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

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

FINAL REPORT
(VOLUME I MAIN REPORT)

OCTOBER 2014

JAPAN INTERNATIONAL COOPERATION AGENCY

KATAHIRA & ENGINEERS INTERNATIONAL

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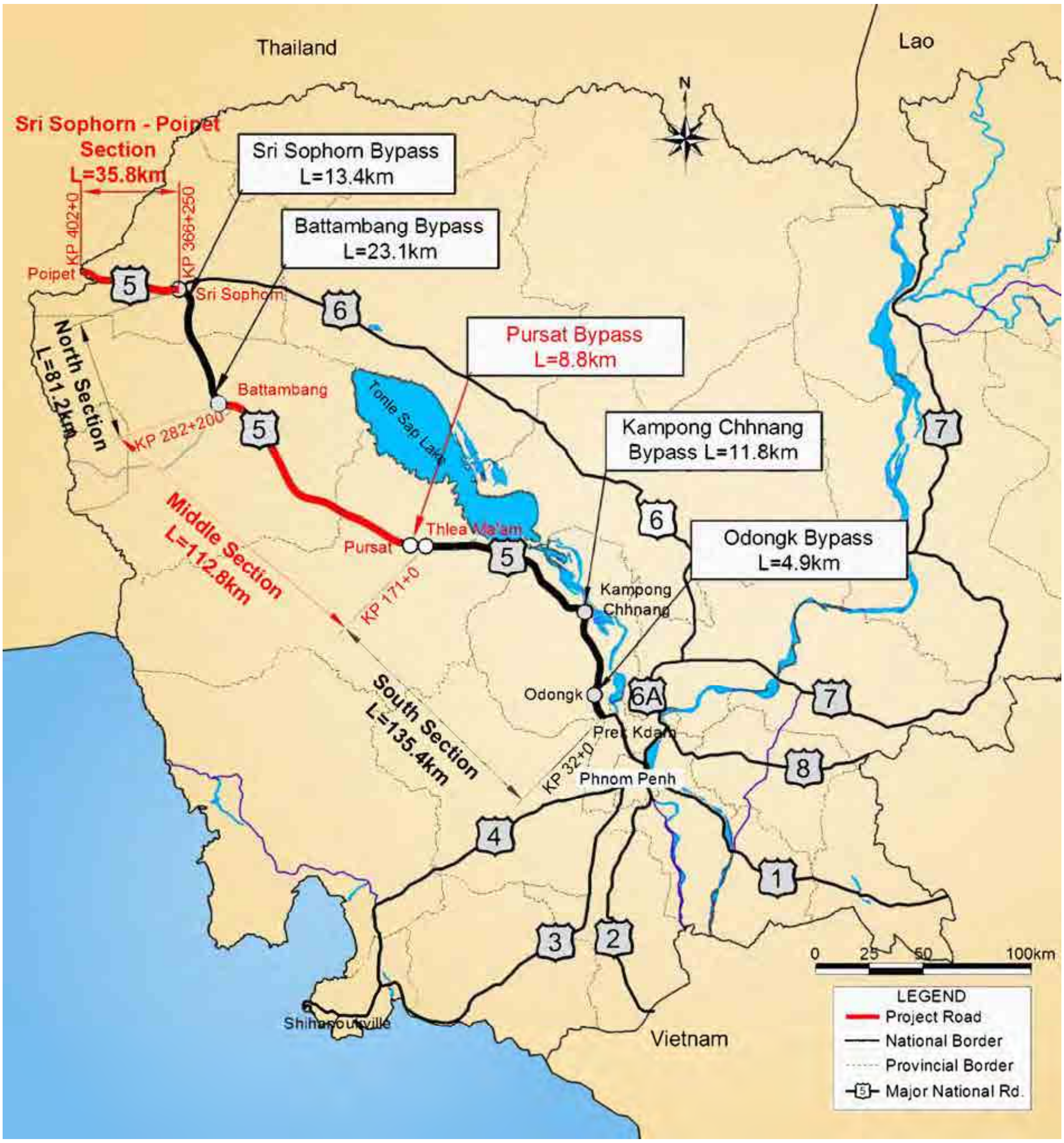
As of August 2014

Location Map of Survey Area



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LIST OF ABBREVIATIONS (1/4)

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
ALEF	: Axle Load Equivalent Factor
APs	: Affected People
ASEAN	: Association of South East Asian Nations
ASTM	: America Society for Testing and Materials
Bc	: Box Culvert
B/C	: Benefit Cost ratio
BM	: Bench Marks
BP	: Bypass
BQ	: Bill of Quantities
Br	: Bridge
CBR	: California Bearing Ratio
CBTA	: Cross - Border Transport Agreement
CDC	: Council for the Development of Cambodia
CF	: Community Fishery
CMAC	: Cambodian Action Mine Centre
COI	: Corridor of Impact
CRIP	: Cambodia Road Improvement Project
DBST	: Double Bituminous Surface Treatment
DE	: Department of Environment
DEIA	: Department of Environmental Impact Assessment
D/D	: Detailed Design
DMS	: Detailed Measurement Survey
DPs	: Development Partners
DPWT	: Department of Public Works and Transport
EA	: Executing Agency
EIA	: Environmental Impact Assessment
EIRR	: Economic Internal Rate of Return
EFRP	: Emergency Flood Rehabilitation Project
ESAL	: Equivalent Single Axle Load
ESC	: Environmental and Social Considerations
FAO	: Food and Agriculture Organization
FDRMP	: Flood Disaster Rehabilitation and Mitigation Project

LIST OF ABBREVIATIONS (2/4)

GDP	: Gross Domestic Product
GDI	: Gender-related Development Index
GEM	: Gender Empowerment Measure
GII	: Gender Inequality Index
GL	: Ground Level
GMS	: Grater Mekong Sub region
GOC	: Government of Cambodia
GPS	: Global Positioning System
GRDP	: Gross Regional Domestic Product
HIV	: Human Immunodeficiency Virus
HV	: Heavy Vehicle
ICD	: International Cooperation Department (of MPWT)
ICT	: Information and Communication Technology
IEIA	: Initial Environmental Impact Assessment
IOL	: Inventory of Loss
IP	: Intersection Point
IRC	: Inter-Ministerial Resettlement Committee
IRC-WG	: IRC-Working Group
IRITWG	: Infrastructure and Regional Integration Technical working Committee
JICA	: Japan International Cooperation Agency
kN	: kilo Newton
KP	: Kilometer Post
LA (L/A)	: Loan Agreement
LV	: Light Vehicle
MC	: Motorcycle
MEF	: Ministry of Economic and Finance
MOE	: Ministry of Environment
M/P	: Master Plan
MPWT	: Ministry of Public Works and Transport
MSL	: Mean Sea Level
N.A.	: Not Applicable
NCDM	: National Committee for Disaster Management
NPV	: Net Present Value
NR	: National Road No.
NSDP	: National Strategic Development Plan
OD	: Origin Destination
ODA	: Official Development Assistance

LIST OF ABBREVIATIONS (3/4)

PAPs	: Project Affected Person(s)
Pc	: Pipe Culvert
PC	: Pre-stressed Concrete
PCDG	: Pre-tensioned Precast Concrete Deck Girder
PCU	: Passenger Car Unit
PDEF	: Provincial Department of Economy and Finance
PDPWT	: Provincial Department of Public Works and Transport
PMED	: Provincial / Municipal Environmental Department
PMU	: Project Management Unit
PMU-ES	: Environmental Section of PMU
PPP	: Public Private Partnership
PPUTMP	: Project for Comprehensive Urban Transport Plan in Phnom Penh Capital City
PQ	: Pre-Qualification
PRC	: People's Republic of China
PRRP	: Primary Roads Restoration Project
PRSC	: Provincial Resettlement Sub Committee
PRSC-WG	: PRSC Working Group
PRW	: Provisional Road Width
PSC	: Pre-tensioned Precast Plank hollow slab
PWRC	: Public Work Research Center
RAMP	: Road Assets Management Project
RAP	: Resettlement Action Plan
RC	: Reinforced Concrete
RD	: Resettlement Department (of MEF)
RCDG	: Reinforced Concrete Deck Girder
RCS	: Reinforced Concrete Flat Slab, also Replacement Cost Survey
	: Replacement Cost Survey
RGC	: Royal Government of Cambodia
ROW	: Right of Way
SC	: Steering Committee
SEZ	: Special Economic Zone
SHM	: Stakeholder Meeting
SN	: Structure Number
SPT	: Standard Penetration Test
STRADA	: System for Traffic Demand Analysis
TSBR	: Tonle Sap Biosphere Reserve
UNDP	: United Nations Development Plan

LIST OF ABBREVIATIONS (4/4)

UNESCO	: United Nations Educational, Scientific and Cultural Organization
UXO	: Unexploded Ordnance
VAT	: Value Added Tax
VCR	: Traffic Volume per Capacity Ratio

CHAPTER 1 INTRODUCTION

1.1 Background of the Survey

In the Kingdom of Cambodia ("Cambodia"), the road transport accounts for around 65% of the passenger transport, for 70% of the freight transport, and plays the most important role in the domestic transport. During the civil war in the 70's to 80's, most of the roads were deteriorated due to poor (practically non - existent) maintenance. Since 1993, the rehabilitation has progressed with the assistance of Japan, the United State, Australia, Asian Development Bank (ADB), World Bank and other development partners.

National Road No.5 (NR 5) is the trunk national road connecting the capital city of Phnom Penh to a major city of Battambang and then to Bangkok through Thai border city of Poipet. It is also designated as Asian Highway No.1 or the Southern Economic Corridor of Grater Mekong Sub-region (GMS). However, all the road surface type is double-layered bituminous surface treatment (DBST) and the surface condition is being deteriorated due to rapidly increasing heavy vehicles, as well as inundation / flood except the surface of the sections of 12.6 km from Phnom Penh and between Sri Sophorn and Poipet where asphalt concrete (AC) is adopted to their surfaces.

Under such situation, Japan International Cooperation Agency (JICA) dispatched a survey team to Cambodia in November 2010 and reached agreement to conduct the Preparatory Survey on improvement of North Section (between Battambang and Sri Sophorn) and South Section (between Prek Kdam Bridge and Thlea Ma'am) of NR 5. The survey named as "Preparatory Survey for National Road No.5 Rehabilitation Project" started in February 2011. As the result of this survey, the North Section (Approx. 68 km) was selected as the high priority section. Loan agreement for improvement of the North Section was signed by the Royal Government of Cambodia (RGC) and Japan on 16th of May, 2013.

After that, 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 (approx. 139 km). The survey named as "Preparatory Survey for National Road No.5 (South Section) Improvement Project" was completed in December 2013.

From a viewpoint of consistency in road improvement, RGC requested that remaining section of NR 5 (between Thlea Ma'am and Battambang) be surveyed and this survey was started in May 2013. After the commencement of this survey, the Sri Sophorn - Poipet Section was added to the components of the survey in July 2013 in response to its request from RGC.

1.2 Objective of the Survey

This Preparatory Survey is implemented for the Improvement project of NR 5 (between Thlea Ma'am and Battambang, and between Sri Sophorn and Poipet) to obtain data and information required for appraisal of loan project of Japanese ODA (official development assistance), such as the objectives, outline, project cost, implementation schedule, implementation organization, maintenance system and natural and social impacts.

1.3 Survey Area

The Survey Area is provinces of Pursat, Battambang and Banteay Meanchey.

1.4 Scope of Work

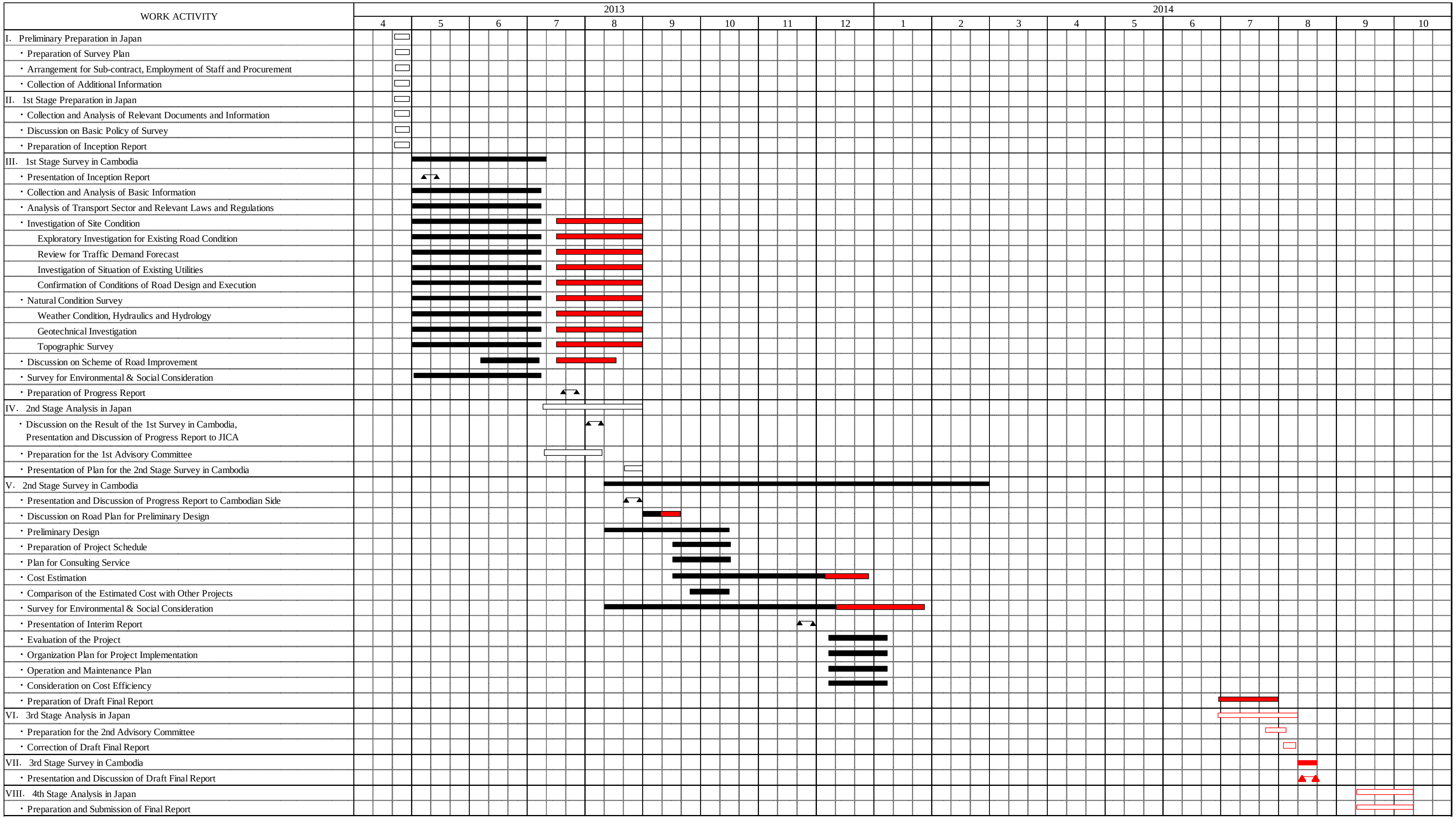
To achieve the above objectives, the following tasks were carried out:

1. Confirmation of the Scope of the Work
2. Collection of Basic Information Regarding the Project
3. Comparison of Law, Regulation, Standard on Transport Sector
4. Investigation of Site Condition
5. Review of Traffic Demand Forecast
6. Natural Condition Survey
7. Weather Condition, Hydraulics and Hydrology
8. Study on the Scheme of Road Improvement
9. Proposal and Discussion on Road Improvement
10. Preliminary Design
11. Study of Measures for Traffic Safety
12. Implementation Schedule of the Project
13. Preparation of Working Plan of Consulting Services
14. Cost Estimation of Project Summary Cost
15. Comparison of Summary Project Cost with Similar Project
16. Evaluation of the Project
17. Organization Plan for Project Implementation
18. Operation & Maintenance System
19. Investigation for Environmental and Social Consideration
    (i) Assistance to MPWT in Preparation of EIA report
    (ii) Assistance to MPWT in Preparation of Resettlement Action Plan (RAP)

1.5 Survey Schedule

The survey on the Middle Section was started in April 2013. The First Steering Committee was held on 8 May 2013 and the Inception Report was explained and discussed. Then, the Sri Sophorn - Poipet Section was added to the Survey Area and the survey schedule was additionally changed. Table 1.5-1 in the next page shows the general schedule of the Survey. In this schedule red bars show the additional tasks or change due to addition of Sri Sophorn – Poipet Section.

Table 1.5-1 Schedule of the Survey



Legend: Original; Additional/Revised due to Addition of Sri Sophom - Poipet Section

1.6 Organization of the Survey

(1) Steering Committee

Steering Committee (SC) has been established for smooth and effective implementation of the Survey. The SC coordinates with MPWT and advise JICA and the Survey Team through MPWT. Table 1.6-1 lists the members of the SC.

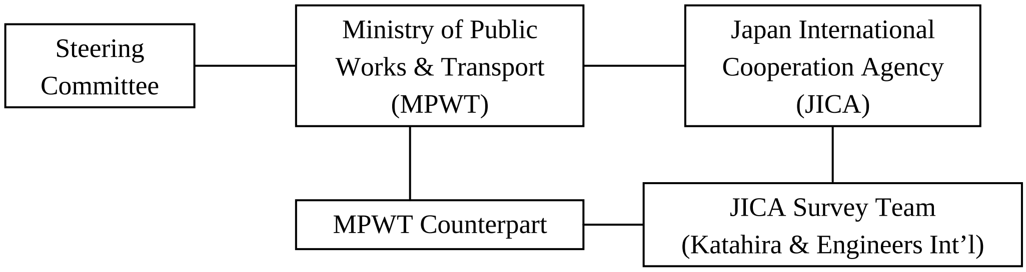


Table 1.6-1 Member List of Steering Committee

Institution	Name	Position
Ministry of Economy & Finance (MEF)	HE Chan Sothy	Deputy Secretary General, Investment and Cooperation
	Mr. Por Yutha	Deputy Director, Investment and Cooperation
	Mr. Sim Samnang	Deputy Director, Resettlement Department
Ministry of Environment (MOE)	Mr. Oung Vuthy	Deputy Director,
Pursat Province	Mr. Hun An	Director, General Affairs
	Mr. Ting Kuong	Deputy Director, DPWT
Battambang Province	Mr. Neang Chanthara	Chief Cross Sectorial Office
	Mr. Sal Satat	Chief Office
Banteay Meanchey Province	Mr. Sok Chantha	Deputy Director
Ministry of Public Works & Transport (MPWT)	H.E. Tauch Chankosal	Secretary of State
	H.E. Kem Borey	Director General of Public Works
	Mr. Chhim Phalla	Director of International Cooperation Department (ICD)
	Mr. Kong Sophal	Deputy Director, ICD
	Mr. Ket Shandararith	Deputy Director, ICD
	Mr. Heng Salpiseth	Officer, ICD
	Mr. SHIMADA Takashi	JICA Experts for MPWT
JICA Headquarter	Mr. TSUCHIHASHI Toru	Deputy Director, Transport & ICT Division 2, Economic Infrastructure Department
JICA Cambodia Office	Mr. ITO Takashi	Senior Representative
	Mr. EGAMI Masahiko	Representative
	Mr. SAY Bora	Program Officer
JICA Survey Team	Mr. SAKURAI Tatsuyuki	Team Leader,
	Mr. NAKAMURA Tomohiko	Deputy Team Leader

(2) JICA Officials in Charge of the Survey

Table 1.6-2 lists the main JICA officials in charge of this Survey.

Table 1.6-2 Main JICA Officials in Charge of Survey and Project

Name	Position	Remarks
JICA Headquarter (in Tokyo)		
MIYAKE Shigeki	Director, Transport & ICT Division 2, Economic Infrastructure Department	
TSUCHIHASHI Toru	Deputy Director, Transport & ICT Division 2,	
KANEKO Yutaro	Transport & ICT Division 2,	
FUKAWA Kensuke	Director, Southeast Asia Division 4, Southeast Asia & Pacific Department	
NAKANO Akihiko	Southeast Asia Division 4, Southeast Asia & Pacific Department	Up to May 2014
NO Daichi		
YOSHIDA Risa	Deputy Assistant Director, Southeast Asia Division 4	From May 2014
TSUBOTA Yumiko	Southeast Asia Division 4	
KAWANO Takaaki	Director, Environmental & Social Consideration Division, Credit Risk & Environmental Review Department	
SUZUKI Eri	Senior Safeguard Officer, Environmental and Social Considerations Review Division	From May 2014
HANAI Akane	Environmental and Social Considerations Review Division	
JICA Cambodia Office		
ITO Takashi	Senior Representative, JICA Cambodia Office	
EGAMI Masahiko	Representative, JICA Cambodia Office	

(3) Survey Team Member

Table 1.6-3 lists the member of the Survey Team.

Table 1.6-3 Survey Team Member List

Name	Position	Company
SAKURAI Tatsuyuki	Team Leader / Road Traffic Planer	KEI
NAKAMURA Tomohiko	Deputy Team Leader	KEI
MURAKAMI Keiichi	Road Engineer	KEI
OHASHI Keiichi	Bridge / Structure Planer	KEI
YASHIRO Syuuichi	Economic Analysis Specialist	KEI
WATANABE Kanji	Environmental Consideration Specialist	KEI
YAMASHITA Akira	Social Consideration / Resettlement Plan Specialist	KEI
KAWAMURA Yoshinori	Natural Condition Survey Specialist	KEI
AOKI Hiromasa	Hydrological & Hydraulic Survey Specialist	KEI
WATANABE Hiroshi	Construction Plan / Cost Estimation Specialist	KEI
TOCHINAKA Masateru	Project Coordination / Assistant Road Engineer	KEI

** KEI: Katahira & Engineers International*

CHAPTER 2 PROFILE OF THE SURVEY AREA

2.1 Physical Profile

(1) Geography

National Road No. 5 (NR 5) starts from Phnom Penh and traverses the southwestern side of Tonle Sap River and Tonle Sap Lake up to Battambang. Between Battambang and Sri Sophorn, it passes through the upstream area of Tonle Sap Lake and finally reaches the border with Thailand. The distance between the city of Sri Sophorn (the northern end of the Survey Section) and Poipet (the border point with Thailand) is approximately 50 km and the distance between Poipet and Bangkok in Thailand is approximately 250 km. Thus, NR 5 forms the main transport route between Phnom Penh and Bangkok.

Figure 2.1-1 Location of NR 5

(2) Topology

Figure 2.1-2 explains the hypsometric conditions of Cambodia.

Cambodia is situated in the northwest of the Gulf of Thailand. The area of the land is approximately 171,000 km^2, The capital is Phnom Penh, situated on the right bank of the Mekong River at the confluence of its principal tributary in this area, the Tonle Sap.

The country is dominated by the Mekong River, which crosses the country from the north to the south. Its heartland is the basin of the Great Lake, fed by rivers draining the hills in the north, west, and south, but above all by the Mekong itself. Every year, between May and October, the Great Lake is replenished by flow up the Tonle Sap River from the Mekong in flood; when the flood waters recede, it is drained by reverse flow down the Tonle Sap into the Mekong.

A low threshold formed by ridges of bedrock near Kampong Chhnang prevents the complete draining of the Great Lake. At its lowest level, the lake has depths of around 1 meter and an area of about 3,000 km^2, while at its maximum it expands its area to 16,000 km^2 and up to 9 meters deep.

In the southwest, the country is mountainous, with the highest summits rising to more than 1,500 meters. This range is known as the Caradamome or Kravanh Mountains. In the north, the land rises gradually from the shores of the Great Lake to the foot of the Dangrek escarpment, the crest of which is the southern edge of the Khorat Plateau and marks the boundary between Cambodia and Thailand.

The east part of the country consists of plains, low hill ranges and plateaus of up to a few hundred meters elevation. In the southeast locates the head of the Mekong Delta, the greater part and mouths of which lie in Vietnam.

Source: Indochina Atlas (1970), U.S. Central Intelligence Agency

Figure 2.1-2 Hypsometric Map of Cambodia (Cropped from Map of Indochina)

(3) Topography

Figure 2.1-3 shows the topography of Cambodia. The ground height along the Middle Section of NR 5 is, in general, around 11 ~ 21 m above sea level, and the one along the section of Sri Sophorn – Poipet is 14 m ~ 41 m. The terrain along the Middle Section of NR 5 is generally flat.

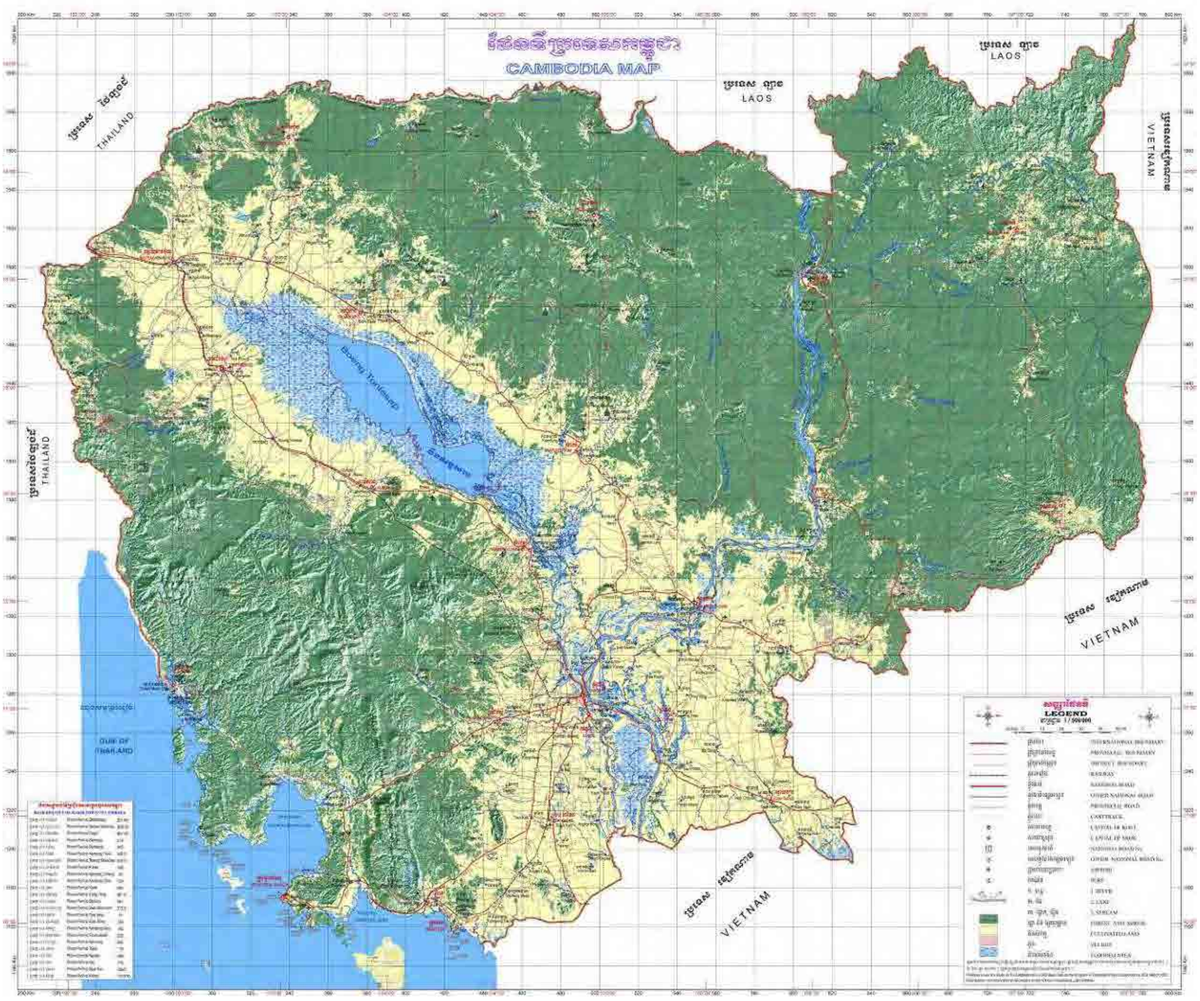


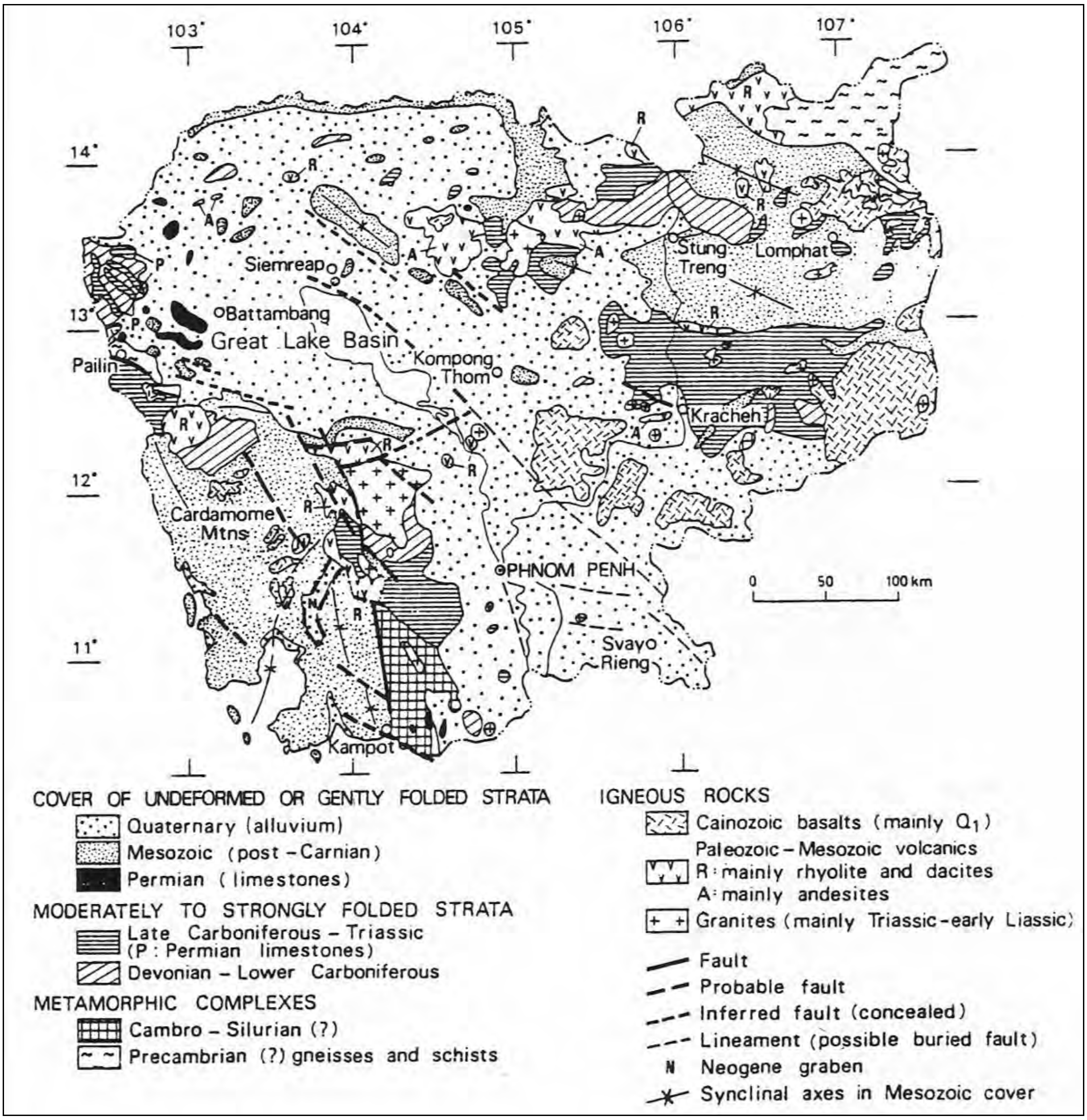
Figure 2.1-3 Topography of Survey Area

The country of Cambodia is often divided into the following five zones related to their relative location and topography as shown in the table below.

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

According to this zoning, survey areas; Pursat, Battambang and Banteay Meanchey belong to the Tonle Sap Zone which extends from Tonle Sap Lake.

(4) Geology



Source: Encyclopedia of European and Asian Regional Geology

Figure 2.1-4 Geological Framework of Cambodia

Figure 2.1-4 summarizes geological condition in Cambodia. The latest geological map prepared by the General Department of Mineral Resources in corporation with JICA in 2010 is attached to Appendix 2.

(a) Stratigraphy

Precambrian

The gneisses and schist of the Proterozoic Kontum Massif in Vietnam extended in the north east of the country. High - grade metamorphic rocks that may be at least partly Precambrian are also found at Pailin in the west.

Paleozoic

Paleozoic rock in Cambodia consists of three major parts: Cambro - Silurian, Devono - Carboniferous, and Permian.

The Cambro - Silurian occurs in the south and shows metamorphic complex; the dominant rock types are quartzite with interbedded rhyolites, quarts - tourmaline schist, sericite schist, and chlorite schist.

The Devono - Carboniferous is widely distributed in Cambodia, especially in the south. The rocks are strongly folded and fractured. The most distinctive units are varicolored chert or jasper, often brecciated. Other rock types in the Devono - Carboniferous sequence include black shale, sandstone, conglomerate and breccia, and some beds of limestone towards the top.

The Permian is distinctive for the wide distribution of limestone. The main occurrences are in the west and in the south, but small limestone lenses in a dominantly clastic succession are seen elsewhere.

Mesozoic: Triassic

Rocks mapped as Triassic occur widely in Cambodia. They are for the most part clastic and only sparsely fossiliferous. Some sequences are continental (with coal in places). Others are marine or alternating marine - continental.

Towards the end of Triassic, there were important earth movements throughout the region, comprising the main phase of the Indosinian Orogeny. In Cambodia, there was moderate to strong folding and general emergence.

The Upper Triassic stages are represented almost entirely by continental and lagoonal facies, and red beds are dominant. These comprise the greater part of the so - called "Terrain Rouge", a thick succession of conglomerate, sandstone and mudstone which extend into the Lower Jurassic and form the basal member of a great thickness of late Mesozoic continental deposit. In Cambodia, the Terrain Rouge covers large areas, especially in the north and east.

Mesozoic: Jurassic - Cretaceous

Following the general Late Triassic emergence, in the Early Jurassic, marine conditions persisted or returned in certain areas. The Early Jurassic is present in the east and around Rovieng in the north in the form of a littoral facies: sandstone and limestone with bivalves and brachiopods. Elsewhere in the east, there are deeper - water marine sediments of the

Early Jurassic age, extending towards the Vietnamese border in the Sre Pok Valley. These beds have yielded many ammonites.

From the Middle Jurassic onwards, deposition was purely continental or paralic. A thick succession of sandstone and conglomerate was laid down, spanning the Middle Jurassic to Lower Cretaceous time interval. The main area where these rocks are found is the Cardamome Mountains in the southwest with the succession of the order of 1,000 ~ 2,000 meters thick. Another prominent occurrence is in the Dangrek escarpment in the north. Elsewhere, these rocks form numerous isolated hill ranges and mesas with flat - lying or only very gently folded strata.

Cenozoic

Pliocene and Peistocene form terraces and plains at elevations of between 25 and 150 meters. They used to be considered as "the Old Alluvium", such as in 1:200,000 geological map prepared under French technical assistance to Cambodia.

Quaternary is very widespread and found at elevations of between 0 and 40 meters. Middle Quaternary forms terraces of reddish sandy deposit around an elevation of 15 meters. Late Quaternary spreads in the north, southeast, and northwest and form undulating terrains surrounding the central plain. Gravel, pebble, sand and clay compose the strata and, in Battambang, the thickness reaches around 200 meters.

The Holocene is found in the beds and floodplains of the present day rivers, coastal plains, and the Great Lake Basin. In many areas, these Alluvium deposits, although extensive, are thin and frequent small exposures of the underlying bedrock are observed.

(b) Igneous Activity

Volcanism

Eruptive rocks, both lavas and tuffs, and their associated subjacent intrusive phases, are common and widely distributed at many levels in the stratigraphic column, notably the late Paleozoic - early Mesozoic (mainly acidic - intermediate types) and the late Cenozoic (basalts). The Cenozoic basalts are clearly related to a phase of extensional tectonics with the development of deep - seated normal faults. These rocks cover some 10,000 km^2 in the east of Cambodia, where they form vast plateaus at elevation of up to a few hundred meters.

Plutonic Rocks

The basement complexes of the Kontum Massif and Pailin are made up in large part of more or less metamorphosed plutonic rocks which may be Paleozoic or older. These are predominantly granodioritic but include both more acidic and more basic types.

Most of the plutonic rocks of Cambodia, which are dominantly granitoids, intrude late Paleozoic and early Mesozoic formations and are likely to have a Triassic - early Jurassic age of emplacement.

(c) Tectonic Evolution

Important unconformities, separating major tectonic stages, occur at the base of the late Paleozoic (Upper Carboniferous - Permian) succession in the west and south and at the base of essentially late Triassic Terrain Rouge throughout the country. The former indicates a post early Carboniferous episode of folding.

The unconformity at the base of the Terrain Rouge marks the main episode of folding of the regional Indosinian Orogeny. It is thought to lie more or less at the Carnian - Norian boundary.

The period from the Norian to the present day constitutes the post - Indosinian tectonic stage. A small - scale angular unconformity in some places between the Terrain Rouge (low dips) and the overlying Middle Jurassic sandstone (very low to zero dips) marks a last, minor pulse of the Indosinian Orogeny. At some point in the late Cretaceous or Tertiary, the post - Indosinian platform cover of continental deposits was epeirogenically raised and warped across the region, forming a series of broad, open anticlines and synclines. The eroded axis of one of the anticlines crosses NW Cambodia from northwest to southeast along the line of the Great Lake. In this area, the Mesozoic sandstones are horizontal, and thus form flat - topped mesas. To the north, dips increase slightly towards the Dangrek escarpment, which is the south face of a cuesta. Similarly, to the south the Cardamome Mountains are formed of Mesozoic sandstone dipping at very low angles to the southwest. There was also important block faulting during this period, including the formation of several graben in the Cardamomes. There were vast outpourings of basalt, indicative of tensional tectonic environment in the late Cenozoic.

In very recent times, the Great Lake Basin was formed by subsidence along NW trending fault lines (Carbonnel, Duplaix and Selo, 1972). The lake itself, and the form of its outlet to the Mekong, are due to the existence of several small NE-trending swells in the surface of the sub - Quaternary bedrock underlying the upper part of the Tonlé Sap River. The subsidence involved in the formation of the Great Lake was in fact very slight, and may have taken place mainly in the Holocene. The lake is believed to be only about 5,000 years old (Carbonnel, 1965).

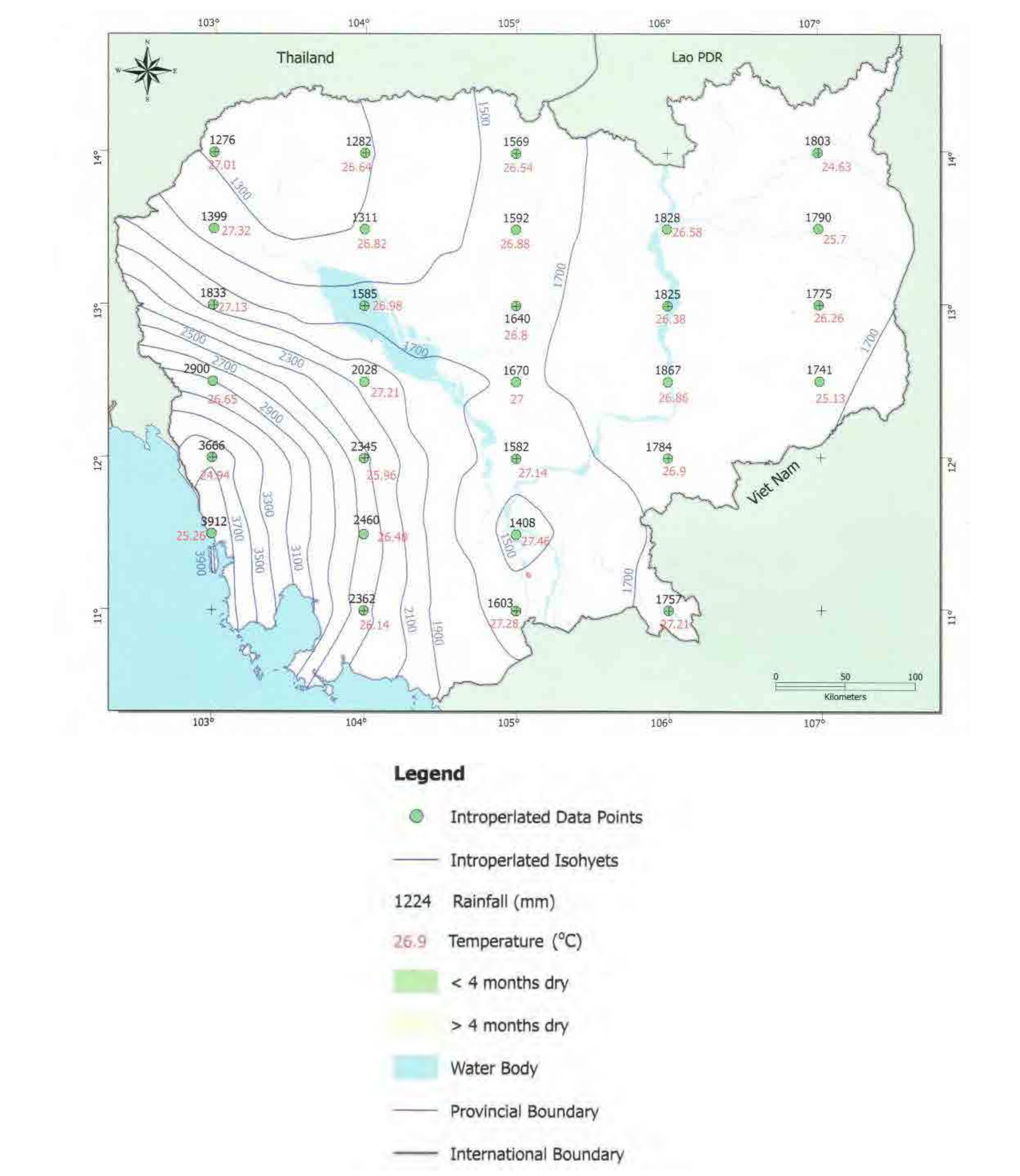
Note:

Carnian: The Carnian lasted from about 235 to 228 million years ago (Ma).

Norian: The Norian lasted from about 228 to 208.5 Ma.

(5) Meteorology

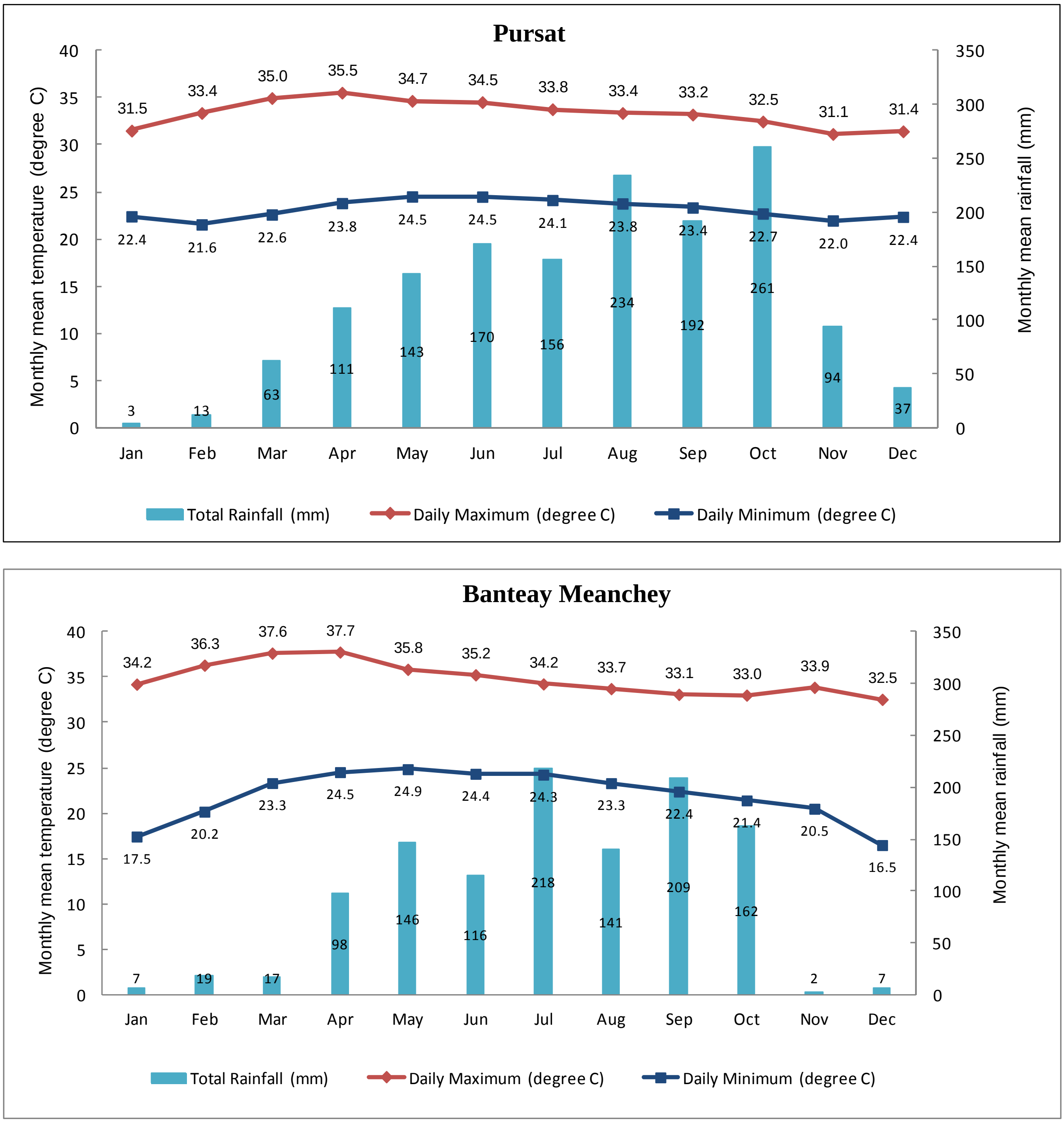
The climate of Cambodia is influenced by the Asian monsoon and the climate can be described as 'hot and humid' in general. Figure 2.1-5 shows annual rainfall in Cambodia. It shows that the annual rainfall of the Survey Area is in the range of 1,400 ~ 1,900 mm/yr.



Source: The Atlas of Cambodia - National Poverty and Environment Maps

Figure 2.1-5 Rainfall and Temperature

Figure 2.1-6 shows the monthly average rainfall and temperature measured at Pursat and Banteay Meanchey. It shows that the rainy season is from May to October and the dry season is from November to April. It also shows that the monthly average temperature ranges between 16 and 38 degrees Celsius.



Source: Department of Meteorology (Information is based on monthly averages for the 5 - year period 2007 - 2011)

Figure 2.1-6 Average Monthly Rainfall and Temperature

2.2 Socio - Economic Profile

(1) Demography

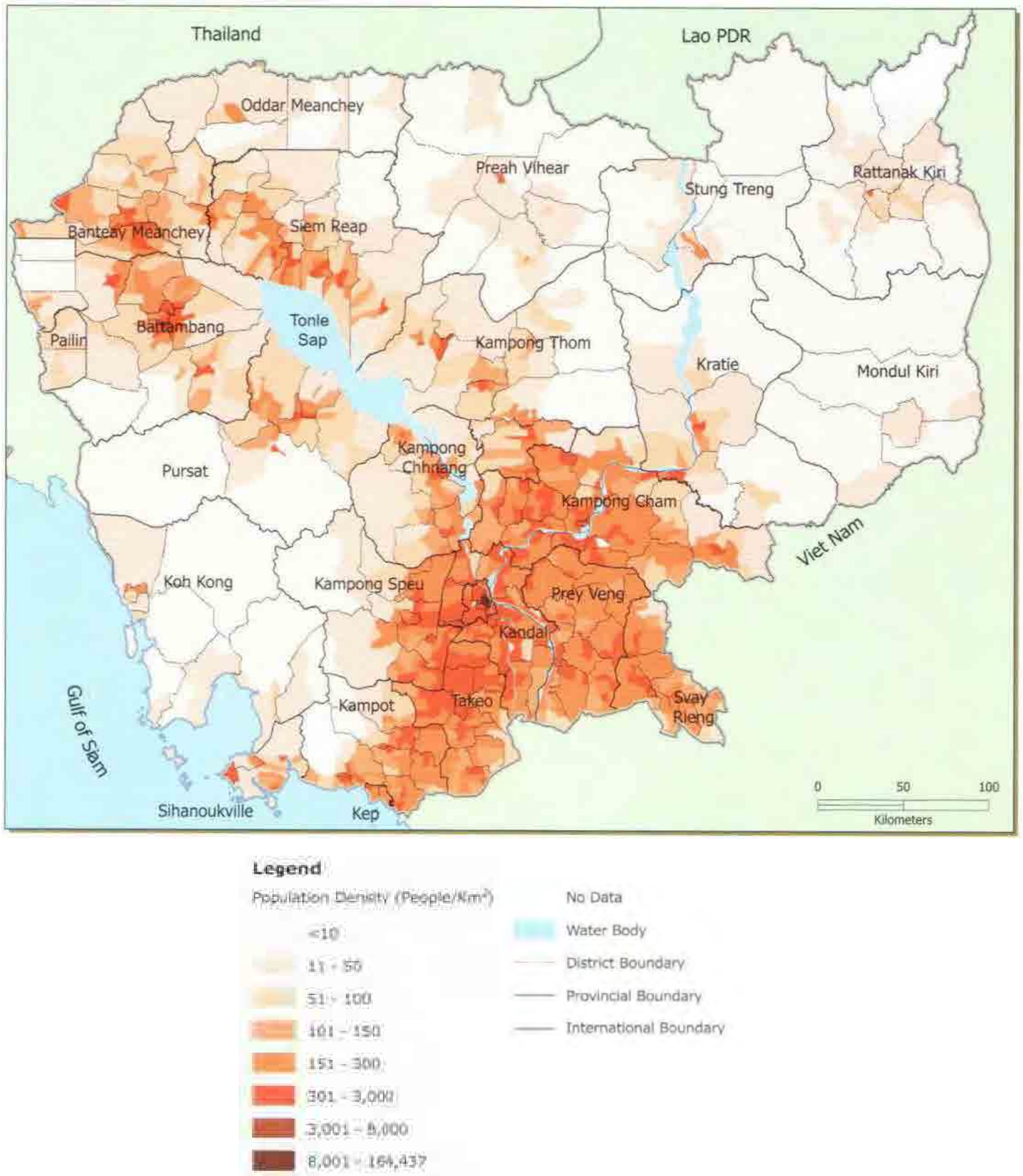
Table 2.2-1 summarizes the socio - economic data of the Survey Area, focusing on the three provinces substantially influenced by the Project.

Table 2.2-1 Socio - Economic Data of Survey Area in 2008 (3 provinces only)

	Pursat	Battambang	Banteay Meanchey	Whole Country	Proportion to Whole Country (%)
Population (1,000)	397	1,025	678	13,396	16
Land Area (km^2)	12,692	11,702	6,679	181,035	17
Population Density	36	88	101	75	-

Source: Statistical Yearbook of Cambodia 2011

The population densities of the provinces in the Survey Area, except Pursat, are higher than the national average, implying that the Survey Area is a developed area in Cambodia. Among the three provinces, Pursat is less populated than the national average.

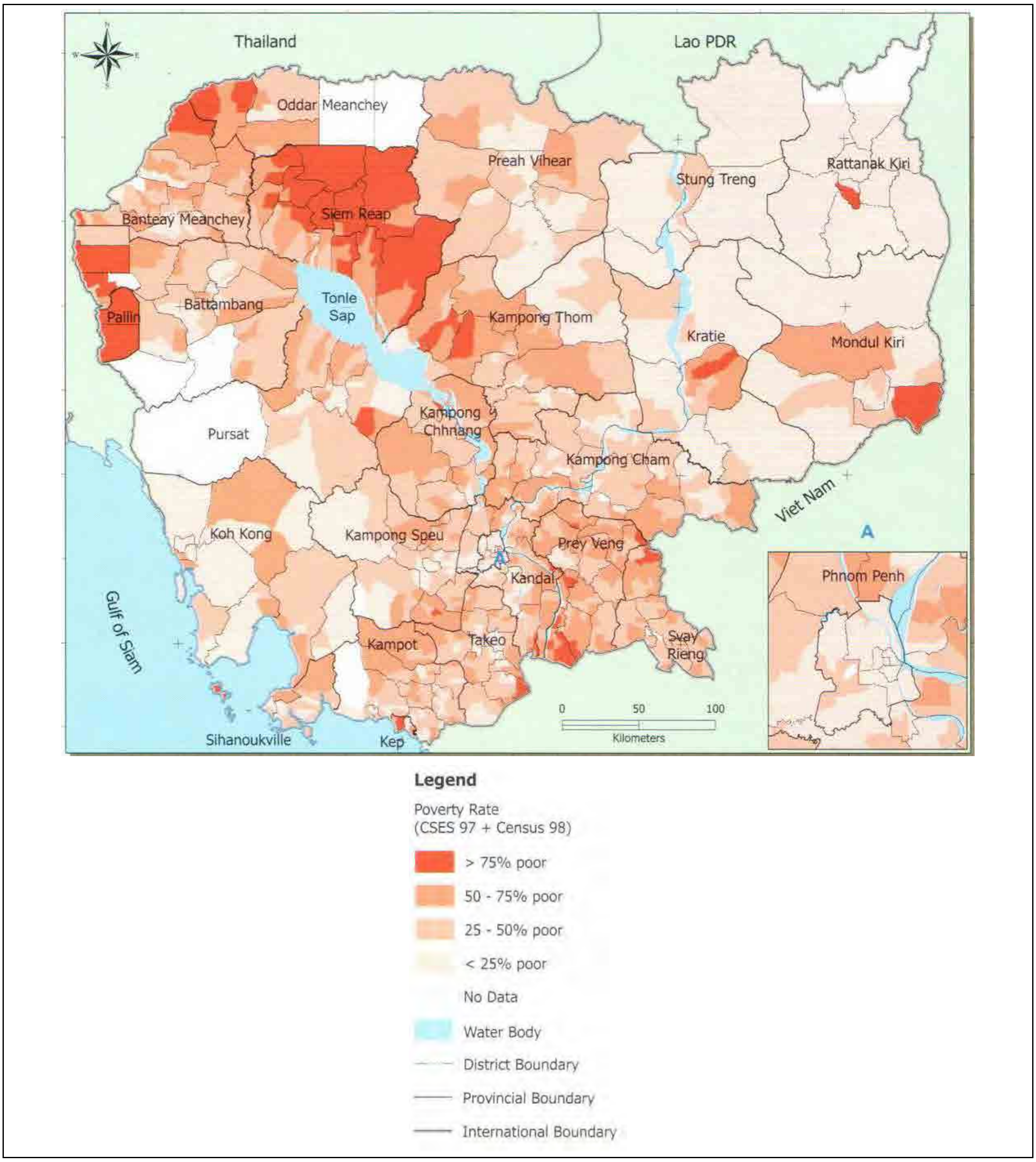


Source: The Atlas of Cambodia; National Poverty and Environmental Maps

Figure 2.2-1 Population Density by Districts

(2) Economy

Figure 2.2-2 shows the poverty level by District. As can be seen in the figure, the income level of Pursat city, Battambang city and Poipet city is relatively high.



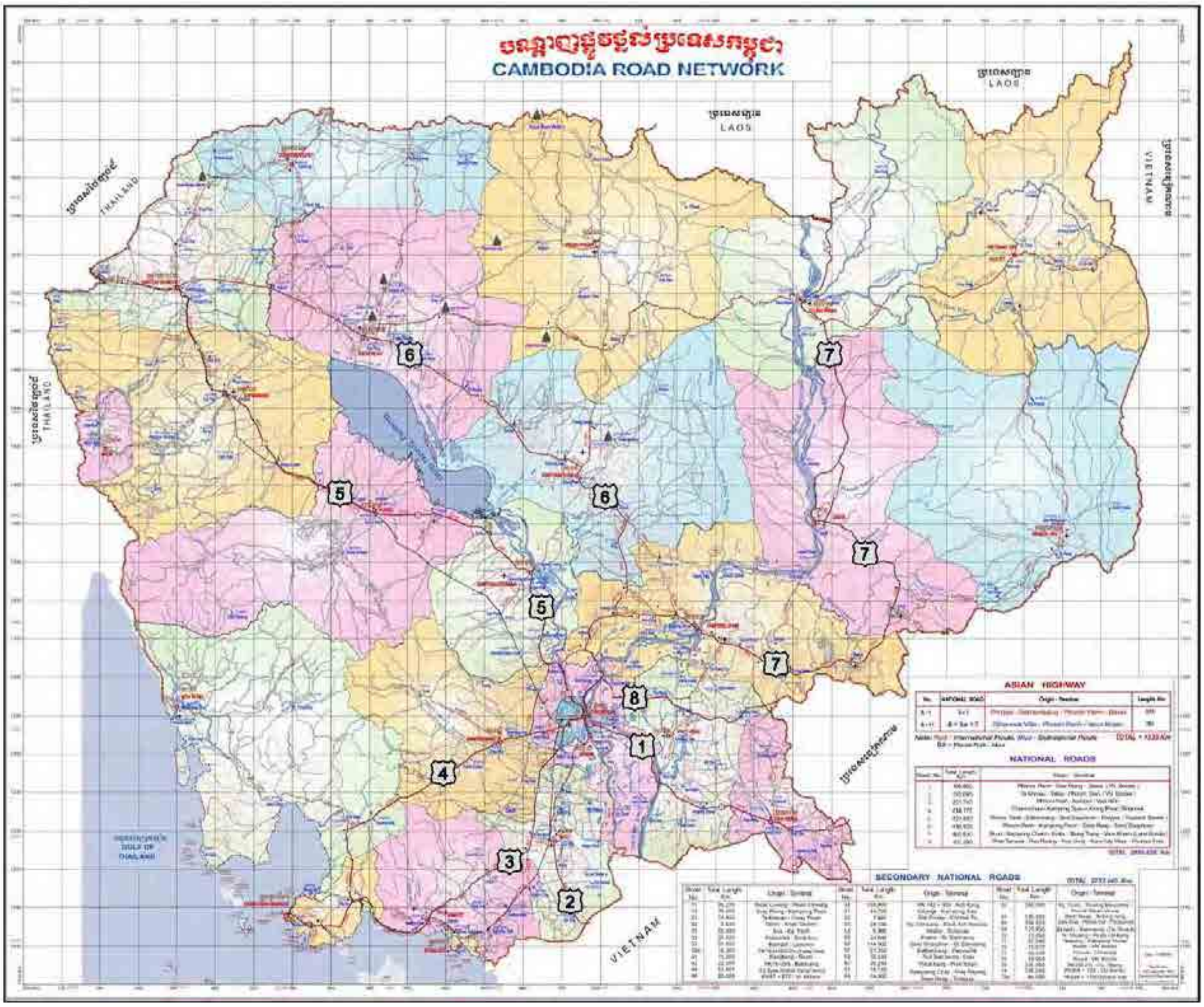
Source: The Atlas of Cambodia; National Poverty and Environmental Maps

Figure 2.2-2 Poverty Level of Districts

CHAPTER 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 road network is 5,604 km (as of July 2014). Out of this 5,604 km, 2,244 km are single digit national roads and 3,360 km are double digit national roads. Figure 3.1-1 show the map of National Road Network of Cambodia. As can be seen in the figure, most of the arterial national roads of Cambodia extend in radial directions centered at Phnom Penh and reach to the border points with neighboring countries of Vietnam and Thailand. They are numbered, in principle, in crock - wise direction starting from No. 1.



Source: MPWT

Figure 3.1-1 National Road Network of Cambodia

Table 3.1-1 shows the lengths and routes of arterial (single - digit) national roads.

Table 3.1-1 Length and Route of Arterial National Road (As of 2008)

Road No.	Length (km)	Route
1	166.9	Phnom Penh - Bavet (Vietnam border)
2	120.7	Ta Kmau - Takeo - Phnom Den (Vietnam border)
3	201.6	Phnom Penh - Kampot - Veal Rinh
4	214.2	Chaom Chau - Kampong Speu - Krong Prea Sihanouk
5	407.5	Phnom Penh - Battambang - Sri Sophorn - Poipet (Thailand border)
6	415.5	Phnom Penh - Kampong Thom - Siem Reap - Sri Sophorn
7	460.8	Skun - Kamopong Cham - Kratie - Steung Treng - Veum Kham (Vietnam border)
8	132.4	Prek Kdam - Pea Reang - Prey Veng - Kamchay Mear - Ponhhea Krek
9	143.3	Stung Treng - Prea Vehear
Total	2,262.9	

3.2 Development Plan

A road improvement project needs to planned in accordance with the master plan for road network development. The road network development master plan should be in conformity with the national development plan. Followings are the status of these plans.

(1) National Strategic Development Plan

National Strategic Development Plan (NSDP) 2006 ~ 2010 adopted 'Rectangular Strategy' as the very basic strategy / policy for national development. 'Further Rehabilitation of Physical Infrastructure' was designated as one of the four components of 'Rectangular Strategy'. The NSDP was updated in 2008 and issued as 'NSDP Update 2009 ~ 2013', which was valid when this survey was started. NSDP Update 2009 ~ 2013 prescribes 'Further Rehabilitation and Construction of Transport Infrastructure' as one of the four sub - components of 'Further Rehabilitation of Physical Infrastructure'. Then, NSDP Update 2009 ~ 2013 states 'Continuing to seek funding for …… (omitted) … the widening of NR 1, NR 4, NR 5 and NR 6'. It is clear that widening of NR 5 is designated as one of the projects for national development.

Since NSDP 2009 -2013 had expired, NSDP 2014 – 2018 was newly prepared and approved by the Council of Ministers on 30 May 2014. **"Widen 1-Digit NRs from 2 lanes to 4 lanes in and around major cities"** and "**Install drainage facilities in 1-Digit National Roads, for flood control"** are listed among the "prioritized policies" in Chapter 4 of NSDP 2014 - 2018. NSDP 2014 – 2018 also lists "Introduce bus public transportation system in the Capital Area" as another activity of "the prioritized policies" showing the Government's recognition of importance of mass transit.

(2) Comprehensive Development Plan for All Transport Sector

Cambodian Government (MPWT) is aware of importance of transport modes other than road and exerting effort to improve / develop, railroad, shipping and aviation, as well as mass transit.

Comprehensive development plan of transport sector was prepared in 2002 through 'Transport Strategy Study' with an assistance of ADB. After this study, master plans of subsectors were prepared and some projects have been, or are being, implemented.

Major projects and studies of these transport modes are as summarized below:

Table 3.2-1 Plans and Projects of Transport Modes Other than Road

Transport Mode	Description of Major Project / Plan
Railroad	· Railroad master plan is being prepared with assistance of Korean government. · Railroad rehabilitation project is has been implemented with financial assistance of ADB. · Phnom Penh - Kampot Section (Approx. 150 km) of the South Line (Phnom Penh - Sihanoukille: 266 km) completed in 2012 and operation started. · Rehabilitation of the remaining section of the South Line is currently being implemented. · Rehabilitation of the North Line has been haltered due to shortage of fund · There are some other plans of railroad development proposed by Chinese and Korean governments.
Mass Transit	· City bus service was proposed in JICA's 'Urban Transport Master Plan Study' 2001 and experimental bus operation was successfully implemented. However, bus service did not materialize. · Study on introduction of monorail between Phnom Penh Airport and the city center Phnom Penh was implemented in 2008 with technical assistance of Japanese Government (Ministry of Economy, Industry and Trade) · Introduction of city tram system in Phnom Penh was studied in 2010 with technical assistance of French Government. · Project for Comprehensive Urban Transport Plan in Phnom Penh Capital City (PPUTMP) was implemented by JICA and completed in 2014. Experimental bus operation was successfully implemented. Concession for bus operation is being offered to possible private operators.
Ship (Sea port and inland water port)	· There are 8 major seaports in Cambodia which are in operation. · Sihanoukville Port is the largest and the main export / import port. Expansion of capacity of Sihanoukville Port is being planned. · There are many inland water ports along Mekong River and its tributaries (Tonle Sap River etc). · Phnom Penh Port is the largest inland water port. · A new Phnom Penh Port has been constructed approx. 25 km downstream along Tonle Sap / Mekong River (along NR 1) where Special Economic Zone (SEZ) is being planned.
Aviation	· Currently there is no master plan. · Two international airports (Phnom Penh and Siem Reap) are under operation. · New airports are being planned (New Phnom Penh Airport and New Siem Reap Airport). · Improvement of five local airports is being discussed.

