MINISTRY OF PUBLIC WORKS AND TRANSPORT(MPWT)
THE ROYAL GOVERNMENT OF THE KINGDOM OF CAMBODIA

PREPARATORY SURVEY ON NATIONAL ROAD NO. 5 IMPROVEMENT PROJECT (THLEA MA'AM–BATTAMBANG SECTION AND SRI SOPHORN–POIPET SECTION) IN THE KINGDOM OF CAMBODIA

FINAL REPORT
EXECUTIVE SUMMARY

OCTOBER 2014

JAPAN INTERNATIONAL COOPERATION AGENCY

KATAHIRA & ENGINEERS INTERNATIONAL

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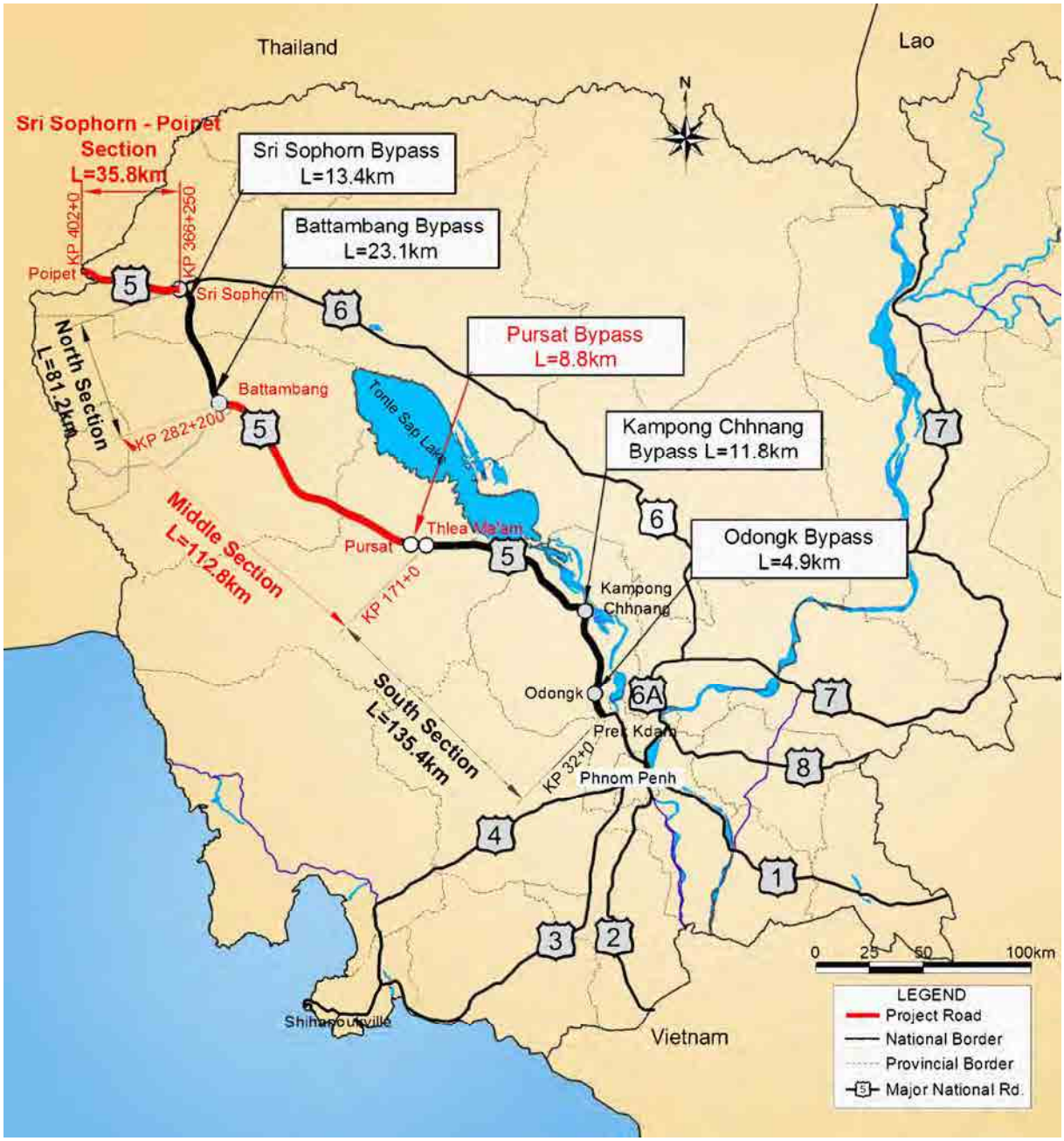
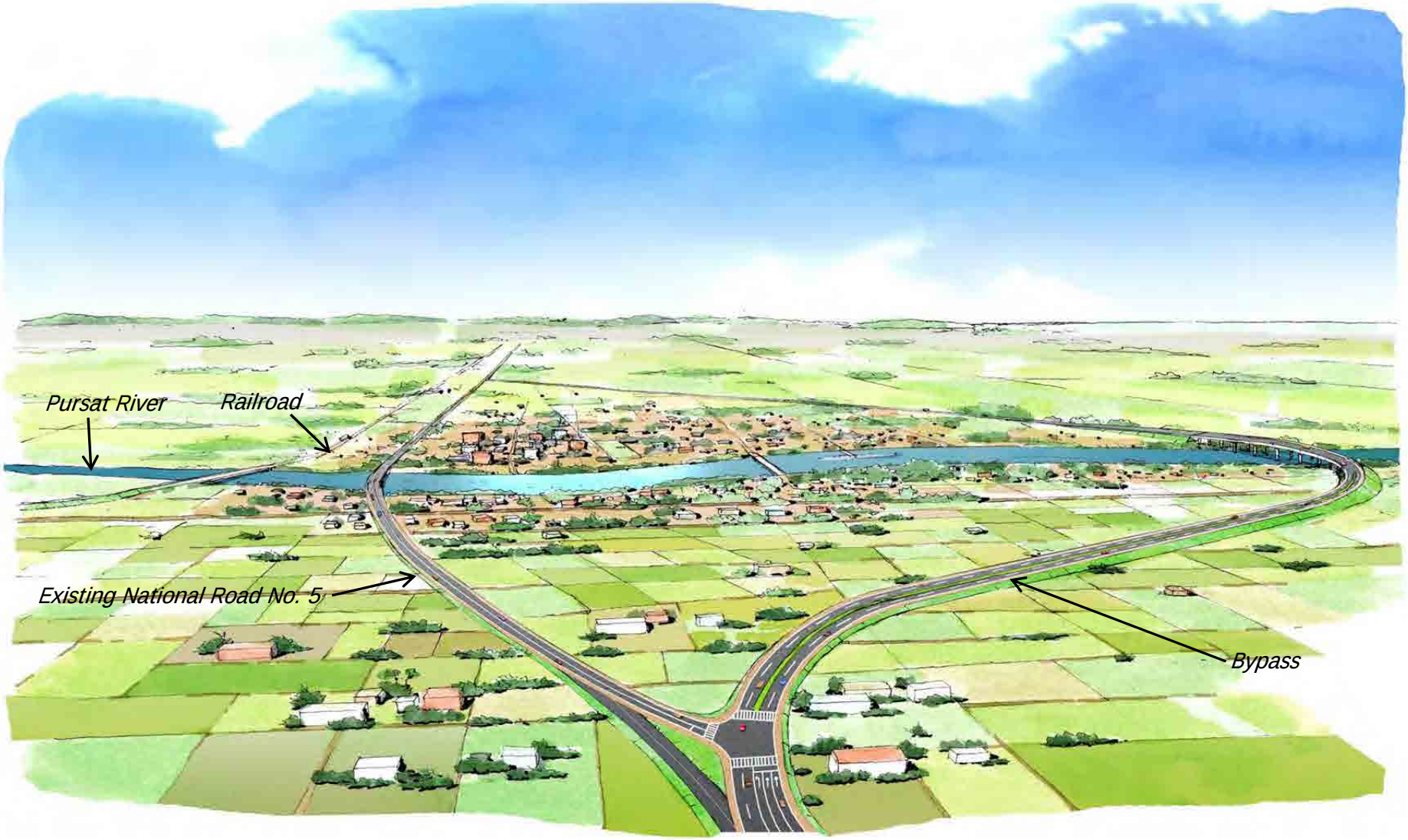
LOCATION MAP OF SURVEY AREA





Perspective Drawing of Pursat Bypass

Perspective Drawing of National Road No. 5 and Access Road to New Border Gate at Poipet

(Subject to Change Depending on the Final Plan of New Border Gate, Access Road and Railroad)

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LIST OF ABBREVIATIONS (1/2)

AASHTO	: American Association of State Highway and Transportation Officials
AC	: Asphalt Concrete
ADB	: Asia Development Bank
AH	: Affected Household / Asian Highway
AIDS	: Acquired Immune Deficiency Syndrome
ASEAN	: Association of South East Asian Nations
B/C	: Benefit Cost ratio
BM	: Bench Marks
Br	: Bridge
CBR	: California Bearing Ratio
CBTA	: Cross-Border Transport Agreement
CRIP	: Cambodia Road Improvement Project
DBST	: Double Bituminous Surface Treatment
DMS	: Detailed Measurement Survey
DPWT	: Department of Public Works and Transport
EIA	: Environmental Impact Assessment
EIRR	: Economic Internal Rate of Return
EMP	: Environmental Management Plan
ESAL	: Equivalent Single Axle Load
FEIA	: Full Environmental Impact Assessment
GDP	: Gross Domestic Product
GMS	: Grater Mekong Sub region
HIV	: Human Immunodeficiency Virus
HV	: Heavy Vehicle
ICD	: International Cooperation Department (of MPWT)
IEIA	: Initial Environmental Impact Assessment
IP	: Intersection Point
IRC	: Inter-Ministerial Resettlement Committee
IRC-WG	: IRC-Working Group
JICA	: Japan International Cooperation Agency
KP	: Kilometer Post
LAP	: Land Acquisition Plan
LV	: Light Vehicle
MC	: Motorcycle
MEF	: Ministry of Economic and Finance
M/P	: Master Plan
MPWT	: Ministry of Public Works and Transport

LIST OF ABBREVIATIONS (2/2)

NPV	: Net Present Value
NR	: National Road No.
NSDP	: National Strategic Development Plan
OD	: Origin Destination
ODA	: Official Development Assistance
PAPs	: Project Affected Person(s)
PC	: Pre-stressed Concrete
PCDG	: Pre-tensioned Precast Concrete Deck Girder
PCU	: Passenger Car Unit
PMU	: Project Management Unit
PQ	: Pre-Qualification
PRSC	: Provincial Resettlement Sub Committee
PSC	: Pre-tensioned Precast Plank hollow slab
RAP	: Resettlement Action Plan
RC	: Reinforced Concrete
RCDG	: Reinforced Concrete Deck Girder
RD	: Resettlement Department (of MEF)
RGC	: Royal Government of Cambodia
ROW	: Right of Way
SN	: Structure Number
STRADA	: System for Traffic Demand Analysis
TSBR	: Tonle Sap Biosphere Reserve
UNESCO	: United Nations Educational, Scientific and Cultural Organization
UXO	: Unexploded Ordnance
VAT	: Value Added Tax

1. INTORODUCTION

1.1 Background

- The road transport is the dominant transport mode in Cambodia.
- The road network had severely deteriorated during the Civil War and was rehabilitated since 1993 with assistances of the development partners including Japan (JICA), ADB and World Bank.
- National Road No.5 (NR 5) is the trunk national road connecting the capital city of Phnom Penh to major cities such as Kampong Chhnang and Battambang.
- It is also designated as Asian Highway No.1 or the Southern Economic Corridor of GMS.
- However, the road surface type is mostly DBST and the surface condition is being deteriorated due to rapidly increasing heavy vehicles, as well as inundation/flood.
- Under such situation, JICA dispatched a survey team to Cambodia in November 2010 and reached agreement to conduct the Preparatory Survey on improvement of North and South Section of NR 5.
- As the result of this survey, the North Section (Battambang–Sri Sophorn: 68km) and two bypasses (Battambang and Sri Sophorn) were selected as the high priority sections.
- Agreement for Japanese ODA loan for the project of improving/constructing the North Section and the two bypasses were signed by RGC and Japanese Government in May 2013.
- After improvement of the North Section and construction of the two bypasses had been selected as high priority project, severe flood occurred in September 2011, and many parts of the South Section were damaged. Thus RGC and JICA agreed to conduct Survey on the South Section.
- The study for improvement of the South Section was completed in December 2013 and the scope for the improvement of the South Section was agreed in May 2014.
- In view of the fact that the Middle Section is the only remaining section which will be left unimproved, JICA and Royal Government of Cambodia (RGC) agree to conduct the survey for the improvement of the Middle Section.
- In the Steering Committee for presentation of the Inception Report held on 8 May 2013, the Cambodian side requested to add Sri Sophorn–Poipet Section to the survey and JICA agreed to this request.

1.2 Objectives

- Objectives of the Rehabilitation Project are as follows:
  - To ensure safe and smooth means of transport
  - To promote socio-economic activity in the area along the Project Road.
- Objectives of this Survey are as follows:
  - To confirm the justification of the Project
  - To obtain data and information required for appraisal of a loan project.

1.3 Survey Area

- The Survey Area is the provinces of Pursat, Battambnag and Banteay Meanchey.

1.4 Scope of Work

- Collection of basic information regarding the Project
- Traffic demand forecast
- Study of, and discussion on scheme of road improvement
- Preliminary design
- Preparation of implementation plan and cost estimates of the Project
- Assistance to MPWT in preparing EIA report and RAP.

1.5 Survey Schedule

- The survey on the Middle Section was started in April 2014. The 4th Steering Committee was held on August 2014 where the Draft Final Report (DFR) was presented and discussed. The Final Report was prepared incorporating the subjects discussed between the Fact-Finding Mission of JICA and RGC.

2. PROFILE OF THE SURVEY AREA

2.1 Topography

- Figure 2-1 shows the topography of Cambodia.
- NR 5 traverses the southwestern side of the Tonle Sap Lake and the terrain along NR 5 is mostly flat.

Figure 2-1 Topography of Survey Area

- Whole country of Cambodia is often diviced into the following 5 zones.

Zone	Province / Municipality
Phnom Penh	**Phnom Penh**
Plains	Kampong Cham, Kandal, Prey Veng, Svay Rieng & Takeo
Tonle Sap	Banteay Meanchey, Battambang, Kampong Thom, Siem Reap, Kampong Chhnang & Pursat
Coast	Kampot, Sihanouk Ville, Kep & Koh Kong
Plateau/ Mountain	Kampong Speu, Kratie, Mondul Kiri, Prea Vehea, Ratanak Kiri, Stung Treng, Odtar Meanchey & Pailin

- NR 5 traverses the southwestern side of the Tonle Sap Lake and the terrain along NR 5 is mostly flat.

2.2 Climate

- Climate of Cambodia is categorized as 'Asian Monsoon', and is hot and humid in general.
- Annual rainfall of the Survey Area ranges from 1,400 to 1,900mm.

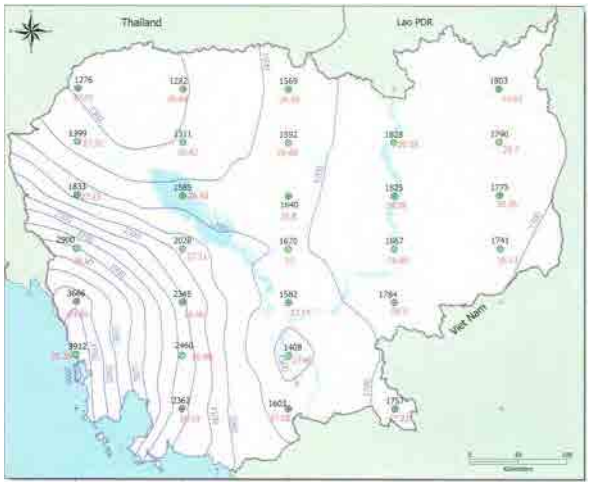


Figure 2-2 Distribution of Annual Rainfall and Temperature

- Rainy season is May–October and dry season is December–February.
- Monthly average temperature ranges 25-34 degrees Celsius.

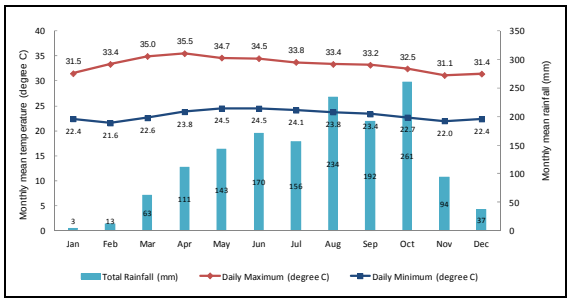


Figure 2-3 Average Monthly Rainfall and Temperature in Pursat

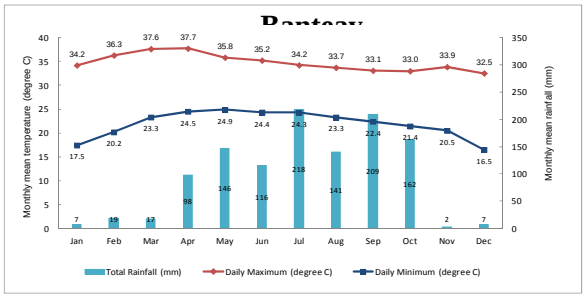


Figure 2-4 Average Monthly Rainfall and Temperature in Banteay Meanchey

2.3 Geology

- Figure 2-5 summarizes geological condition in Cambodia. The geology of the roadside area of NR 5 is mainly alluvium.

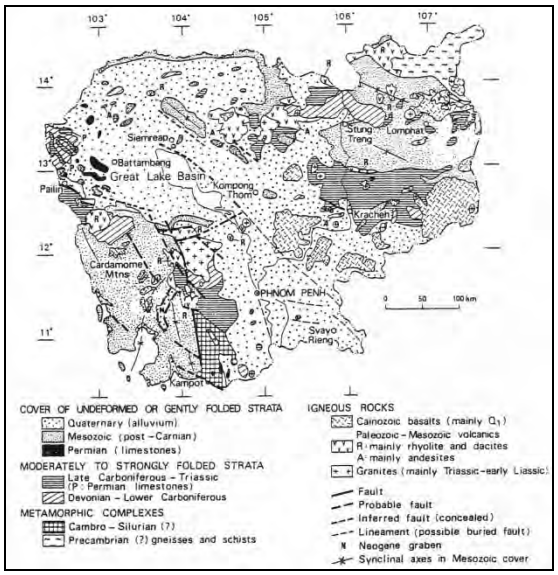


Figure 2-5 Geological Framework of Cambodia

2.4 Socio-Economic Profile

(1) Demography

- The table below summarizes the socio-economic data of the Survey Area, focusing the 3 provinces substantially influenced by the Project.
- The population densities of the provinces in the Survey area, except Pursat, are higher than the national average, implying that the Survey Area is the developed area in Cambodia.

Table 2-1 Socio-Economic Data of Survey Area (3 provinces only)

	Pursat	Battambang	Banteay Meanchey	Whole Country	Proportion to Whole Country (%)
Population (1,000)	397	1,025	678	13,389	16
Land Area (km^2)	12,692	11,702	6,679	181,035	17
Population Density	36	88	101	75	-

(2) Economy

- Figure 2-6 shows the poverty level by District.
- As can be seen in the figure, the income level of the areas along NR 5, especially up to Kampong Chhnang City is relatively high.

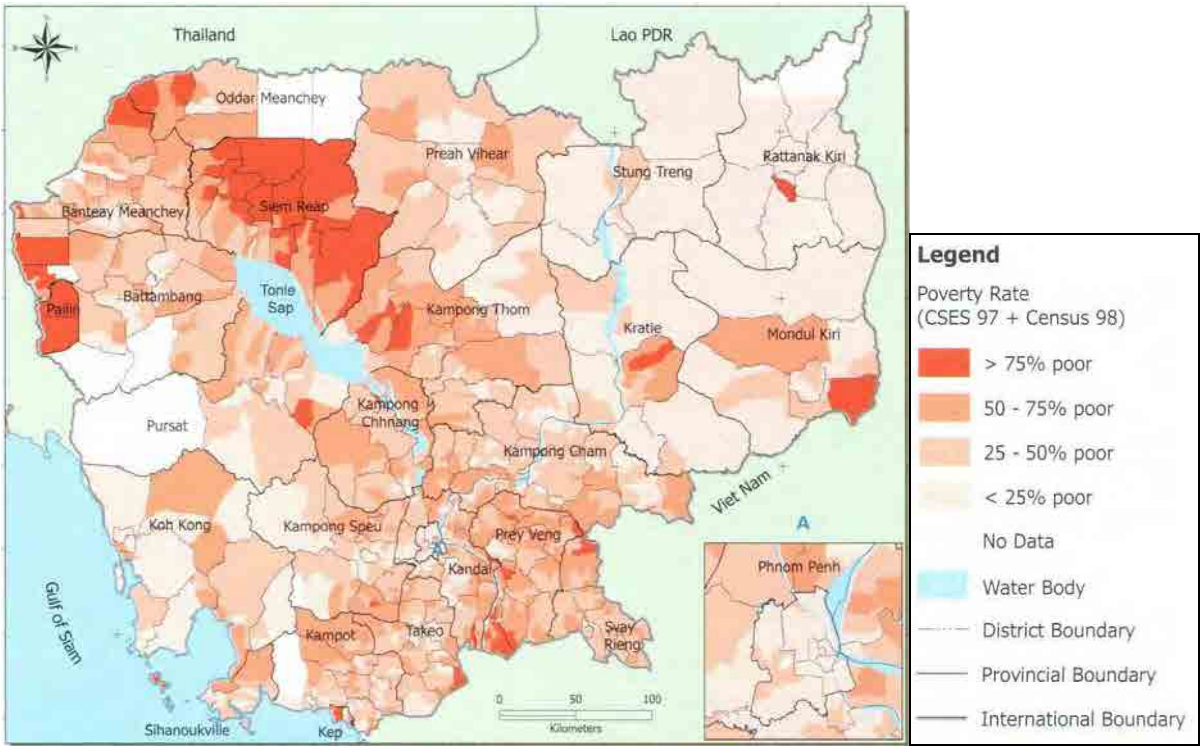


Figure 2-6 Poverty Level of Districts

3. NATIONAL ROAD NETWORK OF CAMBODIA AND ROLE OF NATIONAL ROAD NO. 5

3.1 National Road Network of Cambodia

- National Road Network of Cambodia consists of arterial national roads with single digit numbers (1 to 9) and minor arterial roads with double digit numbers.
- The Total length of National Roads is 5,604km (as of July 2014). Out of this 5,604km, 2,244km are single digit national roads and 3,360km are double digit national roads.
- Figure 3-1 shows the map of National Road Network of Cambodia. NR 5 extends to the border of Thai through Kampong Chhanang, Pursat Battambang and Sri Sophorn from Phnom Penh. Sri Sophorn, Battambang, Pursat, Kampong and Phnom Penh.

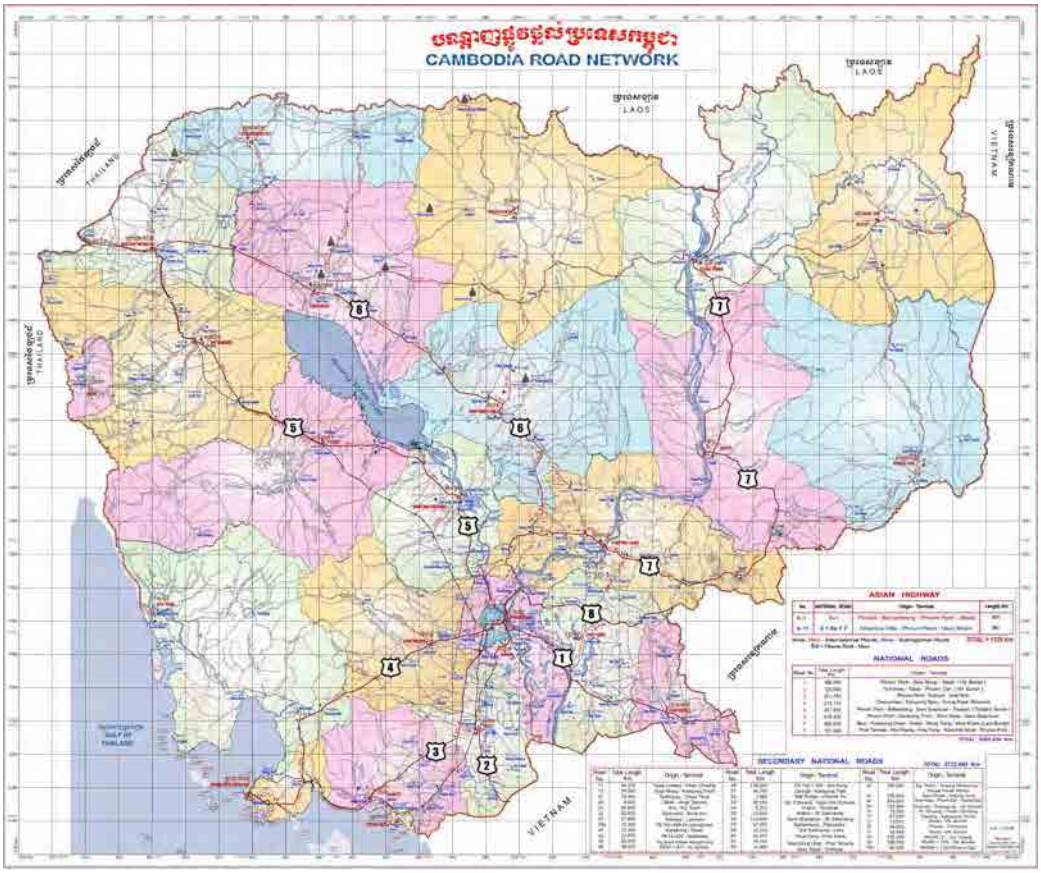


Figure 3-1 National Road Network of Cambodia

3.2 Development Plan

(1) National Strategic Development Plan

- National Strategic Development Plan (NSDP) 2006-2010 adopted 'Rectangular Strategy' as the very basic strategy/policy for national development.
- The NSDP was updated in 2008 and updated again in 2014. NSDP 2014-2018 is in the process of approval by the Cabinet.
- Widening of NR 5 is designated as one of the projects for national development in NSDP.

