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

PREPARATORY SURVEY FOR NATIONAL ROAD NO. 5 IMPROVEMENT PROJECT (PREK KDAM- THLEA MA'AM SECTION) IN THE KINGDOM OF CAMBODIA

FINAL REPORT

NOVEMBER 2013

JAPAN INTERNATIONAL COOPERATION AGENCY
KATAHIRA & ENGINEERS INTERNATIONAL

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LOCATION MAP OF SURVEY AREA

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS (1/3)

AC	: Asphalt Concrete
ADB	: Asia Development Bank
AH	: Affected Household
AP	: Affected People
ASEAN	: Association of South East Asian Nations
BC	: Beginning Curve
BP	: Bypass
Br	: Bridge
CBR	: California Bearing Ratio
CF	: Community Fishery
COM	: Council of Ministers
CRIP	: Cambodia Road Improvement Project
CS	: Construction Stage
DBST	: Double Bituminous Surface Treatment
DE	: Department of Environment
DEIA	: Department of Environmental Impact Assessment
DMS	: Detailed Measurement Survey
DPWT	: Department of Public Works and Transport
EC	: End Curve
EFRP	: Emergency Flood Rehabilitation Project
EIA	: Environmental Impact Assessment
ESC	: Environmental and Social Considerations
GDP	: Gross Domestic Product
GDI	: Gender-related Development Index
GEM	: Gender Empowerment Measure
GII	: Gender Inequality Index
GMS	: Grater Mekong Subregion
GRC	: Grievance Redress Committee
HV	: Heavy Vehicle
ICD	: International Cooperation Department (of MPWT)
I-DMS	: Initial Detailed Measurement Survey
IEIA	: Initial Environmental Impact Assessment
IG	: Welded Steel Plate I Girder
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

TABLE OF ABBREVIATIONS (2/3)

IRP	: Income Restoration Program
Jct.	: Junction
JICA	: Japan International Cooperation Agency
kN	: kilo Newton
KP	: Kilometer Post
LA (L/A)	: Loan Agreement
LV	: Light Vehicle
MAFF	: Ministry of Agriculture, Forestry and Fisheries
MC	: Motorcycle
MEF	: Ministry of Economic and Finance
MLMUPC	: Ministry of Land Management, Urban Planning and Construction
MOC	: Ministry of Commerce
MOE	: Ministry of Environment
M/P	: Master Plan
MPWT	: Ministry of Public Works and Transport
MRC	: Mekong River Commission
N.A.	: Not Applicable
NGO	: Non-Governmental Organization
NR	: National Road No.
OD	: Origin Destination
ODA	: Official Development Assistance
PAP(s)	: Project Affected Person(s)
PC	: Pre-stressed Concrete
PCDG	: Pre-tensioned Precast Concrete Deck Girder
PCS	: Pre-tensioned Precast Concrete Plank hollow Slab
PCU	: Passenger Car Unit
PMO	: Prime Minister’s Office
PMU	: Project Management Unit
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
PS	: Planning Stage
RAMP	: Road Assets Management Project
RAP	: Resettlement Action Plan
RC	: Reinforced Concrete

RD	: Resettlement Department (of MEF)

TABLE OF ABBREVIATIONS (3/3)

RCA	: Reinforced Concrete Arched Rib
RCDG	: Reinforced Concrete Deck Girder
RCS	: Reinforced Concrete Flat Slab, also Replacement Cost Survey
RGC	: Royal Government of Cambodia
RGDP	: Regional GDP
ROW	: Right of Way
SBST	: Single Bituminous Surface Treatment
SHM	: Stakeholder Meeting
SPT	: Standard Penetration Test
SS	: Service Stage
STRADA	: System for Traffic Demand Analysis
UNDP	: United Nations Development Plan
USDA	: United States Department of Agriculture
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 major cities such as Kampong Chhnang and Battambang. It is also designated as Asian Highway No.1 or the Southern Economic Corridor of the Greater Mekong Sub-region (GMS). However, the road surface type is mostly double-layered bituminous surface treatment (DBST) and the surface condition is being deteriorated due to rapidly increasing heavy vehicles, as well as inundation/flood. In particular, North Section and South Section require urgent rehabilitation in view of insufficient road width and poor pavement condition.

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 and South Section of NR 5. The survey by the consultant team started in February 2011. As the result of this survey, the North Section (Battambang-Sri Sophorn: 68 km) and two bypasses (Battambang and Sri Sophorn) were selected as the high priority sections. Agreement for Japanese ODA (official development assistance) loan for the project of improving/constructing the North Section and the two bypasses were signed by Royal Government of Cambodia (RGC) and Japanese Government in May 2013.

After improvement of the North Section and construction of the two bypasses had been selected as high priority project, severe flood occurred in September 2011, and many parts of the South Section were damaged. Thus RGC and JICA agreed to conduct Survey on the South Section.

1.2 Objective of the Survey

This Preparatory Survey is implemented for the rehabilitation project of South Section of NR 5 to obtain data and information required for appraisal of loan project of Japanese ODA, such as the objectives, outline, project cost, implementation schedule, implementation organization, maintenance system and natural and social impacts.

1.3 Survey Area

The Survey Areas are provinces of Kandal, Kampong Speu, Kampong Chhnang, & Pursat.

1.4 Scope of Work

To achieve the above objectives, the following tasks are to be carried out:

(i) Collection of Basic Information regarding the Project: Information to be used in evaluation of the current condition of the South Section and the designing of road improvement are collected. Kinds of information to be collected include the following:

- Laws, regulations and standards of transport sector
- Current site condition (pavement condition, road width, roadside land use etc)
- Natural condition (climate, hydraulic and hydrological data/information, geotechnical data, topographic survey: to be used in road design)

(ii) Traffic Survey and Traffic Demand Forecast

- Survey of current traffic volume, OD survey and future traffic demand forecast
- Travel speed survey (to obtain the baseline data for monitoring of project effect, as well as to find out traffic bottlenecks)
- Axle load survey (to obtain data to be used in pavement design)

(iii) Study of Scheme of Road Improvement

- Based on the obtained data and forecasted traffic demand, optimum scheme of improvement of the South Section is studied and discussed.

(iv) Proposal and Discussion on Road Improvement

- The optimum scheme of improvement of the South Section is proposed and discussed between the Cambodian side and the Japanese side.

(v) Preliminary Design

- Based on the agreed scheme of improvement, a preliminary design of improvement is prepared. This design includes road appurtenances.

(vi) Implementation Plan of the Project

- Implementation schedule
- Organization plan for project implementation
- Operation & maintenance system
- Working plan of consulting services

(vii) Cost Estimation of Project Summary Cost

- Project cost shall be estimated and compared with other similar road projects.

(viii) Evaluation of the Project

- Economic indicators such as economic internal rate of return (EIRR), benefit/cost (B/C) ratio and net present value (NPV) are calculated and justification of the Project is examined.

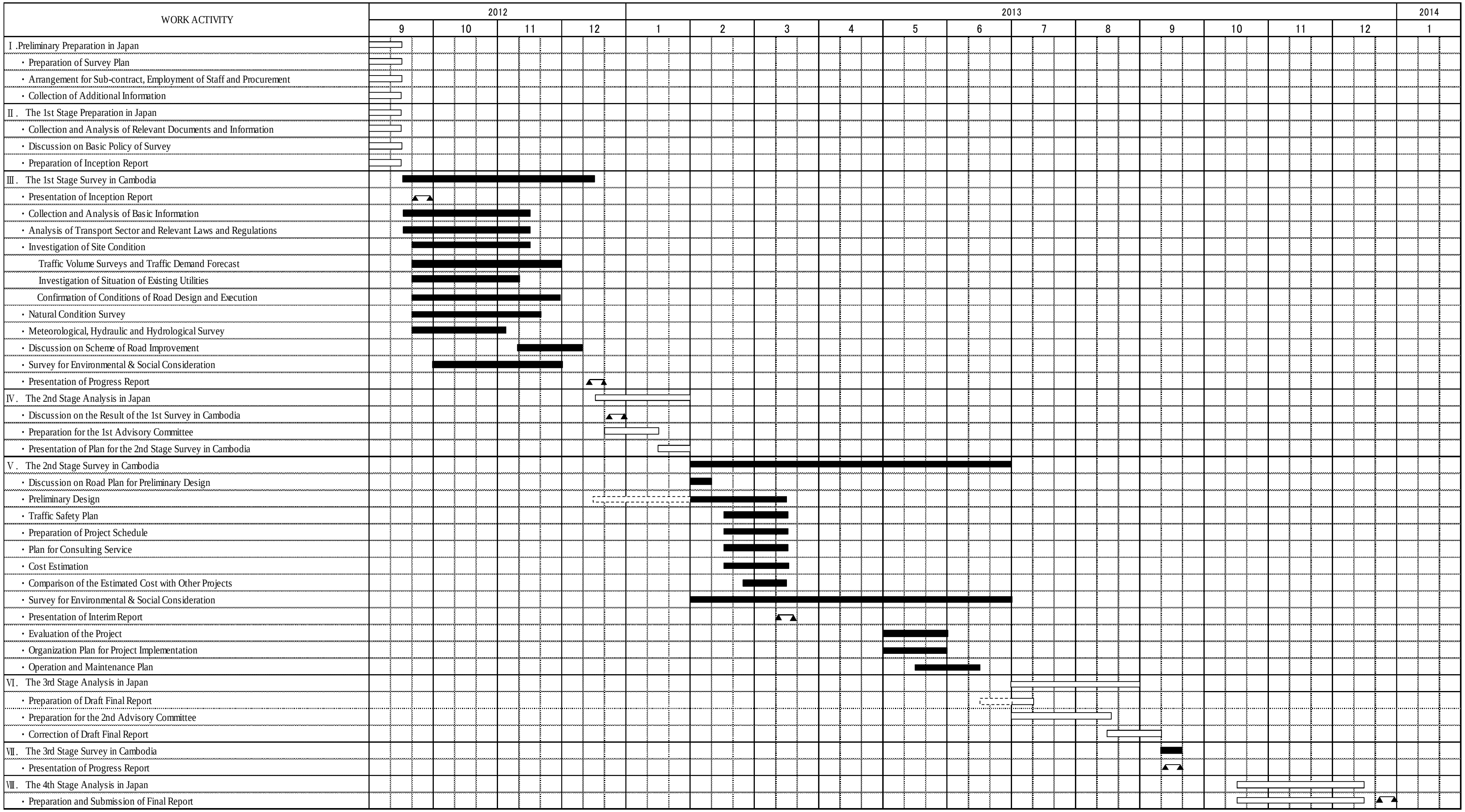
(ix) Investigation for Environmental and Social Consideration

- According to the JICA's Guideline on Environmental and Social Consideration, an environmental impact assessment (EIA) report and Resettlement Action Plan (RAP) need to be prepared. The EIA report needs to be approved in accordance with the legislation of Cambodia. The Survey Team is to assist the Ministry of Public Works and Transport (MPWT) in preparing draft EIA report and application for certification by the Ministry of Environment (MOE). The Survey Team is also to assist MPWT in preparing RAP.

1.5 Survey Schedule

The survey on the South Section was started in September 2012. The First Steering Committee was held on 25 September 2012 and the Inception Report was explained and discussed. The 4th Steering Committee was held in August 2013 where the Draft Final Report (DFR) was presented and discussed. Table 1.5-1 in the next page shows the general schedule of the Survey. The Final Report will be prepared after receiving comments by the RGC on the DFR.

Table 1.5-1 Schedule of the Survey



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.

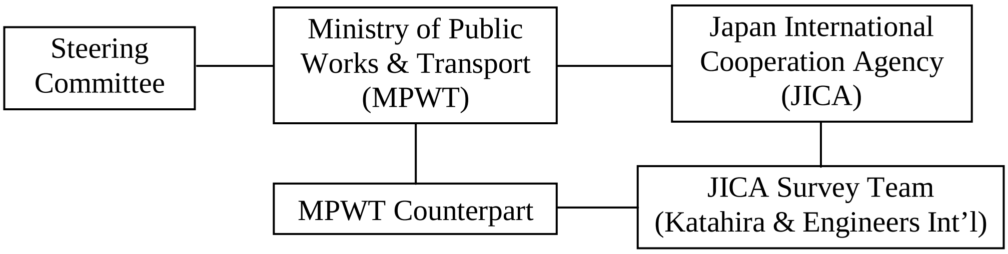


Table 1.6-1 Member List of Steering Committee (As of commencement of the Survey)

Institution	Name	Position
Ministry of Public Works & Transport (MPWT)	H.E. Tauch Chankosal	Secretary of State, Chairperson
	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
Ministry of Economy & Finance (MEF)	H.E. Chan Sothy	Deputy Secretary General, Investment and Cooperation
	Mr. Pao Yutha	Deputy Director, Investment and Cooperation
	Mr. Sim Samnang	Deputy Director, Resettlement Department
Ministry of Environment (MOE)	Mr. Oung Vuthy	Deputy Director,
Kandal Province	Mr. Lim Kimni	Deputy Director, General Affairs
	Mr. Soun Reng	Deputy Director, Road & Bridge Div., DPWT
Kampong Speu Province	Mr. Van Sokha	Director, General Affairs
	Mr. Som Sothea	Deputy Director, DPWT
Kamopong Chhnang Province	Mr. Ouk Dim	Director, General Affairs
	Mr. Yem Vanna	Deputy Director, DPWT
Pursat Province	Mr. Hun An	Director, General Affairs
	Mr. Ting Kuong	Deputy Director, DPWT
JICA Headquarter	Mr. FUKUI Takanori	Deputy Director, Transport and ICT Division 2, Economic Infrastructure Department
	Mr. NAKANO Akihiko	Southeast Asia Division 4, Southeast Asia & Pacific Department
JICA Cambodia Office	Mr. HIRATA Hitoshi	Senior Representative
	Mr. EGAMI Masahiko	Representative
	Mr. SAY Bora	Program Officer
JICA Survey Team	Mr. SAKURAI Tatsuyuki	Team Leader,
	Mr. MURAKAMI Keiichi	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 and the Project of Improvement of South Section:

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

Name	Position	Remarks
JICA Headquarter (in Tokyo)		
MIYAKE Shigeki	Director, Transport and ICT Division 2, Economic Infrastructure Department	
FUKUI Takanori	Deputy Director, Transport and ICT Division 2, Economic Infrastructure Department	Up to July 2013
TSUCHIHASHI Toru	Transport and ICT Division 2, Economic Infrastructure Department	From July 2013
KANEKO Yutaro	Ditto	
FUKAWA Kensuke	Director, Southeast Asia Division 4, Southeast Asia and Pacific Department	
NAKANO Akihiko	Southeast Asia Division 4, Southeast Asia and Pacific Department	Up to July 2013
NO Daichi	Ditto	From July 2013
KAWANO Takaaki	Director, Environmental and Social Consideration Division, Credit Risk and Environmental Review Department	
UEMATSU Kyoko	Environmental and Social Consideration Division 1, Credit Risk and Environmental Review Department	Up to June 2013
HANAI Akane	Ditto	From June 2013
JICA Cambodia Office		
HIRATA Hitoshi	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
MURAKAMI Keiichi	Deputy Team Leader/Road Engineer	KEI
MIZUTANI Jyun	Bridge/Structure Planer	KEI
NISHINO Ken	Traffic Survey/Demand Forecast Specialist	KEI
YASHIRO Syuuichi	Economic Analysis Specialist	KEI
WATANABE Kanji	Environmental Consideration Specialist	KEI (Seconded)
YAMASHITA Akira	Social Consideration/Resettlement Plan Specialist	KEI (Seconded)
OKAMOTO Youichi	Natural Condition Survey Specialist	KEI
SAKAEBARA Keiichi	Hydrological & Hydraulic Survey Specialist	KEI
YAMAUCHI Masafumi	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 Bankgkok.

Figure 2.1-1 Location of NR 5

(2) Topography

Figure 2.1-2 shows the topography of Cambodia. The ground height along NR 5 between Prek Kdam and Thlea Ma'am is, in general, around 10 – 15 m above sea level, except at some sections (KP 43 – 81, KP 109 – 113 and KP 108 – Pursat) passing terraced terrain where ground height is more than 15 m. Thus, the terrain along NR 5 is generally flat.

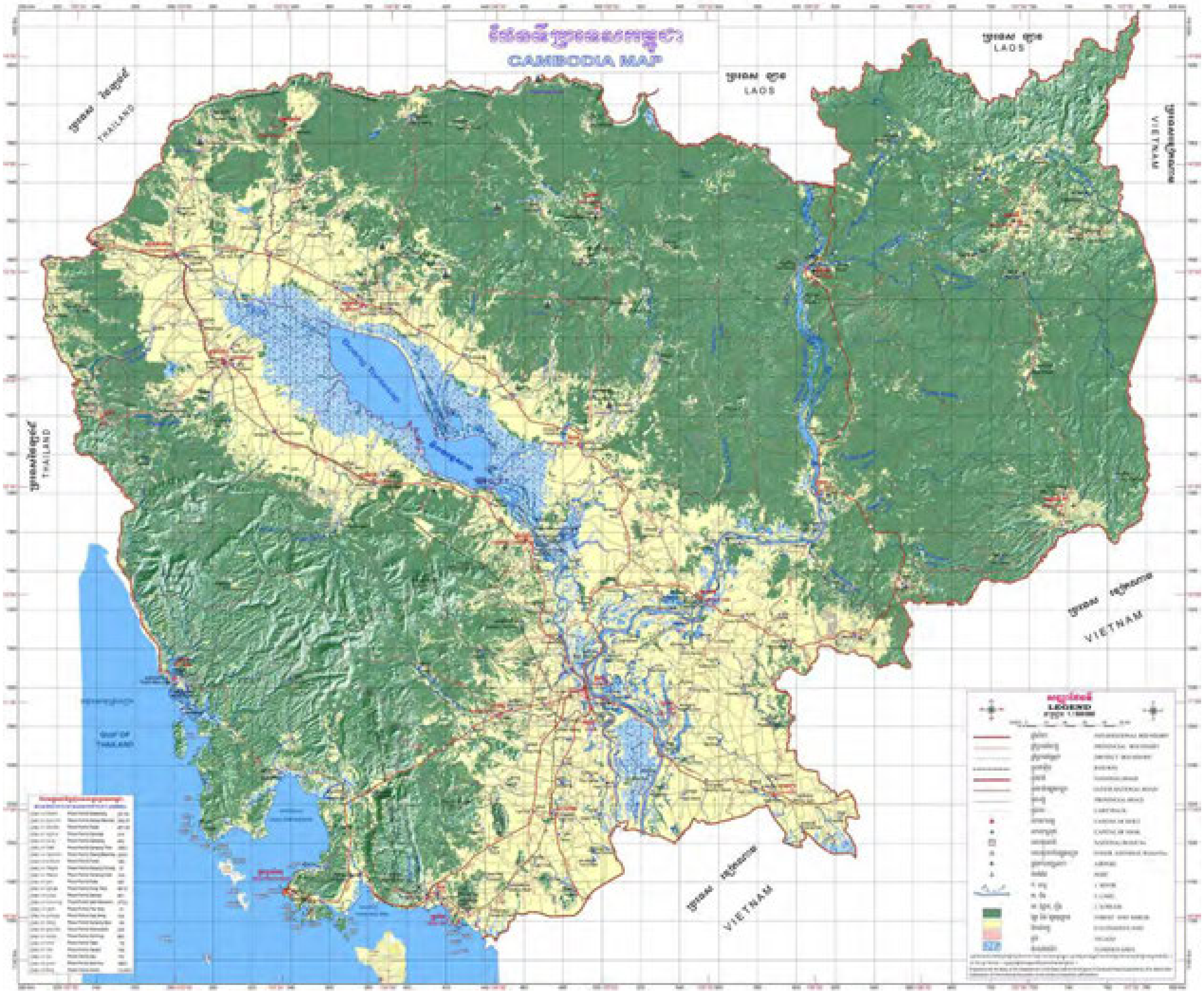


Figure 2.1-2 Topography of Survey Area

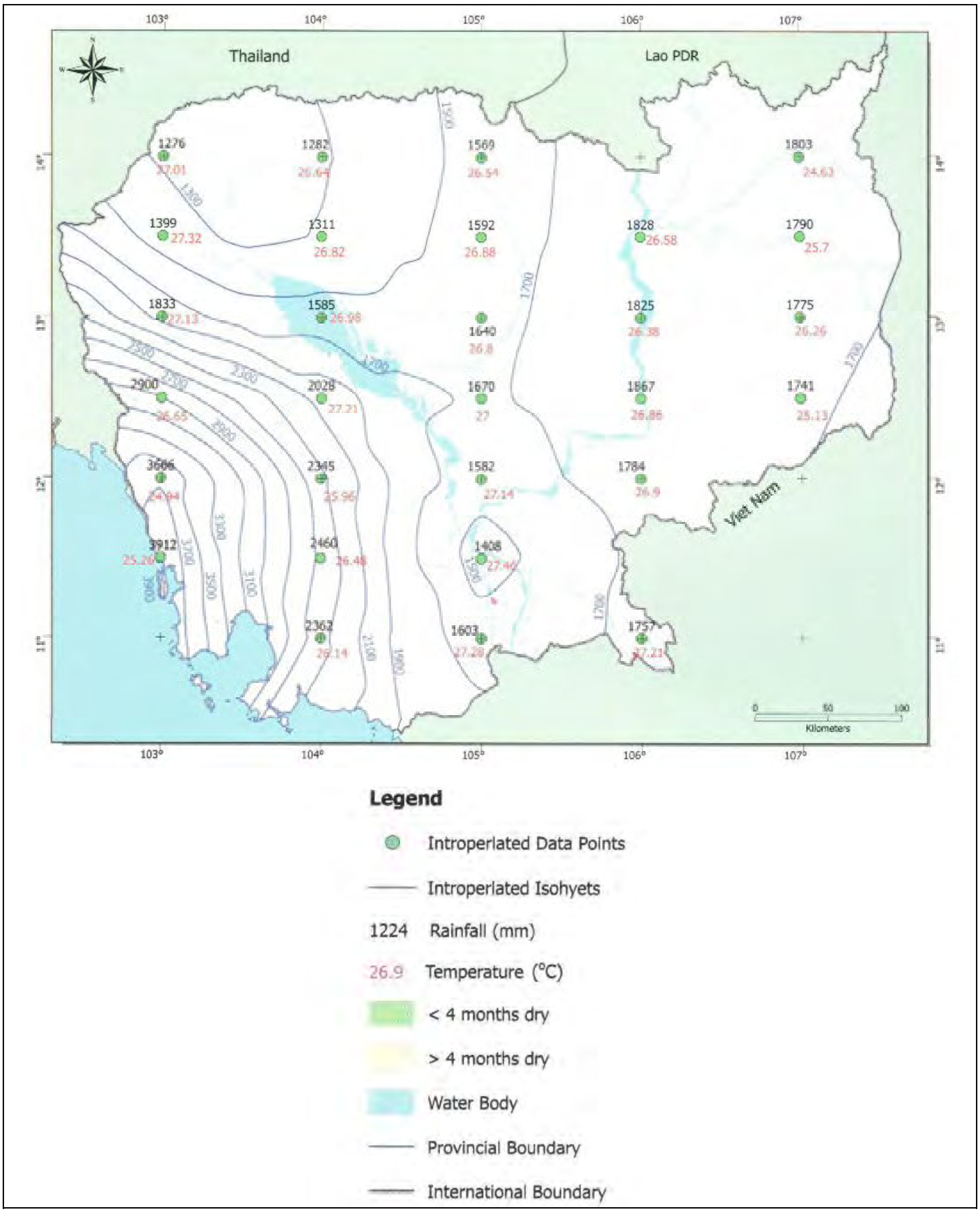
The country of Cambodia is often divided into the following five zones related to their relative location and topography as shown in the table below:

Zone	Province
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, Kampong Speu belongs to the Plateau/Mountain Zone and Kandal belongs to the Plains Zone which mainly extends from the south of Phnom Penh towards Vietnam. However, NR 5 traverses the northern part of Kandal Province located to the north of Phnom Penh and the eastern part of Kampong Speu Province where the terrain is flat and altitude is low.

(3) Meteorology

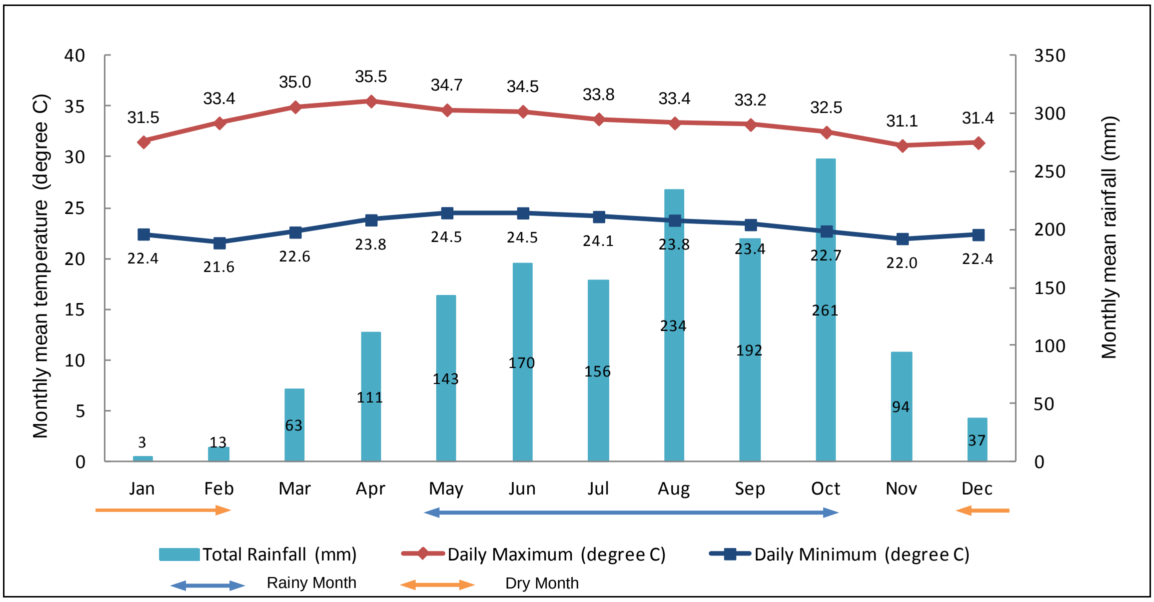
The climate of Cambodia is influenced by the Asian monsoon and the climate can be described as ‘hot and humid’ in general. Figure 2.1-3 shows annual rainfall in Cambodia. It shows that the annual rainfall of the Survey Area is in the range of 1,500 – 1,900 mm/yr.



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

Figure 2.1-3 Rainfall and Temperature

Figure 2.1-4 shows the monthly average rainfall and temperature measured at Pochetong, Phnom Penh. It shows that the rainy season is from May to September and the dry season is from November to April. It also shows that the monthly average temperature ranges between 25 and 34 degree Celsius.



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

Figure 2.1-4 Average Monthly Rainfall and Temperature in Pursat

2.2 Socio-Economic Profile

(1) Demography

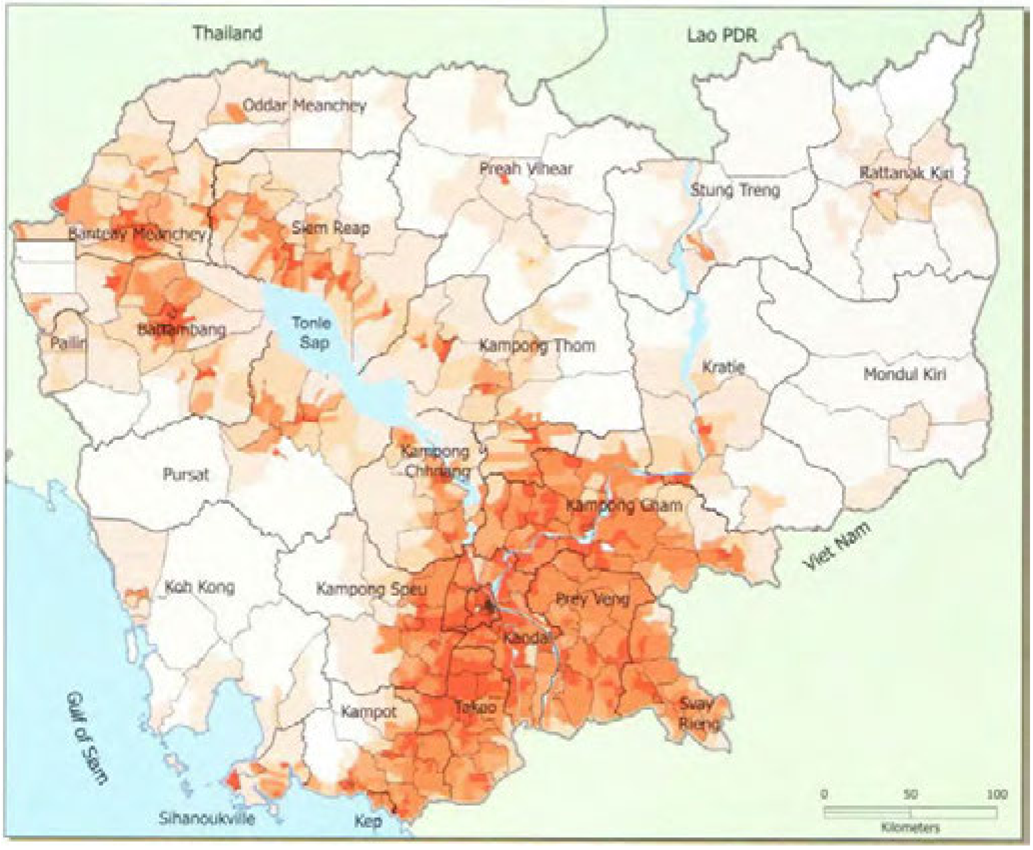
Table 2.2-1 summarizes the socio-economic data of the Survey Area, focusing on the four* provinces substantially influenced by the Project.

