental Parameter	Criteria
1. Air and Noise Pollution	1. Existence of affected local inhabitants and sensitive receptors
2. Riverine Terrestrial Ecology	2. Existence of riverine forest and inhabiting wildlife
3. Water Quality and Aquatic Ecology	3. Current water quality and living conditions of fish resources
4. Cultural/Historical Properties	4. Existence of these properties
5. Soil Erosion and Siltation	5. Soil characteristics and current status of erosion
6. Environmental Aesthetics	6. Changes in existing landscape
7. Human Resettlement	7. Affected commercial facilities/households and agricultural lands
8. Transportation System	8. Possible traffic congestion in the future

Table 8.2 **Checklist of Environmental Parameters for the Candidate Sites**

Environmental Parameters	A-1	A-2	B-1	B-2	C-1	C-2
1. Air and Noise Pollution	O	O	◎	◎	O	-
2. Riverine Terrestrial Ecology	◎	◎	◎	◎	◎	◎
3. Water Quality and Aquatic Ecology	O	O	O	O	O	O
4. Cultural/Historical Properties	-	◎	◎	◎	-	◎
5. Soil Erosion and Siltation	◎	◎	O	◎	◎	◎
6. Environmental Aesthetics	◎	◎	◎	◎	O	O
7. Human Resettlement	O	O	O	◎	-	×
8. Transportation System	O	O	O	O	O	O
9. Other Concerned Natural Environment	N/A	N/A	N/A	×	N/A	N/A

Marks: ◎ : Very Good O: Good -: Fair ×: Bad

8.5 Impact Evaluation for the Candidate Sites

Based on the preliminary environmental survey (PES), it has been determined that some environmental parameters, (i.e., riverine terrestrial ecology, water quality and aquatic ecology, soil erosion and siltation, environmental aesthetics, and transportation systems), do not have major impacts, while other parameters, (i.e., air and noise pollution, cultural/historical properties, human resettlement, and other concerned natural environment), have different magnitude of impacts depending on the candidate locations.

Concerning the parameters having impacts common to all the candidate locations, very minor impacts are expected on riverine terrestrial ecology as no riverine forest exists near the bride construction sites, and very minor impacts are likely on water quality and aquatic ecology, soil erosion and siltation, environmental aesthetics, and transportation systems, although further study will confirm these preliminary evaluation results.

Salient features of other environmental parameters, having different magnitude of impacts by construction site, are described in the sections that follow.

8.5.1 Neak Loeung (A-1 and A-2)

On the west-hand of both A-1 and A-2, small numbers of hovels in which mainly Vietnamese people reside will need to be relocated and small area of agricultural land also need to be abandoned. A primary school is located east of A-1 route and the school may need to be abolished if A-1 is selected.

8.5.2 Prek Tamak (B-1 and B-2)

There are wetland/marsh areas located east of B-2. Wetland/marsh areas typically have a vulnerable ecosystem and creatures living in the system are highly sensitive to any change in habitat.

8.5.3 Kompong Cham (C-1 and C-2)

These sites are considered to have the most significant environmental impacts regarding human resettlement, air and noise pollution, and cultural property. At both sites, some households will need to be relocated. In addition, a relatively developed commercial area can be found at the C-2 route, and a Buddhist temple is located at the C-1 site; they are likely to be affected by the construction of bridge approach roads. An appropriate road alignment should therefore be designed taking into account those affected, i.e., locations of houses, commercial facilities, and a Buddhist temple.

8.6 Considerations on the Optimum Route Selection

Based on Table 12.2, the number of marks, i.e., ◎ (Very Good), O (Good), - (Fair) and x (Bad), given to the alternatives is shown in Table 12.3.

Table 8.3 Indicative Ranking of Alternative Routes

Marks	A-1	A-2	B-1	B-2	C-1	C-2
◎ (Very Good)	3	4	4	6	2	3
O (Good)	4	4	4	2	4	3
-(Fair)	1	0	0	0	2	2
x (Bad)	0	0	0	1	0	0
Rank	3	1	1	6	5	4

Considering the optimum route selection among the six alternatives, it is apparent that B-2 should be immediately taken out because a mark of x is given to this alternative, regarding the impact on wetland/marsh areas. Although B-2 has many good marks, such as ◎ and O, only one x is sufficient to offset these given good points. In this regard, a mark of x could be considered a limiting factor of environmental evaluation on the site selection. Although alternatives of A-1, C-1, and C-2 do not have a limiting factor, there are some -s, one for A-2 (impact on a primary school) and two for C-1 (impacts on a Buddhist temple and human resettlement), and two for C-2 (impacts on air and noise pollution and human resettlement). The remaining two alternatives, A-2 and B-1, have the same numbers of ◎ and O, and no -or x, indicating small adverse impacts on natural and social environment.

In sum, alternatives of B-2 should be eliminated from the selection of the optimum route, and the other five are considered acceptable; A-2 and B-1 are equally good and share a ranking of one, followed closely by A-1, and then C-2 and C-1 with slight differences between them.

8.7 Basic Policy for Environmental Impact Assessment

Throughout the discussion of probable environmental impacts of the bridge construction project, considerable adverse impacts are generally anticipated although the magnitude of the impacts are minor, except at B-2. Whichever route is selected as the optimum one, an EIA is desired to be carried to predict and assess the adverse impacts on specific environmental parameters and eventually to recommend appropriate mitigation measures suitable to the Kingdom of Cambodia.