(2) Development Plans for Other Transport Modes

- Railroad rehabilitation project is on-going with financial assistance of ADB.
- Phnom Penh–Kampot (Approx. 150km) of the South Line (Phnom Penh–Sihanoukille: 266km) completed in 2012 and operation started.

- Rehabilitation of the remaining section of the South Line is currently being implemented.
- Rehabilitation of the North Line is on-going but has been haltered due to fund shortage.
- There are many plans for introduction of mass transit, such as bus, monorail and light rail transit. However, none of them has been materialized.

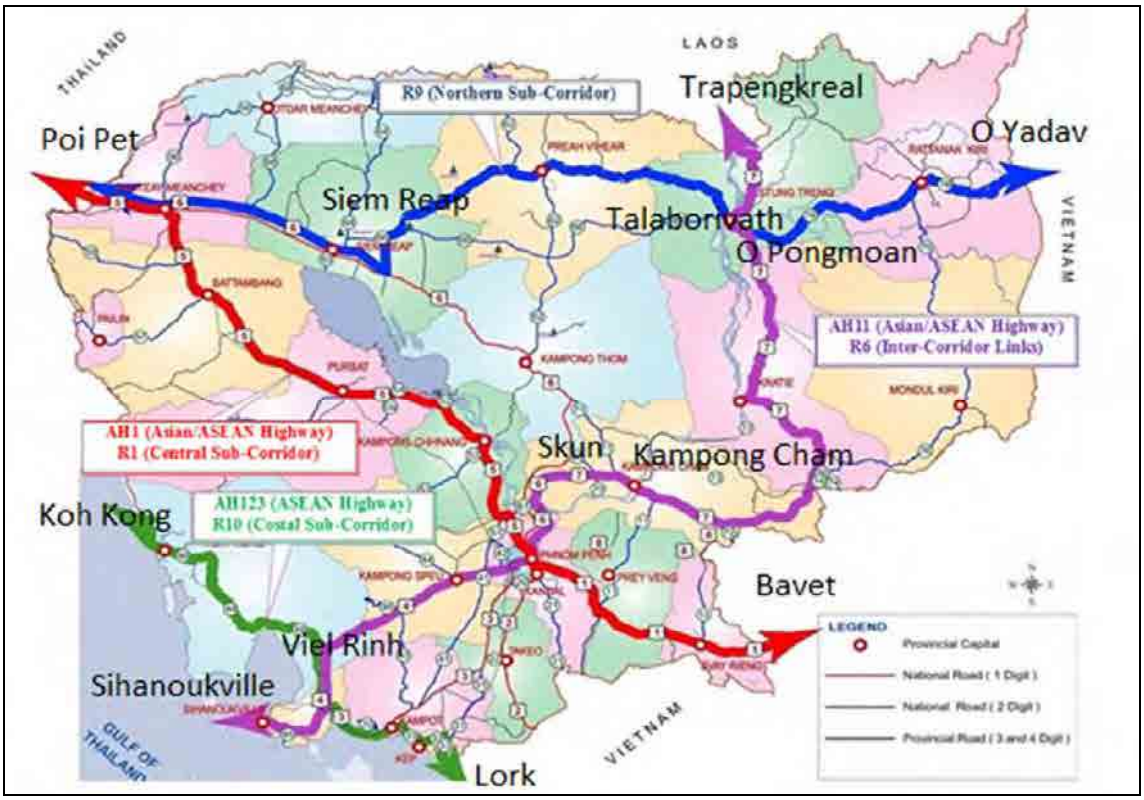
(3) Road Network Plan

- Road network development in Cambodia is planned and implemented basically based on the master plan proposed by 'the Study on the Road Network Development in the Kingdom of Cambodia' conducted in 2006 by JICA (M/P Study).
- In this M/P Study, NR 5 was proposed to be improved to support 'Multi Growth Pole Development' and 'Development of International Corridor', as well as 'Rural Economic Development and 'Poverty Reduction'.

3.3 Role of National Road No. 5

(1) NR 5 as National and International Trunk Road

- NR 5 is an arterial national road connecting Phnom Penh and Poipet, the border point with Thailand.
- NR 5 accommodates the traffic needed for the day-to-day activities of the citizens, including access to the public services such as hospital and school, along the highway.
- NR 5 is an important highway not only for domestic transport in Cambodia but also for international transport in ASEAN and the GMS.
- NR 5 has been designated as ASEAN Highway No. 1 and Asian Highway No. 1



Source: Overview on Transport Infrastructure Sectors in the Kingdom of Cambodia (4th Edition), Infrastructure and Regional Integration Technical Working Group, 2012

Figure 3-2 Economic Corridors of GMS

(2) Cross-Border Transport Agreement

- Importance of NR 5 as an international transport corridor has been recently increasing due to the development of regional cooperation in GMS, as seen in the

signing and ratification of Cross-Border Transport Agreement (CBTA) in 2008.

- Further ASEAN countries are actively negotiating to form ASEAN Economic Community, to be realized by 2015.
- If this will be realized, it is expected to accelerate the regional cooperation in ASEAN and GMS and further increase the importance of NR 5.
- RGC and Thai government have agreed to increase the quota of cross-border traffic and also shifting the border checkpoint for trucks so that cross-border cargo traffic bypasses the urbanized area of Poipet City. This will lead to increase in cross-border traffic.

(3) Benefit to Japanese Businesses

- Since the signing of the 'Agreement between Japan and the Kingdom of Cambodia for the Liberalization, Promotion and Protection of Investment' in June 2006, investment in Cambodia by Japanese businesses have been, and are, accelerating.

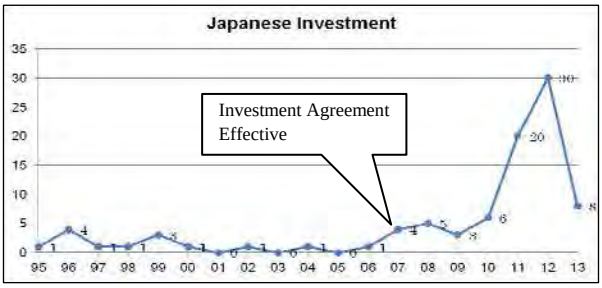


Figure 3-3 Japanese Investment in Cambodia

- Some of them, for example MINEBEA and DENSO, are operating world-wide, including in Thailand and Vietnam. It is supposed that the products of these factories are transported to Thailand via NR 5.

(4) Planned, Ongoing and Past Project for Rehabilitation/Improvement of NR 5 and Other Relevant Project

- Emergency Flood Rehabilitation Project (ADB): This project is to restore the damages caused by floods in the past. Some sections of the South Section are covered by this project.
- Widening of Phnom Penh–Prek Kdam Section by Financial Assistance of Chinese Government: This project is to widen the approximately 31km-long section from Chruoy Changvar Bridge to Prek Kdam into 4-lanes with AC pavement. The project started in October 2012 and is currently on-going.
- Road Asset Management Project (ADB): The main contents of this project are the maintenance work between Phnom Penh (KP 3.9) and Thlea Ma'am (KP 170.9). This project was implemented in years 2010, 2011 and 2012.
- Flood Disaster Rehabilitation and Mitigation Project (JICA): The project aims to rehabilitate and improve the selected roads and drainages in Kampong Chhnang City and bridges along National Road No. 11 under Japanese grant aid.
- GMS Railroad Rehabilitation Project (ADB): Most significant component of this project in relation to NR 5 is rehabilitation of the Northern Line. This component was scheduled to be completed in March 2012, but has been haltered.

3.4 Necessity of Improvement of Thlea Ma'am–Battambnag Section and Sri Sophorn–Poipet Section of NR 5

- The Project of improvement of NR 5 (Middle Section and Sri Sophorn–Poipet Section) is necessary for the following reasons:

(i) Designation in the National Development Plan and Road Network Master Plan: Widening of NR 5 has been designated as one of major projects.

(ii) Improvement of Other Sections of NR 5: The sections of NR 5 except the Middle Section and Sri Sophorn–Poipet Section are either being or planned to be improved) widened into 4 lanes). From viewpoint of consistency of design standard of highway, the remaining sections should be widened to 4 lanes.

(iii) Promotion of regional economic cooperation: ASEAN community is scheduled to be agreed in 2015. NR 5 will enhance regional cooperation. It will also benefit Japanese investment in Cambodia.

4. PRESENT CONDITION OF SOUTH SECTION

4.1 Overall Condition

(1) Meddle Section

- An inventory survey of Middle Section was conducted in the middle of May 2013, with the same method used in the Survey of the North Section.
- The road surface condition observed in May 2013 was worse than that observed in November 2011 (the time the road conditions of whole section of Prek Kdam–Sri Sophorn were initially surveyed).
- Figure 4-1 shows the examples of damages observed in May 2013.
- One of the main causes of the worsened road condition is considered to be the rain water and/or flood water which accumulated at the roadside and consequently penetrated into pavement structure of subgrade and reduced bearing capacities of these materials.

Longitudinal Crack (KP 224)

Mesh Crack (KP 236)

Pothole (KP 229)

Depression (KP 265)

Figure 4-1 Condition of South Section

(2) Sri Sophorn–Poipet Section

- Sri Sophorn–Poipet Section was improved in 2008 under "Cambodia Road Improvement Project" (CRIP), Package 5F financed by ADB.
- The condition of Sri Sophorn–Poipet Section is better than those of other sections of NR 5.
- The pavement is AC which is more durable and the condition of pavement is generally good.
- Occasional defects such as flushing and rutting are observed.
- Figure 4-1 shows the examples of the existing physical conditions of South Section.

Flush (KP 370)

Rutting (KP 386)

Figure 4-2 Condition of Sri Sophorn–Poipet Section

4.2 Geometric Structure

(1) Cross Section

(a) Middle Section

- Existing cross section of the Middle Section is undivided opposed 2-lane.
- The average width of pavement is 10.4m.
- The typical cross section of the Middle Section is shown in Figure 4-3.

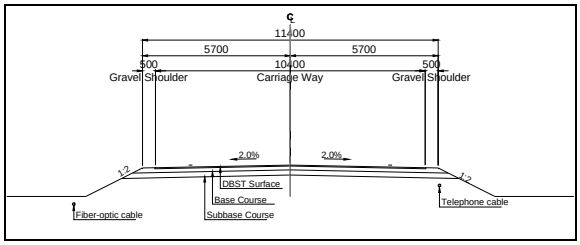


Figure 4-3 Typical Cross Section of Middle Section

(b) Sri Sophorn–Poipet Section

- The cross section of Sri Sophorn–Poipet Section is undivided 2-lane with 1.5m-wide AC-paved shoulders.
- These shoulders can be used as the travel lanes for motorcycles.
- Cross section in urbanized areas is 4-lane with 1.5m-wide shoulders.
- Figure 4-4 shows the typical cross sections of Sri Sophorn–Poipet Section in rural and urbanized areas.

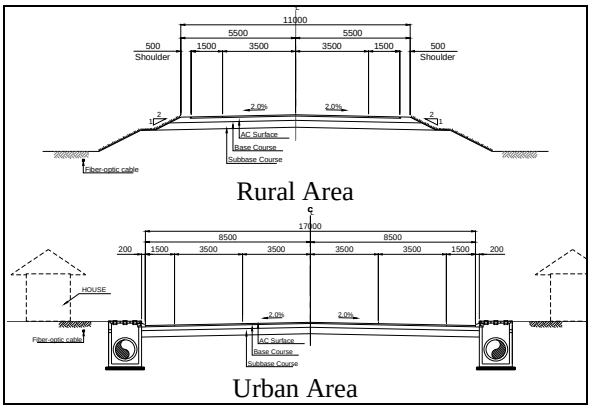


Figure 4-4 Typical Cross Section of Sri Sophorn–Poipet Section

(2) Horizontal Alignment

(a) Middle Section

- Horizontal Alignment of the Middle Section is generally generous. The radii of curve sections are usually large enough.
- There are 6 curve sections with radii smaller than 350m which is the minimum value for design speed of 100km/h.
- The curve lengths at 25 locations, including one location in urban, area are shorter than the minimum value.
- There are 10 curve sections located in the urban areas where the speed is anticipated to be regulated at 40km/h. The design speed of these curves can be lowered to 50km/h and minimum curve radius is 80m.

(b) Sri Sophorn–Poipet Section

- There is no serious problem in the horizontal alignment of Sri Sophorn–Poipet section since this section has been improved under CRIP financed by ADB.
- There are 5 sections passing urbanized areas where the maximum speed is regulated at 40km/h.

(3) Vertical Alignment

(a) Middle Section

- The Middle Section traverses flat terrain and its vertical alignment is generally flat.
- The steepest grade is observed at the approach sections of the bridges.
- Even on the approach sections of the bridges, the gradients are less than 4%, the maximum grade stipulated in the Cambodian Standard for Geometric Design.
- The gradient itself is not imposing problem. Rather, the height of road surface near the bridges needs to be examined in relation to flood/inundation.
- The common embankment height is 1 to 2m and the maximum embankment height is 4m.
- There are many sections where the embankment height is zero, meaning the elevation of the land adjacent to the road is same to that of the road surface.
- Where the elevation of the land adjacent to the road is higher than road surface, rain water flows into the road and causes inundation of road surface. Figure 4-5 shows examples of road surface lower than adjacent land and inundated road surface.

(b) Sri Sophorn–Poipet Section

- The vertical alignment of Sri Sophorn to Poipet Section is slightly climbing in the direction of from Sri Sophorn to Poipet.
- The maximum grade is 0.36% and gradients of most of the sections are less than 0.10%.
- Although the height of road surface was raised in CRIP by more than 60cm, road surface in the urbanized areas is equal to or lower than the ground surface of the adjacent land. Drainage pipes were installed in the urbanized areas.

(4) Pavement

(a) Middle Section

- Existing pavement of the Middle Section is DBST (Double-Layer Bituminous Surface Treatment).
- Maintenance works have been carried out to repair the major damages before the start of rainy seasons.
- However, various types of pavement defects are observed. Commonly found pavement defects include various types of crack, pothole, depression, flushing rutting and damage of pavement edge.

(b) Sri Sophorn–Ppoipet Section

- The pavement condition of the Sri Sophorn–Poipet Section is generally good, and cracks and potholes are occasionally observed.

Figure 4-5 Road Lower than Adjacent Land

Figure 4-6 Inlet of Drainage

4.3 Bridge Condition

- There are 38 bridges on the Middle Section. There is no bridge on the Sri Sophorn–Poipet Section
- Thirty (30) bridges out of 38 are PC hollow type; four (4) bridges are steel girder type and the other four (4) bridges are RC or PC girder type.
- All of the PC hollow type bridges are in good condition.
- The road width on the bridge is 8.5m to 10.1m and some bridges have side walk for pedestrian.
- All bridges have a simple support system. There is no expansion joint but there is an expansion gap spaces of less than 40mm between girders and between a parapet and a girder.
- Almost half of the bridges are not provided with bearing shoes.
- The bridge handrails are steel rail type or PC parapet type. Some of the bridge hand rails were damaged, but most of them, except Br. 59 have been repaired.

Figure 4-7 Damaged Handrail of Br. 59

Table 4-1 List of Existing Bridges on Middle Section

Ref.	Code	KP	Bridge Type	Ref.	Code	KP	Bridge Type
1	40	177 + 200	Steel Girder	20	59	219 + 600	Steel Girder
2	41	178 + 500	PC Hollow	21	60	220 + 800	PC Hollow
3	42	181 + 800	RC Girder	22	61	222 + 650	PC Hollow
4	43	182 + 800	PC Hollow	23	62	223 + 650	PC Hollow
5	44	183 + 300	Steel Girder	24	63	242 + 850	PC Hollow
6	45	183 + 900	PC Hollow	25	64	243 + 600	PC Hollow
7	46	184 + 100	PC Hollow	26	65	244 + 400	PC Hollow
8	47	185 + 700	PC Girder	27	66	245 + 900	RC Girder
9	48	187 + 400	PC Girder	28	67	255 + 250	PC Hollow
10	49	187 + 700	PC Hollow	29	68	255 + 600	PC Hollow
11	50	188 + 100	PC Hollow	30	69	256 + 550	PC Hollow
12	51	188 + 250	PC Hollow	31	70	257 + 900	PC Hollow
13	52	189 + 250	PC Hollow	32	71	265 + 900	PC Hollow
14	53	189 + 900	PC Hollow	33	72	270 + 900	PC Hollow
15	54	190 + 150	PC Hollow	34	73	271 + 700	PC Hollow
16	55	191 + 100	PC Hollow	35	74	272 + 650	PC Hollow
17	56	201 + 800	PC Hollow	36	75	273 + 300	PC Hollow
18	57	208 + 500	PC Hollow	37	76	275 + 650	PC Hollow
19	58	215 + 750	Steel Girder	38	77	276 + 550	PC Hollow

4.4 Roadside Land Use

(1) Middle Section

- The basic form of land use outside of urbanized area is agriculture, especially rice paddy.
- The roadside of Middle Section has been rapidly developed for factories, warehouses commercial buildings and residential buildings.
- Land fill for such development often bury the existing channel in front of them and causing the problem of road drainage.
- Figure 4-8 shows examples of roadside land use along the Middle Section.

(2) Sri Sohorn–Poipet Section

- The main form of roadside land use of Sri Sophorn–Poipet Section is also agriculture/ rice paddy.
- Most of the houses/buildings are located 20m away from the road centerline. These buildings may have been relocated when CRIP was implemented.
- The end point of Sri Sophorn–Poipet Section is the border between Cambodia and Thailand. Thus the roadside of a few kilometers from the border is densely populated.
- Approximately 5km long-section from the border is 4-lane.
- Figure 4-9 shows examples of roadside land use along Sri Sophorn–Poipet Section.

(3) Occupancy of Right of Way by Shops

- In both the Middle Section and Sri Sophorn –Poipet Section, road side areas within the right of way are often occupied by the shops or kiosks.

4.5 Utility

- Various kinds of utilities exist crossing, or in parallel to, the NR 5 in the areas adjacent to the road.
- Figures 4-10 and 4-11 summarize the location and types of utilities along the Middle Section and Sri Sophorn–Poipet Section. Figure 4-12 shows examples of such utilities.

Pursat City (KP 186)

Fill for Factory (KP 193)

Rice Paddy (KP 224)

Rice Mill Factory (KP 242)

Figure 4-8 Roadside Land Use along Middle Section

Urban Area (KP 393)

Cargo Transshipment Terminal (KP 404)

Figure 4-9 Roadside Land Use along Sri Sophorn–Poipet Section

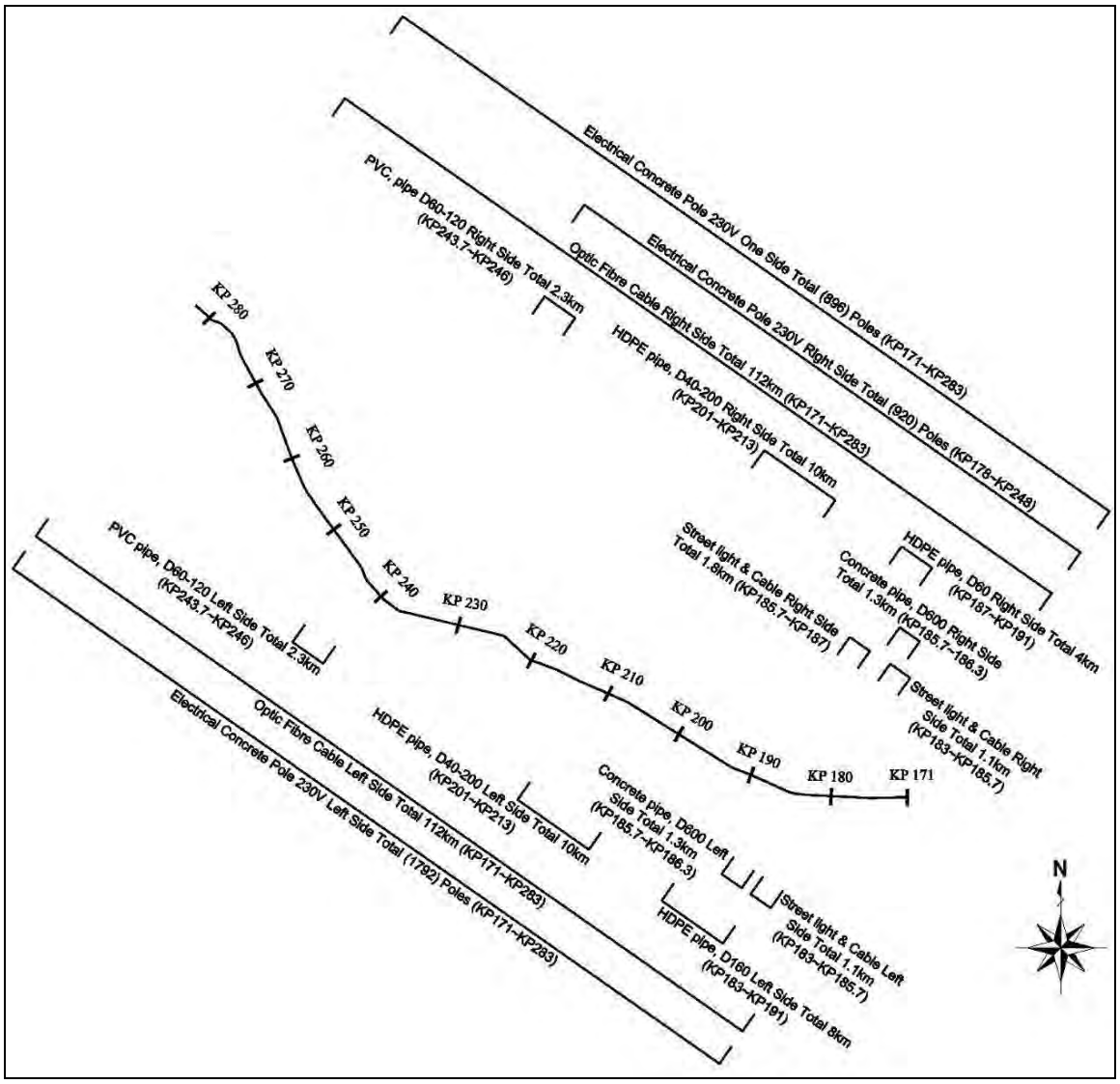


Figure 4-10 Type and Location of Utilities along Middle Section

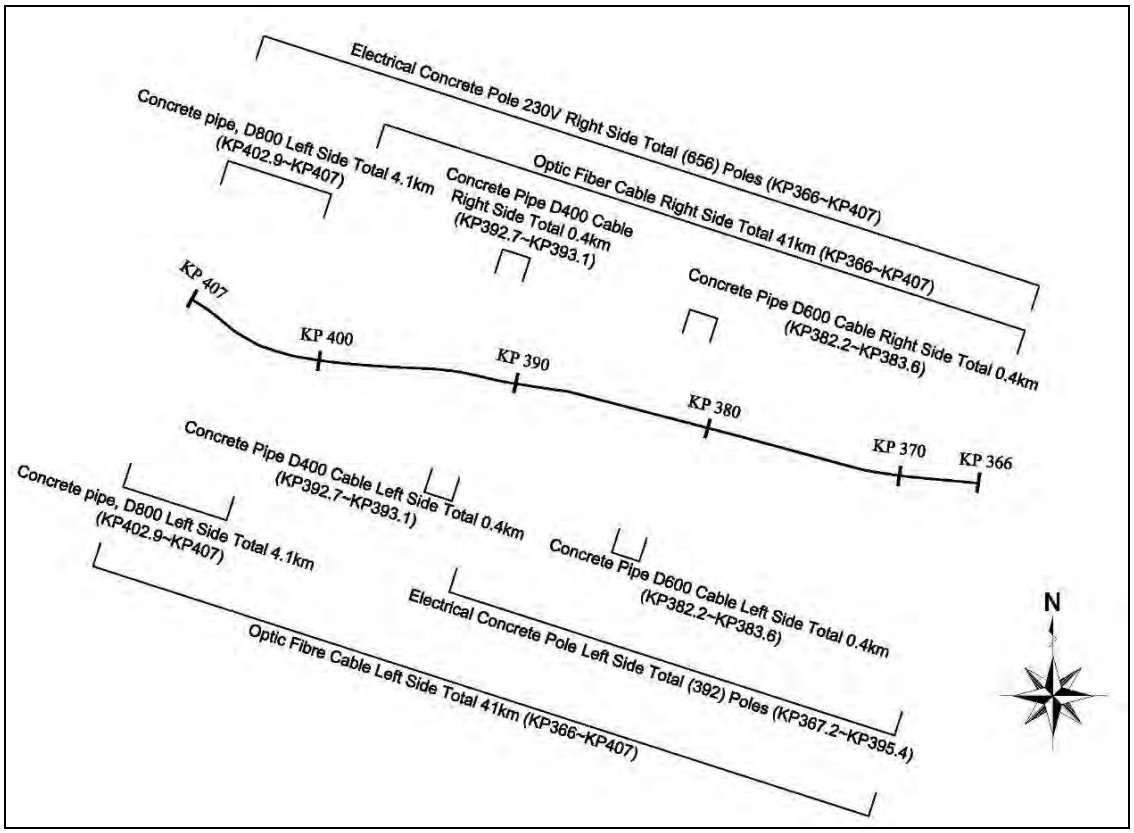


Figure 4-11 Type and Location of Utilities along Sri Sophorn–Poipet Section

Electric Pole in the Vicinity of KP 214

Water Supply Pipe at Br. 48 (KP 187 + 500)

Telecommunication Cable at KP 365 + 800

Street Lightin the Vicinity of KP 186

Figure 4-12 Examples of Utilities

5. FUTURE TRAFFIC DEMAND FORECAST

5.1 Methodology

- Figure 5-1 shows the flow chart of the methodology for the forecast of future traffic demand.
- In this survey, traffic volume is estimated based on the traffic demand forecast model used in the Survey of the South Section and revised socio-economic data.
- Future OD table was adjusted taking into consideration the rapid economic growth in the recent years.