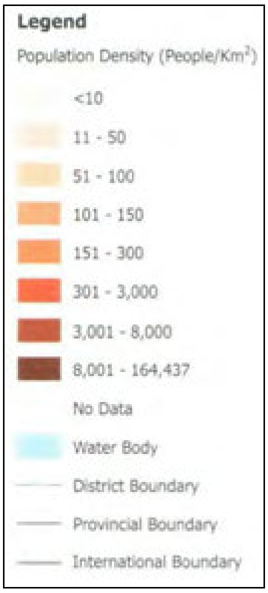
Table 2.2-1 Socio-Economic Data of Survey Area (4 provinces only)

	Kandal	Kampong Speu*	Kampong Chhnang	Pursat	Whole Country	Percentage to Whole Country
Population (1,000)	1,328	717	472	397	13,389	19.0
Land Area (km^2)	3,564	7,017	5,521	12,692	181,035	10.1
Population Density	355	102	86	36	75	-

*Source: Statistical Yearbook of Cambodia 2008 *The length of the section traversing Kampong Speu is about 2 km in Odongk area.*

It is noted that the total population of the four provinces represents approximately 19% of the whole country while the land area is only 10% of the whole country. The population densities of the provinces in the Survey area, except Pursat, are higher than the national average, implying that the Survey Area is the developed area in Cambodia. Among the four provinces, Pursat is less populated than thec national average.



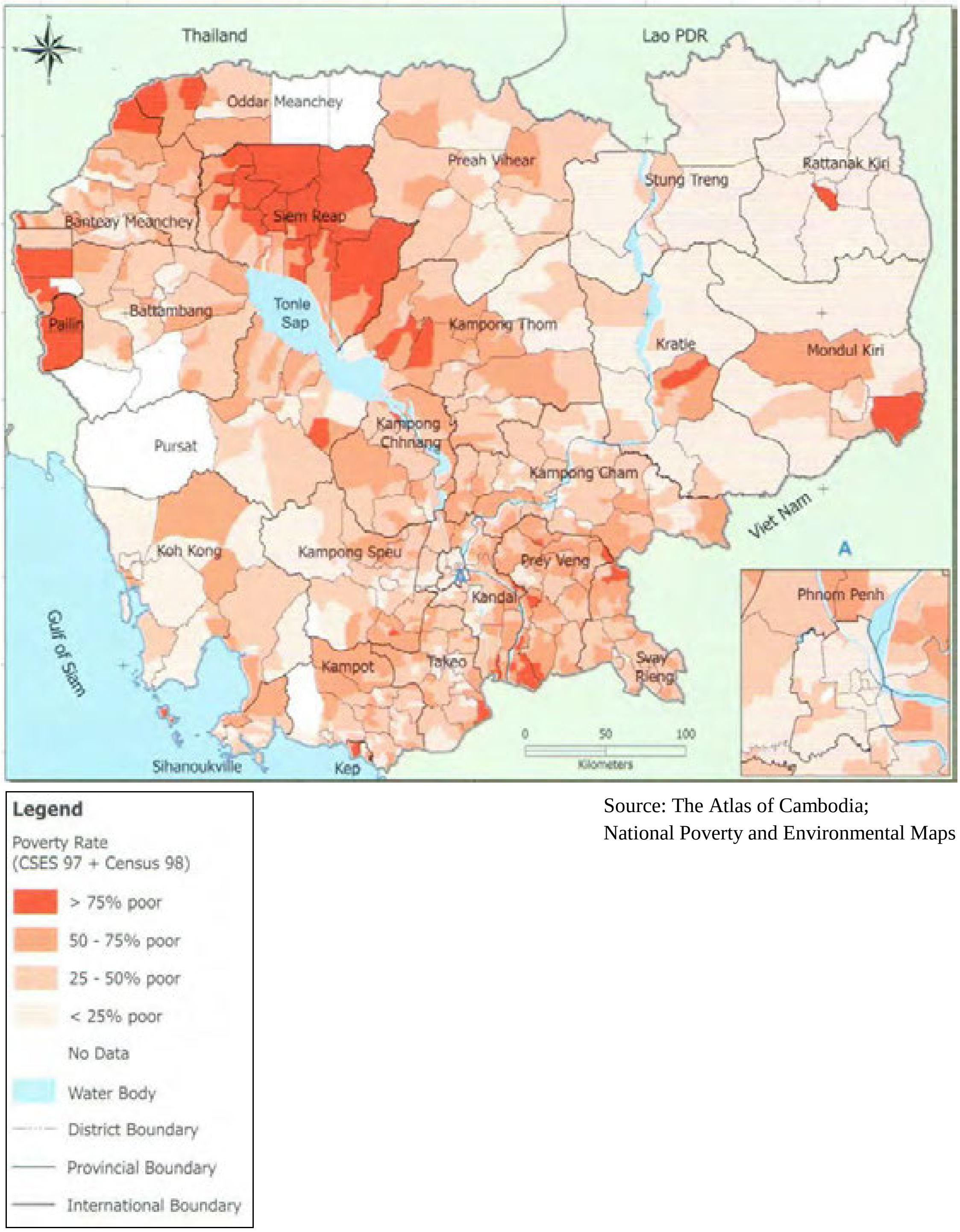


Source: The Atlas of Cambodia;
National Poverty and Environmental Maps

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 the areas along NR 5, especially up to Kampong Chhnang City is relatively high.



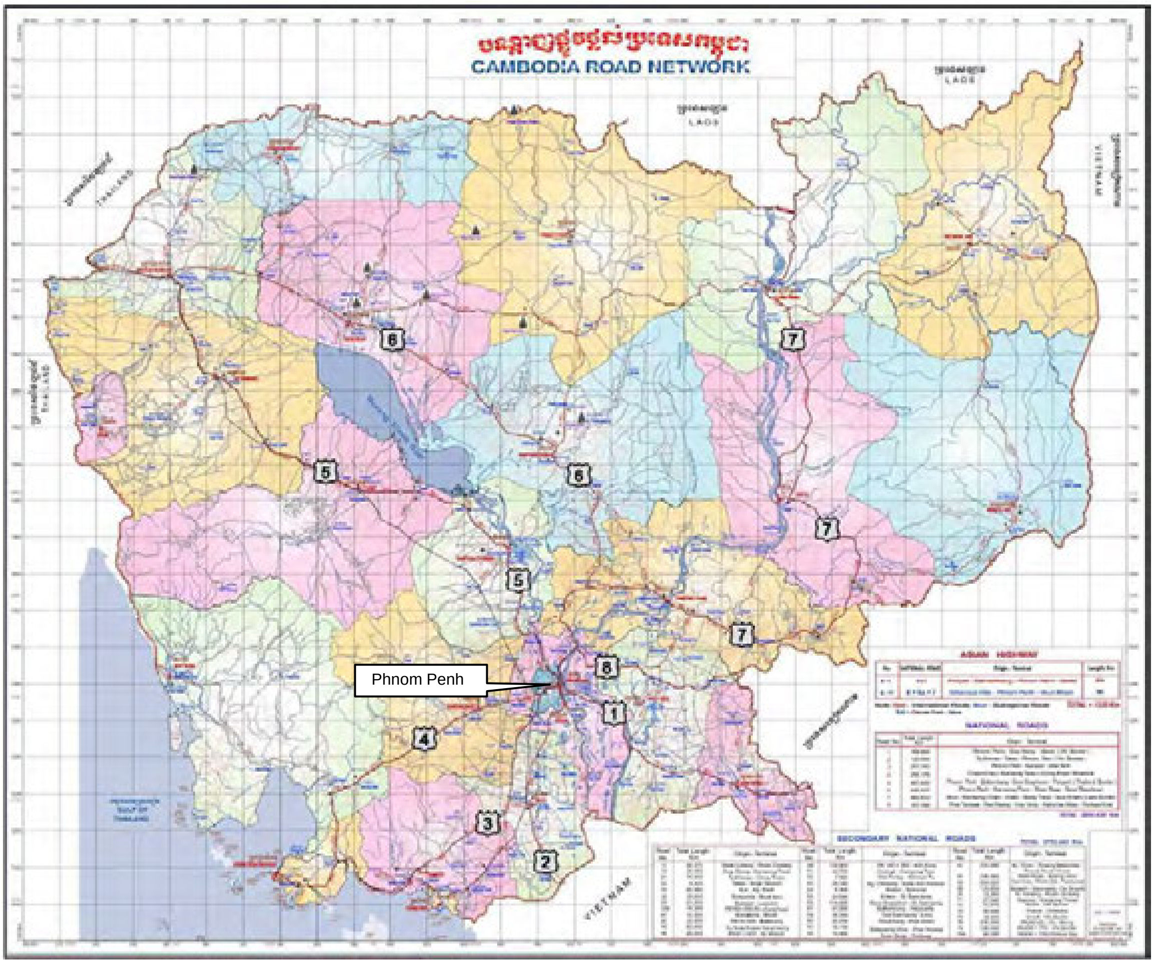
Source: The Atlas of Cambodia;
National Poverty and Environmental Maps

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 Roads is 5,224 km (as of year 2009). Out of this 5,224 km, 2,263 km are single digit national roads and 2,961 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	2,262.7	

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 is currently valid. 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**.

(2) Comprehensive Development Plan for 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. ADB implemented a study on transport sector strategy in Cambodia in 2002. The report mainly focused on the strategy of ADB's operation in Cambodia in the field of transport sector and did not show comprehensive transport strategy. Thus, practically there is no transport master plan spanning over all transport modes.

Thus, projects in each subsector are planned and implemented in accordance with the master plan for each transport subsector. Major projects and studies of these transport subsectors 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 on-going with financial assistance of ADB. · Phnom Penh – Kampot (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 is on-going but haltered due to problem of resettlement. · 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 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. · Comprehensive urban transport master plan study is currently implemented by JICA. This study is expected to propose introduction of mass transit system in Phnom Penh. · Project for Comprehensive Urban Transport Plan in Phnom Penh Capital City (PPUTMP) is currently implemented by JICA. Improvement of urban transport in Phnom Penh is being studied.
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 National Road No.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 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.

In years 2012 to 2013, JICA conducted a survey titled ‘Data Collection Survey on the Trunk Road Network Planning for Strengthening of Connectivity through the Southern Economic Corridor’. In this survey, it was recommended that NR 5, together with NR 1, NR 4 and NR 6, be widened into 4 or more lanes.

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 the fourth edition of “Overview on Transport Infrastructure Sectors in the Kingdom of Cambodia” was published. This publication lists the past, on-going and planned road improvement projects, as shown in Table 3.2-2. Among these projects, those relevant to this Survey, specifically those which influence future traffic demand of NR 5 are incorporated in the traffic forecast presented in Chapter 6.

Table 3.2-2 (1) Past, On-Going 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, On-Going 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 Beychoam	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

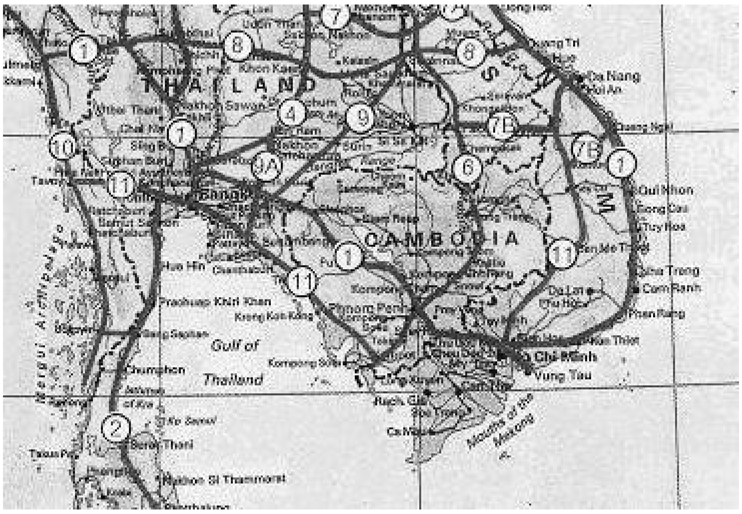
3.3 Role of National Road No. 5

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.

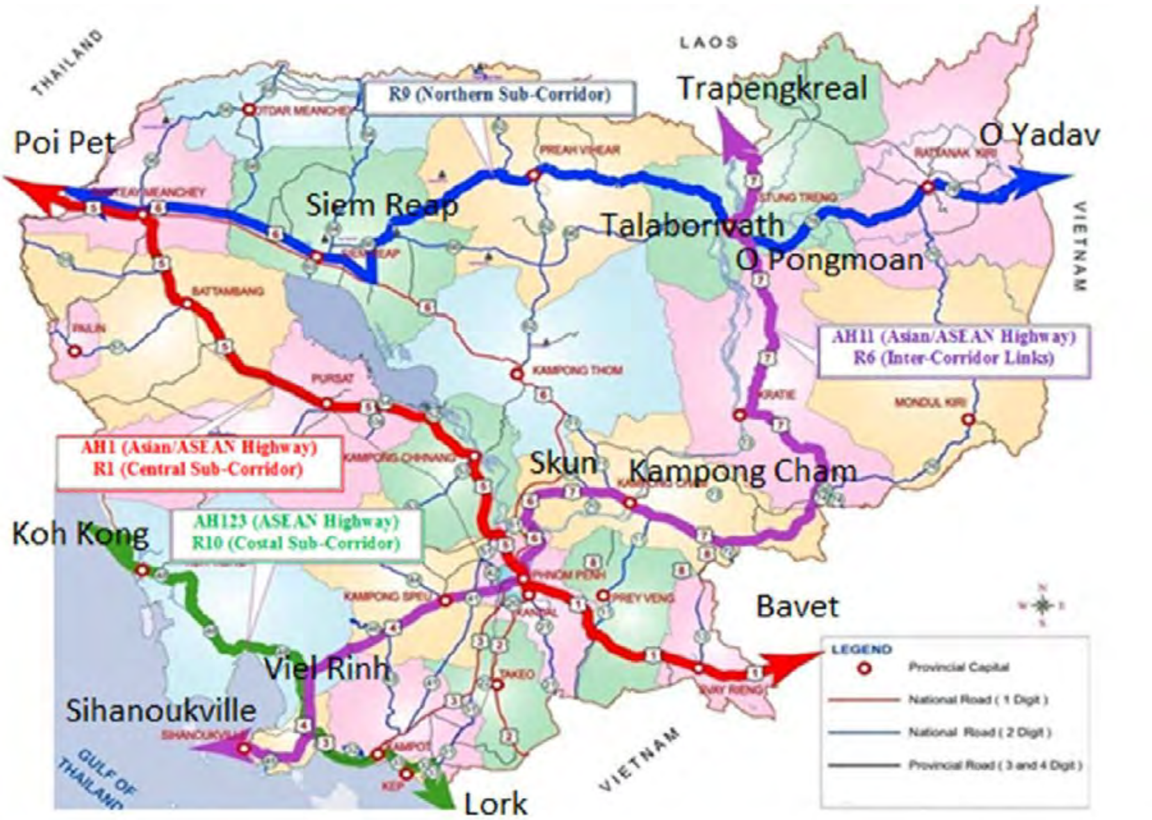
NR 5 also accommodates the traffic transporting goods and passengers between the major cities along the highway, such as Sri Sophorn, Battambang, Pursat, Kampong Chhnang and Phnom Penh. Near to the starting point of the South Section (Prek Kdam), Odongk, the old capital of Cambodia is located. Odongk 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 National Road No. 1 (NR 1) which reaches to Ho Chi Min City in Vietnam and National Road No. 3 (NR 3) and National Road No. 4 (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 National Road No. 1 (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

<u>Regional Cooperation in GMS and Cross-Border Transport Agreement</u>

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, Lao, 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)

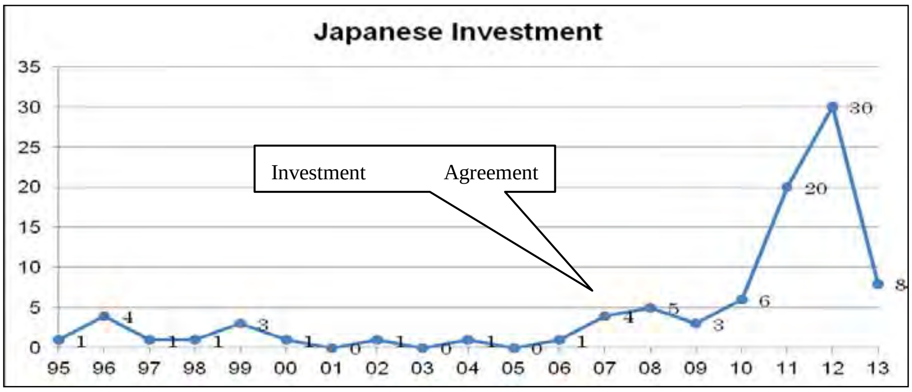
Agreement	Contents	Remarks
With Vietnam	・ Quota of vehicles for cross border transport: 40 units in year 2006 ・ Quota of vehicles: increased to 150 units in year 2009 ・ Quota of vehicles: increased to 300 units in year 2010 ・ Quota of vehicles: increased to 500 units (trucks, scheduled & non-scheduled 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 clear.

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 4-lane with AC pavement by Chinese fund. Thus, this project has close relation with the Project for which this Survey is conducted.

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.

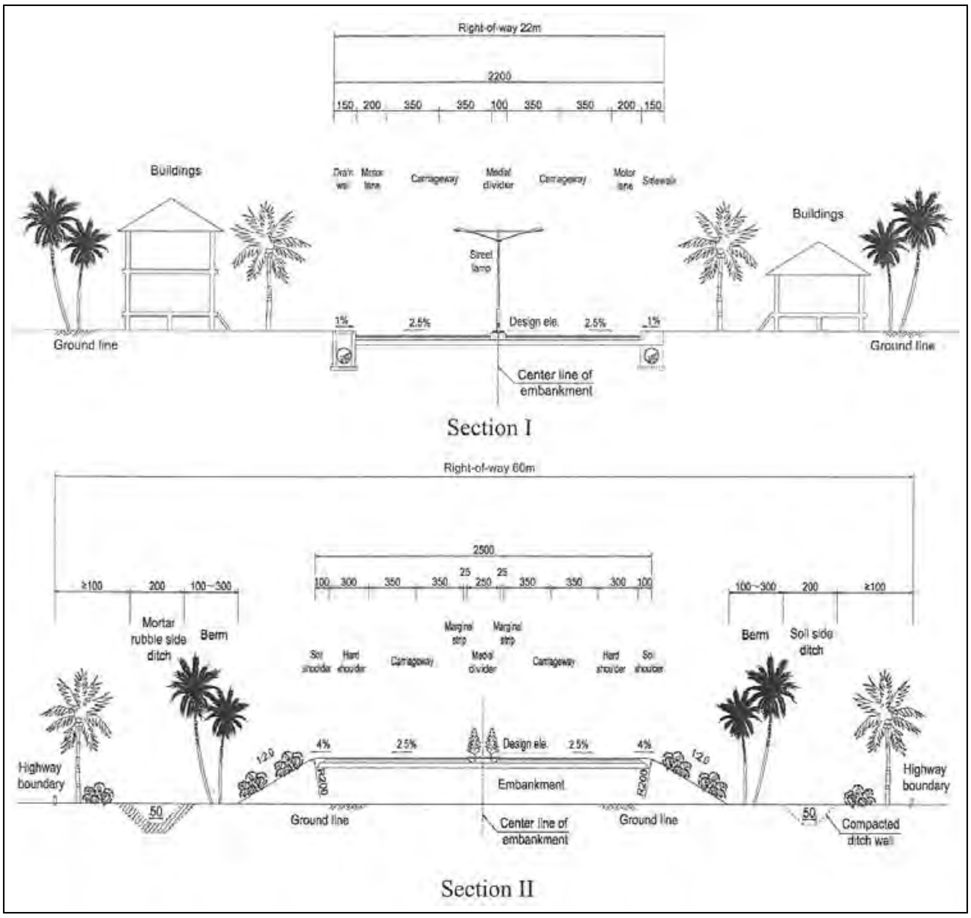


Figure 3.4-1 Typical Cross Section of Widening Under Chinese Fund

(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

(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. The project aims to rehabilitate and improve the selected roads and drainages in Kampong Chhnang City and bridges along National Road No. 11 under Japanese grant aid. The improvement of roads in Kampong Chhnang City includes improvement of pavement, drainages and sidewalks of National Road No. 5 city center section (2.2 km), and related major streets (2.4 km) and installation of drainage way (2.6 km) to be extended to the proper outlet at the river.

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

Table 3.4-1 Project List on National Road No. 5

Section	Project	Year
Phnom Penh ~ Prek Kdam Br.	· Restored by Army · RAMP funded by ADB · 4-lane widening & AC pavement by Phnom Penh Municipality (Chrouy Changvar Br. – P. P./Kandal Border) · Widening to 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 shortage of fund, 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 recently discussed. The outline of expressway network is yet to be studied. However, it seems to be common understanding among MPWT officials and foreign (Japanese, Chinese and Korean) highway experts that main lines of expressways in Cambodia should be in parallel to NR 5 (Phnom Penh – Poipet), NR 1 (Phnom Penh – Bavet) and NR 4 or NR 3 (Phnom Penh – Sihaoukville). These expressways will be planned a few to ten kilometer away from the existing national road to avoid the densely populated areas along the existing national roads. In case of NR 5, it is highly probable that the expressway be constructed on the western side (away from Tonle Sap Lake) to avoid inundation/flood.

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 Prek Kdam – Thlea Ma'am Section of NR 5

Improvement of Prek Kdam – Thlea Ma'am 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 Phnom Penh – Prek Kdam Section of NR 5

As described in Section 3.4 above, the section of Phnom Penh – Prek Kdam is being widened to 4 lanes by the assistance of Chinese Government. From viewpoint of consistency of road standard, it is necessary to widen from Prek Kdam to north.

(4) Promotion of regional economic cooperation and plan of expressway construction

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 SOUTH SECTION

4.1 Overall Conditions

The inventory survey was conducted again in the South Section with the same survey method used in the Survey of the North Section.

In middle September 2012, the road surface condition in the South Section was observed to be similar with that of November, 2011. However, the road condition especially the section between Kampong Chhnang and Thlea Ma'am as of November 2012 had become very bad. The main reasons for the condition getting worse are the rain water accumulating at road side penetrating into the base course and subgrade of the pavement. The weakened pavement is easily damaged. Once water soak into cracks, potholes develop rapidly. Figure 4.1-1 shows examples of the damages observed in November 2012.

Inundation (KP 70)

Poor Drainage (KP 57)

Pavement (KP 136)

Roadside Houses/Shops (KP 39)

Figure 4.1-1 Condition of South Section

Figure 4.1-2 shows examples of the existing physical conditions of South Section in the form of 'Straight Line Diagram'. This diagram was prepared based on the Survey on the North Section and it has been updated through the site survey conducted from middle September to late October 2012.

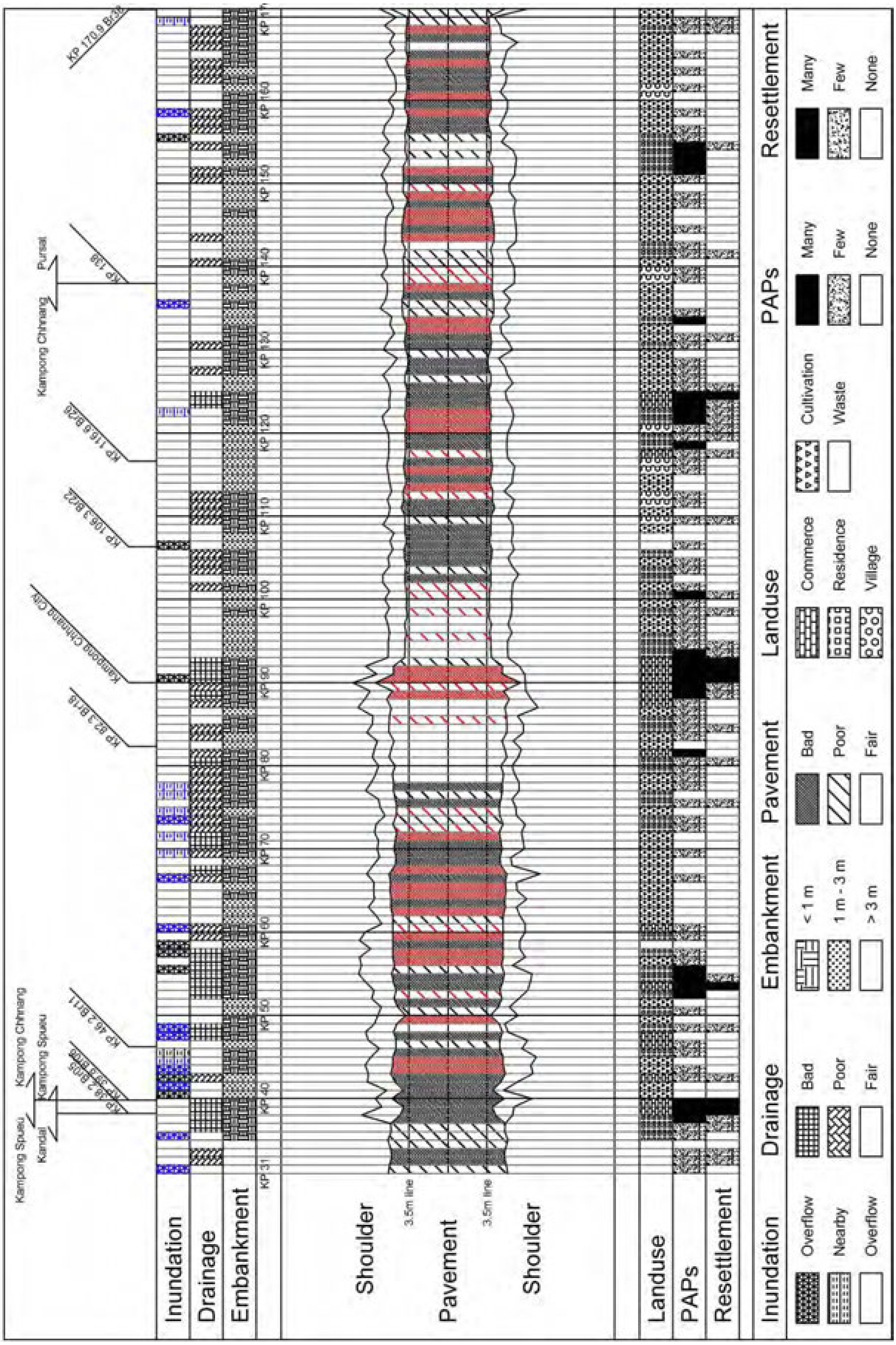


Figure 4.1-2 Straight Line Diagram

The criteria for classification of the conditions shown in the diagram are as described below:

Table 4.1-1 Description of Classification for Straight Line Diagram

Item	Classification	Description
Inundation	Overflow	Overflow on the road surface
	Near by	Water level rose to near but lower than road surface
	None	No report of inundation
Drainage	Bad	Water logs remain on the road after rain
	Poor	Water logs are seen at roadside after rain
	Fine	No remaining water on the road or roadside after rain
Pavement	Bad	Function of pavement substantially lost due to occurrence of several types of defects
	Poor	Function of pavement lost to light degree due to occurrence of a few types of defects
	Fair	No major defects observed
Project Affected Persons (PAPs)	Many	Buildings densely located along the roadside
	Few	Buildings sparsely located along the roadside
	None	No building nearby the road
Resettlement	Many	Roadside heavily populated
	Few	Houses sparsely located close to the road
	None	No houses nearby the road

In the diagram, red color for the pavement condition and blue color for the inundation condition were updated old information in the final report of the North Section based on the site inventory. In this survey, the inundation areas and sections of bad pavement were observed more than the Survey of the North section. The following subsections describe the conditions of each item.

During the period of Survey of the North Section, MPWT installed the 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 GPS apparatus. The distances between KPs measured by the Survey Team are shown in Table 4.1-2. The locations used in this report are those measured from current KPs. The Straight Line Diagram shown in Figure 4.1-2 basically uses the chainage using the current KPs.

Detailed information obtained through the site survey is shown in Appendix 4-1.

Table 4.1-2 Current KP Distances

Unit: m

KP	Distance	KP	Distance	KP	Distance	KP	Distance	KP	Distance
31	1,008	60	970	89	950	118	1,002	147	1,011
32	968	61	1,025	90	766	119	999	148	993
33	926	62	977	91	974	120	1,001	149	1,001
34	1,058	63	997	92	850	121	984	150	988
35	989	64	1,002	93	902	122	1,022	151	1,007
36	1,025	65	1,000	94	931	123	986	152	1,012
37	972	66	997	95	912	124	1,022	153	1,045
38	1,005	67	1,000	96	936	125	1,004	154	951
39	1,006	68	998	97	954	126	1,000	155	993
40	1,245	69	997	98	918	127	986	156	993
41	1,004	70	1,001	99	951	128	996	157	994
42	968	71	998	100	1,008	129	997	158	996
43	1,028	72	1,006	101	1,008	130	993	159	994
44	999	73	987	102	833	131	1,005	160	1,000
45	1,007	74	994	103	1,006	132	1,002	161	995
46	995	75	1,013	104	1,039	133	982	162	998
47	999	76	991	105	1,005	134	1,017	163	1,003
48	999	77	1,000	106	997	135	1,006	164	996
49	1,007	78	998	107	991	136	992	165	1,006
50	1,004	79	1,026	108	1,029	137	997	166	997
51	1,000	80	992	109	1,023	138	1,008	167	1,005
52	1,045	81	1,004	110	984	139	997	168	991
53	987	82	1,010	111	1,000	140	989	169	1,001
54	1,018	83	990	112	987	141	992	170	985
55	1,010	84	991	113	1,012	142	1,014	171	
56	1,017	85	1,001	114	1,010	143	1,003		
57	990	86	1,008	115	1,001	144	1,003		
58	1,006	87	1,001	116	1,022	145	1,001		
59	998	88	996	117	986	146	995		
60		89		118		147			

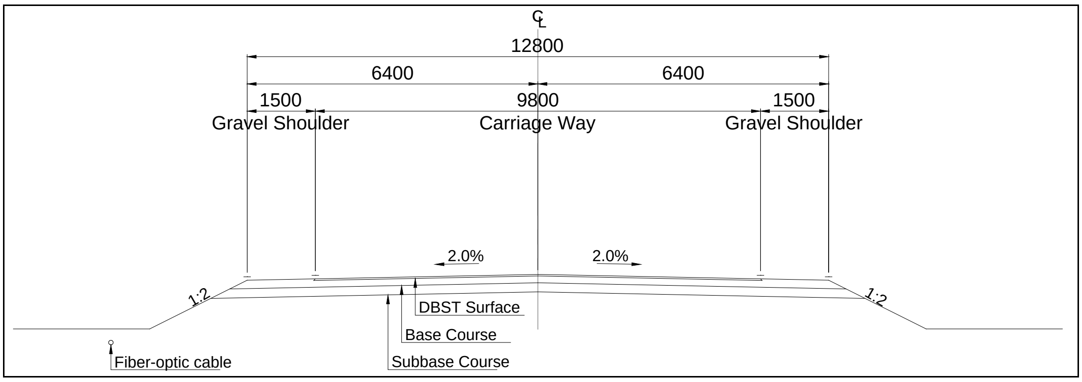
4.2 Geometric Structure

4.2.1 Cross Section

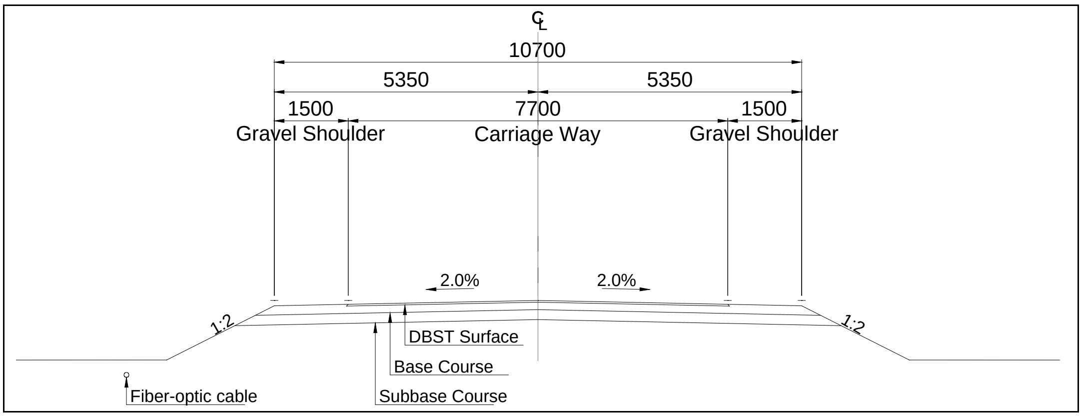
The cross-section of a road accommodates not only for carriage way for motorized vehicles but also other facilities and functions including parking space, drainage, public utilities, space for passage of non-motorized vehicles and pedestrians. Thus, it is required to consider these functions.