While improvement of road network needs to be continued, improvement of other transport modes is indispensable for efficient and comprehensive transport system. Accordingly, it is recommended that the RGC continue the effort to improve these transport facilities.

(3) Road Network Master 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'. M/P Study proposed widening of NR 5 to full 4-lanes between Phnom Penh and Kampong Chhnang and remaining sections were proposed to be 2-lanes. It should be noted that this M/P was prepared when the economic level of Cambodia was still low and it was rather difficult to expect the rapid economic growth which occurred in the last few years, and the proposed road network development plan is sometimes insufficient to support the growth of traffic demand which is expected today.

Infrastructure and Regional Integration Technical Working Group (IRITWG) is a meeting of the development partners and MPWT on implementation of transport infrastructure development. The latest meeting of IRITWG was held in September 2012 and 4th edition[1] of "Overview on Transport Infrastructure Sectors in the Kingdom of Cambodia (OTIS)" was published. This publication lists the past, on - going and planned road improvement projects, as shown in Table 3.2-2.

The 2014 version (5th edition) of OTIS is currently being prepared and is expected to be published in late 2014. The contents of the 5th edition is not confirmed yet.

[1] Version for year 2014 is being prepared, but not completed, as of August 2014.

Table 3.2-2 (1) Past, Ongoing and Planned Road Improvement Projects (1/2)

No.	Org.	Cost (Mill$)	length (km)	Section	Year Start	Fund End	Status	Pavement status
1	Japan	$36.14	43.0	PK: 13+000 – Neak Loeung (2nd phase)	2006	2009	Grant	AC
	Japan	$11.168	11.0	PK: 4+000 – PK: 13+000 (3rd phase)	2010	2011	Grant	AC
	Japan	$19.46	4.0	Monivong Brige – PK: 4+000 (4th Phase)	2010	-	Grant	AC
	Japan	$80.00	57.0	Phnom Penh - Neak Loeung	2005	-	Grant	AC (2010: Korki to Neak Loeung)
	ADB	$50.00	107.0	Neak Loeung - Bavet	1999	2004	Loan	DBST
	WB	$3.00	107.0	Neak Loeung - Bavet	2009	2013	Loan	Road Maintenance (Upgrading)
2	ADB	-	63.0	Kbal Thnal - Takeo	2001		Loan	DBST
	Korea	-	63.0	Kbal Thnal - Takeo	-	-	-	-
	Korea	-	-	Takeo - Ang Tasaom (NR3)	-	-	-	DBST
	Japan	$12.45	51.7	Takeo - Phnum Den	2003	2007	Grant	AC
3	Korea	$36.90	137.5	Chom Chao - Kampot	2008	2010	Loan	DBST
	Korea	$17.05	32.7	Kampot - Trapang Ropaou	2004	2008	Loan	DBST
	WB	$47.60	32.5	Trapang Ropaou - Veal Renh	1999	2006	Loan	DBST
4	USA	$50.50	217.0	Chaom Chao - Sihanoukville		1996		AC
	AZ		217.0	Chaom Chao - Sihanoukville	2001	2035	OT	OT (periodic maintenance)
5	Cambodia		91.0	Phnom Penh - Kampong Chhnang		2003	Trea-sury	DBST
	ADB	>$1	85.0	PK:6+00 - Kampong Chhnang	2010	2011	Loan	Maintenance
	ADB	$68.00	261.0	Kampong Chhnang - Sisophon	2000	2004	Loan	DBST
	ADB	$77.50	48.0	Sisophon - Poipet	2006	2008	Loan	AC
	China	$56.5	30.0	Phnom Penh – Prek Kdam	2011	2014	Loan	AC (4 lanes) – 2%
	Japan	$103.50	139.0 + 68.0	Prek Kdam – Thlea Maorm and Battambang – Banteay Meanchey	2010	-	F/S	AC
6	Japan	$28.00	44.0	Phnom Penh - Chealea	1993	1995	Grant	AC
	Japan			Chealea - Cheung Prey	1996	1999	Grant	AC (deteriorated condition)
	ADB		112.0	Cheung Prey -	2000	2004	Loan	DBST
	WB	$16.10	73.0	Kampong Thom - Ro Lous	1999	2006	Loan	DBST
	Japan	$12.00	15.0	Siem Reap - Bakong temple	2000	2001	Grant	AC
	ADB		100.0	Sisophon - Siem Reap	2006	2008	Loan	AC
	China	$248.8	248.525	Thnal Kaeng – Skun (4 lanes) Skun – Angkrong (2 lanes)	2012	-	Loan	AC (Contracted)
	China	$70.250	40.0	PK: 4+000 to Thnal Keng	2011	2014	Loan	AC (4 lanes) – 32.3%
7	Japan			Cheung Prey - Kompong Cham	1996	1999	Grant	AC
	Japan	$19.00		Kompong Cham - Chob	2001	2003	Grant	AC
	ADB		205.0	Chob - Kratie	2000	2004	Loan	DBST
	China	$67.5	196.8	Kratie - Trapeang Kriel (Lao border)	2003	2007	Loan	DBST
8	China	$71.513	109.0	Preak Ta Mak - Anlong Chrey	2008	2011	Loan	AC
8-1	China	$14.80	5.6	Krabao - Moeun Chey	2010	2012	Loan	AC (96.06%)
8-2	China		18.56	Anlong Chrey - Krek	2010	2012	Loan	
9	China	$116.499	141.68	Tbaeng Meanchey – Thealaborivat	2012	2015	Loan	DBST (Incl. bridge) – 29.84%
11	ADB	-	90.4		2001	2004	Loan	DBST
	Japan			Bridges				
	China	$63	90.4	NR1: Neak Loeung – NR7: Thnal Tortoeung	2015		Loan	AC
13	ADB	-	-	Svay Rieng - Anlong Chey	-	-	-	-
21	ADB	-	77.5		2002	2004	Loan	DBST
	VN		0.4	Chhrey Thom			Loan	Bridge (50%-50% share with RGC)
	Korea	$57.00	25.0		2010			
23	China	$33.00	53.00	Pea Reang Leu – Chombork (border)	2013	-	Loan	DBST
31	WB	$12.90	51.7		2003	2005	Loan	DBST
33	WB		39.8	Takeo - Kampong Trach - Kampot	2002	2005	Loan	
	ADB	$13.00	17.0	Kompong Trach - Lork (Vietnam border)	2007	2010	Loan	DBST
41	WB			National Road 4 - Prek Thnout River	-	-	Loan	DBST
	China	$95.28	46.25	Thal Tortoeng – Chum kiri - Kampot	2011	2014	Loan	DBST (31%)
43	China	$42	77	NR4: Treng Troyeng – NR3: Thvear Thmey	2015	-	Loan	DBST (Under negotiation)
44	China	$80.30	139.607	Chbamorn – Oral – Amleang – Udong	2012	-	Loan	DBST (Under negotiation)
44 + 151	ADB	-	124.0	Kg. Speu town - Oral - U dong	-	-	Loan	DBST
48	Thai	$21.69	151.3	Koh Kong - Sre Ambel	2004	2007	Loan	DBST
	Thai	$7.20	1.6				Grant	4 Bridges

Source: Overview on Transport Infrastructure Sectors in the Kingdom of Cambodia (4th Edition), 2012, IRITWG

Table 3.2-2 (2) Past, Ongoing and Planned Road Improvement Projects (2/2)

No.	Org.	Cost (Mill$)	length (km)	Section	Year Start	Fund End	Status	Pavement status
50C	China	$35+$98	58+3.5	Kg. Thom – Kg. Leng (Kg. Chhnang) + Bridge	2014	-	Loan	DBST (Under negotiation)
51	WB	$5.80	38.9	Udong - Thnal Torteng	2003	2006	Loan	DBST
	China	$27	38.9	Udong - Thnal Torteng	204	-	Loan	AC
55	China	$140	189.70	Pursat – Thmar Da, Thai – Cambodia border	2013	-	Loan	DBST (next 5-year plan)
56	Seeking	-	115.0	Sisophon - Samrong	-	-	-	(Excluding structure)
	Korea	$29.90	84.0	29km from Sisophon to Samrong	-	2009	-	Road improvement
56-68	ADB	$12.50	185.0	Sisophon - Smarong - Kralanh	2005	2007	Loan	Structure only
57	China	$41.88	103.14	Batambang – Pailin - Thai Border	2008	2012	Loan	DBST
57B	China	$176.35	89.98	1) Tmor Kol - Bovel - Sampov Luun 2) Bovel-Samseb-Phnom Prek 3) Samseb - Kamrieng	2011	2013	Loan	DBST (56.53%)
58	China	$77.00	132.0	Banteaychey – Banteay Meanrit – Thmar Daun - Phaong	2014	-	Loan	DBST (Under negotiation)
59	China	$72.89	144.27	NR 59 (Koun Damrey - Malay - Sampov Luun – Phnom Prek – Kamrieng - Pailin)	2011	2013	Loan	DBST (69.47%)
5x	Private	$5.50	13.0	National Road 5 - Thai border (through Chay Chay investment)	2004	-	-	DBST (not yet started)
60B	China	$130	140+1.67	Kg. Thmor – Kratie + Bridge	2015	-	Loan	DBST (+ bridge cost)
61	WB		16.0	Prek Kdam - Thnal Keng (NR6)	2002	2005	Loan	Maintenance
	China	$9.76	16.0	Prek Kdam - Thnal Keng (NR6)	2010	2012	Loan	DBST (52.96%)
62	WB	-	-	Kg.. Thom - Provincial border	2005	-	Loan	Laterite
	Seeking	-	-	Provincial border - Meanchey	-	-	-	-
	China	$57.80	157.0	Koh Ke – Tbeng Meanchey - Preah Vihear temple	2008	2011	Loan	DBST
	China	$52.00	128.0	Kampong thom - Tbaeng Meanchey	2008	2011	Loan	DBST
64C	China	$100	132	Tbaeng Meanchey - Thearaborivat	2011	2014	Loan	DBST
65	WB	-	-	Dam Dek -	2005	-	Loan	DBST
66	WB	$1.40	18.5	Phnom Dek - Rovieng	2004	2006	Loan	DBST
	WB	$3.20	18	Rovieng - River Stung Sen			Loan	DBST (not yet started)
67	Thai	$3.06	18.0	Choam Sa Ngam - Anlong Veng	2006	2007	Grant	DBST
	Thai	$32.50	131.0	Anlong Veng - Siem Reap	2006	2009	Loan	DBST
68	Thai	$35.00	113.0	O Smach - Kralanh	2007	2009	Loan	DBST
70B	China	$90	150	Tonlebet – Srey Santhor – Prek Tamak – Lvear Em – Peam Ro	2015	-	-	DBST
71	Cambodia	-	-	Chomkarleu – Kg. Cham	-	-	-	-
	WB	$1.50	15.5	Traueng (NR7) - Kampong Thmar (NR6)	2004	2006	Loan	DBST
71C	China	$66	110	Tbong Khum – Kroch chmar - Chamkarleu	2015	-	-	DBST (+ Kroch Chmar Bridge)
72	ADB		14.0	Memot – Tropeang Plong	2007	2009	Loan	
71+7+72	China	$112	145	Tropeang Plong – Krek – Troeung – Kg. Thmar	2015	-	-	AC
76	China	$51.90	127.0	Snoul - Sen Monorom	2008	2011	Loan	DBST
	China	$100	171.78	Monorom – Koh Nhek – Lumphat – Taang	2012	2015	Loan	DBST (5%)
78	VN	$25.80	70.0	Bang Lung - O Yadav	2007	2008	Loan	AC
	China	$73.30	123.1	O Pong Moan - Ban Lung	2009	2013	Loan	DBST (92.78%)
78x	Private	$6.00	36.0	Ban Lung - Bou Sra (waterfall)	2008	-	-	DBST (not yet started)
92	China	$75	137	Sam An (NR9) – Kg. Sralaor 2 – Kg. Sralaor 1 – Mom 3	2015	-	-	DBST
134B +135	China	$24	43	Chumkiri – Chhuk – Dorng Tung – Kg. Trach	2015	-	-	DBST
181	WB	$2.00	28	Samraong - Chong Kal	2004	2006	Loan	DBST
207	WB	$1.00	1	Sautr Nikom - Beong Tonle Sap	2004	2006	Loan	DBST
210	Private	$21.50	-	Siem Reap - Koh Ke	2003	-	BOT	DBST
258D	China	$50.00	20.0	Kob (NR5, PK: 383) – O Beychoann	2011	2013	Grant	DBST (48.3%)
378	China	$85	141	NR7: Dong Krolor – NR78: Banlung	2015	-	-	DBST
1551	China	$72	135	NR4: Smach Meanchey – NR55: Promoy	2016	-	-	DBST
1554	China	$41	70	Veal Veng (NR55) – Samlot (PR1577)	2015	-	Loan	DBST
1577	China	$25.00	55.16	Sek Sork – Samlot – Border Pass 400	2015	-	Loan	DBST
3762	China	$14.89	26.45	Sen Monorom - Dakdam	2010	2012	Loan	DBST
3787	China	$98	180	Banlung – Kantuyneak	2015	-	-	DBST
Prek Phnov	Private	$42.00	8.17	Phnom Penh (Prek Phnov) - NR6		2010	BOT	DBST (+ bridge cost)
2nd Ring Road	-	$52	38	NR5, PK: 9+000 – NR2, Prek Ho	2014	-	-	AC

Source: Overview on Transport Infrastructure Sectors in the Kingdom of Cambodia (4th Edition), 2012, IRITWG

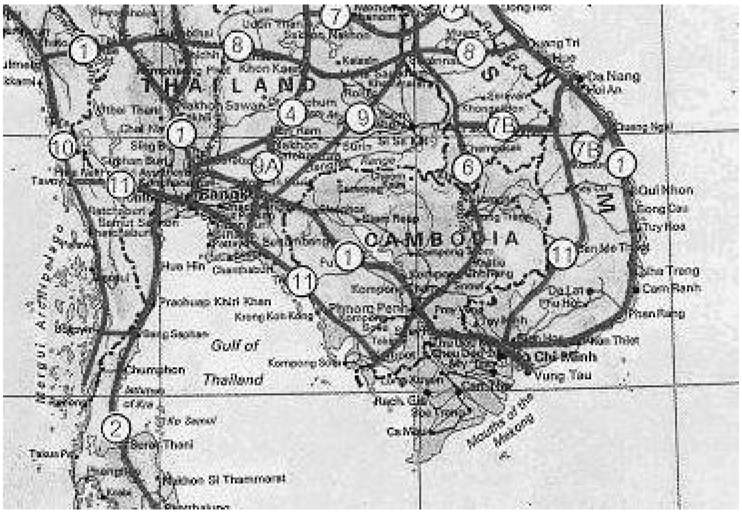
3.3 Role of National Road No. 5

3.3.1 Role in the National Road Network and Role as an International Arterial Road

NR 5 is an arterial national road connecting Phnom Penh and Poipet, the border point with Thailand. It traverses provinces of Kandal, Kampong Speu, Kampong Chhnang, Pursat, Banteay Meanchey and Battambang. Thus, 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.

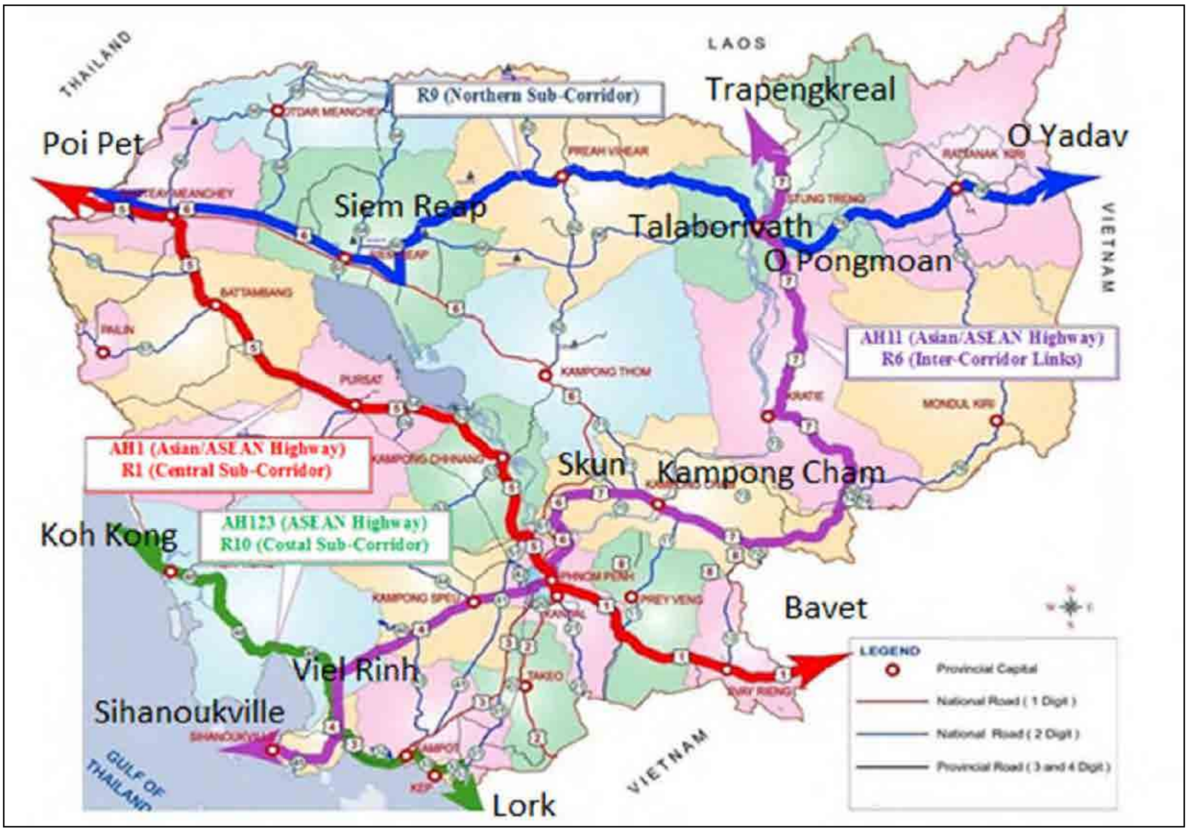
NR 5 also accommodates the traffic transporting goods and passengers between the major cities along the highway, such as Sri Sophorn, Battambang, Pursat, Kampong Chhnang and Phnom Penh. Near to the starting point of the South Section (Prek Kdam Bridge), Odongk, the old capital of Cambodia is located. Odongk is about 40 km away from Phnom Penh and is one of the tourist spots in and near Phnom Penh.

NR 5 is connected, via Phnom Penh, to NR 1 which reaches to Ho Chi Min City in Vietnam and NR 3 and NR 4 which reach to Sihanoukville, the largest international seaport of Cambodia. Thus, NR 5 is an important highway not only for domestic transport in Cambodia but also for international transport in ASEAN and the Greater Mekong Subregion (GMS). NR 5, together with NR 1, forms a route connecting Bangkok, Phnom Penh and Ho Chi Minh City. Thus, NR 5 has been designated as ASEAN Highway No. 1 and Asian Highway No. 1 (see Figure 3.3-2 and Table 3.3-1). With rapid growth in the regional cooperation in GMS in the recent years, the importance of NR 5 is also rapidly growing.



Source: ASEAN Economic Community

Figure 3.3-1 ASEAN Highway



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

Figure 3.3-2 Economic Corridors of GMS

Table 3.3-1 International Road Network in Cambodia

Name of international road			Transit Cities/provinces	Length in Cambodia (km)	International Road Classification				
GMS roads	Asian Highway	ASEAN Highway			Primary	Class I	Class II	Class III	Below Class III
Central Sub-Corridor (R1)	AH1	AH1	Poipet-Sisophon (NR5)	47.5			47.45		
			Sisophon - Phnom Penh (NR5)	360.0				360	
			Phnom Penh - Bavet (NR1)	164.0			57	107	
			Sub-total Length (km)	571.5			104.45	467	
Inter-Corridor Link (R6)	AH11	AH11	Phnom Penh - Sihanoukville (NR4)	226.4			226.4		
			Phnom Penh - Skun (NR6)	75.0			75		
			Skun-Kampong Cham (NR7)	49.0			49		
			Kampong Cham - Trapengkreal (NR7)	411.8				411.83	
			Sub-total Length (km)	762.2			350.4	411.83	
Coastal Sub-Corridor (R1)	-	AH123	Cham Yeam - Koh Kong (NR48)	13.0			13		
			Koh Kong - Sre Ambel (NR48)	138.0				138	
			Sre Ambel - Viel Rinh (NR4)	42.0			42	0	
			Viel Rinh - Kampot (NR3)	36.0				36	
			Kampot - Lork (NR33)	51.8				51.8	
			Sub-total Length (km)	280.8			55	225.8	
Northern Sub-Corridor (R9)	-	-	Siem Reap - Talaborivath (NR66+NR210+NR62+NR9)	305.2				38.8	266.38
			Talaborivath - O Pongmoan (NR7)	19.0				19	
			O Pongmoan - O Yadav border (NR78)	187.7			68.2		119.5
			Sub-total Length (km)	511.9			68.2	57.8	385.9
Grand total length (km)				2,129.4			581.1	1,162.4	385.9

Regional Cooperation in GMS and 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, which is similar to EU in nature, 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.

CBTA is an agreement among 6 countries of GMS; Cambodia, China, Laos, Myanmar, Thailand and Vietnam. Table 3.3-2 shows the contents of Annexes attached to the Agreement. They show the subjects discussed and agreed. Annex 11 is on the road and bridge design standards.

Table 3.3-2 CBTA Status

Item	Description / Title	Countries						
		Cam	PRC	Lao	Mya	Thai	VN	
Annex 1	Carriage of Dangerous Goods	R	R	R	S	S	R	TQ
Annex 2	Registration of Vehicles in International Goods	R	R	R	S	R	R	TI
Annex 3	Carriage of Perishable Goods	R	R	R	S	R	R	TQ
Annex 4	Facilitation of Frontier - Crossing Formalities	R	R	R	S	S	R	C
Annex 5	Cross - Border Movement of People	R	R	R	S	R*	R	I
Annex 6	Transit and Inland Clearance Customs Regime	R	R	R	S	S	S	C
Annex 7	Road Traffic Regulation and Signage	R	R	R	S	R	R	T
Annex 8	Temporary Importation of Motor Vehicles	R	R	R	S	S	R	C
Annex 9	Criteria for Licensing of Transport Operator for Cross - Border	R	R	R	S	R	R	T
Annex 10	Conditions of Transport	R	R	R	S	S	R	T
Annex 11	Road and Bridge Design and Construction Standards & Specifications	R	R	R	S	R	R	T
Annex 12	Border Crossing and Transit Facilities and Services	R	R	R	S	R	R	T
Annex 13a	Multimodal Carrier Liability Regime	R	R	R	S	R	R	T
Annex 13b	Criteria for Licensing of Multimodal Transport Operators for Cross - Border Transport Operations	R	R	R	S	R	R	T
Annex 14	Container Customs Regime	R	R	R	S	S	S	C
Annex 15	Commodity Classifications Systems	R	R	R	S	R	R	C
Annex 16	Criteria for Driving Licenses	R	R	R	S	R	R	TI
Protocol 1	Designation of Corridors, Routes and Points of Entry & Exit Border Crossing	R	R	R	S	R	R	TI
Protocol 2	Charges Concerning Transit Traffic	R	R	R	S	R	R	T
Protocol 3	Frequency and Capacity of Services and Issuance of Quotas and Permits	R	R	R	S	R	R	TI

*Note: * Ratified part 1 - 4*
Legend:
R: Ratification has completed and finished T: Transport, C: Customs, I: Immigration, Q: Quarantine
S: Signed but Ratification still pending
Source JICA Survey Team based on data from ADB website

As implementation of CBTA is difficult as a whole (six countries together), bilateral and tripartite agreements have been sought, like between Cambodia, Laos and Vietnam, and Cambodia and Thailand. Bilateral or tripartite agreements are shown in the table below.

Table 3.3-3 Bilateral / Tripartite Agreement

(unit per day)

Agreement	Contents	Remarks
With Vietnam	・ Quota of vehicles for cross border transport: 40 units in year 2006 ・ Quota of vehicles: increased to 150 units in year 2009 ・ Quota of vehicles: increased to 300 units in year 2010 ・ Quota of vehicles: increased to 500 units (trucks, scheduled & non - scheduled buses) in year 2012 ・ Seven border crossing points: confirmed in year 2012 1) Oyadav (Ratanakiri) - Le Thanh (Gia Lai) 2) Dak Dam (Mundulkiri) - Bu Prang (Dac Nong): pending due to border demarcation 3) Tranpeang Sre (Kratie) - Hoa Lu (Binh Phuoc) 4) Trapeang Phlong (Kampong Cham) - Xa Mat (Tay Ninh) 5) Bavet (Svay Rieng) - Moc Bai (Tay Ninh) 6) Phnom Den (Takeo) - Tinh Bien (An Giang) 7) Prek Chak (Kam Pot) - Ha Tien (Kien Giang)	
With Laos	・ Quota of vehicles for cross border transport: 40 units (trucks) ・ Scheduled buses for cross border transport: 4 units ・ Non - scheduled buses for cross border transport: 20 units under discussion ・ One border crossing point 1) Trapeang Kriel (Stung Treng) - Nong Nokkhien (Chanpasak)	
With Thailand	・ Quota of vehicles for cross border transport: 40 units (trucks & non - schedule buses) (MPWT is currently negotiation with Thai Government to increase this to 500 units.) ・ Scheduled buses for cross border transport: each 3 units ・ One border crossing point 1) Poipet (Banteay Meanchey) - Aranyaprathet (Thailand)	Separate MOU is needed for other cross border point

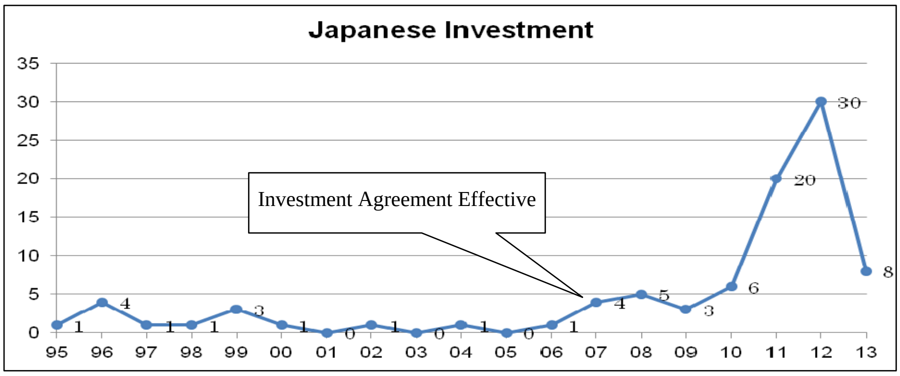
Source MPWT information

As can be seen in the above table, the number of vehicles which are allowed to cross the border with Thailand is limited. MPWT is planning to negotiate with Thai Government to increase the quota of trucks for crossing the border to 500 units/day in the future. When this increase of quota will materialize, the volume of international traffic between Cambodia and Thailand through NR 5 will substantially increase. However, the time schedule for this increase of quota is not clearly drawn.

3.3.2 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 (the Agreement became effective in July 2007), investment in Cambodia by Japanese businesses have been, and are, accelerating. According to the information provided by the Japan Desk of Council for the Development of Cambodia (CDC), the total number of licenses given for Japanese investment in

Cambodia up to the end of year 2012 is 84. Among these 84 investment license, the total of those issued in the 15 - year period of 1995 ~ 2009 was only 28 while those issued during the last 3 years (2010 ~ 2012) was 56. Therefore, the number of investment license issued in the last 3 years is 2 times of that of 16 years of 1995 ~ 2009. Further, additional 8 investment plans have been submitted for license as of January 2013 alone.



Source: Japan Desk, CDC (Original data were in tabular form)

Figure 3.3-3 Japanese Investment in Cambodia

Out of 74 factories of Japanese investment which started, and applied for license, between 2008 and 2013, 34 are located in Phnom Penh SEZ which is located near KP 14 of NR 4. 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. Thus, the improvement of NR 5 is expected to benefit such industries by shortening the transportation time and, as a result, contribute to promote Japanese investment in Cambodia.

3.4 Planned, Ongoing and Past Project for Rehabilitation / Improvement of NR 5 and Other Relevant Project

This subsection summarizes the past projects which contributed to the current condition of NR 5, as well as the on - going and planned project which are expected to improve the current condition of NR 5.

(1) ADB: Emergency Flood Rehabilitation Project (EFRP)

EFRP aims urgently restore the damaged section of NR 5 to their conditions before the flood and contribute to recovery of economic and social activities. The damaged sections of the South Section and North Section, were repaired. Reconstruction of bridges was covered by Package 5E of Primary Roads Restoration Project (PRRP) funded by ADB, which had been removed from PRRP and transferred to EFRP.

(2) Project Funded by Phnom Penh Municipality

The approximately 8 km - long section between Phnom Penh (Chruoy Changvar Bridge) and the boundary between Phnom Penh Municipality and Kandal Province (outs of scope of this Survey), was overlaid with asphalt concrete (AC) recently by the fund of Phnom Penh Municipality. Pavement works had been completed by the end of year 2012.

(3) Widening of Phnom Penh - Prek Kdam Section by Financial Assistance of Chinese Government

This project is to widen the approximately 31 km - long section from Chruoy Changvar Bridge Kandal to Prek Kdam into full 4-lane with AC pavement by Chinese fund. Thus, this project has close relation with the Project of the Survey of the South Section is conducted by JICA Study Team.

The project started in October 2012 and is scheduled to be completed in June 2014. The commencement ceremony was held on 9 October 2012. Figure 3.4-1 shows the typical cross sections (urban section and rural section) of the widening project.

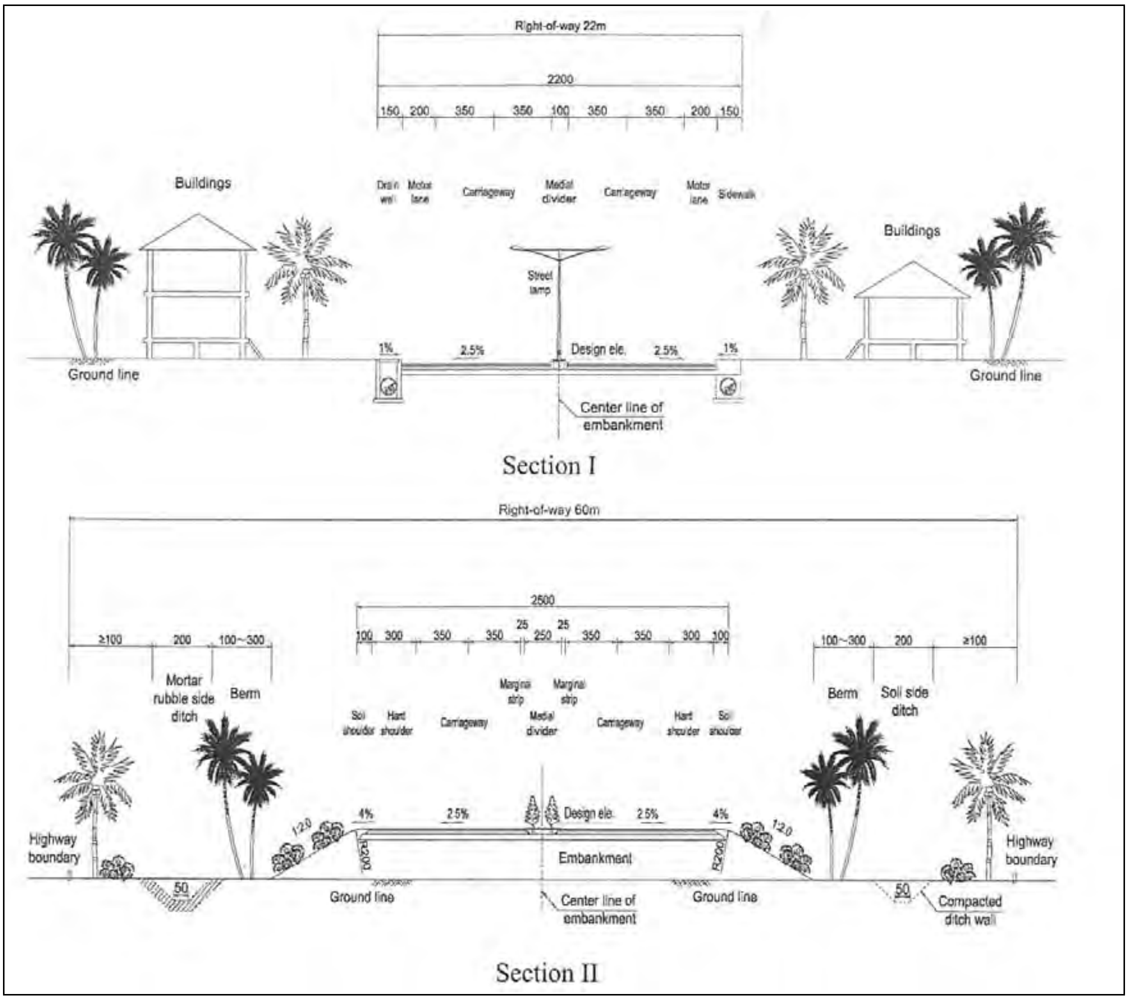


Figure 3.4-1 Typical Cross Section of Widening Under Chinese Fund

(4) ADB: Road Asset Management Project (RAMP)

Road Asset Management Project (RAMP) funded by ADB implemented the maintenance work between Phnom Penh (KP 3.9) and Thlea Ma'am (KP 170.9) in 2010, 2011 and 2012. The contents of the works are the installation of road signs, guide posts, lane marking and kilometer posts. Repairs of pavement such as cracks, potholes, depression, rutting, shoving, corrugation, base course failure, edge break damage, as well as full depth reconstruction of pavement were also carried out. However, no improvement or upgrading works were carried out in this project.

Figure 3.4-2 shows examples of repair works carried out in RAMP.

Vicinity of KP 120

Vicinity of KP 111

Figure 3.4-2 Pavement Repair by RAMP Project

(5) JICA: Flood Disaster Rehabilitation and Mitigation Project (FDRMP)

During the rainy season in 2011, the water level of Mekong River reached almost the same level as that of the serious flooding occurred in 2000. This unusually high rise of the water level in the Mekong River was attributed to the unusually heavy rainfall at the upstream of the Mekong River. Many sections of NR 5 were severely damaged by the flood of 2011. FDRMP 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. The component of road improvement in Kampong Chhnang City includes improvement of pavement, drainages and sidewalks of the city center section of National Road No. 5 (2.2 km) and the related major streets (2.4 km). It also includes extension of drainage (by 2.6 km) to outlet the rain water to the nearest river.

The recent projects on NR 5 as described above are listed in Table 3.4-1.

Table 3.4-1 Project List on NR 5

Section	Project	Year
Phnom Penh ~ Prek Kdam Br.	・ Restored by Army ・ RAMP funded by ADB ・ Full 4-lane widening & AC pavement by Phnom Penh Municipality (Chrouy Changvar Br. – P. P./ Kandal Border) ・ Widening to full 4-lane by Chinese fund	2000 - 2002 2010 - 2011 2012 2012 -
Prek Kdam Br. ~ Kampong Chhnang (South Section)	・ Restored by Army ・ RAMP funded by ADB	2000 - 2002 2010 - 2011
Kampong Chhnang ~ Thlea Ma'am (South Section)	・ EFRP funded by ADB ・ RAMP funded by ADB	2000 - 2004 2011 - 2012
Kampong Chhnang City	・ FDRMP funded by JICA	2012 -

(6) ADB: GMS: Railroad Rehabilitation Project

As listed in Table 3.2-1, the railroad is being rehabilitated under the financial assistance of 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. The civil works started in March 2008. There had been delay in progress due to various problems, such as resettlement, and the contractor abandoned the project in July 2012. Currently, the project is haltered for time being. After completion of rehabilitation of railroad facility, the process of selecting the to whom the concession of operation will be awarded will take place. It is unknown at present how long this process will take.

(7) Plan for Construction of Expressway

As the fundamental improvement of long - distance road transport, construction of expressway network is currently being discussed. A master plan of the national expressway network was prepared by the assistance of the government of Henan Province, China and was presented in April 2014. This master plan proposed an expressway network with a total length of 2,200 km. The expressway along NR 5 is proposed as one of the main lines of the national expressway network, and is planned a few to ten kilometer away from the existing national road on the west side of NR 5 (opposite from Tonle Sap) to avoid the densely populated areas along the existing national roads. This route is also suitable for avoiding inundation/flood. The master plan proposes this expressway along NR 5 be listed among the "medium term projects" but does not mention the time of construction.

After these expressways will be constructed and will be open to traffic, existing NR 5 will be used mainly for the daily activities of the people living along NR 5.

3.5 Necessity of Improvement of the Middle Section and the Sri Sophorn - Poipet Section

Improvement of the Middle Section and the Sri Sophorn - Poipet Section of NR 5 is necessary in view of the facts summarized below:

(1) Designation in the National Development Plan and Road Network Master Plan

Widening of NR 5 has been designated as one of major projects in both of national development plan (NSDP) and road network master plan.

(2) Halter of the railroad rehabilitation project

In view of the uncertainties in railroad rehabilitation, improvement of NR 5 is the only foreseeable improvement of transport infrastructure between Phnom Penh and Sri Sophorn/Poipet.

(3) Improvement of the South Section and the North Section

The North Section and the South Section are to be widened to full 4-lane by the assistance of Japanese Government. From a viewpoint of consistency of road standard, it is necessary to widen from Thlea Ma'am to Battambang and the Sri Sophorn – Poipet Section to the same standard.

(4) Promotion of regional economic cooperation

ASEAN community is scheduled to be agreed in 2015 as described Subsection 3.3.1. Also many foreign companies, including Japanese enterprises, are constructing factories in Cambodia. Thus international transportation between Thailand and Cambodia needs to be improved.

CHAPTER 4 PRESENT CONDITION OF MIDDLE SECTION AND SRI SOPHORN – POIPET SECTION

4.1 Overall Conditions

(1) Overall Road Condition of the Middle Section

An inventory survey of the Middle Section was conducted in the middle of May 2013 utilizing the same survey method used in the Survey of the North Section conducted in February – March 2011. In the inventory survey conducted in the Survey for the North Section intended to evaluate the existing conditions of the entire length of Prek Kdam – Sri Sophorn, and thus, covered all of South, Middle and North Sections.

In the inventory survey conducted in May 2013, it was observed that the road condition had become worse than those observed in the survey in 2011. Figure 4.1-1 shows examples of the damages observed in May 2013. One of the main causes for the worsened road condition is the rain water which accumulated at the roadside and consequently penetrated into the pavement structure and subgrade. Pavement is quickly damaged once the base course and subgrade are weakened by the penetrated water. Once cracks occur, the water seep into the base course and subgrade through cracks and potholes further developing these damages.

Longitudinal Crack (KP 224)

Mesh Crack (KP 236)

Pothole (KP 229)

Depression (KP 265)

Figure 4.1-1 Condition of Middle Section

The road condition of Middle Section is summarized in the straight diagram attached as Appendix 4-1.

Discrepancy in Kilometer Posts

During the period of the Survey of the North Section, MPWT installed kilometer posts (KP) along NR 5. However, there seemed to be some discrepancies between the distances of the installed KPs and those observed by the Survey Team using a GPS apparatus. The distances between KPs measured by the Survey Team are shown in Table 4.1-1. The locations used in this report are those measured from the existing KPs.

Table 4.1-1 Distance between KPs Measured by Survey Team

Unit: km

KP	Distance	KP	Distance	KP	Distance
171		215	1.02	259	1.02
172	1.01	216	1.01	260	1.03
173	0.98	217	1.04	261	1.01
174	1.01	218	1.01	262	1.03
175	1.00	219	1.00	263	1.00
176	0.96	220	1.00	264	1.03
177	1.00	221	1.03	265	0.99
178	1.05	222	1.00	266	1.03
179	1.01	223	1.01	267	1.00
180	1.01	224	1.00	268	1.00
181	0.97	225	1.02	269	1.02
182	0.94	226	1.01	270	1.02
183	0.99	227	1.04	271	1.04
184	0.95	228	1.00	272	1.05
185	0.97	229	1.03	273	1.04
186	1.00	230	1.02	274	1.04
187	0.98	231	1.03	275	1.01
188	0.98	232	1.01	276	1.06
189	0.97	233	1.01	277	1.05
190	1.35	234	1.00	278	1.00
191	0.69	235	1.02	279	1.02
192	1.02	236	1.01	280	1.02
193	1.05	237	1.01	281	0.99
194	1.02	238	0.99	282	1.02
195	1.07	239	0.99	283	Shift to
196	1.03	240	1.00	284	Bypass
197	1.04	241	1.00	285	
198	0.99	242	0.99	286	
199	1.07	243	1.06	287	
200	1.03	244	1.01	288	
201	0.97	245	1.02	289	
202	1.03	246	1.00	290	
203	1.01	247	1.02	291	
204	0.99	248	1.00	292	
205	1.03	249	1.01	293	
206	0.98	250	1.00	294	
207	1.00	251	1.00	295	
208	1.00	252	0.99	296	
209	1.03	253	1.01	297	
210	1.00	254	1.00	298	
211	1.04	255	1.01	299	
212	0.99	256	1.01	300	
213	1.03	257	1.02	301	
214	1.04	258	1.04		

(2) Overall Road Condition of Sri Sophorn - Poipet Section

Sri Sophorn - Poipet Section of NR 5 was improved in 2008 under Cambodia Road Improvement Project (CRIP), Package 5F financed by ADB. The AC pavement was adopted in this section. Therefore, the road surface condition is better than the other sections of NR 5. Problems are found at limited number of locations and most part of the road surface is still in good condition. Flushing and rutting are the main observed problems. Figure 4.1-2 shows examples of the main observed damages.

Flushing (KP 370)

Rutting (KP 386)

Figure 4.1-2 Condition of Sri Sophorn - Poipet Section

The distances between KPs in Sri Sophorn - Poipet Section also measured by GPS apparatus are shown in Table 4.1-2.

Table 4.1-2 Distance between KPs along Sri Sophorn - Poipet Section

(Unit: km)

KP	Distance	KP	Distance	KP	Distance	KP	Distance
366	0.00	377	1.01	388	1.00	399	1.01
367	1.00	378	1.02	389	0.99	400	1.02
368	1.00	379	0.99	390	1.03	401	1.03
369	1.03	380	1.00	391	1.00	402	0.93
370	0.97	381	1.00	392	0.99	403	1.10
371	1.00	382	1.01	393	1.02	404	0.99
372	1.01	383	1.00	394	1.01	405	1.03
373	1.01	384	1.01	395	0.99	406	1.00
374	1.00	385	1.02	396	1.00	407	0.91
375	1.00	386	1.03	397	1.02		
376	1.01	387	0.99	398	1.00		

4.2 Geometric Structure

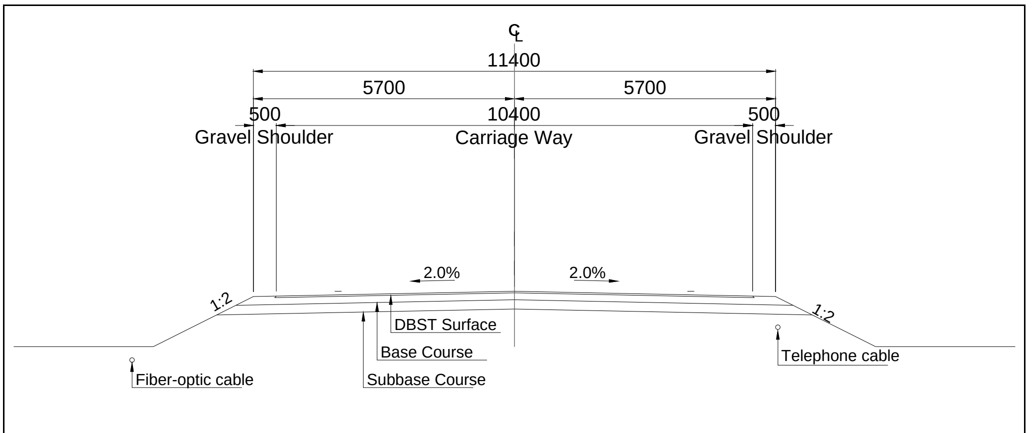
4.2.1 Cross Section

A space of a road is used not only for passage of motorized vehicles but also for other purpose. A road provides space for various facilities including drainage, telecommunication cables and electric power line. Parts of road are also used as the space for passage of non - motorized vehicles and pedestrians. Thus, it is necessary to consider these functions.

(1) Cross Section of Middle Section

The existing cross section of the Middle Section comprises two undivided opposing lanes and shoulders. All of road surface along Middle Section is Double-Layered Bituminous Surface Treatment (DBST) with a gravel shoulder.

The average width of pavement of Middle Section is 10.4 m. The typical cross section of Middle Section is shown in Figure 4.2-1.



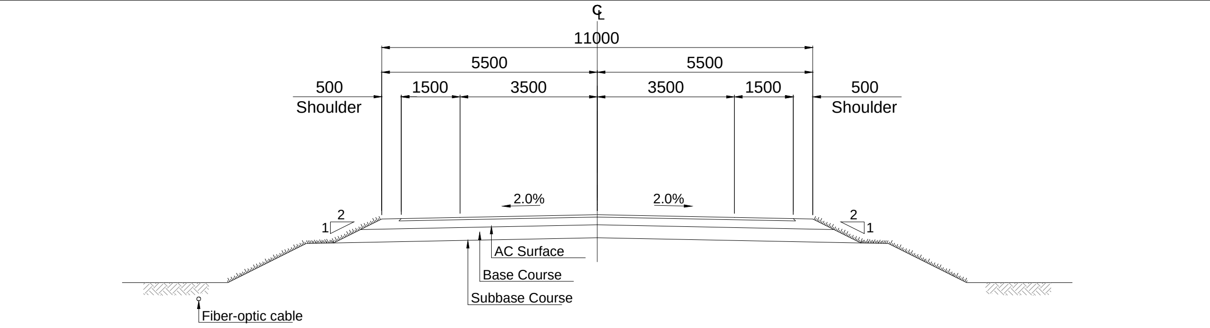
Thlea Ma'am - Battambang Section

Figure 4.2-1 Typical Cross Section of Middle Section

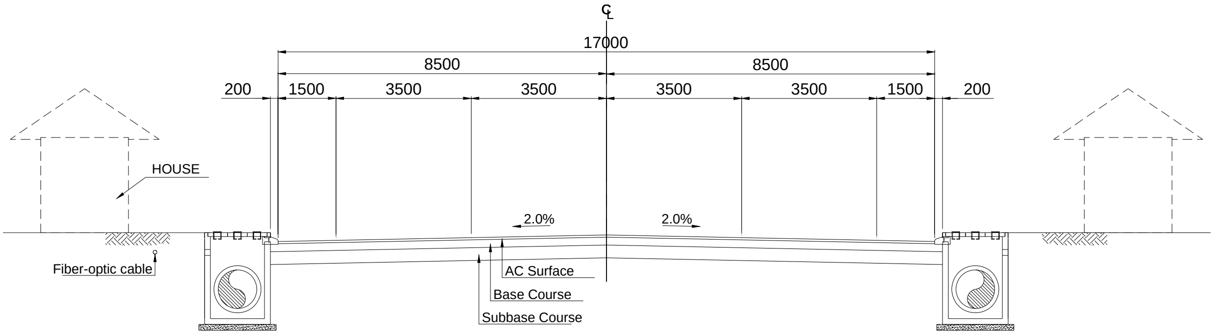
(2) Cross Section of Sri Sophorn - Poipet Section

The cross section of Sri Sophorn - Poipet Section in rural areas comprises two undivided opposed lanes with 1.5 m-wide shoulders on the both sides which can be used by motorcycles and other slows vehicles. All of road surface of this section is AC and the surface of shoulder is covered by gravel. On the other hand, the cross section in urban areas is undivided 4-lane with 1.5 m-wide shoulder. The cross section for urban area starts from KP 403 and ends at KP 407.

The cross sections in rural and urban of the Sri Sophorn - Poipet Section are shown in Figure 4.2-2.



Cross Section between Sri Sophorn - Poipet Section for Rural Area
(KP 366 – KP 402)



Cross Section between Sri Sophorn - Poipet Section for Urban Area
(KP 403 – KP 407)

Figure 4.2-2 Cross Sections of Sri Sophorn - Poipet Section

4.2.2 Horizontal Alignment

Horizontal alignment is one of the most important factors influencing the efficiency and safety of an arterial road such as NR 5. A curve with a small radius results in lower speeds, which in turn, results in reduction in the performance of NR 5 as an arterial road in terms of safety and comfort. Horizontal alignment of NR 5 is generally generous. Where there is a curve, the radius is usually large enough to satisfy the criteria of geometric design of Cambodia.

(1) Horizontal Alignment of Middle Section

In the Middle Section, there are six curves with radii smaller than 350 m which is the minimum value for the design speed of 100 km/h. The curve lengths at 25 locations, including one location in urban area, are shorter than the minimum value. Table 4.2-1 shows the locations and elements of curves including those whose radii are smaller than the criterion.

Table 4.2-1 Elements of Substandard Curves on Middle Section

No.	KP	Radius (m)	Length (m)	Problem *	No.	KP	Radius (m)	Length (m)	Problem *
1	175 + 496	1,817	167	L	14	264 + 875	541	128	L
2	179 + 549	24,538	102	L	15	273 + 962	546	105	L
3	192 + 437	1,024	119	L	16	275 + 942	519	100	L
4	192 + 573	1,475	125	L	17	276 + 259	155	69	R/L
5	199 + 030	135,302	89	L	18	277 + 110	1945	128	L

No.	KP	Radius (m)	Length (m)	Problem *	No.	KP	Radius (m)	Length (m)	Problem *
6	213 + 759	2,239	116	L	19	277 + 450	608	101	L
7	239 + 357	668	137	L	20	277 + 750	121	40	R/L
8	240 + 911	3,329	83	L	21	277 + 889	1098	143	L
9	242 + 424	442	85	L	22	278 + 015	312	111	R/L
10	242 + 693	322	56	R/L	23	278 + 479	248	43	R/L
11	244 + 015	271	73	R/L	24	279 + 264	270	147	R
12	253 + 553	625	41	L	25	279 + 478	1059	114	L
13	255 + 327	1,139	133	L					

**L: Insufficient curve length R: Radius of curve smaller than standard*

There are 10 sections in the Middle Section where the maximum speed is regulated at 40 km/h. Table 4.2-2 shows the location of speed reduction on the Middle Section.

Table 4.2-2 Section of Speed Reduction on Middle Section

No.	KP		Length (km)	Name
	Beginning	End		
1	184 + 100	188 + 200	4.09	Pursat
2	197 + 500	198 + 300	0.83	Andoung Krasang
3	200 + 800	202 + 500	1.75	Bakan
4	208 + 800	212 + 700	4.64	Boeung Khnar
5	215 + 100	217 + 000	1.97	Ou Ta Paong
6	218 + 800	220 + 000	1.12	Svay Daun Keo
7	222 + 400	224 + 900	2.45	Prek Svay
8	230 + 600	231 + 600	0.96	Kalaom Phluk
9	235 + 900	237 + 000	1.17	Prey Svay
10	243 + 700	245 + 600	1.85	Moung Russei

(2) Horizontal Alignment of Sri Sophorn - Poipet Section

In the Sri Sophorn - Poipet Section, the smallest radius of curve is 1,500 m. Thus, there is no serious problem in the present horizontal alignment. There are 5 sections in the urbanized areas where the maximum speed is regulated at 40 km/h. Table 4.2-3 shows the location of speed reduction on the Sri Sophorn - Poipet Section.

Table 4.2-3 Section of Speed Reduction on the Sri Sophorn - Poipet Section

No.	KP		Length (km)	Name
	Beginning	End		
1	372 + 600	373 + 200	0.62	Soryathmi
2	376 + 900	377 + 400	0.50	Soryathmi
3	380 + 000	389 + 200	9.12	Nimit
4	392 + 300	394 + 100	1.79	Koun Damrei
5	401 + 900	407 + 300	5.40	Poipet

4.2.3 Vertical Alignment

Vertical alignment often constitutes the governing factor in design in case of a road traversing mountainous terrain. In case of NR 5, the vertical alignment is generally flat since NR 5 generally traverses flat terrain.

(1) Middle Section

The steepest grade on the Middle Section is observed on the approach sections of the bridges. Even on the sections approaching bridges, the gradients are less than 4 percent, the maximum grade stipulated in the Cambodian Standard for Geometric Design. Thus, the gradient itself is not imposing serious problems. Rather, the height of the road surface near the bridges needs to be examined in relation to flood/inundation. The profile of the Middle Section, drawn based on the cross section survey data, is shown in Figure 4.2-4 to 4.2-5.

The common embankment height is 1 to 2 m and the maximum embankment height is 4 m according to the result of inventory survey. Embankment height of zero means that the elevation of land on both sides of NR 5 is same with 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. Figure 4.2-3 shows examples of road surface lower than the adjacent land and inundated road surface.

Figure 4.2-3 Road Surface Lower than Adjacent Land; Inundation Occurred due to Rain Water Flowing into Road from Adjacent Land

The problem of flood / inundation is discussed in Chapter 6.

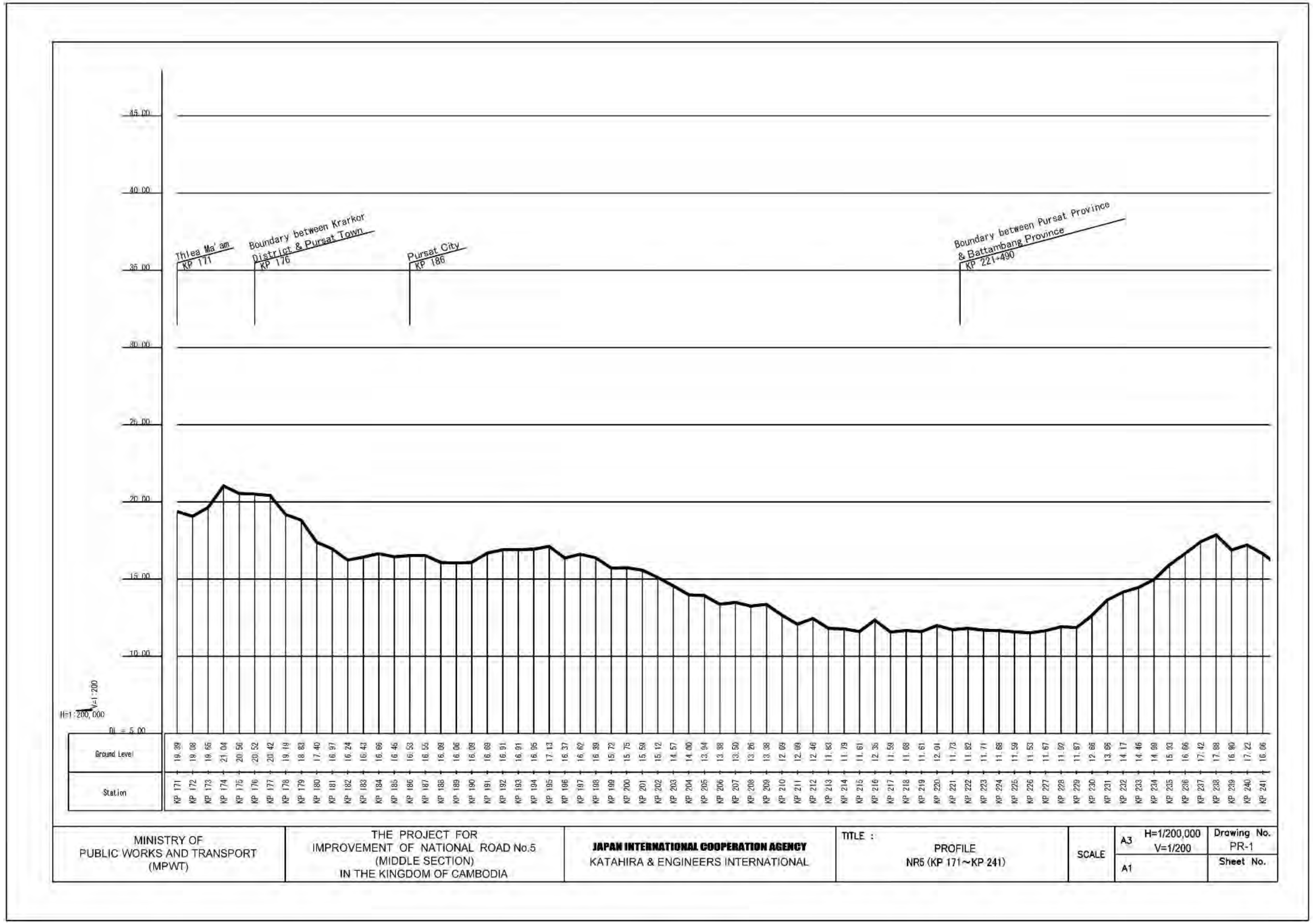


Figure 4.2-4 Road Elevation of Middle Section: from KP 171 to KP 241

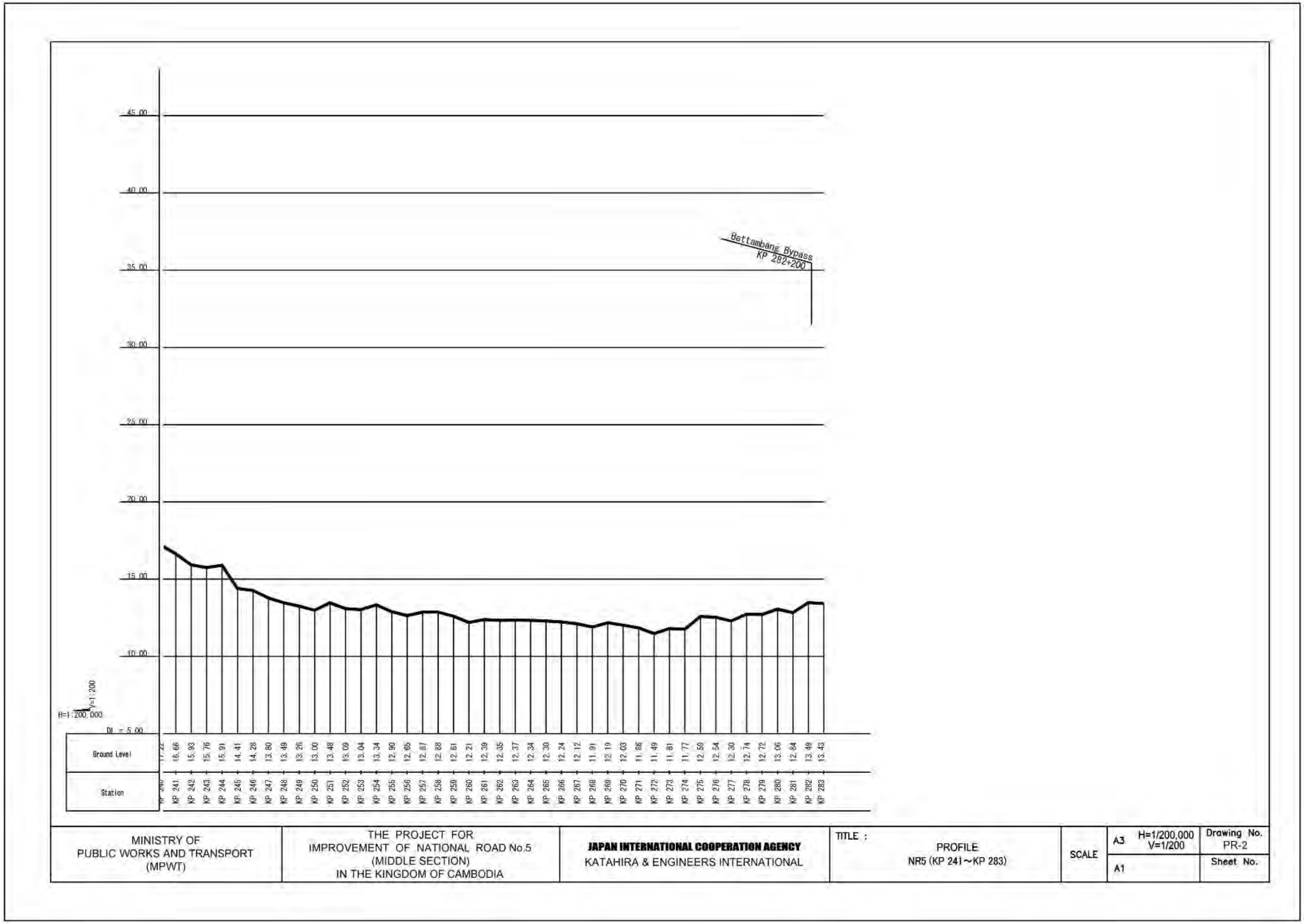


Figure 4.2-5 Road Elevation of Middle Section: from KP 241 to KP 283

(2) 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 percent and gradients of most of the sections are less than 0.10 percent as observed in the as-built drawings prepared in the CRIP financed by ADB. Thus, the gradient itself is not imposing serious problems. Rather, the height of road surface is an important subject in view of the flood/inundation. The embankment height was raised in CRIP by around 60 cm or more from the original embankment height. In the urbanized areas, the road surface level is either equal to, or less than, the level of adjacent land. Drainage pipes for the rain water were installed in CRIP.

Figure 4.2-6 shows examples of road surface lower than the adjacent land where inundation of road surface has occurred (left) and inlet of drainage installed under the sidewalk.

Figure 4.2-6 Road Surface Lower than Adjacent Land in the Commercial Area (Left) and Inlet of Drainage Installed under CRIP

The problem of flood / inundation is discussed more in detail in Chapter 6.

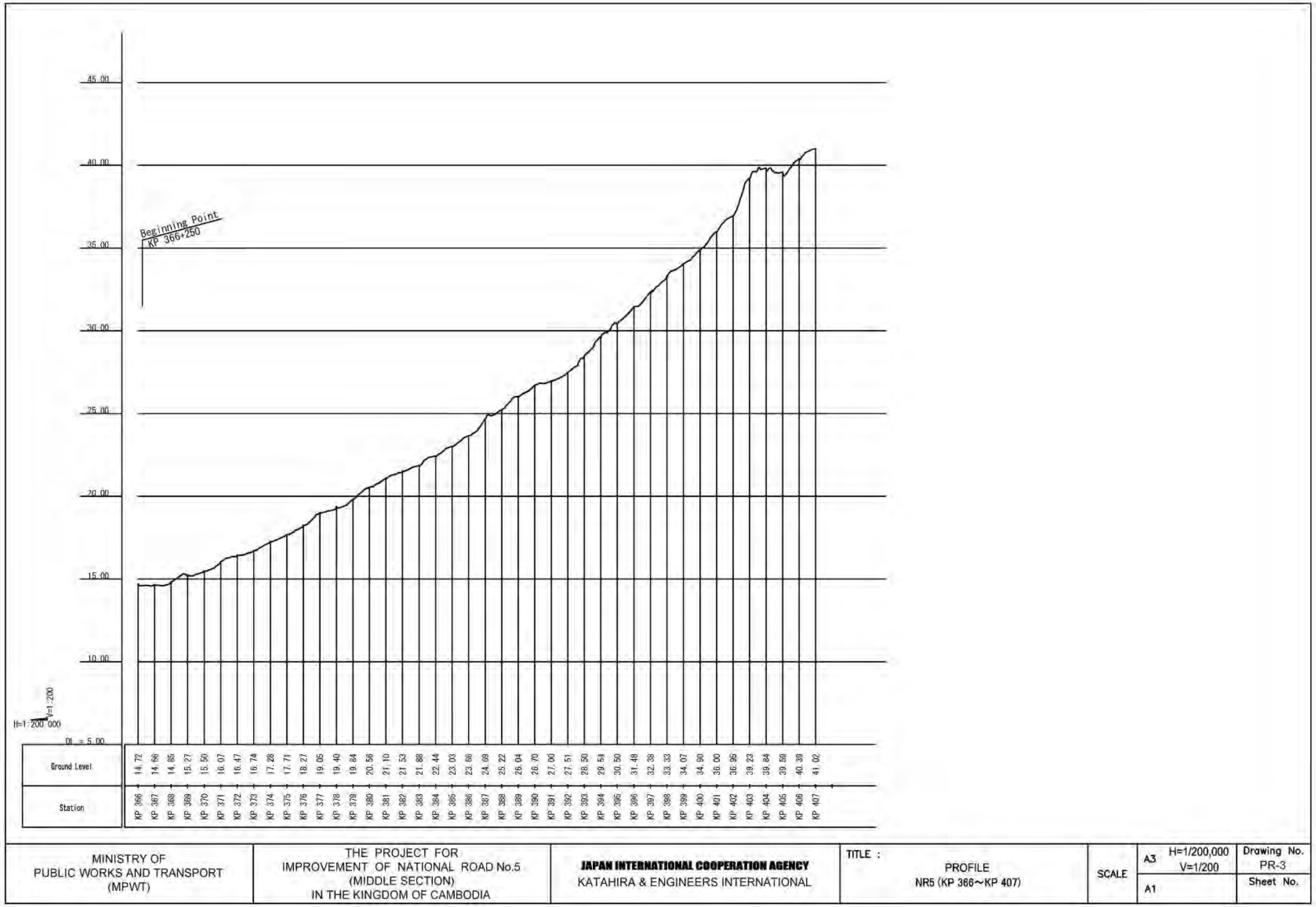
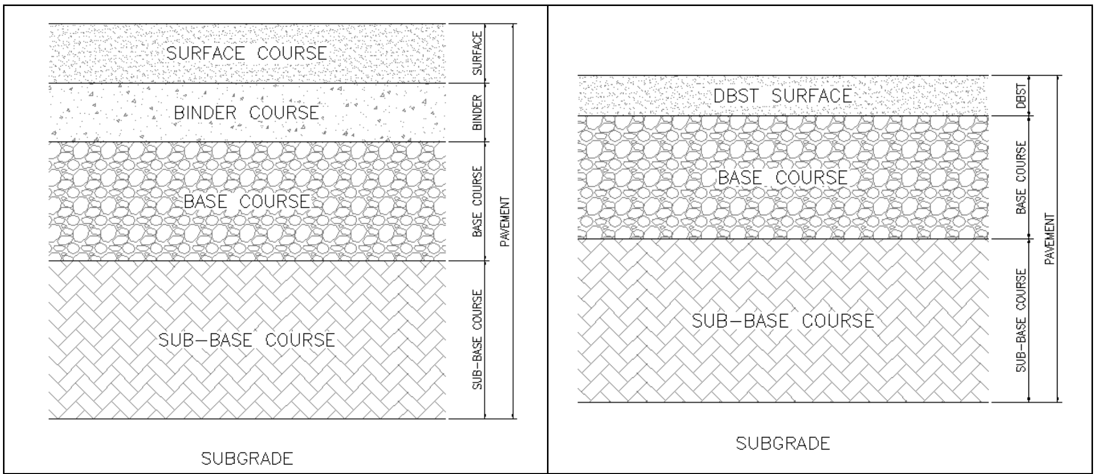


Figure 4.2-7 Road Elevation of Sri Sophorn – Poipet Section: from KP 366 to KP 407

4.3 Pavement

Adequate pavement design is one of the most important aspects of road design. The condition and adequacy of the highway is often judged by the smoothness or roughness of the pavement. Deficient pavement conditions can result in increased user costs, travel delays, excessive braking, increased fuel consumption, vehicle maintenance cost and higher risk of traffic accidents.