5.2 Traffic Survey Data

- Traffic data (counted traffic volume and OD data) surveyed in the Survey for the South Section are used in this traffic forecast.
- Traffic count survey was counted for 24 hours (from 6:00 a.m. to 6:00 a.m. next day) at five (5) stations and for 16 hours (from 5:00 a.m. to 9:00 p.m.) at three (3) stations.
- Traffic count survey was conducted on weekday except Saturday, Sunday and holiday.
- The survey locations were selected at the provincial boundary, city boundary and city center and they are shown in Figure 5-2.
- All the survey locations except Station No. 3a and NR 6-1 were planned so that they coincide with the survey locations used in the Survey on the North Section and "the Study on the Road Network Development" implemented by JICA in year 2006.

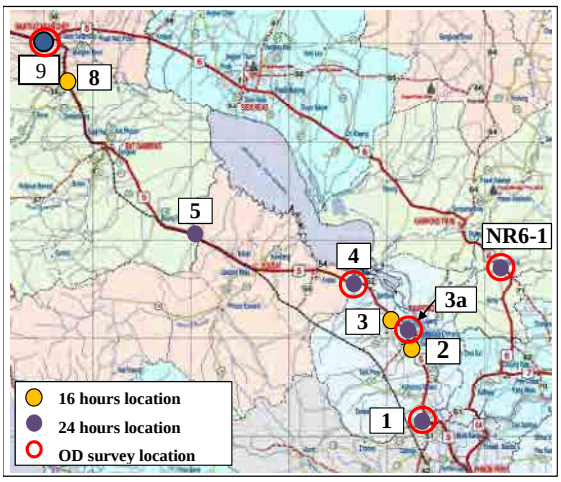


Figure 5-2 Location of Traffic Count Survey

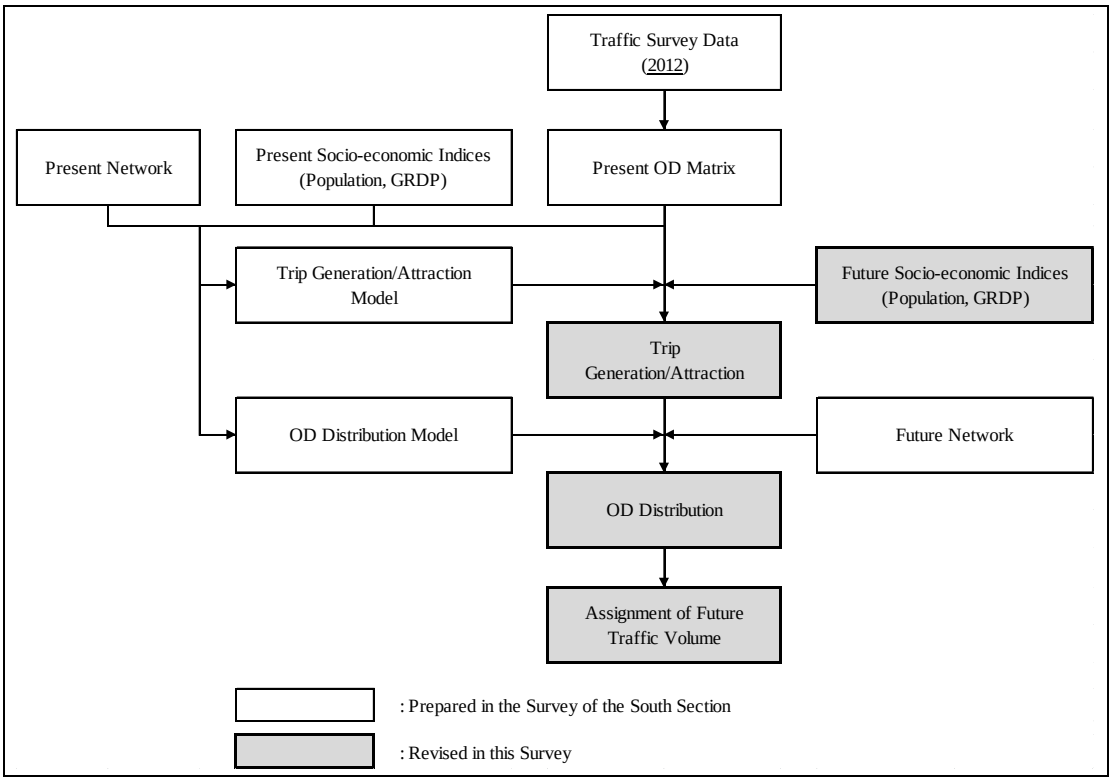


Figure 5-1 Flowchart of Traffic Demand Forecast

- Table 5-1 shows 24-hr traffic volume by vehicle group and classification.
- The 24-hr traffic volumes at the survey station where traffic volumes were counted for 16 hours were calculated using the conversion factor of 24-hr/16-hr ratio.
- The conversion factor obtained from the data observed at the counting station located in the urbanized area (Sta. No.1) was applied to Sta. No. 2 and 3 and that obtained from the data observed at the counting located in the rural areas (Sta. No.4 and 5) are applied to Sta. No. 8.
- OD survey was conducted by interview to the drivers'.
- Sampling rates were more than 15% at all stations except Station No. 3a.
- Station No. 3a was located in the city center of Kampong Chhnang where traffic is busy. The number of sampling exceeded 1,000, and the Survey Team considers this sampling number as acceptable level.

5.3 Future Growth of GDP

- Table 5-2 shows the GDP growth rates predicted by The United States Department of Agriculture (USDA), International Futures at the University of Denver, the International Monetary Fund (IMF) and the Ministry of Economic and Finance (MEF) of RGC.
- Table 5-3 shows the GDP growth rates for the high, medium and low growth scenarios which are assumed considering the growth rates shown in Table 5-2. The "medium growth scenario" was adopted.

Table 5-1 24-Hour Traffic Volume Counted in the Survey for the South Section

Sta.	Motorcycle (MC)			Light Vehicle (LV)				Heavy Vehicle (HV)				Grand Total
	Motor-cycle & Tricycle	Motor-cycle Trailer	Total	Sedan, Wagon &Light Van	Pick-up, Jeep & Light Truck	Mini Bus	Total	Short & Long Body Bus	Short & Long Body Truck	Semi & Full Trailer Truck	Total	
1	5,174	499	5,673	2,037	1,171	669	3,877	229	866	173	1,268	10,818
2	6,041	289	6,330	1,733	900	402	3,034	226	829	82	1,137	10,501
3a	15,495	452	15,947	2,171	966	432	3,569	227	832	145	1,204	20,720
3	3,353	190	3,543	1,102	931	388	2,421	212	500	124	836	6,800
4	943	49	992	876	565	244	1,685	209	609	146	964	3,641
5	1,769	44	1,813	884	552	217	1,653	228	793	167	1,188	4,654
8	3,972	104	4,076	1,589	572	180	2,341	195	290	289	774	7,191
NR6-1	3,619	225	3,844	1,130	714	689	2,533	211	577	144	932	7,309

Table 5-2 GDP Growth Rate Predicted by Various Institutions

Year	2012	2013	2014	2015	2016	2017	2018	2023	2028	2030
USDA	6.8	8.2	8.4	8.3	8.2	8.1	8.0	7.7	7.2	6.8
International Futures	6.2	6.4	6.5	6.7	6.7	7.0	7.3	7.9	8.2	8.0
IMF	6.5	6.7	7.2	7.4	7.4	7.5	7.5			
MEF	7.3	7.6	7.0							

Table 5-3 Scenarios of GDP Growth Rate

Scenario	2012-2018	2018-2023	2023-2028	2028-2033
High Growth	8.5	7.8	7.1	6.3
Medium Growth	7.4	6.8	6.2	5.4
Low Growth	6.5	6.0	5.4	4.8

5.4 OD Zone

- The OD zoning system used in the JICA M/P Study of 2006 and the survey for South Section has been revised and used in this Survey.
- The revision of the OD zoning system is mainly to take into account the change of Districts promulgated after 2006.
- The total number of zones is 206 (194 zones within Cambodia and 12 zones outside of Cambodia).

5.5 Traffic Demand Forecasted

- Traffic demand for the each link of the road network was forecasted using the JICA-STRADA program.
- Traffic demand was forecasted for years 2018, 2023 and 2033. These years correspond to 5, 10 and 20 years from the present.
- Figure 5-3 shows an example of the result of traffic assignment using JICA-STRADA.
- Table 5-4 shows the forecasted traffic demand at the traffic counting stations.

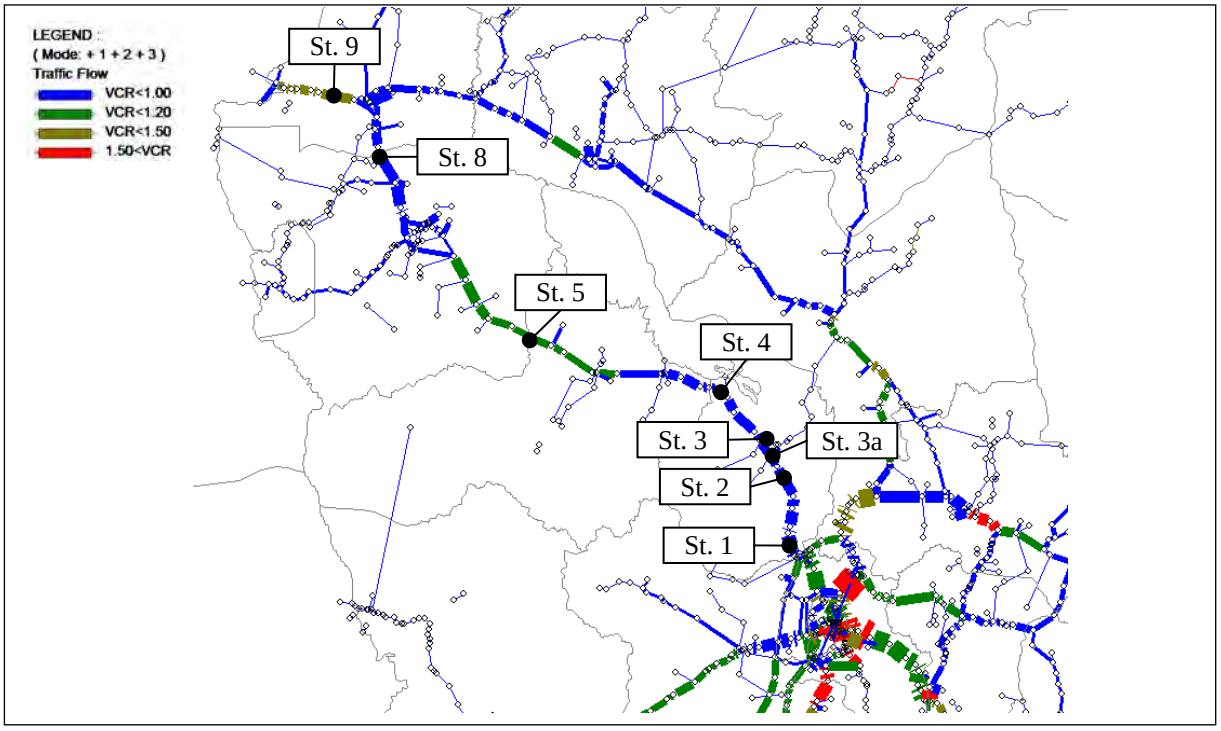


Figure 5-3 Result of Traffic Assignment (Year 2033)

Table 5-4 Forecasted Traffic Demand

(pcu/day)

Section	Station No.	Year					
		2012		2018	2023	2028	2033
		Observed	Assignment Result				
South Section	1	10,352	10,308	17,679	24,176	32,734	42,438
	2	9,103	8,684	15,523	21,365	29,289	38,218
	3a	12,857	-	21,769	22,998	31,245	40,434
	3	6,596	6,474	12,324	17,156	24,332	31,974
Middle Section	4	5,296	5,162	10,650	15,014	21,673	28,714
	5	6,174	6,117	10,138	14,229	20,777	27,484
North Section	8	6,470	6,350	11,822	15,650	22,736	30,410
Sri Sophorn–Poipet	9	-	7,454	11,746	15,566	20,238	25,514
Pursat Bypass	-	-	-	-	11,911	17,639	19,203

6. NATURAL CONDITIONS OF THE SURVEY AREA AND SURVEY ROAD

6.1 Hydrological Conditions

- In the wet season (May to October) inundation occurs frequently on the NR 5, disrupting traffic and economic and social activities.
- The inundation also reduces the bearing capacity of the pavement structure and leads to premature deterioration of the pavement.
- Thus, the countermeasure for inundation or flood is very important in the planning of improvement of NR 5.
- Inundation on the Middle Section of NR 5 is caused by two possible reasons. One is the influence of flooding in the Tonle Sap Lake system, and the other is the discharge of rainwater from mountains and paddy fields located to the west of NR 5.
- The Sri Sophorn–Poipet Section is located far from the Tonle Sap Lake, and the flooding in Tole Sap is unlikely to be the cause of inundation on Sri Sophorn–Poipet Section.
- Possible causes of inundation on Sri Sophorn–Poipet Section are believed to be the discharge of rain water from mountains because of heavy rain, and flood water from Thailand.

6.2 River System in the Survey Area

- The NR 5 runs on the southwest side of Tonle Sap River and Tonle Sap Lake.
- During the dry season, the Tonle Sap River flows downstream as a normal tributary draining into the Mekong.
- During the wet season the level of the Mekong rises higher than that of the Tonle Sap River.
- Figure 6-1 illustrates the major river network in Cambodia. It shows there are two major river systems (Pursat and Doun Tri) in the Survey Area.
- Table 6-1 lists the river systems along the Middle Section.
- The main rivers across the Middle Section are Pursat River and Doun Tri River.s

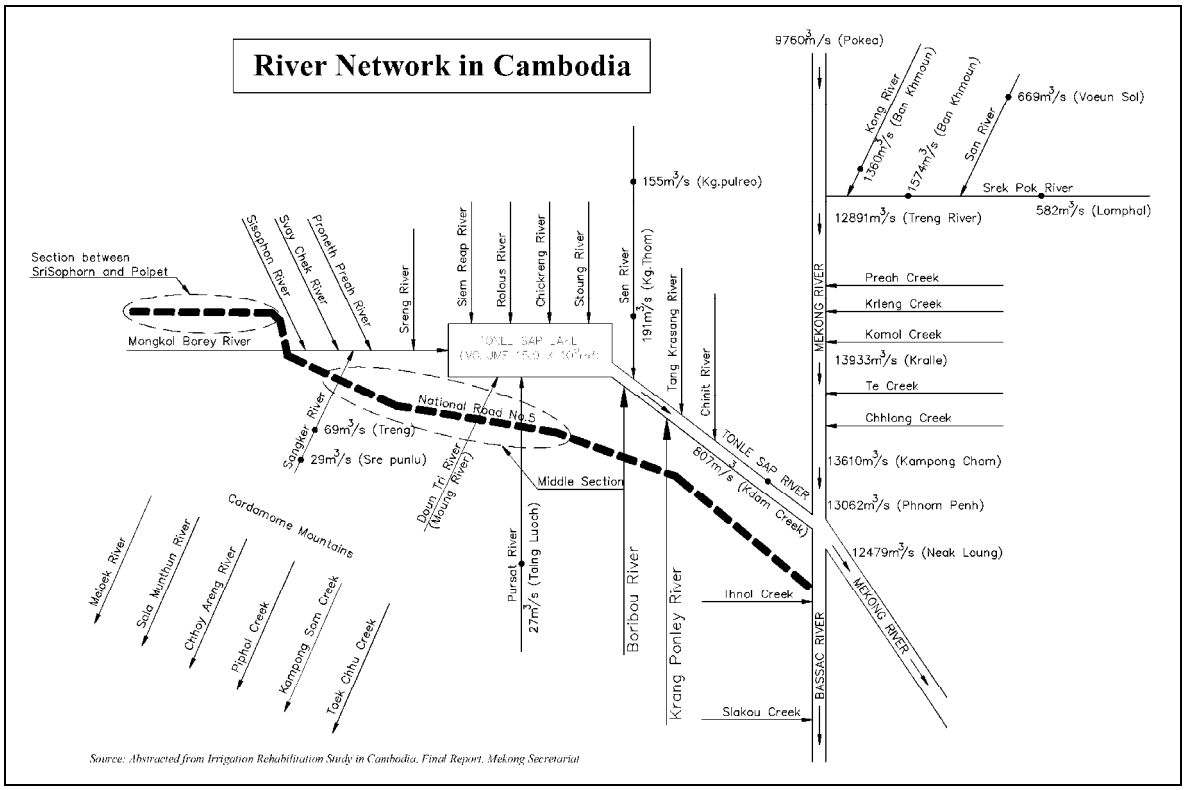


Figure 6-1 River Network in Cambodia

Table 6-1 River System Along the Middle Section

No.	KP (Km)	River System														
1	177+200 ~ 178+400	montane	⇒	Srang Creek	⇒	Daek Creek	⇒	Srang Thum Creek	⇒	*Br40*	⇒	Pousat River	⇒		⇒	Tonle Sap Lake
							⇒	Srang Creek	⇒	*Br41*	⇒	Srang Touch Creek	⇒	Pousat River	⇒	Tonle Sap Lake
2	181+800	montane	⇒	Creek	⇒				⇒	*Br42*	⇒	irrigation canal	⇒	paddy field		
													⇒	flood plain		
3	185+700 ~ 191+100	montane	⇒	Pousat River	⇒				⇒	*Br47*	⇒	Pousat River	⇒	flood plain	⇒	Tonle Sap Lake
					⇒	irrigation canal	⇒		⇒	*Br48~ Br51*	⇒	irrigation canal	⇒	paddy field	⇒	Tonle Sap Lake
													⇒	Pousat River		
					⇒	Svay At Creek	⇒		⇒	*Br55*	⇒	Toch River	⇒	paddy field	⇒	Tonle Sap Lake
							⇒	Sdau Creek	⇒	*Br52*			⇒	flood plain		
4	201+900	paddy field	⇒	Bakan Creek	⇒	Creek			⇒	*Br56*	⇒	Bat Kardaol Pond	⇒	Kandieng Brook	⇒	Tonle Sap Lake
5	208+500	reservoir	⇒	Chambot River	⇒	Kambot River			⇒	*Br57*	⇒	Kambot River	⇒	paddy field	⇒	Tonle Sap Lake
													⇒	flood plain		
6	215+700	paddy field	⇒	Ta Paong Creek	⇒				⇒	*Br58*	⇒	Srah Mokak Creek	⇒	paddy field	⇒	Tonle Sap Lake
7	218+800 ~ 219+700	montane	⇒	Svay Doun Kaev River	⇒				⇒	*Bc62, Bc63*	⇒	Svay Doun Kaev River	⇒	Kbal Toul River	⇒	Tonle Sap Lake
									⇒	*Br59*			⇒	Khnay Tol Creek		
8	221+400	paddy field	⇒	Boeng Prey Creek	⇒	S'at Creek										
			⇒	irrigation canal					⇒	*Bc64*	⇒	irrigation canal			⇒	Tonle Sap Lake
9	240+000 ~ 244+400	montane	⇒	Moung River	⇒				⇒	*Br65*	⇒	Donn Tri River	⇒	flood plain	⇒	Tonle Sap Lake
					⇒	Creek			⇒	*Bc70*	⇒	Creek	⇒	paddy field		
10	251+000 ~ 253+600	paddy field	⇒	Ta Muk River	⇒	Char River	⇒	paddy field								
					⇒	+ Krabuav Creek	⇒		⇒	*Bc74, Pc201*	⇒	Ta Muk River	⇒	paddy field		
11	255+600	paddy field	⇒	Svay Creek	⇒	Chak River	⇒		⇒	*Br68*	⇒	Chak River	⇒	paddy field		
12	265+900 ~ 267+000	paddy field	⇒	irrigation canal					⇒	*Br71, Bc82*	⇒	irrigation canal	⇒	paddy field		
13	273+400	paddy field	⇒	Krieng Creek	⇒	Sanda Creek			⇒	*Br75*	⇒	Sanda Creek	⇒	paddy field		
14	278+000 ~ 285+100	paddy field	⇒	Sralau Creek	⇒				⇒	Bc89	⇒	Chas Sa River	⇒	flood plain	⇒	Tonle Sap Lake
									⇒	Bc90	⇒	Moni Ceek	⇒	paddy field		
					⇒	Rumchek Creek	⇒		⇒	Pc208	⇒	Rumchek Creek	⇒	paddy field		
					⇒	Creek	⇒		⇒	Bc87, Bc88	⇒	Creek	⇒	paddy field		

Source: Topograpic Maps (Scale: 1/100,000)
Note: Br, Bc and Pc mean bridge, box culvert and pipe culvert respectively. Number means their grouping number.

6.3 Existing Drainage Facilities

- There are 38 bridges, 35 box culverts and 62 pipe culverts in the Middle Section.
- There are 68 pipe culverts in the Sri Sophorn–Poipet Section.
- Table 6-2 shows the capacity for water flow across NR 5. The capacities of some groups of the drainage facilities are considered to be insufficient compared to the volume of water flowing across NR 5 in the rainy season.

Table 6-2 Capacity of Existing Drainage Facilities

grouping No.	Existing facilities			Drainage capacity of existing facilities (m^3/s)	drainage area (km^2)	coefficient of runoff	inflow reach		T (min)	estimated flow discharge(m^3/s) rainfall intensity				
	Bridge	Box_C	Pipe_C				waterway length(km)	Gradient (‰)		20 mm/hr	40 mm/hr	60* mm/hr	80 mm/hr	100 mm/hr
1	Br40 - Br41	Bc54 - Bc56	Pc148 - Pc159	552.64	85.7	0.10	20.2	0.7	612	28	56	84	112	140
2	Br42 - Br43	Bc57 - Bc58	Pc160 - Pc161	275.73	41.9	0.10	11.2	2.2	255	23	47	70	93	117
3	Br44 - Br46	-	-	998.16	33.6	0.10	10.0	3.3	202	19	37	56	75	93
4	Br47 - Br55	-	-	2346.08	251.5	0.10	34.3	0.2	1433	35	70	105	140	175
5	Br56	Bc59 - Bc60	Pc162 - Pc169	63.57	116.2	0.10	31.2	0.6	904	26	51	77	103	129
6	Br57	-	Pc170 - Pc180	184.49	182.8	0.10	29.2	0.6	891	41	82	123	164	205
7	Br58	Bc61	Pc181 - Pc186	75.43	121.4	0.10	31.2	1.0	773	31	63	94	126	157
8	Br59	Bc62 - Bc63	Pc187 - Pc189	0.00	225.7	0.10	30.1	0.9	786	57	115	172	230	287
9	Br60 - Br62	Bc64 - Bc65	Pc190 - Pc192	0.00	187.2	0.10	23.1	1.1	580	65	129	194	258	323
10	-	Bc66 - Bc67	Pc193 - Pc197	36.77	115.9	0.10	17.4	0.9	516	45	90	135	180	225
11	-	Bc68 - Bc69	Pc198	22.25	119.9	0.10	24.7	1.4	557	43	86	129	172	215
12	Br63 - Br66	Bc70 - Bc75	Pc199 - Pc201	620.34	244.8	0.10	34.2	1.1	781	63	125	188	251	314
13	Br67 - Br70	Bc76 - Bc78	Pc202	326.31	259.0	0.10	25.6	1.1	642	81	161	242	323	404
14	Br71	Bc79 - Bc82	Pc203	116.25	143.5	0.10	20.3	0.5	693	41	83	124	166	207
15	Br72	Bc83 - Bc84	Pc204 - Pc205	0.00	81.2	0.10	23.7	0.4	897	18	36	54	72	90
16	Br73 - Br77	Bc85 - Bc90	Pc206 - Pc213	188.30	141.7	0.10	22.8	0.4	859	33	66	99	132	165

Note: T means time of flood concentration by Kirpich
** Flood discharges estimated by 60mm of rainfall intensity adopted for the North and South Section will be thus aplied to the Project.*

6.4 Information on Road Inundation/Flood and Flood Water Level of Tonle Sap Lake

- Based on the result of analysis of the recorded data, the flood water level of 10-year return period of Tonle Sap Lake is assumed to be 11.13m above sea level.
- Interview to the officials of DPWTs of relevant provincial governments and the local residents conducted to obtain the information of the inundation on NR 5.
- Figure 6-2 shows an example of flood water level obtained through the interview survey.