The existing cross section of the South Section is composed of undivided opposing 2-lane and shoulders. Almost all the road surface along the NR 5 is DBST (Double Bituminous Surface Treatment) with gravel shoulder except limited part inside Kampong Chhnang City.

There are two types of typical cross section in the South Section. The average width of pavement of the section between Prek Kdam Bridge and Kampong Chhnang is 9.8 m and that of the section between Kampong Chhnang and Thlea Ma'am is 7.7 m. The typical cross sections of the South Section are shown in Figure 4.2-1.



(a) **Prek Kdam – Kampong Chhnang Section**



(b) **Kampong Chhnang – Thlea Ma'am Section**

Figure 4.2-1 Typical Cross Section of South 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 small radius results in lower speeds, which in turn, result in reduction in the performance of NR 5 as 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. In the South Section, there are 34 curves with radii smaller than 350 m which is the minimum value for the design speed of 80 km/h. Five out of 34 sharp curves are located in the urban areas where the design speed can be lowered to 50 km/h and minimum curve radius is 80 m. There are 3 curves out of 5 sharp curves with curve radii smaller than 50 m in the city center of Kampong Chhnang. Table 4.2-1 shows the location and radii of curves on the South Section.

Table 4.2-1 Sharp Curved Section on South Section

No.	KP	Curve Radius	Area	No.	KP	Curve Radius	Area
1	31+597	300	Rural	18	93+101	250	Rural
2	33+106	170	Rural	19	93+557	200	Rural
3	33+911	150	Rural	20	93+838	300	Rural
4	34+080	350	Rural	21	95+635	300	Rural
5	34+621	350	Rural	22	97+204	170	Rural
6	38+521	200	Urban	23	104+413	300	Rural
7	39+699	100	Rural	24	110+923	250	Rural

No.	KP	Curve Radius	Area	No.	KP	Curve Radius	Area
8	49+770	200	Rural	25	115+404	300	Rural
9	58+671	300	Rural	26	117+384	300	Rural
10	59+485	250	Rural	27	118+396	300	Rural
11	83+456	270	Rural	28	119+435	300	Rural
12	89+319	300	Rural	29	120+529	240	Rural
13	89+455	150	Urban	30	122+765	270	Urban
14	90+149	120	Urban	31	124+182	300	Rural
15	90+858	350	Urban	32	127+028	300	Rural
16	91+229	180	Urban	33	130+335	200	Rural
17	91+771	350	Urban	34	153+862	270	Rural

4.2.3 Vertical Alignment

As NR 5 generally traverses flat terrain, its vertical alignment is also generally flat. There are some sections passing through hilly terrain near Kampong Chhang City. However, the gradients of these sections are still mild and do need to improvement. The steepest grade on the South Section, except those on the approach sections to the bridges appears on the section between KP 79 and KP 80. The gradient there is 1.8%. Sections with steep grade are found particularly near the bridges. Even on the approach sections to the bridges, the gradients are less than 4%, the maximum grade stipulated in the Cambodian Standard for Geometric Design. Thus, the gradient itself is not imposing serious problems. Rather, the height of road surface near the bridges needs to be examined in relation to flood/inundation. The profile of the South Section drawn based on the aerial photo survey data is shown in Figure 4.2-2 and Figure 4.2-3.

The height of road surface is an important subject in view of the flood/inundation. The average of embankment height is approximately 1.2 m and the range of embankment is -0.3 to 5.0 m according to the inventory survey conducted on the South Section. Embankment height of minus (-) means that the elevation of land (paddy fields) on both sides of NR 5 is higher than 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 4.2-4 shows examples of road surface lower than the adjacent land and inundated road surface.

Figure 4.2-2 Road Surface Lower than Adjacent Land and Inundated Road Surface

The problem of flood/inundation is discussed in Chapter 7.

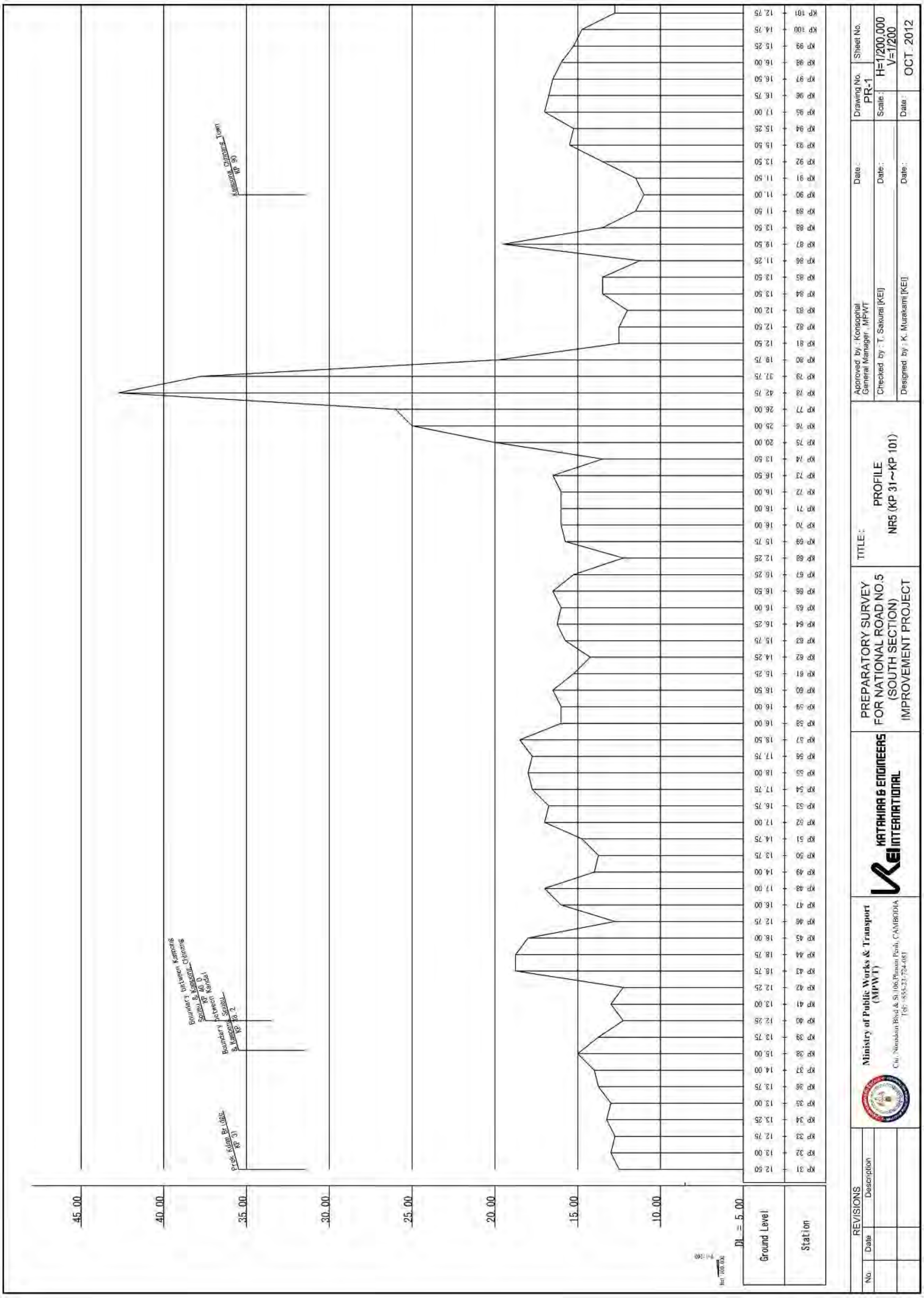


Figure 4.2-3 Estimated Road Elevation KP 31 to KP 101

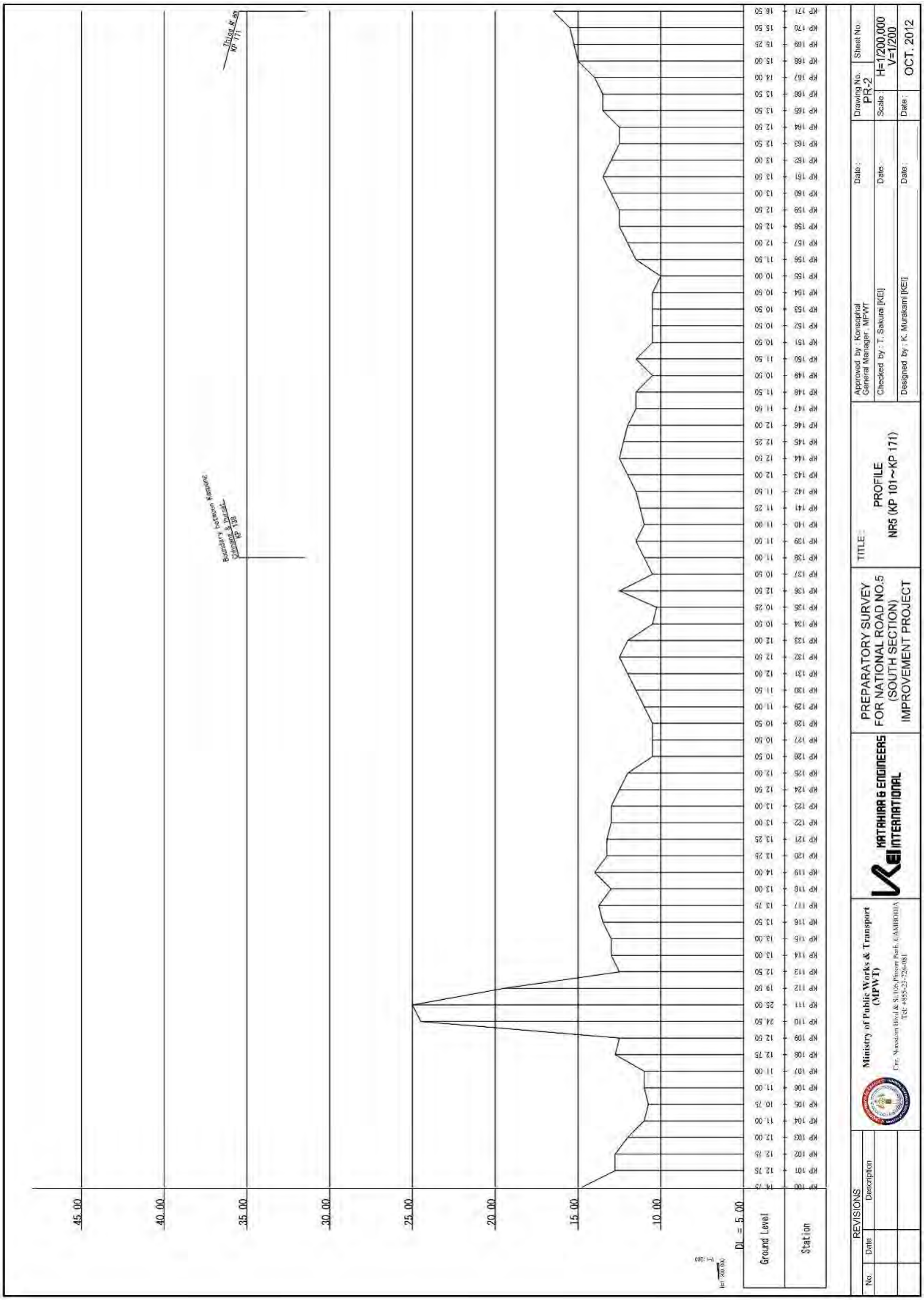
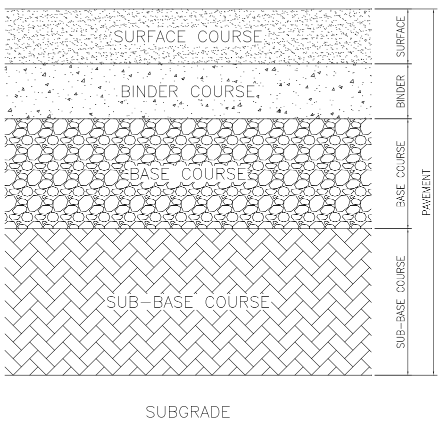


Figure 4.2-4 Estimated Road Elevation KP 101 to KP 171

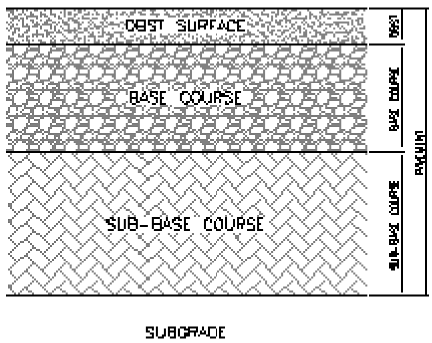
4.3 Pavement

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, braking and fuel consumption, vehicle maintenance repairs and increased risks of traffic accidents.

The actual pavement structure of NR 5 is DBST except a part in Kampong Chhnang City. The standard pavement structure of “Asphalt Concrete Pavement” and “DBST” are shown in Figure 4.3-1. DBST is a pavement technique that consists of having aggregates absorbed in bituminous material over a surface that has been previously primed. DBST is used as the road which there is not much traffic volume and less heavy traffic.



Asphalt Concrete Pavement



DBST

Figure 4.3-1 Standard Pavement Condition

The condition of existing pavement was closely observed at the points of failure and every 1 km interval where fixed kilometer post in the Survey of the North Section. These inventory data are updated in this Survey.

The maintenance of the pavement had been carried out well in general before rainy season of 2012. The inventory survey was carried out at end of rainy season of 2012 (October – November 2012). Therefore, a lot of failures of pavement were observed. The maintenance works under RAMP have been carried out in the section from KP 3.9 to KP 171 of NR 5 and various kinds of pavement defects have been repaired. There are a lot of failure section appeared in the South Section.

The typical failures of the pavement observed on NR 5 are shown in Table 4.3-1. The details of inventory survey data are shown in Appendix 4-1.

Table 4.3-1 Typical Failures of the Pavement

Failures Items	Description	Photo	Location
Crack	There are two types of crack; longitudinal line crack on the shoulder and mesh crack on the depressed area. The longitudinal line cracks are supposed to be caused by the settlement of embanked ground.		KP 31 ~ KP 79, KP 88 ~ KP 169
Pothole	There are a lot of large and small holes. These small halls usually further develop during rainy season.		KP 37 ~ KP 43, KP 47 ~ KP 53, KP 57 ~ KP 77
Depression	Usually observed in the right wheel tracks of vehicles due to insufficient strength of the pavement and/or penetration of water into the pavement structure.		KP 31 ~ KP 77, KP 100 ~ KP 170
Flush (Bleeding)	Seeping out of bituminous material to the pavement surface. Cased by excess use of bitumen.		KP 31 ~ KP 102,
Rutting	Observed on the wheel tracks of vehicles; caused by insufficient strength of the pavement compared to the traffic load.		KP 31 ~ KP 33, KP 40 ~ KP 50, KP 54 ~ KP 81, KP 86 ~ KP 100, KP 106 ~ KP 169
Raveling	Breakaway of surface aggregate is observed on the old surface due to the poor adhesion of deteriorated bitumen or insufficient binder.		KP 90 ~ KP 133, KP 141 ~ KP 165

Failures Items	Description	Photo	Location
Edge Damage	Wear of shoulder caused by action of water and/or vehicle entering to the road.		KP 92 ~ KP 131
Shoving	Usually it is observed near the edge of the pavement due to the ingress of water reducing the bearing capacity of the pavement and/or subgrade.		KP 110 ~ KP 112, KP 119 ~ KP 133, KP 137 ~ KP 164

4.4 Bridge Condition

4.4.1 Inventory of Bridges

A field survey on the existing bridges on the South Section was conducted and the conditions of existing bridges were visually inspected. Location of each bridge was measured from the existing kilometer post along the NR 5 and the distance from the existing KPs to the bridge was measured by the odometer of the car used in the field survey. Accordingly, accuracy of the measured bridge location is to the order of 0.1 kilometer.

Inventory provided by MPWT lists 36 bridges. The field survey conducted by the Survey Team indicated some discrepancies between what are recorded in the MPWT's inventory and what actually exist. Table 4.4-1 lists the bridges observed through the field survey.

Table 4.4-1 List of Existing Bridges on South Section

Ref.	Code	KP (km)	Bridge Type	Length (m)	No. of Span	Width (m)			Built Year	Note No.
						Total	Carriage way	Side		
1	Br. 05	38.1	RC Deck Slab	8.2	1	10.8	10.8	No		
2	Br. 06	39.7	Steel Girder	23.9	2	9.5	7.9	0.8		
3	Br. 07	40.6	Steel Girder	15.0	1	9.0	9.0	No	(1996)	
4	Br. 08	41.1	Steel Girder	24.0	2	9.0	7.0	1.0	1996	1
5	Br. 09	41.3	Steel Girder	24.2	2	9.0	9.0	No	1996	2
6	Br. 10	41.9	Steel Girder	24.2	2	9.0	9.0	No	1996	
7	Br. 11	46.2	RC Deck Slab	16.2	4	10.1	10.1	No		
8	Br. 12	48.4	Steel Girder & RC Rigid Frame	21.0	4	10.4	10.4	No	1996	3
9	Br. 13	48.9	RC Deck Slab	8.5	1	10.2	10.2	No		4
10	Br. 13'	49.7	Steel Girder	24.0	2	9.1	9.1	No		
11	Br. 14	58.3	Steel Girder	12.1	1	9.0	9.0	No	1996	
12	Br. 15	61.9	Steel Girder	24.2	2	9.0	9.0	No	1996	5

Ref.	Code	KP (km)	Bridge Type	Length (m)	No. of Span	Width (m)			Built Year	Note No.
						Total	Carriage way	Side		
13	Br. 16	67.8	Steel Girder	24.2	2	9.0	9.0	No	1996	
14	Br. 16’	72.7	Steel Girder	12.1	1	10.0	10.0	No		
15	Br. 17	82.2	PC Hollow	15.0	1	10.0	10.0	No	2003	
16	Br. 18	82.4	Steel Girder	41.2	2	9.0	9.0	No	1996	6
17	Br. 19	83.1	PC Hollow	20.0	2	10.0	10.0	No	2003	
18	Br. 20	85.9	RC Deck Slab	8.5	1	9.0	9.0	No		
19	Br. 21	90.9	Steel Girder	22.2	2	9.0	9.0	No	1996	
20	Br. 22	106.2	Steel Girder	91.5	3	9.1	7.1	1.0	1996	7
21	Br. 23	106.9	PC Hollow	20.0	1	10.1	10.1	No	2003	
22	Br. 24	113.4	PC Hollow	15.0	1	10.0	10.0	No	2003	
23	Br. 25	113.7	PC Hollow	12.0	1	10.0	10.0	No	2003	
24	Br. 26	116.9	Steel Girder	72.1	3	10.1	7.1	1.5	1996	8
25	Br. 27	134.3	PC Hollow	12.0	1	10.0	10.0	No	2003	
26	Br. 28	135.9	PC Hollow	12.0	1	10.0	10.0	No	2003	
27	Br. 29	140.8	PC Hollow	12.0	1	10.0	10.0	No	2003	
28	Br. 30	141.9	PC Hollow	12.0	1	10.0	10.0	No	2003	
29	Br. 31	147.1	PC Hollow	12.0	1	10.0	10.0	No	2003	
30	Br. 32	147.7	PC Hollow	12.0	1	10.0	10.0	No	2003	
31	Br. 33	150.2	PC Hollow	17.9	1	10.0	10.0	No	2003	
32	Br. 34	150.4	PC Hollow	15.0	1	10.0	10.0	No	2003	
33	Br. 35	151.3	PC Hollow	12.0	1	10.0	10.0	No	2003	
34	Br. 36	153.5	PC Hollow	20.0	2	10.0	10.0	No	2003	9
35	Br. 37	169.8	PC Hollow	20.1	1	10.0	10.0	No	2003	
36	Br. 38	170.6	Steel Girder	42.3	3	10.1	7.1	1.5		10
37	Br. 39	170.9	RC Deck Slab	19.2	4	9.0	9.0	No		

Note No.	Bridge Code	Note
N1	Br. 08	・ Pier table is supported by steel piles (5 numbers) at the center.
N2	Br. 09	・ Cover plate on the edge of A1 abutment on left lane is damaged.
N3	Br. 12	・ There are gateposts for water gate along the left outside of the Br.12.
N4	Br. 13	・ Every pier table of Br.13 is supported by RC piles. ・ One part of steel handrail of Br.13 is damaged by car bumping.
N5	Br. 15, 16	・ Pier table are supported by precast PC piles (column).
N6	Br. 18	・ Galvanized steel girder
N7	Br. 22	・ Every pier table is supported by steel piles (each 12 numbers). ・ Bearing shoe at A2 side cannot be observed because it is covered by deposited sand. ・ Slope protection stone mason at A2 abutment is destroyed partially caused by flood. ・ Galvanized steel girder
N8	Br. 26	・ Every pier table is supported by RC piles (each 12 numbers). ・ Galvanized steel girder ・ Widening at right side has advantages due to the surrounding site condition.
N9	Br. 36	・ Pier table of Br.36 is supported by RC piles (6 numbers).
N10	Br. 38	・ Galvanized steel girder

There are sixteen (16) steel bridges and twenty one (21) concrete bridges in the South Section of NR 5.

All sixteen (16) steel bridges are steel girder type and the maximum girder length is 30 m. Number of girders is five (5) to eleven (11), depending on the girder size as shown in the Figure 4.4-1. Steel main girders are painted or galvanized. Most steel girder bridges on the South Section are located in the section between KP 31 and Kampong Chhnang City.

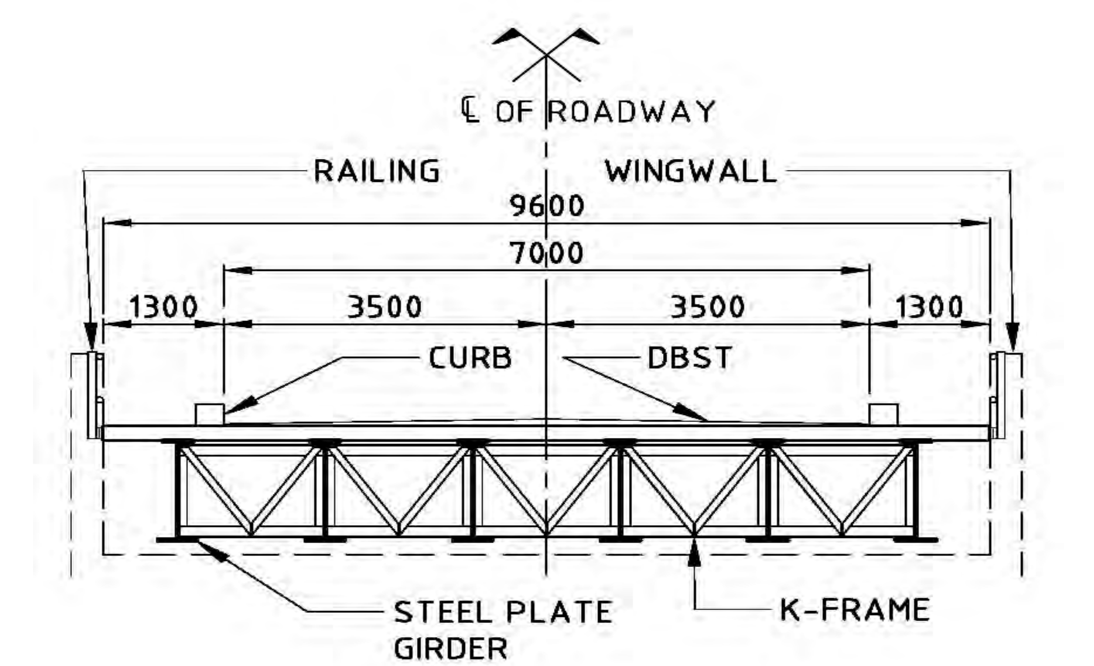


Figure 4.4-1 Typical Cross Section of Steel Bridge

Among the twenty one (21) concrete bridges, there are five (5) RC Deck Slab bridges and sixteen (16) PC Hollow Slab bridges. Girder length of PC Hollow is 10 m to 20 m.

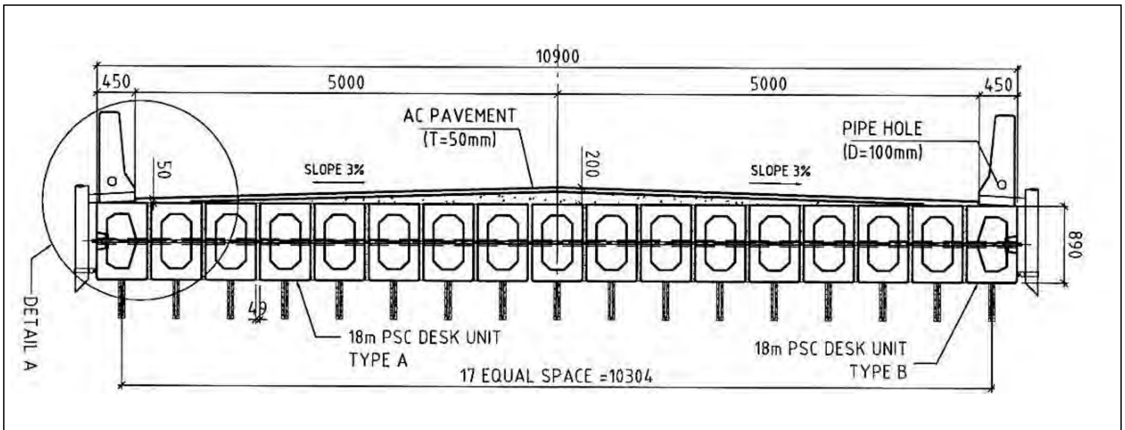


Figure 4.4-2 Typical Cross Section of PC Hollow Bride

4.4.2 Condition of Bridges

The bridges on the South Section are generally in good condition. The photos in Figure 4.4-3 show the general views of the bridges.

Br. 5 (PK 39+7)

Br. 6 (PK 40+0)

Br. 7 (PK 40+6)

Br. 8 (PK 41+1)

Br. 9 (PK 41+6)

Br. 10 (PK 41+9)

Figure 4.4-3 (1) Bridge Condition (1/4)

Br. 11 (PK 46+2)

Br. 12 (PK 48+4)

Br. 13 (PK 49+7)

Br. 14 (PK 58+3)

Br. 15 (PK 61+9)

Br. 16 (PK 67+8)

Br. 17 (PK 82+2)

Br. 18 (PK 82+4)

Figure 4.4–3 (2) Bridge Condition (2/4)

Br. 19 (PK 83+1)

Br. 20 (PK 85+9)

Br. 29 (PK 140+8)

Br. 30 (PK 141+8)

Br. 31 (PK 147+1)

Br. 32 (PK 147+7)

Br. 33 (PK 150+1)

Br. 34 (PK 150+4)

Figure 4.4–3 (3) Bridge Condition (3/4)

Br. 35 (PK 151+3)

Br. 36 (PK 153+4)

Br. 37 (PK 168+8)

Br. 38 (PK 170+6)

Br. 39 (PK 170+9)

Figure 4.4–3 (4) Bridge Condition (4/4)

4.4.3 Condition of Bridge Members

The initial field survey of bridges was conducted during the flood season of Tonle Sap, and it was often difficult to observe the bridges from beneath.

Table 4.4-2 shows the condition of each bridge menders. Conditions of the existing bridge members are good in general.

- Every bridge is a simple support. But, there is no expansion joint on the piers and abutment. Gap space between girders is less than 40 mm. Pavement type on the bridges is DBST and has been repaired with patching.
- Road width is 9.0 m to 10.0 m and some bridges have side walk for pedestrian.

- Sixteen (16) PC bridges are PC Hollow girder bridge type which consists of seventeen (17) girders. Girder width is 600 mm. Girder height is 500 mm to 700 mm.
- Every PC Hollow bride is still in good condition.
- Steel girder bridges are all I-girder type which consists of 5 to 11 girders. Steel girders are painted or galvanized for protection against corrosion. Girder height is 500 mm to 1,000 mm.
- Many bridges are not provided with bearing shoes. Only seven bridges (Br. 9, 10, 13', 18, 22, 26 and 38) have bearing shoes which are steel type or rubber type.
- Bridge handrail is steel rail type or RC parapet type. Some of them have been damaged by car accident and repaired.