The existing pavement structures of the Middle Section is double-layered bituminous surface treatment (DBST) and that of Sri Sophorn - Poipet Section is asphalt concrete (AC). The typical pavement structures of "AC Pavement" and "DBST" are shown in Figure 4.3-1. DBST is used in the road with minimal traffic volume of heavy vehicles.



AC Pavement	DBST

Figure 4.3-1 Standard Pavement Condition

(1) Middle Section

The condition of the existing pavement was observed at the points of failure and at 1 km intervals at the fixed kilometer post in the Survey of the North Section in 2011. These inventory data are updated on May 2013 in this Survey.

The maintenance of the pavement was in general carried out during dry season of 2012 and 2013. The inventory survey was carried out at the end of the dry season of 2013 (May 2013). The maintenance works under DPWTs have been carried out to repair major damages in the Middle Section but many minor failures were left unrepaired.

The typical pavement defects observed on the Middle Section and Sri Sophorn - Poipet Section are shown in Table 4.3-1.

(2) Sri Sophorn - Poipet Section

The condition of existing pavement was closely observed by the same method with the Middle Section. Only the cracks and potholes have been observed in some parts. Generally pavement condition is still kept better than the other parts of NR 5.

Table 4.3-1 Typical Pavement Defects

Type of Failures	Description	Photo
Crack KP 207 ~ KP 214, KP 220 ~ KP 253, KP 260 ~ KP 282, KP 387, KP 390, KP 396 ~ KP 397,	There are two types of crack; longitudinal line crack on the shoulder and mesh crack on the depressed area. The longitudinal line cracks are assumed to be caused by the settlement of embanked surface.	
Pothole KP 192 ~ KP 193, KP 229 ~ KP 243, KP 265 ~ KP 271, KP 274 ~ KP 281 KP 375	There are numerous small holes. These small halls usually develop further during the rainy season.	
Depression KP 235 ~ KP 237, KP 265 ~ KP 271, KP 275 ~ KP 281 KP 393	Usually observed in the right wheel tracks of vehicles. It is caused by insufficient strength of the pavement and / or penetration of water into the pavement structure.	
Flush (Bleeding) KP 200, KP 367 ~ KP 374, KP 380 ~ KP 382, KP 395 ~ KP 398,	Bituminous material seeping out to the pavement surface. Caused by excess use of bitumen.	
Rutting KP 177 ~ KP 182, KP 191 ~ KP 201, KP 226 ~ KP 230, KP 246 ~ KP 251, KP 259 ~ KP 263, KP 366, KP 374, KP 380, KP 382, KP 386 ~ KP 387, KP 391 ~ KP 394,	Observed on the wheel tracks of vehicles: Caused by insufficient strength of the pavement compared to the traffic load.	
Aggregate loss KP 205, KP 248, KP 279	Breakaway of surface aggregate is observed on the old surface: Caused by the poor adhesion of deteriorated bitumen or insufficient binder.	
Edge Damage KP 184 ~ KP 188, KP 239 ~ KP 246	Wear of shoulder caused by action of water and / or vehicle entering to the road.	

4.4 Bridge Condition

4.4.1 Inventory of Bridges

The conditions of existing bridges were visually inspected. The location of each bridge was measured from the existing kilometer post along the NR 5 and the distances from the existing KPs to the bridge were measured by GPS apparatus in the field survey. Accordingly, KP of bridge locations is expressed with 50 meters as the effective number.

A bridge inventory provided by MPWT lists 38 bridges. The field survey conducted by the Team indicated some discrepancies between records in the inventory and the results of the field survey as compared in Table 4.4-1 shown below.

Table 4.4-1 Differences between Inventory of MPWT and Result of Survey

Br. No	Inventory of MPWT		Result of Survey	
	KP	Bridge type	KP	Bridge type
40	177 + 007	RC Steel Bridge	177 + 200	Steel Girder
41	178 + 326	PC Bridge	178 + 500	PC Hollow
42	181 + 584	RC Bridge	181 + 800	RC Girder
43	182 + 525	PC Bridge	182 + 800	PC Hollow
44	182 + 945	RC Steel Bridge	183 + 300	Steel Girder
45	183 + 527	PC Bridge	183 + 900	PC Hollow
46	183 + 720	PC Bridge	184 + 100	PC Hollow
47	185 + 192	PC Bridge	185 + 700	PC Girder
48	186 + 961	PC Bridge	187 + 400	PC Girder
49	187 + 268	PC Bridge	187 + 700	PC Hollow
50	187 + 541	PC Bridge	188 + 100	PC Hollow
51	187 + 725	PC Bridge	188 + 250	PC Hollow
52	188 + 703	PC Bridge	189 + 250	PC Hollow
53	189 + 371	PC Bridge	189 + 900	PC Hollow
54	189 + 931	PC Bridge	190 + 150	PC Hollow
55	190 + 544	PC Bridge	191 + 100	PC Hollow
56	201 + 514	PC Bridge	201 + 800	PC Hollow
57	208 + 237	RC Bridge / PC Bridge	208 + 500	PC Hollow
58	215 + 428	RC Steel Bridge	215 + 750	Steel Girder
59	219 + 274	RC Steel Bridge	219 + 600	Steel Girder
60	220 + 465	PC Bridge	220 + 800	PC Hollow
61	222 + 345	PC Bridge	222 + 650	PC Hollow
62	223 + 291	PC Bridge	223 + 650	PC Hollow
63	242 + 379	PC Bridge	242 + 850	PC Hollow
64	243 + 189	PC Bridge	243 + 600	PC Hollow
65	243 + 938	PC Bridge	244 + 400	PC Hollow
66	245 + 491	RC Bridge	245 + 900	RC Girder
67	254 + 191	PC Bridge	255 + 250	PC Hollow
68	254 + 741	PC Bridge	255 + 600	PC Hollow
69	256 + 043	PC Bridge	256 + 550	PC Hollow
70	257 + 401	PC Bridge	257 + 900	PC Hollow
71	265 + 348	PC Bridge	265 + 900	PC Hollow

Br. No	Inventory of MPWT		Result of Survey	
	KP	Bridge type	KP	Bridge type
72	270 + 378	PC Bridge	270 + 900	PC Hollow
73	271 + 124	PC Bridge	271 + 700	PC Hollow
74	272 + 082	PC Bridge	272 + 650	PC Hollow
75	272 + 775	PC Bridge	273 + 300	PC Hollow
76	275 + 164	PC Bridge	275 + 650	PC Hollow
77	276 + 024	PC Bridge	276 + 550	PC Hollow

Table 4.4-2 shows the details of bridges observed through the field survey.

Table 4.4-2 Details of Existing Bridges on Middle Section

Ref.	Code	KP (Km)	Bridge Type	Length (m)	No. Of Span	Width (m)			Year Built	Note
						Total	Carriage	Side		
1	Br. 40	177 + 200	Steel Girder	23.0	1	9.6	7.0	1.3	1996	· Steel Girder is galvanized. · Slope protections stone mason at A1 abutment and A2 abutment are destroyed partially caused by flood. · Widening at left side has advantages due to the surrounding site condition.
2	Br. 41	178 + 500	PC Hollow	15.1	1	10.1	10.1	No	2003	
3	Br. 42	181 + 800	RC Girder	18.6	4	9.15	9.15	No		
4	Br. 43	182 + 800	PC Hollow	36.0	2	10.1	10.1	No	2003	· Pier table of the bridge is supported by RC piles (6 in total) at the center.
5	Br. 44	183 + 300	Steel Girder	45.6	3	9.05	9.05	No	1996	· Steel Girder is painted. · Each pier table of the bridge is supported by RC piles (10 each). · Widening at left side has advantages due to the surrounding site condition
6	Br. 45	183 + 900	PC Hollow	36.0	2	10.0	10.0	No	2003	· Pier table of the bridge is supported by RC piles (6 in total) at the center.
7	Br. 46	184 + 100	PC Hollow	20.0	1	10.0	10.0	No	2003	
8	Br. 47	185 + 700	PC Girder	120.0	6	9.6	7.0	1.3	1995	· All pier tables of the bridge are supported by RC piles (10 each). · Widening at left side has advantages due to the surrounding site condition
9	Br. 48	187 + 400	PC Girder	28.0	2	8.5	8.5	No		
10	Br. 49	187 + 700	PC Hollow	24.0	2	10.0	10.0	No	2003	· Pier table of the bridge is supported by RC piles (6 in total) at the center.
11	Br. 50	188 + 100	PC Hollow	54.0	3	10.0	10.0	No	2003	· All pier tables of the bridge are supported by RC piles (6 in total).
12	Br. 51	188 + 250	PC Hollow	45.0	3	10.0	10.0	No	2003	· All pier tables of the bridge are supported by RC piles (6 in total).
13	Br. 52	189 + 250	PC Hollow	30.0	2	10.0	10.0	No	2003	· Pier table of the bridge is supported by RC piles (6 in total) at the center.
14	Br. 53	189 + 900	PC Hollow	18.0	1	10.0	10.0	No	2003	
15	Br. 54	190 + 150	PC Hollow	18.0	1	10.0	10.0	No	2003	
16	Br. 55	191 + 100	PC Hollow	30.0	2	10.0	10.0	No	2003	· Pier table of the bridge is supported by RC piles (6 in total) at the center.
17	Br. 56	201 + 800	PC Hollow	12.0	1	10.0	10.0	No	2003	
18	Br. 57	208 + 500	PC Hollow	28.0	2	10.0	10.0	No	2003	
19	Br. 58	215 + 750	Steel Girder	45.6	3	10.0	7.0	1.5	1996	· Steel Girder is painted. · All pier tables of the bridge are supported by RC piles (10 each).

Ref.	Code	KP (Km)	Bridge Type	Length (m)	No. Of Span	Width (m)			Built Year	Note
						Total	Carriage	Side		
20	Br. 59	219 + 600	Steel Girder	91.0	3	9.6	7.0	1.3	1996	・ Steel Girder is galvanized. ・ Slope protection stone mason at A1 abutment is destroyed partially caused by flood. ・ All pier table of the bridge is supported by Steel piles (12 each). ・ One part of steel handrail of the bridge is damaged. ・ Widening at right side has advantages due to the surrounding site condition
21	Br. 60	220 + 800	PC Hollow	24.1	2	10.0	10.0	No	2003	・ Slope protections stone mason at A1 abutment and A2 abutment are destroyed partially caused by flood. ・ Pier table of the bridge is supported by RC piles (6 in total) at the center.
22	Br. 61	222 + 650	PC Hollow	12.1	1	10.0	10.0	No	2003	・ Slope protections stone mason at A1 abutment and A2 abutment are destroyed partially caused by flood
23	Br. 62	223 + 650	PC Hollow	12.1	1	10.0	10.0	No	2003	
24	Br. 63	242 + 850	PC Hollow	18.0	1	10.1	10.1	No	2003	
25	Br. 64	243 + 600	PC Hollow	30.1	2	10.0	10.0	No	2003	・ Pier table of the bridge is supported by RC piles (6 in total) at the center.
26	Br. 65	244 + 400	PC Hollow	24.2	2	10.0	10.0	No	2003	・ Pier table of the bridge is supported by RC piles (6 in total) at the center.
27	Br. 66	245 + 900	RC Girder	9.0	2	9.15	9.15	No		
28	Br. 67	255 + 250	PC Hollow	15.1	1	10.1	10.1	No	2003	
29	Br. 68	255 + 600	PC Hollow	24.0	2	10.0	10.0	No	2003	・ Pier table of the bridge is supported by RC piles (6 in total) at the center.
30	Br. 69	256 + 550	PC Hollow	15.0	1	10.0	10.0	No	2003	
31	Br. 70	257 + 900	PC Hollow	12.1	1	10.0	10.0	No	2003	
32	Br. 71	265 + 900	PC Hollow	12.1	1	10.0	10.0	No	2003	
33	Br. 72	270 + 900	PC Hollow	12.1	1	10.0	10.0	No	2003	
34	Br. 73	271 + 700	PC Hollow	18.5	1	10.0	10.0	No	2003	
35	Br. 74	272 + 650	PC Hollow	12.1	1	10.0	10.0	No	2003	
36	Br. 75	273 + 300	PC Hollow	24.1	2	10.0	10.0	No	2003	・ Pier table of the bridge is supported by RC piles (6 in total) at the center.
37	Br. 76	275 + 650	PC Hollow	12.1	1	10.1	10.1	No	2003	
38	Br. 77	276 + 550	PC Hollow	12.1	1	10.0	10.0	No	2003	

There are four steel bridges and 34 concrete bridges on the Middle Section.

The bridge type of all four steel bridges is girder and the maximum girder length is 30 m. The number of girders in cross section is five to six depending on the girder size. A typical cross section of a steel bridge with six girders is shown in Figure 4.4-1.

Steel main girders are painted or galvanized.

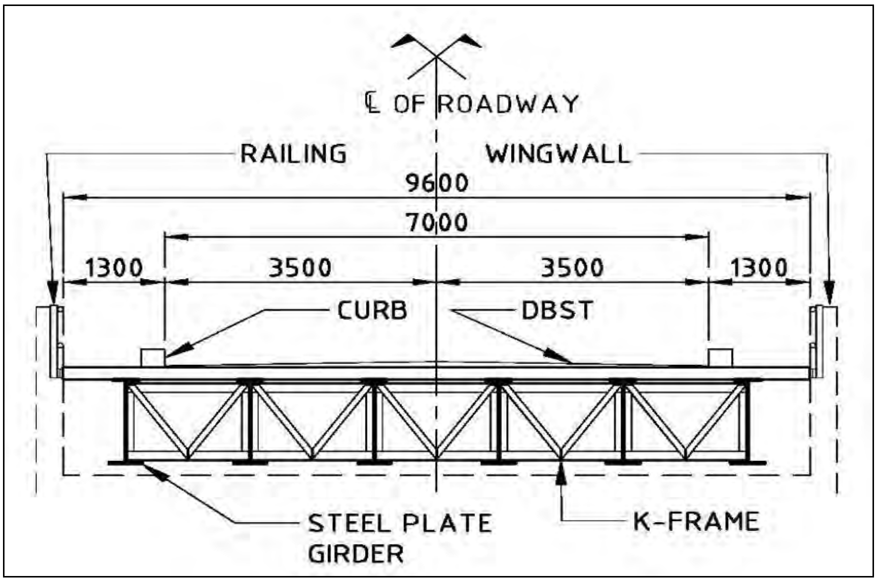


Figure 4.4-1 Typical Cross Section of Steel Bridge

Among the 34 concrete bridges, there are two RC girder bridges, two PC girder bridges and 30 PC hollow slab bridges. The girder length of PC hollow slab is 12 m to 20 m. A typical cross section of a PC hollow slab bridge is shown in Figure 4.4-2.

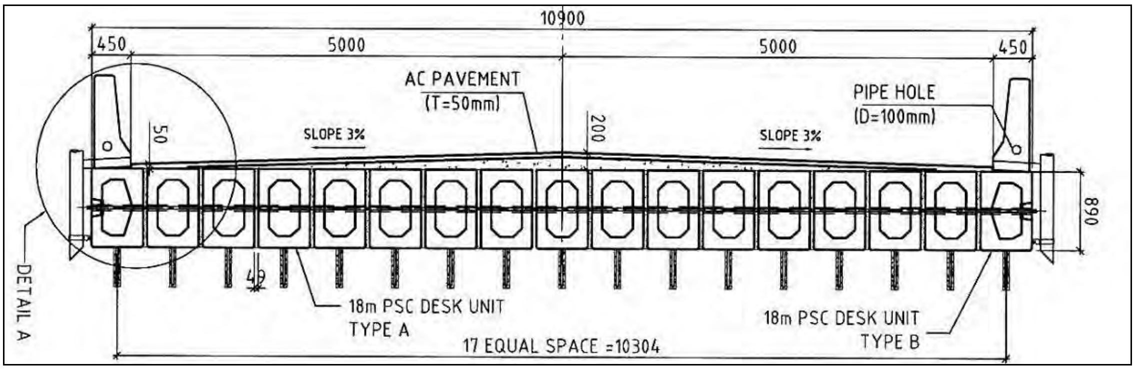


Figure 4.4-2 Typical Cross Section of PC Hollow Bride

4.4.2 Condition of Bridges

The bridges on the Middle Section from KP 171 to KP 282.3 are generally in good condition as shown in Figure 4.4-3 (1) to 4.4-3 (5).

Br. 40 (KP 177 + 200)

Br. 41 (KP 178 + 500)

Br. 42 (KP 181 + 800)

Br. 43 (KP 182 + 800)

Br. 44 (KP 183 + 300)

Br. 45 (KP 183 + 900)

Figure 4.4-3 (1) Bridge Condition (1/5)

Br. 46 (KP 184 + 100)

Br. 47 (KP 185 + 700)

Br. 48 (KP 187 + 400)

Br. 49 (KP 187 + 700)

Br. 50 (KP 188 + 100)

Br. 51 (KP 188 + 250)

Br. 52 (KP 189 + 250)

Br. 53 (KP 189 + 900)

Figure 4.4-3 (2) Bridge Condition (2/5)

Br. 54 (KP 190 + 150)

Br. 55 (KP 191 + 100)

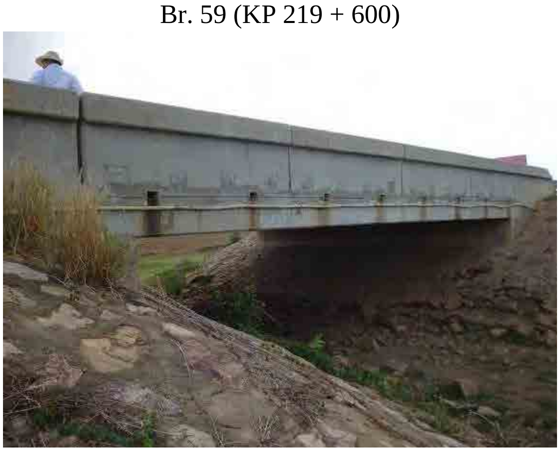
Br. 56 (KP 201 + 800)

Br. 57 (KP 208 + 500)

Br. 58 (KP 215 + 750)

Br. 59 (KP 219 + 600)

Br. 60 (KP 220 + 800)



Br. 61 (KP 222 + 650)

Figure 4.4-3 (3) Bridge Condition (3/5)

Br. 62 (KP 223 + 650)

Br. 63 (KP 242 + 850)

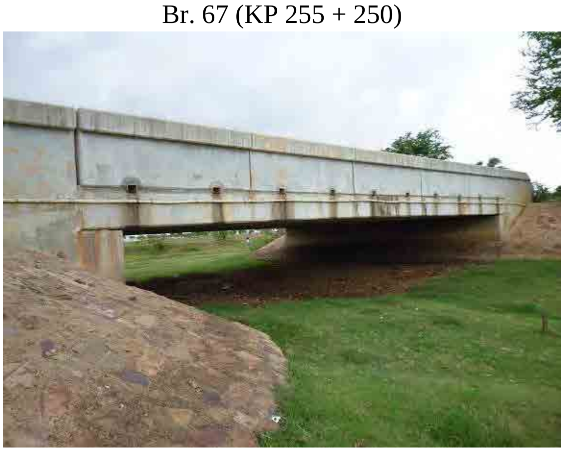
Br. 64 (KP 243 + 600)

Br. 65 (KP 244 + 400)

Br. 66 (KP 245 + 900)

Br. 67 (KP 255 + 250)

Br. 68 (KP 255 + 600)



Br. 69 (KP 256 + 550)

Figure 4.4-3 (4) Bridge Condition (4/5)

Br. 70 (KP 257 + 900)

Br. 71 (KP 265 + 900)

Br. 72 (KP 270 + 900)

Br. 73 (KP 271 + 700)

Br. 74 (KP 272 + 650)

Br. 75 (KP 273 + 300)

Br. 76 (KP 275 + 650)

Br. 77 (KP 276 + 550)

Figure 4.4-3 (5) Bridge Condition (5/5)

4.4.3 Condition of Bridge Members

The field survey of bridges was conducted on the beginning of the rainy season. The following is the result of the observation in the survey.

- Table 4.4-3 shows the condition of each bridge members. Most of the conditions of the existing bridge members are good in general.
- All bridges have a simple support system. There is no expansion joint but the gap spaces of less than 40 mm between girders and between a parapet and a girder. The pavement type on every bridge is DBST and the pavement has been repaired at some patches.
- The road width on the bridge is 8.5 m to 10.1 m and some bridges have side walk for pedestrian.
- 32 PC bridges include 30 PC hollow slab bridges and two I-girder type bridges. PC hollow slab bridges consist of 17 hollow girders. The width of girders of PC hollow slab is 600 mm, the girder height is 430 mm to 700 mm. The width of I - girder is 500 mm to 550 mm, and the height of I-girder is 1,000 mm to 1,150 mm.
- All PC hollow slab bridges are still in good condition.
- All the steel girder bridges are of I-girder type, one of which consists of five to six girders. Every steel girder is painted or galvanized in for anti - corrosion. The girder height is 900 mm to 1,400 mm.
- Two RC bridges are of RC girder type, every one of which consists of nine (9) girders. The girder height is 350 mm to 500 mm.
- While twenty one bridges have bearing shoes of rubber type, almost a half of the whole 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 by car accidents. But most of them were repaired except Br. 59 which was damaged recently.

Figure 4.4-4 Damaged Handrail of Br. 59

Table 4.4-3 Condition of Member of Bridge

Ref	Bridge No.	Bridge Type	GH (mm)	GW (mm)	Gt (mm)	Girder No	Structural Condition			Shoe Type	Handrail Type	Pav.
							A1	Pier	A2			
1	Br. 40	Steel Girder	900	330	20	6	OK	OK	OK	Rubber	Steel Rail	OK
2	Br. 41	PC Hollow	550	650	N.A.	17	OK	NA	OK	NO	RC Parapet	OK
3	Br. 42	RC Girder	500	200	N.A.	9	OK	OK	OK	NO	Steel Rail	OK
4	Br. 43	PC Hollow	600	600	N.A.	17	OK	OK	OK	NO	RC Parapet	OK
5	Br. 44	Steel Girder	1,000	340	30	5	OK	OK	OK	Rubber	Steel Rail	OK
6	Br. 45	PC Hollow	600	600	N.A.	17	OK	OK	OK	NO	RC Parapet	OK
7	Br. 46	PC Hollow	700	630	N.A.	17	OK	OK	OK	NO	RC Parapet	OK
8	Br. 47	PC Girder	1,150	550	200	5	OK	OK	OK	Rubber	Steel Rail	OK
9	Br. 48	PC Girder	1,000	500	200	4	OK	OK	OK	NO	Steel Rail	OK
10	Br. 49	PC Hollow	450	630	N.A.	17	OK	OK	OK	NO	RC Parapet	OK
11	Br. 50	PC Hollow	600	600	N.A.	17	OK	OK	OK	NO	RC Parapet	OK
12	Br. 51	PC Hollow	530	600	N.A.	17	OK	OK	OK	NO	RC Parapet	OK
13	Br. 52	PC Hollow	530	600	N.A.	17	OK	OK	OK	NO	RC Parapet	OK
14	Br. 53	PC Hollow	600	600	N.A.	17	OK	OK	OK	NO	RC Parapet	OK
15	Br. 54	PC Hollow	600	600	N.A.	17	OK	OK	OK	NO	RC Parapet	OK
16	Br. 55	PC Hollow	600	600	N.A.	17	OK	OK	OK	NO	RC Parapet	OK
17	Br. 56	PC Hollow	430	600	N.A.	17	OK	OK	OK	NO	RC Parapet	OK
18	Br. 57	PC Hollow	600	600	N.A.	17	OK	OK	OK	NO	RC Parapet	OK
19	Br. 58	Steel Girder	1,000	320	25	5	OK	OK	OK	Rubber	Steel Rail	OK
20	Br. 59	Steel Girder	1,400	420	25	6	OK	OK	OK	Rubber	Steel Rail	OK
21	Br. 60	PC Hollow	450	600	N.A.	17	OK	N.A.	OK	Rubber	RC Parapet	OK
22	Br. 61	PC Hollow	450	600	N.A.	17	OK	N.A.	OK	Rubber	RC Parapet	OK
23	Br. 62	PC Hollow	450	600	N.A.	17	OK	OK	OK	Rubber	RC Parapet	OK
24	Br. 63	PC Hollow	600	600	N.A.	17	OK	N.A.	OK	Rubber	RC Parapet	OK
25	Br. 64	PC Hollow	600	600	N.A.	17	OK	OK	OK	Rubber	RC Parapet	OK
26	Br. 65	PC Hollow	430	600	N.A.	17	OK	OK	OK	Rubber	RC Parapet	OK
27	Br. 66	RC Girder	350	600	N.A.	9	OK	OK	OK	NO	Steel Rail	OK
28	Br. 67	PC Hollow	530	600	N.A.	17	OK	N.A.	OK	Rubber	RC Parapet	OK
29	Br. 68	PC Hollow	430	600	N.A.	17	OK	OK	OK	Rubber	RC Parapet	OK
30	Br. 69	PC Hollow	530	600	N.A.	17	OK	N.A.	OK	Rubber	RC Parapet	OK
31	Br. 70	PC Hollow	430	600	N.A.	17	OK	N.A.	OK	Rubber	RC Parapet	OK
32	Br. 71	PC Hollow	430	600	N.A.	17	OK	N.A.	OK	Rubber	RC Parapet	OK
33	Br. 72	PC Hollow	430	600	N.A.	17	OK	N.A.	OK	NO	RC Parapet	OK
34	Br. 73	PC Hollow	430	600	N.A.	17	OK	N.A.	OK	Rubber	RC Parapet	OK
35	Br. 74	PC Hollow	430	600	N.A.	17	OK	N.A.	OK	Rubber	RC Parapet	OK
36	Br. 75	PC Hollow	430	600	N.A.	17	OK	OK	OK	Rubber	RC Parapet	OK
37	Br. 76	PC Hollow	430	600	N.A.	17	OK	N.A.	OK	Rubber	RC Parapet	OK
38	Br. 77	PC Hollow	430	600	N.A.	17	OK	N.A.	OK	Rubber	RC Parapet	OK

Denotation: Denotation in Table 4.4-3 are as follows:

GH: Height of girder
GW: Width of lower flange member
Gt: Thickness of lower flange member
G no.: Girder number
Clearance: Distance from the water surface to the soffit of the girder.

OK: Good condition
N/M: Cannot be measured
N.A.: Not applicable
NO: Not exist

4.5 Roadside Land Use

4.5.1 Land Use along NR 5

(1) Middle Section

The roadside of NR 5 has been rapidly developed with factories, commercial facilities and residential buildings. There are also many rice mill factories and warehouses which are functioning as the base stations for transportation of rice in the Middle Section. Also, around 25 villages are located along the Middle Section. The basic form of land use outside urbanized areas is agriculture; predominantly rice paddies. Examples of roadside land use are shown in the Figure 4.5-1.

Pursat City (KP 186)

Land Fill for Factory (KP 193)

Rice Paddy (KP 224)

Rice Mill Factory (KP 242)

Figure 4.5-1 Roadside Land Use (Middle Section)

Salient features of the roadside land use along the Middle Section are summarized below:

(i) The roadside from KP 186 to KP 189 in Pursat City is very densely populated.

(ii) In addition to the above, the roadsides of Bakan (KP 201 ~ KP 203), Boeng Khnar (KP 209 ~ KP 211), Ou Ta Paong (KP 216 ~ KP 217), Svay Doun Kaev (KP 219 ~ KP 220) and Kalaom Phluk (KP 231 ~ KP 232) are urbanized.

(iii) There are many small villages in addition to the urbanized areas as listed above.

(iv) A "road station" (Michi-no-eki) is located at KP 180.

(v) A weigh station is located near KP 191.

(2) Sri Sophorn - Poipet Section

The basic form of land use outside urbanized areas along this section is also cultivation, predominantly rice paddies. Most of the houses and small shops are located about 20 meter away from road centerline. These buildings might have relocated for Cambodia Road Improvement Project (CRIP).

In Poipet City, there are many truck yards. Many semi and full trailer trucks coming from Thailand go back to Thailand after transshipping containers and/or cargos to Cambodian trucks in the truck yards in Poipet.

The examples of roadside land use are shown in the Figure 4.5-2.

Rice Mill Factory (KP 374)

Rice Paddy (KP 391)

Commercial Area (KP 393)

Cargo Terminal for Transshipment (KP 404)

Figure 4.5-2 Roadside Land Use (Sri Sophorn - Poipet Section)

Salient features of the roadside land use along the Sri Sophorn - Poipet Section are summarized below:

(i) The roadsides in Nimit (KP 383 + 300 – KP 384 + 100), Koun Damrei (KP 392 + 800 – KP 393 + 300) and Poipet City (KP 402 – KP 407 + 300) are very densely populated.

(ii) On the other sections, there are small villages.

(iii) A weigh station is located at KP 391 + 350.

(iv) The Poipet Tourist Passenger International Terminal is located at KP 396 + 500.

(v) A container scan station is located at KP 399 + 700.

4.5.2 Occupancy of ROW by Roadside Shops and Utilities

In the urbanized areas, private shops occupy the road shoulder and sidewalk in the designated Right of Way (ROW) to display their merchandise. Outside of the urbanized areas, most of the residential houses are built outside of the ROW

Notice boards announcing that 30 m from the centerline of road is designated as ROW have been installed along NR 5 at an interval of 10 km through an ADB project. Although, these notice board stipulates that electric poles should be installed at least 28 m away from the road center, new electric poles are actually installed approximately 17 m from the road center. This will cause confusion among residents. It is strongly recommend that MPWT issue an instruction to SKL Group who has been installing electric poles to observe the rule.

4.6 Utilities

Various kinds of utilities exist along the NR 5 in the areas adjacent to the road. Some of them are crossing NR 5. The types of utilities exiting in the area adjacent to NR 5 are electric power lines and poles, optic fiber cables, water supply pipes, drainage facilities and street lights.

(1) Middle Section

Test - pitting for confirmation of utilities was carried out at 10 locations in the following towns and villages. It turned out that the electric power lines and poles and optic fiber cables exist along the whole length of NR 5.

<u>Electricity Power Line</u>

Electric poles are located along whole stretch of NR 5. There are around 16 poles per 1 km. The total number of electric poles in the Middle Section is estimated to be around 2,900 poles. Most of electric poles will not need be to be relocated for the widening of the road.

Figure 4.6-1 Electric Poles near KP 214

<u>Telecommunication Cables</u>

There are 2 types of telecommunication cable along NR 5. One is conventional (metal) telephone line and the other is fiber - optic cable. Telephone line is located on the left side (mountain side) and fiber - optic cable is located on the right side (Tonle Sap side). The cables buried on both road sides should be relocated before the widening of the road.

Figure 4.6-2 Telephone Cable on Br. 56 (KP 201 + 800)

<u>Water Supply Pipes</u>

The water supply systems in Bakan, Boeng Khnar and Moung Ruessei are managed by private companies. In Pursat City, the pipes were replaced by the "Project for Replacement and Expansion of Water Distribution System in Provincial Capitals" and it is operated by Ministry of Industry Mines and Energy.

The water supply pipes located on both road sides should be relocated before the construction works start.

Figure 4.6-3 Water Supply Pipes on Br. 48 (KP 187 + 500)

<u>Drainage</u>

There are rain water drainage pipes under the ground on both road sides only in Pursat City. The total length of the pipe is 2.6 km for both roadside. Diameter of the pipe is 600 mm. Drainage pipes are clogged in many places with litter and/or soils.

Figure 4.6-4 Clogged Drainage Pipe near KP 186 + 500

<u>Street Light</u>

There are street lights from KP 183 to KP 187 in Pursat City. The street lights are installed from KP 183 to Br. 47 (KP 185+700) on both sides and from Br. 47 to KP 187 on right side only. Most of street light poles would need to be relocated if the existing road in Pursat City would be widened. However, construction of a bypass around Pursat City is propped and the existing road will not be widened. Thus, relocation of the street light will not be necessary.

Figure 4.6-5 Street Light near KP 367

Figure 4.6-6 shows the plan of existing water supply pipe system in Pursat city.

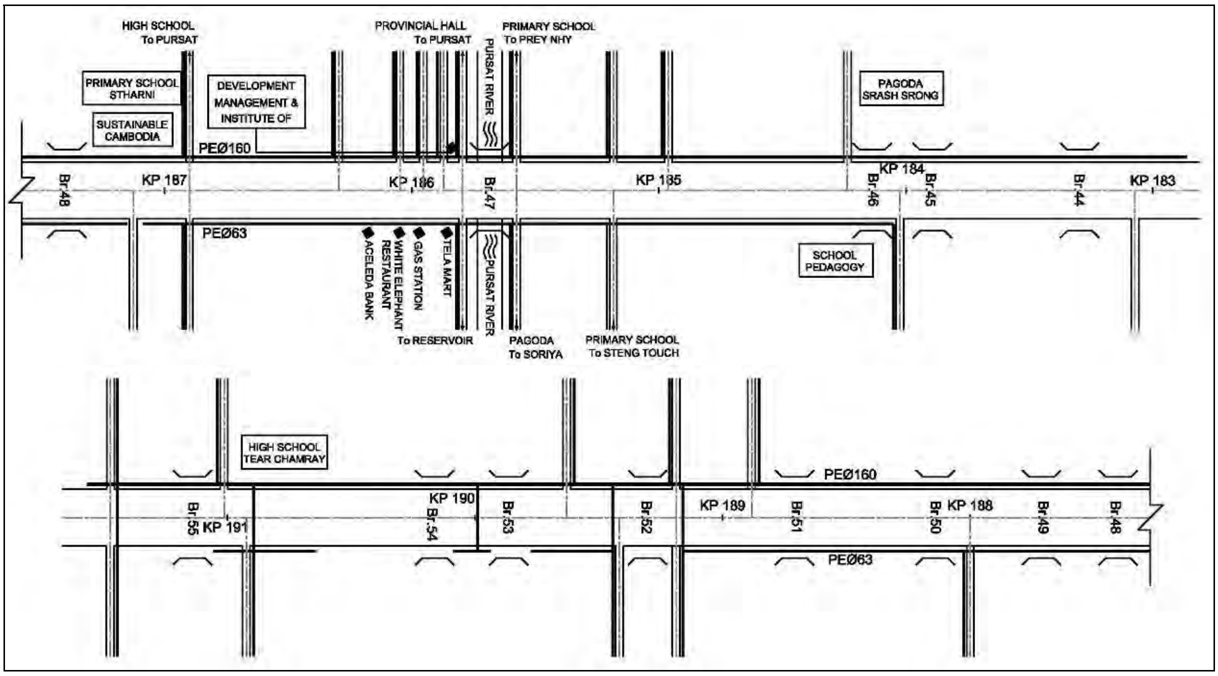


Figure 4.6-6 Plan of Water Supply Pipes in Pursat

Table 4.6-1 shows the summary of the major utilities along the Middle Section.

Table 4.6-1 Major Utility along Middle Section

Type of Utility	Location	Side	Distance from Centerline	Quantity	Owner / Operator
1.Electricity Power Line					
Electric pole (concrete); 230 kV	KP 171 ~ 283	L	15 ~ 20 m	112 km (About 16 no. /km)	[1]EDC
Electric pole (concrete); 230 kV	KP 178 ~ 248	R	15 ~ 20 m	70 km (About 16 no. /km)	EDC
2.Telecommunication Cables					
Electric pole (concrete)	KP 171 ~ 283	L or R	15 m	112 km (About 8 no. /km)	Metfone
Optic fiber cable	KP 171 ~ 283	R	5 ~ 10 m	112 km	[2]Telecom
Optic fiber cable	KP 171 ~ 283	L	7 ~ 30 m	112 km	[3]CFO
3.Water Supply Pipes					
HDPE pipe, D160	KP 183 ~ 191	L	7 ~ 10 m	8 km	[4]MIME
HDPE pipe, D60	KP 187 ~ 191	R	7 ~ 10 m	4 km	MIME
HDPE pipe, D40 - 200	KP 201 ~ 213	L, R	7 ~ 10 m	20 km	Private
PVC pipe, D60 - 120	KP 243.7 ~ 246	L, R	7 ~ 10 m	4.6 km	Private
4.Drainage					
Concrete pipe D600	KP 185.7 ~ 186.3	L, R	8 ~ 9 m	2.6 km	MPWT
5.Street Light					
Street light and Cable	KP 183 ~ 185.7	L, R	9 ~ 12 m	2.2 km (65 no.)	Government of Pursat
	KP 185.7 ~ 187	R		1.8 km (26 no.)	

[1] EDC: Electricite Du Cambodge
[2] Telecom: Telecom Cambodia
[3] CFO: Cambodia Fiber Optic Communication Network
[4] MIME: Ministry of Industry Mines and Energy

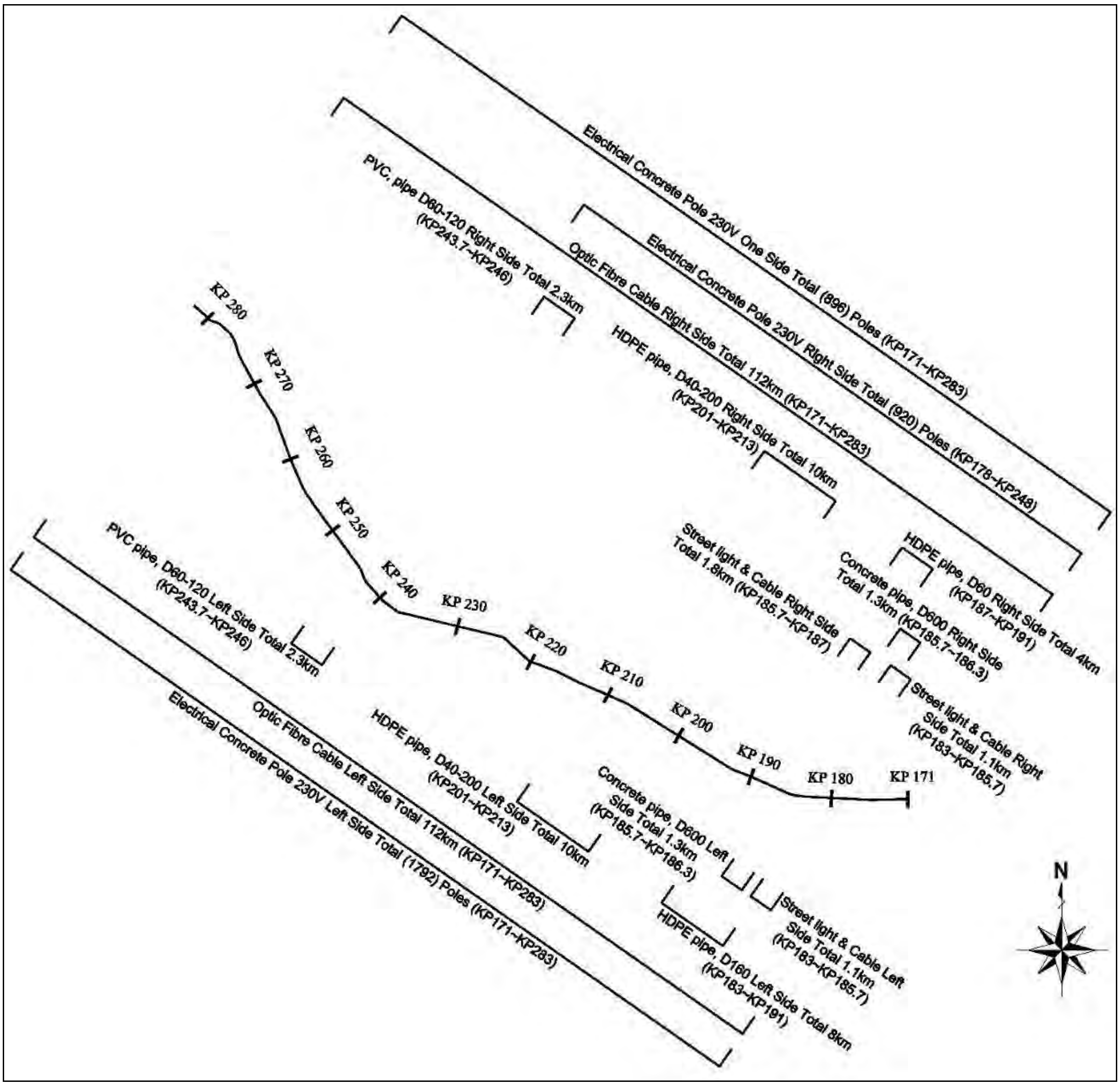


Figure 4.6-7 Major Utility along Middle Section

(2) Sri Sophorn - Poipet Section

Test - pitting for confirmation of utilities was carried out at the 4 points in the following town and village.

(a) KP 383 + 000 (Both Side) in Nimit

(b) KP 403 + 000 (Both Side) in Poipet

<u>Electricity Power Line</u>

Electric power lines are located along NR 5 along Sri Sophorn - Poipet Section as well. There are approximately 14 poles per 1 km. The total number of electric poles in Sri Sophorn - Poipet Section is estimated at approximately 1,000. Most of the electric poles will not need to be relocated for the widening of the road.

Figure 4.6-8 Electric Power Line in the Vicinity of KP 186

<u>Telecommunication Cables</u>

There are 2 types of telecommunication cable (conventional telephone line and optic – fiber cable) in Sri Sophorn – Poipet Section as well. The cables located on both sides should be relocated before the widening of the road.

Figure 4.6-9 Telecommunication Cable at KP 365 + 800

<u>Water Supply Pipes</u>

The water supply system in Poipet City is operated by a private company. The water supply pipes located on the both sides of road should be relocated before the widening of the road.

Figure 4.6-10 Water Supply Map in Poipet City

<u>Drainage</u>

There are rain water drainage pipes under the ground on both sides in Nimit, Koun Damrei and Poipet City

Figure 4.6-11 Inlet of Drainage at KP 393

Figure 4.6-12 shows the plan of existing water supply pipe system in Poipet city.

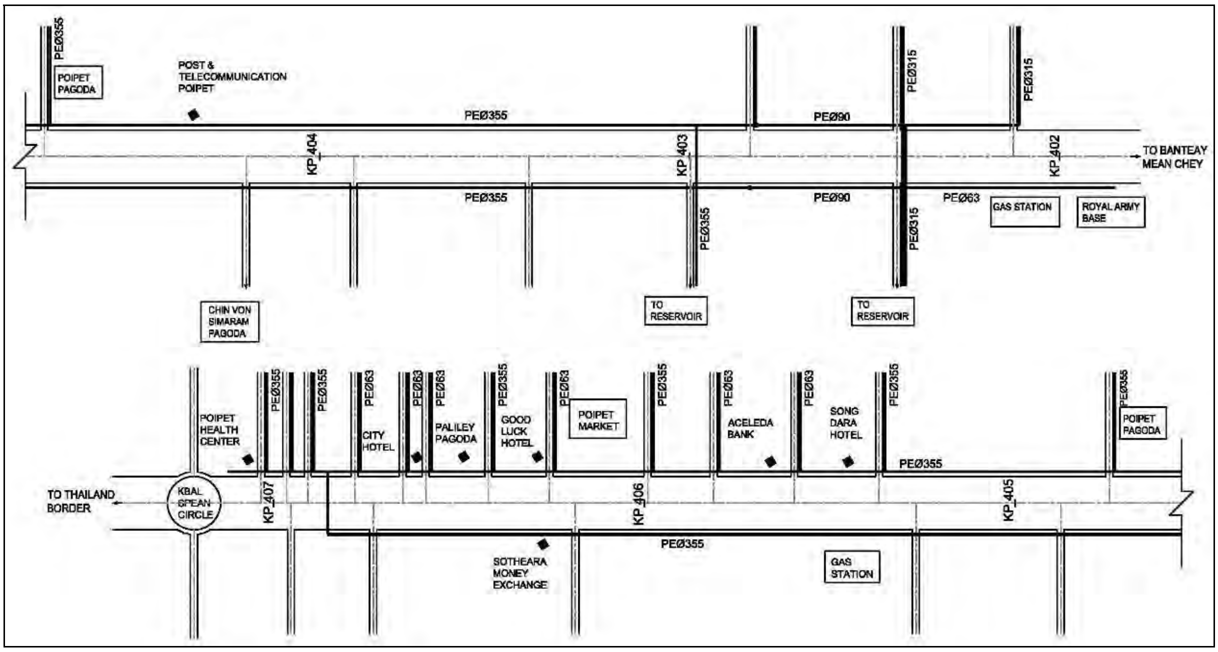


Figure 4.6-12 Plan of Water Supply Pipes in Poipet

Table 4.6-2 shows the utilities of Sri Sophorn – Poipet Section.

Table 4.6-2 Major Utility along Sri Sophorn – Poipet Section

Type of Utility	Location	Side	Distance from Centerline	Quantity	Owner / Operator
1.Electricity Power Line					
Electric pole (concrete); kV	KP 367.2 ~ 395.4	L	15 ~ 20 m	28 km (About 14 no. /km)	[1]PSTC
Electric pole (concrete); 230 kV	KP 366 ~ 407	R	15 ~ 20 m	41 km (About 16 no. /km)	EDC
2.Telecommunication Cables					
Electric pole (concrete)	KP 366 ~ 407	L	15 m	41 km (About 8 no. /km)	Metfone
Optic fiber cable	KP 366 ~ 407	R	4.5~5.0 m	41 km	Cambodian Post
Optic fiber cable	KP 366 ~ 407	L	7 ~ 30 m	41 km	[3]CFO
3.Water Supply Pipes					
HDPE pipe, D160	KP 183 ~ 191	L	7 ~ 10 m	8 km	[4]MIME
HDPE pipe, D60	KP 187 ~ 191	R	7 ~ 10 m	4 km	MIME
HDPE pipe, D40 - 200	KP 201 ~ 213	L, R	7 ~ 10 m	20 km	Private
PVC pipe, D60 - 120	KP 243.7 ~ 246	L, R	7 ~ 10 m	4.6 km	Private
4.Drainage					
Concrete pipe D600	KP 383.2 ~383.6	L, R	8 ~ 9 m	0.4 km	MPWT
Concrete pipe D400	KP 392.7 ~393.1	L, R	8 ~ 9 m	0.4 km	MPWT
Concrete pipe D800	KP 402.9 ~407	L, R	8 ~ 9 m	4.1 km	MPWT

[1] *EDC: Electricite Du Cambodge*
[2] *Telecom: Telecom Cambodia*
[3] *CFO: Cambodia Fiber Optic Communication Network*
[4] *MIME: Ministry of Industry Mines and Energy*

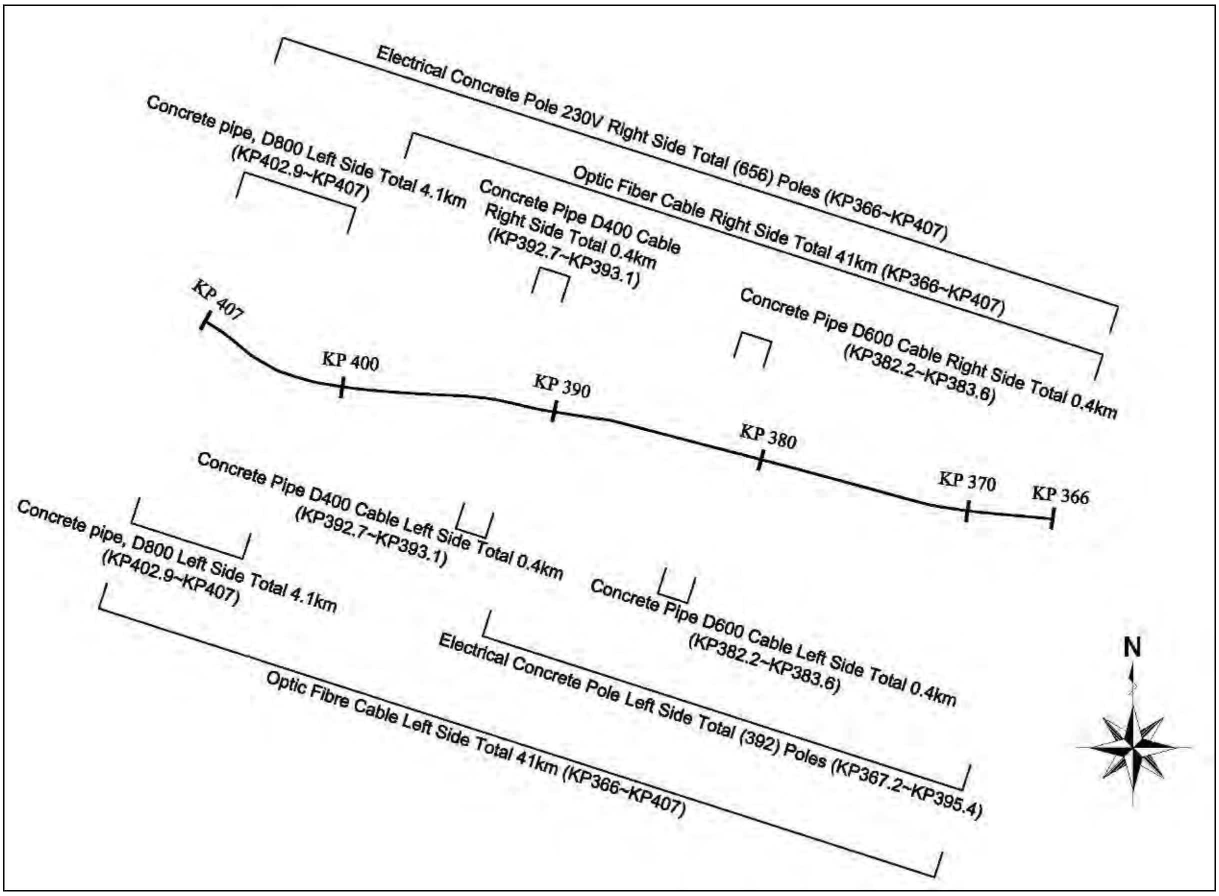


Figure 4.6-13 Major Utility within the Study Area in the Sri Sophorn – Poipet Section

CHAPTER 5 FUTURE TRAFFIC DEMAND FORECAST

A forecast of future traffic demand is the basis of highway planning and economic analysis. This chapter describes the methodology and data used in the traffic demand forecast, as well as the results of the forecast.

Future traffic demand was estimated for the target years of 2018, 2023, 2028 and 2033. Years 2018, 2023, 2028 and 2033 correspond to 5 years, 10 years, 15 years and 20 years from the present time.

5.1 Methodology

Figure 5.1−1 shows the flow future traffic forecast. In this survey, traffic volume is estimated based on traffic demand forecast model used in the Survey of the South Section and revised socio-economic data.

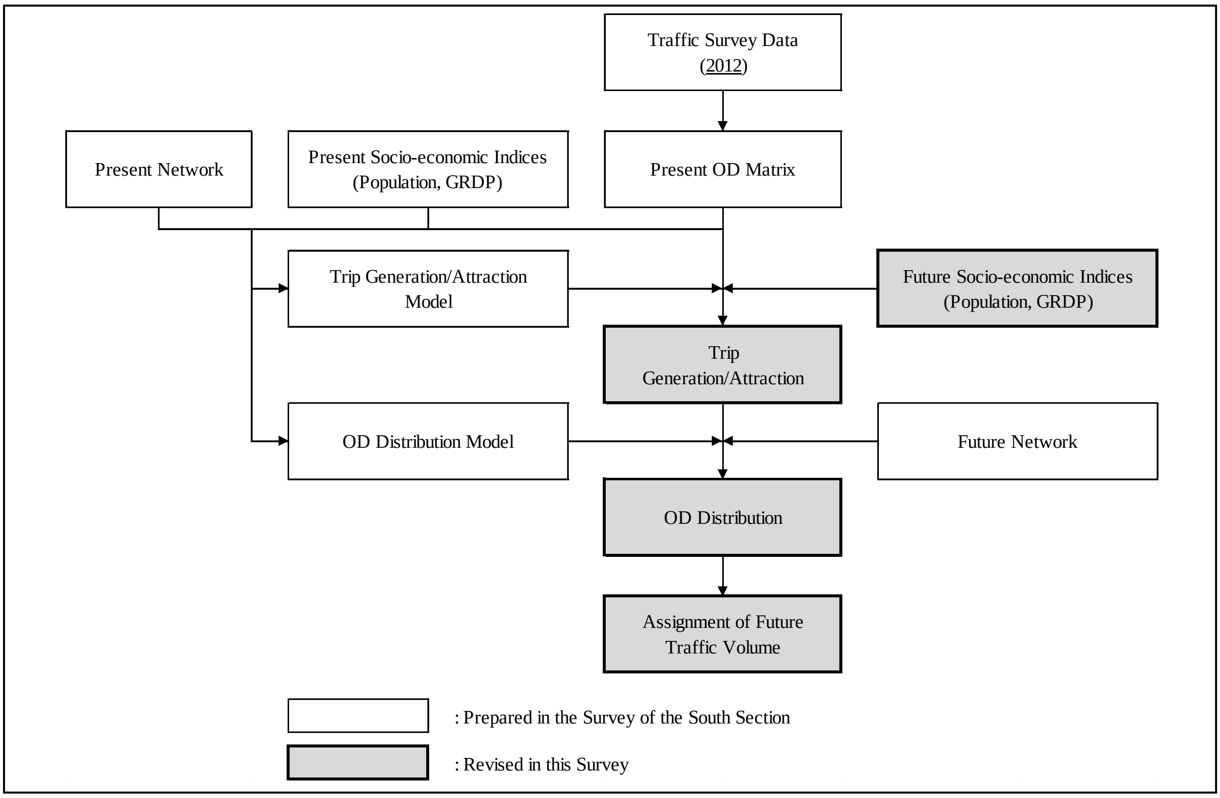


Figure 5.1-1 Traffic Demand Forecast Flowchart

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.

In the Survey for the South Section, the traffic counts were conducted 2 times to verify the daily fluctuation of traffic volume. The First Survey was conducted on 24th – 25th of October 2012 and the Second Survey was conducted on 7th of November 2012. Traffic volumes were 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 in the First Survey. The Second Survey for traffic counts were conducted at five (5) stations from 5:00 a.m. to 9:00 p.m.

The survey locations were selected at the provincial boundary, city boundary and city center and they are shown in Table 5.2-1 and Figure 5.2-1, respectively. All the survey locations except Station No. 3a and NR6-1 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. Station No. 3a was selected to know traffic volume within the city of Kampong Chhnang, and Station NR6-1 was selected to understand the present traffic pattern of National Road No. 6 which is an alternative route of NR 5.

Traffic volumes were counted for at Stations No. 1. 3a, 4, 5 and 6 while they were counted for 16 hours at Stations No. 2, 5 and 8. 16-hour traffic counts were converted to 24-hour traffic counts using the 24-hour/16-hour ratios of the similar traffic characteristics (urban, suburban or rural). Table 5.2-2 shows 24-hour traffic volume actually counted (Stations No. 1. 3a, 4, 5 and 6) and converted from 16-hour traffic count (Stations No. 2, 5 and 8).

Table 5.2-1 Location of Traffic Count Survey (Conducted in the Survey for the South Section)

No	Survey Station		Period	
	Road No	City	The first survey	The confirmation survey
1	5	Provincial Boundary (between Kampong Speu and Kampong Chhnang)	24 hrs	16 hrs
2	5	Kampong Chhnang city (Southern suburbs)	16 hrs	16 hrs
3a	5	Kampong Chhnang (City center)	24 hrs	16 hrs
3	5	Kampong Chhnang city (Northern suburbs)	16 hrs	16 hrs
4	5	Provincial Boundary (between Kampong Chhnang and Pursat)	24 hrs	16 hrs
5	5	Provincial Boundary (between Prusat and Battambang)	24 hrs	–
8	5	Provincial Boundary (between Battambang and Banteay Meanchey)	16 hrs	–
NR6-1	6	Intersection of NR 6 & NR 71	24 hrs	–
		Note: 24 hrs: 6:00 AM - 6:00 AM (Next day) *16 hrs: 5:00 AM - 21:00 PM* *The first day survey was conducted from 24th to 25th October 2012 (Wed and Thu).* *The second day survey was conducted 7th November 2012 (Wed).*		

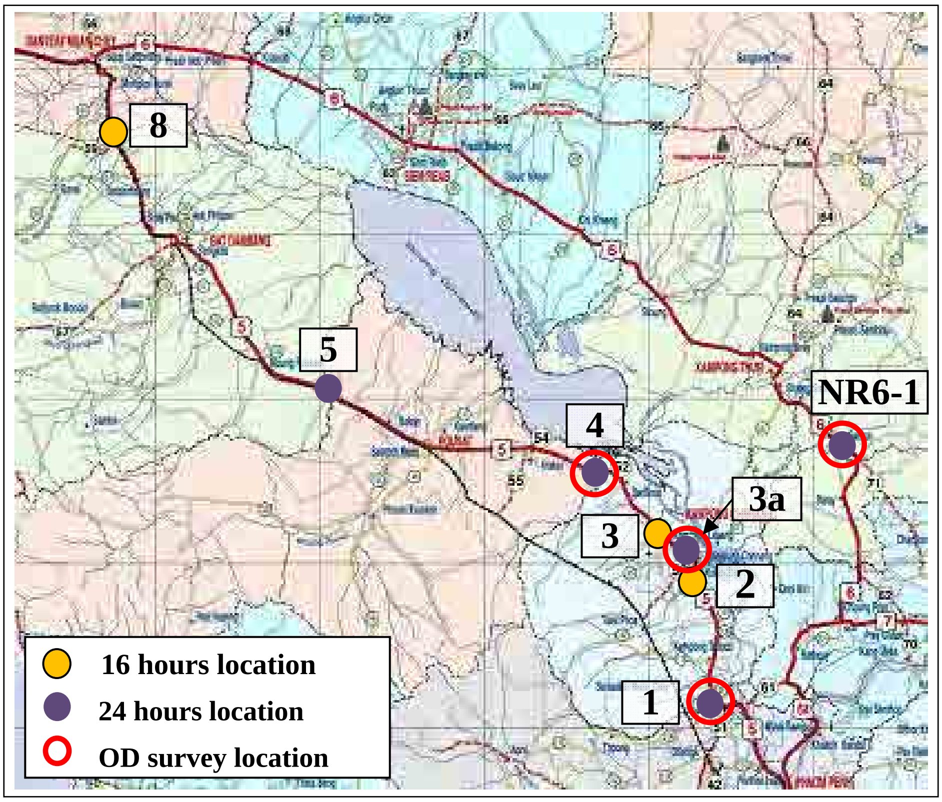


Figure 5.2-1 Location of Traffic Count Survey (Conducted in the Survey for the South Section)

Table 5.2-2 Daily (24 Hours) Traffic Volume

(Unit: Vehicle/day)

Sta.	Motorcycle (MC)			Light Vehicle (LV)				Heavy Vehicle (HV)				Grand Total
	Motorcycle & Tricycle	Motorcycle 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

5.3 Socio-Economic Framework

5.3.1 Future Socio-Economic Framework

Since transportation supports the social activities of the citizens and the economic activities of the industries and commerce, traffic demand is governed by socio-economic factors. Future trip generation/attraction estimated in the Survey of the South Section is used after being updated based on the updated population and Gross Regional Domestic Product (GRDP).

(1) Population Projection

The "General Population Census of Cambodia 2008", published in January 2011 by the National Institute of Statistics; Ministry of Planning is the latest population projection for Cambodia.

The survey team estimate population projection in 2033 based on the "General Population Census of Cambodia 2008". The population projection by province up to 2033 is shown in Table 5.3-1. The predicted growth rate of the whole of Cambodia (nationally) between 2012 and 2033 is 1.28.

Table 5.3-1 Population and Predicted by Province

(Unit: Person)

Provinces	2012	2018	2023	2028	2033	2033 / 2012 Growth
Banteay Meanchey	**760,770**	**853,065**	**927,392**	**993,625**	**1,052,624**	**1.38**
Battambang	**1,148,444**	**1,283,223**	**1,391,110**	**1,485,232**	**1,567,294**	**1.36**
Kampong Cham	1,745,184	1,733,442	1,711,003	1,670,485	1,611,142	0.92
Kampong Chhnang	**520,398**	**563,997**	**595,744**	**620,555**	**639,103**	**1.23**
Kampong Speu	**775,704**	**818,486**	**849,778**	**874,611**	**891,289**	**1.15**
Kampong Thom	673,247	695,256	710,988	722,060	726,036	1.08
Kampot	615,944	638,360	666,893	701,685	739,242	1.20
Kandal	**1,383,298**	**1,504,195**	**1,601,111**	**1,685,123**	**1,759,963**	**1.27**
Koh Kong	137,033	162,771	185,915	209,381	233,132	1.70
Kratie	357,249	396,156	426,789	455,158	481,435	1.35
Mondul Kiri	73,080	88,907	103,725	119,931	137,260	1.88
Phnom Penh	**1,637,473**	**2,018,312**	**2,262,593**	**2,413,511**	**2,497,710**	**1.53**
Preah Vihear	188,297	205,430	220,916	237,155	253,175	1.34
Prey Veng	980,811	991,128	1,020,035	1,066,655	1,122,529	1.14
Pursat	**430,837**	**466,168**	**500,675**	**537,494**	**576,133**	**1.34**
Ratanak Kiri	169,609	189,558	207,423	225,854	243,849	1.44
Siem Reap	1,023,990	1,167,456	1,278,650	1,377,823	1,467,987	1.43
Preah Sihanouk	253,654	292,404	323,420	350,703	375,147	1.48
Stung Treng	125,166	141,813	159,038	178,857	200,638	1.60
Svay Rieng	500,745	508,949	524,863	548,318	576,438	1.15
Takeo	879,328	898,226	931,305	976,431	1,027,010	1.17
Otdar Meanchey	227,353	277,792	317,402	352,538	383,163	1.69
Kep	41,420	52,097	65,027	81,351	101,000	2.44
Pailin	92,379	122,730	148,036	172,321	196,398	2.13
Cambodia	14,741,414	16,069,921	17,129,834	18,056,858	18,859,697	1.28

Source: "General Population Census of Cambodia 2008, Population Projections of Cambodia", National Institute of Statistics, Ministry of Planning Population in 2033 is estimated by Survey Team.