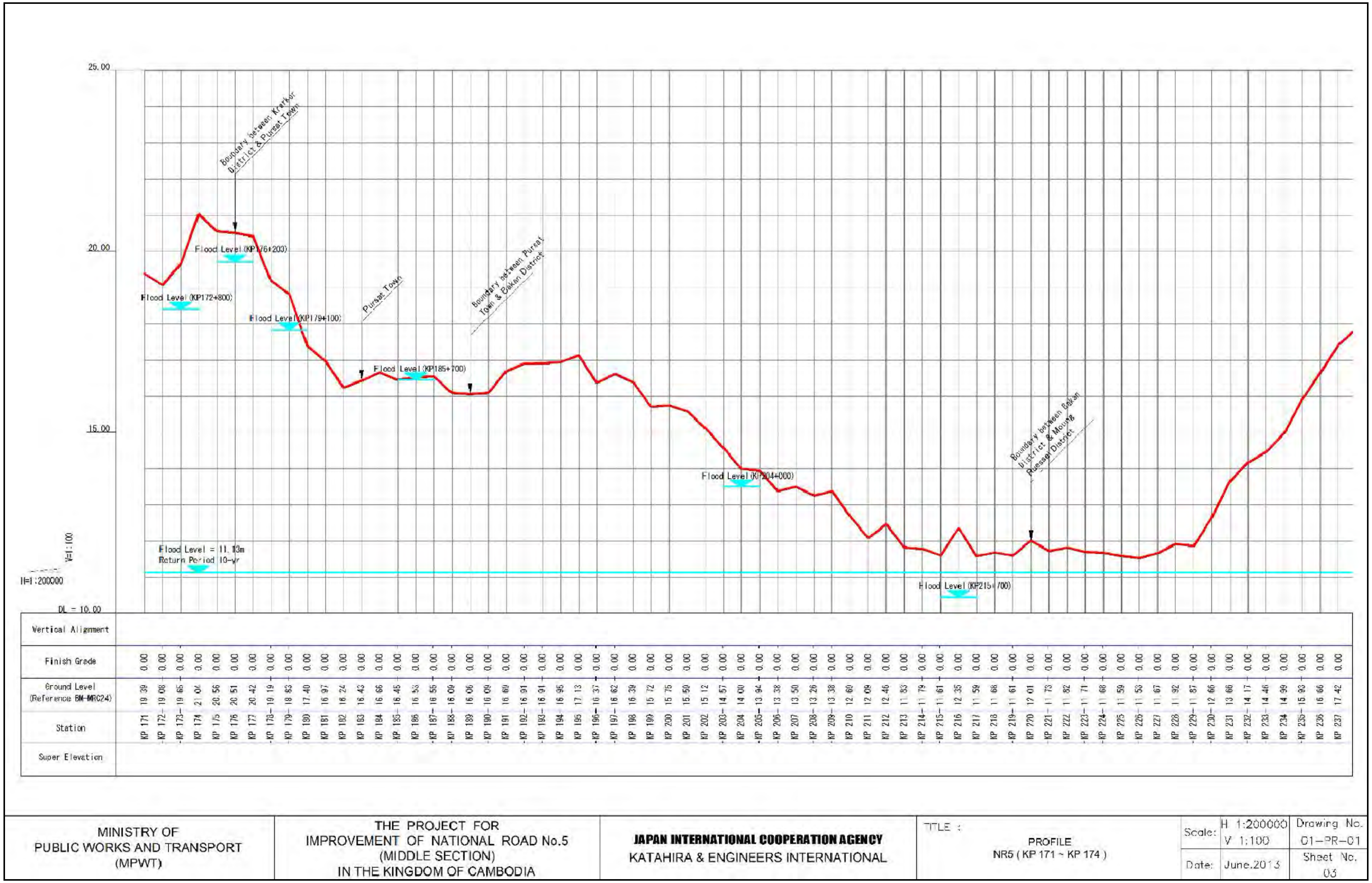


Figure 6-2 Example of Record of Flood Water Level Obtained Through Interview

- As seen in the above figure, the interview survey showed that inundation has occurred at the locations where the elevation of the road surface was much higher than the flood water level of Tonle Sap Lake, implying that the cause of the inundation was not the flood in the Tonle Sap Lake.

6.5 Flood of October 2013

- The section of in the south of Battambang City (KP 250-282) experienced severe inundation in October 2013 as shown in Figure 6-3.
- This inundation occurred at the locations where the elevation of the road surface is considerably higher than the flood water level of the Tonle Sap Lake.
- Thus, this inundation is suspected to have been caused by the rain water flowing from upstream areas towards the Tonel Sap Lake.

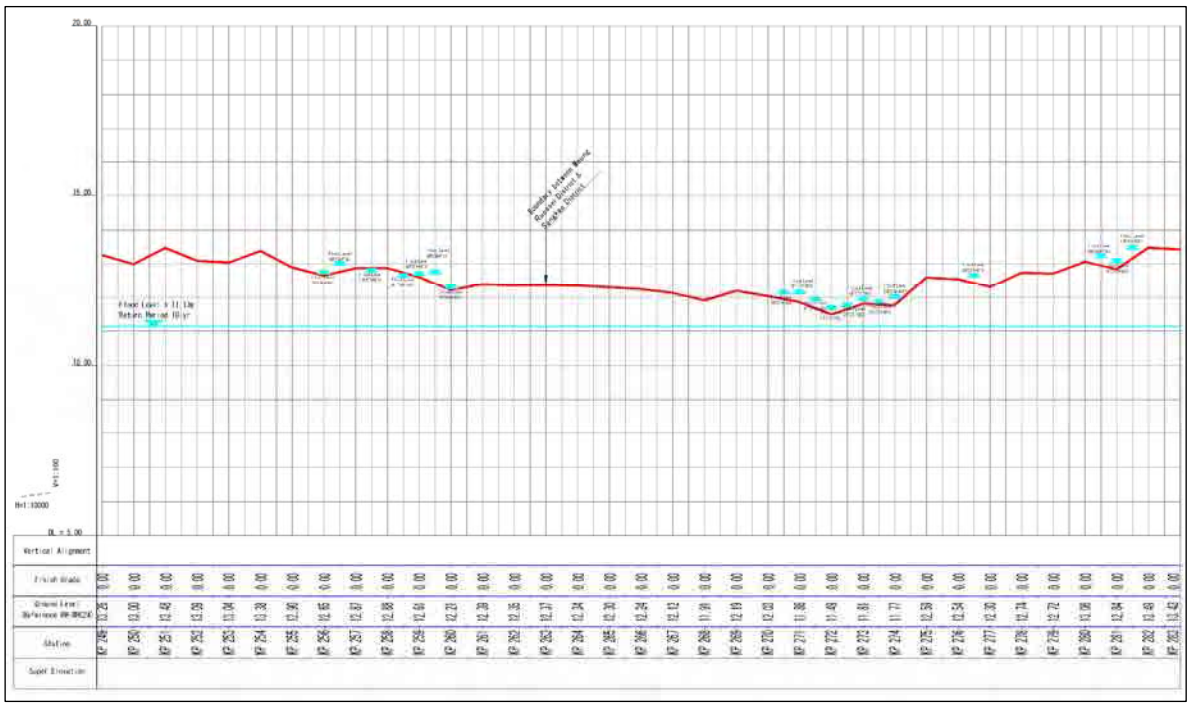


Figure 6-3 Locations of Inundation Which Occurred in October 2014

- The total volume of flood water which overtopped KP 250-382 of NR 5 has been estimated to be 230m^3/sec/km.
- It is proposed to install additional culverts to ensure sufficient capacity for the water flow, as well as raising the road surface at the locations where the inundation occurred.
- The number of units of box culverts required to let the flood water and lower the water level was estimated assuming various elevation of road surface.
- Figure 6-4 shows the relation between the number of box culverts and drainage capacity with various elevations of the road surface.
- Considering the practical elevation of road surface, it is proposed to install 8 units of box culvert per kilometer are newly installed.

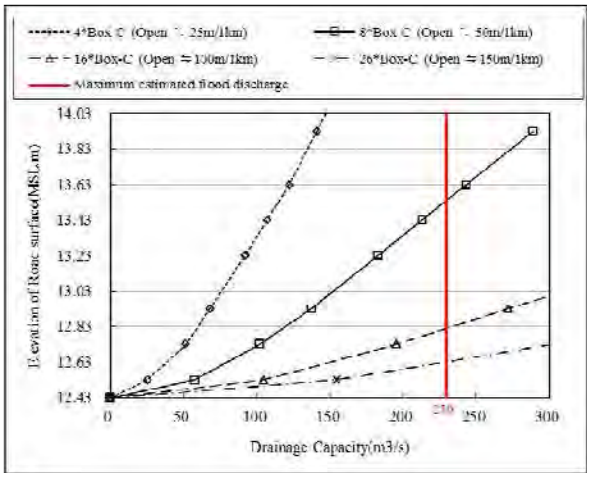


Figure 6-4 Relation between Number of Culvert Box and Drainage Capacity

6.6 Topographical Survey

- Topographical surveys on the existing NR 5 (Middle Section and Sri Sophorn–Poipet Section) and the selected route of Pursat Bypass were conducted to obtain the data required for the preliminary road design, estimation of drainage capacities of the rivers, and bridge planning.
- The contents of topographical surveys are summarized as Table 6-3.

Table 6-3 Summary of Topographical Survey

Road	Work Item	Q'ty
Existing Road (Middle Section)	Length Setting up BM Cross Section	112km 23 points 112 sections
Existing Road (Sri Sophorn–Poipet Section)	Length Setting up BM Cross Section Survey	41km 8 points 41 sections
Pursat Bypass	Length Setting up BM Road Center Line Survey/ Longitudinal Survey Cross Section Survey Cross Section Survey of River	8.8km 5 points 8.8km 440 sections 240m
2- & 3-Digit National Roads	Cross Section Survey (for Hydrological Analysis) Cross Section	8 sections 1 set
Bridge to be Replaced	Location Longitudinal Survey Profile	3 300m 1 set
New Bridge Construction	Location Longitudinal Survey River Cross Section Topographical Survey	5 location 700m 15 sections 1 set

- Air photos were taken using the powered paraglider. The photos taken were used to prepare the digital maps.
- These photos were used also for preliminary survey of the houses located on the roadside which need to be relocated.

6.7 Geotechnical Investigation

- Geotechnical investigations were conducted to obtain the information on the properties of soil materials and the foundation conditions needed for the design of bridges.
- Soil samples were taken by test-pitting and used for the laboratory test to obtain the data of CBR of the existing subgrade.
- Fifty-six (56) sample were taken from the Middle Section and twenty (20) samples were taken from the Sri Sophorn–Poipet Section.
- The CBR values of the existing subgrade of the Middle Section ranges between 2% and 4%, after discarding the extremely deviated values.
- The CBR values of some samples of the exiting subgrade of Sri Sophorn–Poipet Section (beneath the existing AC pavement) are very low. The CBR values of 14 samples out of 20 are 2% or less.
- Boring was conducted to obtain the geotechnical data at 12 bridge sites.
- The bore holes were drilled up to 25m from the ground surface.
- The boring logs show that the ground along the Middle Section consists of lateration of sand, clay and sandy clay, in general.
- The depth of the candidates for the bearing layers (N = 30 or more) for the bridge foundations known from the boring is varied 12-25m below the ground surface.
- At the site of Bridge No. 58, no bearing layer was found within 25m from the ground surface.
- Table 6-4 lists the candidates of bearing layers for the bridge foundation.

Table 6-4 Candidates of Bearing Layers

Bridge Site	Bearing Layer		
	Emerging Depth (GL-m)	Strata	Description
Br 42	22.00	QS3	Clayey sand, N>=30, Thickness shall be confirmed in DD.
Br 44	25.00	QC4	Clay, N>=50, *Thickness shall be confirmed in DD.*
Br 47	12.00	QC3 ~	Clay with sand, clayey sand, N>=40
Br 48	16.00	QC4	Sandy clay, N>=30
Br 50	20.00	QC5	Sandy clay, N>=40
Br 55	24.00	QCS2	Alternatio of clay and sand, N>=30, *Thickness shall be confirmed in DD.*
Br 57	18.00	QC3	Clay with sand, N>=30
Br 58	No layers with N-values of N>=30 within the drilled depths.		
Br 59	18.00	QC3	Sandy clay, N>=30, except GL-23~24m where SPT N-values were N=25 and 29.
Br 66	20.00	QS2 / QC4	Clayey sand with gravel, N>=50, Clay with sand, sandy clay, N>=30, except GL-23m where N=28.
Br 68	22.00	QC6	Clay with sand, clay, N>=40 *Thickness shall be confirmed in DD.*
Br 75	22.00	QC4	Clay with sand, clay, N>=30 *Thickness shall be confirmed in DD.*

* Name of strata is unique for each borehole;
same name of strata does not mean the same strata between boreholes.

7. PROBLEMS OF EXISTING ROAD CONDITION AND GENERAL SCHEME OF IMPROVEMENT

7.1 Problems of Existing Road Condition

(1) The Middle Section

- Problems of the existing road conditions of the Middle Section of NR 5 can be summarized as listed below:
  - Insufficient road width
  - Weak pavement structure
  - Vulnerability to inundation/flood
  - Passing through urbanized areas

(2) The Sri Sophorn–Poipet Section

- Problems of the existing road conditions of the Sri Sophorn–Poipet Section of NR 5 can be summarized as listed below:
  - Insufficient road width
  - Deteriorating pavement condition

7.2 General Scheme of Improvement

- To cope with the above problems, the following improvements are proposed:

(1) Section to be Improved

- It is proposed that the sections as shown in Figure 7-1 be included in the project of improvement of the Middle Section and the Sri Sophorn–Poipet Section.
- It is proposed that the section of the exiting NR 5 which is parallel to the proposed Pursat Bypass be excluded from the Project.
- These sections to be included in the Project shall be finalized through the consultation between JICA and the Royal Government of Cambodia (RGC).

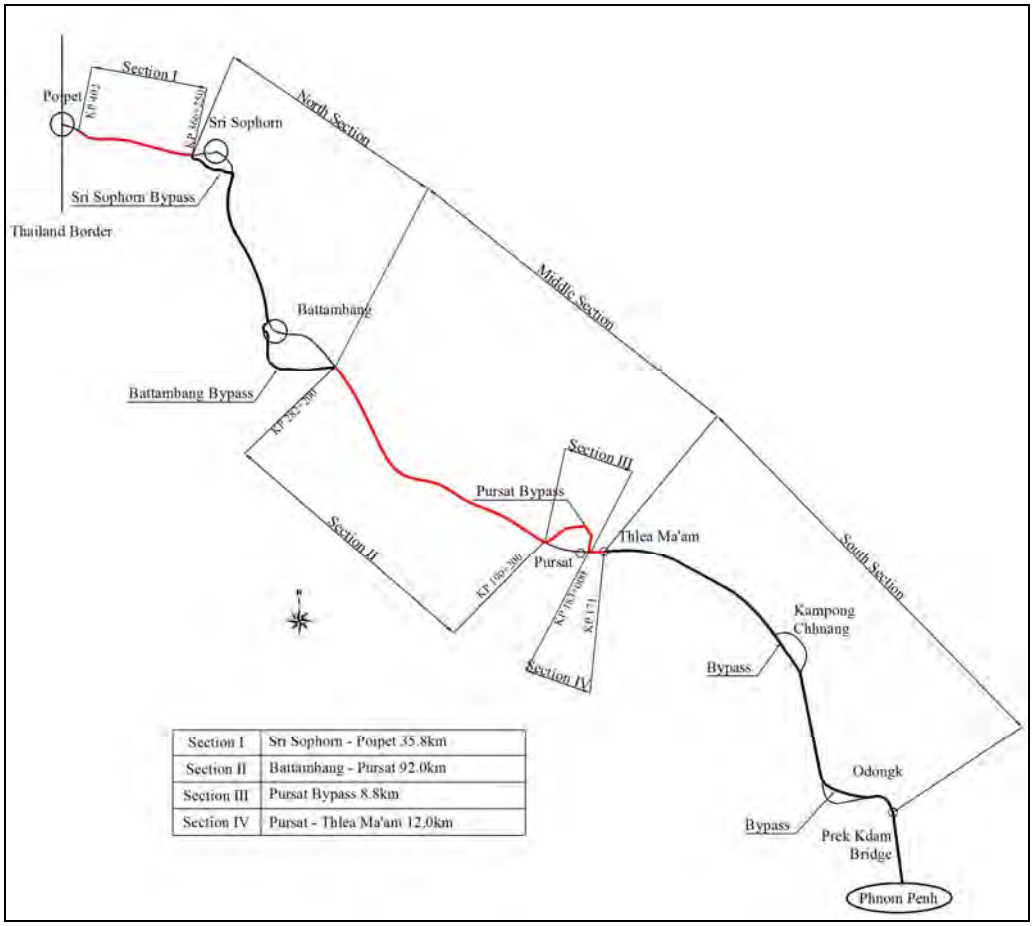


Figure 7-1 Section to be Improved

- It is proposed that the end point of the Sri Sophorn–Poipet Section near the town of Poipet be set at KP 402 where the 4-lane section of the existing NR 5 starts toward the town of Poipet.

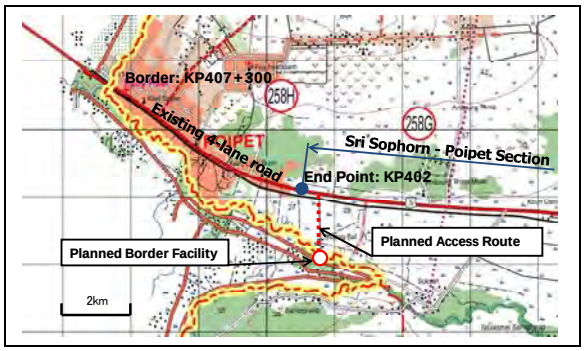


Figure 7-2 Proposed End Point of Sri Sophorn–Poipet Section

(2) Widening

- To accommodate increased traffic demand in the future, it is proposed to widen NR 5 into 4-lanes.
- This proposal is made considering the following aspects:
  - Traffic demands on the Middle Section and the Sri Sophorn–Poipet Section are forecasted to reach approximately 27,500 and 25,000 pcu, respectively, in year 2033, 10 years after completion of the Project. This traffic demand requires 4 lanes for flowing smoothly.
  - NR 5 is an important national and international transport corridor. Thus, it needs some safety margin of traffic capacity for smooth traffic operation.
  - Consistency in design standard: The South Section and the North Section are to be widened into 4-lane. The road width of the Middle Section and Sri Sophorn–Poipet Section should be same to these sections.
  - Traffic safety: Accident rate of NR 5 the highest among the single-digit national roads. Securing traffic safety by providing 4 lanes and separation slow traffic and high-speed traffic is vital.

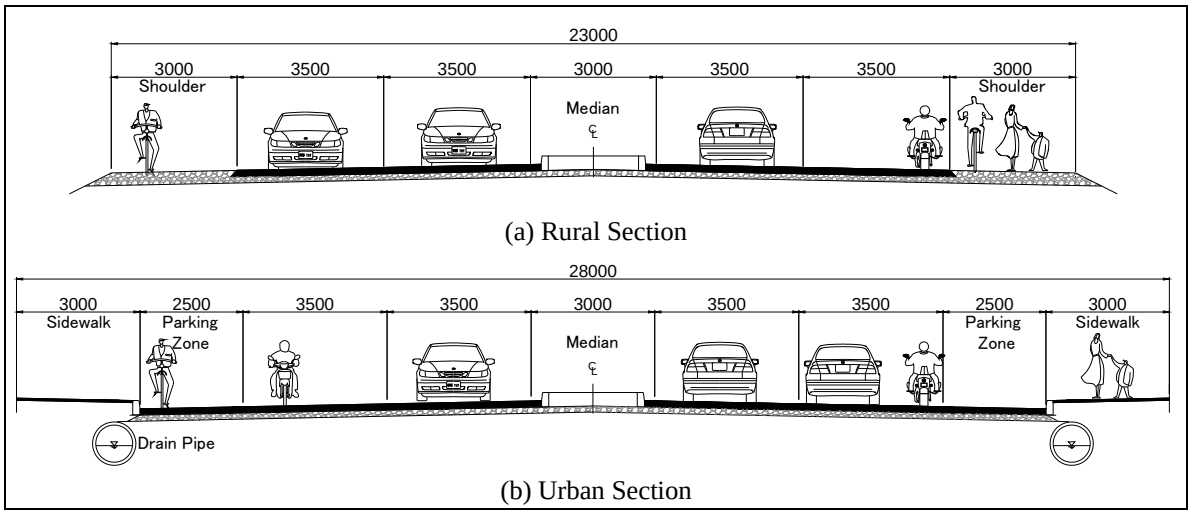


Figure 7-3 Proposed Typical Section (4 Lanes)

(3) Improvement of Pavement Structure

- The existing pavement of the Middle Section is DBST. It is proposed to improve the pavement type into asphalt concrete (AC). This is necessary to reduce maintenance cost which is increasing due to increase in traffic volume of heavy vehicles.

(4) Countermeasure Against Flood/ Inundation

- The elevation of the road surface of the Middle Section is higher that the flood water level of Tonle Sap Lake. Nevertheless inundation occurred in October 2014.
- Thus, it is proposed that the road surface be raised and additional culverts be newly installed.

7.3 Construction of Bypass

- To avoid resettlement of large number of resettlement of houses/households, construct- ion of a bypass around the city of Pursat is proposed.
- Seven alternative routes as shown in Figure 7-4 were studied.
- After discussion among MPWT, DPWT of Pursat and the JICA Team, Rout N-1 was selected as shown in Figure 7-5.
- It is proposed that the Pursat Bypass be constructed as 4-lane highway, considering that the forecasted traffic volumes on the bypasses exceed 19,000 pcu in year 2033.

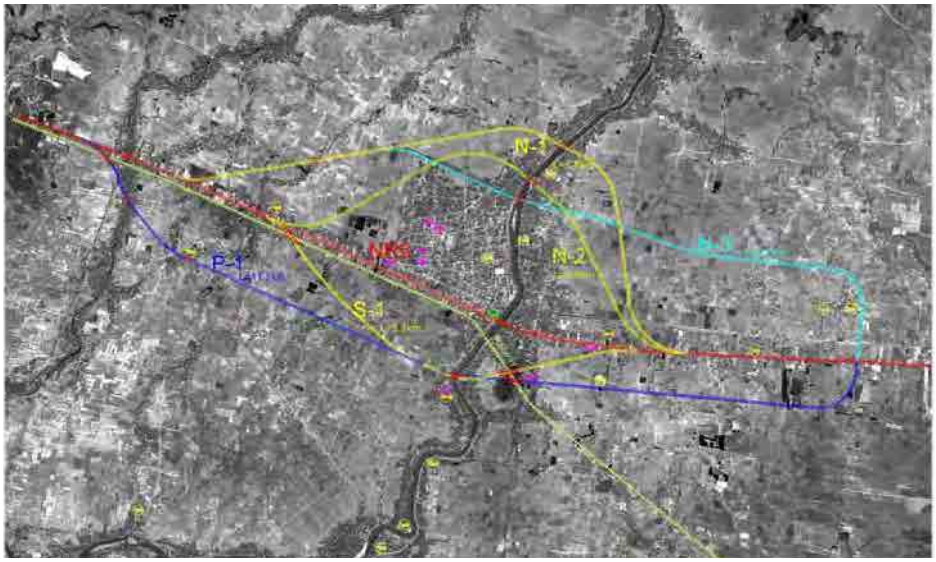


Figure 7-4 Alternative Routes of Pursat Bypass

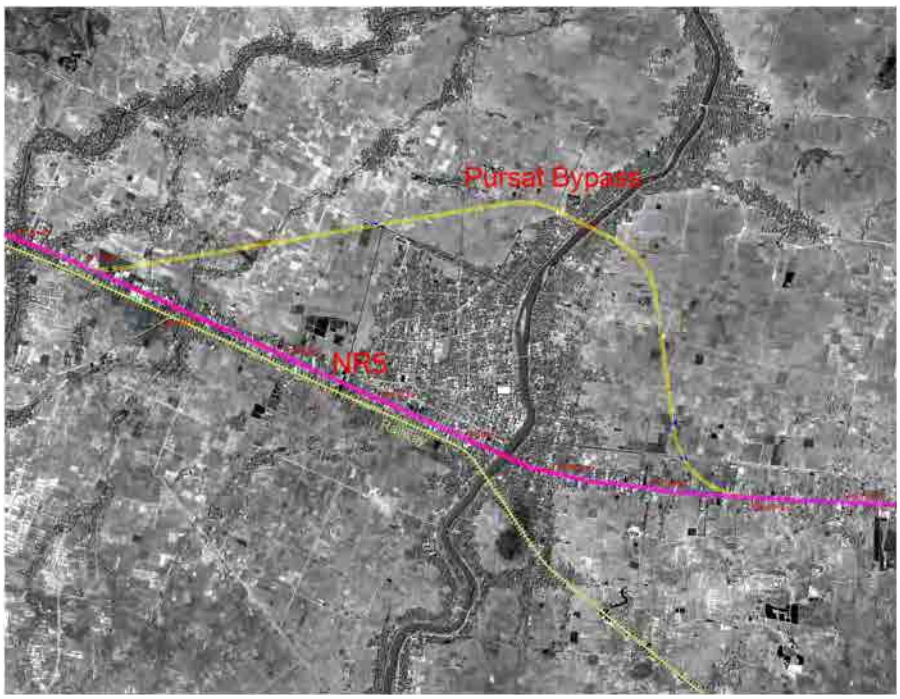


Figure 7-5 Selected Route of Pursat Bypass

- A long bridge will need to be constructed on the Pursat Bypass to cross the Pursat River. There are roads on the both bank of the river.
- After consultation with the provincial government of Pursat, it is proposed that the bypass cross the dike roads with grade separation.
- Figure 7-6 shows the conceptual general view of the bridge and grade separation.