Table 4.4-2 Detail of Bridge Condition

Ref	Bridge No.	Bridge Type	GH (mm)	GW (mm)	Gt (mm)	Girder No	Clearance (m)	Structural Condition			Shoe Type	Handrail Type	Pav.
								A1	Pier	A2			
1	Br. 05	RC Deck Slab	N/M	NA	NA	NA	N/M	OK	NA	OK	NO	Steel rail	OK
2	Br. 06	Steel Girder	600	200	15	11	0.70	OK	OK	OK	NO	RC Parapet	OK
3	Br. 07	Steel Girder	995	315	20	5	0.65	OK	NA	OK	NO	Steel rail	OK
4	Br. 08	Steel Girder	495	200	13	11	1.15	OK	OK	OK	NO	Steel rail	OK
5	Br. 09	Steel Girder	900	310	20	5	1.00	OK	OK	OK	Steel	Steel rail	OK
6	Br. 10	Steel Girder	790	165	20	5	0.69	OK	OK	OK	Steel	Steel rail	OK
7	Br. 11	RC Deck Slab	400	300	NA	2	2.00	OK	OK	OK	NO	Steel rail	OK
8	Br. 12	Steel Girder & RC Rigid Frame	500	200	20	6	1.00	OK	OK	OK	NO	Steel rail	OK
9	Br. 13	RC Deck Slab	500	NA	NA	NA	1.18	OK	NA	OK	NO	Steel rail	OK
10	Br.13’	Steel Girder	1000	320	25	5		OK	OK	OK	Steel	Steel rail	OK
11	Br. 14	Steel Girder	590	200	15	10	2.90	OK	NA	OK	NO	Steel rail	OK
12	Br. 15	Steel Girder	590	200	15	10	2.50	OK	OK	OK	NO	Steel rail	OK
13	Br. 16	Steel Girder	590	200	15	10	2.30	OK	OK	OK	NO	Steel rail	OK
14	Br.16’	Steel Girder	600	200	15	10		OK	NA	OK	NO	Steel rail	OK
15	Br. 17	PC Hollow	600	600	NA	17	1.25	OK	NA	OK	NO	RC Parapet	OK
16	Br. 18	Steel Girder	870	320	20	6	1.25	OK	OK	OK	Rubber	Steel rail	OK
17	Br. 19	PC Hollow	400	600	NA	17	N/A	OK	OK	OK	NO	RC Parapet	OK
18	Br. 20	RC Deck Slab	400, 510	400, 560	NA	4, 4	0.50	OK	NA	OK	NO	Steel rail	OK
19	Br. 21	Steel Girder	600	200	15	10	2.00	OK	OK	OK	NO	Steel rail	OK
20	Br. 22	Steel Girder	1400	420	20	6	3.00	OK	OK	OK	Rubber	Steel rail	OK
21	Br. 23	PC Hollow	600	600	NA	17	1.20	OK	NA	OK	NO	RC Parapet	OK
22	Br. 24	PC Hollow	600	600	NA	17	0.60	OK	NA	OK	NO	RC Parapet	OK
23	Br. 25	PC Hollow	500	600	NA	17	0.95	OK	NA	OK	NO	RC Parapet	OK
24	Br. 26	Steel Girder	1090	360	20	6	3.75	OK	OK	OK	Rubber	Steel rail	OK
25	Br. 27	PC Hollow	500	600	NA	17	2.00	OK	NA	OK	NO	RC Parapet	OK
26	Br. 28	PC Hollow	500	600	NA	17	1.90	OK	NA	OK	NO	RC Parapet	OK

Ref	Bridge	Bridge Type	GH	GW	Gt	Girder	Clearance	Structural Condition			Shoe	Handrail	Pav.
27	Br. 29	PC Hollow	500	600	NA	17	1.30	OK	NA	OK	NO	RC Parapet	OK
28	Br. 30	PC Hollow	500	600	NA	17	1.65	OK	NA	OK	NO	RC Parapet	OK
29	Br. 31	PC Hollow	500	600	NA	17	1.40	OK	NA	OK	NO	RC Parapet	OK
30	Br. 32	PC Hollow	500	600	NA	17	1.28	OK	NA	OK	NO	RC Parapet	OK
31	Br. 33	PC Hollow	650	600	NA	17	1.30	OK	NA	OK	NO	RC Parapet	OK
32	Br. 34	PC Hollow	600	600	NA	17	1.00	OK	NA	OK	NO	RC Parapet	OK
33	Br. 35	PC Hollow	500	600	NA	17	1.90	OK	NA	OK	NO	RC Parapet	OK
34	Br. 36	PC Hollow	450	600	NA	17	0.30	OK	OK	OK	NO	RC Parapet	OK
35	Br. 37	PC Hollow	700	600	NA	17	3.50	OK	NA	OK	NO	RC Parapet	OK
36	Br.38	Steel Girder	1000	320	25	5	0.60	OK	OK	OK	Rubber	Steel rail	OK
37	Br.39	RC Deck Slab	300	NA	NA	NA	1.80	OK	OK	OK	NO	Steel rail	OK

GH: Height of girder	OK: Good condition	NO: Do not exist
GW: Width of lower flange member	N/M: Cannot be measured	NA: Not applicable
Gt: Thickness of lower flange member	Clearance: Distance from the water surface to the soffit of the girder	

4.5 Roadside Land Use

The cities, towns and villages are developed along NR 5. Many factories, shops, stalls, vendors, benches and houses are observed adjacent to the carriageway. The basic form of land use outside of urbanized area is agriculture, especially rice paddy. There are many rice mill factories and warehouses along the road and are functioning as the base stations of transportations of rice.

Negligence of Drainage

The roadside of existing route has been developed rapidly with new factories, commercial activities and residential buildings. Land fill for such development often pay very little attention to the necessity of drain channel at road shoulder. Some houses and shops bury the existing drainage channel in front of them for their convenience of access. As a result, rain water stays on the road surface or penetrates through the road bed and subgrade soil causing damage to the pavement.

Occupancy of ROW by Roadside Shops and Utilities

In town areas, private shops occupy the road shoulder and sidewalk to display their merchandise, and their buildings are placed within Right of Way. On the other land, most of the residential houses are built outside of Right of Way and some houses are moving to their backyard by their intention. It may be the effect of the notice board installed by ADB project to announcing the width of Right of Way of 30 m from the center of existing road. The boards are installed on roadside at many locations on the whole stretch of NR 5.

Although, it is instructed on the board that electric poles should be installed 28 m away from the road center, actual installation work of new electric poles is ongoing approximately 17 m away from the road center. This will bring confusion among the residents. It is strongly recommend that MPWT shall issue the warning to SKL Group, who has been installing electric poles within the road reserves.

4.6 Utility

Various kinds of utilities exist crossing, or in parallel to, the NR 5 in the areas adjacent to the road. The types of utilities exiting in the area adjacent to NR 5 are electric power lines, optic fiber cables, water supply pipes, and drainage facilities. They need to remain in-service during construction. Table 4.6-1 summarizes the types and quantities of utilities found along NR 5.

Table 4.6-1 Major Utility within the Study Area

Type of Utility	Location	Side	Distance from Centerline	Q`ty	Owner/ Operator
1.Electricity					
Electric pole (concrete); 230 kV	KP 31 – 81	L, R	15-20 m	302 no	*EDC
Electric pole (concrete); 230 kV (under construction)	KP 98 – 171	L, R	15-20 m	86 no	EDC
2. Telecommunication					
Electrical concrete pole	KP 31 – 81	L, R	15 m	430 no	Metfone
Electrical concrete pole	KP 98 – 171	L, R	15 m	730 no	Metfone
Optic fiber cable	KP 31 – 81	R	5-10 m	50 km	**Telecom
Optic fiber cable	KP 98 – 171	R	5-10 m	73 km	Telecom
Optic fiber cable	KP 31 – 81	L	15-30 m	50 km	***CFO
Optic fiber cable	KP 98 – 171	L	15-30 m	73 km	CFO
3. Water supply					
PVC pipe; D160-180	KP 36 – 38	L	7-10 m	1.3 km	Private
PVC pipe; D60-100	KP 38 – 40	L, R	7-10 m	3.0 km	Private
HDPE pipe; OD225 (under construction)	KP 40 – 49	R	15-20 m	8.5 km	Private
HDPE pipe; OD225 (in the planning)	KP 40 – 49	L		8.5 km	Private
PVC pipe; D60-100	KP 50 – 55	L, R	10-15 m	9.0 km	Private
PVC pipe; D90-140	KP 152 – 155	L, R	12 m	6.0 km	Private
4. Drainage					
Concrete pipe; D60	KP 51 – 53	L, R	12 m	1,255 m	MPWT
Concrete pipe; D60	KP 60 – 61	R	12 m	250 m	MPWT
Concrete pipe; D60	KP 80 – 81	R	12 m	500 m	MPWT
Concrete pipe; D80	KP 80 – 81	R	12 m	410 m	MPWT
U-shape drain; U-0.6 x 0.5	KP 81 – 90	L		202 m	MPWT
U-shape drain; U-0.4 x 0.6	KP 90 – 91	L		108 m	MPWT
U-shape drain; U-0.8 x 0.8	KP 90 – 91	R		112 m	MPWT

** EDC: Electricite Du Cambodge*
***Telecom: Telecom Cambodia*
****CFO: Cambodia Fiber Optic Communication Network*

4.7 Traffic Accident

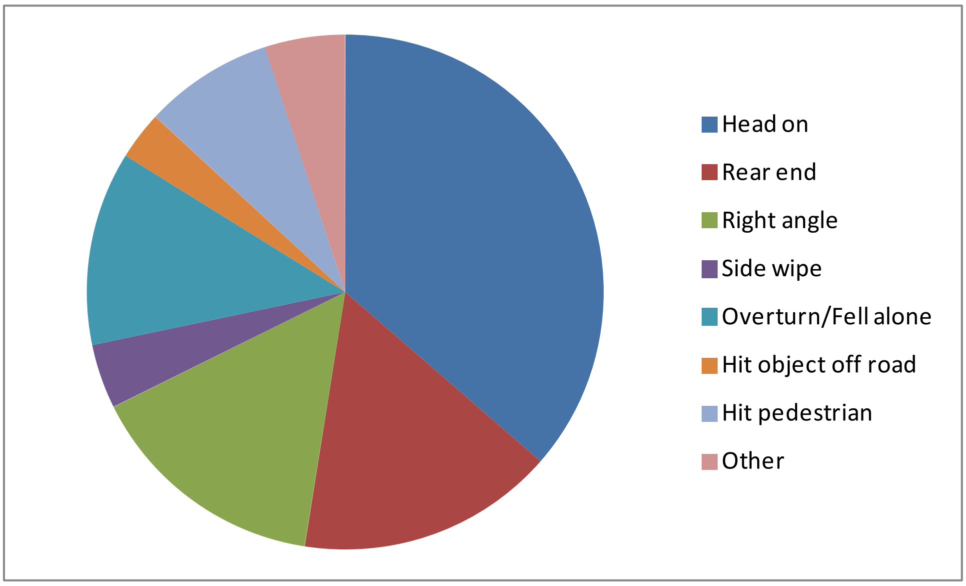
Traffic accident statistics show that NR 5 is most hazardous road among the single-digit national roads.

Table 4.7-1 Traffic Accident on Single-Digit National Road

Road No.		1	2	3	4	5	6	7
Length	(km)	184	144	202	229	431	412	463
2009	No.	277	218	130	260	741	455	284
	/km	1.505	1.513	0.644	1.135	1.719	1.104	0.613
2010	No.	222	207	139	235	750	435	318
	/km	1.206	1.438	0.688	1.026	1.740	1.056	0.689
Total	No.	499	425	269	495	1,491	890	602
Average	/km	1.356	1.476	0.666	1.081	1.730	1.080	0.650

Source: Road Accident Data by National Police Commission Department, Ministry of Interior

The statistics on type of accident show that the head-on collision counts for the largest share. Although these statistics is with regard to all roads, similar tendency can be reasonably assumed as for NR 5. If this is the case, the high accident rate of NR 5 may attributed to the narrow road width.



Source: 2011 Annual Report, National Road Safety Commission

Figure 4.7-1 Type of Accident (All Raods)

CHAPTER 5 TRAFFIC SURVEYS

Traffic surveys were carried out on the National Road No. 5 (NR 5) and National Road No. 6 (NR 6). The objectives of the surveys were to have a better understanding on the characteristics of the Survey Area, as well as the present traffic pattern. Four (4) types of survey were conducted; (i) a traffic count survey (16hr and 24hr), (ii) an origin destination (O-D) interview survey, (iii) a travel speed survey, and (iv) an axle load survey. The outline, method and result of the surveies are explained in the sections below.

5.1 Traffic Count Survey

5.1.1 Outline

The traffic counts were conducted at eight (8) stations with observations being recorded under three (3) vehicle groups and eight (8) vehicle classifications. Table 5.1-1 shows the vehicle classifications.

The traffic counts were conducted 2 times to verify the daily fluctuation of traffic volume. The First Survey was conducted on the 24th and 25th of October 2012 and the Second Survey was conducted on the 7th of November 2012. In the first survey the 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. The second traffic count survey was conducted at five (5) stations from 5:00 a.m. to 9:00 p.m. The time for the day time survey was extended from the 12 hours adopted in the survey of the North Section to 16 hours in this survey to fully cover both of the morning and evening peak traffic.

Table 5.1-1 Vehicle Classification for the Traffic Count Survey

Group		Classification	
I	Motor Cycle (MC)	1	Motorcycle and Motor Tricycle
		2	Motorbike Trailer
II	Light Vehicle (LV)	3	Sedan, Wagon, Light Van and Pick-up (for passenger)
		4	Pick-up (for commodity), Jeep and Light Truck (>3.5 t)
		5	Mini Bus (Van type and Pick-up Type)
III	Heavy Vehicle (HV)	6	Short and Long Body Bus
		7	Short and Long Body Truck (<3.5 t)
		8	Semi and Full Trailer Truck

5.1.2 Location of Traffic Count Survey

The survey locations were selected at the provincial boundary, the city boundary and the city center and they are shown in Table 5.1-2 and Figure 5.1-1, 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 understand 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 to route of NR 5.

Table 5.1-2 Location of Traffic Count Survey

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 of the survey was conducted 7th November 2012 (Wed).

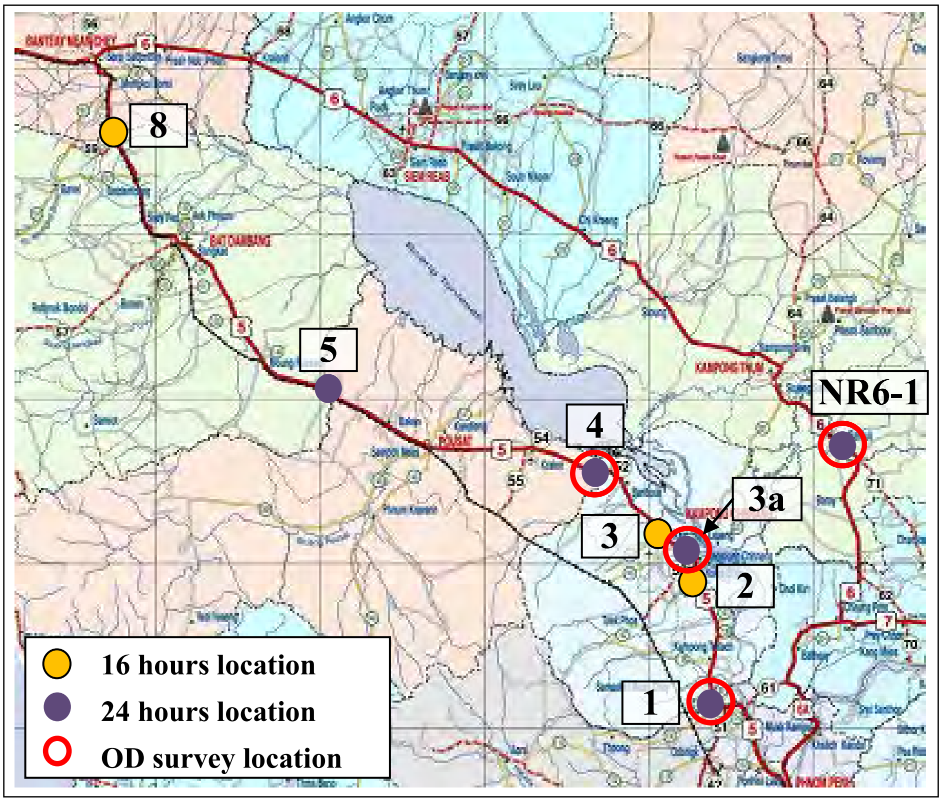


Figure 5.1-1 Location of Traffic Count Survey Stations

5.1.3 Survey Result

The results of the traffic count survey are as described below.

(1) 16-hour traffic volume

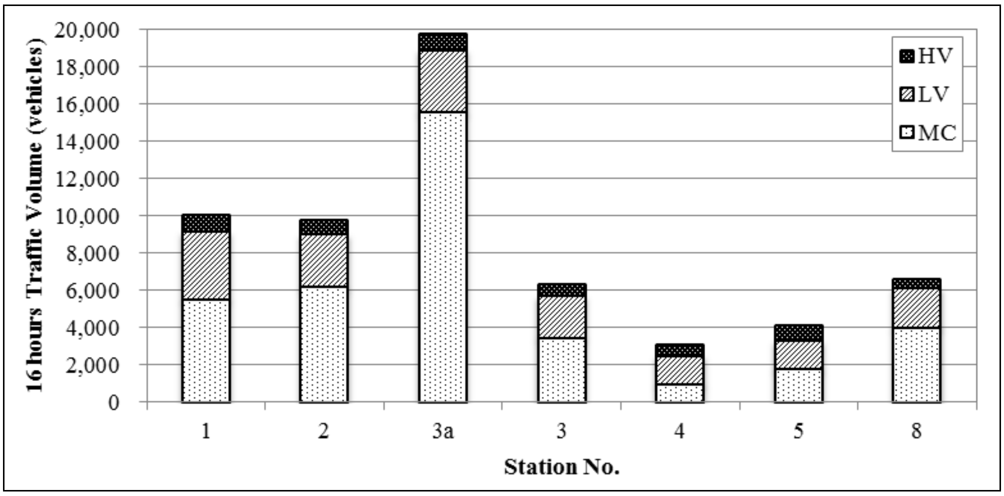
Table 5.1-3 and Figure 5.1-2 show 16 hours traffic volume by vehicle group and classification. The traffic volumes at Station No. 1 to No. 3a (Kampong Chhnang) were considerably larger than those at other stations. Also, there were significant differences in the traffic volumes of MC between survey stations. Traffic volume of MC at Station No. 3a (city center of Kampong Chhnang) was larger than those at other stations such as Station Nos. 4, 5 and 8 (provincial boundary) and Station No. 3 (city boundary). Traffic volume of LV and HV did not show large difference among locations.

Table 5.1-3 Traffic Volume for 16 Hours

(Unit: Vehicles)

Station	Motorcycle (MC)			Light Vehicle (LV)				Heavy Vehicle (HV)				Grand Total
	Motorcycle & Tricycle	Motorbike 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	5,055	473	5,528	1,930	1,045	633	3,608	198	592	116	906	10,042
2	5,902	274	6,176	1,642	803	380	2,825	195	567	55	817	9,818
3a	15,155	436	15,591	2,048	878	405	3,331	201	554	82	837	19,759
3	3,276	180	3,456	1,044	831	367	2,242	183	342	83	608	6,306
4	935	47	982	799	481	224	1,504	183	343	85	611	3,097
5	1,736	43	1,779	810	494	202	1,506	196	566	84	846	4,131
8	3,912	101	4,013	1,453	499	166	2,118	169	188	156	513	6,644
NR6-1	3,537	208	3,745	1,054	644	639	2,337	180	434	101	715	6,797
Total	39,508	1,762	41,270	10,780	5,675	3,016	19,471	1,505	3,586	762	5,853	66,594

Note: Station NR6-1 is on National Road No. 6



Note: Station NR6-1 is excluded.

Figure 5.1-2 Traffic Volume Recorded in the 16 Hours Survey

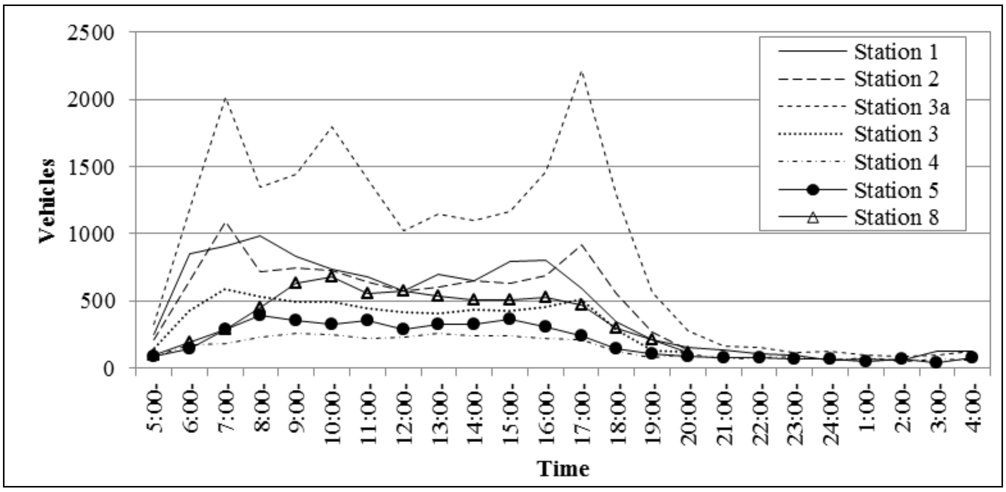
(2) Peak hour traffic volume

Table 5.1-4 shows the peak hour traffic volumes and peak hour ratios. Figure 5.1-3 shows traffic volume by the hour. The largest hourly traffic volumes were recorded in the morning at all stations except Station No. 3a. Traffic volumes between 7:00 a.m. - 10:00 a.m. and those between 16:00 p.m. - 17:00 p.m. were greater than other time periods.

Table 5.1-4 Peak Hour Traffic Volume

Station	16-hr Volume	24-hr Volume	Peak Hour Volume	Peak Hr. Ratio (Peak-hr/24-hr)	Peak Hours
1	10,042	10,818	1,031	0.10	8:15 - 9:15
2	9,818	10,501	1,116	0.11	6:45 - 7:45
3a	19,759	20,720	2,215	0.11	17:00 - 18:00
3	6,306	6,800	594	0.09	6:45 - 7:45
4	3,097	3,641	267	0.07	9:30 - 10:30
5	4,131	4,654	404	0.09	8:15 - 9:15
8	6,644	7,191	721	0.10	9:45 - 10:45
NR6-1	6,797	7,309	626	0.09	7:45 - 8:45

Note: 24-hr Volume is calculated in Table 5.1-6



Note: Station NR6-1 is excluded.

Figure 5.1-3 Traffic Volume by Hour

(3) 24-hour/16-hour ratio

The 24 hour traffic count was carried out at five (5) stations (No.1, 3a, 4, 5 and NR6-1) in order to confirm the trend of the traffic volume in rural, suburban and urban areas. The ratios of 24 hour volume/16-hour volume by vehicle classification are shown in Table 5.1-5. The 24-hour / 16-hour ratio of Short & Long Body Truck and Semi & Full Trailer Truck are greater than the other vehicle classifications. The 24-hr : 16-hr ratios of MC, LV and HV are in the rages of 1.02 – 1.03, 1.07 – 1.11 and 1.30 – 1.48, respectively. The smaller (close to 1.0) ratios of MC and LV can be interpreted as showing that MC and LV do not travel during the night, while the larger ratio of HV is considered to show that HVs travel constantly over 24 hours.

Table 5.1-5 24-Hour/16-Hour Ratio

Duration	Station (area)	Motorcycle (MC)			Light Vehicle (LV)				Heavy Vehicle (HV)				Grand Total
		Motorcycle & Tricycle	Motorbike 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	
16 hour	1 (Suburban)	5,055	473	5,528	1,930	1,045	633	3,608	198	592	116	906	10,042
	3a (Urban)	15,155	436	15,591	2,048	878	405	3,331	201	554	82	837	19,759
	4 (Rural)	935	47	982	799	481	224	1,504	183	343	85	611	3,097
	5 (Rural)	1,736	43	1,779	810	494	202	1,506	196	566	84	846	4,131
	NR6-1 (Rural)	3,537	208	3,745	1,054	644	639	2,337	180	434	101	715	6,797
24 hour	1 (Suburban)	5,174	499	5,673	2,037	1,171	669	3,877	229	866	173	1,268	10,818
	3a (Urban)	15,495	452	15,947	2,171	966	432	3,569	227	832	145	1,204	20,720
	4 (Rural)	943	49	992	876	565	244	1,685	209	609	146	964	3,641
	5 (Rural)	1,769	44	1,813	884	552	217	1,653	228	793	167	1,188	4,654
	NR6-1 (Rural)	3,619	225	3,844	1,130	714	689	2,533	211	577	144	932	7,309
24/16 Ratio	1 (Suburban)	1.03			1.07				1.40				1.08
	3a (Urban)	1.02			1.07				1.44				1.05
	4, 5 (Rural)	1.02			1.11				1.48				1.15
	NR6-1 (Rural)	1.03			1.08				1.30				1.08

Note: Station NR6-1 is on National Road No.6.

(4) Conversion to 24 hours (daily) traffic volume

The 24 hours (daily) traffic volumes were calculated at the survey station where traffic volumes were counted for 16 hours by using a conversion factor calculated from the 24-hr/16-hr ratio found for rural area and suburban. The conversion factor obtained from the data observed at Station No.1 is applied to Station No. 2 and 3 and that obtained from the data observed at Station No.4 and 5 are applied to Station No. 8. The 24-hr traffic volumes thus calculated are shown in Table 5.1-6.

Table 5.1-6 Daily (24 Hours) Traffic Volumes

(Unit: Vehicles/day)

Station	Motorcycle (MC)			Light Vehicle (LV)				Heavy Vehicle (HV)				Grand Total
	Motorcycle & Tricycle	Motorbike 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) Comparison of Traffic Volume Observed in First Survey and Second Survey

Table 5.1-7 shows the 16 hours traffic volume on the Second Survey (the survey conducted on 7 November 2012) by vehicle type and classification. Figure 5.1-4 compares traffic volumes at Station No. 1, 2, 3a, 3 and 4 counted in the First Survey and the Second Survey. The traffic volume of MC at Station No. 3a observed in the Second Survey is slightly different from that of the First Survey. Other 16-hr traffic volumes of the Second Survey generally agree with those of the First Survey.

Table 5.1-7 Traffic Volumes for 16 Hours in the Second Day

(Unit: Vehicles/day)

Station	Motorcycle (MC)			Light Vehicle (LV)				Heavy Vehicle (HV)				Grand Total
	Motorcycle & Tricycle	Motorbike 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	4,961	458	5,419	2,013	1,190	671	3,874	165	509	182	856	10,149
2	6,346	287	6,633	1,774	820	375	2,969	158	494	110	762	10,364
3a	16,932	446	17,378	2,260	958	413	3,631	170	484	167	821	21,830
3	3,318	194	3,512	1,135	776	362	2,273	163	306	135	604	6,389
4	1,340	59	1,399	923	474	250	1,647	164	277	117	558	3,604

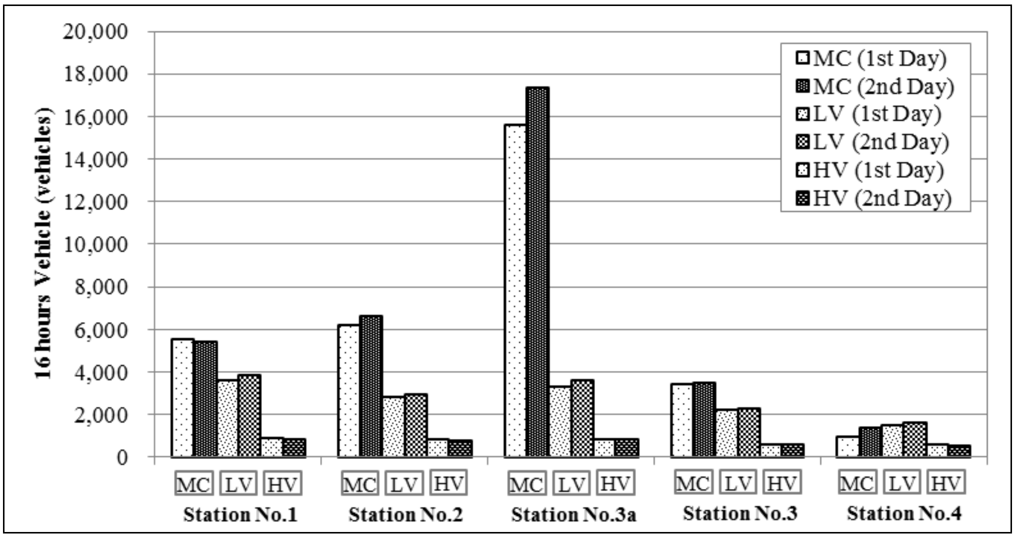


Figure 5.1-4 Comparison of Traffic Volumes Observed on the First Day and the Second Day

(6) Comparison of Observed Traffic Volume of year 2012 and year 2011

Table 5.1-8 and Figure 5.1-5 compare the traffic volumes observed in years 2011 and 2012. The traffic volumes observed at Station No. 1, 2, 4 and 5 increased slightly from 2011 to 2012 while those observed at Station No. 3 and 8 decreased slightly.