(2) Future Growth of GDP

➢ GDP Growth Rate Predictions by Different Institutions

Cambodia's long term growth of GDP to 2030, has been predicted by The United States Department of Agriculture and International Futures at the University of Denver and the short term GDP growth rate has been predicted by The International Monetary Fund and The Ministry of Economic and Finance. According to this prediction, the short term GDP growth rate is around 7%. Actual GDP growth rate in 2012 was upper than the prediction in last year, and the GDP growth rate prediction by each organizations were revised to high side compared with the prediction used in the Survey for the South Section.

Table 5.3-2 Predicted Annual Growth Rate of GDP by Agency

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							

Source: Economic Research Service, United states Department of Agriculture (USDA)
International Futures, University of Denver (International Futures)
World Economic Outlook, International Monetary Fund (IMF)
Cambodia Macroeconomic Framework 2010-2011, Ministry of Economic and Finance (MEF)

➢ Scenario of Future GDP Growth and GDP Per Capita

Considering the above-stated predictions, as well as the economic growth that actually happened in Cambodia in the past, three scenarios of the GDP growth have been assumed.

Table 5.3-3 Scenarios of Future GDP Growth

(Unit: %/Yr)

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

Table 5.3-4 Scenarios of GDP Per Capita

(Unit: USD, Constant 2012 rice)

Scenario	2018	2023	2028	2033
High Growth	1,428	1,953	2,610	3,388
Medium Growth	1,338	1,734	2,203	2,730
Low Growth	1,277	1,602	1,979	2,396

(3) GRDP

After the future GDP of the whole of Cambodia has been estimated, the GRDP of each Province is then estimated. The procedure of estimating GRDP is shown in Figure 5.3-1. Table 5.3-5 shows the result of the GRDP estimation by province.

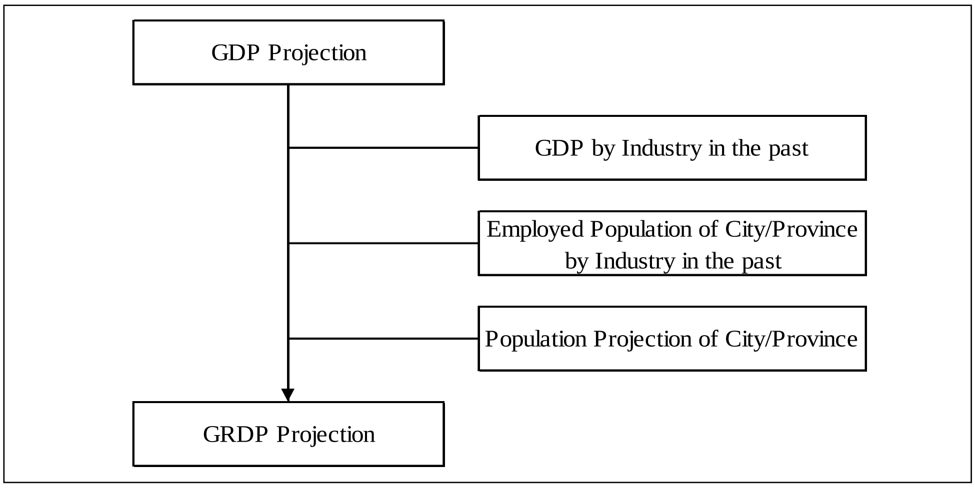


Figure 5.3-1 Procedure for GRDP Estimation

Table 5.3-5 GRDP Projection (at Constant 2005 Prices)

(Unit: $million)

Province	Year				
	2012	2018	2023	2028	2033
Banteay Meanchey	**439**	**668**	**915**	**1,225**	**1,580**
Battambang	**575**	**883**	**1,215**	**1,625**	**2,100**
Kampong Cham	757	1,046	1,322	1,613	1,897
Kampong Chhnang	**226**	**336**	**454**	**592**	**753**
Kampong Speu	**353**	**527**	**719**	**935**	**1,176**
Kampong Thom	257	383	516	664	820
Kampot	235	351	486	640	831
Kandal	**997**	**1451**	**1,938**	**2,562**	**3,280**
Koh Kong	87	143	208	293	397
Kratie	150	228	320	434	563
Mondul Kiri	33	58	91	136	190
Phnom Penh	**3,429**	**5,192**	**7,033**	**9,213**	**11,618**
Preah Vihear	69	113	166	231	304
Prey Veaeng	367	530	718	944	1,221
Pursat	**176**	**270**	**375**	**510**	**677**
Ratanak Kiri	67	111	167	236	314
Siemreap	510	797	1,119	1,526	1,995
Preah Sihanouk	227	354	491	663	865
Stung Treng	52	85	128	186	255
Svay Rieng	206	297	398	522	674
Takeo	338	500	685	901	1,167
Otdar Meanchey	100	173	258	361	478
Kep	17	32	53	84	126
Pailin	53	96	144	211	292

5.4 Future OD Table

5.4.1 Zoning System

The OD zoning system that used the JICA M/P Study has been revised and used in this Survey. The revision of the OD zoning system is mainly to take account of the change of Districts promulgated after 2006. The total number of zones is 206 (194 zones within Cambodia and 12 zones outside of Cambodia). Table 5.4-1 shows the list of OD zones.

Table 5.4-1 OD Zones

Province Name	Zone No.	District Name	Traffic Zone
Banteay MeanChey	1	Mongkol Borei	1
		Phnum Srok	2
		Preah Netr Preah	3
		Ou Chrov	4
		Serei Saophoan	5
		Thma uok	6
		Svay Chek	7
		Malai	8
		Paoy Paet	9
Battambang	2	Banan	10
		Thma Koul	11
		Battambang	12
		Bavel	13
		Aek Phnum	14
		Moung Ruessei	15
		Rotonak Mondol	16
		Sangkae	17
		Samlout	18
		Sampov Lun	19
		Phnum Proek	20
		Kamrieng	21
		Koas Krala	22
		Rukh Kiri	23
Kampong Cham	3	Batheay	24
		Chamkar Leu	25
		Cheung Prey	26
		Dambae	27
		Kampong Cham	28
		Kampong Siem	29
		Kang Meas	30
		Kaoh Soutin	31
		Krouch Chhmar	32
		Memot	33
		Ou Reang Ov	34
		Ponhea Kraek	35
		Prey Chhor	36
		Srei Santhor	37
		Steung Trang	38
		Tboung Khmun	39
		Suong	40
Kampong Chhnang	4	Baribour	41
		Chol Kiri	42
		Kampong Chhnang	43
		Kampong Leaeng	44
		Kampong Tralach	45
		Rolea Bier	46
		Sameakki Mean Chey	47
		Tuek Phos	48
Kampong Speu	5	Basedth	49
		Chbar Mon	50
		Kong Pisei	51
		Aoral	52
		Odongk	53
		Phnum Sruoch	54
		Samraong Tong	55
		Thpong	56
Kampong Thom	6	Baray	57
		Kampong Svay	58
		Stueng Saen	59
		Prasat Baliangk	60
		Prasat Sambour	61
		Sandan	62
		Santuk	63
		Stoung	64
Kampot	7	Angkor Chey	65
		banteay Meas	66
		Chhuk	67
		Chum Kiri	68
		Dang Tong	69
		Kampong Trach	70
		Tuek Chhou	71
		Kampot	72
Kadal	8	Kandal Stueng	73
		Kien Svay	74
		Khsach Kandal	75
		Kaoh Thum	76
		Leuk Daek	77
		Lvea Aem	78
		Mukh Kampul	79
		Angk Snuol	80
		Ponhea Lueu	81
		S'ang	82
		Ta Khmau	83
Koh Kong	9	Botum Sakor	84
		Kiri Sakor	85
		Kaoh Kong	86
		Khemara Phoumin	87
		Mondol Seima	88
		Srae Ambel	89
		Thma Bang	90
Kratie	10	Chhloung	91
		Kracheh	92
		Preaek Prasab	93
		Sambour	94
		Snuol	95
		Chetr Borei	96
Mondul Kiri	11	Kaev Seima	97
		Kaoh Nheaek	98
		Ou Reang	99
		Pech Chreada	100
		Saen Monourom	101
Phnom Penh	12	Russey Keo	102
		Toulkok	103
		Daun Penh	104
		7 Makara	105
		Chamkarmorn	106
		Meanchey	107
		Dang Kor	108
		SenSok	109
		PoSenChey	110
Preah Vihear	13	Chey Saen	111
		Chhaeb	112
		Choam Ksant	113
		Kuleanen	114
		Rovieng	115
		Sangkum Thmei	116
		Tbaeng Mean Chey	117
		Preah Vihear	118
Prey Veng	14	Ba Phnum	119
		Kamchay Mear	120
		Kampong Trabaek	121
		Kanhchriech	122
		Me Sang	123
		Peam Chor	124
		Peam Ro	125
		Pea Reang	126
		Preash Sdach	127
		Prey Veng	128
		Kampong Leav	129
		Sithor Kandal	130
		Svay Antor	131
Pursat	15	Bakan	132
		Kandieng	133
		Krakor	134
		Phnum Kravanh	135
		Pursat	136
		Veal Veaeng	137
Ratanak Kiri	16	Andoung Meas	138
		Ban Lung	139
		Bar Kaev	140
		Koun Mom	141
		Lumphat	142
		Ou Chum	143
		Ou Ya Dav	144
		Ta Veaeng	145
		Veun Sai	146
Siem Reap	17	Angkor Chum	147
		Angkor Thum	148
		Banteay Srei	149
		Chi Kraeng	150
		Kralanh	151
		Puok	152
		Prasat Bakong	153
		Siem Reap	154
		Soutr Nikom	155
		Srei Snam	156
		Svay Leu	157
		Varin	158
Preah Sihanouk	18	Preah Sihanouk	159
		Prey Nob	160
		Stueng Hav	161
		Kampong Seila	162
Stung Treng	19	Sesan	163
		Siem Bouk	164
		Siem Pang	165
		Stueng Traeng	166
		Thala Barivat	167
Svay Reang	20	Chantrea	168
		Kampong Rou	169
		Rumduol	170
		Romeas Haek	171
		Svay Chrum	172
		Svay Rieng	173
		Svay Teab	174
		Bavet	175
Takeo	21	Angkor Borei	176
		Bati	177
		Borei Cholsar	178
		Kiri Vong	179
		Kaoh Andaet	180
		Prey Kabbas	181
		Samraong	182
		Doun Kaev	183
		Tram Kak	184
		Treang	185
Oddar Meanchey	22	Anlong Veang	186
		Banteay Ampil	187
		Chong Kal	188
		Samraong	189
		Trapeang Prasat	190
Kep	23	Damnak Chang'aeur	191
		Kaeb	192
Paillin	24	Pailin	193
		Sala Krau	194
Laos	25	NR7	195
Thailand	26	NR5	196
	27	NR48	197
	28	NR57	198
	29	NR67	199
	30	NR68	200
Vietnam	31	NR1	201
	32	NR2	202
	33	NR21	203
	34	NR33	204
	35	NR72	205
	36	NR76	206

5.4.2 Preparation of Present OD Table

The OD table of year 2012 used in the Survey of the South Section is used in this survey also.

5.4.3 Trip Generation and Attraction

(1) Trip Generation and Attraction Model

A future trip generation and attraction model formulated in the Survey of the South Section is used in this survey. The model parameters are calibrated as shown in Table 5.4-2.

$G_i = a_i \times X1_i + b_i \times X2_i$

$A_j = a_j \times X1_j + b_j \times X2_j$

G_i : Generation from Zone i

A_j : Attraction to Zone j

$X1$, $X2$: Attributes in Zone i, j

a_i, a_j, b_i and b_j : Coefficient

Table 5.4-2 Trip Distribution Model Parameters

Model Type	Vehicle Category	Population (a_i, a_j)	GRDP (b_i, b_j)	Multiple Correlation Coefficient (R^2)
Trip Generation	MC	0.00576	13.53175	0.919
	LV	0.00046	6.74668	0.927
	HV	0.00024	1.24503	0.978
Trip Attraction	MC	0.00594	13.25812	0.915
	LV	0.00070	6.48985	0.928
	HV	0.00023	1.25918	0.974

(2) Trip Production (Total of Generation and Attraction)

The number of the total trips by vehicle type for the years 2012, 2018, 2023 and 2033 are shown in Table 5.4-3.

Table 5.4-3 Future Trip Production

(Unit: Vehicle/day)

Year	2012	2018	2023	2028	2033	(2033/2012)
MC	216,283	296,666	379,173	473,612	579,652	2.68
LV	68712	107,247	144,117	188,169	238,225	3.47
HV	15,357	22,446	29,606	38,033	47,563	3.10
Total	300,352	426,359	552,896	699,814	865,440	2.88

(3) Generation and Attraction

The predicted trip generation and attraction by vehicle type for 2012, 2018, 2023, 2028 and 2033 are shown in Tables 5.4-4 to 5.4-8.

Table 5.4-4 Trip Generation and Attraction by Vehicle Type in 2012

Zone No.	Province	Trip Generation in 2012			Trip Attraction in 2012		
		MC	LV	HV	MC	LV	HV
2	Battambang	14,398	4,408	986	14,451	4,531	985
15	Pursat	4,865	1,386	320	4,895	1,442	320
4	Kampong Chhnang	6,051	1,761	403	6,084	1,826	402
5	Kampong Speu	9,248	2,739	622	9,293	2,832	621
8	Kandal	21,454	7,359	1,566	21,435	7,430	1,569
12	Phnom Penh	55,828	23,884	4,654	55,190	23,390	4,689

Table 5.4-5 Trip Generation and Attraction by Vehicle Type in 2018

Zone No.	Province	Trip Generation in 2018			Trip Attraction in 2018		
		MC	LV	HV	MC	LV	HV
2	Battambang	19,088	6,530	1,391	19,072	6,595	1,394
15	Pursat	6,263	2,029	443	6,272	2,066	443
4	Kampong Chhnang	7,711	2,518	547	7,720	2,561	548
5	Kampong Speu	11,774	3,929	846	11,777	3,983	847
8	Kandal	28,067	10,463	2,151	27,938	10,435	2,160
12	Phnom Penh	81,198	35,904	6,911	80,125	35,018	6,970

Table 5.4-6 Trip Generation and Attraction by Vehicle Type in 2023

Zone No.	Province	Trip Generation in 2023			Trip Attraction in 2023		
		MC	LV	HV	MC	LV	HV
2	Battambang	24,445	8,831	1,839	24,367	8,848	1,845
15	Pursat	7,931	2,746	582	7,920	2,769	583
4	Kampong Chhnang	9,560	3,329	704	9,545	3,353	706
5	Kampong Speu	14,580	5,219	1,091	14,540	5,236	1,094
8	Kandal	35,492	13,833	2,793	35,254	13,712	2,808
12	Phnom Penh	108,676	48,725	9,332	107,156	47,443	9,414

Table 5.4-7 Trip Generation and Attraction by Vehicle Type in 2028

Zone No.	Province	Trip Generation in 2028			Trip Attraction in 2028		
		MC	LV	HV	MC	LV	HV
2	Battambang	30,546	11,646	2,372	30,374	11,579	2,384
15	Pursat	10,000	3,689	761	9,958	3,685	765
4	Kampong Chhnang	11,583	4,278	883	11,534	4,272	886
5	Kampong Speu	17,686	6,708	1,369	17,590	6,674	1,376
8	Kandal	44,374	18,058	3,586	43,981	17,798	3,609
12	Phnom Penh	138,568	63,264	12,037	136,489	61,468	12,149

Table 5.4-8 Trip Generation and Attraction by Vehicle Type in 2033

Zone No.	Province	Trip Generation in 2033			Trip Attraction in 2033		
		MC	LV	HV	MC	LV	HV
2	Battambang	37,483	14,902	2,986	37,195	14,732	3,003
15	Pursat	12,504	4,843	980	12,424	4,805	985
4	Kampong Chhnang	13,901	5,386	1,090	13,812	5,343	1,096
5	Kampong Speu	21,116	8,374	1,679	20,957	8,281	1,689
8	Kandal	54,538	22,939	4,498	53,963	22,512	4,531
12	Phnom Penh	171,193	79,317	15,013	168,481	76,931	15,158

Figure 5.4-1 to Figure 5.4-5 show the total trip production (the total of generation and attraction) by zone in 2012, 2018, 2023, 2028 and 2033.

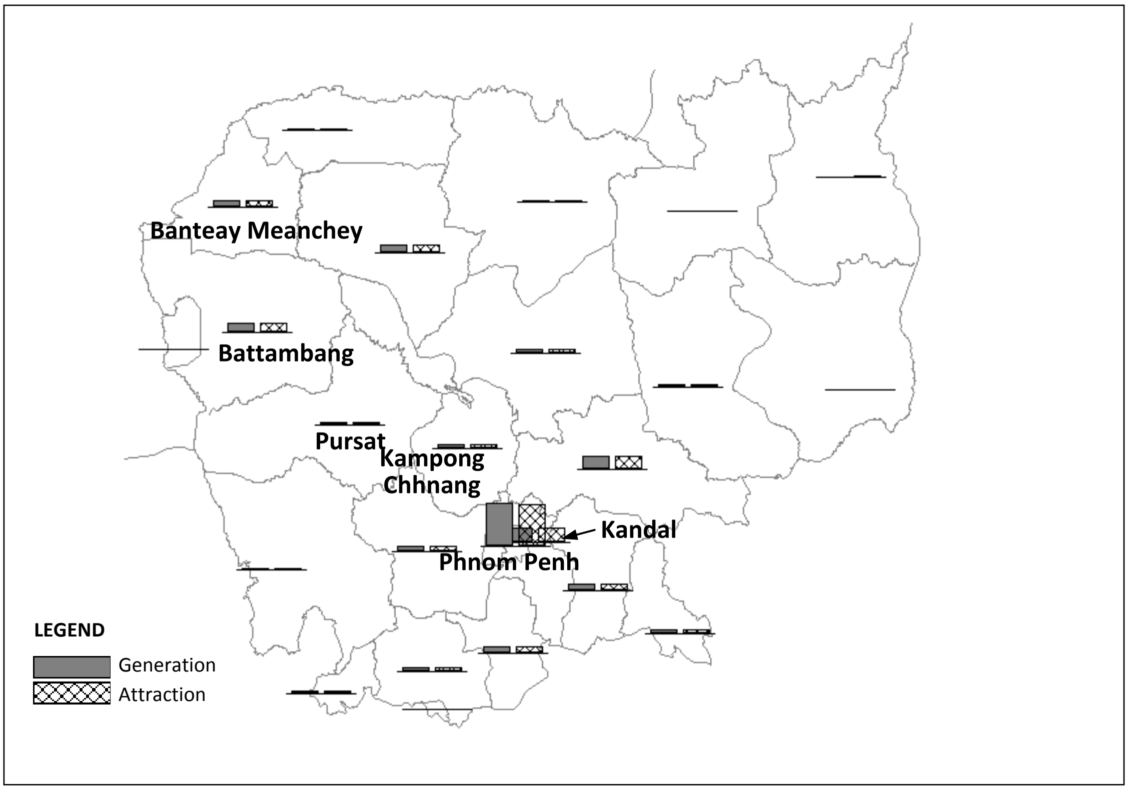


Figure 5.4-1 Trip Generation and Attraction in 2012 (Total Vehicle)

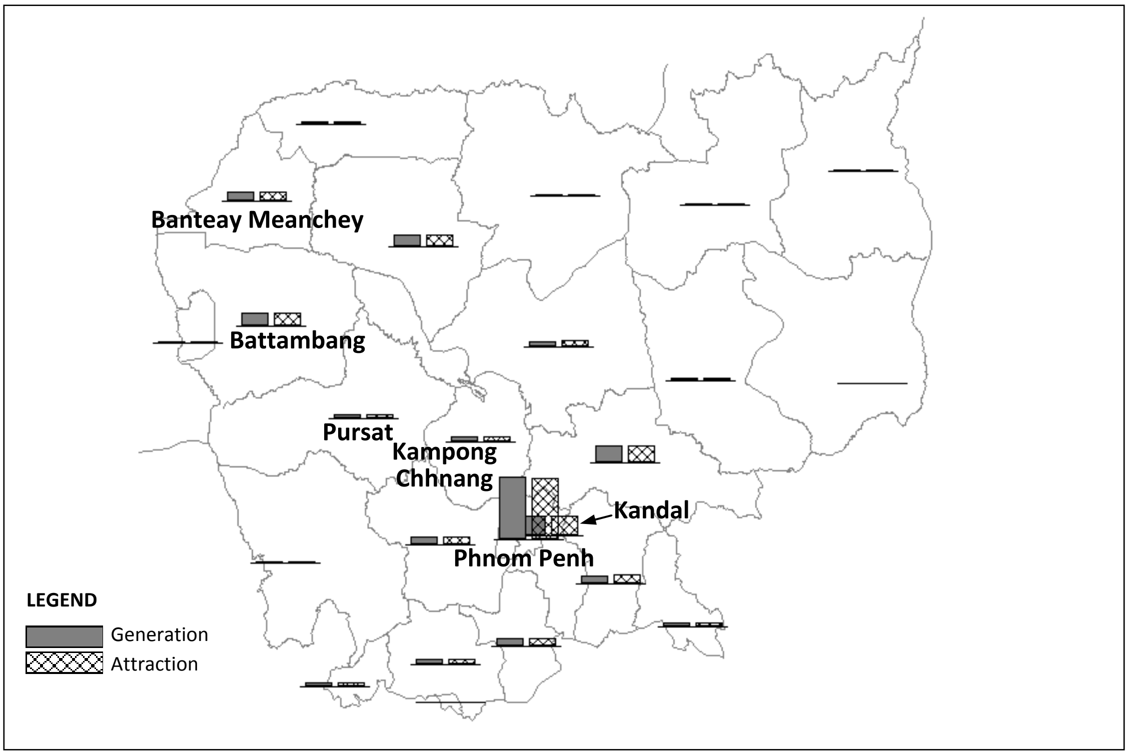


Figure 5.4-2 Trip Generation and Attraction in 2018 (Total Vehicle)

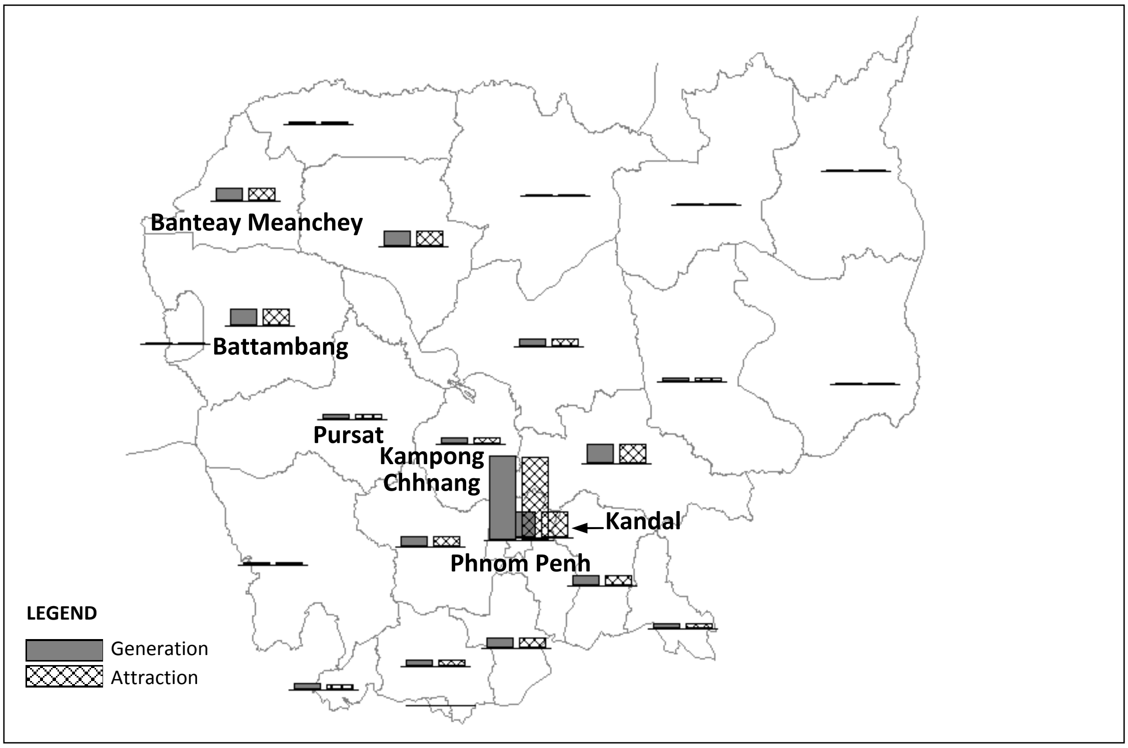


Figure 5.4-3 Trip Generation and Attraction in 2023 (Total Vehicle)

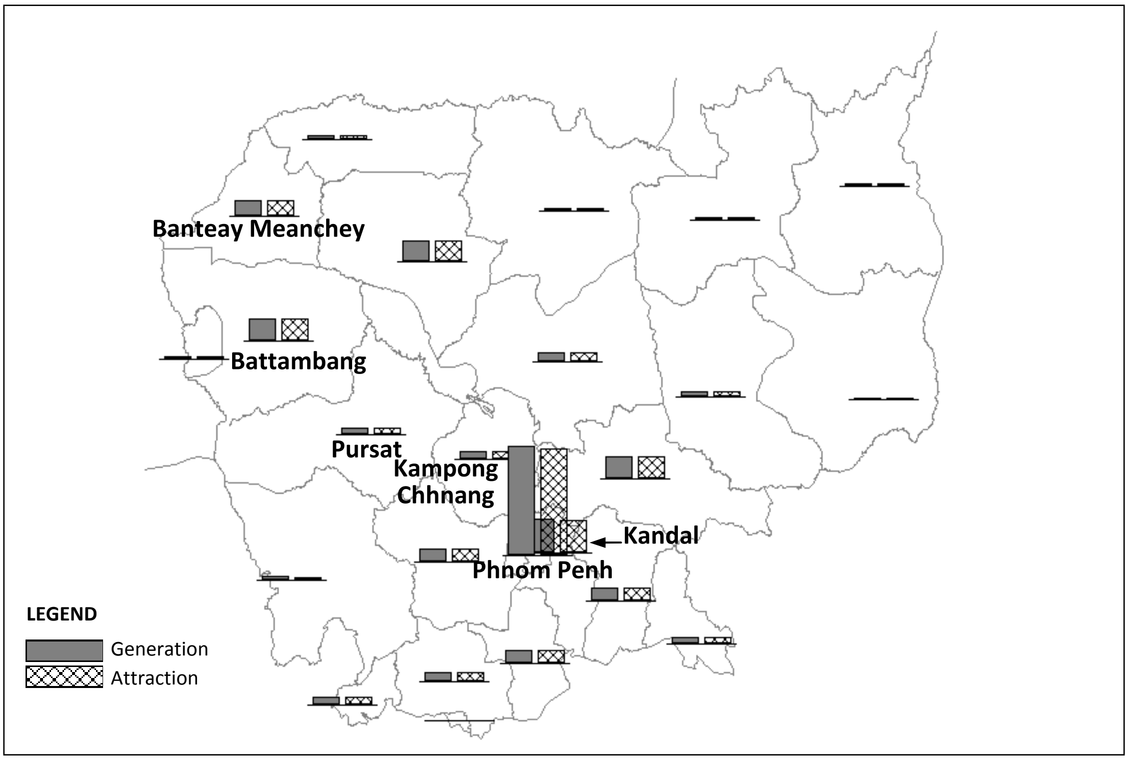


Figure 5.4-4 Trip Generation and Attraction in 2028 (Total Vehicle)

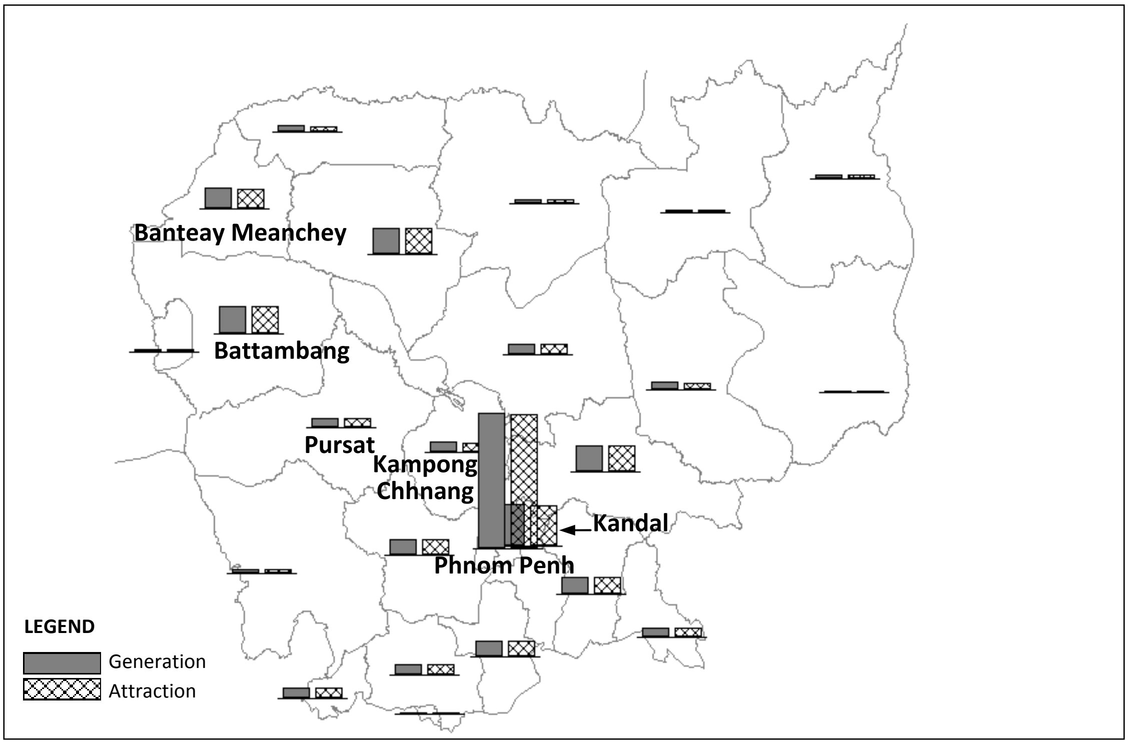


Figure 5.4-5 Trip Generation and Attraction in 2033 (Total Vehicle)

5.4.4 Future OD Matrix (Future Traffic Demand)

The future OD matrixes are estimated by the Frator Method using the present OD matrix and the estimated trip generation and attraction. The future OD matrices expressing the future traffic demand between the traffic zones were prepared in a form of tables. Then, this traffic demand data is converted into a form of 'desire line' as shown in Figure 5.4-6.

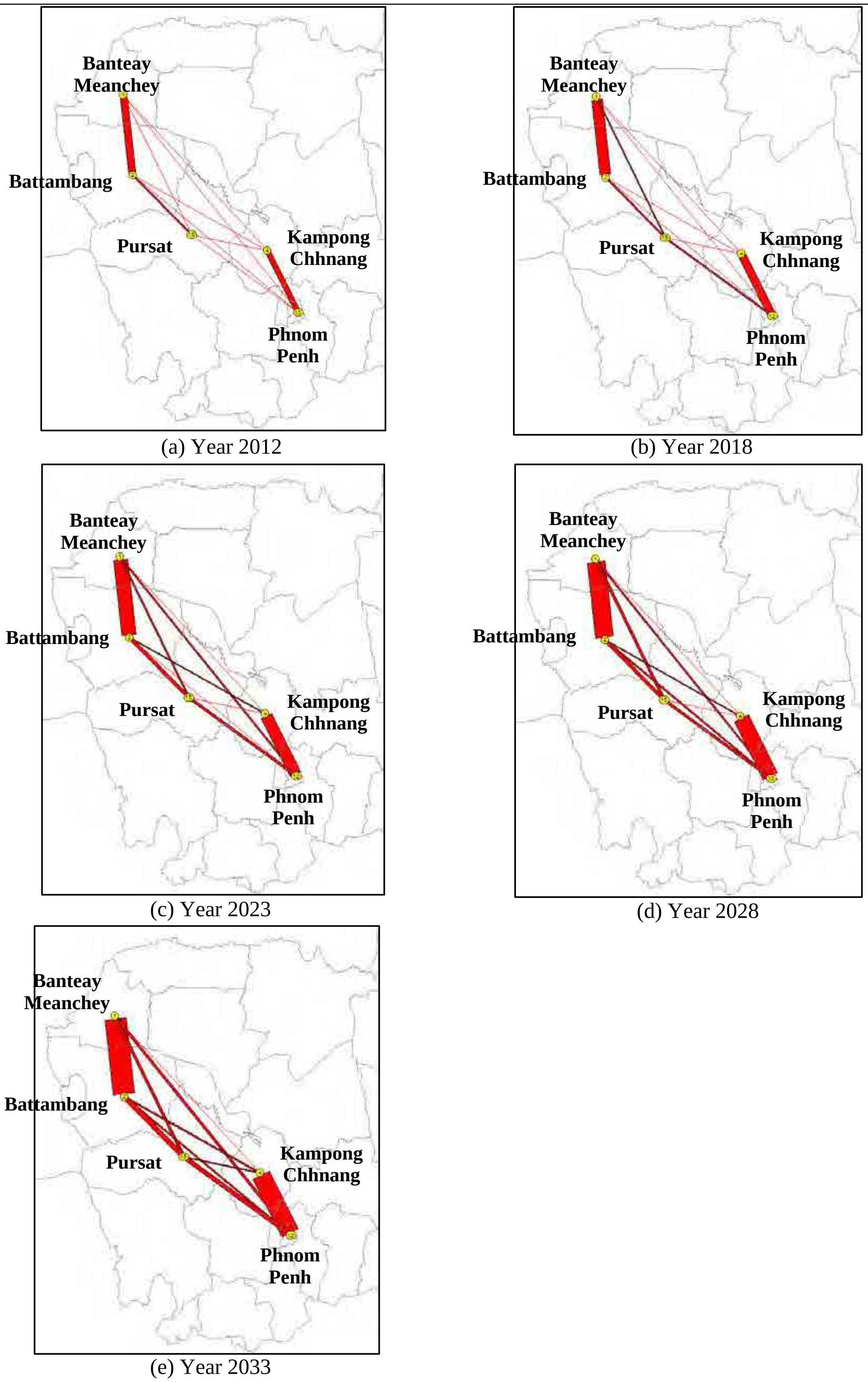


Figure 5.4-6 Desire Line for 2012, 2018, 2023, 2028 and 2033

5.4.5 Modal Split

(1) Railroad

A railroad line (North Line) between Poipet and Phnom Penh, is running in parallel to NR 5. This railroad is currently being rehabilitated with a financial assistance of ADB. The 30-years concession to manage and upgrade Royal Cambodian Railways has been awarded to Toll Holding, an joint venture of Australian investor and Royal Group. The Master Plan for the Development of the Railway Network in Cambodia has been prepared by Korea and MPWT. However, the operation plan is not publically available. Therefore, the diversion of cargo and/ or passengers from automobile to railroad is not considered in this traffic forecast, but the overall examination of forecasted traffic volume is presented in Item (5) of Subsection 5.4.1 below.

(2) Bus Service

Many long-distance bus services are available on NR 5. It is not conceivable that the share of transport by such long-distance buses greatly increase in the future as the income level of the people will be upgraded. Therefore, diversion to long-distance bus service is not taken into account in this future traffic demand forecast.

(3) Inland Water Transport

There are four (4) inland water ports (Phnom Penh, Kampong Chhnang, Battambang and Siem Riap) along NR 5. "The master plan on Waterborne Transport in the Mekong River System in Cambodia" was established under the assistance of Belgian Technical Cooperation. An agreement to promote inland water transport was signed between the RGC and the government of Vietnam in December 2009. This will encourage the inland water transport along Mekong River, Tonle Sap River, Tonle Sap Lake and Bassac River. However the diversion of cargo or passenger from NR 5 to such inland water transport is considered to be limited. Thus, such diversion is not considered in this traffic forecast.

5.5 Traffic Demand Forecast

5.5.1 Traffic Assignment

The prediction of future traffic volume by road link is estimated by traffic assignment program of JICA STRADA. JICA STRADA adopt the "minimum paths" method, in which the vehicles are assumed to take the path with the minimum cost (sum of travel time cost and vehicle operation cost) among the road links of the network connecting the pair of OD zones.

(1) Passenger Car Unit

In the traffic assignment, traffic volume is expressed in the form 'Passenger Car Unit' (PCU). The PCU equivalents used in this Survey are shown in Table 5.5-1.

Table 5.5-1 Passenger Car Unit

Categories	MC	LV	HV
PCU Equivalents	0.30	1.25	3.00

Normally, the PCU of sedan and pick-up truck is set at 1.0. In this Survey, the PCU of Light Vehicle (LV) has been set at 1.25 for the reason that this category includes light trucks and pick-up trucks. Their speeds light trucks and pick-up tracks are slower than that of passenger cars because of cargo and therefore their contribution to traffic congestion is larger than ordinary passenger cars.

(2) Road Network

The future road network used for traffic assignment needs to incorporate the planned improvements. The 4th edition of publication of the Infrastructure and Regional Integration Technical Working Group (IRITWG), which was published in September 2012 lists the past and future improvement of National Roads. Among these improvement plans, the following projects are incorporated in the future road network used in this traffic forecast.

Table 5.5-2 Future Improvements to Road Network

<table>
<tr><th>Year</th><th>Road No</th><th>Section</th><th>Content</th></tr>
<tr><td rowspan="5">2018</td><td>NR 5</td><td>Phnom Penh – Prek Kdam</td><td>Widening (4 lanes)</td></tr>
<tr><td rowspan="3">NR 5
(North Section)</td><td>Battabang – Sisophon</td><td>Widening (4 lanes)</td></tr>
<tr><td>Battambang Bypass</td><td>New Construction</td></tr>
<tr><td>Sri Soporn Bypass</td><td>New Construction</td></tr>
<tr><td>NR 6</td><td>Phnom Penh - Thnal Keng</td><td>Widening (4 lanes)</td></tr>
<tr><td rowspan="5">2023</td><td rowspan="3">NR 5
(South Section)</td><td>Prek Kdam - Thlea Ma'am</td><td>Widening (4 lanes)</td></tr>
<tr><td>Odongk Bypass</td><td>New Construction</td></tr>
<tr><td>Kampong Chhnang Bypass</td><td>New Construction</td></tr>
<tr><td rowspan="2">NR 6</td><td>Siem Reap Bypass</td><td>New Construction</td></tr>
<tr><td>Thnal Keng - Skun</td><td>Widening (4 lanes)</td></tr>
</table>

Other improvement plans are not incorporated in the future road network, but their influences are individually examined in "(5) Overall Examination of Forecasted Traffic Volume".

(3) Traffic Assignment Result

Figure 5.5-1 to Figure 5.5-5 shows the result of the traffic assignment for year 2012, 2018, 2023 and 2033.

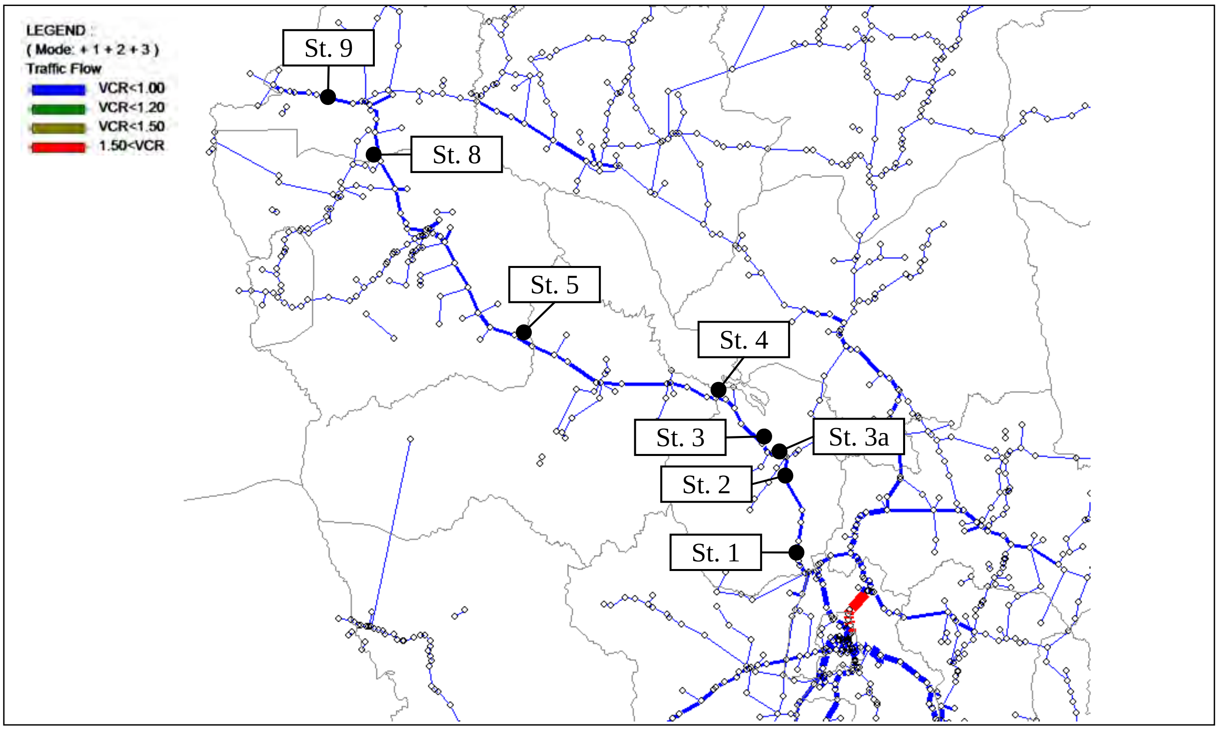


Figure 5.5-1 Results of Traffic Assignment for Year 2012

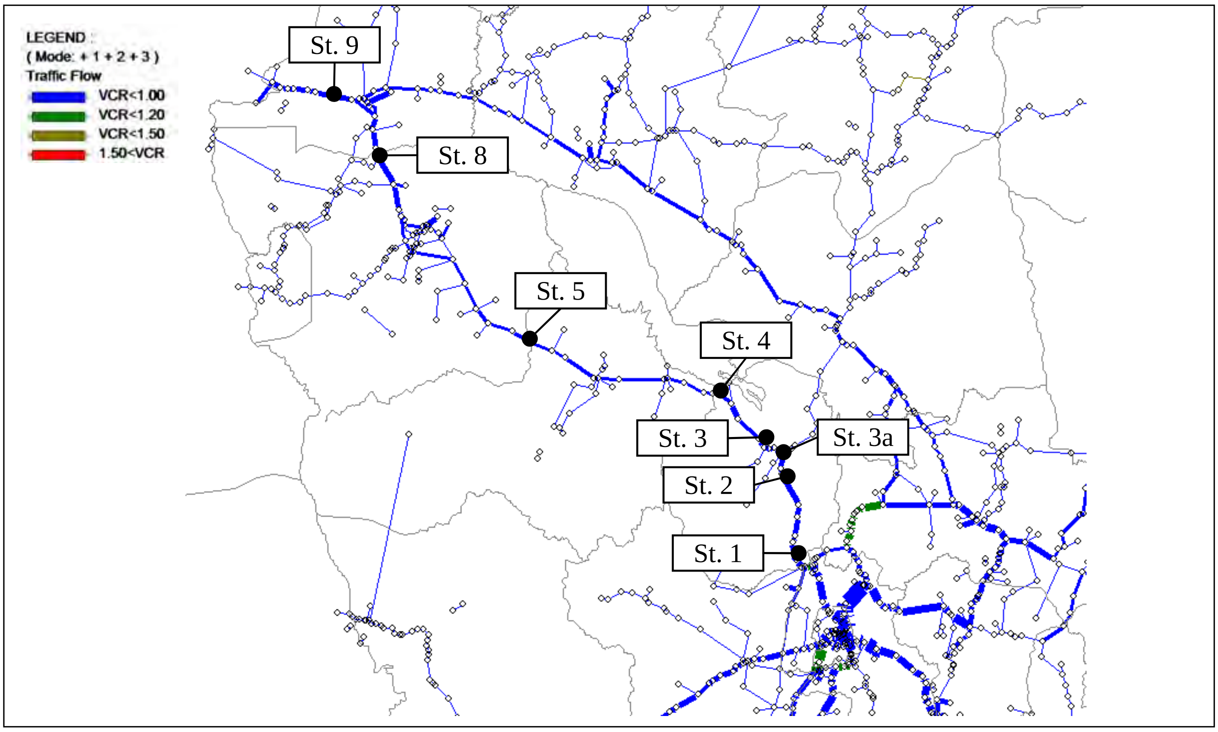


Figure 5.5-2 Results of Traffic Assignment for Year 2018

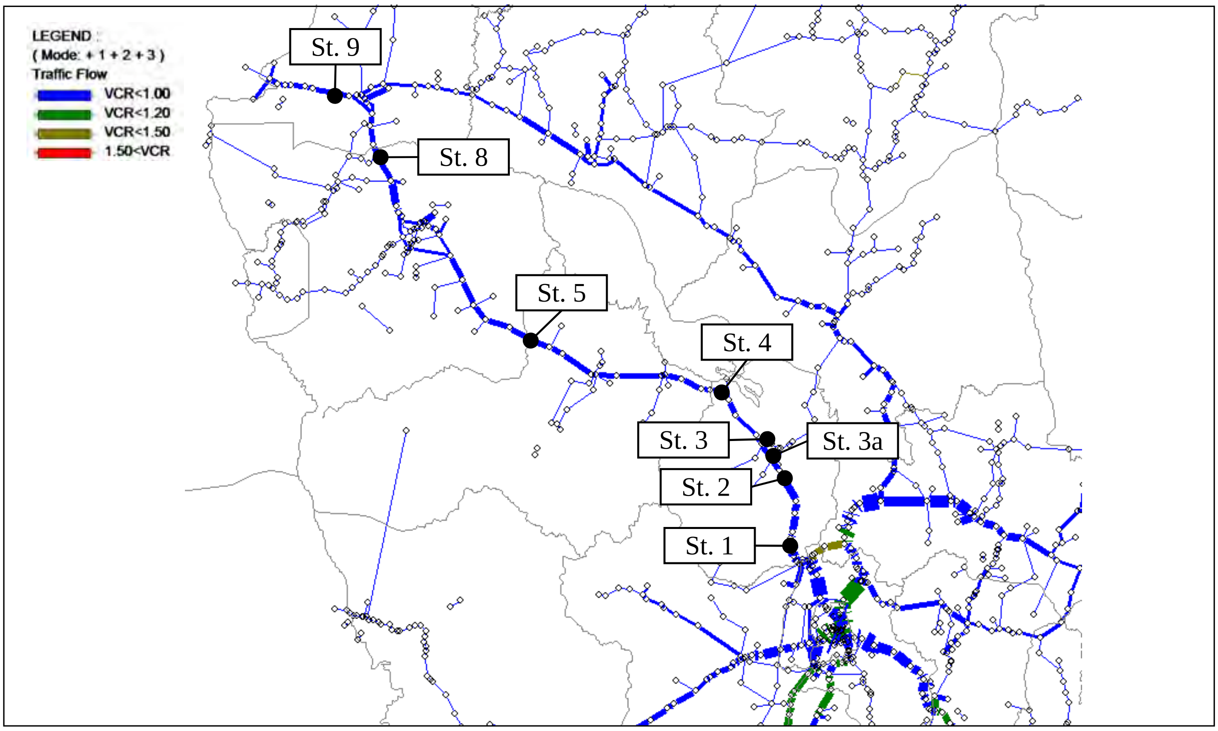


Figure 5.5-3 Results of Traffic Assignment for Year 2023

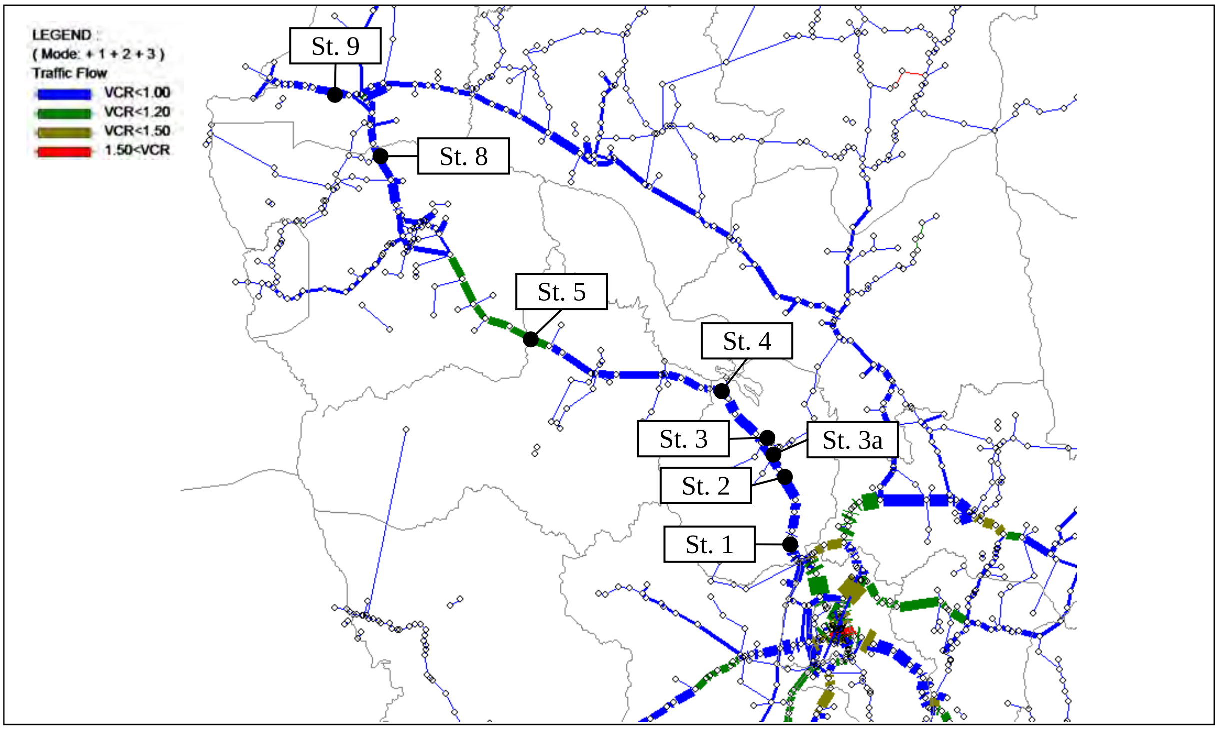


Figure 5.5-4 Results of Traffic Assignment for Year 2028

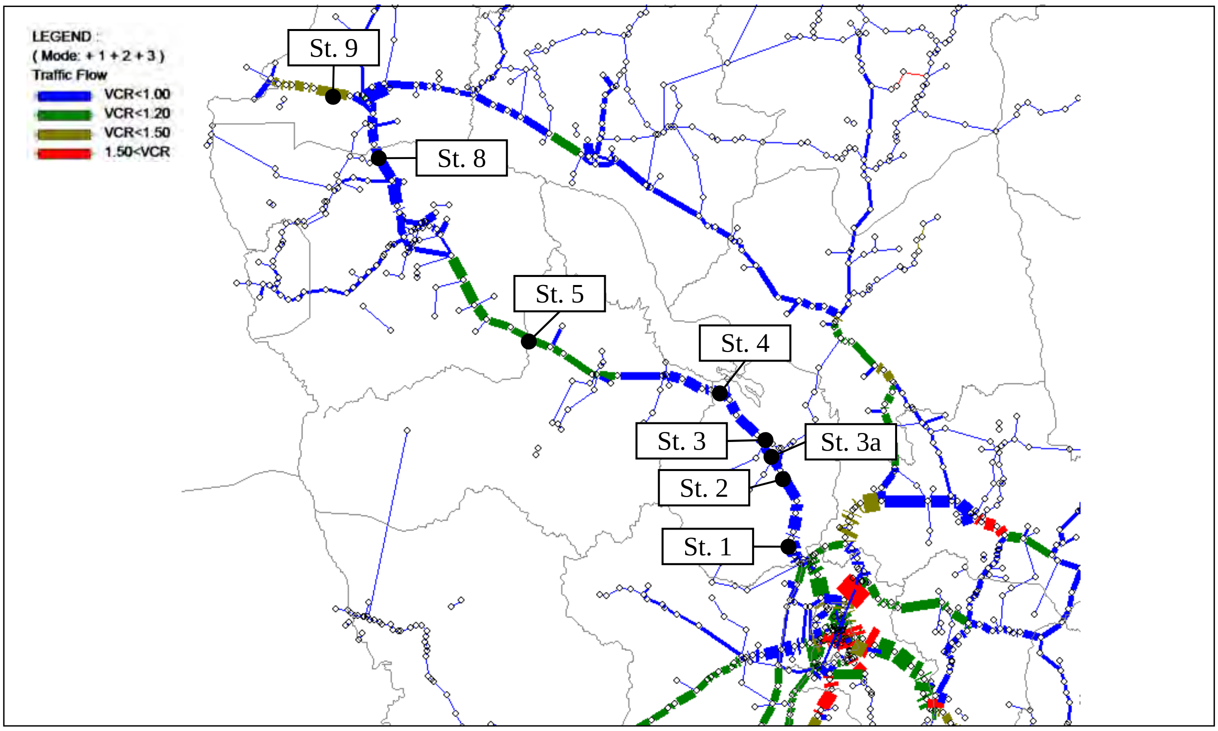


Figure 5.5-5 Results of Traffic Assignment for Year 2030

(4) Future Traffic Volume at Traffic Counting Stations

Table 5.5-3 and Table 5.5-4 lists the forecasted traffic volumes at the traffic counting stations for the years 2012, 2018, 2023 and 2033. Figure 5.5-6 shows the forecasted traffic volume between Prek Kdam and Sri Sophorn on NR 5.

Table 5.5-3 Result of Traffic Assignment by Counting Stations

(Unit: 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

Note: Assignment result at Station No.3a in 2012 is not shown in this table. The Result of the traffic volume count survey at Station No.3a included the short trips within the city, because Station No.3a was located at the city center of Kampong Chhnang. However the future traffic volume forecast in this Survey does not estimate the short trips within the city. The Assignment results at Station No.3a in 2018, 2023, 2028 and 2033 are estimated based on assignment result and result of traffic count survey in the Survey of the South Section .

Table 5.5-4 Traffic Volume by Vehicle Type, Actual and Predicted

Station	2012 (Actual)					2018 (Predicted)				
	MC	LV	HV	Total (Veh.)	PCU	MC	LV	HV	Total (Veh.)	PCU
1	5,727	3,788	1,285	10,800	10,308	8,633	6,820	2,188	17,641	17,679
2	5,637	2,964	1,096	9,697	8,684	8,550	6,044	1,801	16,395	15,523
3a	15,947	3,569	1,204	20,720	12,857	21,067	7,660	1,958	30,685	21,769
3	3,303	2,123	943	6,370	6,474	4,677	5,002	1,556	11,235	12,324
4	867	1,738	910	3,514	5,162	2,130	4,415	1,497	8,043	10,650
5	1,583	1,660	1,189	4,432	6,117	2,260	3,525	1,685	7,469	10,138
8	3,897	2,282	776	6,955	6,350	6,733	4,654	1,328	12,715	11,822
9	4,027	3,432	652	8,111	7,454	8,753	4,236	1,275	14,264	11,746

Station	2023 (Predicted)					2028 (Predicted)				
	MC	LV	HV	Total (Veh.)	PCU	MC	LV	HV	Total (Veh.)	PCU
1	12,487	9,350	2,914	24,751	24,176	15,700	12,695	4,052	32,447	32,734
2	12,390	8,324	2,414	23,128	21,365	15,590	11,442	3,437	30,468	29,289
3a	21,857	7,821	2,221	31,900	22,998	27,065	10,851	3,188	41,103	31,245
3	7,217	6,950	2,101	16,268	17,156	9,053	9,939	3,064	22,057	24,332
4	4,057	6,174	2,026	12,257	15,013	5,230	8,953	2,971	17,154	21,673
5	4,140	4,967	2,259	11,367	14,228	5,260	7,507	3,272	16,039	20,778
8	8,003	6,346	1,772	16,121	15,650	10,443	9,390	2,622	22,455	22,736
9	11,210	5,723	1,683	18,616	15,566	14,130	7,567	2,180	23,877	20,238

Station	2033 (Predicted)				
	MC	LV	HV	Total (Veh.)	PCU
1	19,013	16,302	5,452	40,768	42,438
2	18,880	14,727	4,715	38,322	38,218
3a	32,604	13,961	4,400	50,966	40,434
3	10,830	12,718	4,276	27,824	31,974
4	6,253	11,484	4,161	21,898	28,714
5	6,163	9,686	4,509	20,358	27,483
8	13,107	12,352	3,679	29,138	30,410
9	17,417	9,660	2,738	29,815	25,514

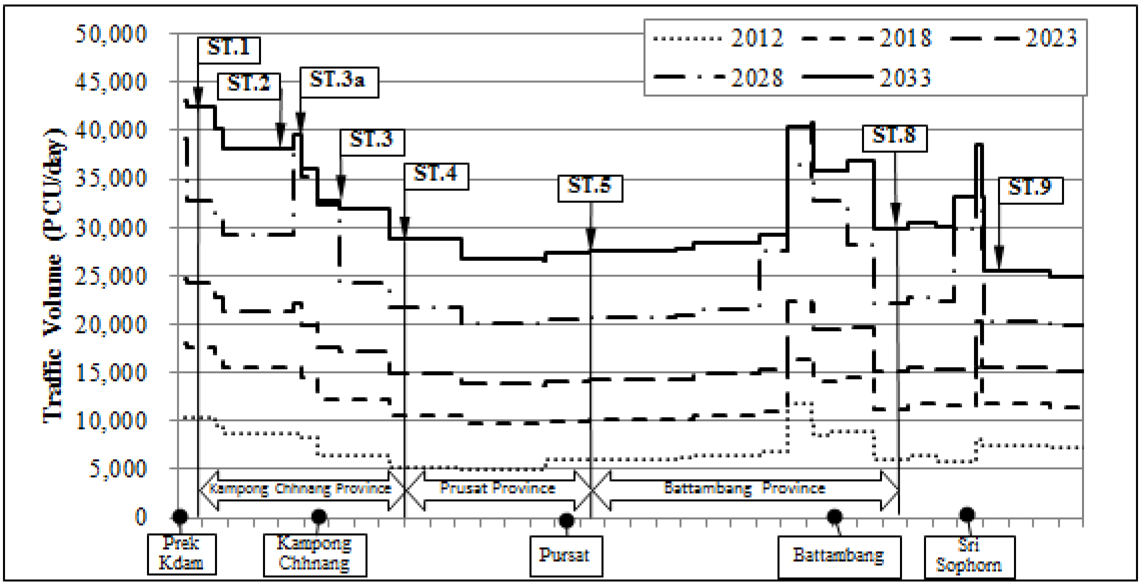


Figure 5.5-6 Result of Traffic Assignment

(5) Overall Examination of Forecast Traffic Volume

➢ Influence of Rail Road

Rehabilitation of the North Line of the railroad along NR 5 is being implemented. However the diversion of trips from automobile to railroad is not considered in the traffic assignment (Table 5.5-3), because the operation plan of the railroad and the route of the new road are not fixed yet. Based on the experience of Japan and USA, as well as considering the routes and other conditions of rail transport and NR 5, it is assumed that traffic of heavy vehicles is may be subject to diversion to rail transport. Railroad carry mainly heavy cargo like construction material. Result of OD interview survey in the survey of the South Section, 10% of heavy vehicles carried cargo of construction. If 10% of traffic of heavy vehicles divert to rail transport, future total traffic volume on NR 5 will be reduced by 4 % from Table 5.5-3 in year 2033.

➢ Influence of Expressway

Expressway routes in the Kingdom of Cambodia is under consideration now. It is assumed that the expressway will be planned along NR 1, NR 4 and NR 5, since these routes are selected as Asian highway. If 50% of Light Vehicle and Heavy Vehicle will divert to expressway, future total traffic volume on NR 5 will be reduce by 45% from Table 5.5-3 in year 2033.

5.5.2 Peak Hour Traffic Volume and Congestion

Table 5.5-5 shows the traffic volumes in peak hour at the traffic counting stations. The degree of congestion expressed in the form of the ratio of traffic volume against traffic capacity of the road (v/c ratio or VCR). VCR of 0.85 is usually considered to be the allowable limit of congestion in road planning.

By the year 2033, at all the traffic counting stations , the VCR is predicted to exceed 0.85. Thus these sections require widening by that time.

Table 5.5-5 Peak Hour Traffic Volume and Congestion Degree

Station No.	Peak Hour Volume (PCU)					Congestion Degree VCR					Link Capacity	No. of Lane
	2012	2018	2023	2028	2033	2012	2018	2023	2028	2033		
1	927	1,582	2,177	2,927	3,763	0.34	0.59	0.81	1.08	1.39	2,700	1.5×2
2	754	1,330	1,843	2,498	3,226	0.28	0.49	0.68	0.93	1.19	2,700	1.5×2
3a	1,147	3,226	1,978	2,648	3,382	0.42	1.19	0.73	0.98	1.25	2,700	1.5×2
3	517	983	1,380	1,940	2,522	0.26	0.49	0.69	0.97	1.26	2,000	2
4	408	868	1,235	1,777	2,335	0.20	0.43	0.62	0.89	1.17	2,000	2
5	656	1,081	1,527	2,222	2,932	0.24	0.40	0.57	0.82	1.09	2,700	1.5×2
8	584	1,092	1,440	2,082	2,770	0.29	0.55	0.72	1.04	1.38	2,000	2
9	698	1,099	1,455	1,890	2,228	0.35	0.55	0.73	0.94	1.11	2,000	2

It should be noted that daily traffic volumes at all Stations exceed 20,000 PCU by year 2033 (see Table 5.5-3). 20,000 PCU is generally considered to be, or close to be, the capacity of an opposed 2-lane road. Thus, the traffic at these locations is anticipated to be congested. By year 2033, the daily traffic volume at Station No. 4 and No. 5 is predicted to exceed, 20,000 PCU and widening of the Middle Section will become an absolutely necessary.

5.5.3 Traffic Volume on Bypass

One of the tasks included in the Scope of this Survey is to study the possibility of construction of bypasses around Pursat. Table 5.5-6 shows the forecasted traffic volume on these bypasses.

Table 5.5-6 Future Traffic Volume on Bypass

Section	2023					2028				
	MC	LV	HV	Total (Veh.)	PCU	MC	LV	HV	Total (Veh.)	PCU
Bypass	2,878	4,150	1,953	8,981	11,911	3,698	6,330	2,873	12,900	17,639
City Center	723	972	246	1,941	2,170	940	1,266	321	2,526	2,826

Station	2033				
	MC	LV	HV	Total (Veh.)	PCU
Bypass	4,017	7,059	3,154	14,230	19,203
City Center	1,033	1,435	366	2,835	3,203

Note: The future traffic volume forecast in this Survey is not estimated the short trips within the city.

CHAPTER 6 NATURAL CONDITION OF SURVEY AREA/SURVEY ROAD

In this chapter, the natural conditions in the Survey Area which will affect planning and designing of NR 5 and its bypass are discussed in (i) the hydrological conditions/ potential for flood, (ii) the topography of the existing road, and (iii) the geotechnical conditions.

6.1 Hydrological Condition and Flood Records

The climate of Cambodia is classified as tropical monsoonal and dominated by annual monsoon cycle with its alternating wet and dry season. In wet season, May to October, inundations occur frequently on the NR 5, disrupting traffic and economic and social activities. Thus inundations cause considerable loss to the economy and social activities. With regard to the road structure, inundation also reduces the bearing capacity of the pavement structure and then cause premature deterioration of pavement. Inundation on the Middle Section of NR 5 is caused by two possible reasons. One is influence of flooding in the Tonle Sap Lake system, and the other is discharge of rainwater from mountains and paddy field located in the west of NR 5.

Sri Sophorn – Poipet Section is located far from the Tonle Sap Lake. Thus 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 supposed to be discharge of rain water from mountains because of heavy rain, and flood water from Thailand.

6.1.1 River System and Existing Drainage Facilities

NR 5 runs southwest side of Tonle Sap River and Tonle Sap Lake. The Tonle Sap River and Lake play an important role not only as a buffer (a natural flood retention basin) for the floods of the Mekong River System but also as a source of water for agriculture and other purposes during the dry season. During the dry season, Tonle Sap River flows downstream as a normal tributary draining into the Mekong. During wet season, however, the level of the Mekong rises higher than the Tonle Sap River. Consequently, the Tonle Sap River flows upstream as water from the Mekong flows into Tonle Sap Lake. Table 6.1-1 shows the hydrological features of the Mekong River and Tonle Sap River.