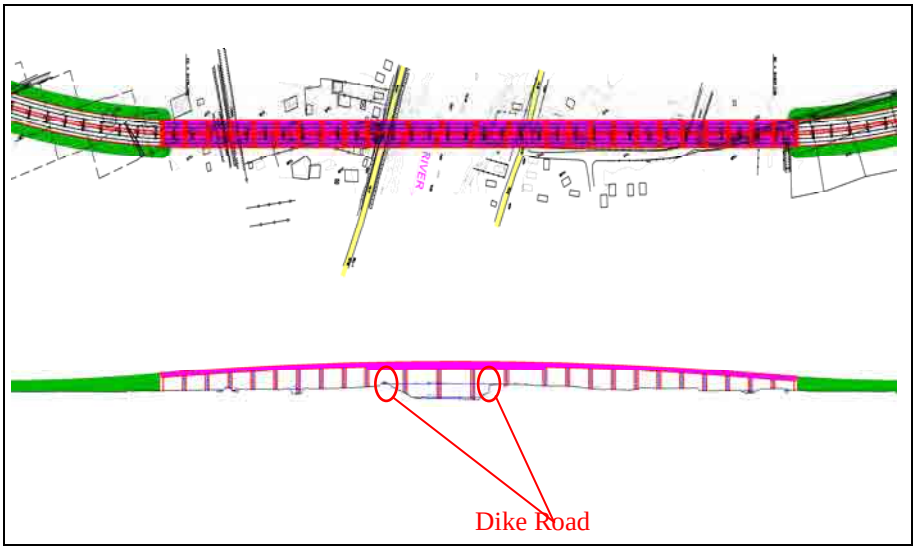


Figure 7-6 Conceptual General View of the Bridge on Pursat Bypass and Dike Roads

7.4 Manner of Widening

- Within the designated ROW of 30m from the centerline of the road, the density of houses located the road increases as the distance from the road increases.
- Thus, if the road is widened on one side of the existing road, the required land needs to be extended to the areas where the houses are densely located.
- On the other hand, the land to be required remains in the area where the density of houses are low and the number of houses to be relocated will be less than the above. Thus it is proposed to widen equally on the both sides.
- Figure 7-7 conceptually compares the difference of number of houses to be relocated.

	Widening on both Sides			Widening on One Side		
Schematic Illustration	Widened Part	Existing NR 5	Widened Part		Existing NR 5	Widened Part
Number of Houses to be Relocated		Small			Large	

Figure 7-7 Comparison of Number of Houses to be Relocated

8. HIGHWAY DESIGN

8.1 Highway Design of Improvement of the Existing NR 5 (Middle Section and Sri Sophorn–Poipet Section)

(1) Basic Design Policy and Design Criteria

- The design policy should be consistent with those the North Section and the South Section.
- NR 5 is designated as Class I road of Asian Highway. It is desirable to satisfy the design criteria of Asian Highway Class I.
- At the same time, NR 5 is an arterial road of Cambodia and it needs to satisfy the Road Design Standard of Cambodia.
- Table 8-1 compares the design criteria of Asian Highway Class I and Road Design Standard of Cambodia. The table also shows the recommended value.

(2) Cross Section

- Table 8-2 compares the design criteria of Asian Highway Class I and Road Design Standard of Cambodia. The table also shows the recommended value.
- As discussed in Chapter 7, it is proposed that existing NR 5 be widened to 4 lanes.
- From viewpoint of consistency of design standard, the cross section adopted in the North Section is adopted.
- Figures 8-1 (a) and (b) show proposed typical cross section for rural area and urban area, respectively.
- In the cross section for urbanized area where many vehicles are anticipated to be parked on street, 2.5m-wide parking spaces are provided on both sides.
- Also 3.0m-wide sidewalks are provided and installed drainage pipe under the sidewalks.

Table 8-1 Comparison of Design Speed and Criteria

Standard	Asian Highway	Cambodian Standard		Recommended	
Road Class	Class I	R5 (Rural)	U5 (Urban)	Rural	Urban
Design Speed	100km/h (Flat)	100km/h (Flat)	50km/h (type 3)	100km/h	50km/h
Min, Curve Radius (superelevation)	350m (10%)	415m (6%)	90m (6%)	350m (10%)	80m (10%)

Table 8-2 Comparison of Design Criteria

Items	Asian Highway	Cambodian Standard		Recommended
Road Class	Class I	R5 (Rural)	U5 (Urban)	
Lane Width	3.50m	3.50m		3.50m
Shoulder Width	3.00m (Flat)	3.00m (Flat)	2.50m (Type 3)	3.00m
Median Strip	3.00m (Flat)	4.0-12.0m (Flat)	2.0-4.0m (Type 3)	0.5-3.0m
Cross Slope	2.0% (AC)	2.5-3.0% (AC)		2.0%
Shoulder Slope	3.0-6.0%	3-4% (sealed)	3%	
Vertical Clearance	4.5m			4.5m

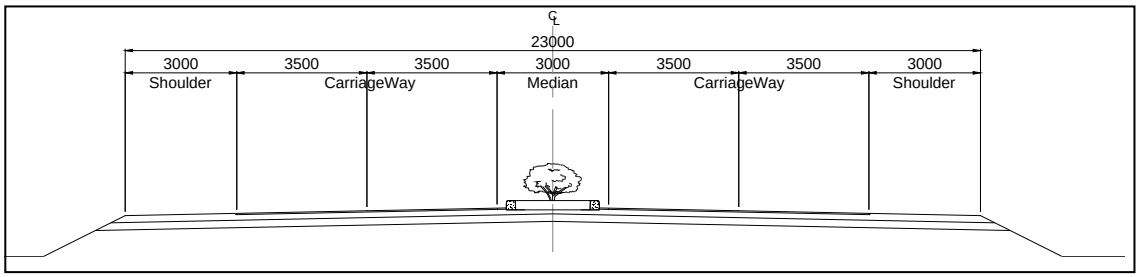


Figure 8-1 (a) Proposed Typical Cross Section (Rural Area)

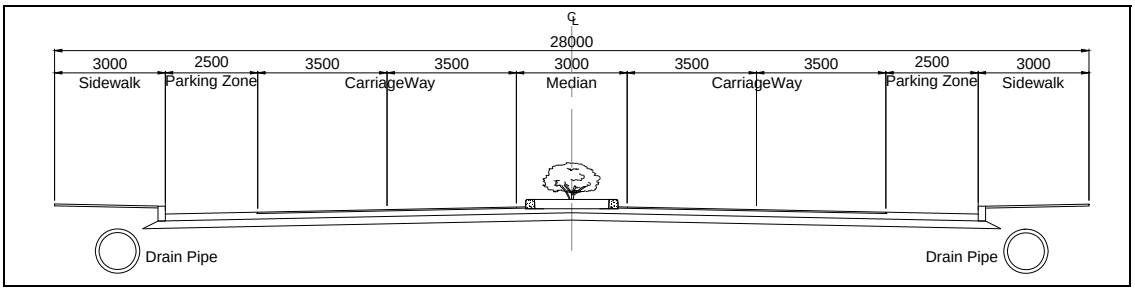


Figure 8-1 (b) Typical Cross Section Composition (Urban Area)

(3) Horizontal Alignment

- The horizontal alignment of the Middle Section and Sri Sophorn–Poipet Section of NR 5 is good in general. However there are some problems as follows:
  - There are curve sections where do not meet the design criteria shown in Table 8-1.
  - There are many curve sections where the lengths of curve are short and do not meet the design criteria.
- The speed limit for urban section is 40km/h. Design speed 50km/h is adopted for urban section in this Survey. Table 8-3 shows urban section where design speed of 50km/h is applied.

Table 8-3 Urban Sections Designed with Design Speed of 50km/h

KP	Length	Name of Location
Middle Section		
KP 184+100 – KP 188+200	4,100m	Pursat
KP 197+500 – KP 198+300	800m	Andoung Krasang
KP 200+800 – KP 202+500	1,700m	Bakan
KP 208+100 – KP 212+700	4,600m	Boeung Khnar
KP 215+100 – KP 217+000	1,900m	Ou Ta Paong
KP 218+800 – KP 220+000	1,200m	Svay Daun Keo
KP 222+400 – KP 224+900	2,500m	Pray Svay
KP 230+600 – KP 23 +600	1,000m	Kalaom Phluk
KP 235+900 – KP 237+000	1,100m	Pray Svay
KP 243+700 – KP 245+600	1,900m	Moung Russei
Sri Sophorn–Poipet Section		
KP 372+600 – KP 373+200	620m	Soryathmi
KP 376+900 – KP 377+400	500m	Soryathmi
KP 380+000 – KP 389+200	1,700m	Nimit
KP 392+300 – KP 394+100	9,200m	Koun Damrei
KP 401+900 – KP 407+300	5,400m	Poipet

- Table 8-4 shows the curve sections with substandard curve radii and proposed improvement value.

Table 8-4 Curves with Small Radii

IP	KP of IP	Land	Radii of Curve		Center Shift
			Existing	Proposed	
93	242 + 693	Rural	322	1,000	2.6
149	276 + 259	Rural	155	400	6.2
153	277 + 750	Rural	121	550	5.8
156	278 + 015	Rural	312	Move IP	
158	278 + 479	Rural	248	1,000	2.9
160	279 + 264	Rural	270	350	3.1

- Example of the improvement is shown in below (next page).

Figure 8-2 Example of Improvement (KP 276 + 498 – KP 276 + 676)

(4) Vertical Alignment and Height of Road

- The road surface in some sections needs to be raised as the countermeasures for inundation/flood.
- Inundation/flood was studied as discussed in Sections 6.4 and 6.5 above.
- In the Middle Section, the section Between KP 255 and KP 283 was inundated during the flood occurred in October 2013. The

road surface in this section is proposed to be raised.

- Table 8-5 shows the proposed amount of raising road surface.

Table 8-5 Amount of Raising of Road Surface

Location	Flood Water Level (Below Road Surface)	Amount of Raising Road Surface (m)
Middle Section		
KP 256 + 000 – KP 257 + 000	0.05m	0.55
KP 258 + 500 – KP 260 + 000	0.05m	0.55
KP 270 + 500 – KP 271 + 500	0.25m	0.75
KP 272 + 000 – KP 274 + 000	0.15m	0.65
KP 276 + 500 – KP 277 + 000	0.10m	0.60
KP 280 + 500 – KP 281 + 500	0.20m, low surface	0.70
Sri Sophorn–Poipet Section		
KP 366 + 000 – KP 371 + 000	-0.20m	0.30

(5) Pavement Design

- AASHTO's "Pavement Design Manual" is adopted for the design.
- In the design method presented in this manual, the traffic load is converted to cumulative 18-kip Equivalent Single Axle Load (ESAL). Structure Number (SN) is calculated with CBR and ESAL and pavement structure is designed to satisfy the calculated SN.
- The CBR values used in the design of the pavement structure were selected based on the results of the laboratory test conducted on the samples taken from the exiting subgrade of NR 5.
- The CBR values are as shown in Figures 8-3 (a)-(c). Extremely high and low values found in KP 190-283 were discarded.

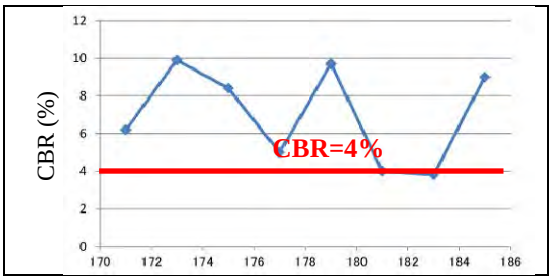


Figure 8-3 (a) CBR Values of KP 171 – KP 183

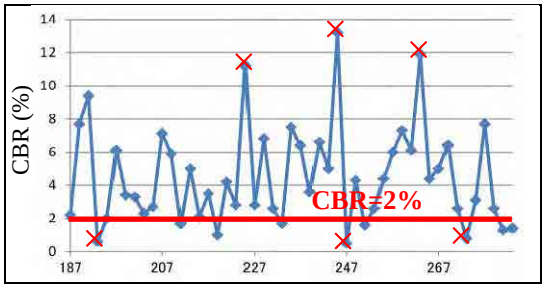


Figure 8-3 (b) CBR Values of KP 190 – KP 283

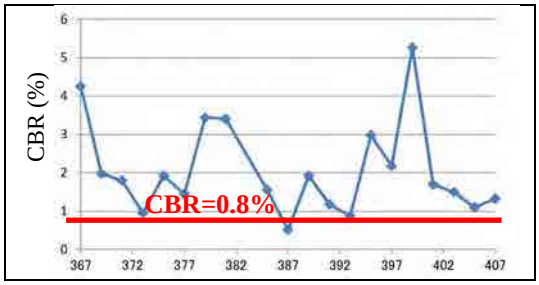


Figure 8-3 (c) CBR Values of Sri Sophorn–Poipet Section

- Table 8-6 shows the design condition and calculated SN.

Table 8-6 Condition and Result of Pavement Design

(Middle Section)

Item	KP 171-183	KP 190-255	KP 256-283
Design Period	10 years		
Reliability	80%		
Design CBR	6%	4%	6%
ESAL	1.483×10^7	1.627×10^7	1.627×10^7
SN	4.64	5.33	4.64

(Sri Sophorn –Poipet Section)

Item	KP 366-371	KP 371-402
Design Period	10 years	
Reliability	80%	
Design CBR	6%	3%
ESAL	1.82×10^7	
SN	5.07	5.55

- According to Cambodian Standard, 15cm AC thickness is adopted for highway with large traffic volume, and 10cm AC thickness is adopted for highways with less traffic volume.

- 15cm-thick AC is adopted for this Project.
- Existing pavement shall be utilized as subbase curse. It can reduce the cost and industrial waste.
- The designed pavement structures are shown in Table 8-7.

Table 8-7 Designed Pavment Structure

(Middle Section)

Layer	Material	KP 171-183	KP 190-255	KP 255-283
Surface & Binder	AC	15 cm		
Base	Gravel	20c m	25 cm	20 cm
Subbase	Crusher run	30c m	40 cm	30cm

(Sri Sophorn –Poipet Section)

Layer	Material	KP 366-371	KP 371-402
Surface & Binder	AC	15 cm	
Base	Gravel	20c m	25 cm
Subbase	Crusher run	30c m	45 cm

(6) Appurtenances

Drainage Facilities

- There are 35 box culverts and 62 pipe culverts on the existing Middle Section and 68 pipe culverts in the Sri Sophorn–Poipet Section. All of those culverts are required to be extended to fit with widened road width.
- It is proposed also that 230 units of box culverts be newly installed in the section of KP 253-282.
- This section was severely inundated during the flood which occurred in October 2013. It is necessary to increase the flow area for flood water to flow across NR 5 in this section.

Guardrail

- The section of embankment more than 4m is the criteria to install the guardrail. section near KP 33 and Odongk Bypass are planned to install the guardrail.
- The approach for the bridge shall be protected by guardrail to prevent swerved into the water hazard. The guardrails are installed on both sides of bridges with 20m each in length.

Rumble Strip

- Ramble strips shall be planned at entrance of town area, near school and market to give drives warning.
- Figure 8-4 shows example of rumble strip.

Figure 8-4 Example of Rumble Strip

Street Light

- Lighting is provided at major intersections and bridges to consider the visibility at hazardous locations during night.

(7) Intersection with the Access Road to the New Border Facility

- The policy for intersection design for the Sri Sophorn Section is the same as that of the Middle Section, except for the intersection for the access road to the new border facility.
- The feasibility study for the access road is currently implemented by the government of Thailand, and the route of the access road and the location of the intersection of the access road with NR 5 has not been fixed yet.
- The construction cost of the access road is expected to be financed by the government of Thailand. Under such circumstances, it is difficult to design the intersection of the access road with NR 5.
- Possible configurations of the intersection are shown in Figure 8-5 (a grade-separated ramp for right-turn traffic from NR 5) and Figure 8-6 (a roundabout intersection).
- It is proposed that the cost of this intersection be excluded from the cost of this Project since the access road is expected to be constructed with the financial assistance of Thailand.

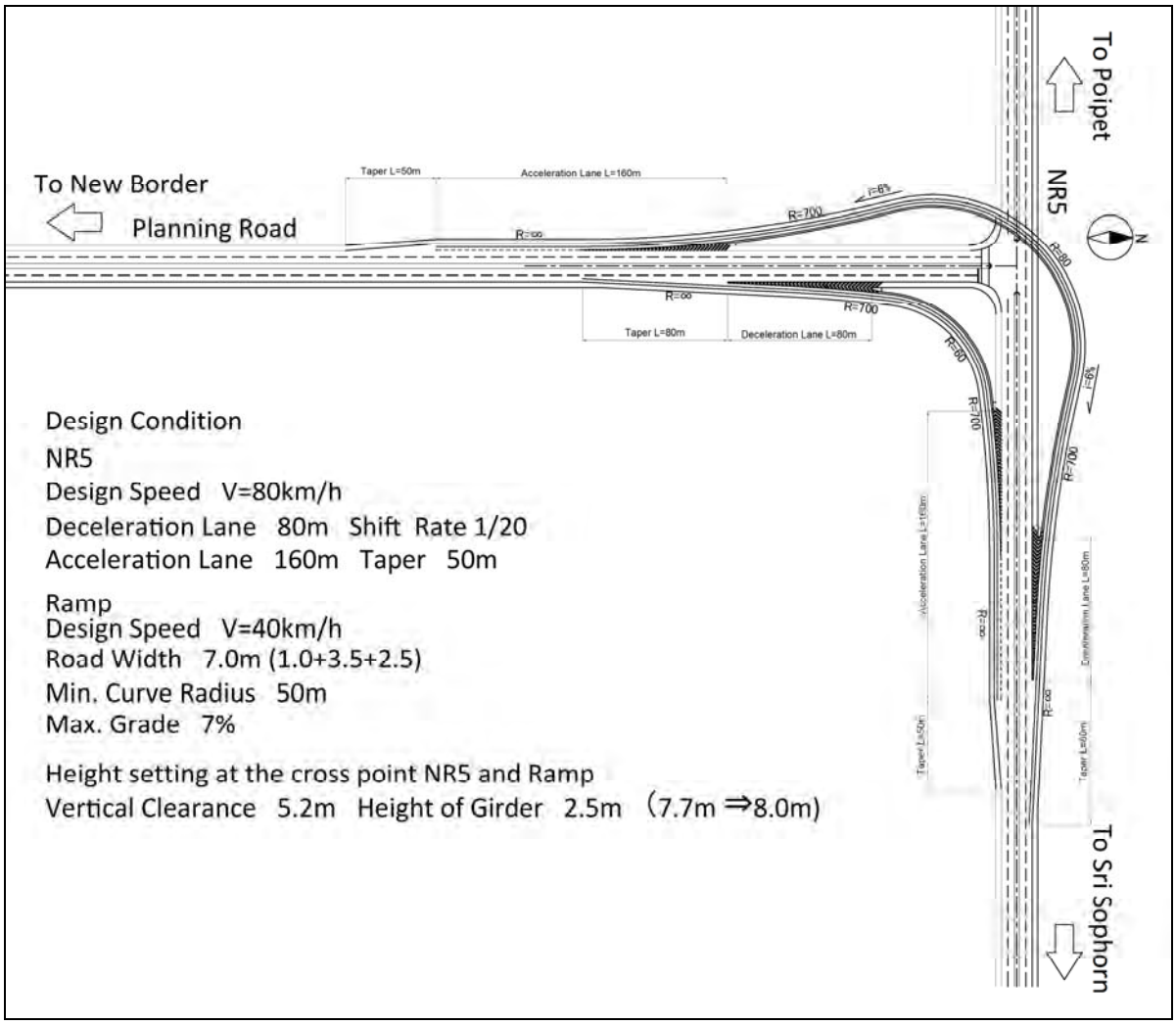


Figure 8-5 Intersection with the Access Road to the New Border Facility (With Grade-Separated Left-Turn Ramp)

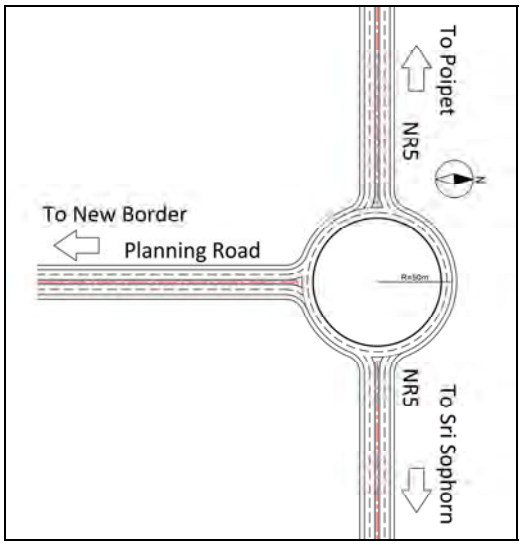


Figure 8-6 Intersection with the Access Road to the New Border Facility (Round About)

8.2 Design of Pursat Bypass

(1) Cross Section

- As discussed in Chapter 8, the estimated traffic volume (19,200 pcu/day in 2033) of Pursat requires the capacity of 4 lanes.
- The same cross section with rural section of NR 5 is adopted for the Pursat Bypass.
- Figure 8-7 shows the proposed cross section of the Pursat Bypass.

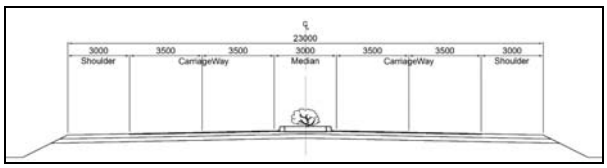


Figure 8-7 Typical Cross Section of Pursat Bypass

(2) Horizontal Alignment

- The route of the bypass selected is as discussed in Chapter 7.
- It is proposed that the same criteria as that used for the improvement of the existing NR 5 is applied to the Pursat Bypass.

(3) Vertical Alignment

- The elevation of the existing NR 5 at the points of intersections with the bypass is sufficiently high above the flood level, although the nearby paddy areas are often covered by the flood water. The height of the embankment of the bypass should be sufficiently higher than water level as far as it is equal, or close to that of the exiting NR 5.

(4) Pavement Design

- The same design procedures as adopted in the pavement design for the existing NR 5 is adapted for the pavement design of the bypass.
- Table 8-8 shows design conditions and calculated SN.

Table 8-8 Conditions of Pavement Design for Pursat Bypass

Item	Adopted Value
Design Period	10 years
Reliability	80%
Design CBR	6%
Traffic Load	4.010×10^7
SN	5.33

(5) Major Intersection

- Intersections of the Bypass with the existing NR 5 are designed so that the main direction is for the Bypass. Figures 8-8 and 8-9 show the design of at-grade intersections.

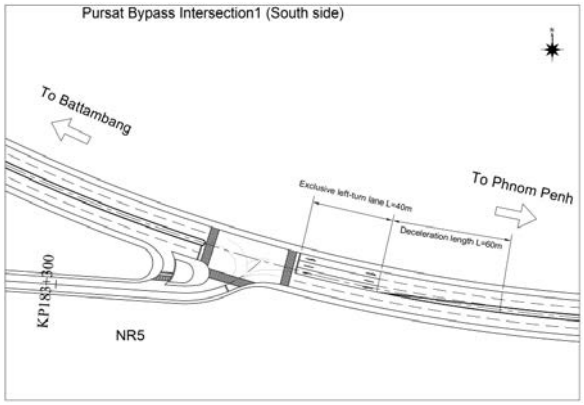


Figure 8-8 Southern Intersection of Pursat Bypass with Existing NR 5

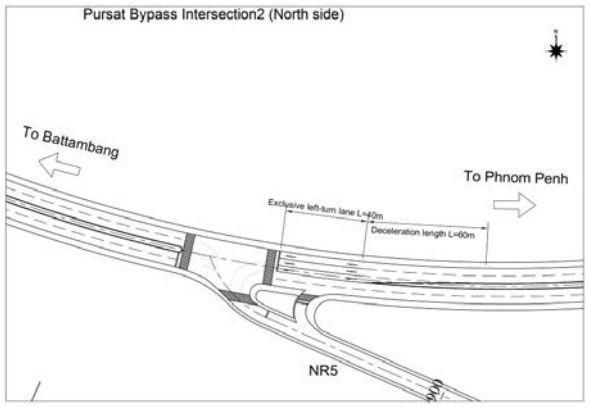


Figure 8-9 Northern Intersection of Pursat Bypass with Existing NR 5

9. BRIDGE PLANNING

9.1 List of Existing Bridge

- There are 38 bridges along the Middle Section. Out of these 38 bridges, 10 are located in the section KP 183 – KP 190 which are proposed to be out of proposed scope of the Project because this section is parallel to the proposed bypass.
- Thus, 28 bridges are required to be replaced, widened or supplemented with an additional adjacent bridge.