Table 5.1-8 Traffic Volumes (24 hours) in year 2011 and year 2012

(Unit: Vehicles/day)

Station	Traffic count survey in 2011				Traffic count survey in 2012				2012:2011 Ratio
	MC	LV	HV	Total	MC	LV	HV	Total	
1	5,039	3,572	1,512	10,122*	5,673	3,877	1,268	10,818	1.07
2	5,622	3,284	735	9,641*	6,330	3,034	1,137	10,501**	1.09
3	4,123	2,556	772	7,451*	3,543	2,421	836	6,800**	0.91
4	800	1,771	780	3,351*	992	1,685	964	3,641	1.09
5	1,724	1,718	956	4,398	1,813	1,653	1,188	4,654	1.06
8	4,312	2,372	1,411	8,094*	4,076	2,341	774	7,191**	0.89
Total	21,620	15,273	6,166	43,058	22,427	15,011	6,166	43,605	1.01

Note: Traffic count survey at Station No.3a and NR6-1 were not conducted in year 2011.
** Converted from 12 hours traffic volume.*
*** Converted from 16 hours traffic volume.*

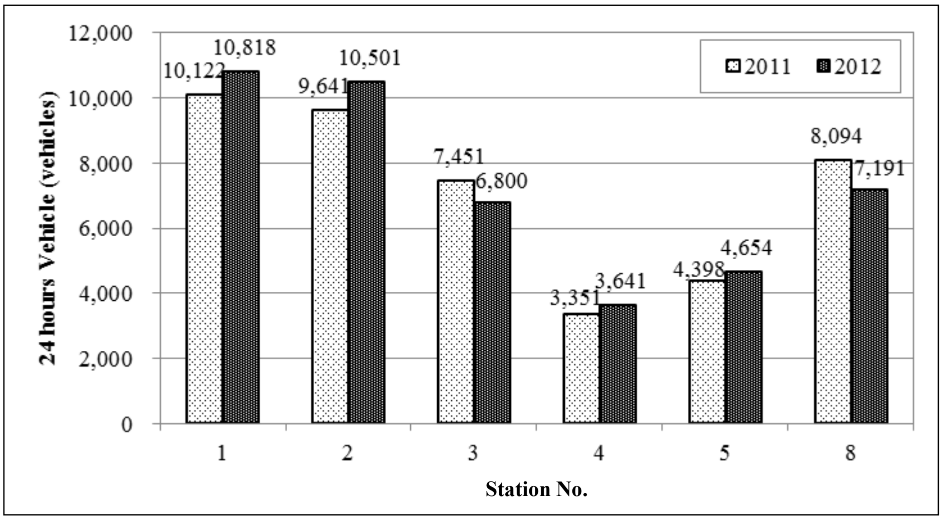


Figure 5.1-5 Traffic Volume (24 hours) in Year 2011 and Year 2012

5.2 Origin-Destination (OD) Survey

5.2.1 Outline

An Origin-Destination (OD) survey was carried out to establish the survey area travel patterns (where vehicle are moving from and to). ODs of vehicles were surveyed by roadside interviews with drivers. This method is the most commonly practiced method. Interviews with vehicle drivers were carried out in the 12 hours from 6:00 a.m. to 18:00 p.m. on Wednesday, 24th of October during same time as the traffic count survey (see Table 5.1-2 and Figure 5.1-1). The target sample rate was set at 10%. The vehicles were stopped on a random sampling basis, and drivers were interviewed.

The following information was collected in the driver's interview

- Trip purpose (to home, to office/work place, to school, at work/business, or private)
- Origin and destination
- Number of passengers (including driver)
- Estimated travel time
- Major cargo/loading factor (for truck)

5.2.2 Survey Result

(1) Number of samples and sampling rate

The number of samples and the sampling rate achieved at each station are shown in Table 5.2-1. Sampling rates exceeded the target of 10% at all stations except Station No. 3a. The OD interview survey at Station No. 3a needed to be conducted with care not to hinder the traffic flow, because Station No. 3a was located in the city center of Kampong Chhnang where traffic is busy. The number of samples exceeded 1,000 and consequently, the Survey Team considers this sampling number an acceptable level.

Table 5.2-1 Number of Sampling and Rate

Station	Traffic Volume (12 hrs)	Number of Samples	Sampling Rate
1	9,090	1,936	21.3%
3a	17,309	1,469	8.5%
4	2,706	860	31.8%
NR6-1	6,026	979	16.2%
Total	35,131	5,244	14.9%

(2) Average Passenger Occupancy

The average passenger occupancy by vehicle classification is shown in Table 5.2-2. It is noted that the average occupancy of “Motorcycle and Tricycle” is 1.6, implying that about one out of two motorcycles is carrying one person in addition to the operator.

Table 5.2-2 Average Passenger Occupancy

Motorcycle (MC)		Light Vehicle (LV)			Heavy Vehicle (HV)		
Motorcycle & Tricycle	Motorbike Trailer	Sedan, Wagon & Light Van	Pick-up, Jeep & Light Truck	Mini Bus	Short & Long Body Bus	Short & Long Body Truck	Semi & Full Trailer Truck
1.6	4.0	3.4	3.5	9.0	36.7	2.4	2.0

(3) Major cargo and load factor

Table 5.2-3 shows the major types of cargo carried by truck and trailer truck. The cargo type was classified into ten (10) categories. Cargos of “Agriculture”, “Chemical” and “Construction” count for approximately 55% of all cargos.

Table 5.2-3 Major Cargo

Cargo	Share
Agriculture (rice, vegetable, fruits, etc.,)	31.8%
Forest products (log, timber)	5.1%
Marine (fish seafood, fish sauce, etc.,)	4.3%
Mineral (coal, copper etc.,)	0.4%
Metal & Machine (steel, car, motorbike, equipment, etc.,)	8.9%
Chemical (petroleum, etc.,)	12.2%
Light Industry (machines, parts, electronics, etc.,)	0.9%
Miscellaneous Industry (garments, shoes, etc.,)	4.8%
Construction (sand, gravel, concrete, brick, etc.,)	10.6%
Others (water bottle, cosmetic, recycled materials (can, paper, steel), animals, etc.,)	20.9%
Total	100.0%

Figure 5.2-1 shows the loading factor (the percentage of actual cargo load against the capacity of vehicle). Approximately 50% of truck-type vehicles are fully loaded.

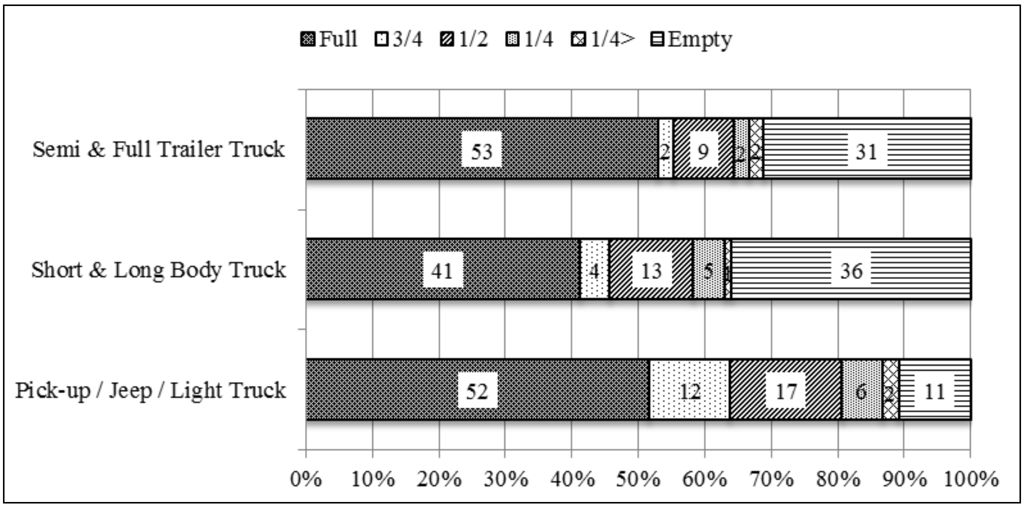


Figure 5.2-1 Loading Factor by Vehicle Classification

(4) Trip purpose

Figure 5.2-2 shows trip purpose by vehicle classification. Except for Motorcycle and Tricycle, the trip purpose with the largest share is ‘At work/Business’.

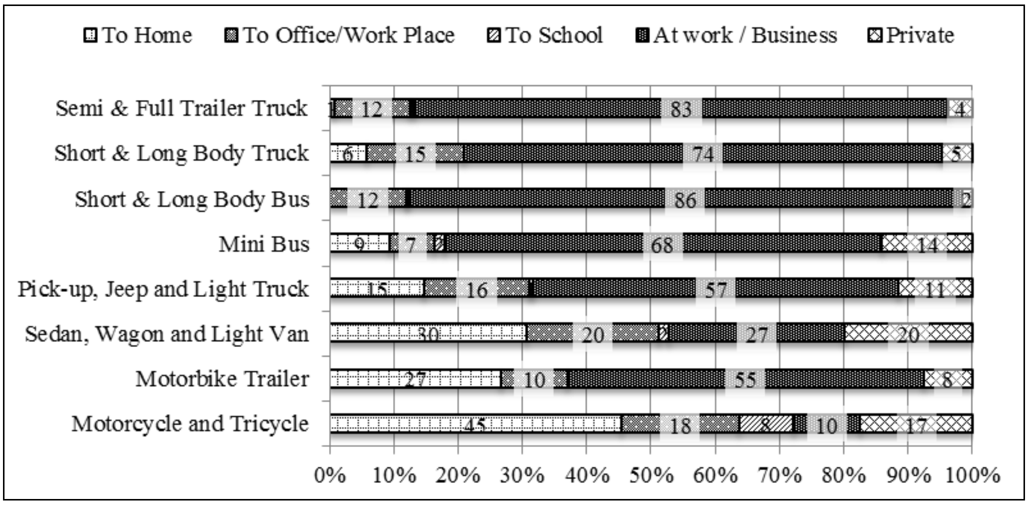


Figure 5.2-2 Trip Purpose by Vehicle Classification

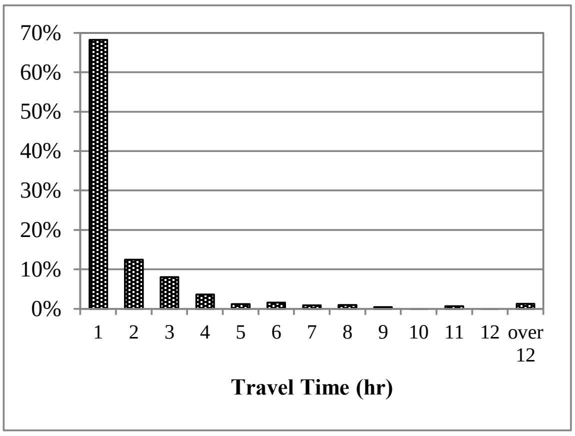
(5) Travel time

Table 5.2-4 shows the distribution of estimated travel time by vehicle classification. The travel time from origin to destination was estimated based on the driver’s perception. The average travel time of “Heavy Vehicle” is more than 400 minutes, while the average travel time of “Motorcycle and Tricycle” is approximately one and a quarter hours. Figure 5.2-3 shows the distribution of travel time by vehicle category. 68% of MC travel within 1 hour, and more than 50% of HV travel times are over 7 hours.

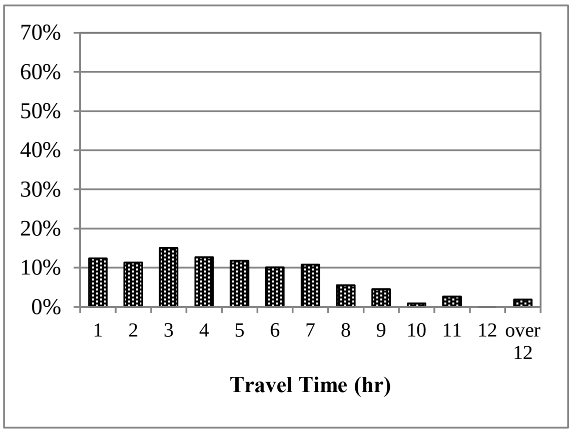
Table 5.2-4 Average Travel Time by Vehicle Classification

(Unit: Minutes)

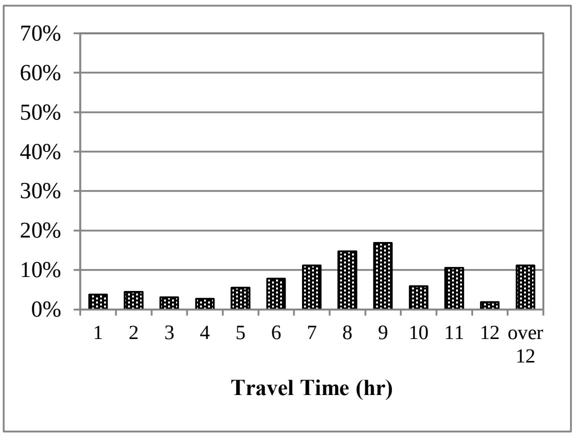
Motorcycle (MC)		Light Vehicle (LV)			Heavy Vehicle (HV)		
Motorcycle & Tricycle	Motorbike Trailer	Sedan, Wagon & Light Van	Pick-up, Jeep & Light Truck	Mini Bus	Short & Long Body Bus	Short & Long Body Truck	Semi & Full Trailer Truck
74	172	209	255	256	457	402	513



(1) Motorcycle



(2) Light Vehicle



(3) Heavy Vehicle

Figure 5.2-3 Distribution of Travel Time by Vehicle Classification

(6) OD trip pattern

The percentage of journeys between two points (OD pair) found from the OD interview survey is shown in Tables 5.2-5 to 5.2-8.

- Station No. 1 (the province boundary between Kampong Speu and Kampong Chhnang)

  Thirty nine percent of those interviewed were travelling between the OD zones of Kampong Chhnang and Phnom Penh and the area in south of Phnom Penh. Those traveling between the OD zones of Kampong Speu and Kampong Chhnang counted for 30% of the total.

- Station No. 3a (Kampong Chhnang)

  Fifty eight percent of those interviewed were travelling between the OD pair of inner city – inner city .

- Station No. 4 (the province boundary between Kampong Chhnang and Pursat)

  Fifty two percent of those interviewed were travelling between the OD pair of Battambang and north and Phnom Penh and south and of this total 26% were travelling between the OD pair of Pursat and Phnom Penh and south.

- Station NR6-1 (cross section of National Road No. 6 and No. 71)

  Thirty four percent of those interviewed were travelling between the OD pair of inner city – inner city (Kampong Thom) and the OD pair of Siem Reap and Phnom Penh and south counted for 23% of trips.

Table 5.2-5 OD Trip Pattern (Survey Station No.1)

Destination / Origin	Battambang & North	Pursat	Kampong Chhnang	Kampong Speu	Phnom Penh &South	Total
Battambang & North	0%	0%	0%	0%	10%	10%
Pursat	0%	0%	0%	0%	4%	4%
Kampong Chhnang	0%	0%	0%	**13%**	**21%**	34%
Kampong Speu	0%	0%	**17%**	0%	0%	18%
Phnom Penh & South	11%	5%	**18%**	0%	0%	34%
Total	11%	5%	35%	14%	35%	100%

Table 5.2-6 OD Trip Pattern (Survey Station No.3a)

Destination / Origin	Battambang & North	Pursat	Kampong Chhnang	Kampong Speu	Phnom Penh & South	Total
Battambang & North	0%	0%	0%	0%	9%	10%
Pursat	0%	0%	0%	0%	5%	6%
Kampong Chhnang	0%	0%	**58%**	0%	5%	64%
Kampong Speu	0%	0%	0%	0%	0%	1%
Phnom Penh & South	10%	4%	5%	0%	0%	20%
Total	11%	5%	64%	1%	19%	100%

Table 5.2-7 OD Trip Pattern (Survey Station No.4)

Destination / Origin	Battambang & North	Pursat	Kampong Chhnang	Kampong Speu	Phnom Penh & South	Total
Battambang & North	0%	0%	1%	0%	**25%**	26%
Pursat	0%	0%	5%	0%	**13%**	18%
Kampong Chhnang	3%	10%	0%	0%	0%	13%
Kampong Speu	1%	1%	0%	0%	0%	1%
Phnom Penh & South	**27%**	**13%**	0%	0%	0%	41%
Total	31%	24%	6%	1%	38%	100%

Table 5.2-8 OD Trip Pattern (Survey Station NR6-1)

Origin \ Destination	Banteay Meanchey & North	Siem Reap	Kampong Thom	Kampong Cham	Phnom Penh & South	Total
Banteay Meanchey & North	0%	0%	0%	1%	1%	2%
Siem Reap	0%	0%	1%	2%	**12%**	15%
Kampong Thom	0%	1%	**34%**	8%	11%	55%
Kampong Cham	1%	2%	4%	0%	0%	7%
Phnom Penh & South	1%	**11%**	9%	0%	0%	22%
Total	3%	13%	48%	11%	25%	100%

Note: Station NR6-1 is on National Road No.6

5.3 Travel Speed Survey

5.3.1 Objective

The objectives of the travel speed survey are (i) to get the effectiveness indicator for the project, (ii) to find the location of queuing traffic and (iii) to have understanding on the characteristic of the Survey Area. The travel speed survey was conducted between Prek Kdam Bridge and Kampong Chhnang, and between Kampong Chhnang and Prusat on Wednesday, 26th of September, Thursday 27th, of September (weekday survey), and on Sunday 11th of November (weekend survey). The survey was conducted by sedan car traveling at the average speed of the traffic flow while the location and elapsed time were recorded at locations of major speed changes.

5.3.2 Route and Sections of Travel Speed Survey

The travel speed survey was conducted six (6) times on four (4) routes. The routes and survey start times are shown in Figure 5.3-1, Table 5.3-1 and Table 5.3-2.

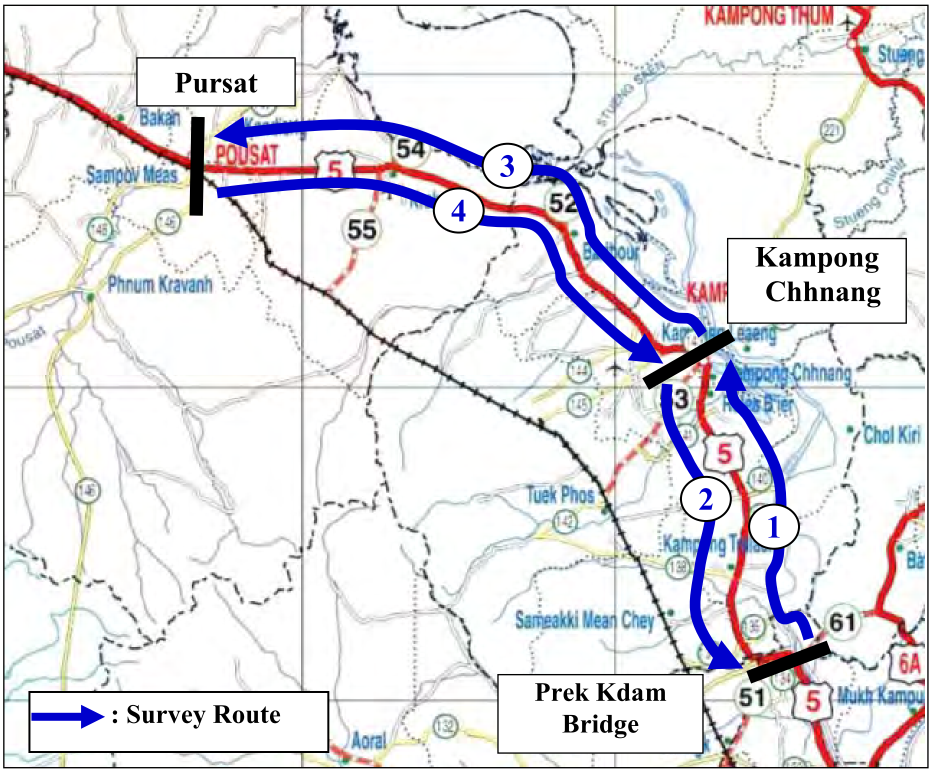


Figure 5.3-1 Travel Speed Survey Route

Table 5.3-1 Survey Section and Start Time (Weekday Trip)

Route	From	To	Survey Start Time					
			First	Second	Third	Fourth	Fifth	Sixth
1	Prek Kdam	Kampong Chhnang	7:00	8:00	8:50	14:00	15:00	16:00
2	Kampong Chhnang	Prek Kdam	7:00	8:00	8:50	14:00	15:00	16:00
3	Kampong Chhnang	Pursat	7:00	8:50	10:00	13:00	14:30	16:10
4	Pursat	Kampong Chhnang	7:00	8:30	10:20	13:00	14:40	16:00

Note: This survey was conducted on Wednesday 26th and Thursday 27th of September.

Table 5.3-2 Survey Section and Start Time (Weekend Trip)

Route	From	To	Survey Start Time					
			First	Second	Third	Fourth	Fifth	Sixth
1	Prek Kdam	Kampong Chhnang	7:30	8:00	10:20	14:00	15:00	16:10
2	Kampong Chhnang	Prek Kdam	7:00	8:40	8:50	14:00	15:00	16:00
3	Kampong Chhnang	Pursat	7:00	8:30	10:40	13:00	14:30	16:00
4	Pursat	Kampong Chhnang	7:00	8:30	10:00	13:00	14:30	16:00

Note: This survey was conducted on Sunday 11th of November.

5.3.3 Survey Result

(1) Travel Speed on Weekday

The travel times recorded for each route are shown in Figure 5.3-2, Figure 5.3-3 and Table 5.3-3. The travel times of Route No. 1 and Route No. 2 were a little more than 50 minutes and average travel speed was about 65 km/h. The travel times of Route No. 3 and Route No. 4 were a little more than 80 minutes and average travel speed was 70 km/h. Average travel speed between Prek Kdam and Kampong Chhnang, and between Kampong Chhnang and Pursat in the Survey of the North Section in 2011 were 61.3 km/h and 70.9 km/h. There is not a significant difference between the average travel speed last year and this year.

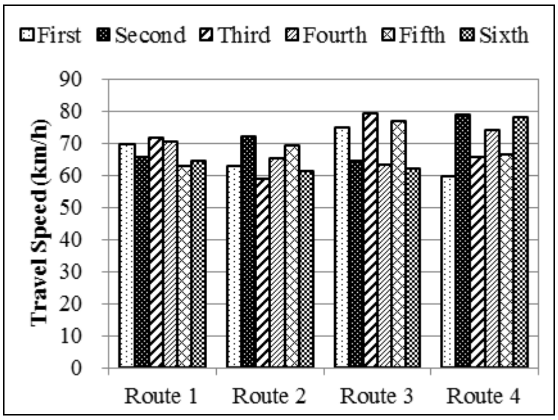


Figure 5.3-2 Travel Speed (Weekday)

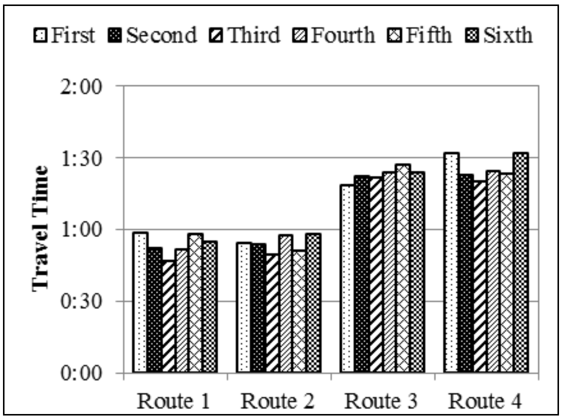


Figure 5.3-3 Travel Time (Weekday)

Table 5.3-3 Travel Speed and Travel Time on a Weekday

Route	Distance	Travel Speed /Travel Time	First	Second	Third	Fourth	Fifth	Sixth	Average
1	59 km	Speed (km/h)	69.5	65.6	71.4	70.5	62.9	64.4	67.4
		Time (h:mm)	0:50	0:53	0:49	0:49	0:55	0:54	0:52
2	59 km	Speed (km/h)	62.7	71.9	58.7	65.2	69.4	61.1	64.8
		Time (h:mm)	0:56	0:49	1:00	0:54	0:51	0:57	0:54
3	96 km	Speed (m/h)	74.7	64.4	79.3	63.0	76.7	62.1	70.0
		Time (h:mm)	1:17	1:29	1:12	1:31	1:15	1:33	1:23
4	96 km	Speed (km/h)	59.6	78.8	65.4	73.8	66.3	78.0	70.3
		Time (h:mm)	1:36	1:13	1:28	1:18	1:27	1:14	1:22

<u>Low Speed Area</u>

Vehicle speeds obtained in the morning are shown in Figures 5.3-4 to 5.3-7. Vehicle speeds at Odongk Market, Tranch Market, Kampong Tralacn, Prey Khmer and Kampong Chhnang were under 40 km/h on Route No. 1 and Route No. 2. Vehicle speeds at Kampong Chhnang, Ponley Market, Krokor and Pursat were under 40 km/h on Route No. 3 and Route No. 4. Vehicle speeds in the city and markets were lower than other areas due to the shops along the road, vehicles parked on the road and oxcarts that travel on the road. Traffic queues were not found in the survey.

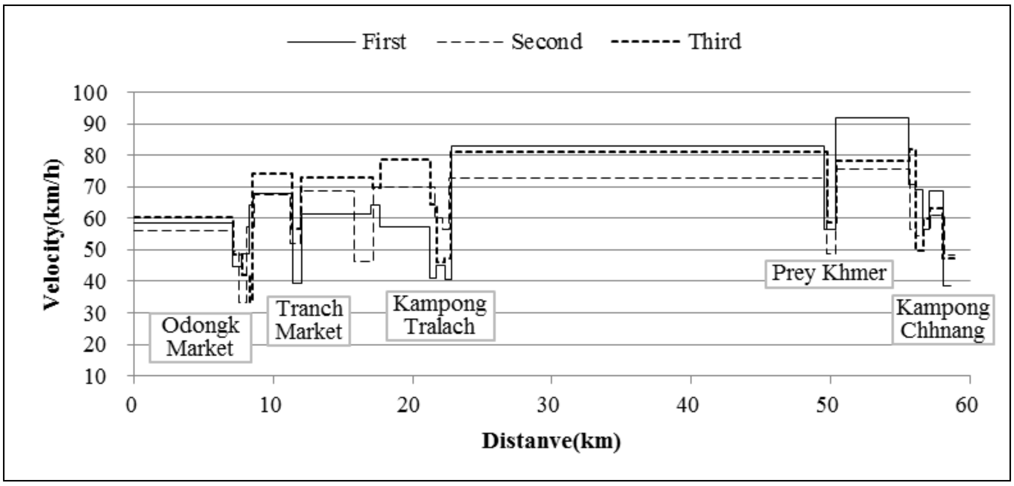


Figure 5.3-4 Travel Speed on Weekday (Route No.1)

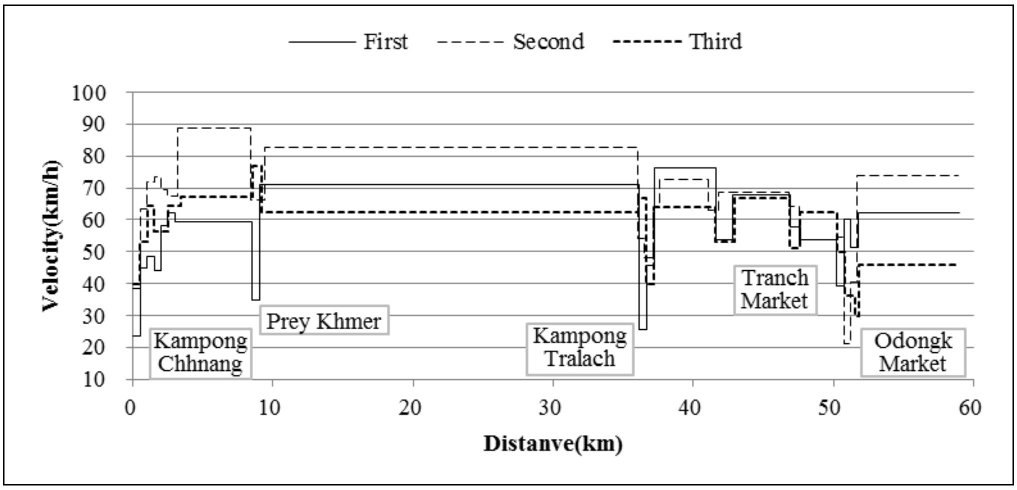


Figure 5.3-5 Travel Speed on Weekday (Route No.2)

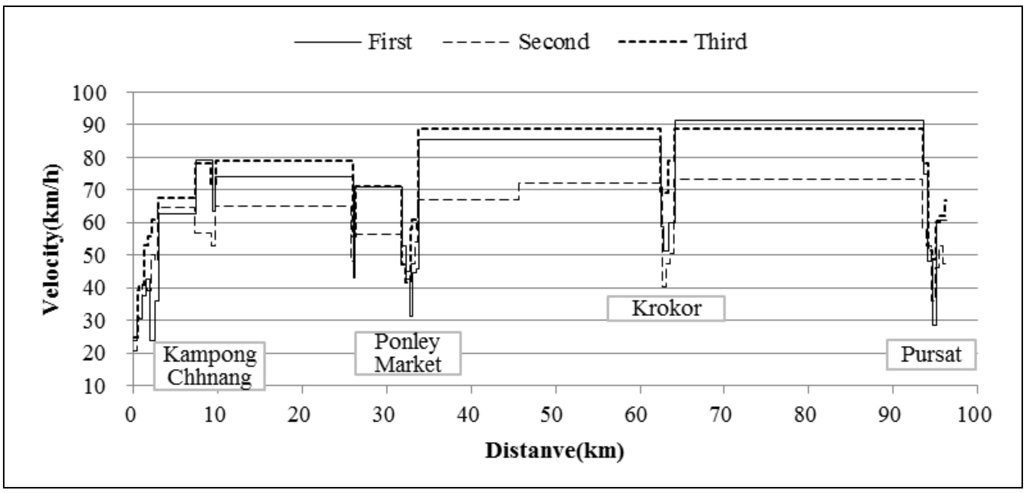


Figure 5.3-6 Travel Speed on Weekday (Route No.3)

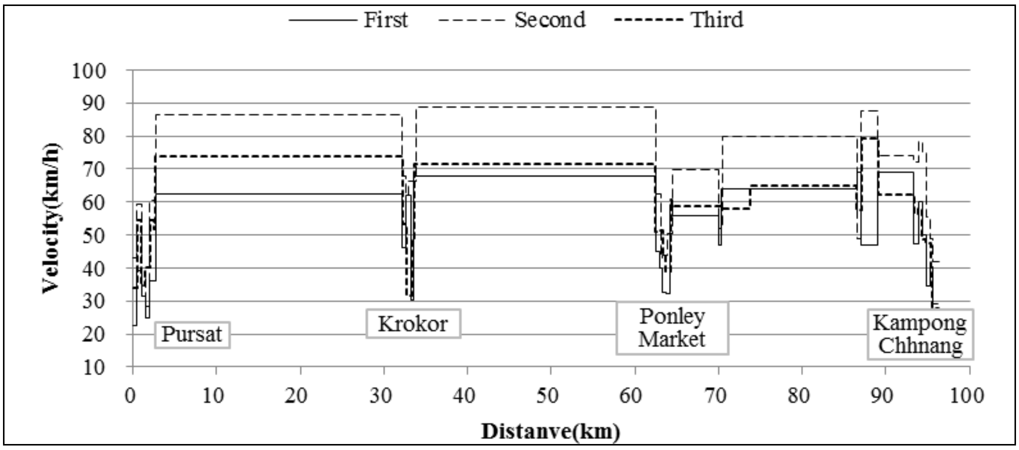


Figure 5.3-7 Travel Speed on Weekday (Route No.4)

(2) The Travel Speed on Weekend

The average travel speed achieved and the travel times by routes are shown in Figure 5.3-8, Figure 5.3-9 and Table 5.3-4. On Route No. 1 and Route No. 2, travel time was about 55 minutes and the average travel speed was about 65 km/h. On Route No. 3 and Route No. 4, travel time was about 85 minutes and the average travel speed was about 70 km/h. There is no significant difference between the times recorded on the weekday survey and on the weekend survey.