Table 6.1-1 Hydrological Features of Mekong River and Tonle Sap River

River Name	Catchment Area (km^2)	River Length (Km)	Average Discharge (m^3/s)
Mekong River	660,000* (795,000 in total)	4,500* (4,880 in total)	11,830** (15,060 in total)
Tonle Sap River	84,400*	120* (400 in total)	1,570**

*Note: * Upstream of Phnom Penh ** At Phnom Penh*

The drainage area along the Middle Section of NR 5 is divided into 16 areas taking the watershed and boundary into consideration based on the prevailing topographic terrain, embankments, and canals on the topographic map of the scale of 1/100,000. There are 14 rivers, streams, and channels crossing NR 5 in the Middle Section (see Table 6.1-2). Some of them flow only during the period of deluge, and thus lack clear shape of river. Figure 6.1-1 illustrates the major river network in Cambodia. It shows there are two major river system (Pursat and Doun Tri) in the Survey Area.

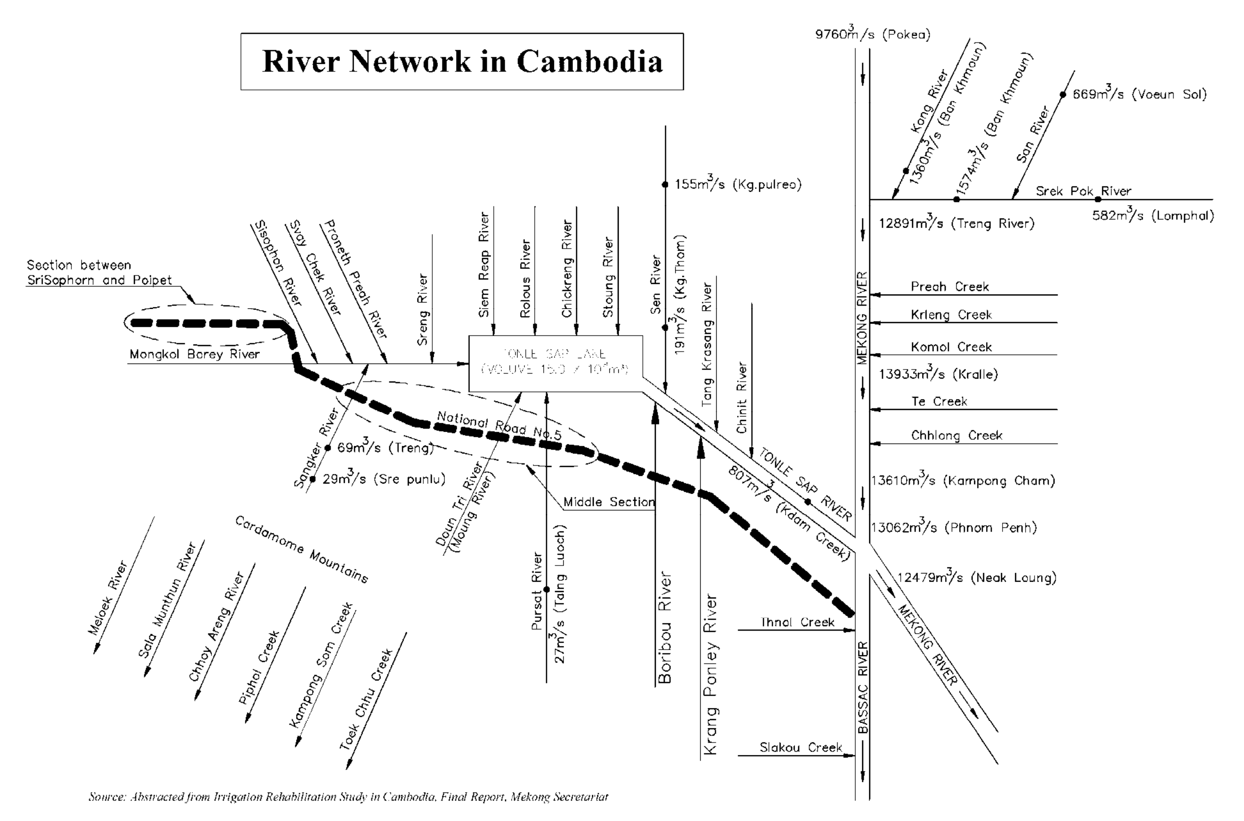


Figure 6.1-1 River Network in Cambodia

Table 6.1-2 shows the river and stream basins and water courses along NR 5. Several streams finally discharge themselves into paddy field or floodplains of the Tonle Sap Lake after crossing NR 5. This means the riverbed gradients of downstream reaches are extremely gentle. Most of the streams, however, directly flow into the Tonle Sap Lake.

As shown in Figure 6.1-1 above, a number of rivers and streams originate from the Cardamome Mountains, located in the southwestern of the Tonle Sap Lake, and cross NR 5 flowing into the Tonle Sap Lake. Thus, drainage system of the NR 5 governs the flow into the Tonle Sap Lake from the southwestern side. Table 6.1-3 summarizes the existing bridges functioning as opening or channel for water flow across NR 5.

Table 6.1-4 to Table 6.1-5 shows the inventory of the existing box culverts and pipe culverts. Appendix 6-1 provides details. In the survey, at some culverts, silting-up at both of inlet and outlet and a couple of pipe culverts are completely covered or demolished are observed.

In the Sri Sophorn - Poipet Section, flood water from Thailand flow into Cambodia and goes to the east along NR 5, and finally, flows into the Tonle Sap Lake through the Sri Sophorn River. There is no rivers/creek across NR 5 between Sri Sophorn and Poipet.

While there are many pipe culverts on Sri Sophorn – Poipet Section, as shown Table 6.1-6, there are no bridges/box culverts which have much larger drainage capacity than pipe culverts. Thus, drainage pipe culverts installed under NR 5 are supposed to be not for drainage flood water but for irrigation.

Table 6.1-2 River Systems along 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 ⇒ Pousat River	⇒ Tonle Sap Lake
				⇒ 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 ⇒ flood plain	⇒ Tonle Sap Lake
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* ⇒ *Br59*	⇒ Svay Doun Kaev River	⇒ Kbal Toul River ⇒ Khnay Tol Creek	⇒ Tonle Sap Lake
8	221+400	paddy field	⇒ Boeng Prey Creek	⇒ S'at Creek		⇒ *Bc64*	⇒ irrigation canal		⇒ Tonle Sap Lake
			⇒ irrigation canal						
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.

Table 6.1-3 Existing Bridges (Middle Section)

Province	Bridge No.		KP(km)		JICA*					Bridge Type	Remarks
	PWRC	JICA*	PWRC	JICA*	Width (m)	No. of Span	Span (m)	Length (m)	Hight (m)		
Pursat	Br40	Br40	177+007	177+200	9.6	1	23.1	23.1	5.5	RC Steel Bridge	across Srang Thum Creek
	Br41	Br41	178+326	178+400	10.0	1	19.8	19.8	4.4	PC Bridge	across Srang Touch Creek
	Br42	Br42	181+584	181+800	9.1	4	4.8*4	19.2	2.2	RC Bridge	
	Br43	Br43	182+525	182+800	10.0	2	21.3*2	42.6	3.5	PC Bridge	
	Br44	Br44	182+945	183+300	9.0	3	15.1*3	45.3	4.9	RC Steel Bridge	
	Br45	Br45	183+527	183+850	10.0	2	21.25*2	42.5	5.0	PC Bridge	
	Br46	Br46	183+720	184+100	10.1	1	26.45	26.5	3.9	PC Bridge	
	Br47	Br47	185+192	185+700	10.0	6	20.0*6	120.0	8.4	RC Bridge	across Pursat River
	Br48	Br48	186+961	187+300	8.8	2	19.55*2	39.1	6.1	RC Bridge	
	Br49	Br49	187+268	187+600	10.0	2	15.25*2	30.5	3.4	PC Bridge	
	Br50	Br50	187+541	188+000	10.0	3	18.0*1 21.5*2	61.0	2.5	PC Bridge	
	Br51	Br51	187+725	188+200	10.0	3	15.0*1 18.25*2	51.5	2.9	PC Bridge	
	Br52	Br52	188+703	189+300	10.0	2	18.25*2	36.5	3.6	PC Bridge	across Sdau Creek
	Br53	Br53	189+371	189+900	10.0	1	24.5	24.5	2.1	PC Bridge	
	Br54	Br54	189+931	190+100	10.0	1	24.5	24.5	1.9	PC Bridge	
	Br55	Br55	190+544	191+100	10.0	2	18.2*2	36.4	4.9	PC Bridge	across Toch River
	Br56	Br56	201+514	201+900	10.0	1	18.5	18.5	2.4	PC Bridge	
	Br57	Br57	208+237	208+500	10.0	2	17.2*2	34.4	4.4	PC Bridge/RC Bridge	across Kambot River
	Br58	Br58	215+428	215+700	10.0	3	15.2*1 15.1*2	45.4	3.0	RC Steel Bridge	across Srah Mokak Creek
	Br59	Br59	219+274	219+700	9.0	3	30.15 30.20 30.40	90.8	6.8	RC Steel Bridge	across Svay Doun Kaev River
	Br60	Br60	220+465	220+800	10.0	2	15.2*2	30.4	4.2	PC Bridge	
Battdam bang	Br61	Br61	222+345	222+700	10.0	1	18.5	18.5	2.9	PC Bridge	
	Br62	Br62	223+291	223+500	10.0	1	18.5	18.5	3.0	PC Bridge	
	Br63	Br63	242+379	242+800	10.0	1	24.5	24.5	3.0	PC Bridge	
	Br64	Br64	243+189	243+600	10.0	2	18.5*2	37.0	3.1	PC Bridge	
	Br65	Br65	243+938	244+400	10.0	2	15.25*2	30.5	6.3	PC Bridge	across Donn Tri River
	Br66	Br66	245+491	245+900	9.1	2	7.9*2	15.8	2.4	RC Bridge	
	Br67	Br67	254+191	255+300	10.0	1	21.5	21.5	2.4	PC Bridge	
	Br68	Br68	254+741	255+600	10.0	2	15.25*2	30.5	2.3	PC Bridge	across Chak River
	Br69	Br69	256+043	256+600	10.0	1	21.5	21.5	2.5	PC Bridge	
	Br70	Br70	257+401	257+900	10.0	1	18.5	18.5	3.0	PC Bridge	
	Br71	Br71	265+348	265+900	10.0	1	18.5	18.5	2.9	PC Bridge	
	Br72	Br72	270+378	270+900	10.0	1	18.5	18.5	2.8	PC Bridge	
	Br73	Br73	271+124	271+600	10.0	1	18.5	18.5	2.4	PC Bridge	
	Br74	Br74	272+082	272+600	10.0	1	18.5	18.5	2.3	PC Bridge	
	Br75	Br75	272+775	273+400	10.0	2	15.25*2	30.5	3.4	PC Bridge	across Sanda Creek
	Br76	Br76	275+164	275+700	10.0	1	18.5	18.5	2.5	PC Bridge	
	Br77	Br77	276+024	276+500	10.0	1	18.5	18.5	2.4	PC Bridge	

Source: Public Works Research Center(PWRC). General Directorate of Public Works, Ministry of Public Works and Transport, Kingdom of Cambodia
**JICA Survey Team carried out the inventory on May 2013*

Table 6.1-4 Existing Box Culverts (Middle Section)

Province	No.		KP(km)		Dimension No. of Box×W×H					Remarks
	PWRC	JICA	PWRC	JICA	Total Width(m)	No. of Span	Width (m)	Hight (m)	Length (m)	
Pursat	Bc54	Bc54	171+628	171+800	2.90	1	2.80	1.70	13.6	
	Bc55	Bc55	178+851	179+100	6.40	2	2.80	1.90	13.7	
							2.80	1.90		
	Bc56	Bc56	179+275	179+500	6.25	2	2.85	1.90	13.6	
							2.85	1.90		
	Bc57	Bc57	179+578	179+800	9.60	3	2.85	1.65	12.2	
							3.00	1.80		
							2.85	1.65		
	Bc58	Bc58	181+818	182+200	2.90	1	2.80	1.75	13.6	
	Bc59	Bc59	196+150	196+500	3.10	1	3.00	1.60	14.0	
	Bc60	Bc60	199+008	199+300	3.10	1	3.00	1.45	13.8	
	Bc61	Bc61	213+724	214+100	9.45	3	2.80	1.75	13.7	
							2.95	2.00		
							2.80	1.75		
	Bc62	Bc62	218+402	218+800	3.10	1	3.00	2.55	15.2	
	Bc63	Bc63	218+532	218+900	3.10	1	3.00	1.95	15.3	
	Bc64	Bc64	221+109	221+400	4.10	2	1.80	2.00	13.7	
							1.80	2.00		
	Bc65	Bc65	221+373	221+700	6.30	2	3.00	1.80	16.2	
							3.00	1.80		
Battdam bang	Bc66	Bc66	230+014	230+400	6.30	2	3.00	1.80	13.7	
							3.00	1.80		
	Bc67	Bc67	232+448	232+800	3.20	1	3.10	1.45	13.7	
	Bc68	Bc68	237+087	237+400	3.10	1	3.00	1.55	13.7	
	Bc69	Bc69	237+745	238+200	3.10	1	3.00	1.90	13.7	
	Bc70	Bc70	239+613	240+000	9.65	3	2.80	1.85	13.7	
							3.00	2.10		
							2.80	1.85		
	Bc71	Bc71	244+876	245+400	9.50	3	2.80	1.80	13.8	
							3.00	2.05		
							2.80	1.80		
	Bc72	Bc72	248+025	248+500	6.35	2	2.85	2.00	13.7	
							2.85	2.00		
	Bc73	Bc73	248+579	249+000	3.10	1	3.00	2.05	13.8	
	Bc74	Bc74	250+516	251+000	9.70	3	2.85	2.00	13.7	
							3.00	2.20		
							2.85	2.00		
	Bc75	Bc75	251+949	252+400	9.50	3	2.85	0.75	13.7	
							3.00	1.00		
							2.85	0.75		
	Bc76	Bc76	254+182	254+700	8.80	2	4.30	1.45	13.5	
							4.30	1.45		
	Bc77	Bc77	255+396	255+900	6.20	2	2.80	1.60	13.8	
							2.85	1.60		
	Bc78	Bc78	258+795	259+100	6.20	2	2.75	1.90	13.7	
							2.85	1.90		
	Bc79	Bc79	260+801	261+400	8.60	2	4.15	1.90	13.7	
							4.15	1.90		
	Bc80	Bc80	261+868	262+300	6.30	2	2.85	2.00	13.7	
							2.85	2.00		
	Bc81	Bc81	263+620	264+100	6.20	2	2.85	1.80	13.7	
							2.85	1.80		
	Bc82	Bc82	266+492	267+000	9.60	3	2.85	1.95	13.7	
							3.00	2.20		
							2.85	1.95		
	Bc83	Bc83	269+194	269+700	6.30	2	3.00	2.00	13.0	
							3.00	2.00		
	Bc84	Bc84	269+898	270+400	6.30	2	3.00	1.90	13.1	
							3.00	1.90		
	Bc85	Bc85	273+781	274+200	2.90	1	2.85	1.65	13.7	
	Bc86	Bc86	275+608	276+100	2.90	1	2.85	1.95	13.7	
	Bc87	Bc87	280+156	280+700	3.10	1	3.00	1.80	13.7	
	Bc88	Bc88	281+215	281+700	9.50	3	2.85	1.95	13.7	
							3.00	2.20		
							2.85	1.95		

Source: Public Works Research Center (PWRC), General Directorate of Public Works and Transport, Kingdom of Cambo
JICA Survey Team carried out the inventory on May 2013

Table 6.1-5 Existing Pipe Culverts (Middle Section)

Province	No.		KP(km)		Dimension No. of Pipe×D				Remarks
	PWRC	JICA	PWRC	JICA	Total Width(m)	No. of Pipe	φ (cm)	Length (m)	
Pursat	Pc148	Pc148	171+677	171+800	4.55	3	100 100 100	15.6	
	Pc149	Pc149	172+048	172+200	1.20	1	100	13.3	
	Pc150	Pc150	173+802	174+100	1.23	1	95	13.5	
	Pc151	Pc151	174+484	174+700	4.70	3	100 100 100	13.3	
	Pc152	Pc152	174+773	175+000	2.90	2	95 95	12.8	
	Pc153	Pc153	175+336	175+600	1.25	1	100	13.3	
	Pc154	Pc154	175+877	176+100	1.20	1	100	13.2	
	Pc155	Pc155	175+943	176+200	1.30	1	100	13.4	
	Pc156	Pc156	176+121	176+400	4.70	3	100 100 100	15.5	
	Pc157	Pc157	176+197	176+500	1.30	1	100	14.8	
	Pc158	Pc158	176+400	176+700	0.95	1	80	14.5	
	Pc159	Pc159	177+735	177+900	1.00	1	70	14.5	
	Pc160	Pc160	180+354	180+500		-	-	-	demorished
	Pc161	Pc161	182+250	182+600	10.50	8	80 80 80 80 100 100 80 80	13.7	
	Pc162	Pc162	191+504	192+100	0.95	1	80	13.5	
	Pc163	Pc163	192+077	192+700	1.50	1	120	17.3	
	Pc164	Pc164	193+145	193+600	1.25	1	100	13.6	
	Pc165	Pc165	193.579	194+100	1.50	1	120	16.0	
	Pc166	Pc166	193+877	194+400	5.25	3	120 120 120	14.8	
	Pc167	Pc167	197+044	197+300	1.25	1	100	13.5	
	Pc168	Pc168	198+538	198+800	1.20	1	100	13.4	
	Pc169	Pc169	200+544	200+300	3.00	2	100 100	13.5	
	Pc170	Pc170	203+395	203+400	3.00	2	100 100	13.7	
	Pc171	Pc171	203+687	204+000	1.05	1	80	13.5	
	Pc172	Pc172	204+423	204+700	1.20	1	100	13.6	
	Pc173	Pc173	205+854	206+600	1.20	1	100	14.8	
	Pc174	Pc174	205+951	206+300	1.20	1	100	14.7	
	Pc175	Pc175	206+825	207+200	3.00	2	100 100	16.1	
	Pc176	Pc176	207+096	207+400	1.20	1	100	16.0	
	Pc177	Pc177	209+987	210+300	1.40	1	120	14.9	
	Pc178	Pc178	210+820	211+100	1.20	1	100	13.5	
	Pc179	Pc179	211+109	211+400	1.20	1	100	13.6	
	Pc180	Pc180	211+222	211+500	1.05	1	80	13.6	
	Pc181	Pc181	212+557	212+800	1.20	1	100	13.6	
	Pc182	Pc182	212+915	213+200	2.50	2	80 80	14.8	
	Pc183	Pc183	213+219	213+500	3.20	2	100 100	13.6	
	Pc184	Pc184	213+337	213+600	2.60	2	80 80	13.5	
	Pc185	Pc185	214+181	214+500	3.10	2	100 100	16.1	
	Pc186	Pc186	214+602	214+900	1.15	1	100	13.6	
	Pc187	Pc187	216+489	216+800	3.10	2	100 100	15.9	
	Pc188	Pc188	217+476	217+800	3.10	2	100 100	14.9	
	Pc189	Pc189	217+950	218+300	3.10	2	100 100	16.0	
Battdambang	Pc190	Pc190	224+362	224+700	5.30	4	100 100 100 100	11.1	
	Pc191	Pc191	226+319	226+700	4.20	3	100 100 100	10.9	
	Pc192	Pc192	227+382	227+700	-	1	-	-	inlet is covered
	Pc193	Pc193	227+649	228+000	5.20	3	120 120 120	13.6	
	Pc194	Pc194	228+227	228+600	1.15	1	100	11.7	
	Pc195	Pc195	230+308	230+700	2.75	2	100 100	9.9	
	Pc196	Pc196	231+359	231+700	4.00	3	100 100 100	10.9	
	Pc197	Pc197	231+859	232+200	2.45	2	100 100	11.2	
	Pc198	Pc198	238+875	239+200	1.20	1	100	16.0	
	Pc199	Pc199	249+728	250+100	3.30	2	120 120	13.8	
	Pc200	Pc200	252+664	253+100	3.30	2	120 120	16.1	
	Pc201	Pc201	253+221	253+600	3.00	2	120 120	15.3	
	Pc202	Pc202	256+612	257+000	3.00	2	100 100	13.6	
	Pc203	Pc203	260+287	260+800	3.00	2	100 100	16.0	
	Pc204	Pc204	267+944	268+500	2.80	2	100 100	17.2	
	Pc205	Pc205	269+127	269+600	1.30	1	100	18.3	
	Pc206	Pc206	271+645	272+200	1.40	1	120	16.1	
	Pc207	Pc207	274+497	275+000	1.75	1	150	16.1	
	Pc208	Pc208	277+579	278+000	3.30	2	120 120	14.5	
	Pc209	Pc209	278+633	279+200	3.85	2	100 100	13.8	
	Pc210	Pc210	281+810	282+300	3.75	3	80 80 80	13.7	
	Pc211	Pc211	282+553	283+100	5.35	3	120 120 120	13.8	

Source: Public Works Research Center (PWRC), General Directorate of Public Works and Transport, Kingdom of Cambod
JICA Survey Team carried out the inventory on May 2013

Table 6.1-6 Existing Pipe Culverts (Sri Sophorn - Poipet Section)

No.	X	Y	Category	Type	Code	Length	When Construction	PK
459	273850	1501947	Pipe Culvert	Concrete	Pc242	ø1.20	2008	365 + 704
460	273355	1501995	Pipe Culvert	Concrete	Pc243	ø1.20	2008	366 + 206
461	272727	1502053	Pipe Culvert	Concrete	Pc244	ø1.20	2008	366 + 835
462	272158	1502106	Pipe Culvert	Concrete	Pc245	ø1.20	2008	367 + 412
463	271564	1502173	Pipe Culvert	Concrete	Pc246	ø1.20	2008	367 + 999
464	270967	1502260	Pipe Culvert	Concrete	Pc247	ø1.20	2008	368 + 610
465	270238	1502369	Pipe Culvert	Concrete	Pc248	2ø1.20	2008	369 + 352
466	269925	1502423	Pipe Culvert	Concrete	Pc249	2ø1.20	2008	369 + 663
467	269341	1502555	Pipe Culvert	Concrete	Pc250	2ø1.20	2008	370 + 263
468	268583	1502761	Pipe Culvert	Concrete	Pc251	2ø1.20	2008	371 + 041
469	267630	1503024	Pipe Culvert	Concrete	Pc252	ø1.20	2008	372 + 030
470	267208	1503139	Pipe Culvert	Concrete	Pc253	ø1.20	2008	372 + 466
471	266611	1503301	Pipe Culvert	Concrete	Pc254	ø1.20	2008	373 + 087
472	266016	1503465	Pipe Culvert	Concrete	Pc255	ø1.20	2008	373 + 709
473	265341	1503650	Pipe Culvert	Concrete	Pc256	ø1.20	2008	374 + 406
474	264769	1503803	Pipe Culvert	Concrete	Pc257	2ø1.20	2008	375 + 005
475	264198	1503955	Pipe Culvert	Concrete	Pc258	ø1.20	2008	375 + 588
476	263721	1504083	Pipe Culvert	Concrete	Pc259	ø1.20	2008	376 + 094
477	262936	1504293	Pipe Culvert	Concrete	Pc260	ø1.20	2008	376 + 899
478	262655	1504370	Pipe Culvert	Concrete	Pc261	ø1.20	2008	377 + 195
479	261949	1504552	Pipe Culvert	Concrete	Pc262	ø1.20	2008	377 + 916
480	261101	1504773	Pipe Culvert	Concrete	Pc263	2ø1.20	2008	378 + 803
481	260501	1504926	Pipe Culvert	Concrete	Pc264	ø1.20	2008	379 + 418
482	259836	1505102	Pipe Culvert	Concrete	Pc265	ø1.20	2008	380 + 109
483	259402	1505214	Pipe Culvert	Concrete	Pc266	ø1.20	2008	380 + 555
484	259276	1505248	Pipe Culvert	Concrete	Pc267	ø1.20	2008	380 + 692
485	258087	1505557	Pipe Culvert	Concrete	Pc268	ø1.20	2008	381 + 905
486	257335	1505754	Pipe Culvert	Concrete	Pc269	ø1.20	2008	382 + 686
487	257023	1505838	Pipe Culvert	Concrete	Pc270	ø1.20	2008	383 + 014
488	256179	1506060	Pipe Culvert	Concrete	Pc271	2ø1.20	2008	383 + 885
489	255727	1506175	Pipe Culvert	Concrete	Pc272	ø1.20	2008	384 + 341
490	255061	1506352	Pipe Culvert	Concrete	Pc273	ø1.20	2008	385 + 038
491	254124	1506517	Pipe Culvert	Concrete	Pc274	2ø1.20	2008	385 + 990
492	253626	1506586	Pipe Culvert	Concrete	Pc275	2ø1.20	2008	386 + 498
493	253124	1506667	Pipe Culvert	Concrete	Pc276	ø1.20	2008	387 + 001
494	252589	1506750	Pipe Culvert	Concrete	Pc277	ø1.20	2008	387 + 549
495	252094	1506829	Pipe Culvert	Concrete	Pc278	ø1.20	2008	388 + 048
496	251584	1506910	Pipe Culvert	Concrete	Pc279	ø1.20	2008	388 + 563
497	250954	1507043	Pipe Culvert	Concrete	Pc280	ø1.20	2008	389 + 217
498	250493	1507150	Pipe Culvert	Concrete	Pc281	ø1.00	2008	389 + 685
499	250022	1507258	Pipe Culvert	Concrete	Pc282	ø1.00	2008	390 + 173
500	248475	1507520	Pipe Culvert	Concrete	Pc283	ø1.00	2008	391 + 738
501	247897	1507568	Pipe Culvert	Concrete	Pc284	ø1.00	2008	392 + 318
502	247524	1507593	Pipe Culvert	Concrete	Pc285	ø1.00	2008	392 + 689
503	246956	1507615	Pipe Culvert	Concrete	Pc286	4ø1.00	2008	393 + 250
504	246525	1507633	Pipe Culvert	Concrete	Pc287	2ø1.00	2008	393 + 689
505	245710	1507677	Pipe Culvert	Concrete	Pc288	2ø1.20	2008	394 + 509
506	245112	1507717	Pipe Culvert	Concrete	Pc289	2ø1.20	2008	395 + 108
507	244554	1507754	Pipe Culvert	Concrete	Pc290	ø1.20	2008	395 + 669
508	243903	1507807	Pipe Culvert	Concrete	Pc291	ø1.20	2008	396 + 324
509	243305	1507858	Pipe Culvert	Concrete	Pc292	ø1.00	2008	396 + 926
510	242752	1507919	Pipe Culvert	Concrete	Pc293	ø1.00	2008	397 + 476
511	242115	1508010	Pipe Culvert	Concrete	Pc294	ø1.00	2008	398 + 118
512	241512	1508105	Pipe Culvert	Concrete	Pc295	2ø1.20	2008	398 + 724
513	240980	1508199	Pipe Culvert	Concrete	Pc296	ø1.00	2008	399 + 272
514	240396	1508343	Pipe Culvert	Concrete	Pc297	ø1.00	2008	399 + 867
515	239238	1508720	Pipe Culvert	Concrete	Pc298	ø1.00	2008	401 + 087
516	238946	1508846	Pipe Culvert	Concrete	Pc299	ø1.00	2008	401 + 410
517	238593	1509056	Pipe Culvert	Concrete	Pc300	ø1.00	2008	401 + 821
518	238246	1509256	Pipe Culvert	Concrete	Pc301	ø1.00	2008	402 + 214
519	237989	1509399	Pipe Culvert	Concrete	Pc302	ø1.00	2008	402 + 524
520	237770	1509573	Pipe Culvert	Concrete	Pc303	2ø1.00	2008	402 + 798
521	237301	1509955	Pipe Culvert	Concrete	Pc304	3ø1.00	2008	403 + 412
522	237082	1510141	Pipe Culvert	Concrete	Pc305	ø1.00	2008	403 + 701
523	236757	1510406	Pipe Culvert	Concrete	Pc306	ø1.00	2008	404 + 127
524	236122	1510833	Pipe Culvert	Concrete	Pc307	ø1.00	2008	404 + 881
525	235927	1510957	Pipe Culvert	Concrete	Pc308	ø1.00	2008	405 + 118
526	235768	1511057	Pipe Culvert	Concrete	Pc309	ø1.00	2008	405 + 306

Source: Public Works Research Center (PWRC), General Direcorate of Public Works and Transport, Kingdom of Cambodia

Table 6.1-7 to Table 6.1-9 summarizes drainage capacity of the existing bridges, box culverts and pipe culverts, respectively. In estimation of drainage capacity, following conditions are employed:

- Drainage capacity is evaluated by steady flow analysis with HEC-RAS model.
- Water level of the inlet (mountain side) is 1.00 m lower than road surface.
- Water level of the outlet (Lake side) is 11.13 m (MSL), the water level of the Tonle Sap Lake with return period of 10-yr by statistical analysis. For details, refer to 6.1.2 "Water Level of Mekong River and Tonle Sap River/Lake". If downstream normal depth is higher than 11.13 m (MSL), it is taken as the water level of the outlet.
- If water level of inlet is lower than its outlet, drainage capacity is evaluated as zero (0 m^3/s).

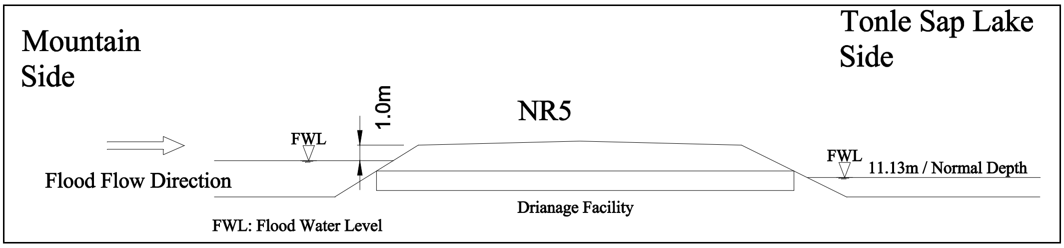


Figure 6.1-2 Assumed Water Level for Evaluating Drainage Capacity

Water surface are computed from one cross section to the next by solving the Energy Equation iterative procedure. The Energy Equation is written as follows:

$$Z_2 + Y_2 + \frac{a_2 V_2^2}{2g} = Z_1 + Y_1 + \frac{a_1 V_1^2}{2g} + he$$

Where,

Z_1, Z_2 : Elevation of the main channel inverts (m)

Y_1, Y_2 : Depth of water at cross section (m)

V_1, V_2 : Average velocities (m/s)

a_1, a_2 : Velocity weighting coefficients

g : Gravitational acceleration (m/s^2)

he : Energy head loss (m)

The energy head loss (*he*) between two cross sections is comprised of friction losses and contraction or expansion losses. The equation for the energy head loss is as follows:

$$he = L\overline{S}_f + C\left|\frac{a_2 V_2^2}{2g} - \frac{a_1 V_1^2}{2g}\right|$$

Where,

L : Reach length (m)

$\overline{S}_f$: Representative friction slope between two sections

C : expansion or contraction loss coefficient

Table 6.1-7 Drainage Capacity of Existing Bridges

Province	No.	Location KP(km)	Bridge Type	Dimension					Drainage Capacity (m^3/s)	Remarks
				No. of Span	Span (m)	Length (m)	Hight (m)	Water level of upstream (MSLm)		
Pursat	Br40	177+200	RC Steel Bridge	1	23.1	23.1	5.5	18.98	94.4	across Srang Thum Creek
	Br41	178+400	PC Bridge	1	19.8	19.8	4.4	17.45	95.3	across Srang Touch Creek
	Br42	181+800	RC Bridge	4	4.8*4	19.2	2.2	15.32	27.4	
	Br43	182+800	PC Bridge	2	21.3*2	42.6	3.5	15.39	195.5	
	Br44	183+300	RC Steel Bridge	3	15.1*3	45.3	4.9	15.26	349.1	
	Br45	183+850	PC Bridge	2	21.25*2	42.5	5.0	15.64	465.7	
	Br46	184+100	PC Bridge	1	26.45	26.5	3.9	15.63	182.1	
	Br47	185+700	RC Bridge	6	20.0*6	120.0	8.4	15.06	1461.2	across Pursat River
	Br48	187+300	RC Bridge	2	19.55*2	39.1	6.1	14.78	262.1	
	Br49	187+600	PC Bridge	2	15.25*2	30.5	3.4	15.21	123.8	
	Br50	188+000	PC Bridge	3	18.0*1 21.5*2	61.0	2.5	15.09	85.5	
	Br51	188+200	PC Bridge	3	15.0*1 18.25*2	51.5	2.9	15.09	81.1	
	Br52	189+300	PC Bridge	2	18.25*2	36.5	3.6	15.07	200.2	across Sdau Creek
	Br53	189+900	PC Bridge	1	24.5	24.5	2.1	15.09	18.7	
	Br54	190+100	PC Bridge	1	24.5	24.5	1.9	15.15	11.3	
	Br55	191+100	PC Bridge	2	18.2*2	36.4	4.9	15.71	384.5	across Toch River
	Br56	201+900	PC Bridge	1	18.5	18.5	2.4	14.17	29.1	
	Br57	208+500	PC Bridge/RC Bridge	2	17.2*2	34.4	4.4	12.32	136.2	across Kambot River
	Br58	215+700	RC Steel Bridge	3	15.2*1 15.1*2	45.4	3.0	11.13	*N/A*	across Srah Mokak Creek
	Br59	219+700	RC Steel Bridge	3	30.15 30.20 30.40	90.8	6.8	10.49	*N/A*	across Svay Doun Kaev River
	Br60	220+800	PC Bridge	2	15.2*2	30.4	4.2	10.79	*N/A*	
Battdambang	Br61	222+700	PC Bridge	1	18.5	18.5	2.9	10.74	*N/A*	
	Br62	223+500	PC Bridge	1	18.5	18.5	3.0	10.69	*N/A*	
	Br63	242+800	PC Bridge	1	24.5	24.5	3.0	14.79	92.9	
	Br64	243+600	PC Bridge	2	18.5*2	37.0	3.1	14.85	63.6	
	Br65	244+400	PC Bridge	2	15.25*2	30.5	6.3	14.24	230.4	across Donn Tri River
	Br66	245+900	RC Bridge	2	7.9*2	15.8	2.4	13.29	27.3	
	Br67	255+300	PC Bridge	1	21.5	21.5	2.4	11.82	55.6	
	Br68	255+600	PC Bridge	2	15.25*2	30.5	2.3	11.75	45.7	across Chak River
	Br69	256+600	PC Bridge	1	21.5	21.5	2.5	11.78	52.7	
	Br70	257+900	PC Bridge	1	18.5	18.5	3.0	11.88	74.8	
	Br71	265+900	PC Bridge	1	18.5	18.5	2.9	11.25	53.6	
	Br72	270+900	PC Bridge	1	18.5	18.5	2.8	10.87	*N/A*	
	Br73	271+600	PC Bridge	1	18.5	18.5	2.4	10.61	*N/A*	
	Br74	272+600	PC Bridge	1	18.5	18.5	2.3	10.68	*N/A*	
	Br75	273+400	PC Bridge	2	15.25*2	30.5	3.4	10.79	*N/A*	across Sanda Creek
	Br76	275+700	PC Bridge	1	18.5	18.5	2.5	11.56	46.4	
	Br77	276+500	PC Bridge	1	18.5	18.5	2.4	11.42	38.2	

Table 6.1-8 Drainage Capacity of Existing Box Culverts

Province	No.	Location KP(km)	Dimension							Drainage Capacity (m^3/s)
			Total Width(m)	No. of Span	Width (m)	Hight (m)	Water level of upstream (MSLm)	t (m)	Length (m)	
Pursat	Bc54	171+800	2.90	1	2.80	1.70	18.11	0.85	13.6	10.8
	Bc55	179+100	6.40	2	2.80	1.90	17.68	0.53	13.7	18.9
					2.80	1.90				
	Bc56	179+500	6.25	2	2.85	1.90	17.11	0.62	13.6	20.8
					2.85	1.90				
	Bc57	179+800	9.60	3	2.85	1.65	16.68	0.73	12.2	33.8
					3.00	1.80		0.48		
					2.85	1.65		0.73		
	Bc58	182+200	2.90	1	2.80	1.75	15.28	0.65	13.6	9.5
	Bc59	196+500	3.10	1	3.00	1.60	15.48	0.80	14.0	12.0
	Bc60	199+300	3.10	1	3.00	1.45	14.73	0.75	13.8	8.9
	Bc61	214+100	9.45	3	2.80	1.75	10.77	0.97	13.7	*N/A*
					2.95	2.00		0.72		
					2.80	1.75		0.97		
	Bc62	218+800	3.10	1	3.00	2.55	10.62	0.75	15.2	*N/A*
	Bc63	218+900	3.10	1	3.00	1.95	10.61	1.05	15.3	*N/A*
	Bc64	221+400	4.10	2	1.80	2.00	10.77	0.80	13.7	*N/A*
					1.80	2.00				
	Bc65	221+700	6.30	2	3.00	1.80	10.80	1.25	16.2	*N/A*
					3.00	1.80				
Battdam bang	Bc66	230+400	6.30	2	3.00	1.80	12.06	0.65	13.7	21.5
					3.00	1.80				
	Bc67	232+800	3.20	1	3.10	1.45	13.43	0.75	13.7	8.8
	Bc68	237+400	3.10	1	3.00	1.55	16.63	0.80	13.7	9.8
	Bc69	238+200	3.10	1	3.00	1.90	16.70	0.62	13.7	11.3
	Bc70	240+000	9.65	3	2.80	1.85	16.22	0.75	13.7	42.0
					3.00	2.10		0.50		
					2.80	1.85		0.75		
	Bc71	245+400	9.50	3	2.80	1.80	13.36	1.30	13.8	52.0
					3.00	2.05		1.05		
					2.80	1.80		1.30		
	Bc72	248+500	6.35	2	2.85	2.00	12.37	0.45	13.7	21.4
					2.85	2.00				
	Bc73	249+000	3.10	1	3.00	2.05	12.26	0.65	13.8	13.0
	Bc74	251+000	9.70	3	2.85	2.00	12.48	0.72	13.7	44.2
					3.00	2.20		0.52		
					2.85	2.00		0.72		
	Bc75	252+400	9.50	3	2.85	0.75	12.07	1.20	13.7	18.9
					3.00	1.00		0.95		
					2.85	0.75		1.20		
	Bc76	254+700	8.80	2	4.30	1.45	12.03	1.10	13.5	34.8
					4.30	1.45				
	Bc77	255+900	6.20	2	2.80	1.60	11.68	0.70	13.8	16.9
					2.85	1.60				
	Bc78	259+100	6.20	2	2.75	1.90	11.57	0.75	13.7	21.3
					2.85	1.90				
	Bc79	261+400	8.60	2	4.15	1.90	11.37	1.05	13.7	28.2
					4.15	1.90				
	Bc80	262+300	6.30	2	2.85	2.00	11.35	0.45	13.7	15.7
					2.85	2.00				
	Bc81	264+100	6.20	2	2.85	1.80	11.34	0.55	13.7	14.3
					2.85	1.80				
	Bc82	267+000	9.60	3	2.85	1.95	11.12	0.75	13.7	*N/A*
					3.00	2.20		0.50		
					2.85	1.95		0.75		
	Bc83	269+700	6.30	2	3.00	2.00	11.08	0.55	13.0	*N/A*
					3.00	2.00				
	Bc84	270+400	6.30	2	3.00	1.90	10.96	0.60	13.1	*N/A*
					3.00	1.90				
	Bc85	274+200	2.90	1	2.85	1.65	10.93	0.55	13.7	*N/A*
	Bc86	276+100	2.90	1	2.85	1.95	11.52	0.55	13.7	9.6
	Bc87	280+700	3.10	1	3.00	1.80	11.91	0.65	13.7	10.7
	Bc88	281+700	9.50	3	2.85	1.95	12.29	1.05	13.7	52.5
					3.00	2.20		0.80		
					2.85	1.95		1.05		

Note: " t " means hight from top of culvert to road surface.

Table 6.1-9 (1) Drainage Capacity of Existing Pipe Culvert

Province	No.	Location KP(km)	Dimension						Drainage Capacity (m^3/s)
			No. of Pipe	φ (cm)	Water level of upstream (MSLm)	s (m)	t (m)	Length (m)	
Pursat	Pc148	171+800	3	100	18.11	0.10	1.45	15.6	5.09
				100		0.10	1.45		
				100		0.10	1.45		
	Pc149	172+200	1	100	18.21	0.35	0.65	13.3	0.19
	Pc150	174+100	1	95	19.99	0.05	0.80	13.5	0.63
	Pc151	174+700	3	100	19.70	0.20	0.75	13.3	1.49
				100		0.20	0.75		
				100		0.20	0.75		
	Pc152	175+000	2	95	19.56	0.10	0.90	12.8	1.47
				95		0.10	0.90		
	Pc153	175+600	1	100	19.53	0.00	0.98	13.3	1.11
	Pc154	176+100	1	100	19.51	0.00	1.08	13.2	1.28
	Pc155	176+200	1	100	19.50	0.00	0.90	13.4	0.96
	Pc156	176+400	3	100	19.48	0.00	1.55	15.5	6.09
				100		0.00	1.55		
				100		0.00	1.55		
	Pc157	176+500	1	100	19.47	0.00	1.22	14.8	1.53
	Pc158	176+700	1	80	19.45	0.00	1.15	14.5	0.82
	Pc159	177+900	1	70	18.31	0.00	1.15	14.5	0.59
	Pc160	180+500	-	-	16.16	-	-	-	demorished
	Pc161	182+600	8	80	15.36	0.00	1.65	13.7	11.95
				80		0.00	1.65		
				80		0.00	1.65		
				80		0.00	1.65		
				100		0.00	1.45		
				100		0.00	1.45		
				80		0.00	1.65		
				80		0.00	1.65		
	Pc162	192+100	1	80	15.91	0.00	0.95	13.5	0.57
	Pc163	192+700	1	120	15.91	0.00	1.60	17.3	3.12
	Pc164	193+600	1	100	15.93	0.10	1.05	13.6	1.10
	Pc165	194+100	1	120	15.96	0.05	1.55	16.0	2.93
	Pc166	194+400	3	120	16.01	0.00	1.00	14.8	5.46
				120		0.00	1.00		
				120		0.00	1.00		
	Pc167	197+300	1	100	15.54	0.00	0.90	13.5	0.97
	Pc168	198+800	1	100	14.85	0.00	0.65	13.4	0.56
	Pc169	200+300	2	100	14.70	0.00	0.90	13.5	1.92
				100		0.00	0.90		
	Pc170	203+400	2	100	13.32	0.20	0.85	13.7	1.26
				100		0.20	0.85		
	Pc171	204+000	1	80	13.00	0.00	0.80	13.5	0.41
	Pc172	204+700	1	100	12.96	0.20	1.00	13.6	0.86
	Pc173	206+600	1	100	12.45	0.00	0.98	14.8	1.11
	Pc174	206+300	1	100	12.42	0.00	1.10	14.7	1.32
	Pc175	207+200	2	100	12.45	0.10	1.45	16.1	3.36
				100		0.10	1.45		
	Pc176	207+400	1	100	12.41	0.10	1.68	16.0	1.96
	Pc177	210+300	1	120	11.51	0.15	1.45	14.9	2.05
	Pc178	211+100	1	100	11.12	0.20	0.90	13.5	*N/A*
	Pc179	211+400	1	100	11.24	0.40	0.95	13.6	0.34
	Pc180	211+500	1	80	11.27	0.30	0.65	13.6	0.02
	Pc181	212+800	1	100	10.90	0.30	0.35	13.6	*N/A*
	Pc182	213+200	2	80	10.82	0.40	0.43	14.8	*N/A*
				80		0.40	0.43		
	Pc183	213+500	2	100	10.81	0.20	1.00	13.6	*N/A*
				100		0.20	1.00		
	Pc184	213+600	2	80	10.81	0.30	1.00	13.5	*N/A*
				80		0.30	1.00		
	Pc185	214+500	2	100	10.70	0.00	1.15	16.1	*N/A*
				100		0.00	1.15		
	Pc186	214+900	1	100	10.63	0.00	0.75	13.6	*N/A*
	Pc187	216+800	2	100	10.74	0.20	1.45	15.9	*N/A*
				100		0.20	1.45		
	Pc188	217+800	2	100	10.67	0.00	1.05	14.9	*N/A*
				100		0.00	1.05		
	Pc189	218+300	2	100	10.66	0.20	1.35	16.0	*N/A*
				100		0.20	1.35		

Note: " t " means hight from top of culvert to road surface.
" s " means blocked depth of culvert.

Table 6.1-9 (2) Drainage Capacity of Existing Pipe Culvert

Province	No.	Location KP(km)	Dimension						Drainage Capacity (m^3/s)
			No. of Pipe	φ (cm)	Water level of upstream (MSLm)	s (m)	t (m)	Length (m)	
Battdam bang	Pc190	224+700	4	100	10.62	0.00	1.20	11.1	*N/A*
				100		0.00	1.20		
				100		0.00	1.20		
				100		0.00	1.20		
	Pc191	226+700	3	100	10.63	0.00	1.22	10.9	*N/A*
				100		0.00	1.22		
				100		0.00	1.22		
	Pc192	227+700	1	-	10.85	-	-	-	inlet is covered
	Pc193	228+000	3	120	10.92	0.00	1.00	13.6	*N/A*
				120		0.00	1.00		
				120		0.00	1.00		
	Pc194	228+600	1	100	10.89	0.10	1.03	11.7	*N/A*
	Pc195	230+700	2	100	12.36	0.40	1.20	9.9	1.53
				100		0.40	1.20		
	Pc196	231+700	3	100	13.02	0.25	1.40	10.9	4.06
				100		0.25	1.40		
				100		0.25	1.40		
	Pc197	232+200	2	100	13.24	0.60	1.25	11.2	0.83
				100		0.60	1.25		
	Pc198	239+200	1	100	15.97	0.20	1.20	16.0	1.15
	Pc199	250+100	2	120	12.05	0.00	0.93	13.8	3.28
				120		0.00	0.93		
	Pc200	253+100	2	120	12.07	0.00	1.25	16.1	4.83
				120		0.00	1.25		
	Pc201	253+600	2	120	12.24	0.10	1.55	15.3	5.63
				120		0.10	1.55		
	Pc202	257+000	2	100	11.87	0.00	0.95	13.6	2.12
				100		0.00	0.95		
	Pc203	260+800	2	100	11.35	0.20	1.00	16.0	1.56
				100		0.20	1.00		
	Pc204	268+500	2	100	11.05	0.10	1.20	17.2	*N/A*
				100		0.10	1.20		
	Pc205	269+600	1	100	11.09	0.30	1.85	18.3	*N/A*
	Pc206	272+200	1	120	10.55	0.00	0.89	16.1	*N/A*
	Pc207	275+000	1	150	11.59	0.20	1.30	16.1	1.34
	Pc208	278+000	2	120	11.74	0.40	0.72	14.5	1.08
				120		0.40	0.72		
	Pc209	279+200	2	100	11.78	0.00	0.70	13.8	1.23
				100		0.00	0.70		
	Pc210	282+300	3	80	12.47	0.15	0.74	13.7	0.64
				80		0.15	0.74		
				80		0.15	0.74		
	Pc211	283+100	3	120	12.42	0.30	0.88	13.8	3.09
				120		0.30	0.88		
				120		0.30	0.88		

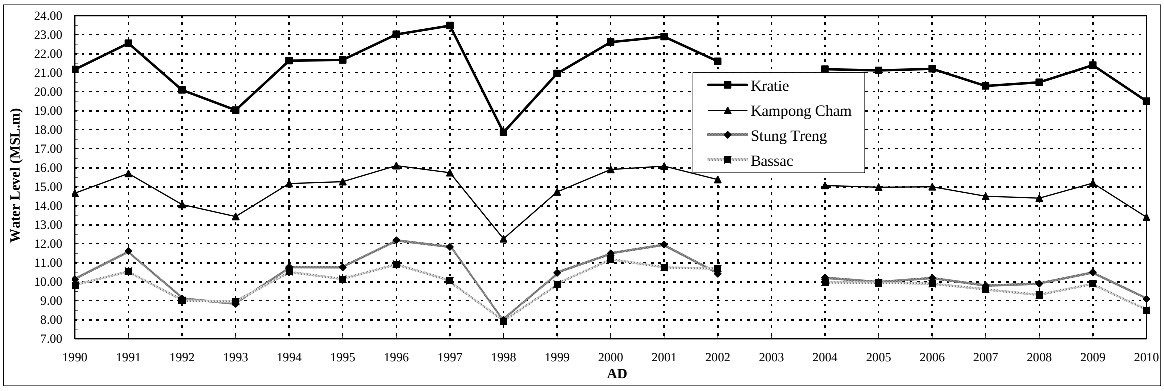
Note: " t " means hight from top of culvert to road surface.
" s " means blocked depth of culvert.

6.1.2 Water Level of The Mekong River and The Tonle Sap River and Lake

Figure 6.1-3 illustrates annual maximum water level records at four gauging stations along the Mekong River in Cambodia. Throughout the last decade, no obvious trend of rising or lowering in flood water level is recognized.

Figure 6.1-4 compares daily water levels of the Tonle Sap Lake at Kampong Luong Gauging Station from June up to November, i.e., rainy season, for several years from 1996. In 2011, the high water level exceeded the flood water-level (10 m) for more than one month (26th Sep ~ 11th Nov). Figure 6.1-5 shows the hyetograph updated at Pursat and Svay Donkeo, while Figure 6.1-6 depicts daily water level of three gauging stations, Pursat River, Svay Doun Kaev River and Tonle Sap Lake (Kampong Luong). In the period of deluge, the water level of the Svay Kaev River, which flows lower place in the Survey Area, rises because of backwater effects of the Tonle Sap Lake. On the other hand, the water level of the Pursat River, whose river bed is higher than the water level of the Tonle Sap Lake, is dominated by rainfall.

Table 6.1-10 summarizes the estimated maximum water level of the Tonle Sap Lake (1924 -1959, 1995 - 2008). As a result, water level of 11.13 m (MSL) with return period of 10-yr by Log-Pearson III method, is widely used in the Mekong basin, can be applied to the Project.



(Unit: MSL.m)

Station	Warning WL	Item	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Kratie	22.00	WL	21.17	22.55	20.09	19.03	21.63	21.67	23.02	23.48	17.86	20.96	22.61	22.90	21.60		21.19	21.12	21.20	20.30	20.50	21.40	19.50
		Date	6-Sep	8-Sep	23-Aug	16-Sep	6-Aug	8-Sep	28-Sep	5-Aug	24-Aug	5-Aug	17-Sep	22-Aug	25-Sep		17-Sep	12-Sep	8-Aug	8-Oct	9-Aug	5-Oct	5-Sep
Kampong Cham	15.20	WL	14.66	15.70	14.07	13.44	15.17	15.27	16.11	15.74	12.26	14.73	15.91	16.09	15.38		15.07	14.98	15.00	14.50	14.40	15.20	13.40
		Date	7-Sep	9-Sep	1-Sep	17-Sep	12-Sep	10-Sep	29-Sep	7-Aug	24-Sep	8-Aug	18-Sep	22-Aug	26-Sep		18-Sep	16-Sep	18-Aug	10-Oct	13-Aug	6-Oct	6-Sep
Stung Treng	10.70	WL	10.13	11.62	9.12	8.84	10.77	10.76	12.19	11.83	8.00	10.47	11.49	11.96	10.42		10.22	9.98	10.20	9.80	9.90	10.50	9.10
		Date	5-Sep	30-Aug	29-Aug	22-Aug	5-Aug	7-Sep	24-Sep	5-Aug	23-Sep	1-Aug	16-Sep	20-Aug	12-Sep		15-Sep	11-Sep	19-Aug	14-Oct	15-Aug	7-Oct	6-Sep
Bassac	10.50	WL	9.82	10.56	9.02	8.95	10.53	10.14	10.93	10.05	7.92	9.88	11.20	10.75	10.70		9.97	9.95	9.90	9.60	9.30	9.90	8.50
		Date	8-Oct	11-Sep	3-Sep	19-Sep	29-Sep	18-Sep	2-Oct	1-Oct	1-Oct	6-Oct	20-Sep	19-Sep	30-Sep		25-Sep	1-Oct	14-Oct	19-Oct	29-Sep	10-Oct	23-Oct

Source: Statistical Yearbook 2006 & 2011

Figure 6.1-3 Annual Maximum Water Levels of Mekong River in Cambodia

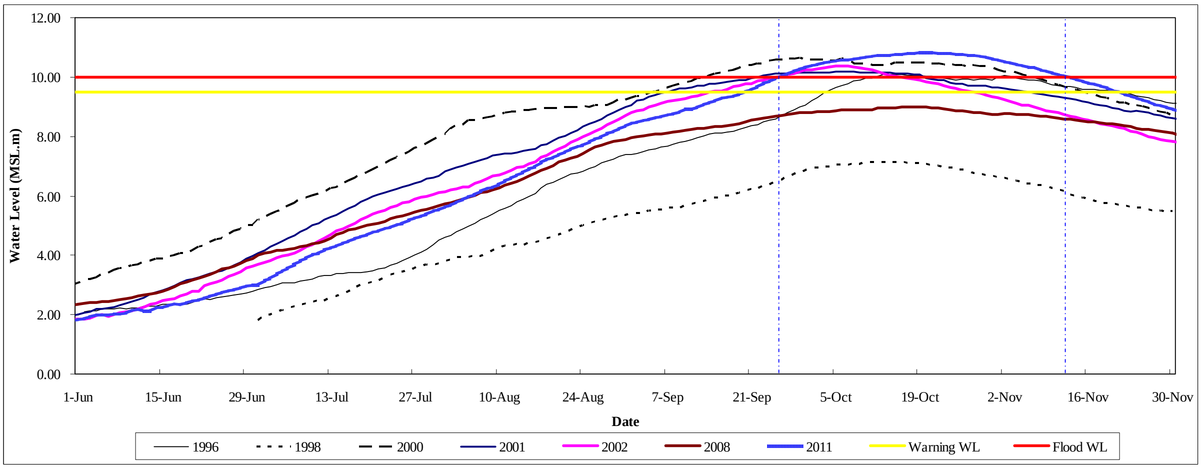


Figure 6.1-4 Water Levels at Kampong Luong Gauging Station (June ~ November)

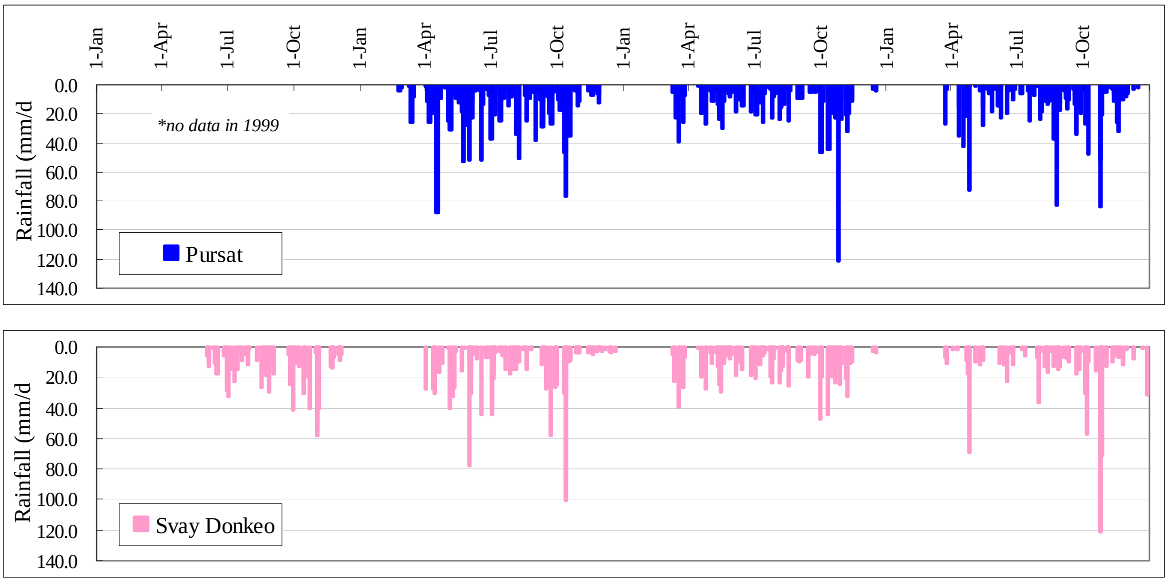


Figure 6.1-5 Hyetograph at Pursat (above) and Svay Donkeo (below) Station (1999 ~ 2002)

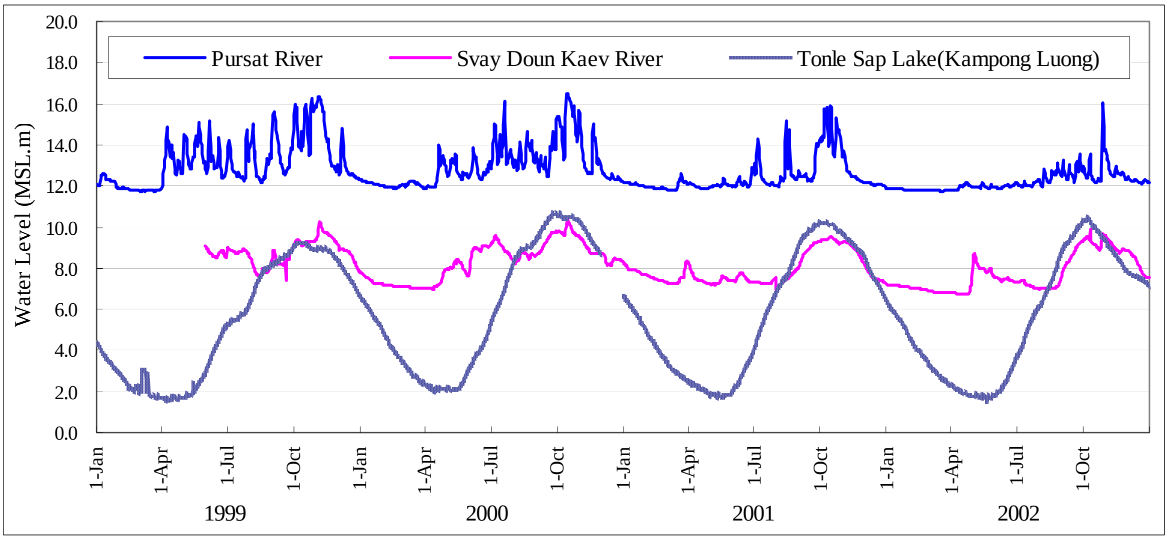


Figure 6.1-6 Hydrograph at Rivers along NR 5 and Tonle Sap Lake (1999 ~ 2002)

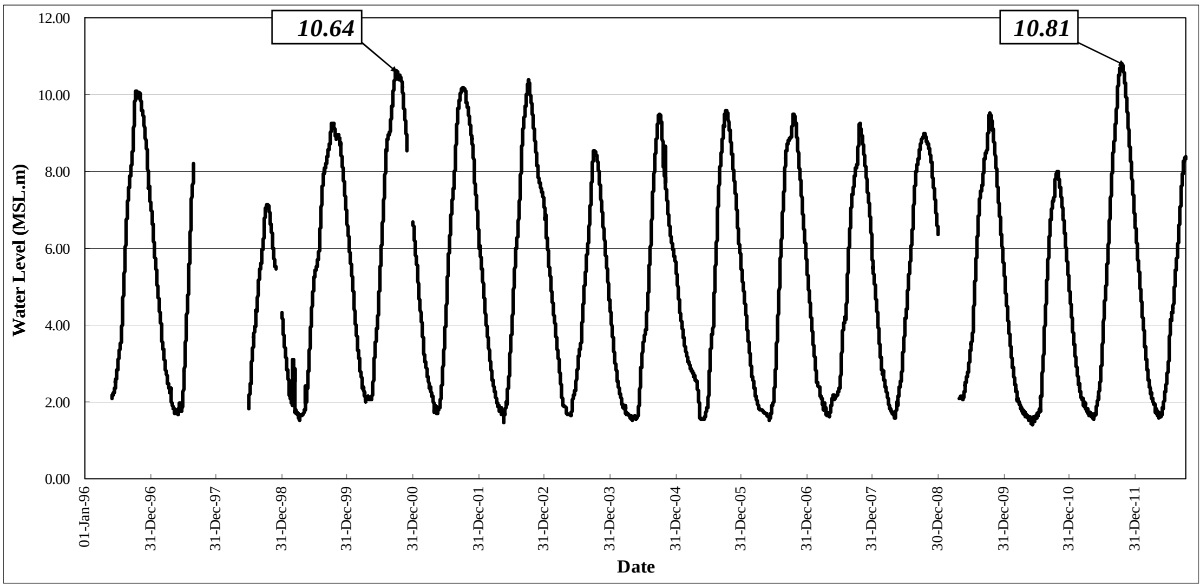


Figure 6.1-7 Hyetograph at Kampong Luong Gauging Station, Tonle Sap Lake (1996 ~ 2011)

Table 6.1-10 Flood Water Level Estimated by Statistic Analysis

Return Period	Estimated Design Magnitude (Design Hydrologic Data)							
	Normal	Log-Normal (Lg-N)	Pearson III (P III)	Log-Pearson III (Lg-P III)	Gumbel & Chow (EV I)	Gumbel (EV II)	Weibull	Hazen
2 -yr	9.75	9.72	9.78	9.56	9.64	9.65	9.72	9.72
5 -yr	10.59	10.09	10.29	10.60	10.20	10.27	10.32	10.29
10 -yr	11.03	10.30	10.54	11.13	10.57	10.68	10.65	10.60
20 -yr	11.40	10.48	10.74	11.67 (25-yr)	10.93	11.07	10.93	10.86
50 -yr	11.80	10.68	10.95	12.01	11.39	11.58	11.25	11.16

As for Sri Sophorn - Poipet Section, hydrological records in a time series imply the mechanism of flood/inundation. Figure 6.1-8 shows water level of the Sri Sophorn River and the Tonle Sap Lake (Kg. Loung), and rainfall observed at Sri Sophorn station, respectively (2010 - 2012). It is seen that the water level of the Sri Sophorn River rose quickly in August and October 2010 while that of Tonle Sap Lake rose almost at constant rate in the same period. In addition, rainfall intensity prior to the time when level of the Sri Sophorn River rose sharply was not high. Thus, it can be said that the rainfall did not substantially influence the rise of water level of Sri Sophorn River in August and October 2010. Therefore, it may be reasonable to assume that the flood of Tonle Sap or rainfall. According to the local residents the flood in August/October was caused by the water coming from Thailand (see Subsection 6.1.3 below).

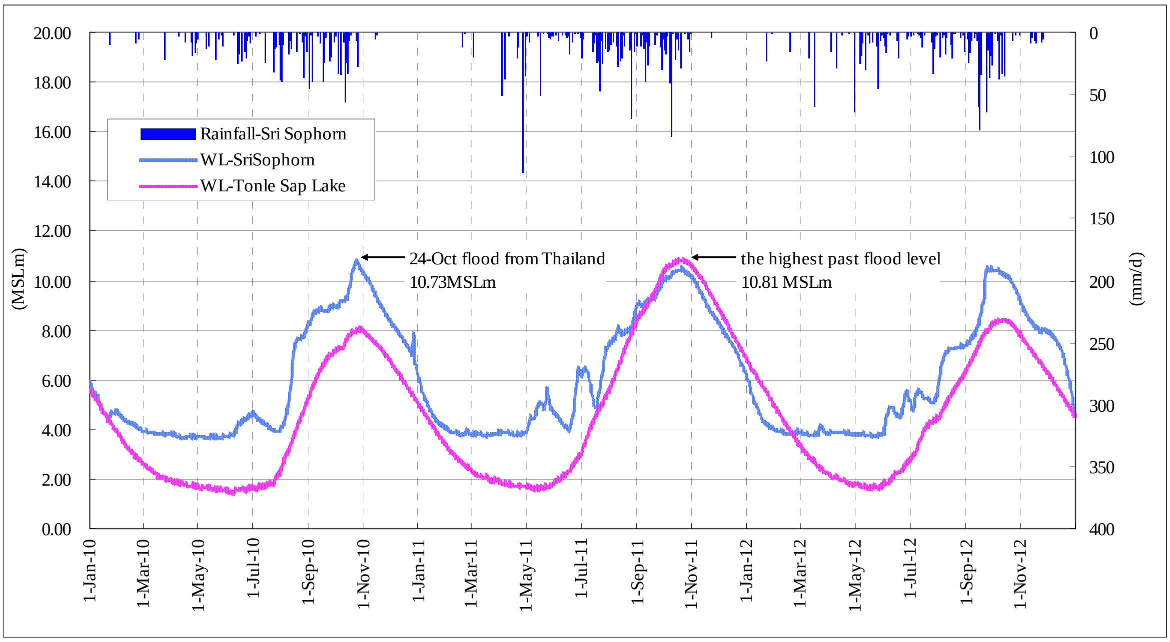


Figure 6.1-8 Hydrograph & Hyetograph of Sri Sophorn and Water Level of Tonle Sap Lake

6.1.3 Information of Road Inundation/Flood

(1) Interviews Survey for Gather Information on Inundation/ Flood

The Team carried out an interview survey to the residents living along or close to NR 5. Appendix 6-2 provides its details. In addition, the Team visited DPWT offices in Pursat and Battambang to collect additional information on damaged and flood-prone sections.