9.2 Widening Plan

- Widening design for each bridge is selected based on bridge location, bridge condition, road alignment, built year and result of site survey.
  - Replacement of Existing Bridge: 13 bridges
  - Construction of Additional Bridge: 3 bridges
  - Widening of Existing Bridge: 12 bridges
- Table 9-1 summarizes the method of bridge widening.

(1) Replacement of Existing Bridge

- In the Middle Section, some bridges need to be replaced as the embankments of the adjacent sections need to be raised as the countermeasure for inundation/flood. The bridges located adjacent to such embankment sections need to be raised so that the height of the bridge surface is equivalent to the height of embankment section.
- Type of new bridge is selected taking the following aspects into consideration, (i) to minimize impact on road profile, (ii) to ensure existing river clearance, (iii) to ensure necessary waterway opening, and (iv) to minimize the maintenance cost.
- PSC bridges are selected as the new bridges.
- Standard drawings for PSC bridge have been prepared for MPWT approval under The Strengthening of Construction Quality Control Project, JICA. The survey team uses the standard drawing.
- Figure 9-1 shows the typical cross section of replacement bridge.

(2) Construction of Additional Bridge

- Type of additional bridges are selected taking the following aspects in to consideration, (i) to minimize impact on road profile, (ii) to ensure existing river clearance, (iii) to construct new pier on the same station with existing bridge, and (iv) to minimize the maintenance cost.
- PSC bridge is selected for the bridge which span length is shorter than 25m. And PCDG bridge is selected for the bridge which span length is longer than 25m.
- Standard drawings for PSC bridge and PCDG bridge have been prepared for MPWT approval under The Strengthening of Construction Quality Control Project, JICA.
- Figure 9-2 shows examples of typical cross section of additional bridge.

(3) Widening of Existing Bridge

- 12 bridges of PSC deck are proposed to be widened by adding deck slab. The deck widening concept will therefore be substantially the same for all affected bridges.
- The deck widening concept will make use of similar section PSC units placed on extended substructure and transversely pre-stressed to the existing units of the deck.
  - (i) Option 1 proposes to break out the cement mortar at each anchorage recess and to use couplers to extend the pre-stressing bars.
  - (ii) Option 2 proposes to construct separate superstructure connected by longitudinal joint. With this option, the additional deck can be constructed regardless of existing bridge condition.
- Figure 9-3 shows concept of widening of existing bridge.

Table 9-1 Summary of Bridge Widening

No.	Code	KP	Existing Bridge Length (m)	No. of Span	Existing Type	Widening Method
1	Br.40	177 + 200	23.0	1	Steel Girder	Construction of additional bridge (LHS)
2	Br.41	178 + 500	15.1	1	PSC	Widening of existing bridge
3	Br.42	181 + 800	18.6	1	RCDG	Replacement of existing bridge
4	Br.43	182 + 800	36.0	2	PSC	Widening of existing bridge
5	Br.44	183 + 300	45.6	3	Steel Girder	Out of scope of the project
6	Br.45	183 + 900	36.0	2	PSC	Out of scope of the project
7	Br.46	184 + 100	20.0	1	PSC	Out of scope of the project
8	Br.47	185 + 700	120.0	6	PCDG	Out of scope of the project
9	Br.48	187 + 400	28.0	1	PCDG	Out of scope of the project
10	Br.49	187 + 700	24.0	2	PSC	Out of scope of the project
11	Br.50	188 + 100	54.0	3	PSC	Out of scope of the project
12	Br.51	188 + 250	45.0	3	PSC	Out of scope of the project
13	Br.52	189 + 250	30.0	2	PSC	Out of scope of the project
14	Br.53	189 + 900	18.0	1	PSC	Out of scope of the project
15	Br.54	190 + 150	18.0	1	PSC	Widening of existing bridge
16	Br. 55	191 + 100	30.0	2	PSC	Widening of existing bridge
17	Br. 56	201 + 800	12.0	1	PSC	Widening of existing bridge
18	Br. 57	208 + 500	28.0	2	PSC	Widening of existing bridge
19	Br. 58	215 + 750	45.6	3	Steel Girder	Construction of additional bridge (LHS)
20	Br. 59	219 + 600	91.0	3	Steel Girder	Construction of additional bridge (LHS)
21	Br. 60	220 + 800	24.1	2	PSC	Widening of existing bridge
22	Br. 61	222 + 650	12.1	1	PSC	Widening of existing bridge
23	Br. 62	223 + 650	12.1	1	PSC	Widening of existing bridge
24	Br. 63	242 + 850	18.0	1	PSC	Widening of existing bridge
25	Br. 64	243 + 600	30.1	2	PSC	Widening of existing bridge
26	Br. 65	244 + 400	24.2	2	PSC	Widening of existing bridge
27	Br. 66	245 + 900	9.0	2	RCDG	Replacement of existing bridge
28	Br. 67	255 + 250	15.1	1	PSC	Replacement of existing bridge
29	Br. 68	255 + 600	24.0	2	PSC	Replacement of existing bridge
30	Br. 69	256 + 550	15.0	1	PSC	Replacement of existing bridge
31	Br. 70	257 + 900	12.1	1	PSC	Replacement of existing bridge
32	Br. 71	265 + 900	12.1	1	PSC	Replacement of existing bridge
33	Br. 72	270 + 900	12.1	1	PSC	Replacement of existing bridge
34	Br. 73	271 + 700	18.5	1	PSC	Replacement of existing bridge
35	Br. 74	272 + 650	12.1	1	PSC	Replacement of existing bridge
36	Br. 75	273 + 300	24.1	2	PSC	Replacement of existing bridge
37	Br. 76	275 + 650	12.1	1	PSC	Replacement of existing bridge
38	Br. 77	276 + 550	12.1	1	PSC	Replacement of existing bridge

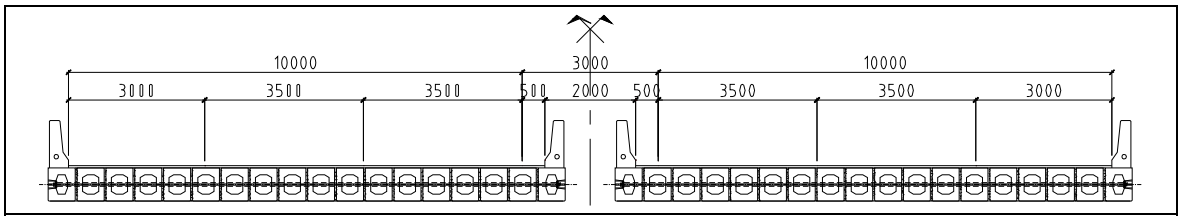


Figure 9-1 Typical Cross Section of Replacement Bridge

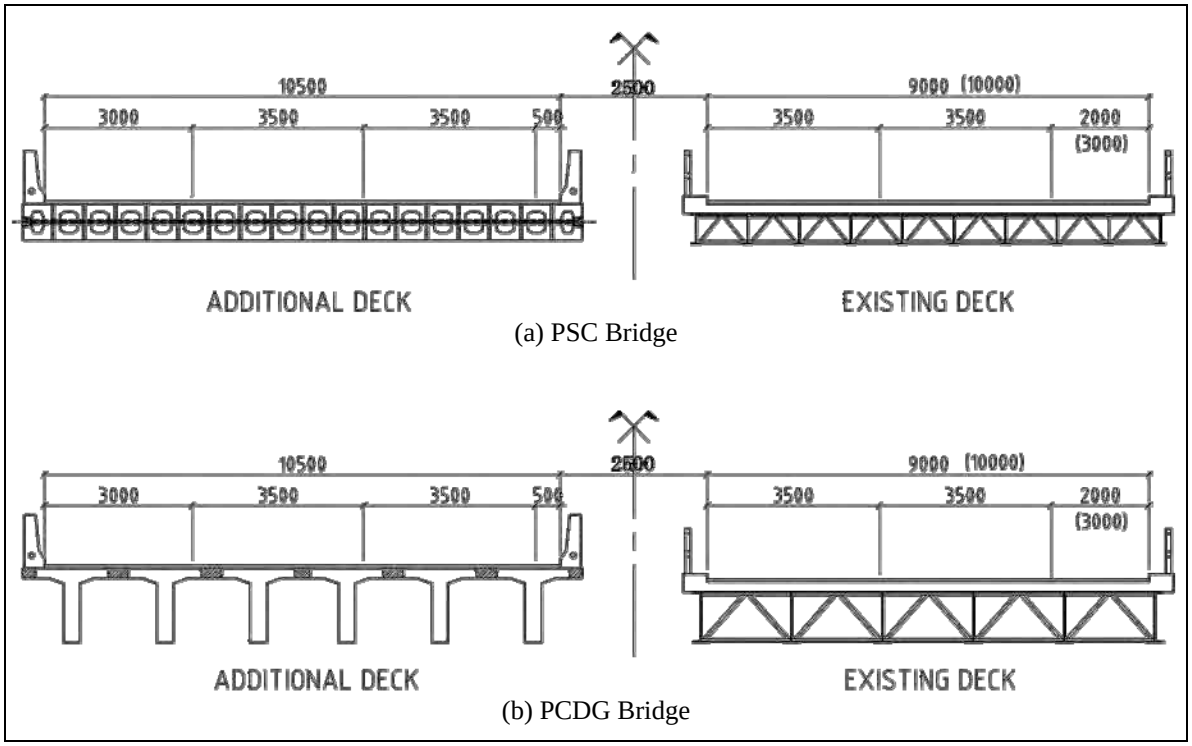


Figure 9-2 Typical Cross Section of Additional Bridge

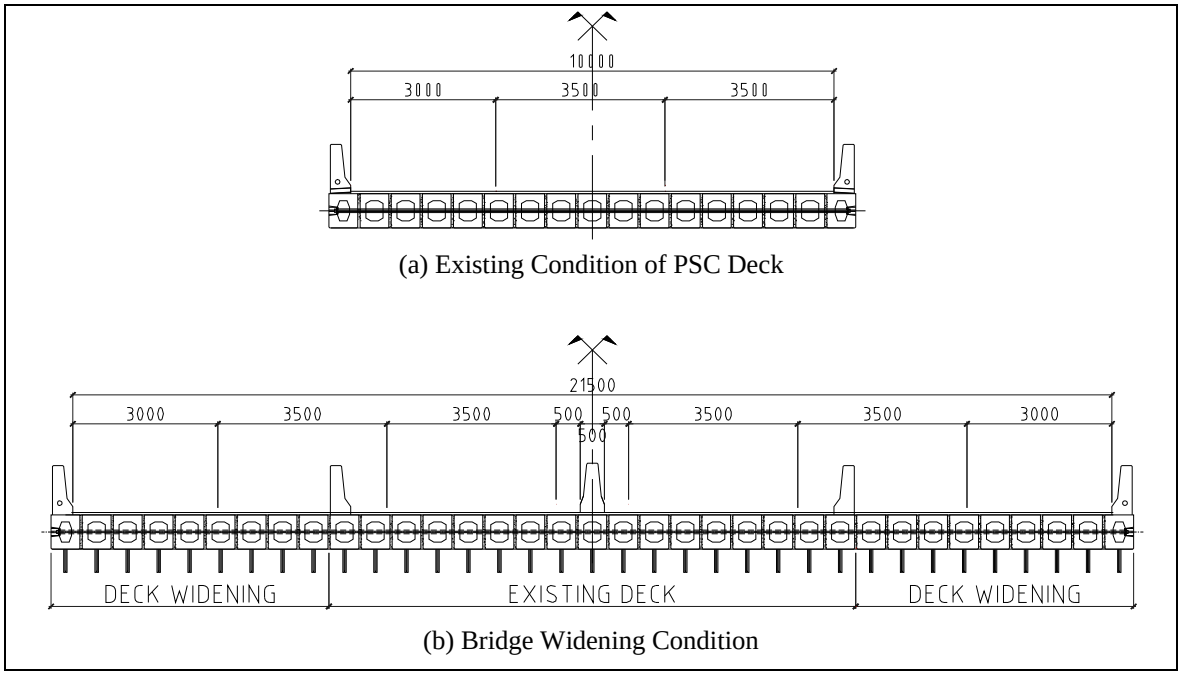


Figure 9-3 Typical Cross Section of Widening of Existing Bridge

9.3 Bridge on Pursat Bypass

- The proposed Pursat Bypass crosses the Pursat River.
- The river is approximately 70m in width at the crossing point.
- As discussed in Section 7.3, there are roads on the both banks of the Prusat River. The bridge is to cross these bank roads by grade-separation.
- To secure the required clearance above the bank roads, the highest point of the bridge becomes considerably high.
- Thus, the both sides of the main portion of the bridge need to be planned as bridge/ viaduct.
- The total length of the bridge is planned to be approximately 700m.

Figure 9-4 shows general view of the bridge.

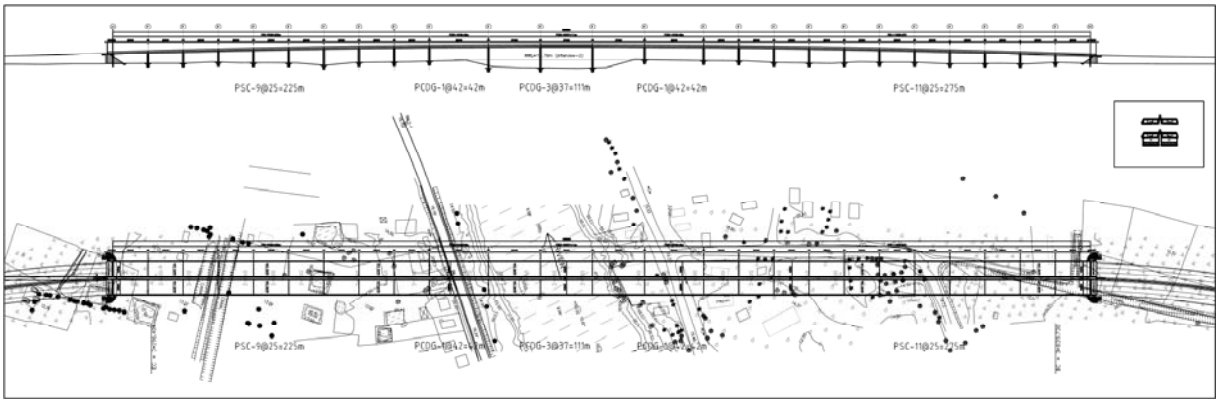


Figure 9-4 General View of the Bridge of Pursat Bypass for Crossing Pursat River

9.4 Additional Box Culvert

- Existing waterway opening length in some sections are insufficient. These section need to be constructed additional waterway opening. Pipe culvert or box culver need to be constructed to make waterway opening in these sections.

Table 9-2 Additional Box Culverts

KP	Length (km)	No. of Culverts
KP 227 + 700 – KP 235+800	8.1	3
KP 235 + 800 – KP 239 + 900	4.1	4
KP 256 + 0 – KP 260 + 0	4.0	64
KP 270 + 0 – KP 277 + 0	7.0	112
KP 280 + 0 – KP 282 + 0	2.0	32

- Figure 9-5 shows the general view of the box culvert.

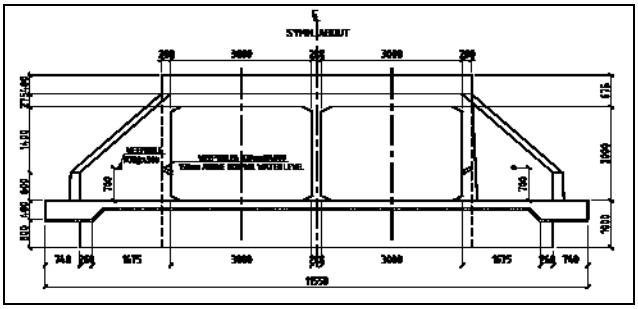


Figure 9-5 General View of Box Culvert

10. COST ESTIMATION

10.1 Scope of Work

- From the viewpoint of packaging for civil works contract, NR 5 Improvement Project of the Middle Section and the Sri Sophorn–Poipet Section are proposed to be divided into 4 sections, as shown in Figure 10-1.
- These sections are divided considering the size of work volume or the contract amount of each package.
- Table 10-1 shows the start point, end point and the road length of each contract package.
- The Pursat Bypass is proposed to be one package considering the estimated work volume and construction cost.
- In addition to the civil works, renewal of the existing weigh stations and construction of new ones is proposed as Package 5.

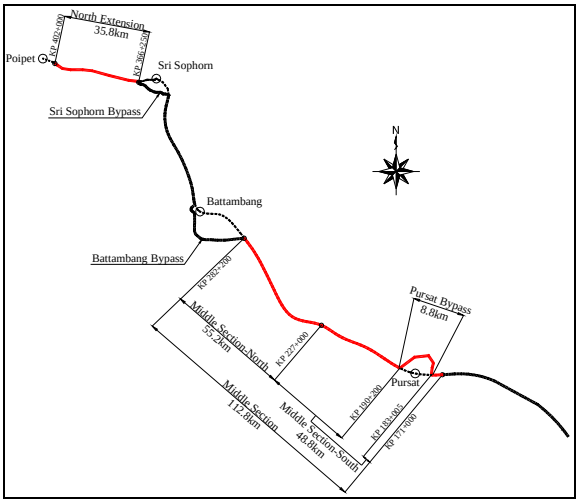


Figure 10-1 Civil Works Contract Package

Table 10-1 Start Point and End Point of Contract Package

Packages	Package Names	Components	Start Point	End Point	Length (km)
Package 1	Middle Section-South	Existing Road No.5	KP 171 + 000	KP 227 + 000	48.8
Package 2	Middle Section-North	Existing Road No.5	KP 227 + 000	KP 282 + 200	55.2
Package 3	Pursat Bypass	New bypass	KP 183 + 005	KP 190 + 000	8.8
Package 4	North Extension	Existing Road No.5	KP 366 + 250	KP 402 + 000	35.8
Package 5	Weigh Station	Eight weighbridges			
				Total	148.6

10.2 Project Cost

- The computed project cost is summarized in Table 10-2.
- The construction cost and the cost for consulting services are to be financed by the Japanese ODA loan while the costs of relocation of utilities, survey and clearance of mines and UXO, and administration are to be financed by the RGC.

10.3 Annual Progress

- Annual progress of the project cost is calculated by distributing the project cost to each year in accordance with the implementation schedule discussed in Chapter 11. The annual progress thus calculated is shown in Table 10-3.
- It should be noted that annual progress for the RGC will be significantly large in the first few years due to land acquisition and resettlement. Ensuring sufficient budget in each year, particularly in the first few years is indispensable for successful implementation of the Project.

10.4 Repayment Schedule

- JICA loan conditions applying to Cambodia are as follows.
  - Interest rate : 0.01%
  - Repayment period : 40 years
  - Grace period : 10 years
- The amount per year is calculated using the following formula.
  - Repayment per year $= \dfrac{P \times I}{1-(1+I)^{-t}}$
- Using the above formula, repayment is calculated at approximately USD 13.2 million per year over thirty years (2025-2054).

Table 10-2 Summary of Project Cost

(Unit: US$1,000)

Item		FC	LC	Total
A. ELIGIBLE PORTION				
I)	Procurement/Construction	277,969	95,916	373,885
	Package 1 (Middle Section-South)	61,667	20,010	81,677
	Package 2 (Middle Section-North)	82,754	25,813	108,567
	Package 3 (Pursat Bypass)	38,813	10,694	49,507
	Package 4 (North Extension)	40,969	13,657	54,626
	Package 5 (Weigh Stations)	4,816	1,211	6,027
	Dispute Board (PKG1)	260	0	260
	Dispute Board (PKG2)	779	0	779
	Dispute Board (PKG3)	260	0	260
	Dispute Board (PKG4)	177	0	177
	Base cost for JICA financing	230,495	71,385	301,880
	Price escalation	22,204	15,811	38,015
	Physical contingency	25,270	8,720	33,990
II)	Consulting services	13,362	7,121	20,483
	Base cost	11,843	5,743	17,586
	Price escalation	883	1,039	1,922
	Physical contingency	636	339	975
Total (I+II)		291,331	103,037	394,368
B. NON ELIGIBLE PORTION				
a	Procurement/Construction	0	15,036	15,036
	Utilities Relocation	0	11,254	11,254
	Mines and UXOs Removal	0	930	930
	Base cost	0	12,184	12,184
	Price escalation	0	1,485	1,485
	Physical contingency	0	1,367	1,367
b	Land Acquisition	0	8,060	8,060
	Base cost	0	8,060	8,060
c	Administration cost	0	4,175	4,175
d	VAT and Import Tax	0	40,940	40,940
Total (a+b+c+d+e)		0	68,211	68,211
TOTAL (A+B)		291,331	171,248	462,579
C. Interest during Construction		173	0	173
	Interest during Construction(Construction)	162	0	162
	Interest during Construction (Consultant)	11	0	11
GRAND TOTAL (A+B+C)		291,504	171,248	462,752
E. JICA finance portion (A+C)		291,504	103,037	394,541

Table 10-3 Annual Progress

(Unit: US$1,000)

Items \ Year		2015	2016	2017	2018	2019	2020	2021	2022	Total
Annual Progress	JICA portion	2,030	3,870	71,885	109,620	106,057	81,419	19,072	588	394,541
	RGC portion	223	9,449	23,714	12,056	11,663	8,952	2,093	61	68,211
	Total	2,253	13,319	95,599	121,676	117,720	90,371	21,165	649	462,752

11. IMPLEMENTATION PLAN

11.1 Execution Plan

(1) Road works

- In this Project, there are two types of road works; one is widening of the existing road and the other is new construction of the bypasses around the city of Pursat.
- The main scope of work of Packages 1, 2, 4 and 5 is to widen the existing NR 5 on the both sides or either side in order to accommodate the additional two lanes.
- Filling additional road embankment and consequent pavement works are the main work.
- Since NR 5 is a part of major road network in Cambodia, hindrance to the traffic needs to be minimal during construction.
- Therefore, construction works should be carried out half by half to maintain traffic capacity similar to that of the existing road during construction.
- The process of road works of the widening of the exiting NR 5 allowing the smooth flow of traffic is illustrated in Figures 11-1 to 11-4.

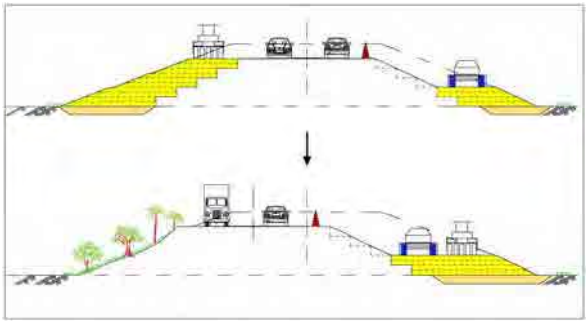


Figure 11-1 Embankment Works (1)

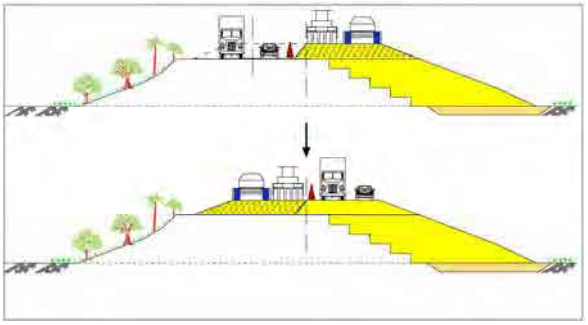


Figure 11-2 Embankment Works (2)

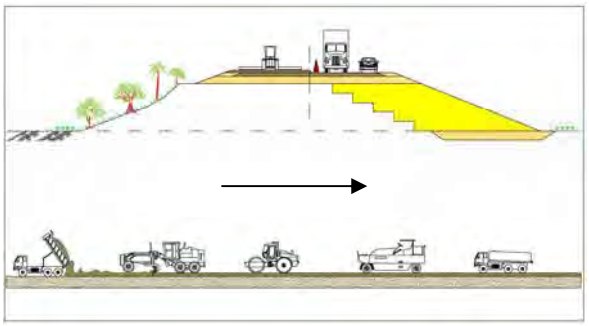


Figure 11-3 Base and Subbase Course Works

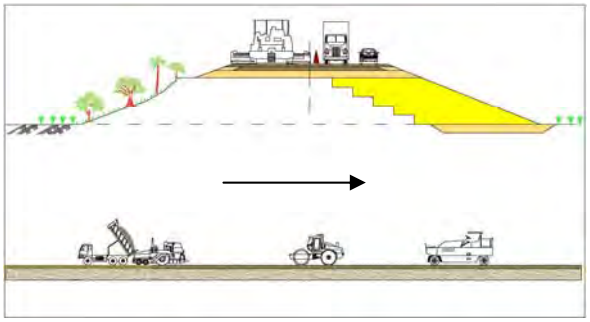


Figure 11-4 Asphalt Concrete Works

- On the other hand, construction of the Pursat Bypass (Package 3) is construction of a new road mainly in paddy field or vacant land, and the works are relatively straight- forward.