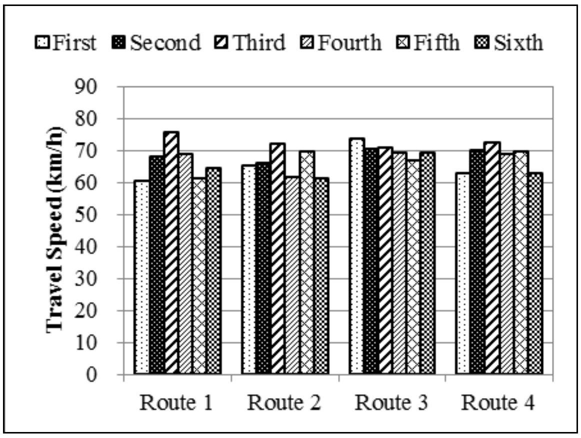


Figure 5.3-8 Travel Speed (Weekend)

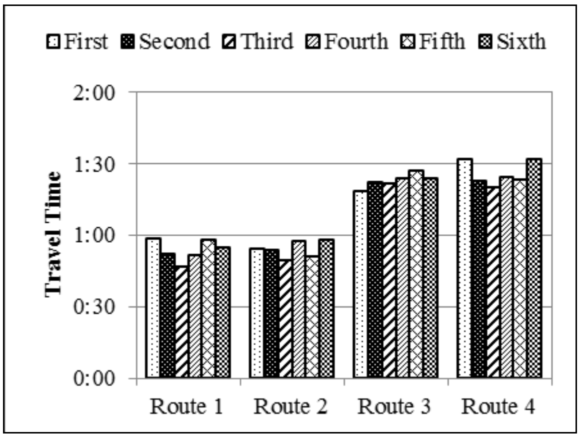


Figure 5.3-9 Travel Time (Weekend)

Table 5.3-4 Travel Speed and Travel Time on Weekend

Route	Distance	Travel Speed /Travel Time	First	Second	Third	Fourth	Fifth	Sixth	Average
1	59 km	Speed (km/h)	60.4	68.1	75.5	68.9	61.0	64.4	66.4
		Time (h:mm)	0:58	0:51	0:46	0:51	0:57	0:54	0:53
2	59 km	Speed (km/h)	65.0	65.9	72.1	61.4	69.8	61.3	65.9
		Time (h:mm)	0:54	0:53	0:49	0:57	0:50	0:57	0:53
3	96 km	Speed (m/h)	73.7	70.4	70.8	69.2	66.6	69.0	69.9
		Time (h:mm)	1:18	1:22	1:21	1:23	1:26	1:23	1:22
4	96 km	Speed (km/h)	62.8	69.8	72.3	68.7	69.4	62.9	67.6
		Time (h:mm)	1:31	1:22	1:19	1:24	1:23	1:31	1:25

Low Speed Area

Vehicle speeds observed in the morning are shown in Figures 5.3-10 to 5.3-13. Vehicle speeds at the markets and in the city were lower than other areas. Vehicle speed at Odongk Market on the weekend was lower than on the weekday. It seems that many people go to the market on the weekend. Traffic queues were not found in the survey.

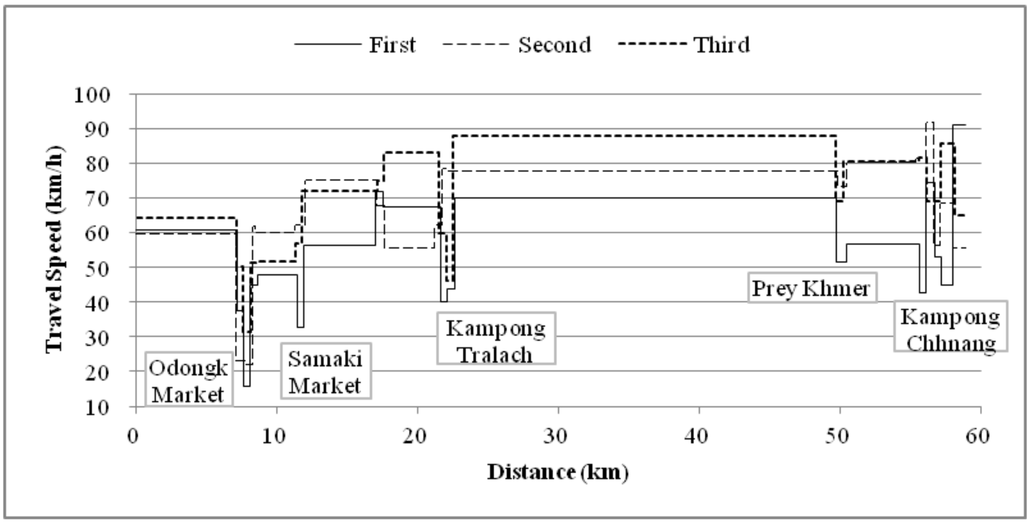


Figure 5.3-10 Travel Speed on the Weekend (Route No.1)

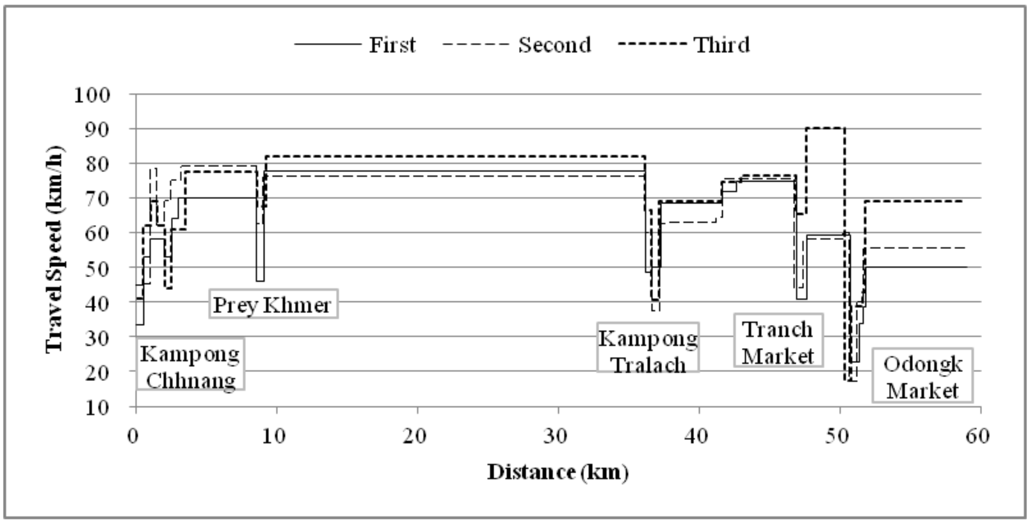


Figure 5.3-11 Travel Speed on the Weekend (Route No.2)

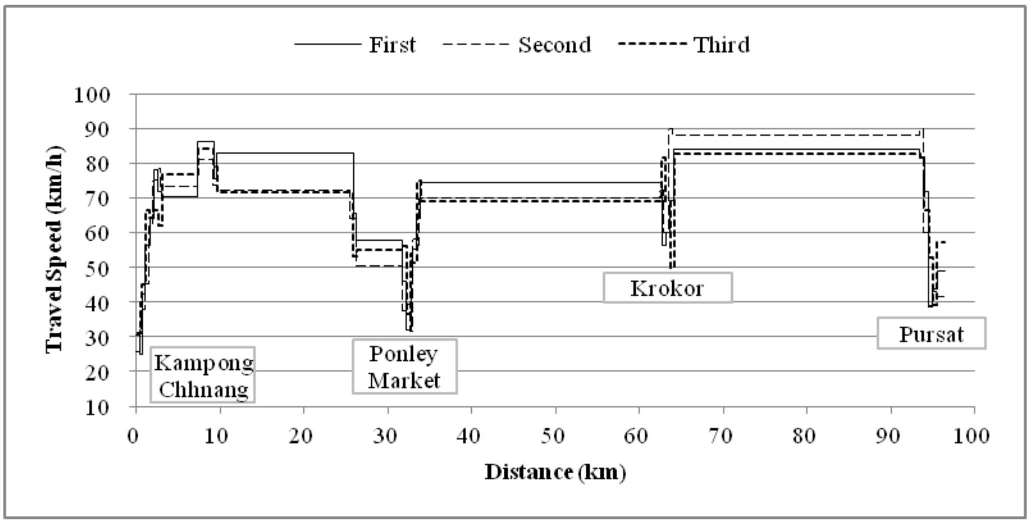


Figure 5.3-12 Travel Speed on the Weekend (Route No.3)

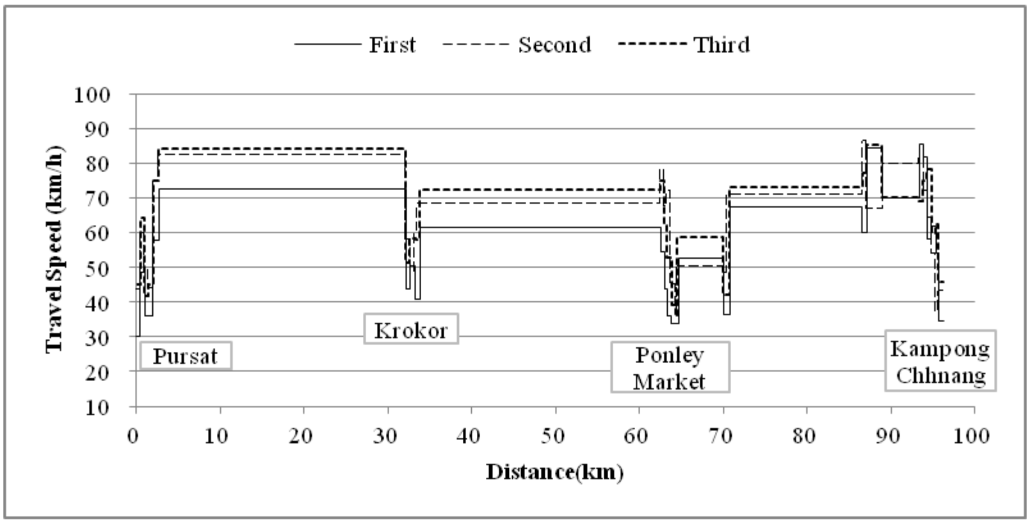


Figure 5.3-13 Travel Speed on the Weekend (Route No.4)

5.4 Axle Load Survey

5.4.1 Objective

Axle load is a decisive factor in pavement design. The axle load survey was conducted to collect the data for pavement design. The surveyed axle loads were converted to Axle Load Equivalent Factors (ALEF) as defined in "Design Guide for Pavement Structure, AASHTO 1994". These ALEF will be used in the pavement design in the later stage of this Survey.

5.4.2 Survey Result and Calculation of ALEF

(1) Survey Date and Time

The axle load survey was conducted at Long Veaek Weigh Station (KP 48 km on NR 5) from

3:00 a.m. to 10:00 a.m. on Monday, 11th of November.

(2) Number of Sample

A total of 219 heavy vehicles were measured. The number in each sample is shown in Table 5.4-1.

Table 5.4-1 Number of vehicles sampled

Direction	Short & Long Body Bus	Short & Long Body Truck	Semi & Full Trailer Truck	Total
From Phnom Penh	31	45	6	82
To Phnom Penh	16	100	21	137
Total	47	145	27	219

(3) Calculation of ALEF

The average of ALEF was 2.97. There was one vehicle with an exceptionally heavy axle load (24.3 ton). When this vehicle is excluded, the average ALEF becomes 2.48. The average ALEF in the direction towards Phnom Penh was larger than in the direction from Phnom Penh. Table 5.4-2 and Figure 5.4-1 shows the average ALEF and the distribution of ALEF.

Table 5.4-2 Average of Axle Load Equivalency Factor (ALEF)

Direction	ALEF	ALEF (Excluding exceptionally heavy vehicle)
From Phnom Penh	1.71	1.71
To Phnom Penh	3.73	2.95
Total	2.97	2.48

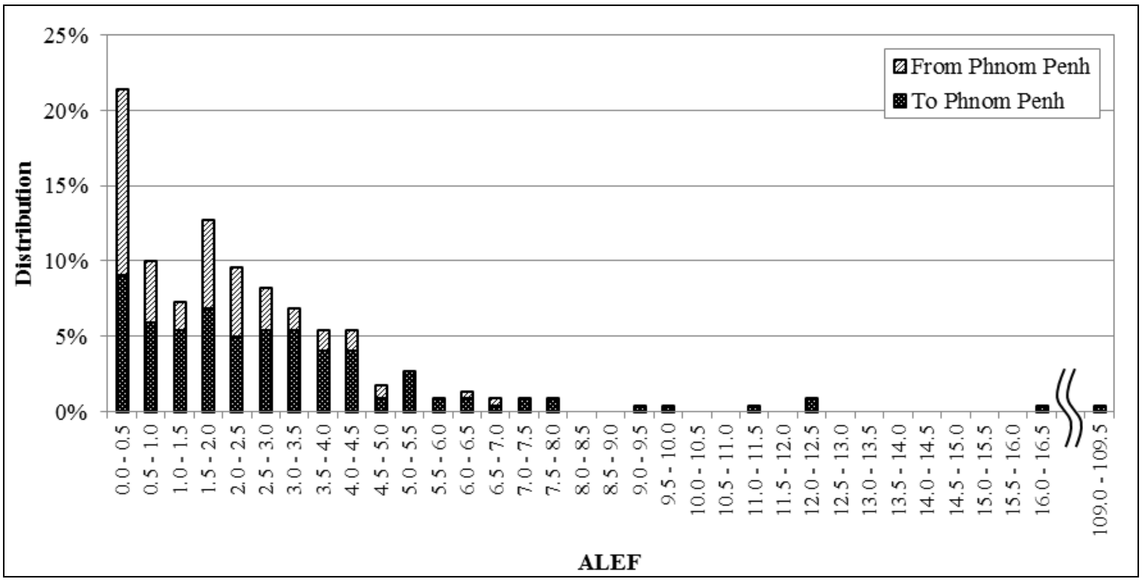


Figure 5.4-1 Distribution of ALEF

CHAPTER 6 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 2016, 2021 and 2030. These target years are determined to correspond with the Survey of the North Section.

6.1 Methodology

Figure 6.1-1 Flowchart showing the methodology for future traffic forecast.

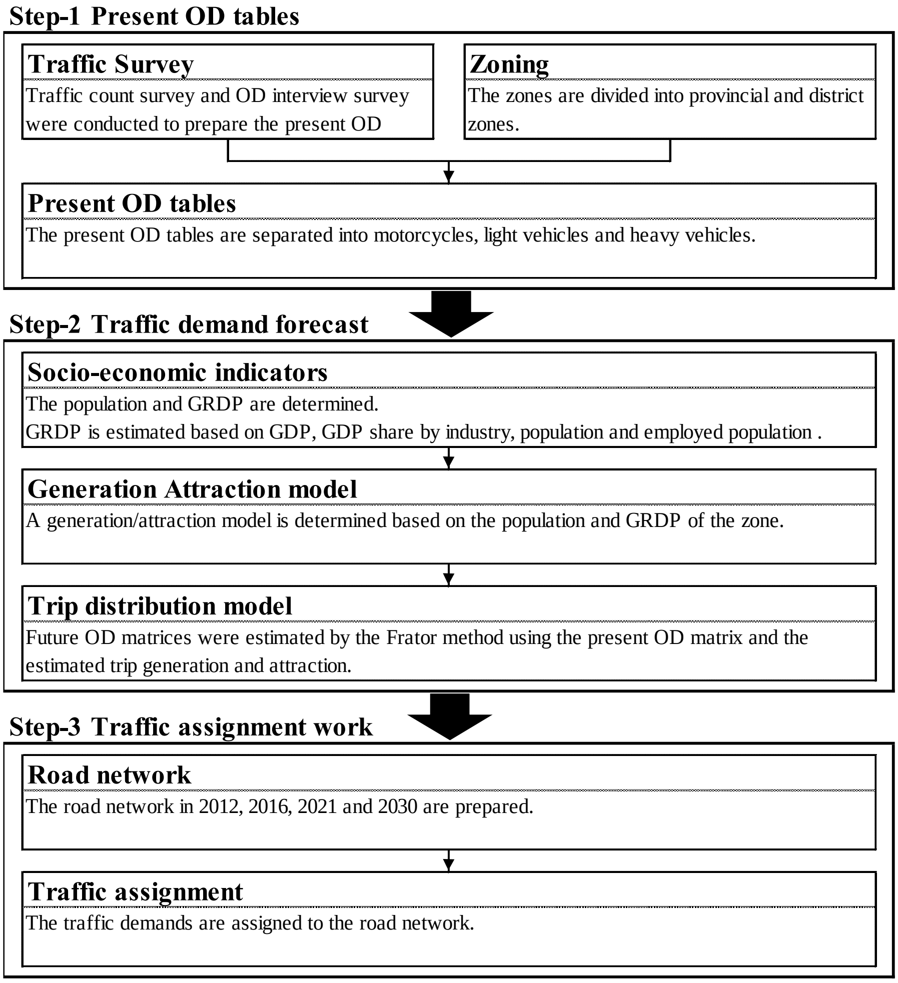


Figure 6.1-1 Traffic Demand Forecast Flowchart

First, the future OD table is prepared based on the present OD table and taking into account future socio-economic indices, such as population and GRDP forecast. The future OD tables are forecasted through the use of the trip generation and the attraction model, and the OD distribution. The future traffic demand is forecasted by assigning the future OD table onto the future network on the JICA STRADA program.

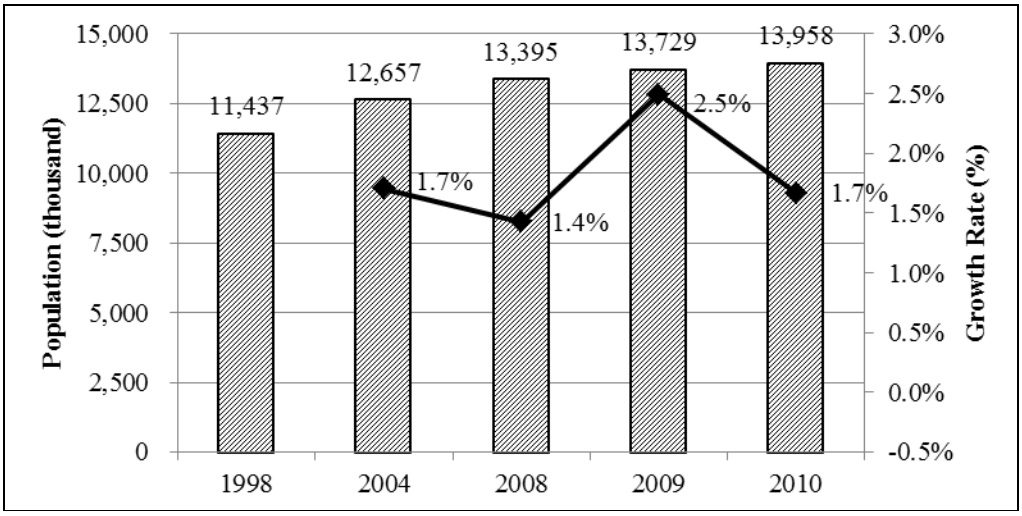
6.2 Socio-Economic Framework

Since transportation supports the social activities of the citizens and the economic activities of industry and commerce, traffic demand is governed by socio-economic factors. In this survey, future traffic demand is estimated based on the total population, the employed population and GRDP, as shown in Figure 6.1-1. This section describes the present conditions and future forecast of socio-economic factors that is used in estimation of the future traffic demand.

6.2.1 Existing Socio-Economic Frameworks

(1) Population

Figure 6.2-1 shows the historical trend of Population and the Population Growth Rate of Cambodia in 1998, 2004 and from 2008 to 2010. The data show that Cambodian's population has been increasing from the year 1998 to 2010 with an average annual growth rate of 1.7%.

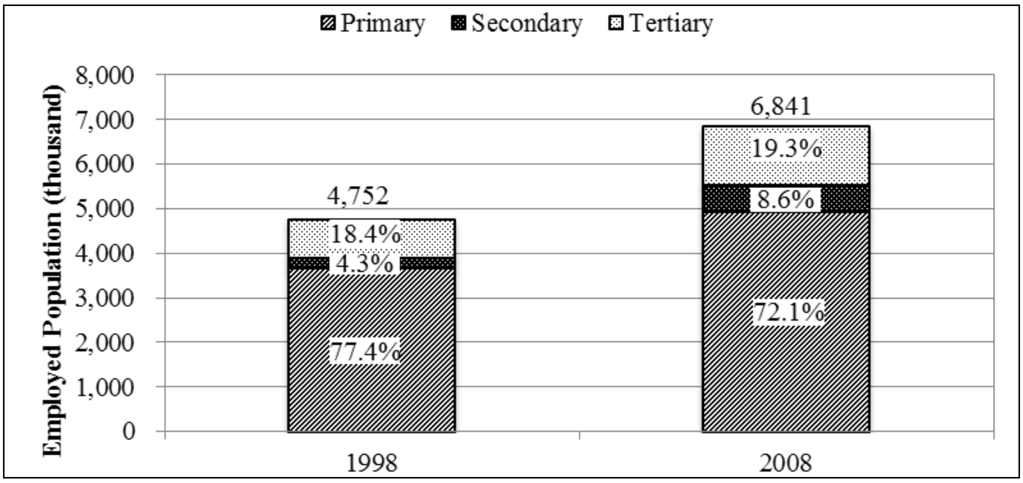


Source: "Cambodia Socio-Economic Survey 2010", National Institute of Statistics, Ministry of Planning

Figure 6.2-1 Population and Population Growth Rate

(2) Employed Population

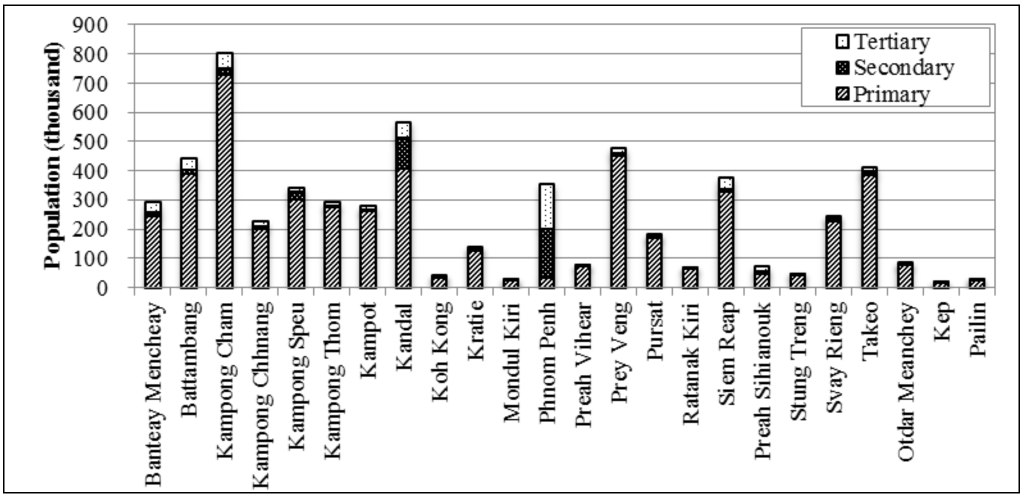
The employed population by industry in 1998 and 2008 are shown in Figure 6.2-2. Total employed population was increasing from the year 1998 to 2008. The share of primary industry decreased from 77.4% in year 1998 to 72.15% in year 2008.



Source: "General Population Census of Cambodia 2008, Economic Activity and Employment", National Institute of Statistics, Ministry of Planning

Figure 6.2-2 Employed Population Aged 15 and over in 1998 and 2008

The employed population of each province by industry is shown in Figure 6.2-3. The percentage of the population in the survey areas (Kampong Chhnang, Kampong Speu, Prusat, Kandal) that is employed in primary industries (agriculture, fishery, mining, forestry) is larger than any other sector.



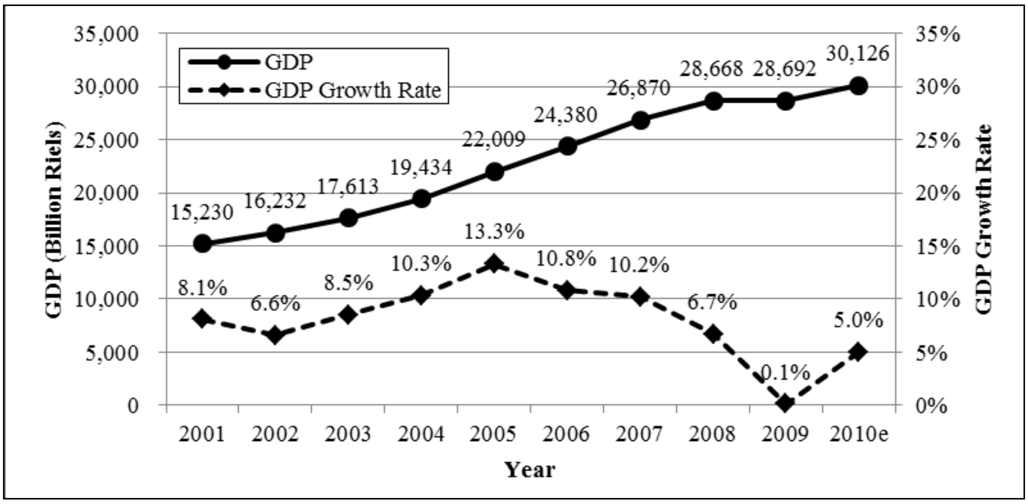
Source: "General Population Census of Cambodia 2008, Economic Activity and Employment", National Institute of Statistics, Ministry of Planning

Figure 6.2-3 Employed Population by Industry Sector in 2008

(3) GDP

➢ <u>GDP and GDP Growth Rate</u>

Figure 6.2-4 shows the historical trend of the GDP of Cambodia from 2001 to 2010 at constant 2000 prices (inflation adjusted). The data show that Cambodia's economy grew continuously from the year 2001 to 2010 with an average annual growth rate of 8.0%. A considerable decrease in growth rate was experienced between 2008 to 2009, probably due to the influence of the economic trend of the world (so-called 'Lehman Shock').



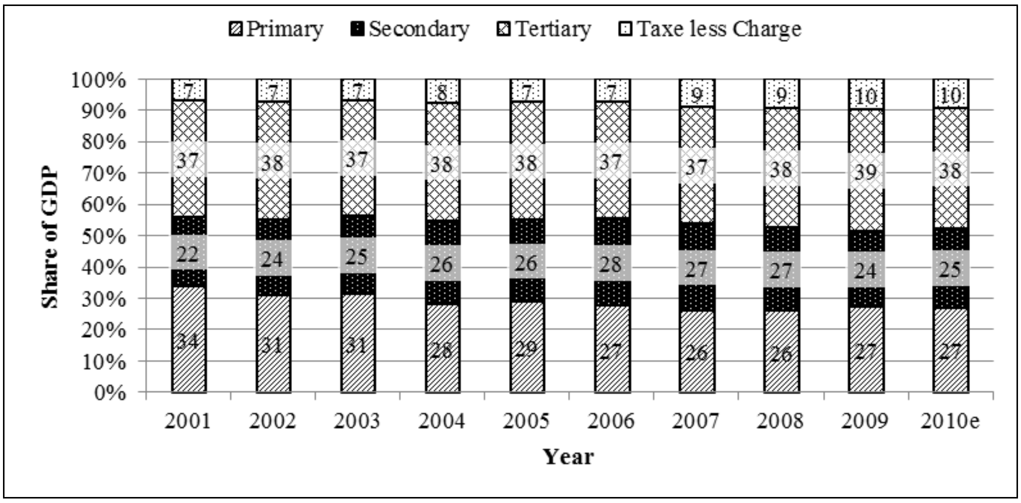
Note: e = estimated

Source: "Cambodia Macroeconomic Framework 2000-2011", Ministry of Economic and Finance

Figure 6.2-4 Historical Data Showing the Trend of GDP and GDP Growth Rate (at Constant 2000 Prices)

➢ <u>GDP by Industry Sector</u>

Figure 6.2-5 shows the historical trend of GDP share by industry sectors from 2001 to 2010. GDP shares of the primary, secondary and tertiary industry sectors in 2010 were 27%, 25% and 38%, respectively. The most significant changes in the distribution of the GDP in the past ten (10) years is the decrease of share of the primary industry (34% in 2001 to 27% in 2010).



Note: e = estimated

Source: "Cambodia Macroeconomic Framework 2000-2011", Ministry of Economic and Finance

Figure 6.2-5 Share of GDP by Industry Sector

6.2.2 Future Socio-Economic Framework

(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 population projection by province up to 2030 is shown in Table 6.2-1. The predicted growth rate of the whole of Cambodia (nationally) between 2012 and 2030 is 1.25.