The result of the interview survey showed that the highest past flood levels at most of the surveyed locations along the Middle Section are at least 1.0 m from the ground height. After the road rehabilitation of NR 5 (2004 - 2006), the flood water has never reached the surface of the road. Table 6.1-11 summarizes the information/records on flood/inundation along NR 5 obtained through the interview and those provided by DPWTs. It is noteworthy that the direction of the flood flow in 2011 on the section between KP 269 and KP 272 (Tonle Sap => Mountain) is reverse to other sections (Mountain => Tonle Sap Lake). The highest past flood level of each interviewee spotted are shown in Figure 6.1-9.

Table 6.1-11 Information/Records on Road Flood/Inundation Conditions (Middle Section)

KP	Flood					Source
(Km)	Period	Level	Duration	Flow Direction	Frequency	
172+800	Oct ~ Nov-01	-100cm	2-3 days	⇒Tonle Sap Lake	Seldom	Survey Team
176+200	Rainy season	-20cm	2-3 days	⇒Tonle Sap Lake	Every year	Survey Team
179+100	Rainy season	-100cm	1 week	⇒Tonle Sap Lake	Every year	Survey Team
185+700	Sep ~ Oct-08	-3cm	3~4 days	⇒Tonle Sap Lake	Seldom	DPWT*
188+200	Never flooded					Survey Team
204+000	Sep ~ Nov-07	-50cm	2-3 days	⇒Tonle Sap Lake	Seldom	Survey Team
215+700	Rainy season	-150cm	3-4 days	⇒Tonle Sap Lake	Every year	Survey Team
227+700	Never flooded					Survey Team
245+400	Rainy season	-100cm	2-3 days	⇒Tonle Sap Lake	Every year	Survey Team
265+900	Oct-11	-100cm	2-3 days	⇒Tonle Sap Lake	Seldom	Survey Team
269+700	Oct ~ Nov-11	-125cm	4~5 days	⇒Mountain Side	Seldom	Survey Team
272+600	Oct ~ Nov-11	-125cm	4~5 days	⇒Mountain Side	Seldom	Survey Team
286+400	Rainy season	-200cm	2-4 days	⇒Tonle Sap Lake	Every year	Survey Team

*Note: * Pursat, DPWT, MPWT ** Battambang, DPWT, MPWT JICA means JICA Survey Team*

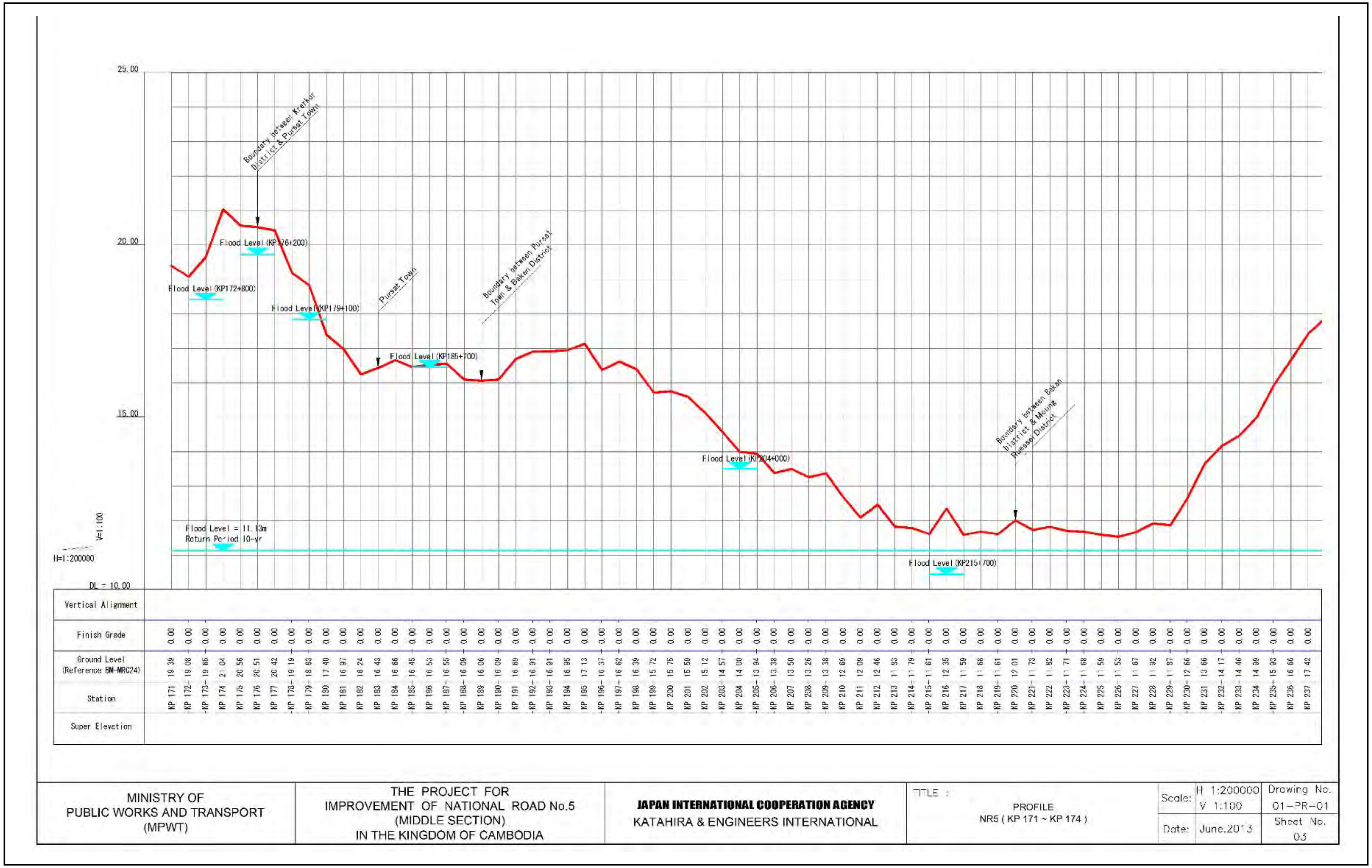
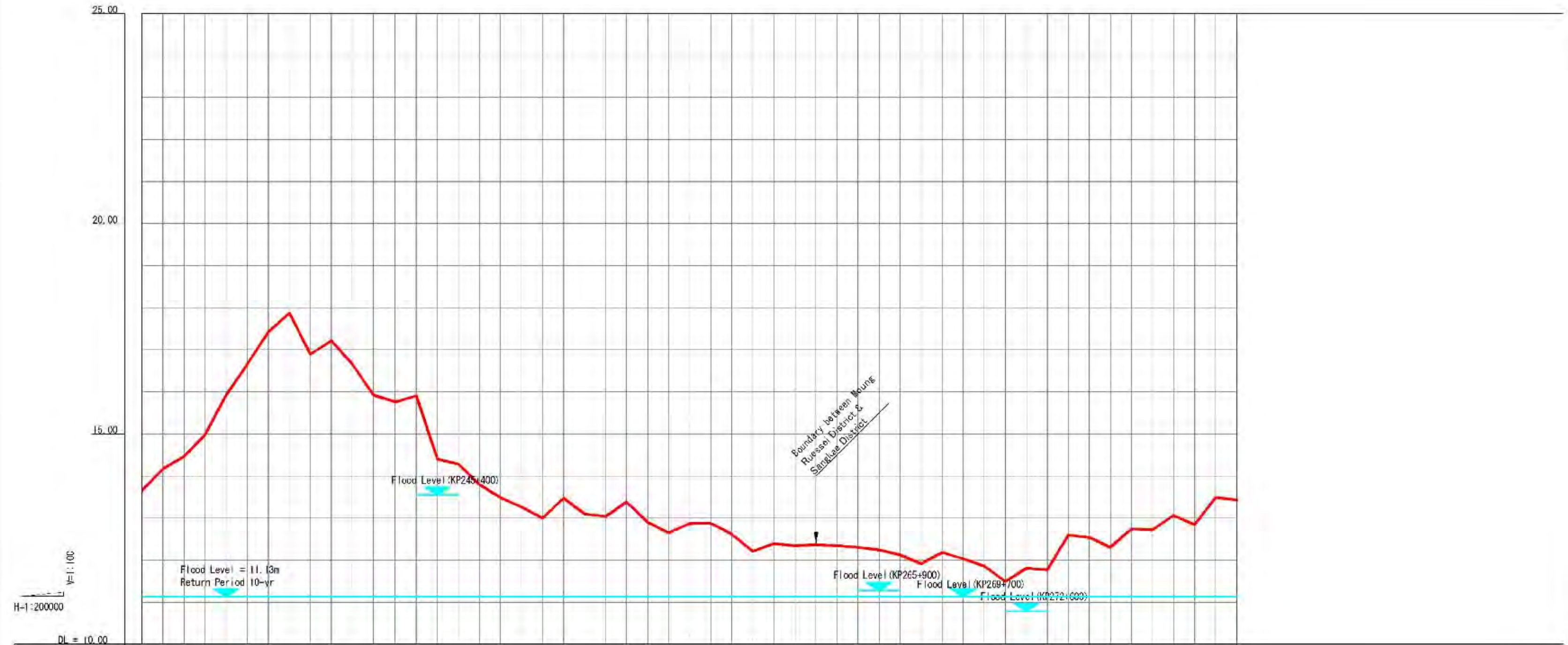


Figure 6.1-9 (1) Estimated Flood Level along the Middle Section



Vertical Alignment / Super Elevation: (blank)

Station	Finish Grade	Ground Leve (Reference BM-MRC24)
KP 231	0.00	13.66
KP 232	0.00	14.17
KP 233	0.00	14.46
KP 234	0.00	14.99
KP 235	0.00	15.93
KP 236	0.00	16.66
KP 237	0.00	17.42
KP 238	0.00	17.83
KP 239	0.00	16.90
KP 240	0.00	17.22
KP 241	0.00	16.66
KP 242	0.00	15.93
KP 243	0.00	15.76
KP 244	0.00	15.91
KP 245	0.00	14.41
KP 246	0.00	14.28
KP 247	0.00	13.80
KP 248	0.00	13.49
KP 249	0.00	13.26
KP 250	0.00	13.00
KP 251	0.00	13.48
KP 252	0.00	13.09
KP 253	0.00	13.04
KP 254	0.00	13.38
KP 255	0.00	12.90
KP 256	0.00	12.65
KP 257	0.00	12.87
KP 258	0.00	12.88
KP 259	0.00	12.61
KP 260	0.00	12.21
KP 261	0.00	12.39
KP 262	0.00	12.35
KP 263	0.00	12.37
KP 264	0.00	12.34
KP 265	0.00	12.30
KP 266	0.00	12.24
KP 267	0.00	12.12
KP 268	0.00	11.91
KP 269	0.00	12.19
KP 270	0.00	12.03
KP 271	0.00	11.86
KP 272	0.00	11.49
KP 273	0.00	11.81
KP 274	0.00	11.77
KP 275	0.00	12.59
KP 276	0.00	12.54
KP 277	0.00	12.30
KP 278	0.00	12.74
KP 279	0.00	12.72
KP 280	0.00	13.06
KP 281	0.00	12.84
KP 282	0.00	13.49
KP 283	0.00	13.43

MINISTRY OF PUBLIC WORKS AND TRANSPORT (MPWT)	THE PROJECT FOR IMPROVEMENT OF NATIONAL ROAD No.5 (MIDDLE SECTION) IN THE KINGDOM OF CAMBODIA	JAPAN INTERNATIONAL COOPERATION AGENCY KATAHIRA & ENGINEERS INTERNATIONAL	TITLE : PROFILE NR5 (KP 174 ~ KP 177)	Scale: H 1:200000 V 1:100	Drawing No. 01-PR-02
				Date: June.2013	Sheet No. 04

Figure 6.1-9 (2)   Estimated Flood Level along the Middle Section

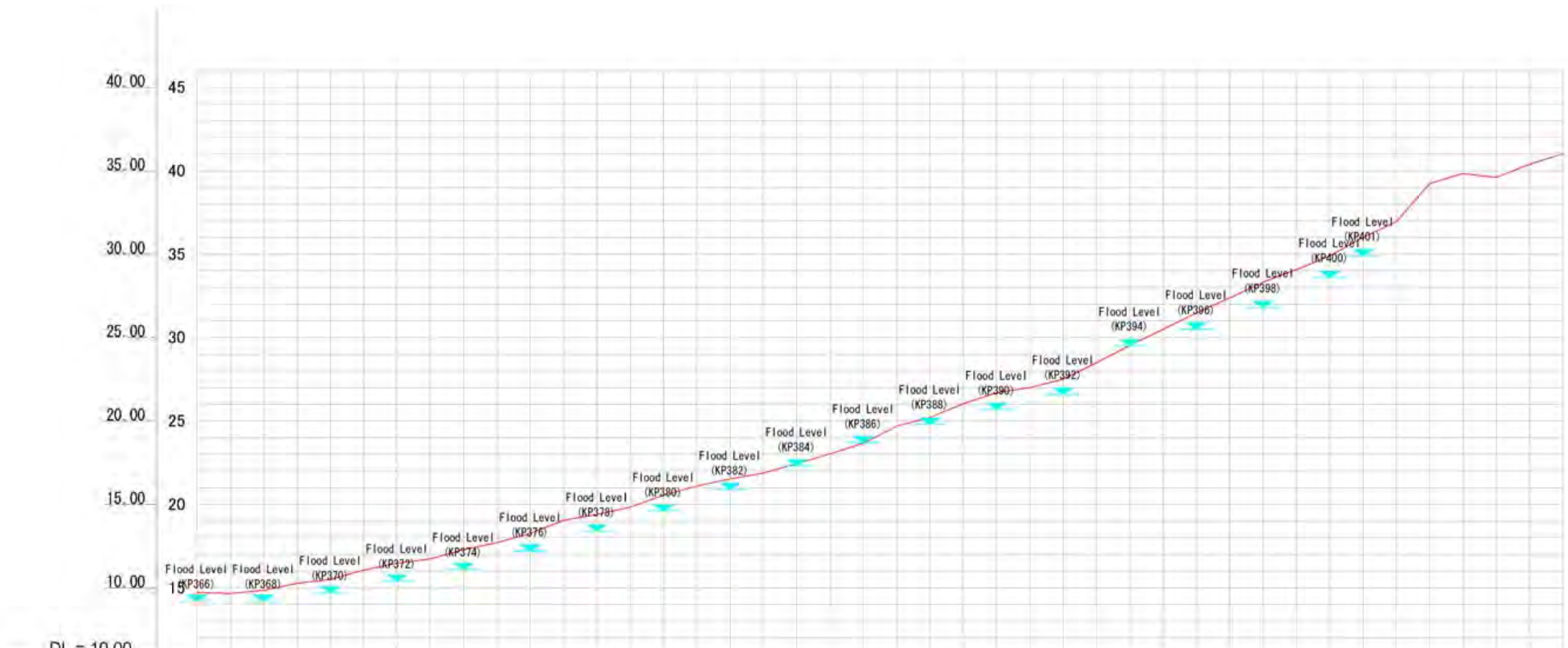
As for Sri Sophorn – Poipet Section, the flood which occurred in Sep – Oct 2013 recoded the highest water level in the past. The flood water, however, did not reach the surface of the road. Table 6.1-12 summarizes the information/records on flood condition obtained through the survey. According to the survey results, flood water, mainly flows from the west to the east, flows from the north side to the south side between Sri Sophorn and Ou Chrov, while flood water flows in opposite direction between Ou Chrov and Poipet. As a result, Sri Sophorn – Poipet Section of NR 5 hardly influences the flood flow because the flood water flows along NR 5.

Figure 6.1-10 shows profile of the road surface and estimated flood level of this section.

Table 6.1-12 Information/Records of Influence of Road Floods (Sri Sophorn – Poipet Section)

KP (Km)	Flood						Source
	Period	Level (North side)	Level (South side)	Duration	Flow Direction	Frequency	
366+000	Sep ~ Oct-13	-50cm	-50cm	1 month	Popet(Thailand) ⇒ Sri Sophorn	Seldom	JICA
368+000	Sep ~ Oct-13	-65cm	-83cm	2 weeks	Popet(Thailand) ⇒ Sri Sophorn	Seldom	JICA
372+000	Sep ~ Oct-13	-105cm	-110cm	2 weeks	Popet(Thailand) ⇒ Sri Sophorn	Seldom	JICA
374+000	Sep ~ Oct-13	-116cm	-104cm	-	Popet(Thailand) ⇒ Sri Sophorn	Seldom	JICA
376+000	Sep ~ Oct-13	-105cm	-123cm	2 weeks	Popet(Thailand) ⇒ Sri Sophorn	Seldom	JICA
378+000	Sep ~ Oct-13	-97cm	-100cm	10 days	Popet(Thailand) ⇒ Sri Sophorn	Seldom	JICA
380+000	Sep ~ Oct-13	-94cm	-126cm	2 ~ 3weeks	Popet(Thailand) ⇒ Sri Sophorn	Seldom	JICA
382+000	Sep ~ Oct-13	-66cm	-80cm	10 days	Popet(Thailand) ⇒ Sri Sophorn	Seldom	JICA
384+000	Sep ~ Oct-13	-15cm	-55cm	10 ~ 15 days	Popet(Thailand) ⇒ Sri Sophorn	Seldom	JICA
386+000	Sep ~ Oct-13	-56cm	0cm (ground*)	2 weeks	Popet(Thailand) ⇒ Sri Sophorn	Seldom	JICA
388+000	Sep ~ Oct-13	-52cm	-45cm	10 days	Popet(Thailand) ⇒ Sri Sophorn	Seldom	JICA
390+000	Sep ~ Oct-13	-123cm	-100cm	1 week	Popet(Thailand) ⇒ Sri Sophorn	Seldom	JICA
392+000	Oct-12 (Sep ~ Oct-2013)	-5 ~ -10 cm (-90cm)	-5 ~ -10 cm (-98cm)	1 week	Popet(Thailand) ⇒ Sri Sophorn	Seldom	JICA
394+000	Sep ~ Oct-13	-143cm	0cm (ground*)	10 days	Popet(Thailand) ⇒ Sri Sophorn	Seldom	JICA
396+000	Sep ~ Oct-13	-132cm	-102cm	-	Popet(Thailand) ⇒ Sri Sophorn	Seldom	JICA
400+000	Sep ~ Oct-13	-127cm	-127cm	2 weeks	Popet(Thailand) ⇒ Sri Sophorn	Seldom	JICA

*Note: *ground level is same as road surface. JICA means JICA Survey Team*



Vertical Alignment

Station	Finish Grade	Ground Level (Referance BM-MRC24)
KP 366	0.00	14.72
KP 367	0.00	14.66
KP 368	0.00	14.85
KP 369	0.00	15.27
KP 370	0.00	15.50
KP 371	0.00	16.07
KP 372	0.00	16.47
KP 373	0.00	16.74
KP 374	0.00	17.28
KP 375	0.00	17.71
KP 376	0.00	18.27
KP 377	0.00	19.05
KP 378	0.00	19.40
KP 379	0.00	19.84
KP 380	0.00	20.56
KP 381	0.00	21.10
KP 382	0.00	21.53
KP 383	0.00	21.88
KP 384	0.00	22.44
KP 385	0.00	23.03
KP 386	0.00	23.66
KP 387	0.00	24.69
KP 388	0.00	25.22
KP 389	0.00	26.04
KP 390	0.00	26.70
KP 391	0.00	27.00
KP 392	0.00	27.51
KP 393	0.00	28.50
KP 394	0.00	29.54
KP 395	0.00	30.50
KP 396	0.00	31.48
KP 397	0.00	32.38
KP 398	0.00	33.33
KP 399	0.00	34.07
KP 400	0.00	34.90
KP 401	0.00	36.00
KP 402	0.00	36.95
KP 403	0.00	39.23
KP 404	0.00	39.84
KP 405	0.00	39.59
KP 406	0.00	40.39
KP 407	0.00	41.02

Super Elevation

MINISTRY OF PUBLIC WORKS AND TRANSPORT (MPWT)	THE PROJECT FOR IMPROVEMENT OF NATIONAL ROAD No.5 (MIDDLE SECTION) IN THE KINGDOM OF CAMBODIA	**JAPAN INTERNATIONAL COOPERATION AGENCY** KATAHIRA & ENGINEERS INTERNATIONAL	TITLE : PROFILE NR5 (KP 366 ~ KP 407)	Scale: H 1:10000 V 1:100 / Date: August 2013	Drawing No. 01-PR-01 / Sheet No. 01 / 01

Figure 6.1-10 Estimated Flood Level along the Sri Sophorn - Poipet Section

In the survey for Sri Sophorn - Poipet Section, most of the interviewees answered that the flood along this section was caused by (i) the flood water coming from Thailand and (ii) heavy rain. The flood water coming from Thailand passed two routes; one from Ou Bei Choan (northern side) and the other from Malai (southern side) (see Figure 6.1-11). The gradient of the ground surface along this section of NR 5 (west to east) is approximately 1/1,500 and it is much steeper than in the direction of north to south.

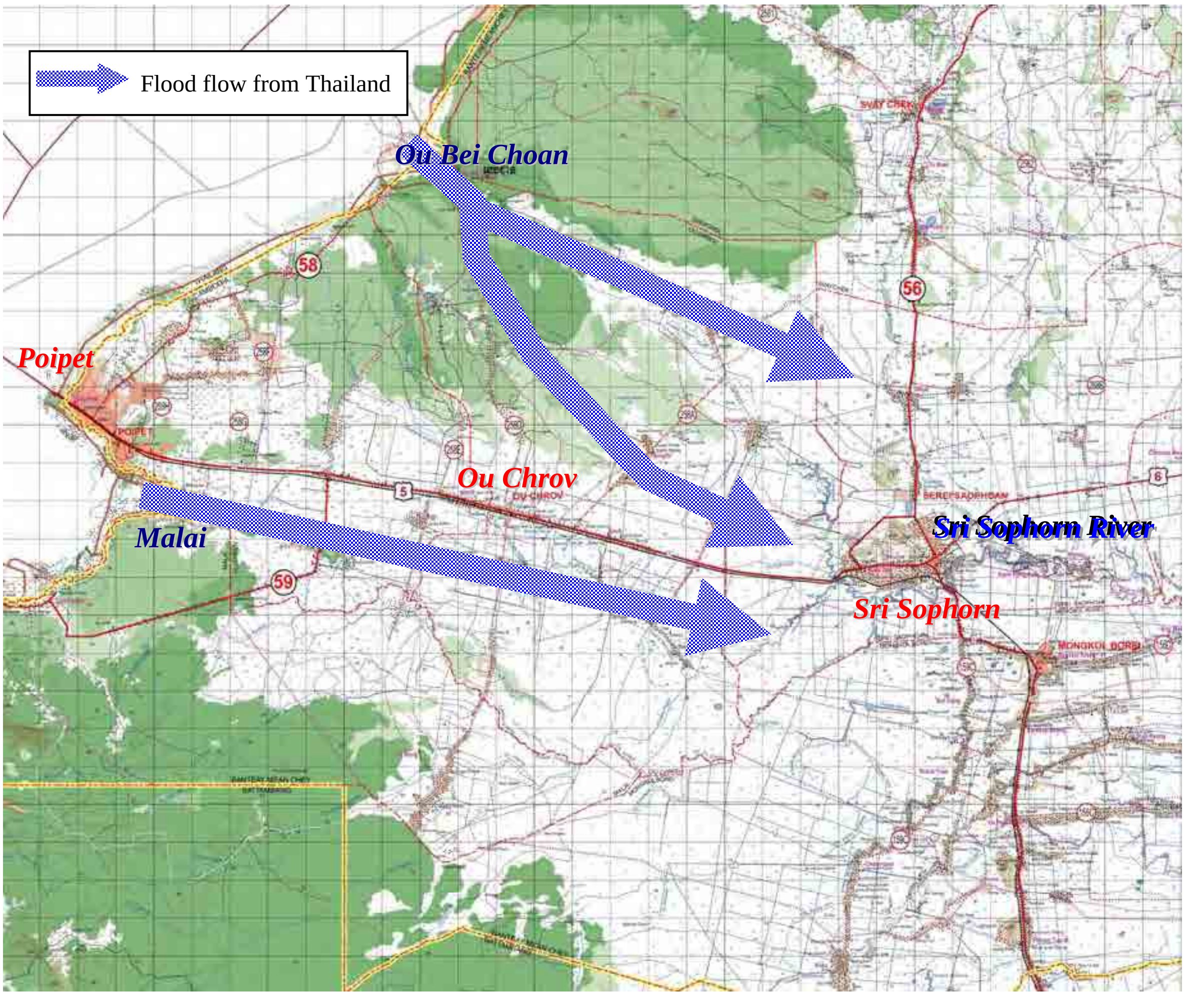
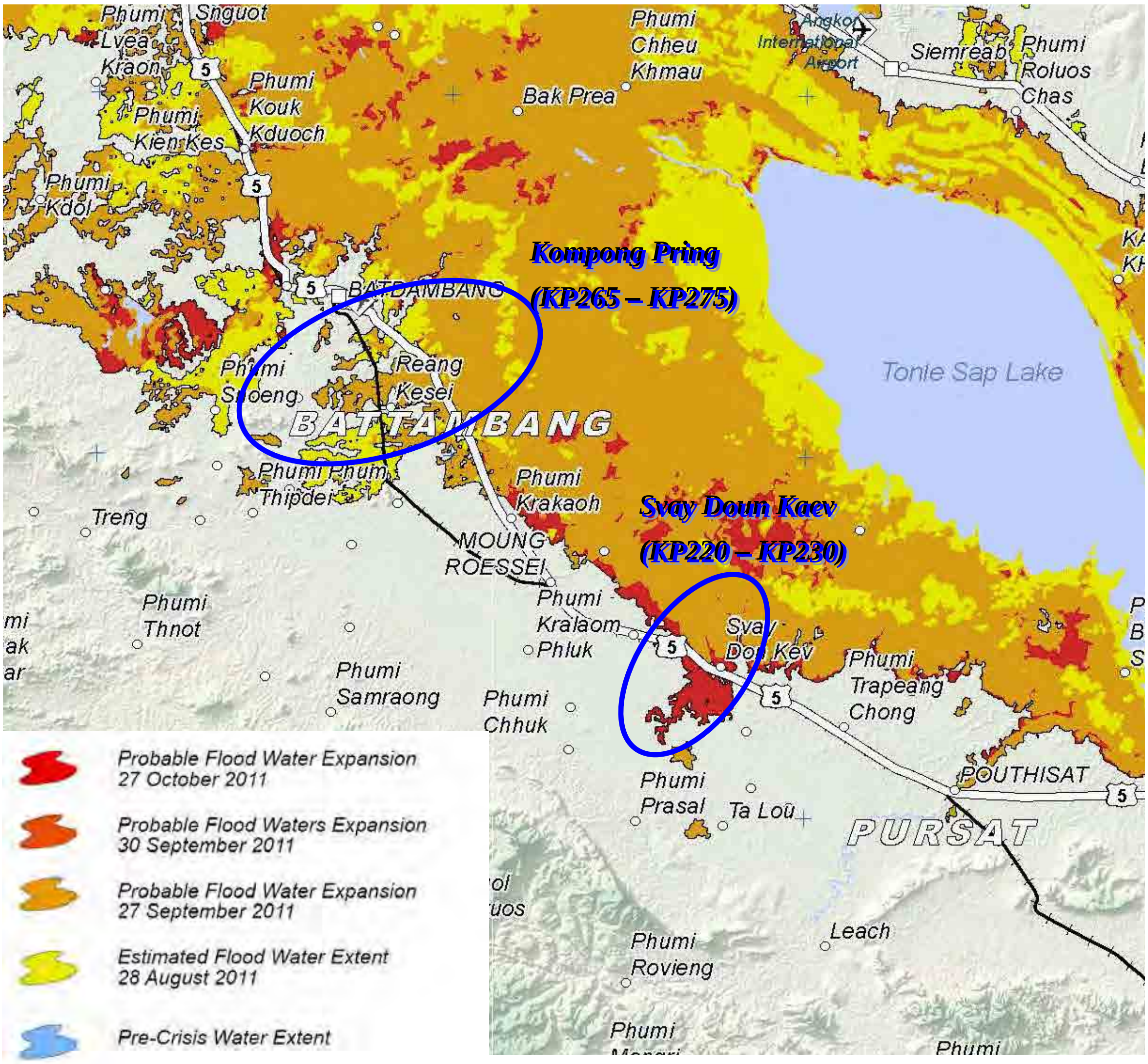


Figure 6.1-11 Flood Flow along the Sri Sophorn - Poipet Section

(2) Road Flood Effects seen in Satellite Image

In addition to the information obtained through the interview survey, a study with satellite images were carried out to understand flood condition. Figure 6.1-12 presents potential standing flood waters/flood land over the affected area surrounding the Tonle Sap Lake. The satellite image indicates that flood water expanded over the lake area between 28 August and 27 October 2011. The satellite image indicates two flood-prone areas in the Middle Section; Svay Doun Kaev (KP 220 – KP 230) and Kampong Pring (KP 265 – KP 275), as shown in Figure 6.1-12 with blue circles. According to the information available to JICA Survey Team, it is highly likely that the flood in the Tonle Sap Lake in 2011 reached these two sections.



Source: Map produced 10-11-2011 by UNOSAT

Figure 6.1-12 Overview of Flood Water along Tonle Sap Lake

6.1.4 Estimated Flood Discharge from Mountains

Three factors affect runoff and flood discharge from a catchment area, namely; (i) rainfall and weather characteristics; (ii) terrain characteristics; and (iii) stream characteristics. Rainfall and weather characteristics are obtained from statistical analysis of rainfall record. This method is applicable for a watershed which has the annual maximum floods records for 25 years or more. Probability for 50 to 200 years is used depending on damageable value of flood-prone area or design life period for a targeted structure.

Basically, hydrological component of a road design is concerned with estimation of probable flood discharges. Several models or formulae have been proposed and used for estimating probable flood discharges in drainage basins. Among these model/formulae, "rainfall-runoff model" is one of the most commonly used methods. This model evaluates the drainage area considering the various factors employed in the model. One of the factors is hydraulic characteristics of river or drainage canal such as cross sectional area, and slope of stream allowing velocity of flow. Another factor is the available records of discharges observed on in river or drainage canal at the site or at any other site in its vicinity.

The "Rational Method" is an empirical formula, and is one of the most widely used methods of rainfall-runoff models due to its simplicity and easy application. The formula is as shown below:

$$Q = \frac{CIA}{3.6}$$

Where,

Q : Peak design discharge for a given return period (m^3/s)

C : Coefficient of runoff

I : Rainfall intensity for a given return period (mm/hr)

A : Catchment (Drainage) area (km^2)

Catchment area, A, of each particular site is obtained by defining drainage boundaries such as the ridges, terrain, and artificial structures like embankments and canals, read in the 1:100,000 scale topographic maps provided by MPWT. In this study, the area of rainfall which causes inundation is assumed be substantially smaller than the catchment area defined by the topographic boundaries. Thus the area defined with "squall lines" is adopted instead of catchment area. The area of squall lines is assumed according to classification of the climate of the area. Extent of "squall line" in tropical monsoon region like Cambodia is said to be meso-beta scale (20 ~ 200 km^2). Thus, discharge computed by "Rational method" could be overestimated if catchment area is larger than Meso-beta scale. Each catchment area using for rational method, therefore, was adjusted to approximately 200 km^2 or less. Consequently, the drainage area along NR 5(Middle Section) was divided into 16 areas.

To obtain a value of I, the time of concentration, referred to as t, was initially computed using the formula developed by Kirpich. According to hourly rainfall records, duration of rainfall was less than six hours. Thus, if time of flood concentration is over six hours, rainfall intensity was converted into it of six hours for an estimate by rational method.

$$t = \frac{L^{1.15}}{51.408\, H^{0.385}}$$

Where,

t = Time of flood concentration (min)

H = Difference in elevation between the point of interest and the most remote point (m)

L = Maximum flow length (m)

Coefficient of runoff, referred to as C, is a function of the soil type and gradient of watershed.

Type of drainage area was classified as Lawns: Sandy soil, flat, 2% (C=0.10) in the Survey Area.

Table 6.1-13 Coefficients of Runoff

Type of Drainage Area	Max Runoff Coefficient
Downtown areas	0.95
Neighborhood areas	0.70
Single-family areas	0.50
Multi-units, detached	0.60
Multi-units, attached	0.75
Suburban	0.40
Apartment dwelling areas	0.70
Industrial: Light areas	0.80
Industrial: Heavy areas	0.90
Parks, cemeteries	0.25
Playgrounds	0.40
Railroad yard areas	0.40
Unimproved areas	0.30
Lawns: Sandy soil, flat, 2%	0.10
Lawns: Sandy soil, average, 2 - 7%	0.15
Lawns: Sandy soil, steep, 7%	0.20
Lawns: Heavy soil, flat, 2%	0.17
Lawns: Heavy soil, average, 2 - 7%	0.22
Lawns: Heavy soil, steep, 7%	0.35
Streets: Asphaltic	0.95
Streets: Concrete	0.95
Streets: Brick	0.85
Streets: Drives and walks	0.85
Roofs	0.95

Applying the above-mentioned factors for the Project area, Table 6.1-14 summarizes the estimated flood discharge for the grouping facilities mentioned above.

Table 6.1-14 summarizes estimated flood discharge with various rain intensity by rational method and drainage capacity of grouping facilities. It compares each volume and shows that grouping drainage facilities have insufficient drainage capacity against estimated flood discharge with hatching of blue. At grouping No.8, No.9,and No.15, drainage capacity is evaluated as zero, in addition, all drainage facilities of grouping No.7 is also evaluated their drainage capacity as zero except Br. 58. The reason is that water level of upstream for computation is lower than 11.13 m(MSL) which is the flood water level of the Tonle Sap Lake, as it was mentioned in 6.1.1 River System and Existing Drainage Facilities. Consequently, grouping No.5, No.7 ~ No.11, No.14, and No.15 are needed to increase drainage capacity for maintaining bearing capacity of pavement from reducing in the case of rainfall with return period of 10-yr.

Table 6.1-14 Estimated Flood Discharge and Drainage Capacity of Grouping 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.*

The drainage capacities of each group increases with raising road surface. Table 6.1-15 shows grouping No.7 ~ No.9 and No.14 ~ No.16 are able to gain enough drainage capacity with raising road surface more than 0.4 m. However, drainage capacities of grouping No.10 and No.11 are still insufficient even if raising road surface more than 1.0 m. Thus, considering number of box culvert for gaining enough capacity is shown next.

Actually, the surface of NR 5 will be above at least 0.8 m because of rehabilitation. So insufficient discharge of No,10 and No.11 are 66 m^3/s and 94 m^3/s respectively. Drainage capacity of one additional box culvert is estimated 24.3 m^3/s. Consequently, grouping No.10 is required 3 additional box culverts, and No.11 is required 4 as well. Dimension of assumed additional box culvert is shown by Figure 6.1-13.

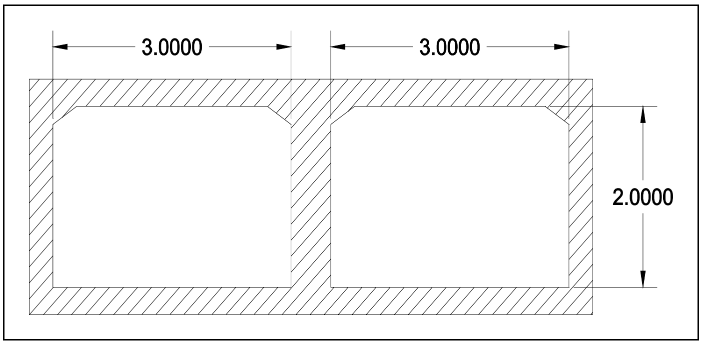


Figure 6.1-13 Typical Box-Culvert

Table 6.1-15 Increase of Drainage Capacity with Raising Surface of NR 5

Group No.	KP	Existing Drainage facilities			Estimated flood discharge(m3/s)	Drainage capacity of existing facilities (m3/s) with Raising height of Road Surface										
		Bridge	Box_C	Pipe_C	(r=60*mm/h)	+0.0m (current)	+0.1m	+0.2m	+0.3m	+0.4m	+0.5m	+0.6m	+0.7m	+0.8m	+0.9m	+1.0m
1	171 ~ 179+700	Br40 - Br41	Bc54 - Bc56	Pc148 - Pc159	84	553	-	-	-	-	-	-	-	-	-	-
2	179+700 ~ 183+200	Br42 - Br43	Bc57 - Bc58	Pc160 - Pc161	70	276	-	-	-	-	-	-	-	-	-	-
3	183+200 ~ 185+400	Br44 - Br46	-	-	56	1001	-	-	-	-	-	-	-	-	-	-
4	185+400 ~ 191+100	Br47 - Br55	-	-	105	2359	-	-	-	-	-	-	-	-	-	-
5	191+100 ~ 202	Br56	Bc59 - Bc60	Pc162 - Pc169	77	78	-	-	-	-	-	-	-	-	-	-
6	202 ~ 211+600	Br57	-	Pc170 - Pc180	123	184	-	-	-	-	-	-	-	-	-	-
7	211+600 ~ 216	Br58	Bc61	Pc181 - Pc186	94	75	89	103	117	143	168	190	212	232	251	271
8	216 ~ 220+700	Br59	Bc62 - Bc63	Pc187 - Pc189	172	0	254	385	488	573	653	743	825	898	970	1041
9	220+700 ~ 227+700	Br60 - Br62	Bc64 - Bc65	Pc190 - Pc192	194	0	0	0	56	210	332	441	525	596	659	719
10	227+700 ~ 235+800	-	Bc66 - Bc67	Pc193 - Pc197	135	37	40	43	50	55	59	63	66	69	72	75
11	235+800 ~ 239+900	-	Bc68 - Bc69	Pc198	129	22	24	26	28	29	31	32	34	35	36	38
12	239+900 ~ 254+600	Br63 - Br66	Bc70 - Bc75	Pc199 - Pc201	188	584	-	-	-	-	-	-	-	-	-	-
13	254+600 ~ 259+500	Br67 - Br70	Bc76 - Bc78	Pc202	242	348	-	-	-	-	-	-	-	-	-	-
14	259+500 ~ 267+700	Br71	Bc79 - Bc82	Pc203	124	116	163	194	218	240	259	277	294	311	328	345
15	267+700 ~ 271	Br72	Bc83 - Bc84	Pc204 - Pc205	54	0	10	26	39	84	141	168	188	201	213	225
16	271 ~ 285+600	Br73 - Br77	Bc85 - Bc90	Pc206 - Pc213	99	76	191	404	488	597	671	738	790	843	900	952

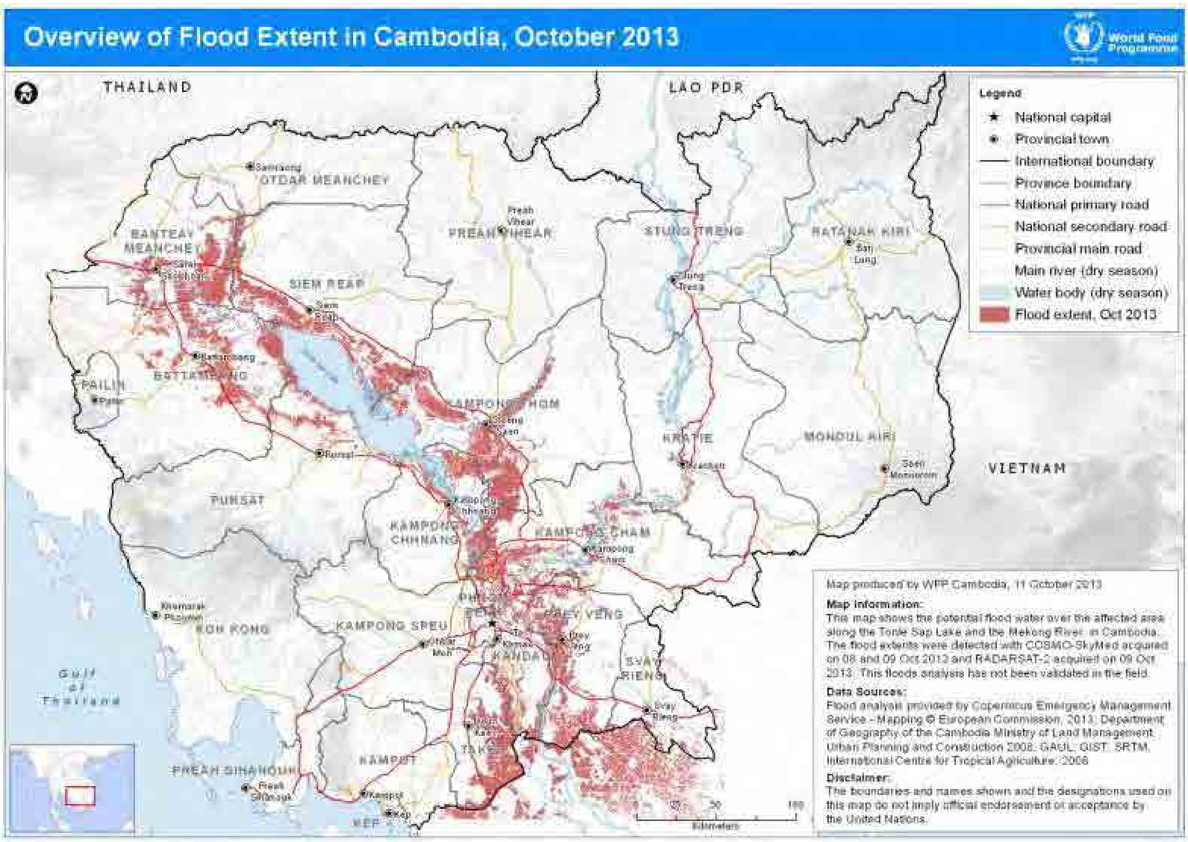
6.1.5 Study of the Flood of 2013

(1) Flood Condition of 2013

Heavy rain since the third week of September resulted in floods in at least 17 provinces through the north-west and along the Mekong River in central Cambodia. The continuous rains in neighboring countries caused repeated flash floods in some provinces, including Banteay Meanchey. In addition, the north-western provinces of Banteay Meancheay, Battambang and Siem Reap affected by flash floods caused by a combination of heavy rains and increase in water levels, as well as overflow from Thailand.

According to latest National Committee for Disaster Management (NCDM) figures published on 12 October, there were 134 confirmed deaths, with approximately 377,695 households (or approximately 1,737,397 people) affected, and more than 26,619 households (approximately 122,447 people) evacuated.

The Team observed flood condition of the Middle section, and summarized it in Table 6.1-16 and Figure 6.1-14. And also, flood condition of the Sri Sophorn - Poipet Section was observed. From KP 366 to KP 376, the flood water level was about 20 cm below the road surface elevation.



Source: Cambodia: Floods Humanitarian Response Forum (HRF) Situation Report No. 03

Figure 6.1-14 Flood Area of Oct. 2013

Table 6.1-16 Overflow Water Level of the Flood of 2013

KP	Depth of Flood	Elevation of Road Surface	Flood Elevation	KP	Depth of Flood	Elevation of Road Surface	Flood Elevation
241+000		16.659	16.659	264+000		12.344	12.344
241+500		16.287	16.287	264+500		12.178	12.178
242+000		15.929	15.929	265+000		12.300	12.300
242+500		15.659	15.659	265+500		12.237	12.237
243+000		15.759	15.759	266+000		12.242	12.242
243+500		15.784	15.784	266+500		12.035	12.035
244+000		15.908	15.908	267+000		12.124	12.124
244+500		15.773	15.773	267+500		11.946	11.946
245+000		14.406	14.406	268+000		11.907	11.907
245+500		14.202	14.202	268+500		12.000	12.000
246+000		14.280	14.28	269+000	0.00	12.186	12.186
246+500		13.776	13.776	269+500		12.266	12.266
247+000		13.799	13.799	270+000	0.00	12.032	12.032
247+500		13.486	13.486	270+500	0.20	11.902	12.102
248+000		13.486	13.486	271+000	0.25	11.856	12.106
248+500		13.485	13.485	271+500	0.30	11.612	11.912
249+000		13.263	13.263	272+000	0.15	11.490	11.640
249+500		13.087	13.087	272+500	0.10	11.626	11.726
250+000		12.996	12.996	273+000	0.10	11.805	11.905
250+500		12.942	12.942	273+500	0.15	11.679	11.829
251+000		13.476	13.476	274+000	0.20	11.768	11.968
251+500		12.858	12.858	274+500	0.00	12.205	12.205
252+000		13.094	13.094	275+000	0.00	12.593	12.593
252+500		13.041	13.041	275+500		12.484	12.484
253+000		13.04	13.04	276+000		12.541	12.541
253+500		13.428	13.428	276+500	0.10	12.512	12.612
254+000		13.342	13.342	277+000	0.00	12.303	12.303
254+500		12.983	12.983	277+500		12.537	12.537
255+000	0.00	12.898	12.898	278+000		12.742	12.742
255+500	0.00	13.037	13.037	278+500		13.025	13.025
256+000	0.05	12.651	12.701	279+000		12.715	12.715
256+500	0.05	12.911	12.961	279+500		13.191	13.191
257+000	0.00	12.873	12.873	280+000		13.064	13.064
257+500	0.05	12.712	12.762	280+500	0.10	13.087	13.187
258+000	0.00	12.877	12.877	281+000	0.20	12.844	13.044
258+500	0.05	12.564	12.614	281+500	0.05	13.392	13.442
259+000	0.05	12.612	12.662	282+000		13.486	13.486
259+500	0.05	12.668	12.718	282+500		13.303	13.303
260+000	0.05	12.208	12.258	283+000		13.431	13.431
260+500	0.00	12.184	12.184				
261+000		12.391	12.391				
261+500		12.338	12.338				
262+000		12.345	12.345				
262+500		12.309	12.309				
263+000		12.366	12.366				
263+500		12.227	12.227				

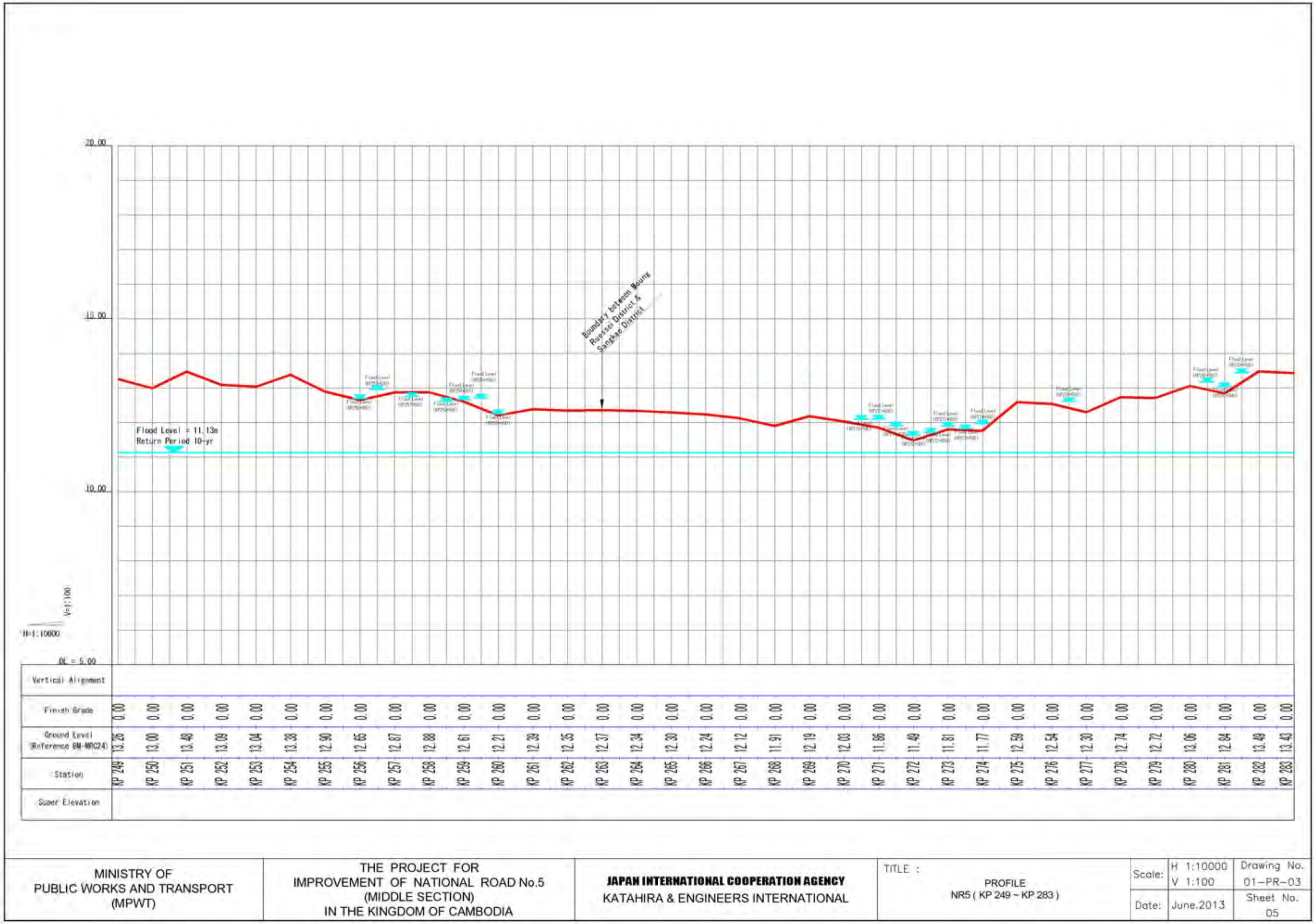


Figure 6.1-15 Flood Water Level at Oct. 2013

Figure 6.1-16 graphs the Hyetograph updated at Pursat, Battambang and Sri Sophorn and it shows heavy rain occurred from 3 until 5 October especially at Battambang.

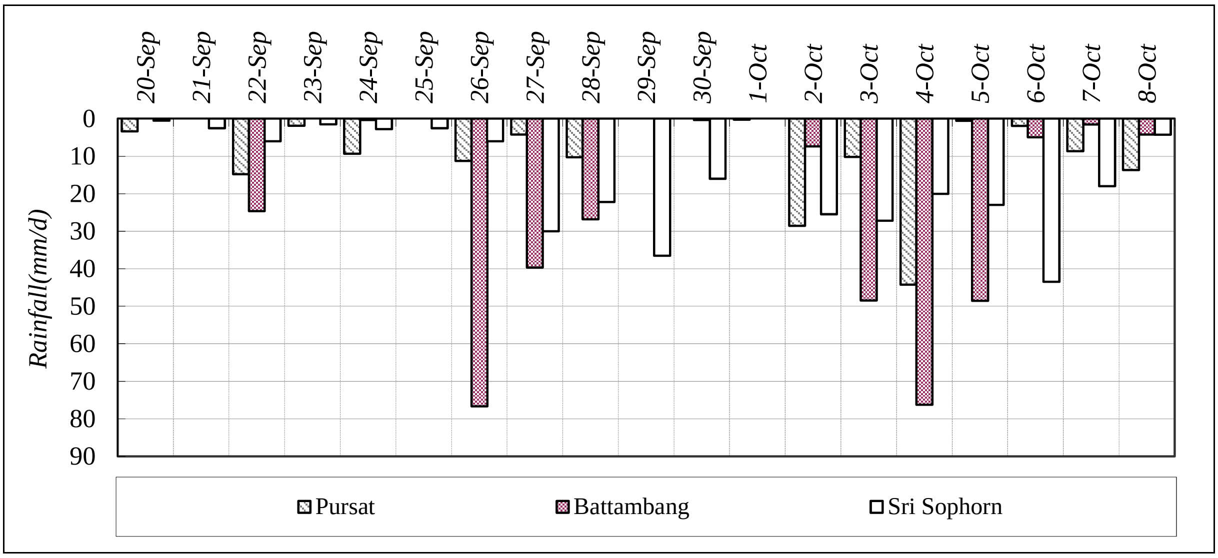


Figure 6.1-16 Hyetograph at Pursat, Battambang and Sri Sophorn (20 Sep. ~ 8 Oct. 2013)

Comparing this flood and average about monthly total and daily maximum, rain condition was not so furious except on September at Battambang.

Table 6.1-17 Rain Condition of 2013

Station	Rainfall		Jun	Jul	Aug	Sep	Oct*
Pursat	Total (mm)	average	154.6	167.2	209.4	220.5	246.6
		2013	281.8	225.6	239.3	172.1	108.4
	Max(mm/d)	average	34.8	43.9	41.2	47.4	57.3
		2013	76.4	32.1	49.8	34.8	44.3
Battambang	Total (mm)	average	153.3	146.1	177.5	194.7	252.5
		2013	278.6	147.4	86.4	334.8	191.6
	Max(mm/d)	average	30.7	40.3	41.2	53.7	77.3
		2013	50.9	29.5	24.0	76.7	76.3
Sri Sophorn	Total (mm)	average	96.2	120.7	152.2	309.4	199.0
		2013	247.2	222.3	245.0	247.3	161.5
	Max(mm/d)	average	22.9	35.1	38.5	72.0	51.3
		2013	41.5	42.0	156.6	62.0	43.5

Note: Total Rainfall of Oct. 2013 is total amount of rainfall from 1 Oct. to 8 Oct.

(2) Estimated Flood Discharge at the Flood of 2013

Flood discharge of the flood of 2013 is able to be estimated by depth of flood water on NR 5. As a result of consideration, because the maximum flood water depth was 0.30 m, flood discharge is estimated at most 230 $m^3/s/km$.

Figure 6.1-18 summarize estimated flood discharge of each depth of flood water. In consideration of flood discharge, following condition is assumed for computation:

- Flood discharge is evaluated by steady flow analysis with HEC-RAS model.
- Water level of downstream is normal depth (I=1/10,000) calculated each discharge case.
- Model channel width is 1 km.
- Depth of flood water above NR 5 is computed with model channel by each discharge cases respectively.

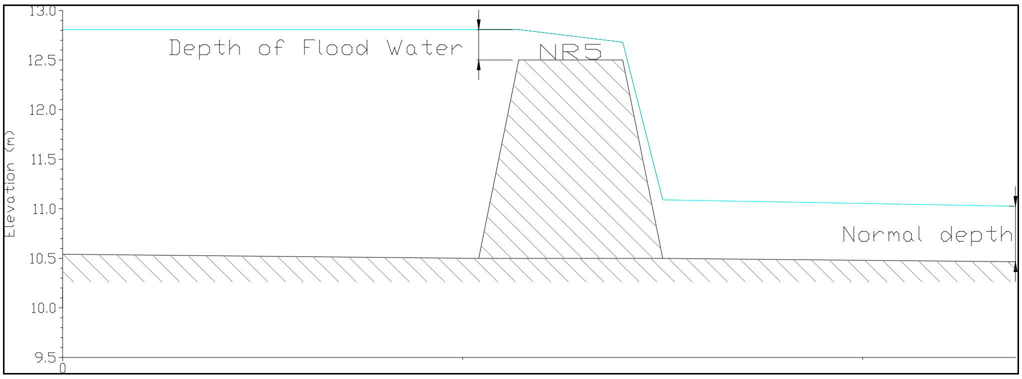
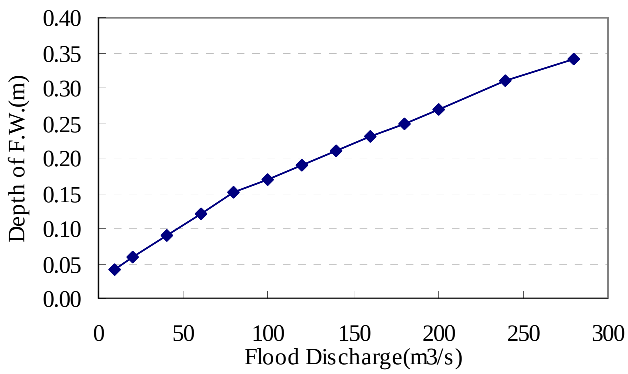


Figure 6.1-17 Model Channel for Evaluating Flood Discharge (Profile View)



Depth (m)	Q Total
0.00	0.0
0.05	15.0
0.10	46.7
0.15	80.0
0.20	130.0
0.25	180.0
0.30	230.0

Figure 6.1-18 Estimated Flood Discharge

(3) Measures for the Flood

As shown in Table 6.1-16 and Figure 6.1-14, the flood water gathered lower land (around KP 270 ~ KP 280). Thus, the section which was inundated by this flood is required much more drainage capacity than the others. There are two factors to increase drainage capacity of inundated section: raising road surface and establishing drainage facilities.

Consideration to measures for flood like 2013 uses these two factors, specifically, upstream water level which does not reduce bearing capacity of pavement (at least 1.3 m below road surface) is computed under several case of number of opening width of embankment. Table 6.1-18 and Figure 6.1-20 summarizes result of computation.

In consideration of upstream water level and opening width, following condition is assumed for computation:

- Water level of upstream is evaluated by steady flow analysis with HEC-RAS model.
- Water level of downstream is 11.13 m (MSL), the water level of the Tole Sap Lake with return period 10-yr by statistical analysis.
- Model channel width is 1 km.
- Flow discharge is 230 m^3/s/km which is maximum estimated flood discharge.
- Opening width of embankment (NR 5) is simulated as number of box culvert. For example, 2 box culverts means 24 m of opening.
- Box culvert has same dimension as Figure 6.1-13.

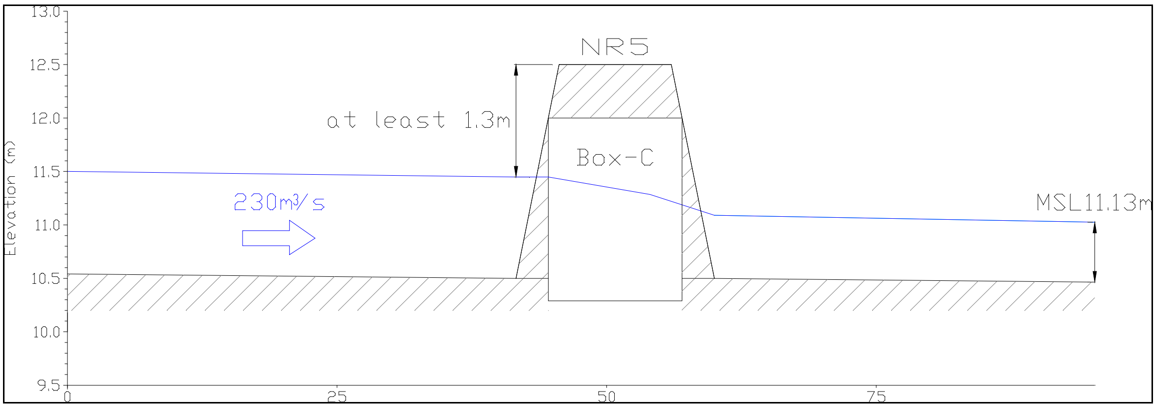


Figure 6.1-19 Model Channel for Estimating Flood Water Level (Profile View)

Table 6.1-18 Elevation of Road Surface with Box Culverts

4*Box-C (Open ≒ 25m/1km)		8*Box-C (Open ≒ 50m/1km)		16*Box-C (Open ≒100m/1km)		26*Box-C (Open ≒150m/1km)	
Elevation of Road Surface (MSL.m)	Drainage capacity (m3/s)	Elevation of Road Surface (MSL.m)	Drainage capacity (m3/s)	Elevation of Road Surface (MSL.m)	Drainage capacity (m3/s)	Elevation of Road Surface (MSL.m)	Drainage capacity (m3/s)
12.43	0.0	12.43	0.0	12.43	0.0	12.43	0.0
12.53	25.6	12.53	57.8	12.53	105.0	12.53	155.0
12.73	51.7	12.73	102.2	12.73	195.4	12.73	301.4
12.93	68.3	12.93	137.6	12.93	272.3	12.93	444.3
13.23	92.1	13.23	183.0	13.23	387.7	13.23	658.6
13.43	107.3	13.43	213.3	13.43	464.6	13.43	801.4
13.63	122.4	13.63	243.6	13.63	541.5	13.63	944.3
13.93	141.2	13.93	289.1	13.93	656.9	13.93	1158.6

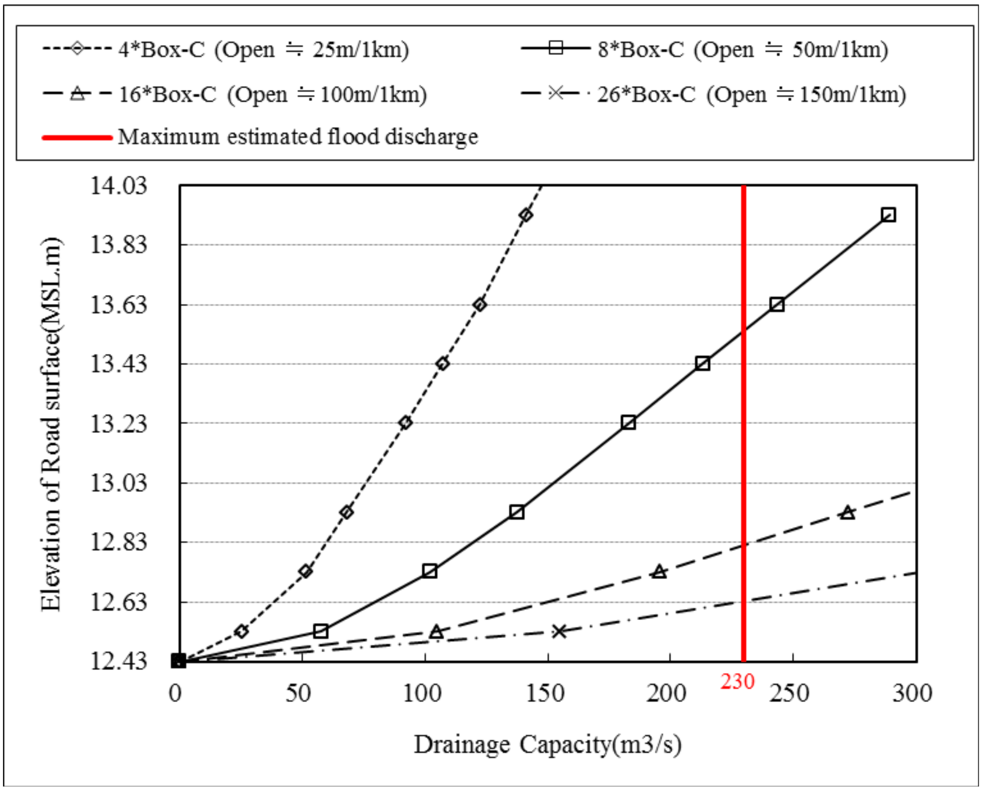


Figure 6.1-20 Elevation of Road Surface with Box Culverts

6.2 Topographical Survey

6.2.1 Objective

Topographical surveys were carried out along NR 5 in the Middle Section and the Sri Sophorn - Poipet Section, and at the selected bridges of NR 5 (Middle Section) for the preliminary road design and the cost estimation.

(1) Middle Section

Existing Road (NR 5)

- Longitudinal survey of the road surface: Necessary for planning of measures against flood
- Cross section survey of every 1 km of the road: Necessary for the preliminary design and the cost estimation of the earthwork of the road construction

Selected Bridges

- Longitudinal survey of bridges to be replaced: Necessary for the preliminary design and the cost estimation of the bridge construction
- Longitudinal survey and cross section survey of river bridges: Necessary for a hydrological condition survey

(2) The Sri Sophorn - Poipet Section

Existing Road (NR 5)

- Longitudinal survey of the road surface: Necessary for planning of measures against flood
- Cross section survey of every 1 km of the road: Necessary for the preliminary design, the cost estimation of the earthwork of the road construction and a hydrological condition survey.

(3) Pursat Bypass

- Cross section survey of every 20 m of the road: Necessary for the preliminary design and the cost estimation of the earthwork of the road construction
- To prepare a topographical map: Used in the design of Pursat bypass

6.2.2 Contents

The topographical survey consists of the following parts.