Concerning an EIA for specific environmental parameters, human resettlement, air and noise pollution, and water quality and aquatic ecology will be studied in depth for the selected optimum site, because these matters are related directly to probable changes in living conditions of local inhabitants. The number, type and size of affected households and properties will be identified in terms of human resettlement, and appropriate compensation measures, such a procedures of land acquisition and the provision of compensation to those affected, will be recommended. Regarding pollution, the conditions of air and noise pollution, will be examined at selected locations and, based on the collected background conditions, probable changes in the quality of air and noise will be predicted.

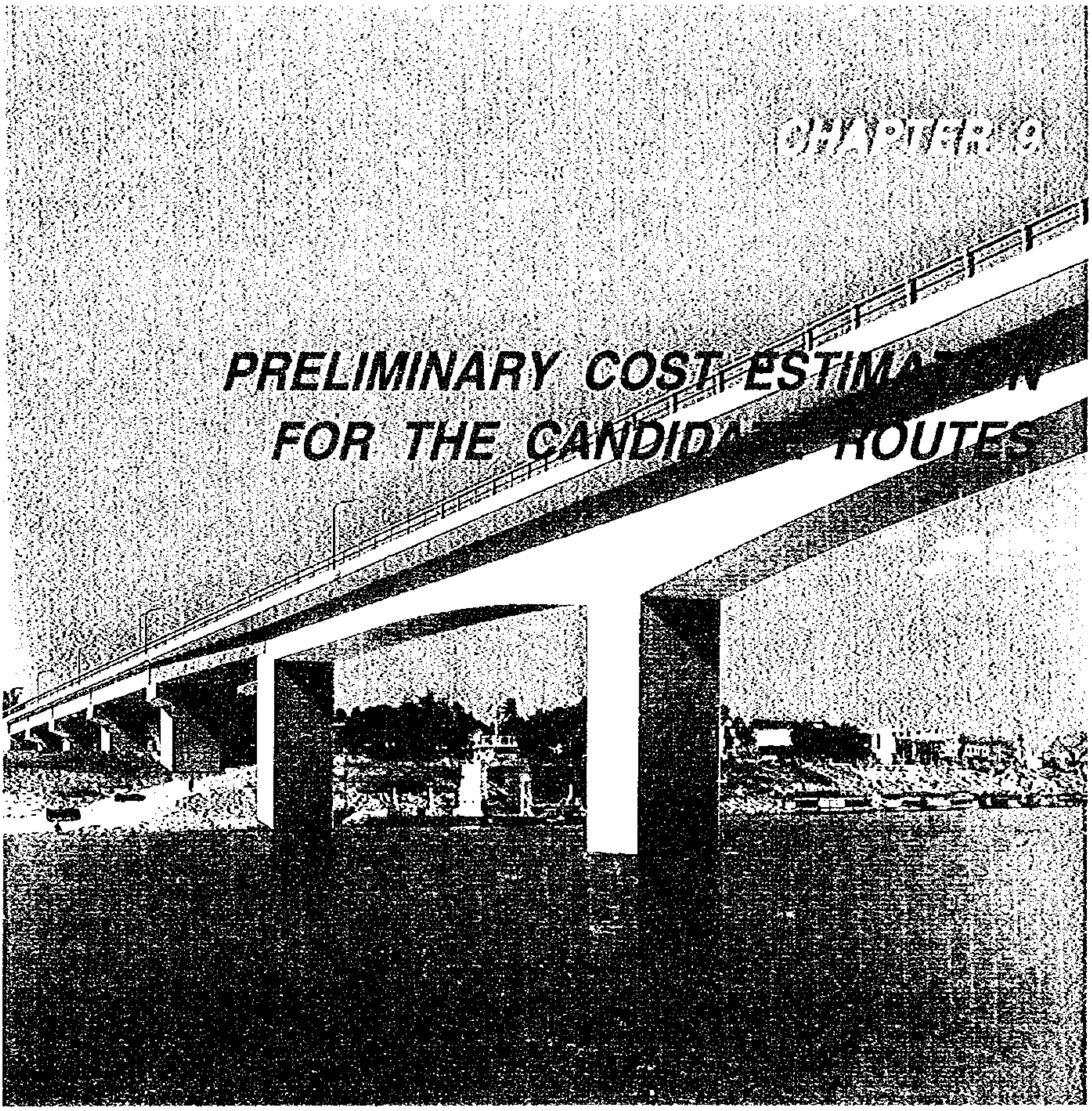
Water quality and aquatic ecology will be studied for the selected optimum route. Methods of study are primarily water quality analysis and living conditions of fish resources. Water sampling method will be applied to water quality analysis, while interviews with local inhabitants will be used to understand the living conditions of fish resources.

Although the impact on soil erosion is considered very minor, soil conditions will be studied regarding soil erosion on river bank and appropriate counter-measures to prevent erosion will be proposed. Soil condition analysis to be conducted by the Study Team will be utilized for the prediction of the overall impacts on river bank erosion and proposal of counter-measures.

Concerning the impacts of the introduction of the bridge on the transportation systems, existing transportation networks and traffic volumes will be identified, and probable traffic volume changes on existing roads and the impacts of these traffic volume changes on transportation systems, with emphasis on future traffic congestion, will be assessed.

The number and location of various types of cultural properties, such as temples, historic structures and archaeological properties, will be identified. If archaeological properties are found near the construction site, their values will be evaluated.

Environmental aesthetics concerns probable landscape changes caused by the emergence of new bridge will be assessed by using the visual presentation method. A series of interviews with local inhabitants at selected bridge construction site will also be undertaken during the EIA stage.


CHAPTER 9
PRELIMINARY COST ESTIMATION
FOR THE CANDIDATE ROUTES