(2) Borrow Pit and Quarry

- More than 3.5 million m^3 of embankment material (soil) and nearly 2.8 million m^3 of aggregate are needed for the Project.
- The JICA Team has surveyed the possible quarries near the Project site and identified 5 candidates of quarries/borrow pits, as shown in Figure 11-5.
- In addition to the quarries/borrow pit shown in Figure 11-5, some other supplier of embankment material, such as sands dredged from the nearby rivers are commercially operating.
- Thus the JICA Team is reasonably convinced that the required soil material and aggregates can be procured with reasonable costs.

Figure 11-5 Location of Candidate Quarries/Borrow Pits

(3) Bridge Works

- There are also two types of bridge works, which are rehabilitation to existing bridges (along the existing NR 5) and new bridge construction (along the bypass).
- Three kinds of bridge works are planned as the rehabilitation of the bridges on the existing NR 5; construction additional bridges, widening of existing bridges and construction of new bridges after demolishing the existing bridges.
- Temporary bridge is required for detour of traffic during construction of some bridges.

11.2 Implementation Schedule

- The followings are most probable schedule in each task.

(i) Feasibility study (FS): The final report is submitted in October 2014.

(ii) RGC Action for Approval on FS: The RGC will take a few months for approval.

(iii) Negotiation of Loan Agreement: This step includes the following process:

- Fact finding mission from by JICA
- JICA appraisal mission
- Pledge of loan
- Signing of loan agreement

(iv) Selection of Consultant: Selection will take 12 months.

(v) Engineering Study: This task will be completed in 9 months.

(vi) Selection of Contractors: Selection will take 15 months, including PQ process (3 months).

(vii) Land Acquisition/Resettlement: This task will take 19 months after basic design.

(viii) Relocation, Removal and/or Protection of Utilities: This task will take twelve months after detail design.

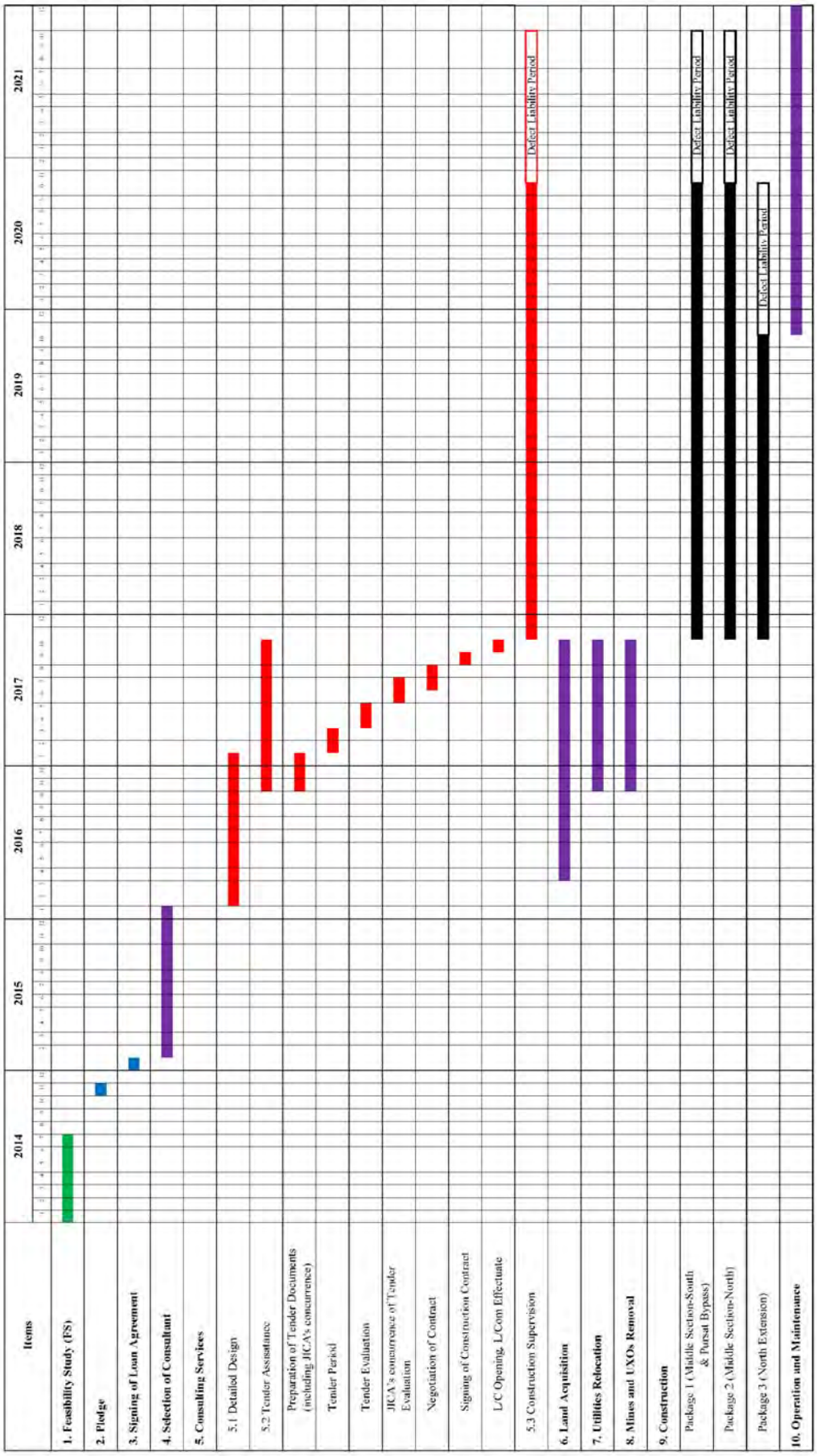
(ix) Detection and Removal of Mines / UXOs: This task will take 4 months after detail design and be carried out during dry season only.

(x) Construction: Packages 1, 2, 4 and 5 is expected to be complete in three years.

(xi) Works of Package 5 (renewal/ construction of weigh stations) can be started in parallel to the pavement works of each packages and is

- The schedule is shown in Table 11-1 Implementation Schedule.
- If the selection of consultant is started in early 2015, the civil works are expected to start in late 2017 and completed in late 2020.

Table 11-1 Implementation Schedule



12. MAINTENANCE AND OPERATION PLAN

12.1 Maintenance and Operation Cost

- There are two kinds of maintenance, which are routine maintenance and periodic maintenance.
- Routine maintenance needs to be implemented every year after completion.
- As described in Chapter 8 Highway Design, the design period of the pavement for this Project is 10 years. Thus, overlay of 5cm thickness becomes necessary every 10 year after completion as the periodic maintenance.
- Unit rate of future routine maintenance cost of the Project road is estimated at US$ 3,000/km, based on the experience in the past and routine maintenance cost is shown in Table 12-1.

Table 12-1 Cost of Routine Maintenance

Section	Unit Rate ($1,000/km)	Length (km)	Amount ($1,000)
Middle Sect.-South	3	49.0	147
Middle Sect.-North	3	55.2	166
Sri Sophorn-Poipet	3	35.8	107
Pursat Bypass	3	9.0	27
Total		149.0	447

- Periodic maintenance cost in each 10-year is computed based on the unit price of US$ 14/m^2 of overlay (5cm-thick asphalt concrete).

12.2 Annual Road Maintenance and Operation Cost

- Annual road maintenance and operation cost with 2013 price and including escalation in each year is as shown Table 12-3.

Table 12-2 Cost of Periodic Maintenance

Items	Unit Rate (USD)	Length (km)	Amount ($1,000)
Middle Section-South			
Rural Area	USD 14/m^2 x 15.0m x 1,000 = USD 210,000/km	47.6	9,996
Urban Area	USD 14/m^2 x 20.0m x 1,000 = USD 280,000/km	1.4	392
Sub-Total		49.0	10,388
Middle Section-North			
Rural Area	USD 14/m^2 x 15.0m x 1,000 = USD 210,000/km	54.7	11,487
Urban Area	USD 14/m^2 x 20.0m x 1,000 = USD 280,000/km	0.5	140
Sub-Total		55.2	11,627
North Extension			
Rural Area	USD 14/m^2 x 15.0m x 1,000 = USD 210,000/km	35.1	7,371
Urban Area	USD 14/m^2 x 20.0m x 1,000 = USD 280,000/km	0.7	196
Sub-Total		35.8	7,567
Pursat Bypass			
Rural Area	USD 14/m^2 x 15.0m x 1,000 = USD 210,000/km	9.0	1,890
Urban Area	USD 14/m^2 x 20.0m x 1,000 = USD 280,000/km	0	0
Sub-Total		9.0	1,890
Total		149.0	31,472

Table 12-3 Annual Road Maintenance and Operation Cost

(Unit: US$1,000)

Year	Costs with 2013 price			Costs with escalation applied		
	Routine Maintenance	Periodic Maintenance	Total	Routine Maintenance	Periodic Maintenance	Total
2020	447		447	536		536
2021	447		447	551		551
2022	447		447	565		565
2023	447		447	581		581
2024	447		447	596		596
2025	447		447	613		613
2026	447		447	618		618
2027	447		447	623		623
2028	447		447	628		628
2029	447	31,472	31,919	634	44,571	45,205
2030	447		447	639		639
2031	447		447	644		644
2032	447		447	649		649
2033	447		447	655		655
2034	447		447	660		660
2035	447		447	666		666
2036	447		447	672		672
2037	447		447	677		677
2038	447		447	683		683
2039	447	31,472	31,919	689	48,450	49,139
2040	447		447	695		695
2041	447		447	700		700
2042	447		447	706		706
2043	447		447	712		712
2044	447		447	718		718
2045	447		447	725		725
2046	447		447	731		731
2047	447		447	737		737
2048	447		447	743		743
2049	447	31,472	31,919	750	52,750	53,500
2050	447		447	756		756
2051	447		447	763		763
2052	447		447	769		769

12.3 Routine Maintenance and Its Cost Required after Completion of the Project

- After this Project will be completed and the pavement will be improved to asphalt concrete (AC), the maintenance cost is expected to be reduced since AC pavement is more durable than DBST.
- On the other hand, more diligent maintenance/operation than those currently practiced will be required after the road improvement will be completed and travel speed of vehicles will increase.

- Also increased volume of international traffic in the future will require road maintenance and operation of international level.
- As a part of ASEAN Highway No. 1, NR 5 will have to be maintained in a good condition.
- Table 12-4 shows the proposed work items and their costs of routine maintenance required after completion of the Project.
- The unit rate maintenance cost per km is estimated at $6,400 which is more than two times of the current expenditure on maintenance of national roads.
- It is strongly recommended that MPWT and MEF consult and secure sufficient budget for such appropriate road maintenance.
- It is possible that the revenue of RGC will be increased in the near future as the national economy will grow and RGC will be able to allocate adequate budget for road maintenance by the time when the project of improvement of NR 5 will be completed.

Table 12-4 Cost of Routine Maintenance Required after Completion of the Project

Toutine Maintenance		Unit Rate (USD 1,000)	Quantity		Frequency per year	Amount (USD 1,000)	Remarks on Assumed Unit Rate	
							Works & assumed Quantity per day	Output per day
Road	Road Cleaning	0.274	149.0	km	2	82	Clean road surface, and dispose of trash and dust: 5 men-day/km x 2km x 2 (both sides) = 20 men-day	2km of road
	Repair of pavement defects	0.861	149.0	km	2	257	Repair pot holes (assuming 6m2 pot hole per 1km road) with cold mix asphalt	1km of road
	Cleaning of side ditch & drainage	0.385	74.5	km	1	29	Clean out side ditchs & drainage along road, and dispose trash and mud: 1 man-day/100m x 2,000m x 2 (both sides) = 40 men-day	2km of road
	Repair of defective traffic sign	0.311	149.0	km	1	46	Clean & check traffic signs, and replace one traffic sign post in 4km of road: 2 signs/km x 4 km x 2 (both sides) = 8 signs; 1.7 case of accident/km/yr x 4 km = 6.8 cases/yr	4km of road
	Repair of defective lane mark	1.080	149.0	km	1	161	Clean lane maks, and remark lines (assuming 300m) in 1km of road:	1km of road
Culvert	Cleaning of culverts	0.347	411	nos	1	143	Clean and wash culverts, and dispose of trash and mud: 3m x 2 x 30m x 0.2 m = 36m3/culvert	2 culverts
Guard Rail	Repair of damaged gurd rail	0.010	3,200	m	1	32	Clean & check guard rails, and replace damaged portion (assuming 4m) in 100m of guard rails: 1.7 accicent/1,000m/yr x 100m = 0.17 accident/yr/100m; Replace 20m/accident 0.17 x 20m = 3.4m -> 4m	100m of guard rails
Street Light	Repair of defective street light	0.176	114	nos	1	20	Clean & check street lights, and replace 2 sets of lamp and lamp shed in 10 of streeet lights	10 street lights
Bridge	Cleaning of bridge surface	0.001	34,216	m2	2	68	Clean out bridge surface & bridge rails, and dispose of trash and dust	460m2 of bridge surface
	Repair of bridge pavement defects	0.001	34,216	m2	2	68	Repair pot holes (assuming 1m2 pot hole per 690m2 per bridge surface)	690m2 of bridge surface
	Cleaning of expansion joints of bridges	0.011	2,265	m	2	50	Clean out expansion joints, and dispose of trash and dust, etc.	50m of expansion joint
	Total					956		
		Unit Rate per Road Length =	6,400	USD/km				

13. PROJECT EVALUATION

13.1 General

- To measure the Project's operational and effectiveness conditions, appropriate indices are established based on the goals, objectives and functional characteristics of the Project.
- Improvement of the Middle Section and Sri Sophorn–Poipet Section of NR 5 and construction of the Pursat Bypass has the direct objective of facilitating transportation of goods and passengers.
- As the result of improvement of traffic and transportation, the Project will contribute to socio-economic development of Cambodia as well as to promote regional development.
- With this concept, goals and objectives of the Project can be stated as follows:

Goals

- To facilitate transportation of goods and passengers,
- To promote and activate regional economy

Direct objectives

- To promote regional development along NR 5.
- To ensure the safety of pedestrian and comfort of travel
- To reduce road maintenance cost by strengthening the pavement structure.
- To improve condition of environment pollution.

13.2 Evaluation Index

- Performance of a project is usually evaluated in two aspects; degree of achievement of the targets in operation stage and their effectiveness.
- Degree of achievement in operation, in case of a road project, mainly refers to traffic volume.
- Effectiveness of a road project is degree of improvement of traffic conditions against increase of traffic demand.
- Operation and effect indicators are designed to evaluate and monitor the project performance and its effectiveness.
- The indicators are divided into two; indicators for direct benefit accruing use of the road and those for indirect benefits which are brought about as the results of improvement in traffic/transport conditions.
- Table 13-1 lists the direct and indirect benefits.

Table 13-1 Direct and Indirect Benefit

Direct Benefit
(a) Increase in traffic volume
(b) Reduction of traffic congestion
(c) Reduction of travel time
(d) Reduction of travel cost
(e) Reduction of traffic accident
(f) Saving in road maintenance cost
(g) Emission gas reduction
Indirect Benefit
(a) Promotion of regional development
(b) Product market expansion
(c) Creation of employment opportunities

13.3 Operation and Effect Monitoring Plan

- The operation and effect of the Project will be monitored by measuring impact indicators.
- The targets of the indictors are estimated in accordance with the planned monitoring timing as shown in Table 13-2.

Table 13-2 Operation and Effect Indicator

Indicators	Road	Year 2012	Present Year	2 years after Completion, Projected as Year 2022
Dauly Traffic (PCU/day)	Thlea Ma'am–Battambang	6,062	-	12,748
	Pursat Bypass	-	-	11,276
	Sri Sophorn–Poipet	7,421	-	14,688
Travel Time (minutes	Middle Section	(Existing NR 5) 116	-	(Improved NR 5 + Bypass) 126
	Sri Sophorn–Poipet	44	-	36

13.4 Economic Analysis

(1) Objective

- The main purpose of economic analysis for this survey is to show the effects of the road improvement of the project from viewpoint of national economy. It aims at evaluating the economic viability of the project implementation.

(2) Methodology

- Economic analysis is carried out through economic cash flow analysis based on 'cost-benefit' analysis. Benefits accruing from the Projects are (i) time saving benefit and (ii) vehicle operation cost saving benefit, while the Project cost consists of (i) construction cost, (ii) land acquisition cost and (iii) operation/maintenance cost.
- Travel time costs (TTC) is the value of time spent in traveling that could be used in other working activities.
- Vehicle operating costs (VOC) is the physical costs of operating a vehicle such as consumption of fuel, lubricants, spare parts, and so on.
- In order to evaluate the road projects from an economic view point, the following economic indicators were estimated:
  - Economic Internal Rate of Return (EIRR)
  - Benefit /Cost Ratio (B/C Ratio)
  - Net Present Value (NPV)
- Evaluation period is set as 30 years after opening to traffic. The annualized factor of the daily benefits is assumed to be 340 days per year taking into consideration the weekly variation in the volume of traffic.
- A discount rate of 12% is assumed, taking into account the opportunity cost of capital in Cambodia.
- The operation of the Project roads are assessed based on the comparative analysis of indices of traffic result in two cases of "with Project" and "without Project".

(3) Estimation of Economic Cost

- Economic cost is converted from financial cost by deducting tax portions and applying the standard conversion factor to the non-trade.

13.5 Economic Evaluation

(1) Cost Benefit Analysis

- The project is evaluated in terms of EIRR, B/C ratio and NPV with assumed operation period of 30 years.
- The social discount rate of 12.0% was used in the economic evaluation.
- Table 13-3 (next page) shows the cost-benefit stream of the Project.
- The result of analysis shows EIRR of 15.1% as shown in Table 13-4 (next page).
- Compared with the discount rate of 12%, it can be said that economic viability is secured at a feasible level.

(2) Sensitivity Analysis

- Sensitivity analysis is made on the cases with +10% and -10% in both of the cost and benefit. The results of the sensitivity analysis are shown in Table 13-5 (next page).
- The results of sensitivity analysis shows that EIRR is nearly 14% even in the worst case with -10 % in the benefits and +10% in the project costs.
- This value exceeds the opportunity cost in Cambodia of 12%. The implementation of the project is judged to be economically feasible from this analysis result.
- Cost-benefit analysis and sensitivity analysis was made also for the case where the upgraded maintenance is practiced and the routine maintenance cost of US$6,400 /km/year is expended.

(3) Economic Analysis with Increased Maintenance Cost

- Table 13-6 (next page) shows the result of the sensitivity analysis with the routine maintenance cost of US$6,400/km/year.

13.6 Conclusion

- The Project will yield sufficient economic return and is viable from economic viewpoint. Traffic volume and travel time are proposed as the indicator for monitoring the performance and effectiveness of the Project.

Table 13-3 Cost-Benefit Stream of the Project

SQ	Year	Project Cost	Maintenance Cost	Total Cost	Benefit	Net Benefit	Discount Cash Flow (at 12%)		
							Cost	Benefit	Net Benefit
	2015	2,231		2,231		-2,231	2,231	0	-2,231
	2016	12,382		12,382		-12,382	11,055	0	-11,055
	2017	93,244		93,244		-93,244	74,333	0	-74,333
	2018	120,470		120,470		-120,470	85,748	0	-85,748
	2019	116,554		116,554		-116,554	74,072	0	-74,072
	2020	89,476		89,476		-89,476	50,771	0	-50,771
1	2021	20,956	436	21,392	13,148	-8,243	10,838	6,661	-4,176
2	2022	641	436	1,077	15,021	13,944	487	6,795	6,308
3	2023		436	436	19,965	19,529	176	8,064	7,888
4	2024		436	436	23,570	23,135	157	8,500	8,343
5	2025		436	436	27,604	27,168	140	8,888	8,747
6	2026		436	436	32,110	31,674	125	9,231	9,106
7	2027		436	436	37,136	36,701	112	9,532	9,420
8	2028		436	436	54,297	53,861	100	12,443	12,343
9	2029		436	436	71,285	70,849	89	14,586	14,497
10	2030		30,685	30,685	90,348	59,663	5,606	16,506	10,900
11	2031		436	436	111,692	111,256	71	18,219	18,148
12	2032		436	436	135,539	135,103	63	19,740	19,677
13	2033		436	436	200,918	200,482	57	26,127	26,071
14	2034		436	436	213,192	212,756	51	24,753	24,702
15	2035		436	436	226,222	225,786	45	23,452	23,406
16	2036		436	436	240,037	239,601	40	22,218	22,177
17	2037		436	436	254,716	254,280	36	21,050	21,014
18	2038		436	436	341,621	341,186	32	25,208	25,175
19	2039		436	436	362,482	362,046	29	23,881	23,852
20	2040		30,685	30,685	384,615	353,930	1,805	22,624	20,819
21	2041		436	436	408,099	407,663	23	21,434	21,411
22	2042		436	436	433,015	432,579	20	20,306	20,285
23	2043		436	436	553,582	553,147	18	23,178	23,160
24	2044		436	436	587,375	586,939	16	21,958	21,942
25	2045		436	436	617,388	616,952	15	20,607	20,593
26	2046		436	436	648,827	648,392	13	19,336	19,323
27	2047		436	436	681,940	681,504	12	18,146	18,134
28	2048		436	436	716,742	716,306	10	17,028	17,018
29	2049		436	436	587,601	587,165	9	12,464	12,455
30	2050		30,685	30,685	617,539	586,854	581	11,696	11,115
	Total	455,953,600	103,823	559,776	8,707,625	8,147,849	318,989	514,631	195,643

Table 13-4 Result of Economic Analysis

Indicator	Result
EIRR (%)	15.1
B/C Ratio	1.62
NPV（US$ million）	195.6

Table 13-5 Result of Sensitivity Analysis

Case		Economic Indicator	Benefits		
			-10%	Base Case	+10%
Costs	-10%	NPV*	156.3	202.3	248.2
		B/C	1.61	1.79	1.97
		EIRR	15.0%	15.8%	16.4%
	Base Case	NPV*	128.7	195.6	220.6
		B/C	1.45	1.61	1.77
		EIRR	14.4%	15.1%	15.7%
	+10%	NPV*	101.1	147.1	195.7
		B/C	1.32	1.47	1.61
		EIRR	13.8%	14.4%	15.1%

Table 13-6 Sensitivity Analysis for Increased Routine Maintenance Expenditure

Case		Economic Indicator	Benefits		
			-10%	Base Case	+10%
Costs	-10%	NPV*	154.4	200.4	246.3
		B/C	1.60	1.77	1.95
		EIRR	15.0%	15.7%	16.4%
	Base Case	NPV*	126.8	193.5	218.7
		B/C	1.44	1.60	1.76
		EIRR	14.3%	15.0%	15.7%
	+10%	NPV*	99.2	145.2	193.6
		B/C	1.32	1.46	1.60
		EIRR	13.7%	14.4%	15.0%

14. NOTE FOR IMPLEMENTATION OF JAPANESE YEN LOAN PROJECT

14.1 General

- Through the long experiences of implementation of Japanese ODA loan projects, JICA has found many important points which need attention from the view point of smooth implementation of projects as well as to fully achieve the objectives of projects.
- MPWT established the Project Management Unit for the North Section in November 2012 to manage the Project.
- The PMU has completed procurement of the consultant services for the detailed design (DD) and construction supervision (C/S) and has accumulated some experience in the procurement of consultant services
- Likewise, the experience of implementation of Japanese ODA loan project will be accumulated within this PMU through implementation of the Project of North Section and the South Section.
- However, the notes for implementation of Japanese ODA loan project is reiterated here to draw attention to important points.

14.2 Pre-Construction Stage

- The issue "Land Acquisition, Relocation and Mitigation Plan for Affected Families" is one of the most important points in the pre-construction stage.
- MPWT is expected to utilize the past experiences, including that of North Section and South Section.
- Sometime, the time spent for approval procedures of key actions, such as approval of selection of consultant for detailed design and construction supervision take longer than expected, and delay in such approval often becomes the main cause of the delay in implementation of the project.

14.3 Procurement Stage

- In the procurement stage, most important thing is to employ competent consultant and good contractors. Competent consultants and good contractors, in many cases, can prevent many risks, such as poor work quality, delay in progress and cost overrun, from occurring.
- To recruit a good consultant, weight of financial proposal in the evaluation of proposal with QCBS needs to be as small as possible. In case of consultant services, low price becomes possible only with low-priced experts who often do not have required skill / knowledge / experience.
- Offering large-size contract packages is one of practical measures for employing good contractors.
- There have been cases in the past where contractors with poor ability were employed. Employment of a competent consultant can prevent to a certain extent the problem caused by a contractor with poor capacity.

14.4 Construction Stage

- Quality control is utmost importance in road construction/rehabilitation.
- Employment of competent consultant and good contractors is the key to successful quality management.