Table 6.2-1 Summary of Contents

Section	Survey Type	Description	Quantities
NR 5 in the Middle Section	Longitudinal and Cross Section Survey	Elevation of road surface at road center, shoulder and toe of embankment at intervals of 1 km	L = 112 km
NR 5 in the Sri Sophorn - Poipet	Longitudinal and Cross Section Survey	Elevation of road surface at road center , shoulder and toe of embankment at intervals of 1 km	L = 41 km

Section	Survey Type	Description	Quantities
Section	Cross Section Survey for hydrological condition survey	Elevation of and distance from the center line of the points which are shoulder of slope, toe of slope on both sides shall be surveyed within 30 m from the center line.	8 sections
Selected Bridges to be replaced	Longitudinal survey	Longitudinal survey at bridge location at intervals of 10 m and changing points	3 no.
Selected Bridges for hydrological condition survey	Longitudinal survey	Longitudinal survey at bridge location at intervals of 10 m and changing points	5 no.
	Cross section survey	Cross section survey at A1 abutment and A2 abutment of bridge, and center of bridge	
Pursat Bypass	Road centerline, Longitudinal section Cross section Topographical survey	Road centerline, longitudinal, cross section and topographical survey shall be surveyed at intervals of 20 m	L=8.8 km (Bypass)
	Longitudinal section Cross section	Longitudinal and cross section survey at bridge location at intervals of 10 m and changing points	1 no. (Bypass)

6.2.3 Detail and Output

(1) Middle Section

Details and output of the topographical survey are shown in Table 6.2-2 to 6.2-7.

Altitude of road surface survey for existing road (NR 5)

Table 6.2-2 Survey Item for NR 5

Survey Item	Description
Control Point Setting	Control Points were installed at approximately 5 km intervals. Their XY coordinates surveyed by hand GPS and elevations were recorded. The control points made of concrete were installed on the firm ground. The size of the concrete is W × L × H = 20 cm × 20 cm × 80 cm (embedded; 60 cm).
Longitudinal Survey	Longitudinal survey along center line was performed by leveling. Points at every 1 km of the center line and changing points were surveyed. Each Control Point was confirmed by longitudinal survey.
Cross Section Survey	The elevation of and the distance from the center line to the following points were surveyed; · The shoulder of the slope on both sides · The toe of the slope on both sides · Any points within 30 m from the center line on both sides if the elevation changes at a height of more than 10 cm.

Table 6.2-3 Output of the Survey for NR 5

Item	Description
Longitudinal Section Drawing	Scale: Horizontal 1:10,000, Vertical 1:100. The water level of the river and canal are indicated.
Cross Section Drawing	Scale: 1:200. Fences, houses, canals, etc. are shown.

Topographical survey for selected bridges to be replaced

Table 6.2-4 Survey Item for Bridges to be Replaced Section

Survey Item	Description
Longitudinal Survey	Longitudinal survey along the center line was performed at intervals of 10 m and changing points. Land altitude within 50 m from center of bridge on both sides including the river bed was surveyed.

Table 6.2-5 Output for Bridges to be Replaced Section

Item	Description
Longitudinal Section Drawing	Scale: 1:250. High water levels are indicated.

Topographical survey for selected bridges over rivers

Table 6.2-6 Survey Item for River Bridges Section

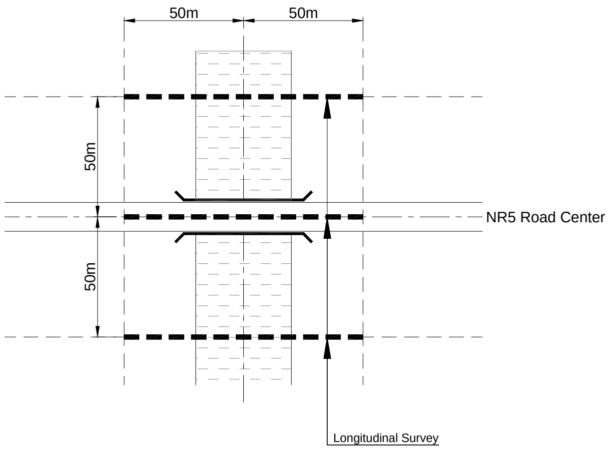
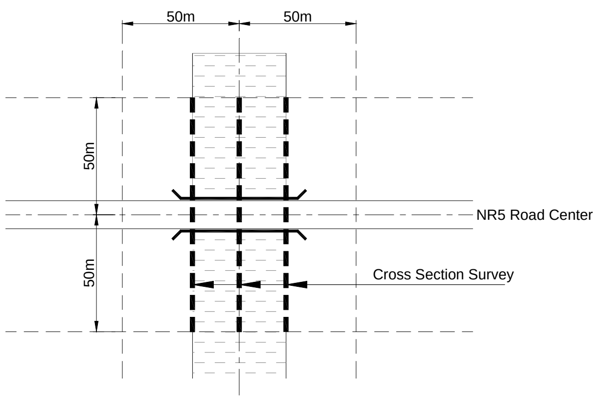
Survey Item	Description
Longitudinal Survey	Longitudinal survey along the 3 lines including center line, upstream and downstream part of a river 50 m apart from bridge was performed at intervals of 10 m and changing points. Land altitude within 50 m from center of bridge both sides including the river bed was surveyed.
	
Cross Section Survey	Cross section survey along the 3 lines passing A1 abutment and A2 abutment of the bridge, and the center of the bridge within 50 m both sides from the center line of the bridge were surveyed at intervals of 10 m and changing points.
	

Table 6.2-7 Output of the Survey for River Bridges Section

Item	Description
Longitudinal Section Drawing	Scale: 1:250. High water level is indicated.
Cross Section Drawing	Scale: 1:200. Fence, house, canal etc. are drawn.

(2) The Sri Sophorn - Poipet Section

Details and output of the topographical survey are shown in Table 6.2-8 to 6.2-10.

<u>Altitude of road surface survey for existing road (NR 5)</u>

Table 6.2-8 Survey Item for NR 5

Item	Description
Leveling	Leveling from KP 283 to KP 366 to connect the BM elevation
Control Point Setting	Control Points were set at approximately 5 km intervals. Their XY coordinates surveyed by hand GPS and Elevations were recorded. The control points made of concrete were installed on the hard ground. The size of the concrete is W × L × H = 20 cm × 20 cm × 80 cm (embedded; 60 cm).
Longitudinal Survey	Longitudinal survey along center line was performed by leveling. Points at every 1 km of the center line and changing points were surveyed. Each Control Point shall be confirmed by longitudinal survey.
Cross Section Survey	The elevation of and the distance from the center line to the following points were surveyed; ・ The shoulder of the slope on both sides ・ The toe of the slope on both sides ・ Any points within 30 m from the center line on both sides if the elevation changes at a height of more than 10 cm.

Table 6.2-9 Survey Item for Hydrological Condition

Item	Description
Cross Section Survey	The elevation of and the distance from the center line to the following points were surveyed; ・ The shoulder of the slope on both sides ・ The toe of the slope on both sides ・ Any points within 30 m from the center line on both sides if the elevation changes at a height of more than 10 cm.

The detail of the cross section survey for hydrological condition is shown in the figure below.

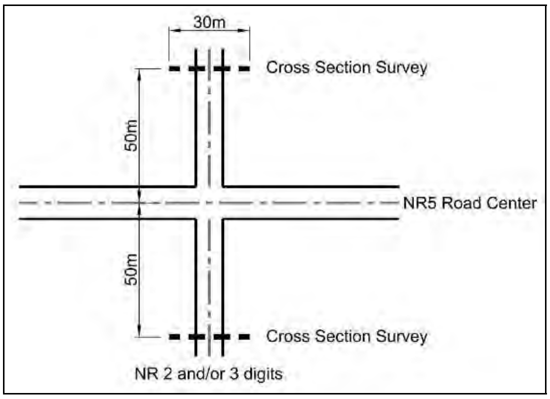


Figure 6.2-1 Detail of Cross Section Survey

Table 6.2-10 Output of the Survey for NR 5 and for Hydrological Condition

Item	Description
Longitudinal Section	Scale: Horizontal 1:10,000, Vertical 1:100. Water level of river and canal are indicated.
Cross Section	Scale: 1:200. Fence, house, canal and etc. are shown.

(3) Pursat Bypass

Details and output of the topographical survey are shown in Table 6.2-11 to 6.2-14.

Table 6.2-11 Survey Item and Output for Road Section

Survey Item	Description
Control Point Setting	Control Points were set at approximately 2 km intervals. Coordination and elevation were recorded. Control point shall be installed on the hard ground by concrete (20 cm x 20 cm x 80 cm (Depth; 60 cm)).
Road Center Line Survey	Setting center line at 20 m intervals, IP, BC, EC shall be set out.
Longitudinal Survey	Longitudinal survey along center line, 20 m interval and changing points were be surveyed.
Cross Section Survey	Cross section survey interval 20 m, changing points within 30 m on both sides of the road were surveyed
Peg Installations	Peg installations at bypass route, intervals 20 m on the centerline, and 20 m on both sides from center line peg Peg installations along NR 5, interval 20 m, and 20 m both side from new centerline Peg (diameter 60 mm, length 1,000 mm) shall be made of wood.
Mapping	Survey houses, culverts, trees, objects and terrain within 30 m on both sides of the road

Table 6.2-12 Output of the Survey for Road Section

Item	Description
Road Plan	Scale: 1:1,000. Contour Line 1 m increments. Road elements and coordinates are indicated.
Longitudinal Section	Scale: Horizontal 1:1,000, Vertical 1:100. Water level of river/canal are indicated.
Cross Section	Scale: 1:200. Fence, house, canal etc. are shown.
BM List	Coordination and elevation

Table 6.2-13 Survey Item for Bridge Section

Survey Item	Description
Longitudinal Survey	Longitudinal survey along center line, 10 m intervals and changing points was surveyed. Within 120 m from center of bridge on both sides were surveyed
Cross Section Survey	Cross section survey intervals 10 m within 120 m on both sides from center of bridge along the road, changing points within 50 m on both sides of centerline were surveyed
Mapping	Survey houses, culverts, trees, objects and terrain within 50 m on both sides of road. Elevation of bore hole for soil investigation were surveyed.

Table 6.2-14 Output of the Survey for Bridge Section

Item	Description
Road Plan	Scale: 1:250. Contour Line 1 m increments.
Longitudinal Section	Scale: 1:250. High Water level shall be indicated.
Cross Section	Scale: 1:200. Fence, house, canal are shown.

6.2.4 Landmine Clearance

The landmine clearance was carried out by RGC under Minutes of Discussion dated 19 November, 2010. The Study Team discussed and explained the landmine clearance for the topographical survey at bypass route in Pursat with MPWT. After the discussion, MPWT coordinated it with relevant organization and Local consultant has gone with Cambodian Action Mine Centre (CMAC) on the site. The topographical survey on Pursat Bypass was started from December, 2013 and was completed in January 2014.

6.2.5 Result of Survey

The results of the topographical survey are summarized below:

<u>Survey of road surface levels for exiting road (NR 5)</u>

(1) Middle Section

In this survey, bench marks (BM) were installed utilizing BMs which were installed by the South Section Survey to be consistent.

The sections where the attitude of road surface is less than 12 m might be concerned about flood according to the South Section Survey.

The sections which are less than ground height 12 m are below:

Beginning Point	Ending Point	Elevation
KP 212 + 600	KP 215 + 800	11.306 ~ 11.971
KP 216 + 150	KP 219 + 500	11.374 ~ 11.900
KP 220 + 100	KP 229 + 300	11.372 ~ 11.978
KP 267 + 200	KP 267 + 500	11.852 ~ 11.946
KP 268 + 000	KP 268 + 400	11.907 ~ 11.964
KP 270 + 400	KP 274 + 400	11.490 ~ 11.952

(2) The Sri Sophorn - Poipet Section

BMs were set correlating with the BMs which had been installed in the Middle section from a viewpoint of consistency.

According to the result of topographical survey, the elevation below 12 m was not observed. The existing road surface gradually goes up from KP 366 (14.72 m) to KP 407 (41.02 m).

In this section, the water flow from Thailand to Sri Sophorn and some parts of this section, there are no difference between the road surface and toe of the embankment. Therefore, the base course and sub-base course in the some parts of this section are lower than water level .

6.3 Aerial Photo Survey

Aerial photos using motored paraglider were taken for the following purpose.

- To prepare digital map to be used in the road design in the later stage
- To check the situation of houses/facilities along NR 5

This survey started in early June 2013 on the Middle Section. In this survey, a propeller equipped paraglider is used in place of an airplane as well as the others sections of NR 5. Use of paraglider makes the entire schedule of the survey more flexible than an ordinary airplane since the flight schedule of a paraglider can be adjusted to weather and other conditions more easily than a ordinary airplane.

(1) Middle Section

Digital Map for the Preliminary Road Design was produced at the end of July 2013. Table 6.3-1 shows the work schedule for the aerial photo survey.

Table 6.3-1 Aerial Photo Survey Schedule (Middle Section)

Item	June				July			
	1st week	2nd week	3rd week	4th week	1st week	2nd week	3rd week	4th week
Mobilization and Digital Database Preparation	■							
Aerial Ortho-Photo Survey								
Aerial Photography		■	■					
Ground Control Point with DGPDS (GCP:X,Y,Z)		■						
Ortho-Photo Processing			■	■	■			
Final Report and Contact Printing						■	■	■
Digital Mapping								
Road Alignment Survey with DGPS (XYZ) every 50 m interval			■	■	■			
Data Processing (generate 1 m contour line of the road Alignment)						■		

Table 6.3-2 summarizes the outline of the activities of aerial photo survey.

Table 6.3-2 Description of Activities of Aero Photo Survey

Item	Description
Aerial Photo	Length of Road : 130 km
	Scale: 1:5,000 (Overlap 60%, Side lap 30%)
	No of Photos : 400 pcs
Ground Survey Control Point	35 points
	Scale : 1:2,000
Digital Mapping	Mapping Area 13,000,000 m^2 (130,000 m × 100 m)

(2) The Sri Sophorn - Poipet Section

Digital Map for the Preliminary Road Design was produced in the middle of August 2013. Table 6.3-3 shows the work schedule for the aerial photo survey.

Table 6.3-3 Aerial Photo Survey Schedule (the Sri Sophorn - Poipet Section)

Item	July				August			
	1st week	2nd week	3rd week	4th week	1st week	2nd week	3rd week	4th week
Mobilization and Digital Database Preparation			■					
Aerial Ortho-Photo Survey								
Aerial Photography (Flying)				■	■	■		
Ground Control Point with DGPDS (GCP:X,Y,Z)			■	■				
Ortho-Photo Processing					■	■	■	
Final Report and Contact Printing							■	■
Digital Mapping								
Road Alignment Survey with DGPS (X,Y,Z) every 50 m Interval				■	■	■		
Data Processing (Generate 1 m contour line of the road Alignment)						■	■	

Table 6.3-4 summarizes the outline of the activities of aerial photo survey.

Table 6.3-4 Description of Activities of Aero Photo Survey

Item	Description
Aerial Photo	Length of Road : 48 km
	Scale: 1:5,000 (Overlap 60%, Side lap 30%)
	No of Photos : 150 pcs
Ground Survey Control Point	15 points
Digital Mapping	Scale : 1:2,000
	Mapping Area 4,800,000 m^2 (48,000 m × 100 m)

6.4 Geotechnical Investigation

6.4.1 CBR Tests of Existing Subgrade

To understand the existing condition of the subgrade under the existing NR 5, CBR tests were carried out with the samples collected from the unpaved shoulder of the road.

Locations of Sampling

The samples were collected from the unpaved shoulder adjacent to the paved shoulder at the intervals of 2 kilometers between the beginning and the ending of the Middle Section, i.e., KP 171 to KP 283, by manual digging of test pits down to 1.5 meters deep from the surface.

(1) Middle Section

Schematic illustrations of the test pits of the Middle Section are attached to Appendix 6-3.

(2) The Sri Sophorn - Poipet Section

Schematic illustration of the test pits of the Sri Sophorn - Poipet Section are attached to Appendix 6-4.

Laboratory Tests

Laboratory tests were carried out following the standards listed below:

- CBR tests — ASTM D 1883 or equivalent
- Moisture - density relation — ASTM D 698 or equivalent
- Specific Gravity — ASTM D 854 or equivalent
- Moisture Content — ASTM D 2216 or equivalent
- Atterberg Limits — ASTM D 4318 or equivalent
- Sieve Analysis — ASTM D 422 or equivalent
- Soil Classification — ASTM D 2487 or equivalent

(1) Middle Section

The results of the laboratory tests are attached to Appendix 6-5 and the Table 6.4-1 summarizes the test results.

Table 6.4-1 Summary of CBR Tests in the Middle Section

CBR -No.	Km	Thickness (mm)				CBR / MDD				Soil Classification	Particle Size Distribution			Specific Gravity	Atterberg Limit			Moisture Content (%)
		DBST	Base Course	Sub Base	Subgrade	CBR at 95%MDD (%)	OMC (%)	MDD (g/cm3)	95% MDD		Fine Content (%)	Sand (%)	Gravel (%)		LL (%)	PL (%)	PI (%)	
1	171	25			800	6.20	7.30	2.162	2.054	A6	42.86	40.63	16.51	2.685	24.20	12.19	12.01	5.78
2	173	20			650	9.90	6.10	2.182	2.073	A4	40.49	45.08	14.43	2.662	32.60	16.90	15.70	3.45
3	175	20			650	8.40	8.30	2.125	2.019	A6	66.65	31.16	2.19	2.569	30.20	12.18	18.02	11.51
4	177	15			700	5.00	7.70	2.148	2.041	A7	35.71	44.87	19.42	2.818	27.30	12.15	15.15	9.64
5	179	15			700	9.70	8.30	2.140	2.033	A6	39.58	40.17	20.25	2.690	32.30	13.63	18.67	8.99
6	181	20			700	4.00	8.30	2.158	2.050	A6	38.16	51.31	10.53	2.637	34.40	11.39	23.01	9.66
7	183	20			700	3.80	8.60	2.108	2.003	A7	49.09	47.54	3.37	2.618	18.70	10.03	8.67	8.32
8	185	20			700	9.00	7.40	2.140	2.033	A4	33.07	48.72	18.21	2.687	25.40	12.30	13.10	4.90
9	187	20			600	2.20	7.40	2.135	2.028	A7	38.61	50.03	11.36	2.644	25.60	12.71	12.89	7.97
10	189	20			700	7.70	9.40	2.095	1.990	A6	35.53	35.92	28.55	2.784	33.70	17.90	15.80	8.13
11	191	20			600	9.40	9.20	2.135	2.028	A4	50.25	33.15	16.60	2.644	30.60	12.61	17.99	9.81
12	193	20		180	500	0.60	6.75	2.184	2.075	A7	34.99	43.31	21.70	2.741	18.70	11.55	7.15	3.91
13	195	20		230	400	2.01	8.56	2.114	2.008	A7	28.85	30.47	40.68	2.829	36.40	16.77	19.63	10.51
14	197	20		330	600	6.10	8.50	2.057	1.954	A6	45.56	32.49	21.95	2.753	34.60	13.32	21.28	12.20
15	199	20		300	400	3.35	9.25	2.020	1.919	A7	51.43	28.93	19.64	2.708	32.60	12.91	19.69	12.46
16	201	20		250	500	3.25	9.50	2.180	2.071	A7	31.99	34.75	33.26	2.846	32.00	12.96	19.04	8.29
17	203	20		300	400	2.30	8.90	2.057	1.954	A7	56.37	23.62	20.01	2.675	35.80	17.23	18.57	10.64
18	205	20		200	400	2.70	7.90	2.160	2.052	A7	43.87	28.46	27.67	2.816	33.00	13.94	19.06	10.95
19	207	20		250	500	7.10	8.20	2.145	2.038	A7	44.32	33.21	22.47	2.781	34.60	13.49	21.11	10.89
20	209	20		200	400	5.90	8.20	2.110	2.005	A7	51.97	30.68	17.35	2.722	30.80	18.17	12.63	11.45
21	211	20		200	500	1.65	8.20	2.100	1.995	A7	46.52	34.08	19.40	2.715	19.80	13.44	6.36	12.85
22	213	15		300	500	5.00	5.00	2.049	1.947	A7	34.59	27.40	38.01	2.684	27.90	13.42	14.48	8.09
23	215	20		180	400	2.05	8.30	2.117	2.011	A7	43.70	29.87	26.43	2.734	32.60	16.53	16.07	11.07
24	217	20			500	3.50	9.40	2.098	1.993	A7	45.65	25.98	28.37	2.760	39.20	15.99	23.21	9.89
25	219	20		300	400	1.00	8.60	2.049	1.947	A7	72.65	19.08	8.27	2.680	32.40	12.77	19.63	8.39
26	221	10		180	600	4.20	8.60	2.114	2.008	A7	38.80	38.19	23.01	2.708	27.00	11.91	15.09	9.95
27	223	25		200	400	2.76	8.20	2.175	2.066	A7	33.48	32.74	33.78	2.800	31.00	11.73	19.27	10.99
28	225	20	250		700	11.20	7.80	2.165	2.057	A6	27.07	29.10	43.83	2.773	27.10	13.85	13.25	7.43
29	227	20		250	600	2.80	9.00	2.132	2.025	A7	40.21	35.31	24.48	2.679	21.20	13.67	7.53	6.51
30	229	20			700	6.80	7.90	2.180	2.071	A7	44.48	34.49	21.03	2.707	27.30	12.39	14.91	4.40
31	231	20		150	500	2.58	9.20	2.010	1.910	A7	40.25	39.89	19.86	2.576	29.10	12.62	16.48	10.71
32	233	20			600	1.65	9.78	2.045	1.943	A7	41.75	32.28	25.97	2.717	38.00	14.66	23.34	11.46
33	235	20			800	7.50	8.00	2.115	2.009	A6	40.50	31.72	27.78	2.788	26.20	12.69	13.51	5.50
34	237	25			600	6.35	8.20	2.100	1.995	A7	39.83	33.06	27.11	2.742	23.20	13.29	9.91	7.01
35	239	25			700	3.55	8.65	2.051	1.948	A7	42.24	37.99	19.77	2.656	34.30	17.67	16.63	7.72
36	241	20			1200	6.60	7.76	2.082	1.978	A7	35.76	33.94	30.30	2.654	27.40	12.55	14.85	5.40
37	243	20		200	500	5.03	9.40	2.022	1.921	A6	38.30	33.02	28.68	2.754	61.00	12.65	48.35	8.33
38	245	20		200	500	13.20	7.90	2.060	1.957	A6	48.01	37.09	14.90	2.621	30.80	12.77	18.03	12.38
39	247	20			850	0.47	7.25	2.113	2.007	A7	35.83	27.28	36.89	2.691	33.00	11.91	21.09	11.48
40	249	20			800	4.30	8.80	2.087	1.983	A7	41.00	36.01	22.99	2.649	27.40	15.75	11.65	13.20
41	251	20			700	1.60	8.50	2.157	2.049	A7	45.15	26.23	28.62	2.741	27.80	18.12	9.68	4.83
42	253	25		200	500	2.80	9.90	1.995	1.895	A7	47.55	27.11	25.34	2.657	30.60	10.56	20.04	12.38
43	255	20		200	600	4.50	7.70	2.160	2.052	A7	36.85	26.31	36.84	2.662	30.60	12.47	18.13	10.67
44	257	20		250	450	5.95	6.77	2.135	2.028	A6	42.15	40.84	17.01	2.699	24.80	14.35	10.45	8.78
45	259	20			850	7.30	6.70	2.150	2.043	A6	43.25	36.65	20.10	2.750	25.10	14.84	10.26	6.87
46	261	20		200	400	6.10	10.75	2.009	1.909	A7	58.63	27.84	13.53	2.563	33.00	13.23	19.77	11.32
47	263	30		200	600	11.90	8.50	2.081	1.977	A4	53.85	31.67	14.48	2.605	32.50	15.37	17.13	11.44
48	265	20		200	450	7.20	10.55	1.991	1.891	A7	53.18	25.49	21.33	2.593	37.30	23.99	13.31	13.02
49	267	20		200	300	5.00	8.10	2.170	2.062	A7	19.16	57.44	23.40	2.702	33.00	15.80	17.20	11.29
50	269	20		200	600	6.40	11.40	1.983	1.884	A7	60.93	26.59	12.48	2.607	41.00	14.40	26.60	13.90
51	271	25		200	400	2.56	8.30	2.158	2.050	A7	54.04	29.33	16.63	2.576	35.00	13.62	21.38	15.73
52	273	20		180	400	0.80	8.55	1.891	1.796	A7	39.54	29.10	31.36	2.556	36.00	12.77	23.23	19.50
53	275	20			1000	3.10	8.50	1.937	1.840	A7	33.80	31.10	35.10	2.608	33.20	11.85	21.35	15.76
54	277	25			600	7.65	8.00	2.048	1.946	A7	46.35	30.80	22.85	2.632	32.00	12.97	19.03	7.44
55	279	20			600	2.51	11.75	1.875	1.781	A7	40.42	32.89	26.69	2.582	29.10	16.11	12.99	10.68
56	281	20			700	1.30	9.10	2.014	1.913	A7	34.43	32.59	32.98	2.611	34.20	13.08	21.12	11.06
57	283	20		200	500	1.40	9.90	1.927	1.831	A7	45.32	29.05	25.63	2.621	44.20	15.72	28.48	14.04

(2) The Sri Sophorn - Poipet Section

The results of the laboratory tests are attached to Appendix 6-6 and the Table 6.4-2 summarizes the test results.

Table 6.4-2 Summary of CBR Tests in the Sri Sophorn - Poipet Section

CBR -No.	Km	Thickness (mm)				CBR / MDD				Soil Classification	Particle Size Distribution			Specific Gravity	Atterberg Limit			Moisture Content (%)
		DBST	Base Course	Sub Base	Subgrade	CBR at 95%MDD (%)	OMC (%)	MDD (g/cm3)	95% MDD		Fine Content (%)	Sand (%)	Gravel (%)		LL (%)	PL (%)	PI (%)	
1	367	40	0	300	300	4.25	10.75	1.910	1.815	A6	39.01	48.2	12.78	2.686	14.49	36.30	21.81	18.16
2	369	35	400	0	400	1.98	10.45	1.975	1.876	A6	49.43	43.73	6.83	2.639	16.59	38.20	21.61	15.71
3	371	40	300	0	300	1.80	10.60	1.952	1.854	A6	34.91	44.26	20.83	2.637	16.97	43.90	26.93	9.01
4	373	30	300	0	300	0.95	11.60	1.920	1.824	A6	43.29	46.01	10.69	2.554	16.26	43.00	26.74	12.87
5	375	30	300	0	250	1.92	10.50	1.925	1.829	A6	58.86	38.81	2.33	2.573	15.31	36.10	20.79	15.29
6	377	50	320	0	250	1.45	11.25	1.910	1.815	A6	43.5	41.63	14.87	2.662	12.71	60.20	47.49	13.04
7	379	40	300	0	250	3.44	9.75	1.975	1.876	A5	39.17	42.02	18.81	2.567	17.35	57.90	40.55	15.93
8	381	40	300	0	250	3.40	11.70	1.915	1.819	A6	40.05	42.19	17.76	2.688	14.10	40.60	26.50	13.28
9	385	40	400	0	180	1.55	7.75	2.120	2.014	A6	55.05	33.01	11.94	2.65	11.98	37.40	25.42	13.38
10	387	40	360	0	250	0.52	8.90	2.035	1.933	A7	44.52	30.93	24.55	2.676	12.05	29.10	17.05	12.5
11	389	30	440	0	300	1.92	9.25	2.060	1.957	A6	34.11	30.83	35.06	2.682	15.16	42.00	26.84	12.03
12	391	30	430	0	400	1.18	9.40	2.040	1.938	A6	64.43	21.51	14.06	2.693	15.16	42.00	26.84	10.79
13	393	40	250	0	400	0.88	10.50	1.955	1.857	A5	54.12	26.17	19.71	2.735	13.47	46.80	33.33	15.15
14	401	35	430	0	150	2.98	7.75	2.105	2.000	A6	44.94	35.37	19.69	2.681	12.05	38.80	26.75	12.46
15	399	40	300	0	250	2.18	7.90	2.090	1.986	A6	32.12	28.68	39.19	2.803	17.01	34.20	17.19	12.4
16	397	30	300	0	280	5.26	7.75	2.100	1.995	A6	45.25	42.26	12.49	2.679	16.50	39.20	22.70	10.82
17	395	35	300	0	250	1.70	7.70	2.090	1.986	A6	52.18	25.47	22.35	2.686	13.39	38.00	24.61	15.94
18	403	0	0	0	400	1.50	11.40	2.000	1.900	A6	36.69	32.86	30.46	2.724	15.71	46.80	31.09	17.21
19	405	0	0	200	200	1.10	11.50	1.930	1.834	A6	44.8	50.03	5.89	2.755	17.00	38.40	21.40	23.57
20	407	10	0	0	0	1.32	11.90	1.894	1.799	A6	53.07	34.74	12.19	2.661	12.41	58.40	45.99	27.42

6.4.2 Geotechnical Investigation for Bridges

(1) Middle Section

As a preliminary investigation for foundations of the bridges along the Middle Section of National Road No.5, 12 boreholes were drilled and Standard Penetration Tests (hereinafter referred to as SPT) were conducted. Laboratory tests were carried out with disturbed and undisturbed samples obtained from the boreholes.

Location of Boreholes

Borehole investigation was done at the following 12 bridge sites:

(a) KP 181 + 900 (Br. 42)

(b) KP 183 + 200 (Br. 44)

(c) KP 185 + 700 (Br. 47)

(d) KP 187 + 500 (Br. 48)

(e) KP 188 + 100(Br. 50)

(f) KP 191 + 100 (Br. 55)

(g) KP 208 + 500 (Br. 57)

(h) KP 215 + 800 (Br. 58)

(i) KP 219 + 700 (Br. 59)

(j) KP 245 + 900 (Br. 66)

(k) KP 255 + 500 (Br. 68)

(l) KP 273 + 300 (Br. 75)

Figure 6.4-1 to 6.4-3 and Appendix 6-7 show the locations of the boreholes.

(2) The Sri Sophorn - Poipet Section

There is no bridge in the section of Sri Sophorn - Poipet. Therefore, geotechnical investigation for bridge is not carried out.

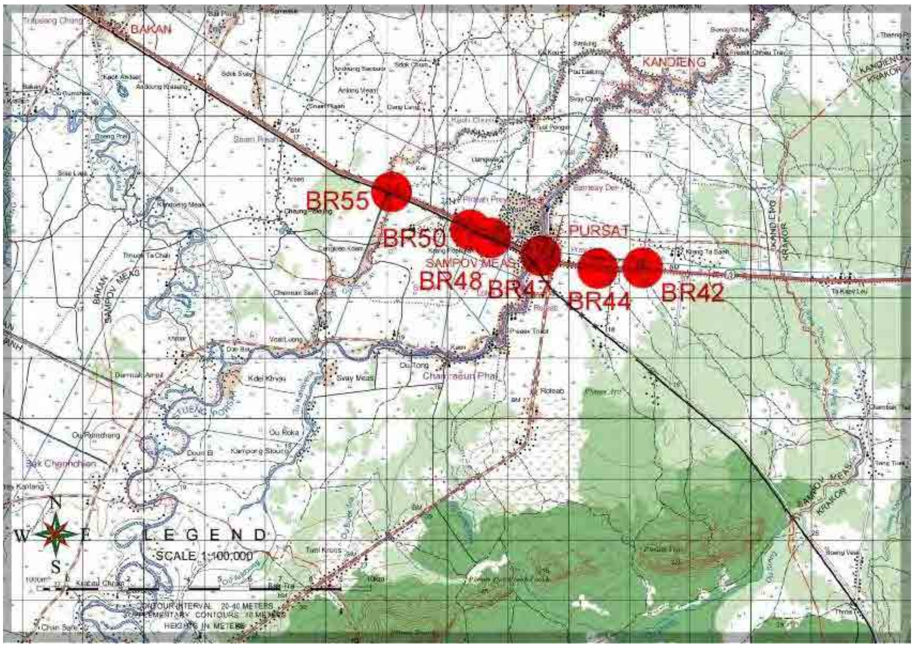


Figure 6.4-1 Location of Boreholes (1)

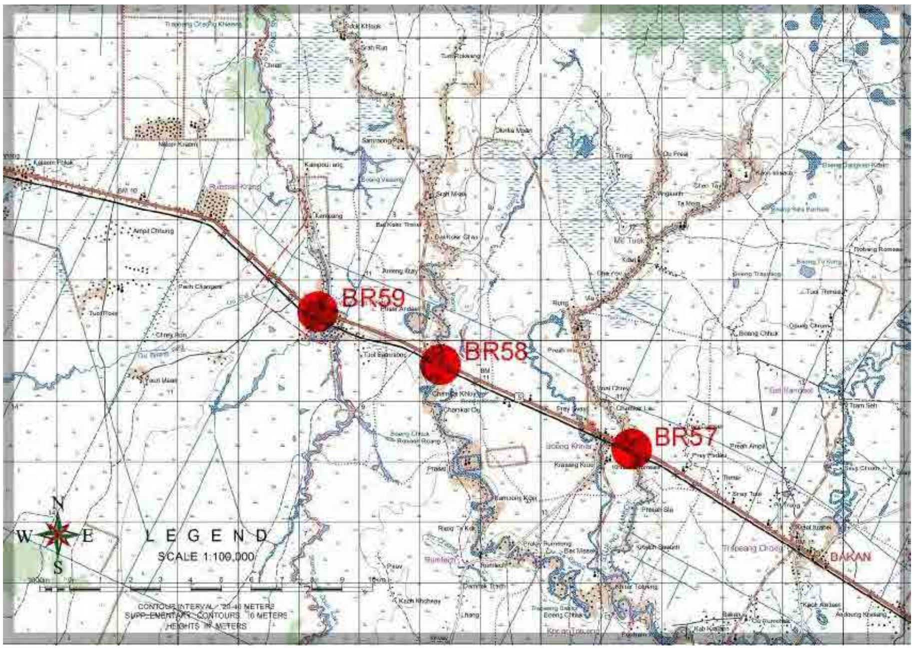


Figure 6.4-2 Location of Boreholes (2)

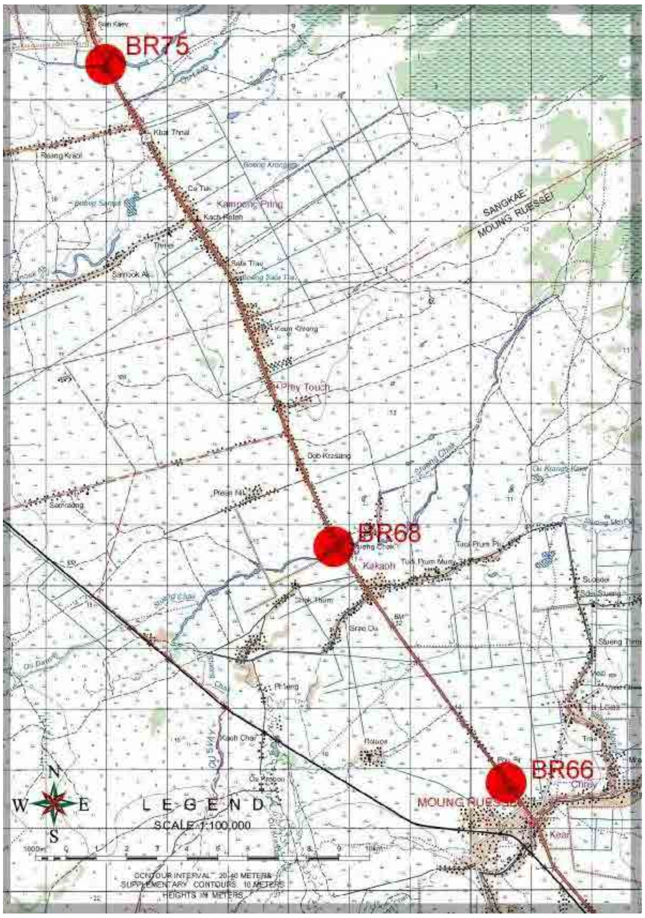


Figure 6.4-3 Location of Boreholes (3)

<u>Geological Condition</u>

This section summarizes stratification, groundwater condition, and distribution of SPT N-values at each borehole. Drilling logs are attached as Appendix 6-8. The borehole investigation was executed with a truck-mounted rotary auger equipped with an apparatus for SPT, shown in Figure 6.4-4.

Figure 6.4-4 Truck-Mounted Rotary Auger, with SPT Apparatus

(1) Br. 42

Figure 6.4-5 shows stratification and distribution of SPT N-values at Br. 42. N-values increase downwards. Recorded groundwater table was GL-2.35 m.

Depth(m)	Thickness (m)	Strata	Apparent Density / Consistency	Description
3.00	3.00	QS1	Loose - Medium Dense	Yellowish Clayey SAND
4.00	1.00	QC1	Very Stiff	Yellowish, light gray Sandy CLAY
7.00	3.00	QC2	Firm - Stiff	Yellowish, grayish Sandy CLAY
16.00	9.00	QC3	Stiff - Very Stiff	Yellowish, graysh, reddish-gray Sandy CLAY
19.00	3.00	QC4	Very Stiff - Hard	Yellowish, grayish, reddish-gray CLAY with Sand
20.00	1.00	QS2	Dense	Reddish-gray Clayey SAND
22.00	2.00	QC5	Very Stiff - Hard	Yellowish, grayish, light gray Sandy CLAY
25.45	3.45	QS3	Dense - Very Dense	Grayish, light gray Clayey SAND

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

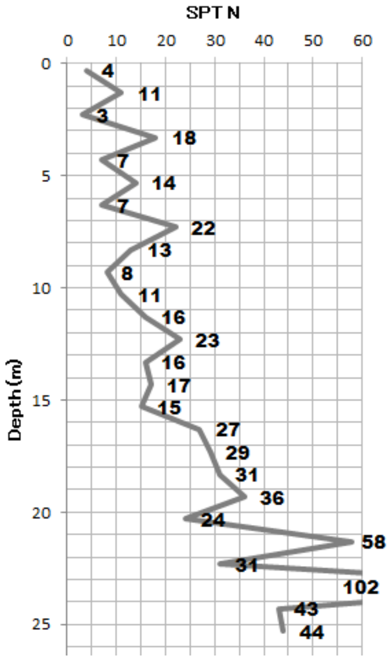


Figure 6.4-5 Br. 42

(2) Br. 44

Figure 6.4-6 shows stratification and distribution of SPT N-values at Br. 44. N-values increase with the depth gradually. Recorded groundwater table was GL-6.00 m.

Depth(m)	Thickness (m)	Strata	Apparent Density / Consistency	Description
3.00	3.00	QS1	Very Loose - Loose	Yellowish-red, yellowish Silty fine Sand with Gravel At the bottom, loose Clayey Sand
7.00	4.00	QC1	Soft - Stiff	Grayish Sandy CLAY
8.00	1.00	QS2	Medium Dense	Yellowish, grayish Clayey coarse SAND
15.00	7.00	QC2	Firm - Very Stiff	Grayish, yellowish CLAY with Sand (upper and bottom) or Sandy CLAY (lower)
21.00	6.00	QS3	Medium Dense - Dense	Yellowish, grayish, light gray Clayey coarse SAND
25.00	4.00	QC3	Very Stiff	Reddish-gray, reddish-yellow, light gray Sandy CLAY
25.45	0.45	QC4	Hard	White Sandy CLAY

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

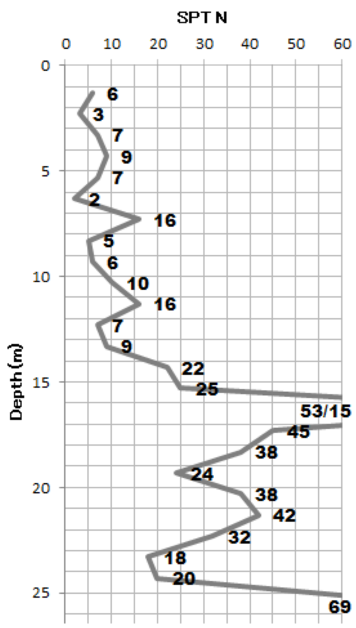


Figure 6.4-6 Br. 44

(3) Br. 47

Figure 6.4-7 shows stratification and distribution of SPT N-values at Br. 47. Clay is dominant in this borehole. N-values show sudden increase at the depth of 12 meters. Recorded groundwater table was GL-5.10 m.

Depth(m)	Thickness (m)	Strata	Apparent Density / Consistency	Description
4.00	4.00	QC1	Soft - Firm	Yellowish, grayish Sandy CLAY At the top, Sandy CLAY with Gravel
9.00	5.00	QS1	Loose - Medium Dense	Yellowish, grayish, dark gray fine to medium SAND. Coarsening-downward. At the top and 6~7m, Clayey SAND.
12.00	3.00	QC2	Stiff - Very Stiff	Reddish -gray, light gray, yellowish Sandy CLAY. At the top CLAY with Sand.
15.00	3.00	QC3	Hard	Reddish -gray, light gray, yellowish CLAY with Sand. At the top Sandy CLAY.
16.00	1.00	QS2	Very Dense	Grayish Silty coarse SAND
19.00	3.00	QC4	Hard	Yellowish, light gray CLAY with Sand. At the bottom, Sandy CLAY
21.00	2.00	QS3	Very Dense	Yellowish, light gray Clayey coarse SAND with Gravel
25.45	4.45	QC5	Hard	Yellowish, reddish-gray, light gray Sandy CLAY

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

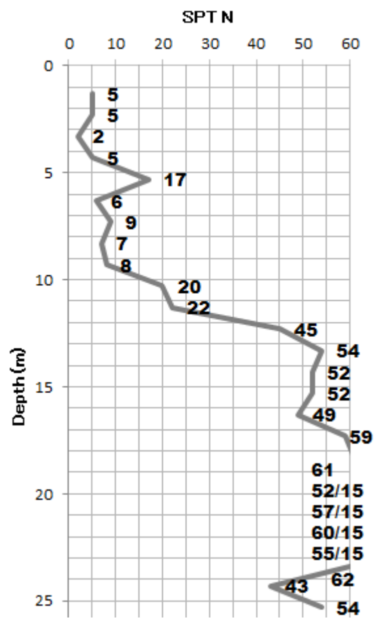


Figure 6.4-7 Br. 47

(4) Br. 48

Figure 6.4-8 shows stratification and distribution of SPT N-values at Br. 48. N-values show downward -increasing profile. Recorded groundwater table was GL-9.70 m.

Depth(m)	Thickness (m)	Strata	Apparent Density / Consistency	Description
2.00	2.00	QC1	Firm - Very Stiff	Yellowish, grayish Sandy CLAY with Gravel
3.00	1.00	QS1	Loose	Grayish, yellowish Silty fine SAND
11.00	8.00	QC2	Firm - Stiff	Yellowish, brownish, grayish CLAY with Sand, overlain and underlain by and interbedded with Sandy CLAY in the middle.
14.00	3.00	QS2	Medium Dense	Yellowish, yellowish-gray Clayey SAND, coarsening upward.
16.00	2.00	QC3	Stiff - Very Stiff	Light gray, yellowish, grayish-yellow Sandy CLAY
25.45	9.45	QC4	Hard	Yellow,white Sandy CLAY. At the top, CLAY with Sand.

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

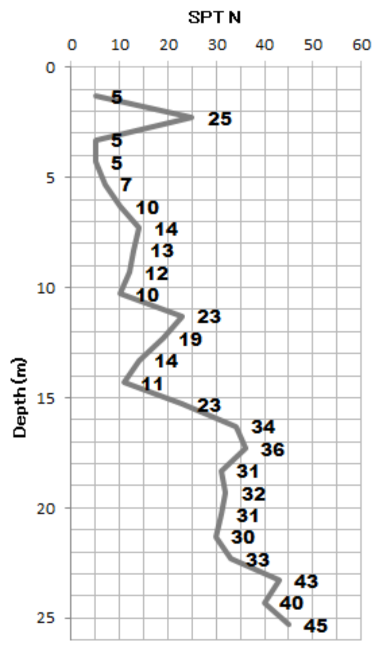


Figure 6.4-8 Br. 48

(5) Br. 50

Figure 6.4-9 shows stratification and distribution of SPT N-values at Br. 50. N-values increase downwards, except between GL-13 and 20 meters. Recorded groundwater table was GL-8.40 m.

Depth(m)	Thickness (m)	Strata	Apparent Density / Consistency	Description
2.00	*2.00*	QS1	Loose - Medium Dense	Reddish-bronw Clayey SAND with Gravel
9.00	*7.00*	QC1	Stiff - Very Stiff	Brownish, dark brown, light gray CLAY (upper) or Sandy CLAY (middle ~ lower)
12.00	*3.00*	QS2	Medium Dense - Dense	Grayish, light gray Clayey coarse SAND
13.00	*1.00*	QC2	Hard	Grayish Sandy CLAY
18.00	*5.00*	QC3	Stiff - Very Stiff	Grayish, yellowish, light gray CLAY with Sand 15~16m, Sandy CLAY
19.00	*1.00*	QS3	Medium Dense	Light gray, yellow Clayey SAND
20.00	*1.00*	QC4	Very Stiff	Light gray, yellow Sandy CLAY
25.45	*5.45*	QC5	Hard	Yellowish, light gray Sandy CLAY

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

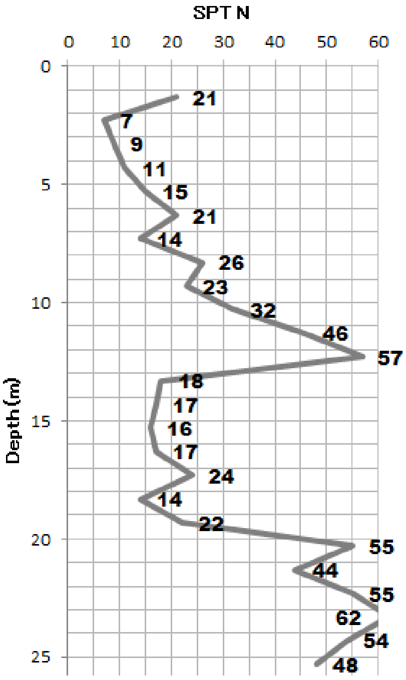


Figure 6.4-9 Br. 50

(6) Br. 55

Figure 6.4-10 explains stratification and distribution of SPT N - values at Br. 55. N - values increase slightly with the depth. Recorded groundwater table was GL-5.85 m.

Depth(m)	Thickness (m)	Strata	Apparent Density / Consistency	Description
5.00	*5.00*	QC1	Soft - Stiff	Reddish-brown, yellowish-gray CLAY with Sand or CLAY
8.00	*3.00*	QS1	Loose - Medium Dense	Yellow fine to medium SAND
11.00	*3.00*	QC2	Firm - Very Stiff	Yellow, gray Sandy CLAY
15.00	*4.00*	QS2	Medium Dense	Grayish, yellowish,light gray Cleyey fine to coarse SAND
20.00	*5.00*	QC3	Very Stiff - Hard	Yellowish, reddish-gray, light gray Sandy CLAY or CLAY with Sand
24.00	*4.00*	QCS1	Medium Dense - Dense / Very Stiff	Alternation of Clayey Sand and CLAY with Sand or Sandy CLAY, colored in gray and yellow.
25.50	*1.50*	QCS2	Dense / Hard	Alternation of Clayey Sand and CLAY, colored in gray, yellow, and brown.

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

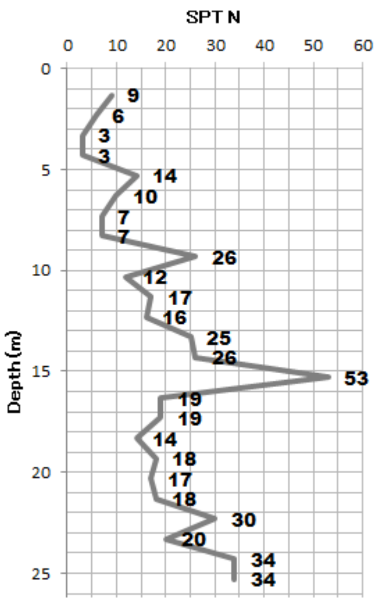


Figure 6.4-10 Br. 55

(7) Br. 57

Figure 6.4-11 shows stratification and distribution of SPT N-values at Br. 57. N-values increase downwards. Groundwater was not confirmed during the drilling.

Depth(m)	Thickness (m)	Strata	Apparent Density / Consistency	Description
4.00	*4.00*	QC1	Firm - Stiff	Brown, gray CLAY with Sand (upper) or CLAY (lower)
11.00	*7.00*	QC2	Very Stiff	Gray, brown, yellowish-brown CLAY with Sand
18.00	*7.00*	QS1	Medium Dense - Dense	Dark gray, yellowish-gray, yellow Clayey fine to coarse SAND
25.45	*7.45*	QC3	Hard	Grayish-brown, reddish gray CLAY with Sand

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

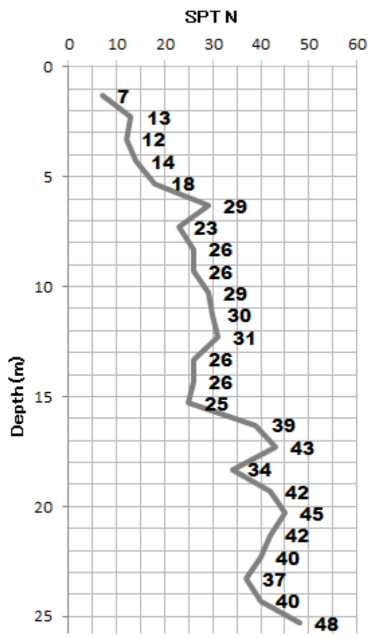


Figure 6.4-11 Br. 57

(8) Br. 58

Figure 6.4-12 shows stratification and distribution of SPT N-values at Br. 58. N-values increase with the depth gradually, except between GL-20 and 22 meters. Recorded groundwater table was GL-2.60 m.

Depth(m)	Thickness (m)	Strata	Apparent Density / Consistency	Description
2.00	*2.00*	QC1	Firm - Stiff	Brown, gray CLAY with Sand
7.00	*5.00*	QS1	Loose	Gray Clayey fine SAND, interbedded with in the middle and underlain by fine sand.
12.00	*5.00*	QC2	Firm - Stiff	Brown, gray CLAY with Sand
15.00	*3.00*	QC3	Stiff - Very Stiff	Yellow, brown CLAY with Sand
20.00	*5.00*	QC4	Very Stiff - Hard	Yellow, grayish-brown, reddish-yellow CLAY with Sand, 18~19m, Clayey SAND with Gravel, 19m~, Sandy CLAY
25.45	*5.45*	QS2	Medium Dense	Yellow, light gray, yellowish gray Clayey fine SAND

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

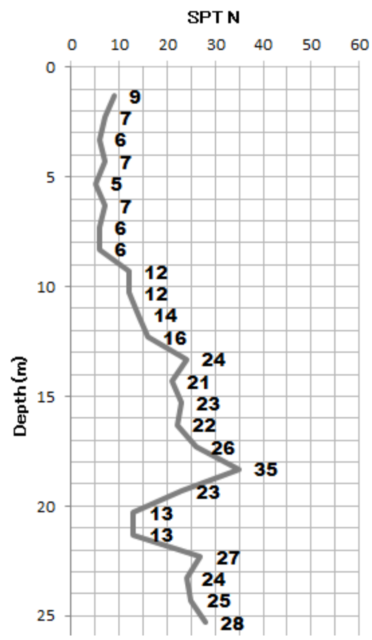


Figure 6.4-12 Br. 58

(9) Br. 59

Figure 6.4-13 shows stratification and distribution of SPT N-values at Br. 59. N-values show downward-increasing profile. The drilling encountered groundwater at GL-15.15 m.

Depth(m)	Thickness (m)	Strata	Apparent Density / Consistency	Description
3.00	*3.00*	QC1	Firm - Stiff	Upper: blown CLAY with Sand, lower: reddish-gray CLAY with Sand.
6.00	*3.00*	QS1	Medium Dense	Yellow Clayey fine SAND
15.00	*9.00*	QC2	Stiff - Very Stiff	Brown, gray, yellow CLAY with Sand (upper, middle) or Sandy CLAY (lower)
18.00	*3.00*	QS2	Medium Dense	Yellow, gray, light gray Clayey coarse SAND
25.45	*7.45*	QC3	Very Stiff - Hard	Gray, light gray, brown Sandy CLAY

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

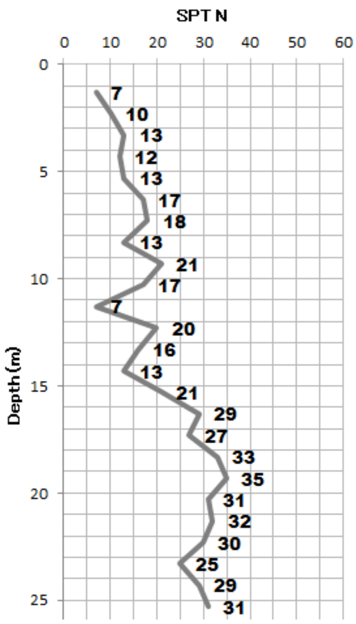


Figure 6.4-13 Br. 59

(10) Br. 66

Figure 6.4-14 shows stratification and distribution of SPT N-values at Br. 66. N-values increase with the depth gradually. Groundwater was not confirmed.

Depth(m)	Thickness (m)	Strata	Apparent Density / Consistency	Description
4.00	*4.00*	QC1	Stiff	Brown, dark brown, yellow CLAY with Sand 2~3m, Sandy CLAY
14.00	*10.00*	QC2	Stiff - Very Stiff	Brown, Yellow CLAY or CLAY with Sand
18.00	*4.00*	QS1	Medium Dense	Brown, yellow, light gray Clayey fine to medium SAND, coarsening-downward
20.00	*2.00*	QC3	Very Stiff	Brown, yellow, gray CLAY (upper) or CLAY with Sand (lower)
21.00	*1.00*	QS2	Very Dense	Reddish-gray Clayey SAND with Gravel
25.45	*4.45*	QC4	Very Stiff - Hard	Brown, yellow, gray CLAY with Sand or Sandy CLAY 24~25m, contains some gravel, 25~25.5m, CLAY

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

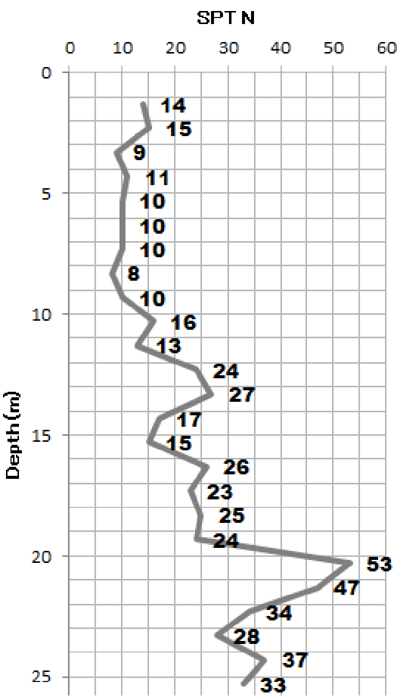


Figure 6.4-14 Br. 66

(11) Br. 68

Figure 6.4-15 shows stratification and distribution of SPT N-values at Br. 68. N-values increase gradually with the depth. The drilling encountered groundwater at GL-5.10 m.

Depth(m)	Thickness (m)	Strata	Apparent Density / Consistency	Description
3.00	*3.00*	QC1	Firm	Reddish-gray, gray Sandy CLAY
4.00	*1.00*	QG1	Medium Dense	Gray Clayey GRAVEL with Sand
7.00	*3.00*	QC2	Firm - Stiff	Gray, light brown CLAY with Sand or Sandy CLAY
8.00	*1.00*	QS1	Loose	Gray Clayey fine SAND
10.00	*2.00*	QC3	Stiff	Light brown, brown CLAY (upper) or Sandy CLAY (lower)
20.00	*10.00*	QC4	Stiff - Very Stiff	Brown, Yellowish-brown, gray CLAY (upper, lower) or CLAY with Sand (middle)
22.00	*2.00*	QC5	Very Stiff	Gray, yellow, brown CLAY with Sand
25.45	*3.45*	QC6	Hard	Gray, yellow, brown CLAY with Sand (upper) or CLAY (lower)

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

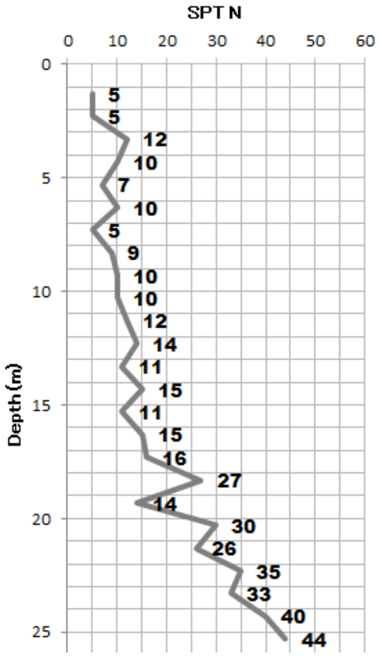


Figure 6.4-15 Br. 68

(12) Br. 75

Figure 6.4-16 shows stratification and distribution of SPT N-values at Br. 75. N-values increase gradually with the depth. Recorded groundwater table was GL-5.20 m.

Depth(m)	Thickness (m)	Strata	Apparent Density / Consistency	Description
3.00	*3.00*	QC1	Soft - Stiff	Dark gray organic CLAY with Sand (upper) or Sandy CLAY (lower)
11.00	*8.00*	QC2	Firm - Very Stiff	Reddish-gray, yellowish-red, dark brown CLAY with Sand or CLAY
19.00	*8.00*	QS1	Medium Dense	Gray, brownish-gray, light gray Clayey fine to coarse SAND 16~17m, Sandy CLAY
22.00	*3.00*	QC3	Very Stiff	Gray, brownish-gray, CLAY with Sand or CLAY 21~22m, Sandy CLAY
25.45	*3.45*	QC4	Hard	Gray, brownish-gray, CLAY with Sand (upper, lower) or CLAY (middle)

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

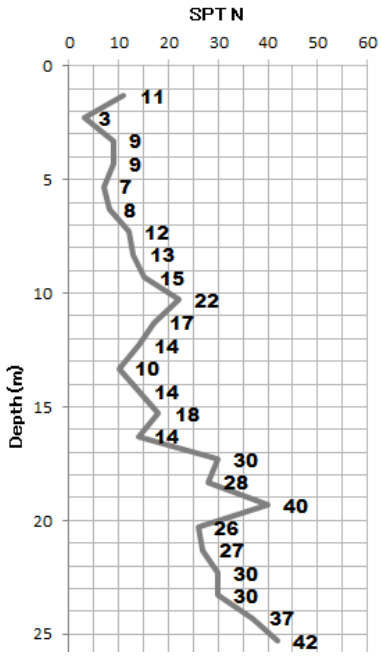


Figure 6.4-16 Br. 75

Laboratory Test

Laboratory tests were implemented utilizing disturbed and undisturbed samples obtained from the boreholes by SPT and undisturbed sampling, for the following test items:

· Specific Gravity	ASTM D 854 or equivalent
· Natural Moisture Content	ASTM D 2216 or equivalent
· Atterberg Limits	ASTM D 4318 or equivalent
· Sieve Analysis	ASTM D 422 or equivalent
· Unconfined Compression Test	ASTM D 2166 or equivalent

The results of the laboratory tests are attached to Appendix 6-9.

6.4.3 Geotechnical Characteristics of the Survey Area

(1) General

Throughout the Middle Section, NR 5 traverses the flat terrain at elevations of between 10 and 18 meters, except around KP 220 and between KP 270 and 280 near Battambang where elevations of the ground are lower than 10 meters. On the other hand, the flood plains surrounding the Great Lake mark elevations a little higher than 4 meters at the southern perimeter of the lake. Thus the flat terrain of NR 5 has distinct difference in elevation with the flood plain. Clear difference is also seen in the hardness of the soil observed at site between the flat terrain and the flood plains. These differences strongly support that the geological condition in the flat terrain of NR 5 is different from that of the flood plain.

Topographic information and site condition described above suggest the sediments of the flat terrain of NR 5 correspond to Middle Quaternary or Late Quaternary, whereas the flood plains, which was formed by the subsidence of the Great Lake Basin in recent several thousand years, is overlain by Holocene Alluvium. Along the NR 5, the sediments of Middle to Late Quaternary may be underlain by Pliocene - Pleistocene or Jurassic - Cretaceous sedimentary rocks.

Another point which may attract attentions is the distance from the marginal parts of the Caradamome Mountains, which stretch its ridges generally in NW - SE trend in the south of NR 5. Around Pursat, the distances between the road and the Caradamomes are 10 km or less, whereas in other sections such as around Battambang or Moung Ruessei, the distances reach around 30 km or more. In and around Pursat, therefore, Pliocene - Pleistocene or Jurassic - Cretaceous are expected to underlie Quaternary in shallower depths than in other sections of the road.

(2) Geotechnical Characteristics

As explained in the previous section, except shallower depths of the boreholes, the strata confirmed in the investigation show stiff or dense conditions which cannot be seen in Holocene Alluvium. In general, the strata show yellow, gray, and brown colors in SPT samples. White and whitish colors are also observed.

The strata often contain both clayey and sandy contents, the proportion of which varies by depths and locations. Thus, even though clay is predominant, alternation of clay and sand is dominant stratification in the area.

The strata occasionally include a small amount of gravels. In some parts, weathered gravels, which is often seen in the strata of Pleistocene or older, were confirmed in SPT samples.

From a geotechnical point of view, the strata of the sites provide favorable condition to be used as bearing layers for pile foundations, rather than unfavorable. Although desirable bearing layers for pile foundations such as layers with SPT N-values of N=50 or more are expected only in the very limited sites, layers with N-values of N=30 or more are confirmed in many locations.

Table 6.4-3 suggests candidates of bearing layers at each site, selected under the following conditions for bearing layers for pile foundations:

- SPT N-value of N=30 or more
- More than 5 meters thick
- No underlying soft layers

Table 6.4-3 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.

(3) Groundwater

Through the drilling on site, groundwater was carefully investigated. Drilling by a rotary auger used in the Study does not require circulation water for cooling drilling bits and evacuating slime and sludge from boreholes. Thus groundwater encountered in the bore holes can be easily detected by checking inner rods of auger pipes and drilling bits equipped at the tip of the inner rods. In addition, at each bore hole, groundwater table was checked one day after the completion of the drilling.

Table 6.4-4 summarizes groundwater condition at the sites.

At Br. 42, Br. 48, Br. 58, and Br. 75, the depths of water table were much shallower than the depths of emergence of groundwater. The strata where groundwater emerged were sandy layers or clayey layers with rich sandy contents and overlain by clayey layers. It is likely, therefore, that the groundwater at these sites is artesian water confined by the overlain clayey layers. Since the works were done in the rainy season, however, there was some possibility that rain water might flow into the boreholes during the period between the completion and the measurement of the water table and then raise the level of water table. Thus confirmation in D/D period is important.

At Br. 57, Br. 59, Br. 66, and Br. 68, water table was not confirmed.

At Br. 59, where drilling was done on the river bed, the depth of water table was unable to be checked, due to the river water flowing into the bore hole and filling it up to the ground level.

Table 6.4-4 Groundwater Condition

Bridge Site	Groundwater			Remark
	Encountered in Drilling (GL-m)	Strata	Watertable 1 Day After Drilling (GL-m)	
Br42	6.15	QC2	2.35	Artesian Water?
Br44	6.40	QC1	6.00	
Br47	5.00	QS1	5.10	
Br48	14.25	QC3	9.70	Artesian Water?
Br50	6.00	QC1	8.40	
Br55	6.00	QS1	5.85	
Br57	None		None	
Br58	4.40	QS1	2.60	Artesian Water?
Br59	15.15	QS2	None	River water flowed into the borehole.
Br66	None		None	
Br68	5.10	QC2	None	
Br75	13.00	QS1	5.20	Artesian Water?

6.4.4 Soil Parameter

Based on the SPT N-value measured at site and the results of laboratory tests, soil parameters of the sites were preliminary calculated. Calculated soil parameter was organized into Appendix 6-10.

(1) Specific Gravity, γt

Specific Gravity, γt , of soil was assumed from the commonly accepted table organized by Ministry of Land, Infrastructure, Transport and Tourism of Japan, shown in Table 6.4-5.

(2) Angle of Shear Resistance, φ

The angle of shear resistance of sandy soil was calculated from the SPT N-value. Figure 6.4-17 shows the way to estimate the angle of shear resistance with SPT N-value and effective overburden pressure.

According to the behavior of clay, angle of shear resistance is assumed to be null.