Table 6.2-1 Population by Province

(Unit: Person)

Provinces	2012	2016	2021	2030	2030/2012 Growth
Banteay Meanchey	760,770	822,187	898,389	1,017,936	1.34
Battambang	1,148,444	1,238,103	1,349,178	1,519,185	1.32
Kampong Cham	1,745,184	1,739,002	1,721,623	1,648,438	0.94
Kampong Chhnang	**520,398**	**549,913**	**583,716**	**628,577**	**1.21**
Kampong Speu	**775,704**	**804,796**	**837,783**	**882,184**	**1.14**
Kampong Thom	673,247	688,305	705,001	724,456	1.08
Kampot	615,944	629,383	654,515	716,987	1.16
Kandal	**1,383,298**	**1,463,411**	**1,563,607**	**1,716,290**	**1.24**
Koh Kong	137,033	153,846	176,552	218,811	1.60
Kratie	357,249	383,382	414,756	465,960	1.30
Mondul Kiri	73,080	83,410	97,607	126,725	1.73
Phnom Penh	**1,637,473**	**1,898,407**	**2,175,636**	**2,450,717**	**1.50**
Preah Vihear	188,297	199,547	214,576	243,681	1.29
Prey Veng	980,811	985,036	1,006,084	1,089,316	1.11
Pursat	**430,837**	**453,467**	**486,491**	**553,067**	**1.28**
Ratanak Kiri	169,609	182,759	200,145	233,141	1.37
Siem Reap	1,023,990	1,120,313	1,235,423	1,414,727	1.38
Preah Sihanouk	253,654	279,419	311,363	360,684	1.42
Stung Treng	125,166	135,778	151,803	187,442	1.50
Svay Rieng	500,745	504,905	517,511	559,726	1.12
Takeo	879,328	889,420	916,272	997,025	1.13
Otdar Meanchey	227,353	261,201	301,968	365,010	1.61
Kep	41,420	47,945	59,427	88,797	2.14
Pailin	92,379	112,509	137,997	181,801	1.97
Cambodia	14,741,414	15,626,444	16,717,422	18,390,683	1.25

Source: "General Population Census of Cambodia 2008, Population Projections of Cambodia", National Institute of Statistics, Ministry of Planning

(2) Future Growth of GDP

➢ <u>GDP Growth Rate Predictions by Different Institutions</u>

Cambodia's long term growth of GDP to 2030 (at constant 2012 prices), has been predicted by the United States Department of Agriculture and International Futures at the University of Denver and the short term GDP has been predicted by the International Monetary Fund and the Ministry of Economic and Finance. According to this prediction, the short term GDP is in the region of 6.5%.

Table 6.2-2 Predicted Annual Growth Rate of GDP by Agency

Year	2012	2013	2014	2015	2016	2017	2021	2030
USDA	6.9	6.7	6.6	6.5	6.4	6.3	6.2	5.6
International Futures	6.5	6.3	6.5	6.4	6.1	6.2	6.7	7.1
IMF	6.2	6.4				7.7		-
MEF	6.5	6.5						-

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

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

Table 6.2-3 Scenarios of Future GDP Growth

(Unit: %/Yr)

Scenario	2012 – 2016	2016 – 2021	2021 – 2030
High Growth	8.0	7.5	6.8
Medium Growth	6.6	6.2	5.6
Low Growth	5.5	5.2	4.7

(3) GRDP

Once 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 6.2-6. Table 6.2-4 shows the result of the GRDP estimation by province.

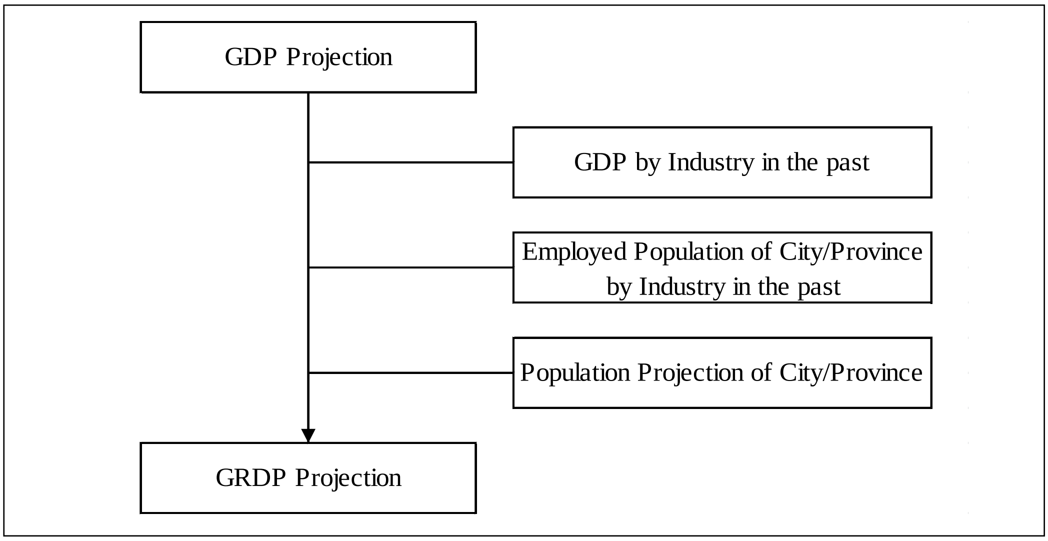


Figure 6.2-6 Procedure for GRDP Estimation

Table 6.2-4 GRDP Projection (at constant 2005 Prices)

(Unit: $million)

Province	Year			
	2012	2016	2021	2030
Banteay Meanchey	439	570	773	1,289
Battambang	575	753	1,024	1,717
Kampong Cham	757	919	1,171	1,636
Kampong Chhnang	**226**	**288**	**387**	**624**
Kampong Speu	**353**	**451**	**611**	**979**
Kampong Thom	257	329	440	689
Kampot	235	300	409	678
Kandal	**997**	**1,253**	**1,663**	**2,694**
Koh Kong	87	119	169	315
Kratie	150	194	267	459
Mondul Kiri	33	47	71	148
Phnom Penh	**3,429**	**4,456**	**5,987**	**9,591**
Preah Vihear	69	94	135	246
Prey Veaeng	367	456	610	997
Pursat	**176**	**230**	**314**	**547**
Ratanak Kiri	67	92	134	252
Siemreap	510	675	932	1,622
Preah Sihanouk	227	300	412	701
Stung Treng	52	71	103	201
Svay Rieng	206	257	341	551
Takeo	338	428	579	953
Otdar Meanchey	100	143	208	384
Kep	17	26	40	94
Pailin	53	78	115	229

6.3 Future OD Table

6.3.1 Zoning System

The OD zoning system that was used in 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 6.3-1 shows the list of OD zones.

Table 6.3-1 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

Province Name	Zone No.	District Name	Traffic Zone
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

6.3.2 Preparation of Present OD Table

The OD table of year 2011 used in the survey of the North Section was adopted as the basis of the present OD table of this Survey. It was adjusted based on the results of OD survey conducted in this Survey, focusing on the traffic along NR 5.

6.3.3 Trip Generation and Attraction

(1) Trip Generation and Attraction Model

A future trip generation and attraction model was formulated by using population and GRDP as described in Section 6.2.2 above. A liner regression model is adopted in this Survey. The model parameters are calibrated as shown in Table 6.3-2.

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

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

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 6.3-2 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

The number of the total trips by vehicle type for the years 2012, 2016, 2021 and 2030 are shown in Table 6.3-3.

Table 6.3-3 Future Trip Production

(Unit: Vehicles/day)

Year	2012	2016	2021	2030	(2030/2012)
MC	216,283	267,234	334,537	493,599	2.28
LV	68,712	93,247	123,232	197,165	2.87
HV	15,357	19,739	25,609	39,771	2.59
Total	300,352	380,220	483,378	730,535	2.43

(3) Generation and Attraction

The predicted trip generation and attraction by vehicle type for 2012, 2016, 2021 and 2030 are shown in Table 6.3-4 to Table 6.3-7.

Table 6.3-4 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 6.3-5 Trip Generation and Attraction by Vehicle Type in 2016

Zone No.	Province	Trip Generation in 2016			Trip Attraction in 2016		
		MC	LV	HV	MC	LV	HV
2	Battambang	17,319	5,648	1,228	17,340	5,747	1,229
15	Pursat	5,723	1,759	393	5,743	1,807	393
4	Kampong Chhnang	7,063	2,195	488	7,085	2,250	487
5	Kampong Speu	10,734	3,410	750	10,758	3,484	750
8	Kandal	25,386	9,126	1,904	25,311	9,150	1,910
12	Phnom Penh	71,240	30,939	5,995	70,368	30,242	6,043

Table 6.3-6 Trip Generation and Attraction by Vehicle Type in 2021

Zone No.	Province	Trip Generation in 2021			Trip Attraction in 2021		
		MC	LV	HV	MC	LV	HV
2	Battambang	21,635	7,532	1,593	21,601	7,587	1,597
15	Pursat	7,053	2,343	505	7,056	2,377	506
4	Kampong Chhnang	8,598	2,878	619	8,599	2,917	620
5	Kampong Speu	13,089	4,504	957	13,075	4,545	959
8	Kandal	31,509	11,937	2,438	31,340	11,879	2,449
12	Phnom Penh	93,542	41,389	7,965	92,302	40,365	8,033

Table 6.3-7 Trip Generation and Attraction by Vehicle Type in 2030

Zone No.	Province	Trip Generation in 2030			Trip Attraction in 2030		
		MC	LV	HV	MC	LV	HV
2	Battambang	31,986	12,282	2,495	31,794	12,200	2,507
15	Pursat	10,590	3,946	811	10,541	3,936	815
4	Kampong Chhnang	12,066	4,500	925	12,011	4,488	929
5	Kampong Speu	18,332	7,012	1,426	18,226	6,968	1,434
8	Kandal	46,346	18,966	3,758	45,923	18,679	3,783
12	Phnom Penh	143,908	65,837	12,518	141,732	63,952	12,634

Figures 6.3-1 to Figure 6.3-4 show the total trip production (the total of generation and attraction) by zone in 2012, 2016, 2021 and 2030.

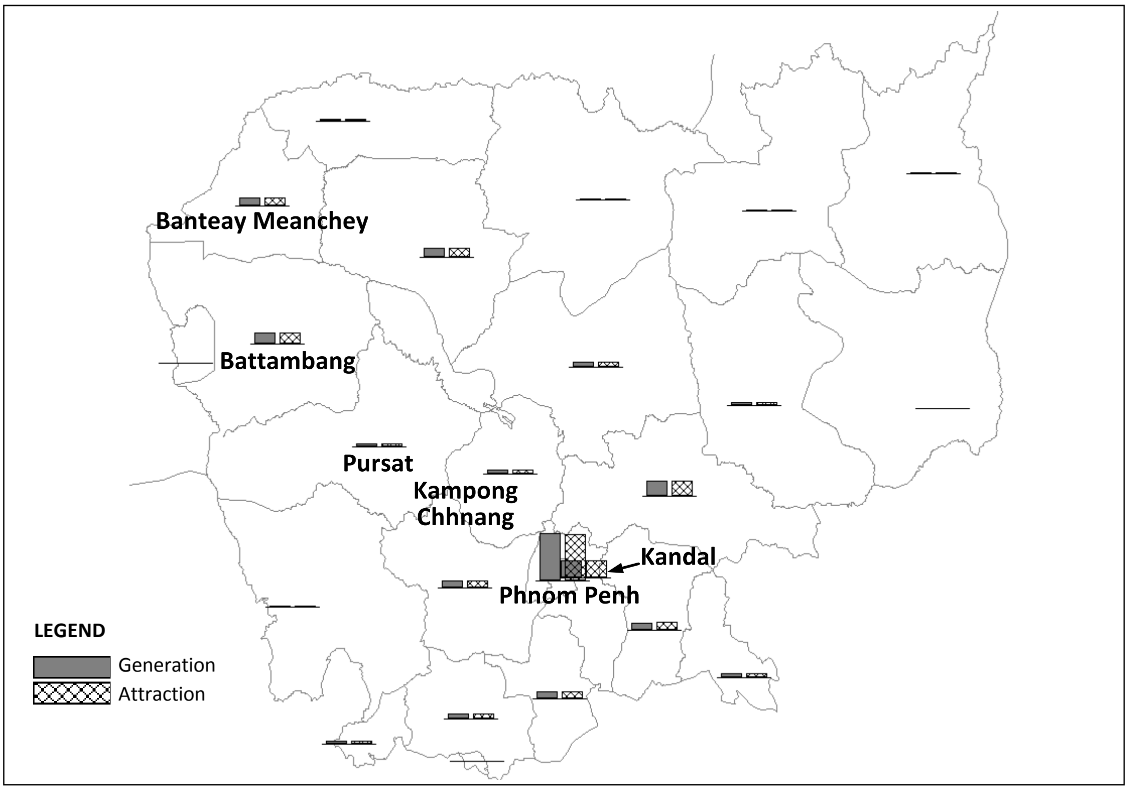


Figure 6.3-1 Trip Generation and Attraction in 2012 (Total Vehicle)

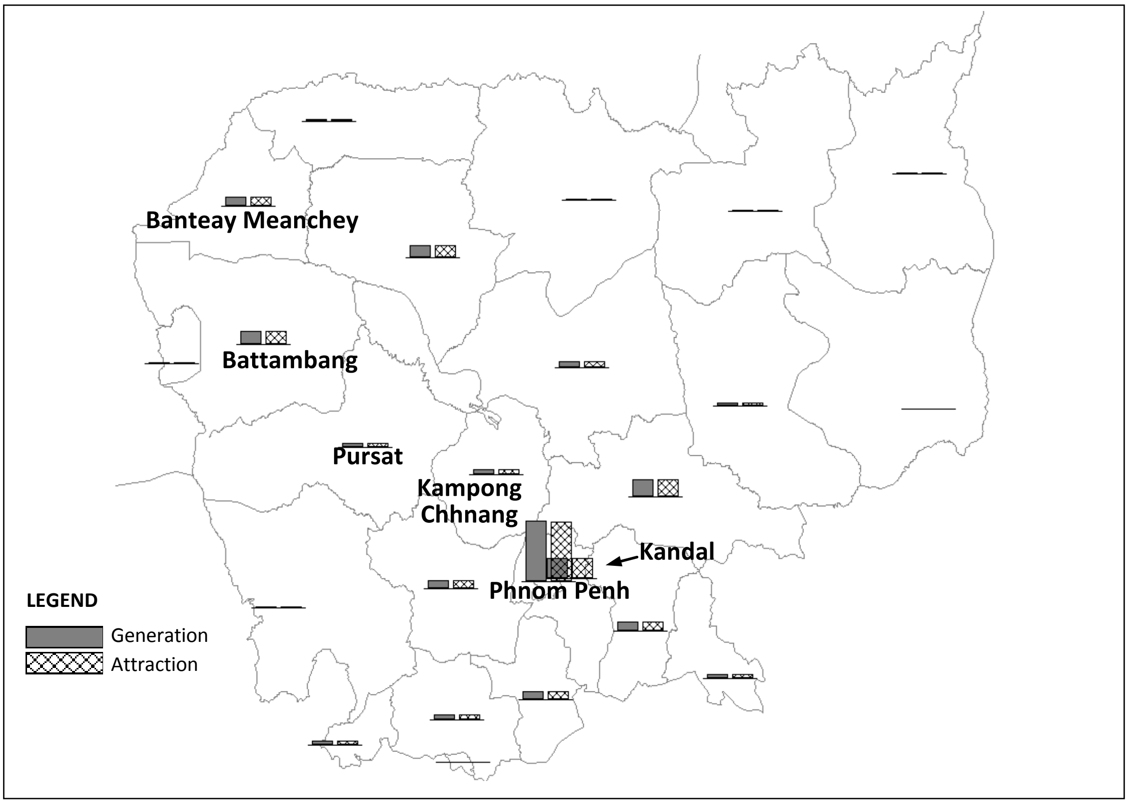


Figure 6.3-2 Trip Generation and Attraction in 2016 (Total Vehicle)

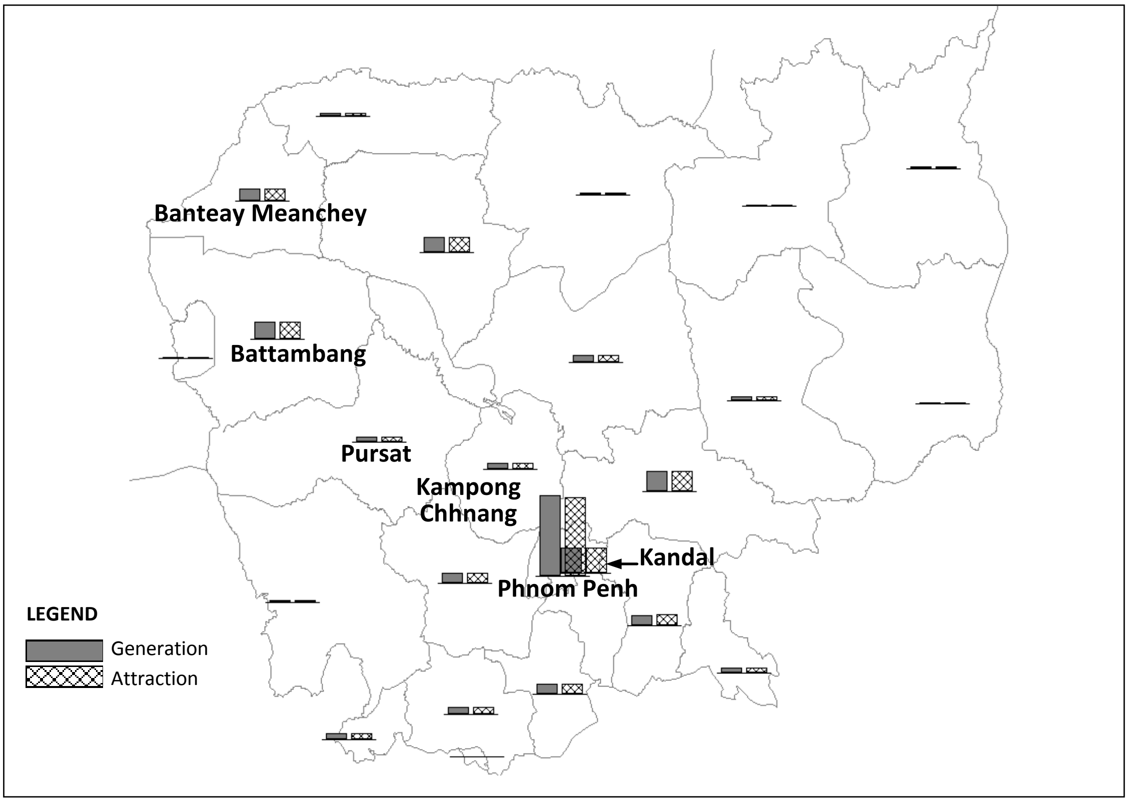


Figure 6.3-3 Trip Generation and Attraction in 2021 (Total Vehicle)

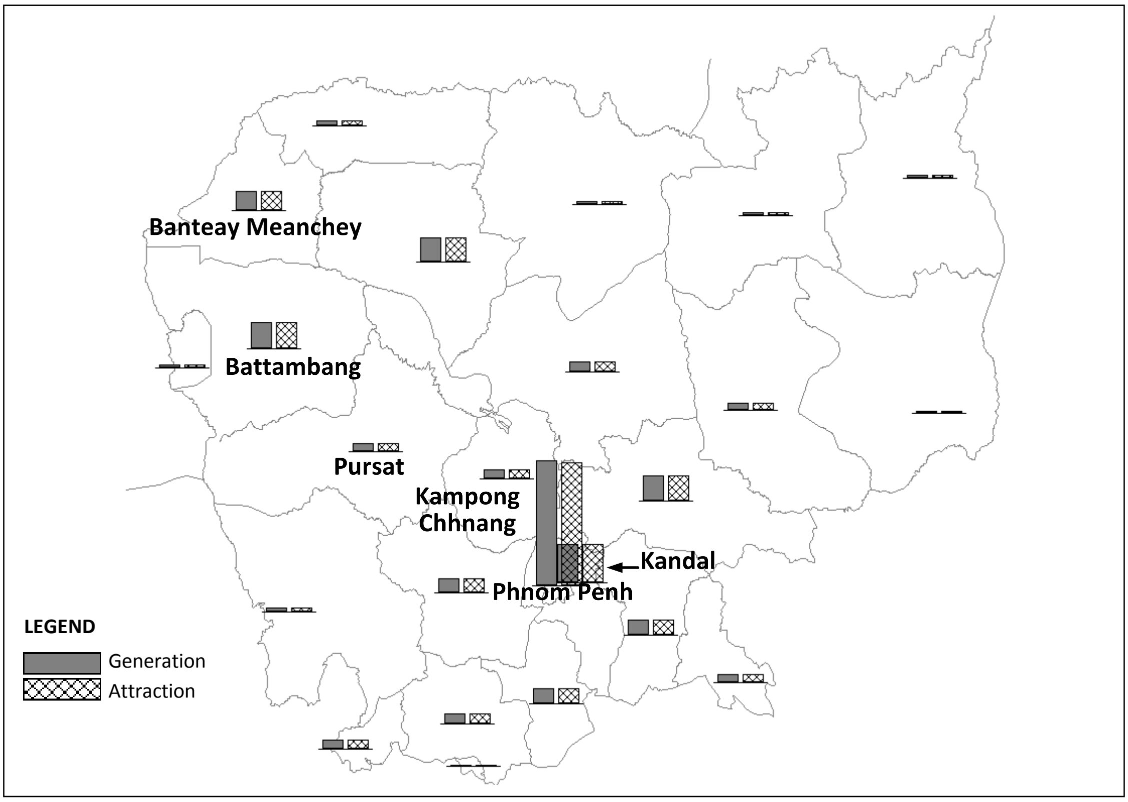


Figure 6.3-4 Trip Generation and Attraction in 2030 (Total Vehicle)

6.3.4 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 6.3-5.

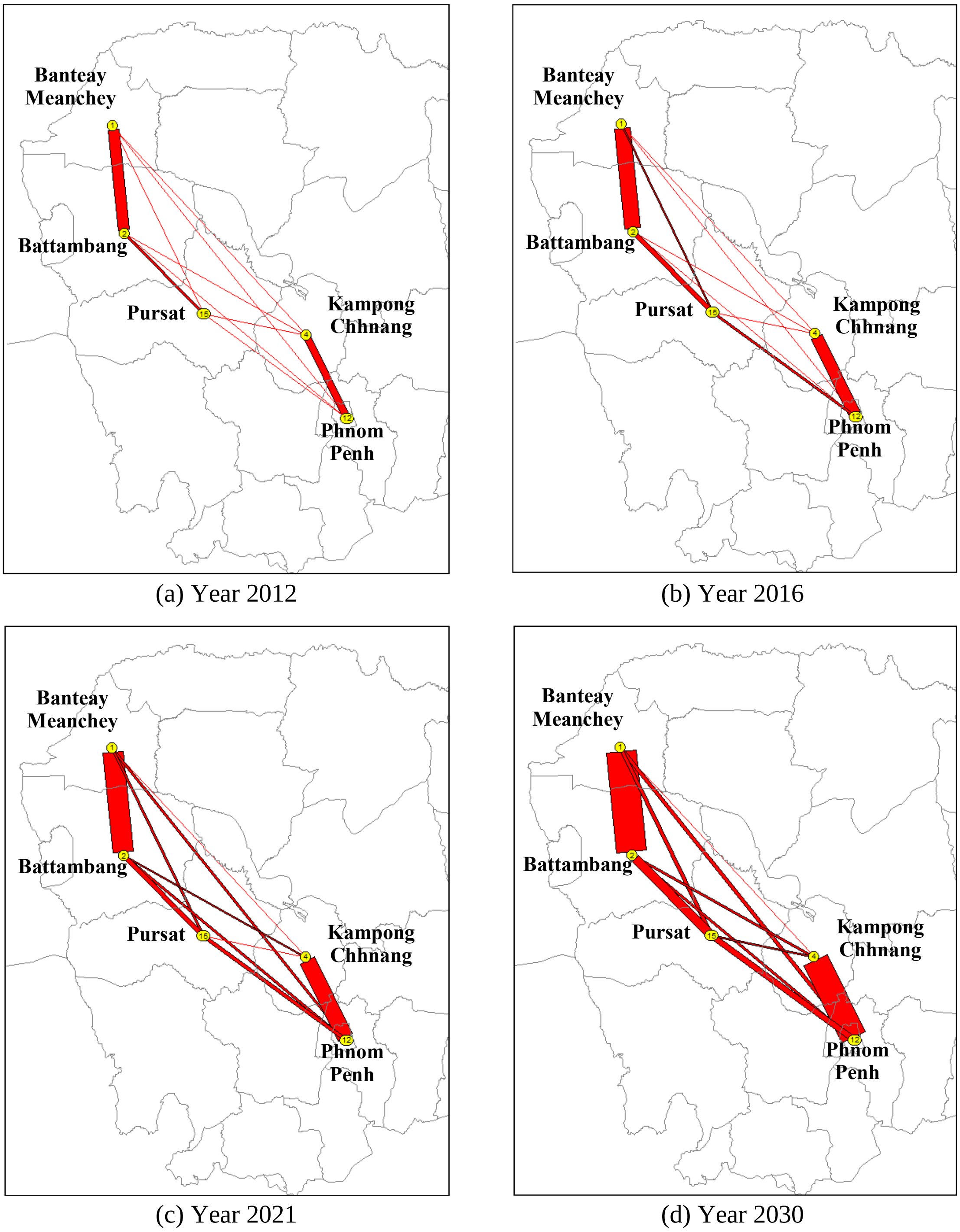


Figure 6.3-5 Desire Line for 2012, 2016, 2021 and 2030

6.3.5 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 (6) of Subsection 6.4.1 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.

6.4 Traffic Demand Forecast

6.4.1 Traffic Assignment

The prediction of future traffic volume by road section is estimated by traffic assignment program of JICA STRADA. JICA STRADA adopts 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 6.4-1.

Table 6.4-1 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 light trucks and pick-up trucks. Their speeds are slower than 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 (Table 1-3 in page 8 – 9). Among these improvement plans, the following projects are incorporated in the future road network used in this traffic forecast.

Table 6.4-2 Future Improvements to Road Network

Year	Road No	Section	Content
2016	NR 5	Phnom Penh – Prek Kdam	Widening (4 lanes)
	NR 6	Phnom Penh - Thnal Keng	Widening (4 lanes)
2021	NR 5	Battabang – Sisophon (North Section)	Widening (4 lanes)
		Battambang Bypass (North Section)	New Construction
		Sri Soporn Bypass (North Section)	New Construction
	NR 6	Siem Reap Bypass	New Construction
		Thnal Keng - Skun	Widening (4 lanes)

Other improvement plans are not incorporated in the future road network, but their influences are individually examined in “(6) Overall Examination of Forecasted Traffic Volume”

(3) Traffic Assignment Result

Figure 6.4-1 to Figure 6.4-4 shows the result of the traffic assignment for year 2012, 2016, 2021 and 2030.