14.5 Operation and Maintenance Stage

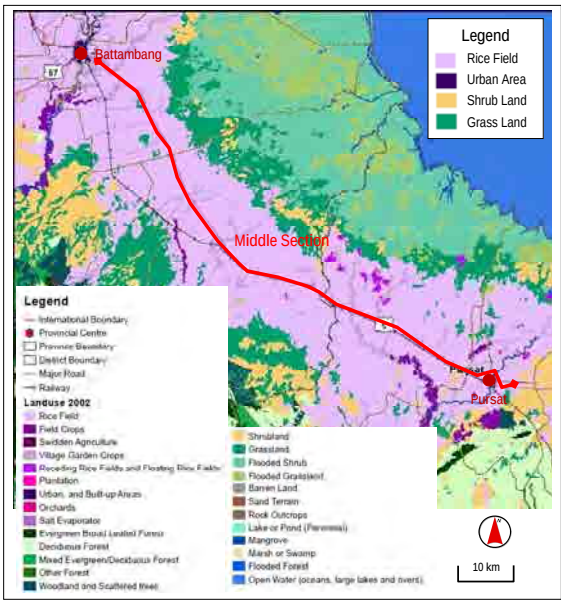
- AC pavement needs rehabilitation every 10 years and MPWT needs to prepare relatively large fund for this pavement rehabilitation.
- After the completion of the Project, higher level of maintenance than preset will be required and larger amount of maintenance budget will be needed.
- Overloaded trucks severely damage pavement. Enforcement against overloaded trucks is indispensable to secure expected life period of pavement
- There is a possibility that some pedestrians cannot respond to the increased speed of vehicles. It is recommended that traffic safety campaign be implemented.

15. ENVIRONMENTAL CONSIDERATION

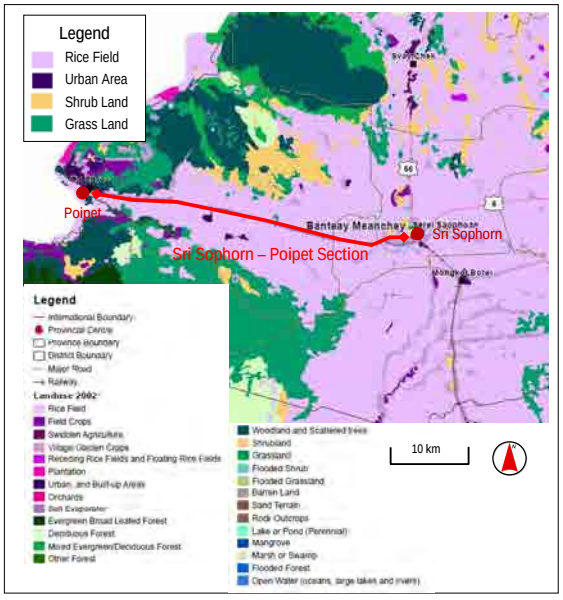
15.1 Natural Environment

(1) Land Use and Forest Area

- The land use around the target section of NR 5 is mostly rice field. The others are mainly shrub land or urban area.
- There are no considerable natural vegetation areas including forest around the project area. Flooded forest zone exists around the Tonle Sap Lake. However, the distance between NR.5 and the forest zone is approximately 7km at the nearest point.



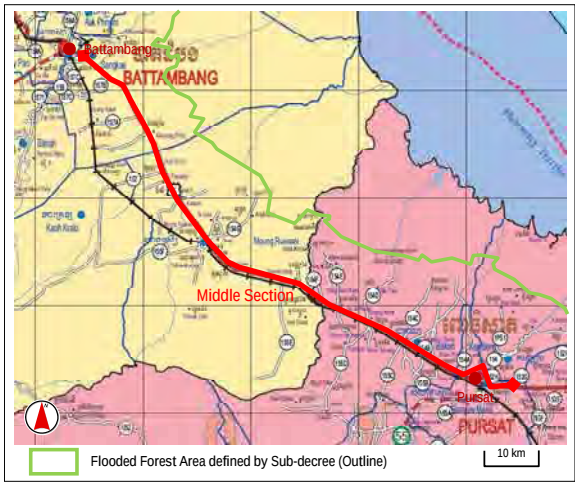
Middle Section



Sri Sophorn–Poipet Section

Source: The Atlas of Cambodia, 2007

Figure 15-1 Land Use around NR 5

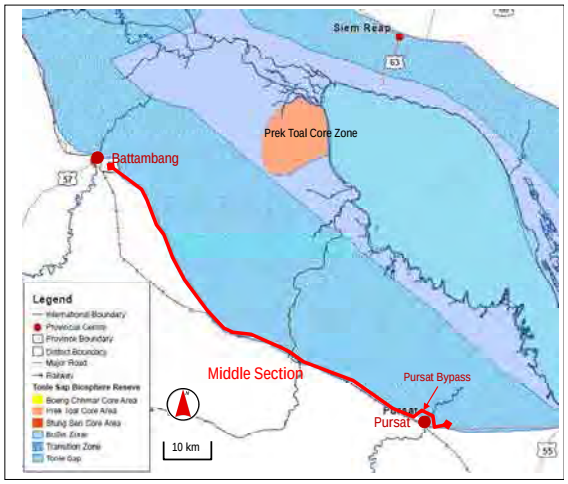


Source: Open Development Cambodia

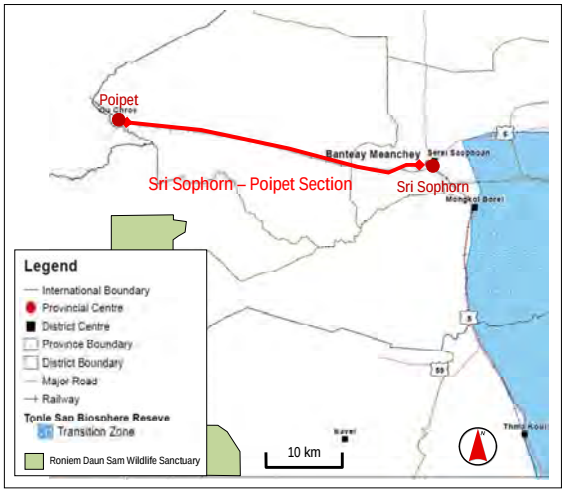
Figure 15-2 Forest Area around NR 5

(2) Protected Area

- The target sections of NR 5 do not pass through protected areas for natural environment.
- However, the middle section runs alongside the line of transition zone in "Tonle Sap Biosphere Resave (TSBR)" that covers Tonle Sap Lake, the largest fresh water lake in Southeast Asia, and its surrounding flood plain and is recognized as a worldwide important zone for sustainable use and conservation of wildlife and research ground.
- TSBR has been designated by UNESCO in 1997 and classified into the core area, buffer zone and transition zone.
- The core areas are defined likewise national park or wildlife sanctuary, where development activities are limited. The distances between the middle section and the core areas or the buffer zone are approximately 30km or 20km at the nearest point, respectively.



Middle Section



Sri Sophorn–Poipet Section

Source: The Atlas of Cambodia, 2007

Figure 15-3 Protected Area around NR 5

15.2 Social Environment

(1) Administration

- The Middle Section covers two provinces of Pursat and Battambang. Under the two provinces, there are six districts in the existing NR 5 and Pursat Bypass sections. The Sri Sophorn–Poipet Section traverses Banteay Meanchey Province. There are two districts in this section of existing NR 5.

(2) Population, Gender and Ethnic Minority

- Based on the census in 2008, the population and household are shown in Table 15-1. The average house hold size is about five persons and same among the three provinces.

Table 15-1 Population and Households

Province	Population			House-holds
	Total	Male	Female	
Pursat	397,161	192,954	204,207	83,745
Battambang	1,025,174	506,531	518,823	210,853
Banteay Meanchey	677,872	331,715	346,157	145,219

Source: General Population Census of Cambodia

- The women's rate is relatively high due to civil conflicts in Cambodia. The women's rate in labor force, regardless official or unofficial, is also high. Around 20% of households are female headed in Tonle Sap Zone.
- People loving along the target section is mainly Khmer (Cambodian). Cham people professing Islam also lives along the project area.

(3) Industry

- Main industry along the target sections is agriculture including paddy rice culture and inland water fisheries. Manufacture including textile industry, retail business and catering trade with small scale are also developed along the target sections. These products are transported to neighborhood areas and Phnom Penh through NR 5.

Figure 15-4 Typical Scenery in Agricultural Village

15.3 EIA System

- According to "Law on Environmental Protection and Natural Resource Management", a project owner defined in "Sub-decree on Environmental Impact Assessment Process" must conduct an EIA study on the basis of "General Guideline for Conducting Initial and full Environmental Impact Assessment Reports" and obtain the approval from the Ministry of Environment. In road sector, national road construction projects with more than 100km long and bridge construction projects with more than 30 ton weight need the EIA study.
- A project owner conducts Initial Environmental Impact Assessment (IEIA) for projects with substantial environmental impacts or Full Environmental Impact Assessment (FEIA) for projects with significant environmental impacts. The Project needs to conduct a FEIA.
- The schedule of EIA procedure for the Project is shown in Table 15-2.

Table 15-2 Schedule of EIA Procedure

Year	2013							2014					
Month	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan ~ May		Jun	Jul	Aug	Sep
Contract with EIA Consultant	▲												
Literature and Field Survey, EIA Study and Reporting by Consultant													
Fixing on Conceptual Design and Alignment by JICA Survey Team						▲							
Review of First Draft EIA by JICA Survey Team													
Submission of Final EIA Report to MOE												▲	
Review of EIA report by MOE													
Approval on EIA report													▲

15.4 Environmental and Social Impact

- The potential environmental and social impacts of the Project are summarized in Table 15-3.

15.5 Main Mitigation Measures

(1) Resettlement:

- Authorities concerned shall prepare and strictly implement a proper Resettlement Action Plan (RAP).

(2) Environmental pollution during construction phase:

- The contractor shall prepare and strictly implement mitigation measures against environmental pollution. The supervision consultant shall monitor the environmental conditions and complaint from the local people. If troubles of some sort occur, the supervision consultant and contractors should reconsider the construction technique and method.

(3) Ecosystem, Hydrology and Water usage:

- To maintain existing surface flow condition, newly constructed bridges and culverts should have sufficient flow capacity and be installed at same locations as existing flow.

(4) Cultural heritage:

- The project owner shall discuss the mitigation and protect measures with Provincial Authorities. The detail design consultant should consider the alignment to escape these properties at first. Proper relocation or storage plans should be prepared in advance. If the removals are required, the removal works should respect and follow Khmer tradition and culture.

(5) Impacts on local society and ecosystem in service phase:

- It is difficult to assess the long term impacts on local society and ecosystem including the Tonle Sap Zone exactly. The authorities concerned should conduct periodical monitoring of each aspect. If troubles of some sort occur, the agencies should consider and implement the countermeasures.

15.6 Environmental Management Plan

- The Environmental Management Plan (EMP) provides institutional arrangement, environmental monitoring plan during construction and operation, and training and staffing.
- The objectives of EMP are to show the tasks which will be implemented by the relevant governmental institutions.
- It should be noted that the EMP is considered as an operational document that will be frequently updated by MPWT with assistance/advice the supervision consultant.

Table 15-3 Potential Environmental and Social Impact

Impact Item	Assessment		Potential Impact / Reason
	Phase		
	Pre-construction and Construction	Operation	
	Activities		
	Land acquisition Construction works	Existence Service	
Environmental Pollution			
Air pollution	B-	B±	**Construction Phase:** ・ Dust and emission gas caused by construction works ・ Dust in borrow pit or quarry site **Operation Phase:** ・ Increase of air pollutants in vehicle exhaust gas due to increase in traffic volume. ・ Decrease of air pollutant due to reduction in fuel consumption of vehicles caused by mitigation of traffic congestion and increase in vehicle speed.
Water pollution	B-	D	**Construction Phase:** ・ Turbid water caused by construction works ・ Accidental massive leaking of fuel or oil ・ Turbid water from borrow pit or quarry site **Operation Phase:** ・ No impact
Waste	B-	C-	**Construction Phase:** ・ Construction waste **Operation Phase:** ・ Illegal dumping of solid waste
Soil pollution	D	D	**Construction Phase:** **Operation Phase:** ・ No impact
Noise and vibration	B-	B-	**Construction Phase:** ・ Noise and vibration caused by construction works ・ Noise and vibration in borrow pit or quarry site **Operation Phase:** ・ Increase in noise level caused by growing vehicles
Ground subsidence	C-	D	**Construction Phase:** ・ Subsidence caused by filling works **Operation Phase:** ・ No impact
Offensive odors	D	D	**Construction Phase:** **Operation Phase:** ・ No impact
Bottom sediment	D	D	**Construction Phase:** **Operation Phase:** ・ No impact
Natural Environment			
Protected areas	B-	C-	**Construction Phase:** ・ Newly constructed Pursat Bypass will pass through the transition zone of "Tonle Sap Biosphere Reserve (TSBR)". ・ Impacts of construction works on water flow in river or stream ・ Loss of roadside vegetation along TSBR **Operation Phase:** ・ Indirect impacts on TSBR
Ecosystem	B-	C-	**Construction Phase:** ・ Loss of roadside vegetation including roadside trees and riverside vegetation ・ Impact on agricultural ecosystem ・ Impact of turbid water caused by bridge construction on aquatic life **Operation Phase:** ・ Impact of change of surface water flow in embankment sections on remote aquatic ecosystem
Hydrology	B-	B-	**Construction Phase:** ・ Alteration of water flow in river or stream by construction works **Operation Phase:** ・ Impact caused by newly constructed embankment on surface water flow

Impact Item	Assessment		Potential Impact / Reason
	Phase		
	Pre-construction and Construction	Operation	
	Activities		
	Land acquisition Construction works	Existence Service	
Geographical features	B-	D	**Construction Phase:** ・ Change of topography in bypass or embankment sections, borrow pit and quarry site. **Operation Phase:** ・ No impact
Social Environment			
Resettlement/ Land Acquisition	A-	D	**Pre-Construction Phase:** ・ Resettlement and additional land acquisition **Construction Phase:** ・ Temporal lease of land for construction yard **Operation Phase:** ・ No impact
Poor people	B-	B-	**Pre-Construction Phase:** **Operation Phase:** ・ Impact including loss of business opportunity of resettlement on poor people
Ethnic minorities and indigenous peoples	C-	D	**Pre-Construction Phase:** **Operation Phase:** ・ Impacts of widening works on ethnic minorities living in roadside **Operation Phase:** ・ No impact
Local economies, such as employment, livelihood, etc.	B±	B±	**Pre-Construction Phase:** ・ Impact of land acquisition and resettlement on livelihood of Project Affected Persons **Construction Phase:** ・ Creation of job opportunities to local people ・ Impacts of bridge construction on local fishery **Operation Phase:** ・ Contribution to local economies ・ Widening gap in local economy
Land use and utilization of local resources	B-	B+	**Construction Phase:** ・ Change of land use in bypass sections **Operation Phase:** ・ Development of economy and social condition ・ Contribution to utilization of local resources
Water usage	B-	B-	**Construction Phase:** ・ Impact caused by newly constructed bypass or widening works on existing agricultural cannels **Operation Phase:** ・ Impact caused by newly constructed bypass, embankment or culvert on surface water flow
Existing social infrastructures and services	B-	B±	**Pre-Construction Phase:** ・ Relocation or protection of existing utilities **Construction Phase:** ・ Temporary traffic congestion **Operation Phase:** ・ Improvement of access to social services ・ Spilt of local communities or widening disparity
Social institutions such as social infrastructure and local decision making institutions	D	C-	**Operation Phase:** ・ Because of existing road improvement, no impact **Construction Phase:** ・ Spilt of local communities caused by newly constructed bypass
Misdistribution of benefits and damages	D	B-	**Pre-Construction Phase:** **Construction Phase:** ・ Because of existing road improvement, no impact **Operation Phase:** ・ Misdistribution of benefit between new bypass and existing NR 5 (old route)

Impact Item	Assessment		Potential Impact / Reason
	Phase		
	Pre-construction and Construction	Operation	
	Activities		
	Land acquisition Construction works	Existence Service	
Local conflicts of interest	D	D	**Construction Phase:** **Operation Phase:** ・ Because of existing road improvement, no impact
Cultural heritage	B-	C-	**Construction Phase:** ・ Impact caused by widening works on cultural or religious properties **Operation Phase:** ・ Impact of tourism development on religious value
Landscape	B-	D	**Construction Phase:** ・ Loss of road side trees **Operation Phase:** ・ No impact
Gender	C-	C-	**Construction Phase:** **Operation Phase:** ・ Impact on street women's venders
Children's rights	D	B±	**Construction Phase:** ・ No impact **Operation Phase:** ・ Traffic accident of children due to more traffic volume and faster vehicle speed ・ Improvement of safety by widening footpath
Infectious diseases such as HIV/AIDS	B-	D	**Construction Phase:** ・ Infection risks of HIV/AIDS **Operation Phase:** ・ No impact
Working conditions (including occupational safety)	B-	D	**Construction Phase:** ・ Dust and emission gas caused by construction works ・ Deterioration of sanitary conditions **Operation Phase:** ・ No impact
Accidents	B-	B±	**Construction Phase:** ・ Traffic accident surrounding of construction site **Operation Phase:** ・ Improvement of traffic safety by road widening and vehicle separation ・ Traffic disturbance caused by newly installed center divider ・ Traffic accident due to more traffic volume and faster vehicle speed
Other			
Trans-boundary impacts or climate change	D	C±	**Construction Phase:** ・ Construction works having trans-boundary impacts including climate change will not be conducted. **Operation Phase:** ・ Increase of CO_2 emission from vehicles due to increase in traffic volume. ・ Decrease of CO_2 emission due to reduction in fuel consumption of vehicles caused by mitigation of traffic congestion and increase in vehicle speed.

A+/-: Significant positive/negative impact is expected.
B+/-: Positive/negative impact is expected to some extent.
C+/-: Extent of positive/negative impact is unknown. (An environmental monitoring is needed.)
D: No impact is expected.

* Impact Items refer to "JICA Guidelines for Environmental and Social Considerations April 2010"

16. RESETTLEMENT ACTION PLAN

16.1 Institutional Arrangement

- Inter-Ministerial Resettlement Committee (IRC) is established for each specific project between MEF and Project Owner.
- IRC is headed by chairman from MEF and composed of representatives from concerned line ministries.
- The Resettlement Department (RD) of the Ministry of Economy and Finance (MEF) has a function of secretariat for IRC. IRC-WG under IRC management implements field activities with provincial resettlement sub-committee (PRSC).
- The Environmental Section of PMU, composed of International Cooperation Department (ICD), was assigned to work closely with RD of MEF and IRC for the preparation, updating, and implementation of RAP.

16.2 Legal Framework

- Article 44 of 1993 Constitution established governing principles pertaining to land acquisition.
- Land Law of 2001 governs land and property rights in Cambodia based on the provisions of 1993 Constitution.
- The Land Law defines the scope of ownership of immovable properties such as land, trees and fixed structures.
- Expropriation Law February 2010 prescribes procedures for acquiring private properties for national or public interest.
- There are several relevant Sub-Decrees and Prakas.

16.3 Project Resettlement Policy

- The objective of the project resettlement policy is to ensure that AHs are not worse off because of the project. The project should provide an opportunity for the local people to derive benefits from it, and it should likewise serve as an occasion for the local people to participate in its planning and implementation, thereby engendering a sense of ownership over the same.

16.4 Project Impacts and Compensation

(1) Total Number of Affected Households

- People whose properties, such as land, structures, fences, fruit trees, etc., will be affected by the project are estimated as Table 16-1.

Table 16-1 Number of AHs with Land

Province	Number of AHs			Total
	Thlea Ma'am–Battambang	Serei Sophorn–Poipet	Pursat Bypass	
Pursat	779	0	224	1,003
Battambang	819	0	0	819
Banteay Meanchey	0	555	0	555
Grand Total	**1,598**	**555**	**224**	**2,377**

(2) Land

- Project affected area is limited within ROW (30m from centerline in both sides) in principle and most sections required around 20m from centerline for construction. Land within ROA is not compensated but assisted with alternative relocation site if the people becomes landless.
- Pursat bypass sections require private land acquisition with the area of 296,069 m^2. Of these, more than 90% of land is used for growing rice. Totally 247 households are affected for private land acquisition.

(3) Structures

- Structures and other belongings are affected by the project and setback, physical relocation, and partial lost will be required.
- Compensation will be done based on replacement cost which is decided by house type categories.
- Table 16-2 shows AHs who lost their structures by the Project.

Table 16-2 Number of AHs with land

Province	Number of AHs			Total
	Thlea Ma'am–Battambang	Serei Sophorn–Poipet	Pursat Bypass	
Pursat	636	0	23	659
Battambang	653	0	0	653
Banteay Meanchey	0	500	0	500
Grand Total	**1,289**	**500**	**23**	**1,812**

(4) Allowance

- Social vulnerable groups (ex. widow-headed, handicap, poor) are the target for special allowance with normal compensation
- Disruption fee is paid for AHs who relocates their main structures

16.5 Public Participation and Consultation

- During RAP preparation stage, the following public consultations were held at different stages.
  - (i) Provincial Stakeholder Meeting: Participated by governors of Districts, DPWT staff, MPWT staff and consultant employed by JICA Team.
  - (ii) Public Stakeholder Meeting (before cut-off date): Participated by the people of Communes traversed by the Project Road and Bypass and other concerned parties.
  - (iii) Public Stakeholder Meeting (after cut-off date): Participated by the people of Communes traversed by the Project Road and Bypass and other concerned parties.
- In the Provincial stakeholder meeting, project outline and possible bypass alternative were disclosed.
- In the Public Stakeholder Meetings, there were not strong opposition to the proposed Project, and many questions raised were on the procedures of resettlement including compensation.

16.6 Grievance Redress

- Grievance Redress Mechanism is widely informed to PAPs through Public Meeting and project brochures as well as RAP disclosure.
- Grievance will pass through three stages (commune, district, and province) before it may be elevated to a court of law as a last resort. MPWT will shoulder all administrative and legal fees that will be incurred in the resolution of grievances and complaints.

16.7 Relocation Strategy

- IRC-WG in collaboration with PRSC will acquire a piece of land for preparing a resettlement site based on consultation with entitled AHs or their representatives.
- The location of the land will be as close as possible to their original land and will have access to nearby or on-site primary and secondary schools, health facilities and market facilities.
- "Cash for land" option will be provided especially for ethnic minority who has strong community in original residential area

16.8 Income Restoration Strategy

- Restoring the incomes of AHs whose means of livelihood have been disturbed or removed is the most concerns. Therefore, an Income Restoration Program (IRP) will be developed during resettlement implementation stage.
- After DMS, IRC will contract out to implement IRP with possible measures to restore livelihood depending on sort of income sources.

16.9 Monitoring and Evaluation

- PMU in close coordination with IRC will conduct an internal monitoring on resettlement implementation.
- The internal monitoring will include progress reports, the status of the RAP implementation, information on location and numbers of people affected, compensation amounts paid by item, and assistance provided to AHs.
- The report of monitoring results will be prepared by MPWT and submitted to IRC and JICA on quarterly basis.
- External Monitoring Agency (EMA) hired by IRC has the specific responsibility of studying and reporting on social and economic situations of AHs.

17. CONCLUSION AND RECOMMENDATION

17.1 Conclusion

(1) Exiting Condition of the Middle Section and Sri Soporn–Poipet Section

- NR 5 plays a very important role not only as the major primary road of Cambodia but also as one of the trunk road of the ASEAN highway network and Asian Highway network.
- NR 5 is expected to support the development of socio-economic activities of Cambodia, as well as to promote regional cooperation among the ASEAN countries, especially those of GMS.
- The current road widths of the Middle Section and Sri Sophorn–Poipet Section are not sufficient in view of the rapidly growing traffic volume.
- Every year, NR 5 is inundated or flooded at many locations, hampering the traffic flow and the socio-economic activities.
- Number of traffic accidents on NR 5 is the largest among those on the single-digit national roads of Cambodia.

(2) Necessity and Justification of Improvement of the Middle Section and Sri Sophorn–Poipet Section

- In view of the problems of the existing NR 5 as cited above, improvement of NR 5 is an urgent need.
- Improvement of the Middle Section and Sri Sophorn–Poipet Section is necessary from the viewpoint of consistency of the road standard since the improvement of the North Section and the South Section has been decided.
- Improvement of NR 5 is necessary not only for the growth of socio-economic activities of Cambodia but also for regional cooperation among the ASEAN and GMS countries.
- Improvement of NR 5 is expected to benefit the business activities of Japanese firms who have established factories and offices in Cambodia.
- The cost of the National Road No. 5 (Middle Section: Thlea Ma'am–Battambang and Sri Sophorn–Poipet Section) Improvement Project is estimated at USD 462 million. EIRR of this investment is calculated at approximately 15% which is considered to be sufficiently high. Thus, the project is justified.
- The Middle Section of NR 5 traverses the southwestern periphery of the Tonle Sap Biosphere Reserve, but the right of way is designated to be outside of the reserve area.
- The number of the households whose houses and other structure are affected by the project is estimated to be approximately 1,810.
- Necessary actions and measures for the social and environmental impacts are to be taken in accordance with the relevant legislations of Cambodia.

17.2 Recommendation

- It is recommended that the Middle Section and Sri Sophorn–Poipet Section of NR 5 be widened into 4-lane with a 3m-wide median division.
- Construction of the bypasses is proposed around the city of Pursat.
- Construction of the bypasses can greatly reduce the number of affected houses and/or families which will be very large if the existing NR 5 is to be widened.
- It is recommended that the resettlement and land acquisition be implemented in accordance with the Resettlement Action Plan (RAP) and Land Acquisition Plan (LAP) prepared in this survey.
- It is proposed that the impacts on the natural and living environments be mitigated by implementing adequate measures and the impacts be monitored during and after the implementation of the project as recommended in this report.