(3) Undrained Cohesion, c

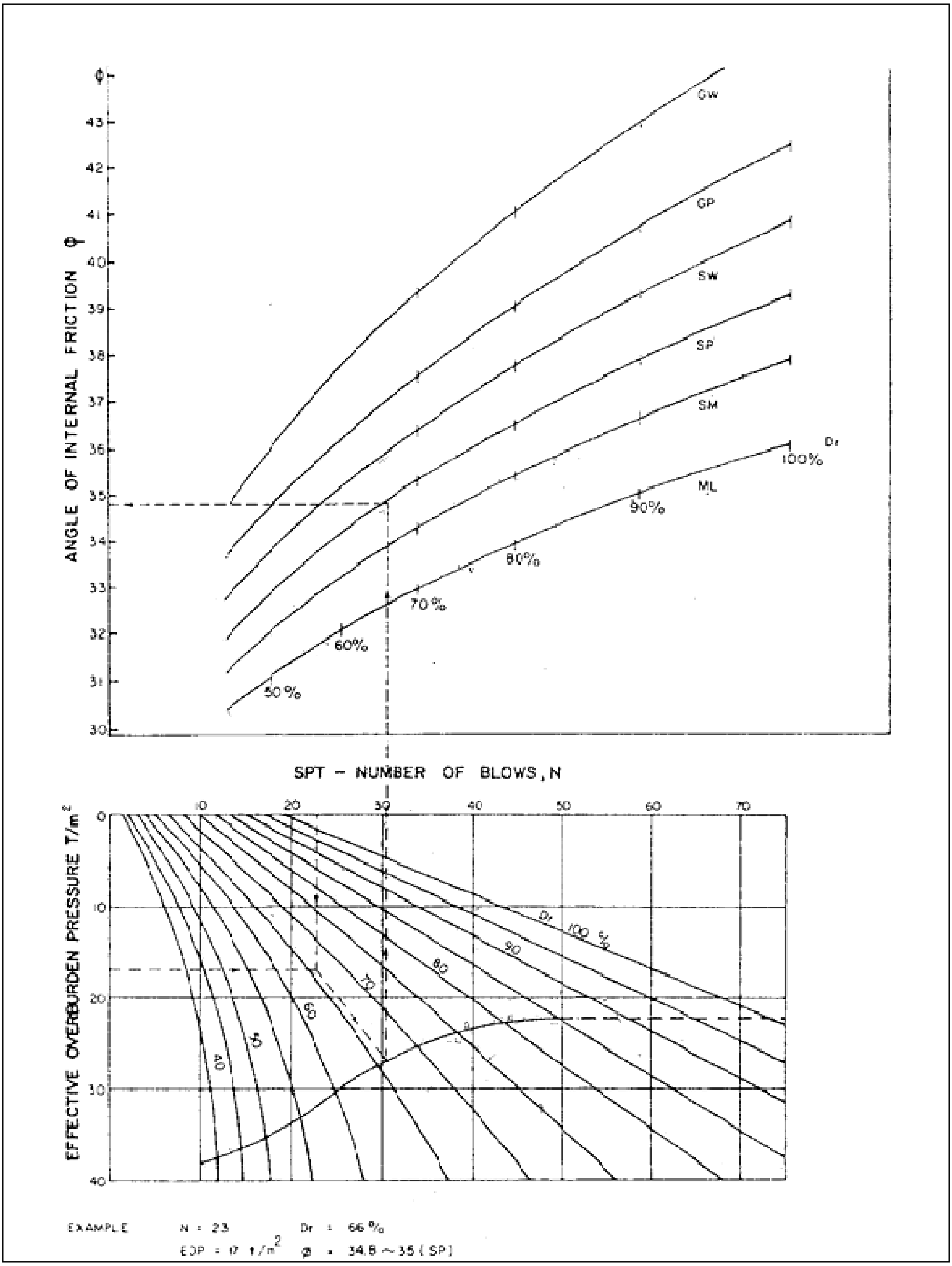
Undrained cohesion was estimated from the SPT N-value of clayey soil. Figure 6.4-18 shows the commonly accepted correlation between undrained cohesion and SPT N-value.

According to the behavior of free-draining materials, cohesion of sandy soil is assumed to be null.

Table 6.4-5 Soil Parameters by Ministry of Land, Infrastructure, Transport and Tourism of Japan

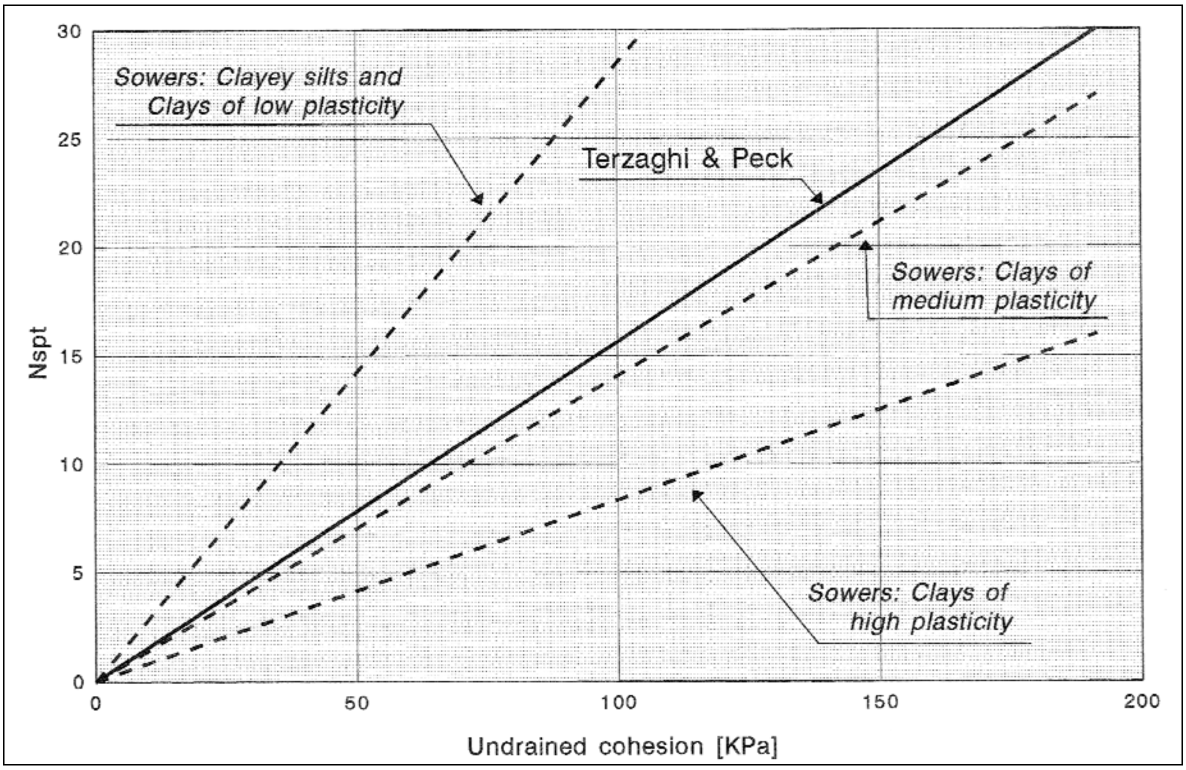
Soil Type		Status		Unit Weight (t/m3)	Angle of Internal Friction (º)	Cohesion (kN/m2)	Unified Soil Classification System
Artificial Ground	Gravel or Sand with Gravel	Well Compacted		2.0	40	0	GW, GP
	Sand	Well Compacted	Well-graded	2.0	35	0	SW
			Poorly-graded	1.9	30	0	SP
	Sandy Soil	Well Compacted		1.9	25	<30	SM, SC
	Clayey Soil	Well Compacted		1.8	15	<50	MH, ML, CH, CL
Natural Ground	Gravel	Well Compacted or Well-graded		2.0	40	0	GW
		Poorly Compacted or Poorly-graded		1.8	35	0	GP
	Sand with Gravel	Well Compacted		2.1	40	0	GW
		Poorly Compacted		1.9	35	0	GP
	Sand	Well Compacted or Well-graded		2.0	35	0	SW
		Poorly Compacted or Poorly-graded		1.8	30	0	SP
	Sandy Soil	Well Compacted		1.9	30	<30	SM, SC
		Poorly Compacted		1.7	25	0	
	Clayey Soil	Stiff (N = 8-15)		1.8	25	<50	ML, CL
		Medium Stiff (N = 4-8)		1.7	20	<30	
		Soft (N = 2-4)		1.6	15	<15	
	Clay or Silt	Stiff (N = 8-15)		1.7	20	<50	CH, MH, ML
		Medium Stiff (N = 4-8)		1.6	15	<30	
		Soft (N = 2-4)		1.4	10	<15	

Translated from: Road Design Manual, Kinki Regional Bureau, Ministry of Land, Infrastructure, Transport and Tourism of Japan



Source: Soil Mechanics Design Manual 7.01, Naval Facilities Engineering Command (Modified from: H.J.Gibbs & W.G.Holtz, 1957)

Figure 6.4-17 Determinations of Dr and φ, Based on SPT N Values



Source: Soil Mechanics Design Manual 7.01, Naval Facilities Engineering Command 7.01

Figure 6.4-18 Determination of Cohesion with SPT N Values

CHAPTER 7 PROBLEMS OF EXISTING ROAD CONDITION AND GENERAL SHCEME OF IMPROVEMENT

7.1 Problems of Existing Road Condition of NR 5

Based on the results of various surveys as cited above, the problems of current Middle Section and the Sri Sophorn – Poipet Section of NR 5 can be summarized as below:

7.1.1 Problems of Existing Road Condition of Middle Section

(1) Insufficient Road Width

- The average width of existing carriageway is 10.4 m. Because of the large volume of slow-speed traffic, such as motorumocks, agricultural tractors and motorcycles, high-speed traffic are forced to slow down. As a result, the efficiency of transport is reduced.
- This mixture of slow-speed traffic and high-speed traffic on a narrow carriageway is creating hazardous traffic situation. In view of the fact that widening of the adjacent sections on the both sides of the Middle Section (South Section and North Section) into full 4 lanes is being planned, it is preferable to widen the Middle Section into 4 lanes to maintain the same level of traffic safety.
- Forecasted traffic demand in 2033 on the section between Thlea Ma'am and Battambang is approximately 27,500 pcu/day. With this traffic volume on 10.4 m-wide carriageway, substantial traffic congestion is anticipated in the peak hours.
- Thus, widening to full 4-lanes will become necessary before year 2033.

(2) Weak Pavement Structure

- Existing pavement is DBST. Because of small bearing capacity of DBST, damages occur every year, especially after rainy season.
- Because of potholes and other defects, vehicles are forced to slowdown. This is causing great economic loss.
- MPWT is spending considerable amount of fund in repair of damaged pavement every year. This is imposing financial burden to the Royal Government of Cambodia (RGC) which can be reduced if the pavement is improved to asphalt concrete (AC).
- Thus, improvement of pavement to AC is needed.

(3) Insufficient Road Height

- Flood water flew over the road surface at some places of the Middle Section in October 2013, severely hampering the traffic. Such slow down and/or interruption resulted in substantial economic loss.

- Thus, raising the height of the road surface at the inundated sections is needed.

(4) Passing Through Urbanized Areas

- The existing NR 5 is passing through cities and towns, such as Pursat.
- This is undesirable not only from the viewpoint of traffic congestion but also from the viewpoint of traffic accident and air pollution.

7.1.2 Problems of Existing Road Condition of the Sri Sophorn – Poipet Section

(1) Insufficient Road Width

- The average width of existing carriage way is 11.0 m composed of 2-lane + MC lane in the rural areas. A carriage way with this width cannot provide with sufficient space for full 4-lanes.
- Forecasted traffic demand in 2033 on the Sri Sophorn – Poipet Section is approximately 25,500 pcu/day as it is forecasted in this Survey. A full 4-lane road is necessary to accommodate this traffic volume.
- Thus, widening to full 4-lane will become necessary before year 2033.

(2) Deteriorating Pavement Condition

- This section was improved and the surface was changed to AC pavement in 2008. The general condition of pavement is still good. However, six years has passed since the construction of the existing pavement and some defects such as cracks and ruts are observed on the surface of the road. (Please see in Chapter 4) It is supposed that rehabilitation of the pavement, such as re-paving or overlay, will become necessary in some years.
- Traffic volume on this section is increasing more rapidly than forecasted for the planning of the rehabilitation in 2008.
- Thus, it is recommended that reconstruction of pavement structure be delivered at the same time as its widening.

Considering these problems, general scheme of the improvement of the Middle Section and the Sri Sophorn – Poipet Section of NR 5 is proposed as presented in the following section:

7.2 General Scheme of Improvement of Middle Section and the Sri Sophorn - Poipet Section

The scheme of improvement of the Middle Section and the Sri Sophorn – Poipet Section is to be discussed and agreed upon between the RGC and JICA at the time of Loan Fact - Finding and Loan Appraisal. The followings are the proposals by the Survey Team to be used as the basis for discussion between RGC and JICA:

7.2.1 Section to be Improved

The surveyed roads are divided into four sections; Section I, II, III and IV as shown in Figure 7.2-1.

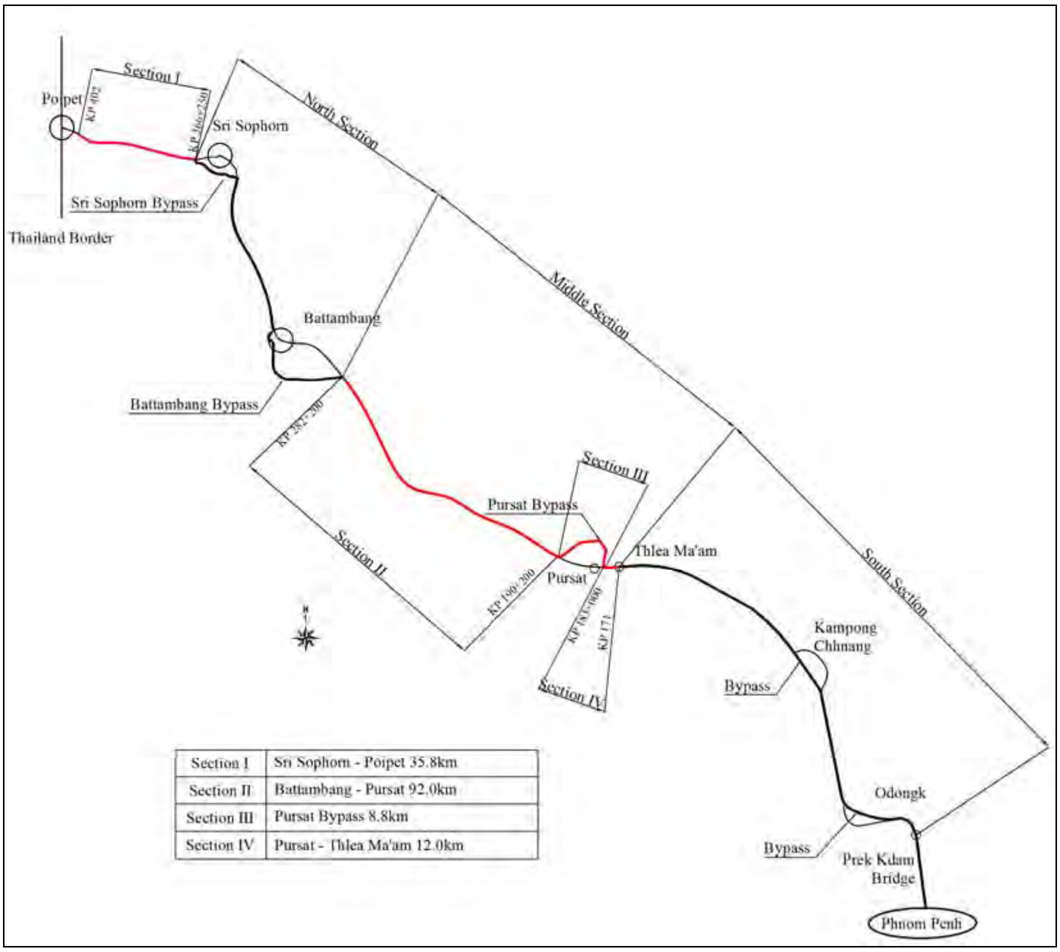


Figure 7.2-1 Section to be Improved

Section I (Sri Sophorn – Poipet Section):

The main scope of work of this section is widening into 4-lane and re-construction of pavement.

This section starts from KP 366+250 at the northern end of Sri Sophorn Bypass which is included in the project of the North Section and end at around KP 402 where the road has already been widened to 4-lane. This section covers planned connection point with the access road to/from the future border facilities between Thailand and Cambodia. The access road to/from the future border facilities is currently being studied by the government of Thailand and is expected to be constructed by the government of Thailand. Therefore, this project is planned not to include this access road.

Figure 7.2-2 shows the end point of this section. And, Figure 7.2-3 shows the detailed drawing of the end point.

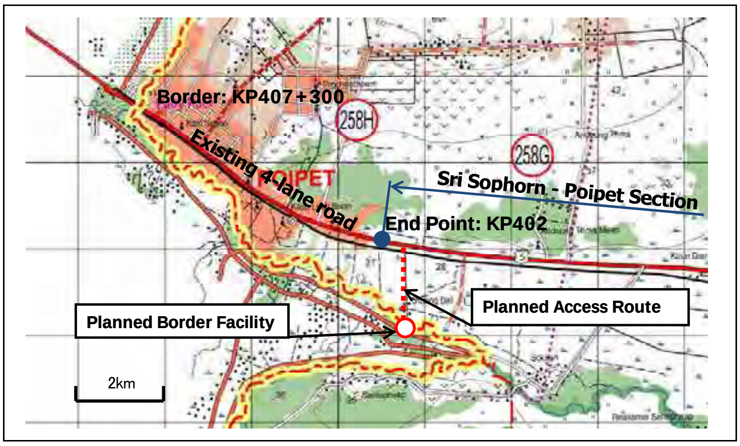


Figure 7.2-2 End Point of Sri Sophorn – Poipet Section

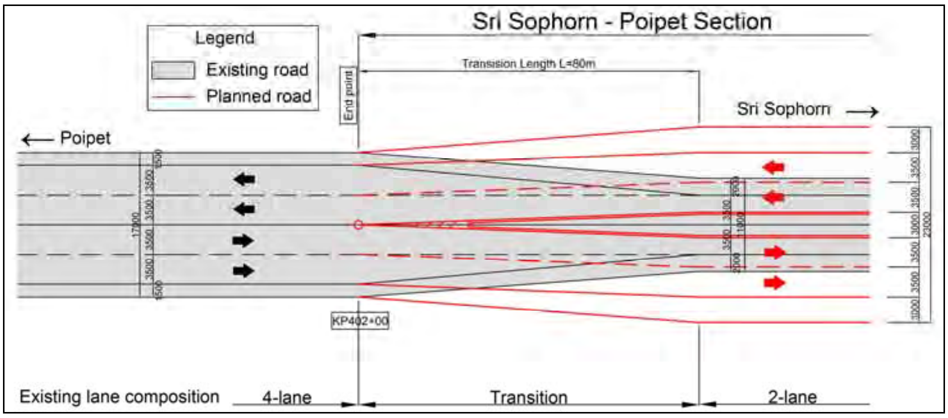


Figure 7.2-3 Plan Drawing of the End Point of Sri Sophorn – Poipet Section

Section II and IV:

The main scope of work of these sections is widening into 4-lane And improvement of pavement from DBST to AC.

Section IV starts from KP 171+000 in Thlea Ma'am at the end of the South Section and end at KP 183+000 which is the starting point of Pursat Bypass (Section III). Section II starts from KP 190+200 (the end point of Pursat Bypass) and end at KP 282+200 which is the starting point of Battambang Bypass, included in the project of the South Section.

Section III:

The main scope of work of this section is construction of Pursat Bypass.

This section is proposed as a bypass to avoid large scale relocation of households/buildings in the urbanized area of Pursat City which is required if this section of the existing NR 5 is to be widened.

7.2.2 Widening

It is proposed that the Middle Section and the Sri Sophorn – Poipet Section of NR 5 be widened into full 4-lane considering the following facts:

(1) Role of NR 5 and Modern Logistics

As discussed in Chapter 3, NR 5 as well as NR 1 and NR 4 is given a very important role in the road network of both Cambodia and GMS. Therefore, such national road needs to be widened into full 4-lane in order to lead to activation of logistics system of Cambodia. Modern logistics require reliable transportation infrastructure which can transport goods in the planned time. Carriage way of 10.4 m in width can accommodate only an opposed '2-lane with MC lanes' road and has little safety margin with regard to the capacity compared to a full 4-lane road. For example, a '2-lane with MC lanes' road is easily jammed if a severe traffic accident occurs and one lane is blocked. On the other hand, traffic in full 4-lane road can be operated even if one lane is blocked, by effectively utilizing remaining 3-lanes and shoulder. Thus, it is recommended that the whole section of NR 5 be widened into full 4-lane.

(2) Consistency of Design Standard

In most countries, uniform design standard is applied on the entire section of a road. Change in design standard often causes confusion on the side of drivers. Of course, design standard is adjusted depending of the planned/estimated traffic volume, terrain and other factors. In the case of the Middle Section and the Sri Sophorn – Poipet Section, estimated traffic volumes (approx. 27,500 pcu/day and approx. 25,500 pcu/day, respectively) are similar to those on the North Section and South Section which are being planned to be widened into full 4-lane road. In addition, the section between Phnom Penh and Prek Kdam is being widened into full 4-lanes. From viewpoint of consistency of road design standard, 4-lane cross section is recommended.

(3) Traffic Situation and Traffic Accident of NR 5

Accident rate of NR 5 is the highest among the single-digit national highways. The statistics of road crashes and casualties in Cambodia in 2011 are summarized in Table 7.2-1. These data/information are not of NR 5 but of the whole road network of Cambodia. However, the general features can be applied to NR 5. Thus, these statistics are considered to show the causes of traffic accidents of NR 5.

The principal causes of traffic accident in Cambodia are over-speeding, drunken driving, hazardous overtaking and not observing traffic rule. They account for approximately 80% of causes of motorbike or pedestrian fatalities. Fatalities of motorbike riders/passengers and pedestrians account for 79% of total fatalities. Human errors are often the main cause of these accidents. Traffic safety education and traffic regulation are deemed to be priority to reduce road crushes and casualties. While the education and regulation are expected to be developed, improvement of road structures should also contribute to reducing road crushes and casualties. Widening to full 4-lane is to separate slow traffic and fast traffic, and thus, reduces the necessity of overtaking.

Table 7.2-1 Summary of Statics of Road Crushes and Casualties in Cambodia in 2011

Percentage of Fatalities by Mode of Transport	Motorbike riders accounted for 66% of total fatalities, followed by pedestrians (13%) and drivers/passengers of passenger cars (8%).
Cause of Motorbike Fatalities	Over speeding accounted for 48%, followed by drunk driving (18%), dangerous overtaking (9%) and not observing priorities between vehicles/traffic flow (9%).
Cause of Pedestrian Fatalities	Over speeding accounted for 65%, followed by drunken driving (6%) and not observing priorities between vehicles/traffic flow (5%).
Percentage of Fatalities by Characteristic of Roads	80% of fatalities happened on straight roads, followed by curve roads (9%). 26% of fatalities on straight road occurred at urban.
Percentage of fatalities by type of collisions	Head-on collision accounted for 36% of the total fatalities, followed by rear-end collisions (16%), right - angle collisions (15%) and overturned/fell alone (12%).
Contribution Factors of Crashes and Fatalities	Human errors contributed to 95% of crashes and fatalities, while vehicle defects accounts for 3.2% and road environment for 1.7%.
Black spots on NR 5	- Nak Tahang and Takol village, Peani and Kampong Tralach commune, Kampong Tralach district, Kampong Chhnang province - Tram village, Tnaot Chum commune, Krakor district, Pursat province - Kbal Khmouch village, Chrey commune, Thmor Koul district, Battambang province - Kbal spean village, Poy Pet municipality, Ou Chrov district, Banteay Meanchey province

Source: "Road Crush and Victim Information System, 2011 Annual Report" issued by National Road Safety Committee.

The road improvement should include traffic control facilities that guide drivers observe the traffic rule. The following facts need to be addressed in planning the scale of improvement of the Middle section and the Sri Sophorn – Poipet Section.

- In rural areas, high speed vehicles tend to go into the opposite lane when they take over slow speed vehicles. Travelling in the opposite lane leads to high risk of serious crush. Physically blocking vehicles' travelling on the opposite lane is expected to substantially reduce serious crushes even if there are vehicles of over speeding and/or drunken driving on the road,. Thus, median division with adequate structure and width needs to be installed.
- There are few pedestrian crossings despite the fact that farmers with domestic animals such as cows or water buffalos cross the road. When the road improvement is completed, road crossing will become more dangerous for those farmers and cattle because vehicles' travelling speed will become higher and the road width will be wider. Thus, pedestrian crossings with traffic signs need to be provided at strategic locations.
- In urban areas, many pedestrians walk along the road and vehicles are parked on the road. In addition, pedestrians cross the road and vehicles turn to go in to the streets connected to NR 5. Considering these, the cross section in urban areas should be as follows:
  - Side walk needs to be provided
  - Parking space should be provided
  - Raised median should not be adopted to allow turning of vehicles.

(4) Structure of Median Division

Design of the structure of a median division is one of the most important design items to reduce traffic accidents. Raised median physically prohibits travelling on the opposite lanes and eliminates the risk of head-on collision. Type of median division is selected considering the following points.

・ Smooth traffic must be assured as the function of both national and international trunk road.

・Cross section and other aspects of geometric design should be distinguished between urban area and rural area because the traffic characteristics are different.

・ In rural area, the prime consideration is safe and smooth traffic with high speed (high mobility).

・In urban area, the prime consideration is accessibility to the connected roads and roadside houses/shops, as well as safety of pedestrians.

The following table shows the comparison of two types of median division. As a result, the type of "raised structure with curb stone" is selected provided that the following measures are adopted in order to improve the week points to the type of "double line with road stud/chatter bar".

・ U-turn lane shall be installed at a regular interval and at strategic locations.

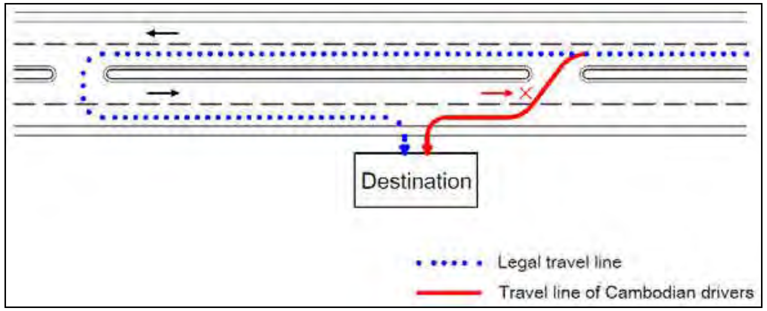
・ Opening in median should be provided at strategic locations.

Table 7.2-2 Comparison of Median Type

Median Type	Double Line only	Double Line with Road Stud/Chatter Bar	Raised with Curb Stone
Sample Picture			
Traffic Safety	**Poor:** Vehicles can easily go beyond the center line and cause head-on collision.	**Fair:** Drivers are discouraged to cross the median by shock when the wheel of the vehicle treads on the stud/chatter bar. Drivers are also warned if crossing the median unintentionally.	**Good (in general):** ・Vehicles are physically prohibited to go into the opposite traffic lane due by the curve. The function of visual guidance also. ・See the bottom box for negative influence.
Pedestrian Safety	**Poor:** Pedestrians are forced to cross the road in a hurry because of large width of full 4-lane.	**Poor:** Same as the left box.	**Good:** Openings of the median can be used as areas for pedestrians and ox carts to evacuate when they cross the road.
Emergency Traffic Operation	**Good:** Even if the carriageway in one direction is closed due to severe accident etc., minimum trafficability is secured by using remaining carriageway.	**Good:** Same as the left box.	**Poor:** If the carriageway in one direction is closed due to severe accident etc., traffic in that direction is stopped.
Travelling Performance	**Fair:** No structure is located at the median and that is normal road.	**Good:** Drivers think that oncoming vehicles of high speed do not come into their traffic lane but slow speed vehicles turning left or road crossing vehicles may disturb their driving.	**Excellent:** Drivers think that no oncoming vehicle or road crossing vehicle disturbs their driving, so driving speed can be kept high.

Median Type	Double Line only	Double Line with Road Stud / Chatter Bar	Mount up with Curb Stone
Access to Road Side Houses/Facilities	**Excellent:** Vehicles can turn left anywhere and there is no limitation for access to road side houses / facilities. Agricultural tractors or ox carts can cross the road easily anywhere.	**Excellent:** Same as the left box.	**Poor:** Access to road side houses/facilities are limited to openings of median.
Landscape	**Fair:** Normal road looking	**Fair:** Normal road looking	**Good:** Planting on the median is possible.
Cost Ratio to "Double Line with Road Stud/ Chatter Bar"	-----	**1.00**	**1.028**
Expected Ratio of Reduced Traffic Accident	-----	**68.7%** (Example rate of Rumble Strips applied in Japan) 	**91.7%** (Example rate of Mount Up Median with Fence applied in Japan) 

Negative influence: Cambodian drivers tend to turn to left and travel on the opposite lane before the location where they want to turn if tuning there is prohibited for some reason such as existence of median.



(5) Traffic Volume against Capacity

In the survey on South Section, the capacity of existing NR 5 was estimated at 19,000 pcu/day as the practical capacity of '2-lane with MC lanes' cross section which allows smooth traffic.

The estimated traffic volume on the Middle Section and the Sri Sophorn - Poipet Section in year 2033 are about 27,500 pcu/day and 25,500 pcu/day, respectively. These figures exceed the practical capacity of '2-lane with MC lanes' cross section as explained above.

(6) Proposed Road Cross Section

In addition to the considerations cited above, natural and social impacts and cost of the project are considered to select the cross section. Three alternatives of cross section are proposed including zero option as shown in the Table 7.2-3 and the comparison table for proposed road cross sections is shown in the Table 7.2-4.

Table 7.2-3 Alternatives of Cross Section

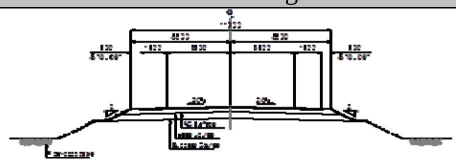
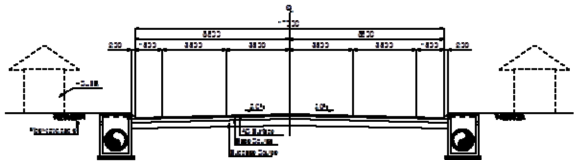
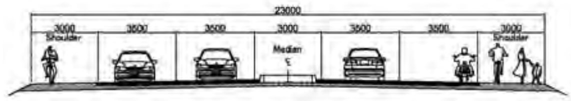
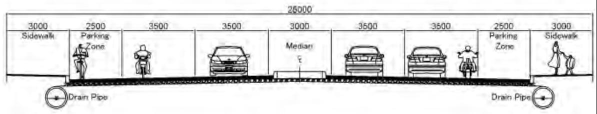
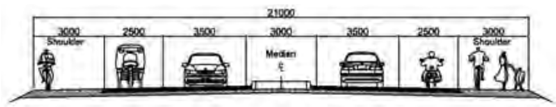
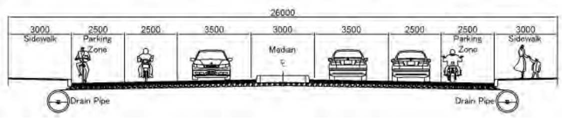
Alternative	Description	Schematic Diagram
ALT-0: Zero Option	No improvement of the road will be made.	 Rural Section  Urban Section
ALT-1: Widening road to full 4-lane and pavement improvement	Smooth traffic will be ensured against the future traffic volume. Slow speed vehicles such as motorcycles and bicycles will be separated from high speed vehicles such as passenger cars, resulting in improvement of traffic safety.	 Rural Section  Urban Section
ALT-2: Widening road to 2-lane with MC lanes and pavement improvement	Likewise ALT-1, smooth traffic will be ensured against the future traffic volume. Slow speed vehicles such as motorcycles and bicycles will be separated from high speed vehicles such as passenger cars resulting in improvement of traffic safety. However, the width of MC lane for slow speed vehicles is narrower than the lane width of ALT-1 (3.5 m) to reduce the impact to social and natural environment and the project cost.	 Rural Section  Urban Section

Table 7.2-4 Comparison of Alternatives of Improvement of Existing NR 5

Evaluation Rank 1st: ◎、2nd: ○、3rd: △、Improper: ×

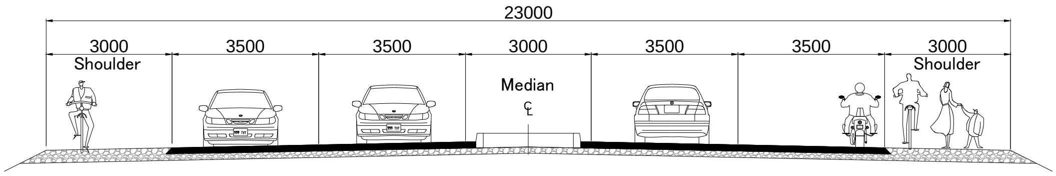
Alternative	ALT-0: Zero Option	ALT-1: Widening Road to full 4-Lane and Pavement Improvement	ALT-2: Widening Road to 2-Lane with MC Lanes and Pavement Improvement
Traffic Characteristic			
Predicted Traffic Volume	Middle Section : 14,200 pcu/day in 2023 : 20,800 pcu/day in 2028 : 27,500 pcu/day in 2033	Sri Sophorn – Poipet :15,600 pcu/day in 2023 :20,200 pcu/day in 2028 :25,500 pcu/day in 2033	
Capacity of Traffic Volume (pcu)	× 19,000	◎ 40,000	× 19,000
Natural Environmental Impact			
Natural Environmental Impact	◎ There is no impact.	○ No great impact is anticipated since this project is widening of the existing road and project site is considerably distant from Tonle Sap Lake and its important natural reserves. However, minor negative impact may occur and diligent consideration to minimize the impacts is required.	○ Same as ALT-1.
Social Impact			
Resettlement, Loss of Agricultural Land	◎ No resettlement will be required. And, no loss of agricultural land is anticipated.	△ Large-scale resettlement is required. And, agricultural land along the road will be lost for by the road.	○ Although they will be less than ALT-1, resettlement of a great number and replacement of agricultural land will arise.
Impact on Living Environment/Pollution	× As traffic volume increases in the future, traffic congestion is likely to occur. In that case, average driving speed will be slower and the increased stop and go will result in increase in the fuel consumption. This will cause increase in emission of air-pollutants.	◎ It is not likely that traffic congestion will arise if traffic volume increased in the near future. Therefore increase of car exhaust will be prevented.	○ It is same as ALT-1 basically but the capacity of traffic is smaller than ALT-1. Therefore, traffic congestion will arise earlier than ALT-1 and emission of air-pollutants will increase.

Alternative	ALT-0: Zero Option	ALT-1: Widening Road to full 4-Lane and Pavement Improvement	ALT-2: Widening Road to 2-Lane with MC Lanes and Pavement Improvement
Access to Public Service Facilities	△ Traffic will be not smooth and it will take more time to access schools, hospitals, etc.	◎ Access to public services, such as schools and hospitals, will become easier as a result of smooth traffic.	○ Easiness of access to public services is basically same as ALT-1, but will be deteriorated earlier than that in ALT-1.
Impact on Socio-Economic Activity	× Hindered smooth traffic will hinder socio-economic activities. Then, it will hamper the regional and national development.	◎ Smooth traffic will enhance socio-economic activities and regional development. The income level of the roadside areas will be upgraded due to improvement of employment opportunity and consumption of local goods during the construction work.	○ Basically same with ALT-1 but the traffic capacity is smaller than that in ALT-1. Therefore, traffic congestion will occur earlier than ALT-1 and affect the socio-economic activities.
Traffic Safety			
Vehicle to Vehicle	× Narrow carriageway width may result in accidents when vehicles overtake.	◎ Slow speed traffic, such as agricultural tractors, and high speed traffic, such as passenger cars, will be separated and traffic safety will be improved. Possibility of serious accidents such as head-on collision will be decreased by elimination of necessity of overtaking using the lane in opposite direction.	○ Traffic safety will be improved, to less extent than that of ALT-1, because slow speed traffic and high speed traffic will be separated (but to less extent than in ALT-1). Possibility of serious accidents such as head-on collision will be decreased by decrease of necessity for overtaking by using the opposite lane. Possibility of accidents for pedestrians when crossing the road is smaller than that of ALT-1 because the carriageway width is narrower than that of ALT-1.
Dangerousness of Crossing Road by Pedestrians/Farm a Animals	◎ Possibility of accidents when pedestrians/farm animals crossing road is the lowest among all of the alternatives because the carriageway	◎ Level of safety approximately same to that of ALT-0 will be achieved with installation of sufficiently wide median where pedestrians	◎ Level of safety approximately same to that of ALT-0 will be achieved with installation of sufficiently wide median.

Alternative	ALT-0: Zero Option	ALT-1: Widening Road to full 4-Lane and Pavement Improvement	ALT-2: Widening Road to 2-Lane with MC Lanes and Pavement Improvement
	width is the narrowest.	and animals can stand and wait passage of vehicles. However, traffic accidents of pedestrians crossing the road hit by high-speed vehicles may increase because of increased speed of vehicles.	
Road and Traffic Function	× As traffic volume increases, traffic congestion will occur and smooth traffic will not be achieved.	◎ Sufficient traffic capacity and smooth traffic will be achieved.	○ Traffic capacity of this alternative is smaller than that of ALT-1, therefore, traffic congestion of this alternative will occur earlier than that of Alt-1 and road widening will be needed again.
Economy			
Construction Cost	◎ No project cost is required.	△ Project including cost for resettlement, cost for road widening and cost for improvement of pavement. is necessary.	○ Cost for this alternative is smaller than that of ALT-1 since the work volume is smaller than that of ALT-1, resulting in reduced cost for resettlement and construction works.
Maintenance Cost	△ Middle Section: Fragile exiting pavement (DBST) is maintained resulting in high maintenance cost. Sri Sophorn – Poipet Section: The existing road was rehabilitated in 2008. Sin the design life period of AC pavement is usually 10 years, rehabilitation with overlay or reconstruction will be necessary in a few years.	◎ Maintenance cost will be decreased because the pavement is improved to durable AC.	◎ Maintenance cost will be decreased because the pavement is improved to durable AC.

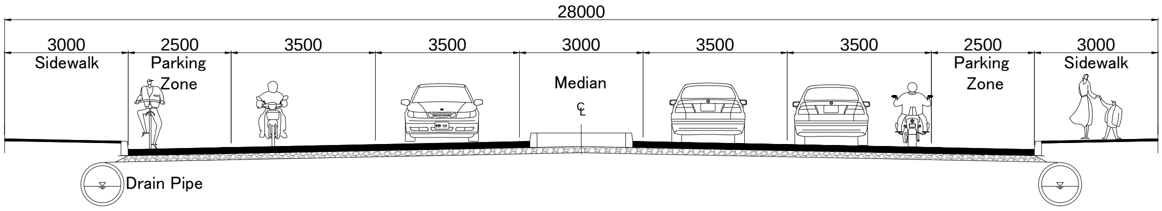
Alternative	ALT-0: Zero Option	ALT-1: Widening Road to full 4-Lane and Pavement Improvement	ALT-2: Widening Road to 2-Lane with MC Lanes and Pavement Improvement
Total Evaluation	×	◎ (Recommended)	○
	ALT-1 is the highest in the total evaluation, and is recommended. Views on the evaluation items of ALT-1 that are evaluated lower compared to other alternatives are as follows. ・“Construction Cost” of ALT-1 is the largest, however ALT=1 yields largest socio-economic benefits. ・Negative social impacts (resettlement and loss of agricultural land) and negative natural environmental impact of ALT-1 is larger than those of other alternatives. However these impacts are considered to be the minimum for achieving the objectives of the Project (achieving socio-economic development of Cambodia and enhancing integration of regional economy through enhancing transport capacity, improving transport efficiency, and improving traffic safety).		

With the considerations as cited above, it is proposed to widen the existing NR 5 into full 4-lanes with raised median division. Figure 7.2-4 and 7.2-5 show the proposed typical cross sections.



Raised Median (w=3.0 m) + full 4-lane Carriageway (w=3.5 m)
+ Shoulder (w=3.0 m)

Figure 7.2-4　Proposed Cross Section (Rural Area)



Raised Median (w=3.0 m) + full 4-lane Carriageway (w=3.5 m)
+ Parking Zone (w=2.5 m) + Sidewalk (w=3.0 m)

Figure 7.2-5　Proposed Cross Section (Urban Area)

7.2.3　Horizontal Alignment of Road

The Middle Section and the Sri Sophorn – Poipet Section of NR 5 will be improved basically maintaining the present road centerline. However, horizontal alignment of some sections of the road not satisfying the minimum radius of curve will be improved.

7.2.4　Elevation of Road Surface

The elevation of most parts of the existing road surface of the Middle Section is more than 1.0 m higher than flood water level of Tonle Sap. Nevertheless, it was observed in October 2013 that water flew over the road at some sections. The elevation of the flood water is discussed in Chapter 6 "6.1.5 Study of the Flood in 2013". Elevation of the road surface and installation of new drainage facilities are planned based on the study on the flood water level.

7.2.5 Improvement of Pavement Structure

The pavement of the Middle Section is DBST. DBST does not possess sufficient bearing capacity against the heavy traffic which is rapidly increasing in recent years. Also, in the smoothness of surface, DBST is inferior to AC. For these reasons, it is proposed that pavement structure be improved to AC.

On the other hand, the pavement of the Sri Sophorn – Poipet Section is AC. Five years have passed since the pavement of this section was constructed, and some defects such as cracks, potholes and flushes are observed. The design period of this section is supposed to be over within five years. It is proposed that the pavement structure of this section be reconstructed considering the strength of subgrade of the road and the future traffic volume.

7.2.6 Route of Pursat Bypass

The section between KP 184 and KP 188 is passing through the urbanized area of Pursat City. Widening of this section requires resettlement of large number of houses/households. Thus, construction of a bypass was studied.

The existing alignment of this section is almost straight. If a bypass is constructed to detour the city, the travel distance unavoidably becomes longer than that in the existing alignment. However, construction of a bypass is the practical solution to avoid the large scale resettlement needed for widening of the existing NR 5.

Five alternative routes were planned and compared. Figure 7.2-6 shows alternative routes.

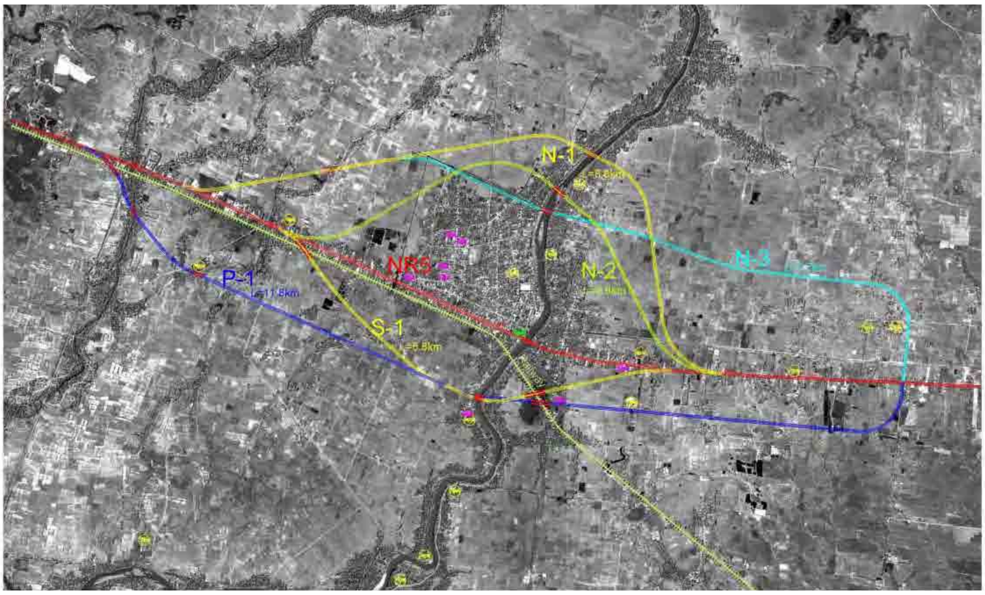


Figure 7.2-6 Alternative Routes of Pursat Bypass

One of the important points in evaluating the alternative routes is that the railroad is passing on the southern periphery of the city which is somewhat hindering the development of urban area towards south. If the bypass is to pass the southern side of the city, two flyovers need to be constructed to avoid at-grade railroad crossing which is not preferable from the viewpoint of traffic safety. Construction of flyover requires considerable amount of cost.

On the other hand, if the bypass is to traverse the northern outskirt of the city, the route becomes longer than the routes passing the southern outskirt of the city. Also, the northern routes are closer to Tonle Sap Lake than southern routes.

Table 7.2-5 compares the advantage and disadvantage of the alternatives. Alternative N-2 was evaluated by the JICA Survey Team as the most practical route. On the other hand, the local government (Pursat Province) preferred to allow future expansion of the urbanized area.

After the discussion between the JICA Survey Team and RGC counterparts, ie MPWT and DPWT of Pursat, “N-1” route was selected. MOWRAM was consulted on the route of N-1 and replied that N-1 route is acceptable since it traverses the transition zone of Tonle Sap Biosphere Reserve where residential houses already exist and agriculture is being done. Figure 7.2-7 shows the selected route of Pursat Bypass.

It is proposed that the section of existing NR 5 which runs parallel to the bypass be excluded from the scope of “the Middle Section Improvement Project”.

Table 7.2-5 Comparison of Alternative Routes of Pursat Bypass

Evaluation Rank 1st: ◎、2nd: ○、3rd: △、Improper: ×

Alternative	Widen Existing NR 5	N-1	N-2	N-3	S-1	P-1
Description	Widen existing NR 5.	Long detour route on the north side of the city.	Short detour on the north side of the city.	Plan intersections of BP with NR 5 at the roundabouts with monument which are located 5 km or more distant from the urbanized area.	Short detour on the south side of the city. Flyovers are constructed for railroad crossings at 2 locations.	Plan intersections of BP with NR 5 at the roundabouts with monuments which are located 5 km or more distant from the urbanized area. Flyovers are constructed for railroad crossing at 2 locations.
Natural Environmental Impact						
Impact on Natural Environment	◎ There is no big impact.	○ The biosphere might be split because new road will be constructed in the outskirt. Construction of a new road in the suburbs of the existing town area may accelerate expansion of urbanized area.	○ Mostly same as N-1.	○ Mostly same as N-1.	○ Mostly same as N-1.	○ Mostly same as N-1.
Social Impact						
Resettlement, Loss of Agricultural Land	× Widening of existing road passing town area still cause much resettlement. Resettlement is the largest among all the alternatives. Loss of agricultural	◎ Magnitude of resettlement is the smallest because this route is the farthest from the town. Loss of agricultural land is the 3rd smallest because the length of the route is the 3rd shortest.	× Magnitude of resettlement is the second largest. Loss of agricultural land is the second smallest because the length of the route is the second	× Resettlement is the third largest. Loss of agricultural land is relatively large because the length of the route is the second longest.	△ Resettlement is the third smallest. Loss of agricultural land is the smallest because the length of the route is the shortest.	○ Resettlement is the second smallest. Loss of agricultural land is the largest because the length of the route is the longest.

Alternative	Widen Existing NR 5	N-1	N-2	N-3	S-1	P-1
	land is minimum.		shortest.			
Impact on Living Environment / Pollution	○ Traffic passing the town will make more noise, vibration and air pollution.	◎ Traffic passing through the town will decrease and noise, vibration and pollution in the town will decrease. Noise, vibration and air pollution will be newly created on the bypass but times of stopping and starting will be decreased. Total impact on the living environment will be smaller compared to that in "Widen Existing NR 5".	◎ Mostly same as N-1.	◎ Mostly same as N-1.	◎ Mostly same as N-1.	◎ Mostly same as N-1.
Impact on Socio-Economic Activity	○ Efficiency of transport is lower than those of other alternatives because vehicles passing the town need to stop at traffic signals.	◎ Smoother traffic than that of "Widen Existing NR 5" will enhance socio-economic activities and promote development of the region.	◎ Same as N-1.	◎ Same as N-1.	◎ Same as N-1.	◎ Same as N-1.
Traffic Safety						
Traffic Safety	× Increased number of vehicles passing the town will worsen the situation of traffic accidents.	◎ Number of traffic accidents in the town will decrease because of decreased number of vehicle passing the town. Meanwhile, traffic accidents in the bypass will occur newly but the total number of traffic accidents will decrease	◎ Same as N-1.	◎ Same as N-1.	◎ Same as N-1.	◎ Same as N-1.

Alternative	Widen Existing NR 5	N-1	N-2	N-3	S-1	P-1
		because the bypass does not pass the urbanized area.				
Traffic Function						
	○	○	○	△	○	△
Advantage	・Shortest travel distance	・ Smooth connection with existing NR 5 ・ The function of bypass can be maintained for long time in the future even if the urbanized area will expand.	・ Smooth connection with existing NR 5	・ Intersections are sufficiently remote from the urbanized area and remain outside of the urbanized area.	・ Increase in travel distance is the smallest. ・ No serious influence to future expansion of the urbanized area.	・ Intersections are sufficiently remote from the urbanized area and remain outside of the urbanized area.
Disadvantage	・ Vehicles passing the town will stop at traffic signals. ・ Time required for pedestrians to cross the road will become longer resulting in increase in stopping time of vehicles while waiting the pedestrians crossing the road.	・ Travel distance will be the longest.	・ The function of the bypass may be reduced as the urbanized area will expand and be close to the bypass in the near future. ・ Travel distance is the second longest.	・ Vehicles are forced to slow down at the intersection on the east which is T-shaped with roundabout.	・ Steep longitudinal grade on the both sides of the flyovers for railroad crossing.	・ Vehicles are forced to slow down at the intersection on the east which is T-shaped with roundabout. ・ Steep longitudinal grade on the both sides of the flyovers for railroad crossing.
Acceptance by PAPs						
Acceptance by PAPs	◎ People along the road generally welcome the road improvement because:	○ People having land along bypass generally welcome because: ・ The land price becomes	○ Mostly same as N-1.	○ Mostly same as N-1.	○ Mostly same as N-1.	○ Mostly same as N-1.

Alternative	Widen Existing NR 5	N-1	N-2	N-3	S-1	P-1
	・ The land price becomes higher, ・ Smooth traffic will be ensured and access to school, hospital, etc. becomes easier, ・ Dust from road is mitigated.	higher, ・ Smooth traffic is ensured and access to schools hospital, etc. becomes easier.				
Economy						
Construction Cost	◎	△	○	×	×	×
Numeric Data						
Length (km) of construction (BP) + improvement (NR 5)	10.8	12.5	11.9	11.8	11.6	11.8
Length (km) of Bypass	---	8.8	7.7	10.4	5.8	11.8
No. of Houses to be Relocated	240	17	78	55	25	18
Total Cost (US$ Million)	22.6	35.3	31.1	37.7	49.4	60.9
BP. Construction	0	29.4	24.3	33.8	41.9	58.1
Widen NR 5	20.2	3.3	4.5	1.2	5.2	0
Resettlement	2.4	1.3	1.4	1.1	1.4	1.1
Land Acquisition	0	1.3	1.0	1.6	0.9	1.8
Total Evaluation		◎ (Recommended)	○	△		
	"Widen Existing NR 5" is not recommended because; the number of houses to be relocated is very large (around 240), although the impact on natural environment of this alternative is minimal,. Alternatives "S-1" and "P-1" are not recommended because; these alternatives pass the southern side of the city crossing the railroad at two location. This result in very high construction costs compared to other alternatives passing the northern side of the city.					

Alternative	Widen Existing NR 5	N-1	N-2	N-3	S-1	P-1
	Thus, N-1, N-2 and N-3 are compared. N-1 has the following advantages to N-2 and N-3: ・N-1 can allow future expansion of the city with maintaining the function of the bypass for a long time because its route is located distant from the exiting urbanized area. ・Number of houses to be relocated is the minimum Considering the above, N-1 is recommended.					

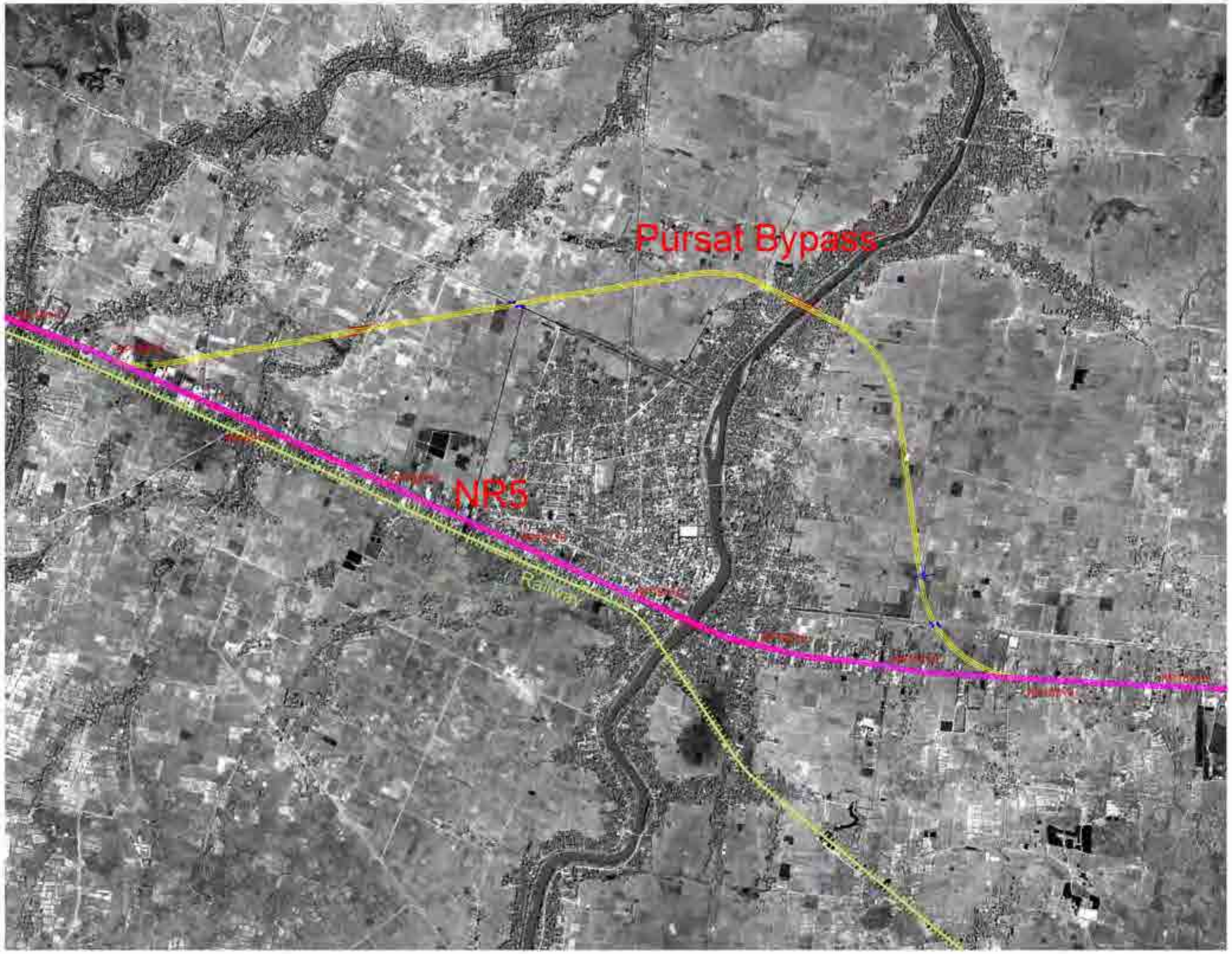


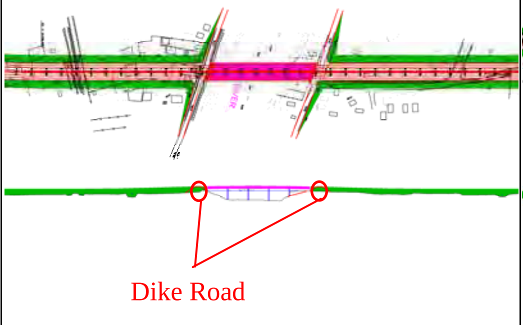
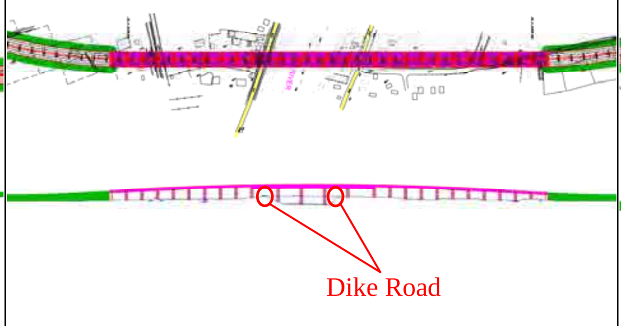
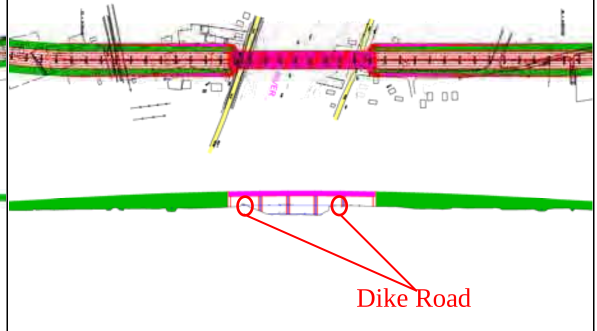
Figure 7.2-7 Selected Route of Pursat Bypass

7.2.7 Bridge over the Pursat River in Bypass

Pursat Bypass needs to cross Pursat River. There are roads on the both banks of the river. Whether or not the bypass be connected to these roads needs careful examination. If these roads on the banks of Pursat River are connected to the bypass with at grade intersection, traffic speed on both the bypass and roads on the river banks will unavoidably reduced due to stop at the intersection. On the other hand, grade separation of these roads need raising of the height of the bridge of the bypass and lead to increase in the construction cost.

Three alternatives for crossing of Pursat River were evaluated as follows and Grade Separation -1 was selected.

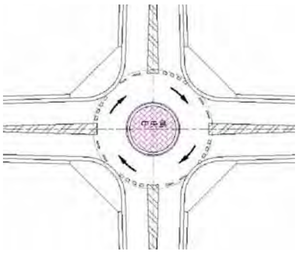
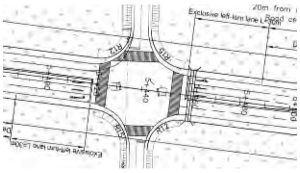
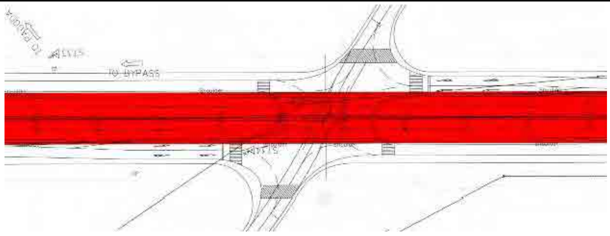
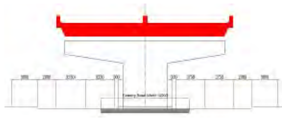
Table 7.2-6 Comparison of Alternatives for Crossing of Pursat River

	At Grade	Grade Separation-1	Grade Separation-2
Plan Longitudinal Cross Section			
Length	Embankment Road: L=8,410 m Bridge: L= 137.5 m (5@27.5)	Embankment Road：L=7,910 m Bridge: L= 695 m (9@25+42+3@27+42+11@25)	Embankment Road：L=8,468 m Bridge: L= 195 m (42+3@27+42)
Characteristics (Community Separation, Flood, Ventilation, etc.)	･Embankment of road will split the community. Box culverts to be installed will have little effect for preventing community separation. ･Area near the road will not be well-ventilated. ･Unexpected flood may break the road embankment.	･Viaduct constructed in place of embankment road will mitigate the community split. ･Area near the road will be well-ventilated. ･Unexpected flood will not affect the road structure.	･Embankment of road will split the community. Box culverts to be installed will have little effect for preventing community separation. ･Area near the road will not be well-ventilated. ･Unexpected flood may break the road embankment.
Traffic Condition	･Traffic flow from the dyke roads will affect the smooth traffic of the bypass. Traffic volume of the dyke roads is approximately 7,000 veh./day.	･The bypass will function well without disturbance of traffic from the dyke roads.	
Construction Cost	USD 36 million	USD 49 million	USD 39 million
Recommendation		○	

7.2.8 Improvement of Intersection

Traffic management at the intersection is studied in order to enable smooth traffic and traffic safety for NR 5 and access road to NR 5. Common types of intersections and their characteristics are shown in Table 7.2-7.

Table 7.2-7 Typical Intersection

	Intersection without traffic signal (Roundabout etc.)	Normal Intersection with/without traffic signal	Grade-Separated Intersection
Image figure	 **Plan**	 **Plan**	 **Plan**  **Profile**  **Cross section**
Characteristic	・ Delay at intersection is small. ・ Capacity of traffic volume is about 1,000 vehicles / hour. ・ Necessary land space is bigger than normal intersection.	・ Delay at intersection is large. ・ Capacity of traffic volume of normal intersection with traffic signal is bigger than that without traffic signal, including roundabout. ・ Necessary land space is smaller than that of roundabout.	・ Capacity of traffic volume is the largest. ・ The traffic flow (straight-going) can be separated from the traffic entering the at-grade intersection. ・ Traffic signal is required at the ground level

In this survey, normal intersection without traffic signal is adopted in the highway design, considering the forecasted traffic volume which can be accommodated by signalized intersections. However, grade-separated intersection may become necessary in the long future.

7.2.9 Manner of Widening of Road to Minimize Resettlement

The land within 30m from the centerline of the road on the both sides has been designated as the right of way (ROW) of the road. However, there are some houses within this boundary of the ROW. The density of houses increases as the distance from the road centerline increases. Contrarily, the density of houses is relatively low near the road (see Figure 7.2-8). Actually, many houses are located near the boundary of ROW (30 m from the road centreline).

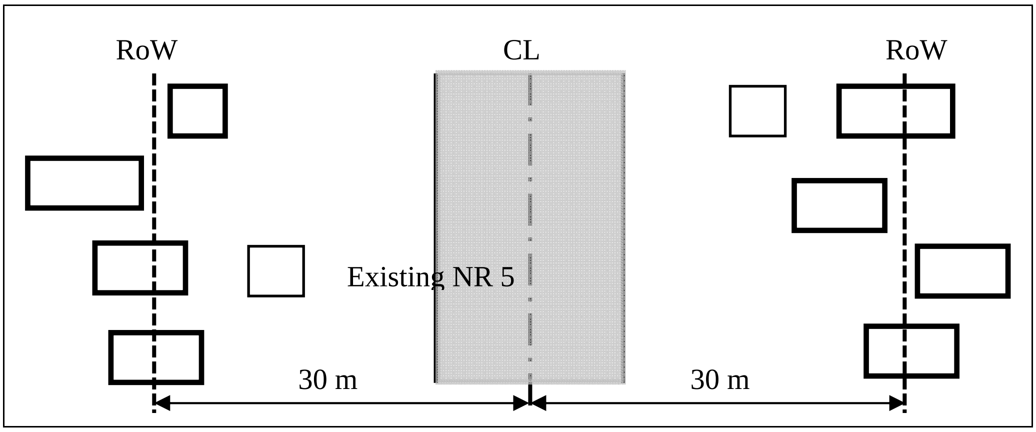


Figure 7.2-8 Schematic Illustration of Density of Houses with Regard to Distance from Centerline of Road

The total width of land required for widening to 4-lane on one side, including embankment slopes is calculated to be approximately 20 m, as shown below:

Carriageway (travel lane + median) + Shoulder: 11.5 m (23 m rural section; see Figure 7.2-4) /2
Embankment Slopes (1 side): 6 m (= H 3 m x Slope 1:2.0)
Margin for construction works: 2 m
Total: 19.5 m

If the road is widened equally on the both sides, the density of houses located in the land to be acquired for widening is generally low. Contrarily, if the road is widened on one side, the land to be acquired needs to extend to the area with relatively high house density. Table 7.2-8 schematically illustrates this situation.

Table 7.2-8 Comparison of Widening Methods on the Road

	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	

Considering such situation of houses to be relocated, widening is basically planed on the both sides.