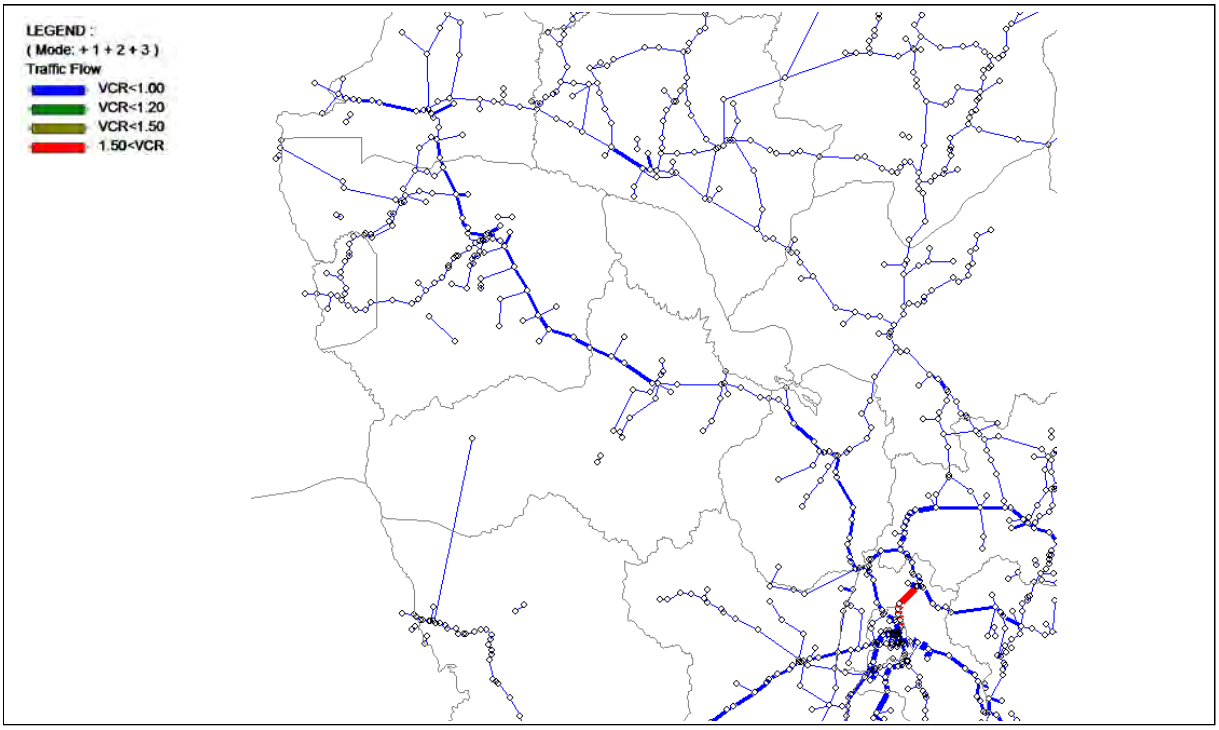


Figure 6.4-1 Results of Traffic Assignment for Year 2012

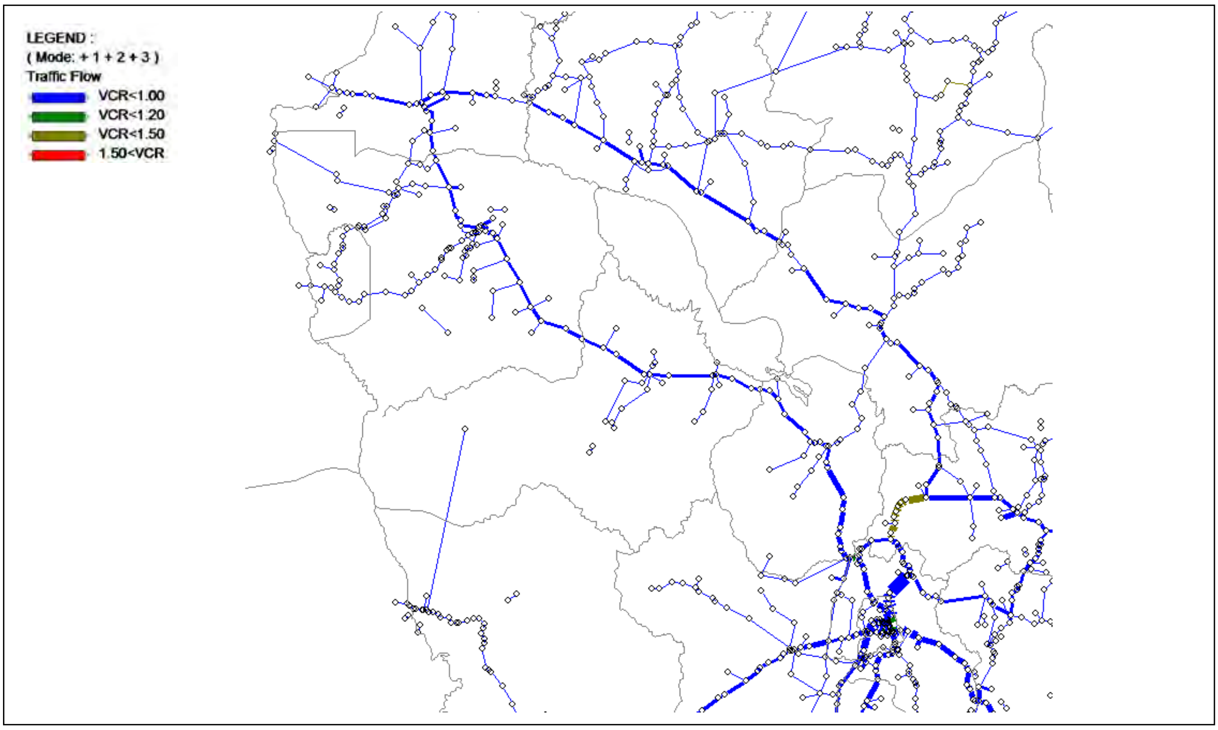


Figure 6.4-2 Results of Traffic Assignment for Year 2016

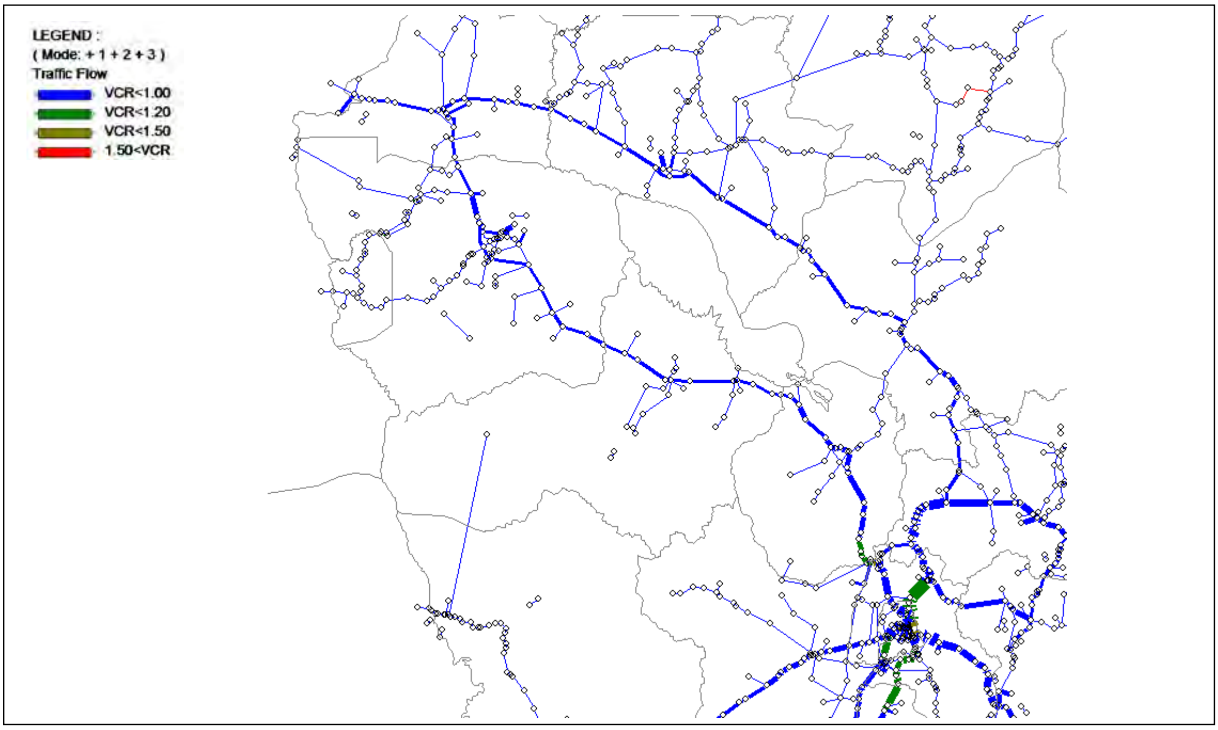


Figure 6.4-3 Results of Traffic Assignment for Year 2021

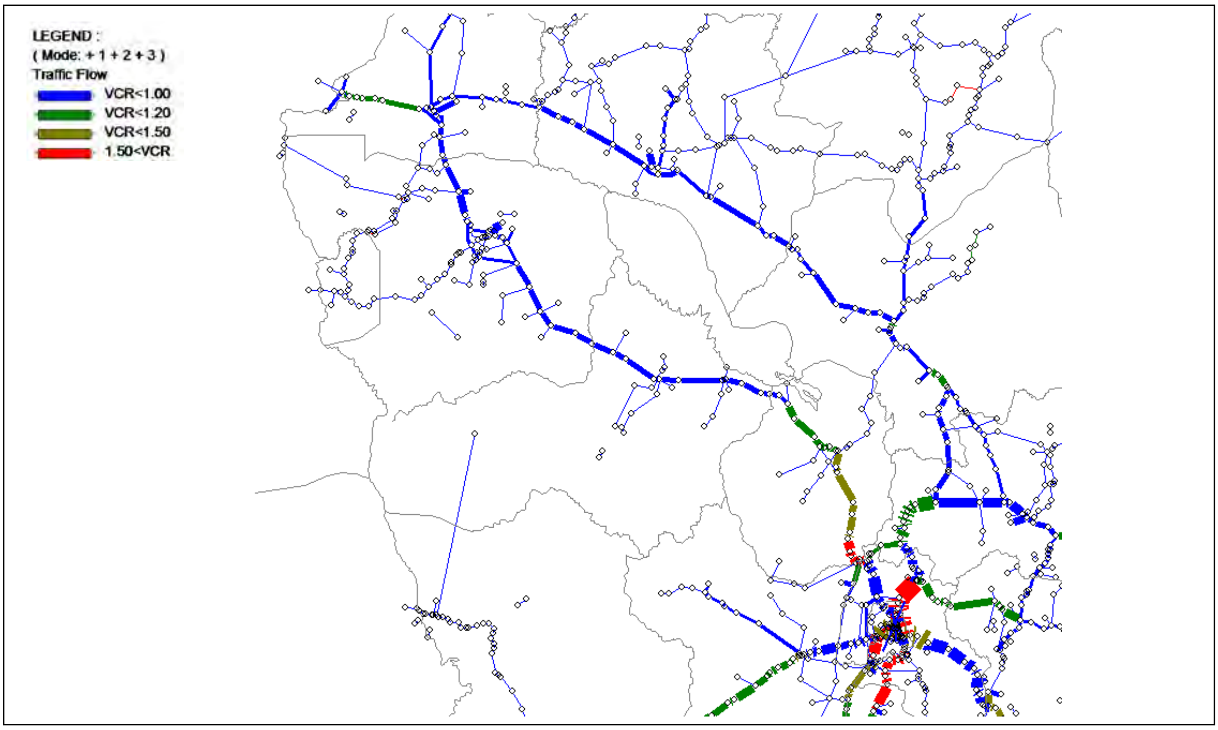


Figure 6.4-4 Results of Traffic Assignment for Year 2030

(4) Future Traffic Volume at Traffic Counting Stations

Table 6.4-3 and Table 6.4-4 lists the forecast traffic volumes at the traffic counting stations for the years 2012, 2016, 2021 and 2030. Figure 6.4-5 shows the forecasted traffic volume between

Prek Kdam and Sri Sophorn on NR 5.

Table 6.4-3 Result of Traffic Assignment by Counting Stations

(Unit: PCU/day)

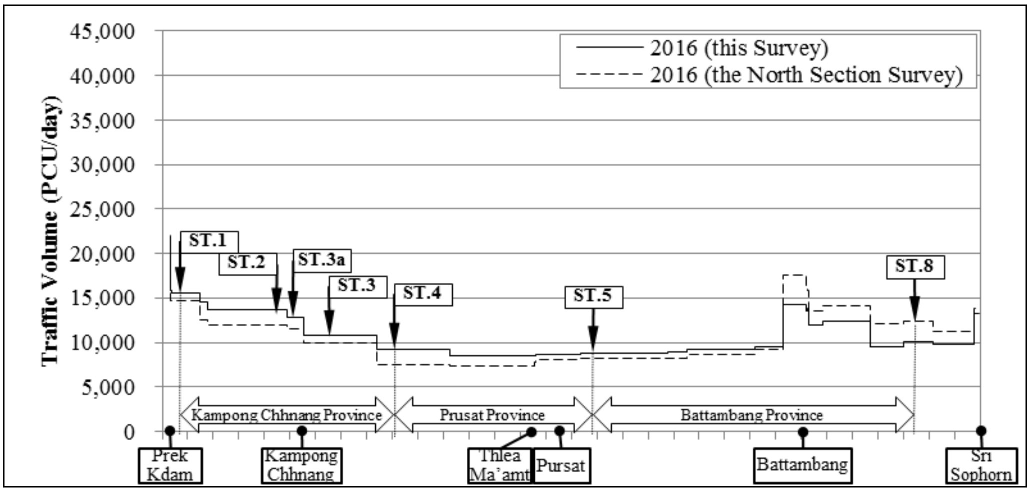
Road No.	Station No.	Year				
		2012		2016	2021	2030
		Observed	Assignment Result			
5	1	10,352	10,308	15,541	20,348	32,105
	2	9,103	8,684	13,649	17,899	28,486
	3a	12,857	-	19,225	25,045	39,458
	3	6,596	6,474	10,760	14,150	22,741
	4	5,296	5,162	9,260	12,263	19,954
	5	6,174	6,117	8,789	11,603	18,761
	8	6,470	6,350	10,030	13,284	21,290
6	NR 6-1	7,115	6,635	11,480	14,887	23,082

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 estimate the short trips within the city. The Assignment results at Station No.3a in 2016, 2021 and 2030 are estimated based on assignment result and result of traffic count survey.

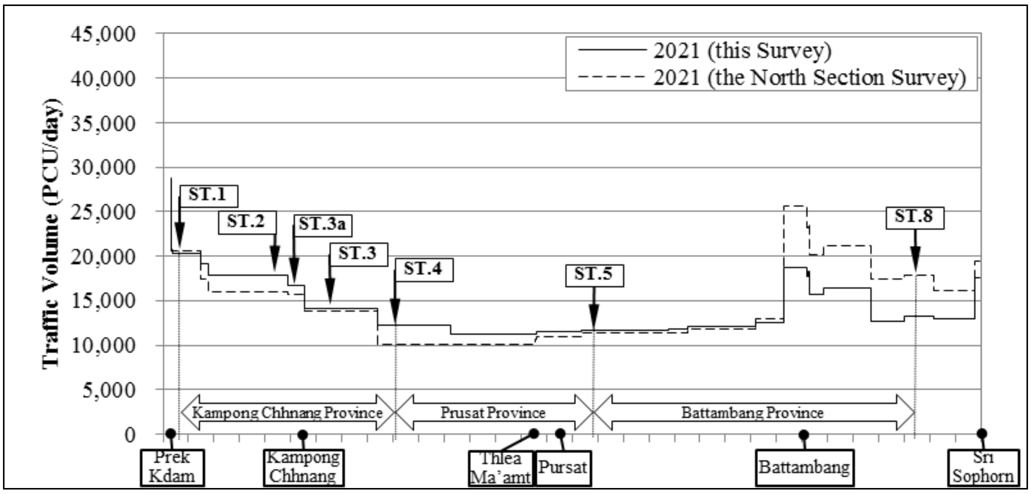
Table 6.4-4 Traffic Volume by Vehicle Type, Actual and Predicted

Station	2012					2016				
	MC	LV	HV	Total (Veh.)	PCU	MC	LV	HV	Total (Veh.)	PCU
1	5,727	3,788	1,285	10,800	10,308	7,710	5,989	1,914	15,613	15,541
2	5,637	2,964	1,096	9,697	8,684	7,637	5,311	1,573	14,521	13,649
3a	15,947	3,569	1,204	20,720	12,857	18,961	6,729	1,708	27,399	19,225
3	3,303	2,123	943	6,370	6,474	4,207	4,399	1,333	9,939	10,760
4	867	1,738	910	3,514	5,162	1,880	3,885	1,280	7,045	9,260
5	1,583	1,660	1,189	4,432	6,117	2,043	3,068	1,447	6,558	8,789
8	3,897	2,282	776	6,955	6,350	5,980	3,906	1,118	11,004	10,030
NR 6-1	2,873	2,470	895	6,239	6,635	5,430	4,566	1,381	11,377	11,480

Station	2021					2030				
	MC	LV	HV	Total (Veh.)	PCU	MC	LV	HV	Total (Veh.)	PCU
1	9,907	7,894	2,503	20,303	20,348	14,993	12,706	3,908	31,608	32,105
2	9,827	7,007	2,064	18,898	17,899	14,883	11,359	3,274	29,517	28,486
3a	24,027	8,875	2,248	35,150	25,045	35,686	14,423	3,575	53,683	39,458
3	5,363	5,809	1,760	12,932	14,150	8,080	9,502	2,813	20,395	22,741
4	2,520	5,140	1,694	9,354	12,263	4,080	8,468	2,715	15,263	19,954
5	2,633	4,090	1,900	8,624	11,603	4,077	6,804	3,011	13,892	18,761
8	7,613	5,260	1,475	14,348	13,284	11,487	8,702	2,322	22,511	21,290
NR 6-1	6,610	6,025	1,791	14,426	14,887	9,387	9,618	2,748	21,752	23,082



Traffic Assignment 2016



Traffic Assignment (2021)

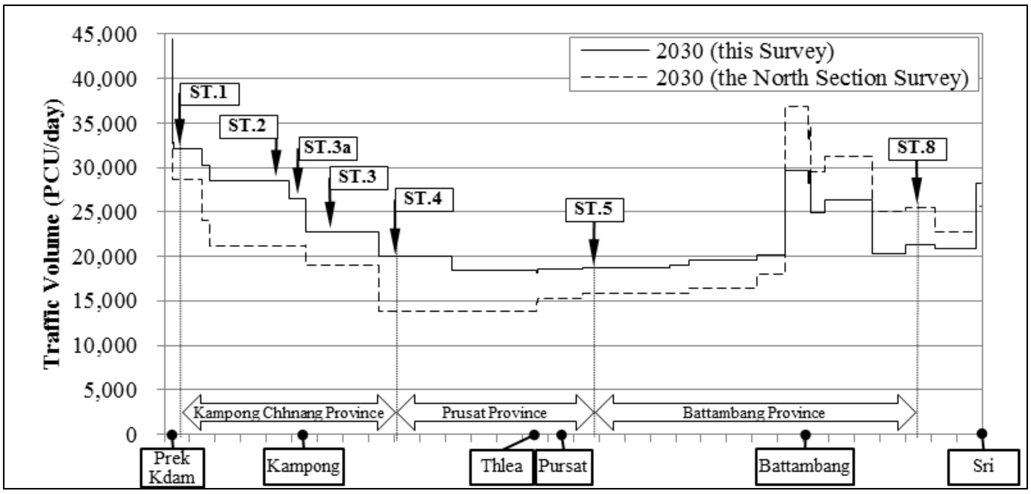


Figure 6.4-5 Result of Traffic Assignment

(5) Verifications

In order to verify the accuracy of the traffic volumes estimated by the method described above, the estimated traffic volume of 2012 at traffic counting stations, as shown in Table 6.4-3 above, are compared with the actually observed traffic volumes. Figure 6.4-6 shows the result of the comparison. The figure indicates a close agreement between the estimated values and actually observed values, with a tendency that the estimated values are slight smaller than observed values.

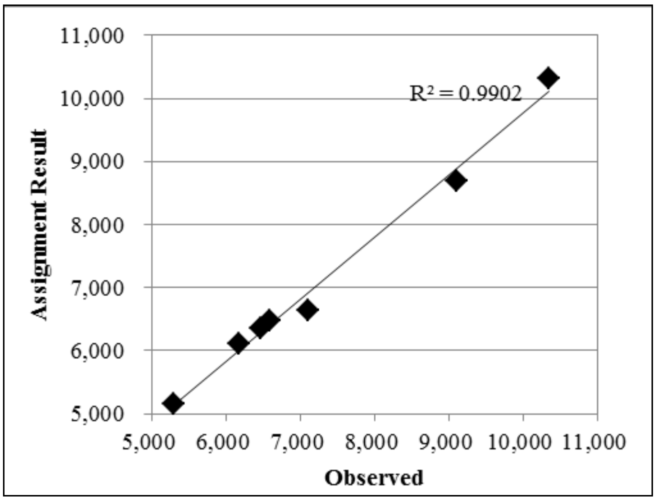


Figure 6.4-6 Verification Between Assignment Result and Actual Traffic Count

(6) Overall Examination of Forecasted Traffic Volume

➢ <u>Influence of Rail Road</u>

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 6.4-3), 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. If 10% of traffic of heavy vehicles divert to rail transport, future total traffic volume on NR 5 will be reduced by 3.7% from Table 6.4-3 in year 2030.

➢ <u>Influence of planned new road between Battambang and Siem Reap</u>

The planned new road between Battambang and Siem Reap is not included in the traffic assignment (Table 6.4-3). The result of traffic assignment including the Battambang - Siem Reap Bypass in the year 2030, found that traffic volume at all stations except Station No.8 are much the same with Table 6.4-3 and traffic volume at Station No.8 decreases by about 10% compared with Table 6.4-3. Traffic volume on the planned new road between Battambang and Siem Reap is estimated to be about 3,000 pcu in year 2030.

➢ Influence of Improvement of NR 44 – Road No. 151

According to the publication of IRITWG, the improvement of NR 44 is planned to be started in 2012. This project is expected to be combined with another project, that of improving the NR 44 and Road No. 151 which connects to Odongk. A traffic forecast incorporating these projects was made to determine their influence. The result of this examination is shown in Table 6.4-5 as "Case 2" (Case 1 is without improvement of NR 44 – 151). As shown in the table, these improvement projects do not give substantial influence to the forecasted traffic volume.

➢ Influence of Construction of a New Road between Kampong Chhnang Airport and Phnom Penh

The improvement of Kompong Chhnang Airport and the transfering of the function of Phnom Penh International Airport (Pochentong) has been recently discussed. In connection with this plan of a new international airport, a plan of constructing a new road connecting the new international airport and Phnom Penh has also discussed. The influence of this new road was examined. The result of examination is shown in Table 6.4-5 as "Case 3". This new road is estimated to give substantial influence to the traffic volume on NR 5 between Kampong Chhnang and Prek Kdam (Phnom Penh). However, the traffic volume on NR 5 is forecasted to be more than 20,000 pcu/day and widening to 4 lanes is necessary.

Table 6.4-5 Influence of Improvement of NR 44 - 151 and Construction of a New Road Between Kampong Chhnang Airport – Phnom Penh (year 2030)

Unit: PCU/day

Station No.	Case 1	Case 2	Case 3	Case 2/Case 1	Case 3/Case 1
1	32,105	32,098	26,307	1.00	0.82
2	28,486	28,479	22,688	1.00	0.80
3a	26,550	26,551	20,760	1.00	0.78
3	22,741	22,734	18,026	1.00	0.79
4	19,954	19,947	19,947	1.00	1.00
5	18,761	18,754	18,754	1.00	1.00
8	21,290	21,267	21,267	1.00	1.00

➢ Influence of Special Economic Zone (SEZ)

Several Special Economic Zones (SEZs) are being constructed or planned. These SEZs are mainly constructed or planned near the existing ones being constructed or near planned ports. Thus the main transport to these SEZs are supposed to be ships. Nevertheless, these SEZs may need road access for supply of goods or materials. At the stage of preparing this Progress Report, the details of SEZ which may influence the traffic volume on NR 5, such as the SEZ planned near the new Phnom Penh Port along NR 1 near KP 30 are not known. Influence of such SEZ will be examined as necessary in the later stage.

➢ Influence of Free Cross-Border Shipment

GMS countries are consulting towards a free cross-border shipment agreement which is scheduled to come into place in 2015. If this agreement is realized, international movement of cargo will substantially increase. However this increase cannot be forecasted in this Survey due to lack of sufficient data/information.

(7) Comparison of Result of Traffic Assignment in the Survey of the North Section and this Survey

Table 6.4-6 shows the result of traffic assignment in the Survey of the North Section and in this Survey. The results of traffic assignment at all stations except Station No.8 in this survey are larger than that in the Survey of the North Section while results of traffic assignment at Station No.8 in this survey is smaller than that in the Survey of the North Section. It is thought that observed traffic volume and estimated future GDP growth rate has an effect on the result of traffic assignment. The observed traffic volume at Station No.8 in this Survey decreased compared with the survey of the North Section. The predicted GDP growth rate published by some organizations in this year slightly increased compared with that published last year.

Table 6.4-6 Comparison of Traffic Volumes Forecasted in the Survey of North Section and this Survey

(Unit: PCU/day)

Station No.	The Survey of the North Section			This Survey			The Survey of the North Section/This Survey		
	2016	2021	2030	2016	2021	2030	2016	2021	2030
1	14,720	20,641	28,637	15,541	20,348	32,105	1.06	0.99	1.12
2	11,519	15,735	21,164	13,649	17,899	28,486	1.18	1.14	1.35
3	10,001	13,775	18,947	10,760	14,150	22,741	1.08	1.03	1.20
4	7,453	10,092	13,888	9,260	12,263	19,954	1.24	1.22	1.44
5	8,232	11,368	15,899	8,789	11,603	18,761	1.07	1.02	1.18
8	12,356	17,812	25,540	10,030	13,284	21,290	0.81	0.75	0.83

6.4.2 Peak Hour Traffic Volume and Congestion

Table 6.4-7 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 2030, at all the traffic counting stations except Station No.5 and 6, the VCR is predicted to exceed 0.85. Thus these sections require widening by that time.

Table 6.4-7 Peak Hour Traffic Volume and Congestion Degree

Station No.	Peak Hour Volume (PCU)				Congestion Degree VCR				Link Capacity	No. of Lane
	2012	2016	2021	2030	2012	2016	2021	2030		
1	927	1,393	1,822	2,874	0.34	0.52	0.67	1.06	2,700	1.5×2
2	754	1,171	1,533	2,428	0.28	0.43	0.57	0.90	2,700	1.5×2
3a	1,147	1,672	2,169	3,393	0.42	0.62	0.80	1.26	2,700	1.5×2
3	517	861	1,131	1,813	0.26	0.43	0.57	0.91	2,000	2
4	408	757	1,002	1,634	0.20	0.38	0.50	0.82	2,000	2
5	656	938	1,238	2,000	0.24	0.35	0.46	0.74	2,700	1.5×2
8	584	928	1,228	1,967	0.29	0.46	0.61	0.98	2,000	2
NR6-1	555	972	1,257	1,941	0.28	0.49	0.63	0.97	2,000	2

It should be noted that **daily traffic volumes** at all Stations except Station No. 4 and 5 exceed 20,000 PCU by year 2030 (see Table 6.4-3). 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 2030, the daily traffic volume at Station No. 1 and 2 is predicted to exceed, 25,000 PCU and widening of the South Section will become an absolutely necessary.

6.4.3 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 Kampong Chhnang and Odongk. Table 6.4-8 shows the forecasted traffic volume on these bypasses.

Table 6.4-8 Future Traffic Volume on Bypass

(Unit: PCU/day)

Area	Section	2012	2016	2021	2030
Kampong Chhnang	Bypass	6,232	10,472	13,819	22,220
	Inner city (Survey Station No. 3)	6,625	8,753	11,226	17,238
Odongk	Bypass	9,100	13,822	18,181	21,380
	Inner city	3,788	5,650	7,296	18,729

Note: Traffic volume on the bypass and inner city are estimated by traffic assignment program of JICA STRADA and result of traffic count survey at Survey Station No.3a.

The above traffic volumes were estimated assuming that the bypasses are constructed as “2-lane with MC lane cross section”. It is felt that the traffic volumes on the bypasses are somewhat limited by the capacity of “2-lane with MC lane” road. Therefore traffic volume estimates where the bypasses are constructed as “4-lane” have been recalculated. Table 6.4-8 shows the result of re-estimation. As can be seen in the table, traffic volumes on Odongk Bypasses is estimated to approach 30,000 pcu/day which justifies the construction of 4-lane bypasses.

Table 6.4-9 Re-Estimation of Traffic Volumes on Bypass

Area	Section	2012	2016	2021	2030
Kampong Chhnang	Bypass	6,232	10,472	13,819	22,354
	Inner city (Survey Station No.3)	6,625	8,753	11,226	17,104
Odongk	Bypass	9,100	13,822	18,181	28,917
	Inner city	3,788	5,650	7,296	11,192

CHAPTER 7 NATURAL CONDITION OF SURVEY AREA/SURVEY ROAD

This chapter discusses the natural conditions of the Survey Area which needs to be taken into account in the planning and designing of the National Road No. 5 (NR 5) and bypass. Such natural conditions include (i) hydrological condition/flood, (ii) topography of the existing road, and (iii) geotechnical conditions.

7.1 Hydrological Condition and Flood Records

Inundations frequently occur on NR 5, hindering traffic and economic and social activities. Thus, inundation of NR 5 is causing considerable loss to the economy and social activities. Inundation reduces bearing capacity of pavement structure and results in premature deterioration of pavement. There are two possible causes of inundation on NR 5; influence of flood in the Tonle Sap River/Lake and discharge of rainwater falling in the upstream side of NR 5. This section discusses these two phenomena.

7.1.1 River System and Existing Drainage Facilities

National Road No. 5 (NR 5) traverses southwest side of Tonle Sap River and Tonle Sap Lake. The Tonle Sap River/Lake plays an important role not only as the buffer (natural flood retention basin) for the floods of the Mekong River System but also as the source of water for agriculture and other purposes during dry season. Thus, the Tonle Sap River is a reversible river during the period of deluge. Table 7.1-1 shows the hydrological features of the Mekong River and Tonle Sap River.

Table 7.1-1 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 river system across NR 5 (South Section: Prek Kdam Bridge - Thlea Ma'am) can be divided into nineteen (19) drainage area basins taking the watershed and boundary into consideration based upon the prevailing topographic terrain on the map with scale of 1/100,000. There are twenty (20) rivers, streams and channels crossing NR 5 in the Survey Area (see Table 7.1-2). Figure 7.1-1 illustrates the major river network of Cambodia. There are two major river system (Krang Ponley and Baribour) in the Survey Area.

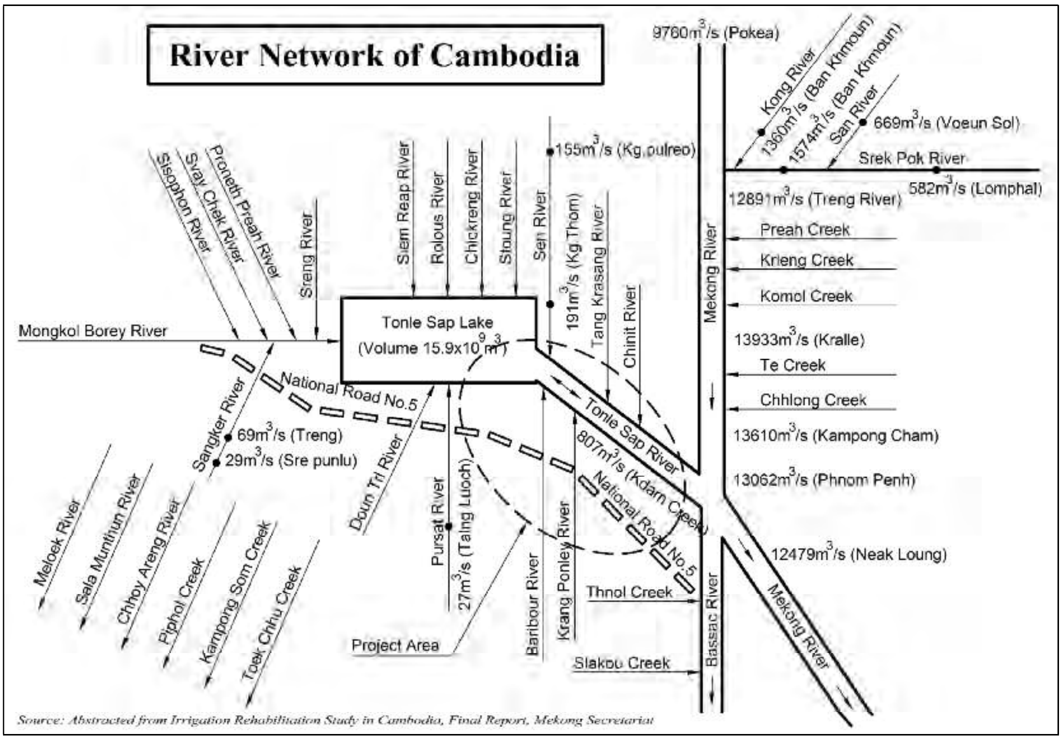


Figure 7.1-1 River Network of Cambodia

Table 7.1-2 presents the river/stream basins and their water courses across NR 5. Several streams finally discharge themselves into floodplains of Tonel Sap lake after crossing NR 5. This means that the riverbed gradients of downstream reaches are extremely mild. However, most of the streams directly flow into the Tonle Sap River or into Tonle Sap Lake.

As can be seen in Figure 7.1-1 above, many rivers/streams flowing from southwestern side of Tonle Sap River/Lake cross NR 5 before they flow into the Tonle Sap River/Lake. Thus, drainage system of NR 5 is governing the flow of water flowing into the Tonle Sap River/Lake from southwestern side. Table 7.1-3 summarizes the existing bridges which are functioning as opening or flow channel for water flowing across NR 5. Table 7.1-4 summarizes the existing box culverts and rates their current conditions (for details, refer Appendix 7-1: Inventory Survey on Box Culverts and Pipe Culverts along National Road No.5). Silting-up at both of inlet and outlet is recognized at most of the culverts and the depth of deposited silt is so high in comparison to the design height/diameter of the culvert that the drainage function of the culvert is lost considerably. Therefore, drainage capacity with various gradients by available dimension for the functioning box culverts can be summarized in Table 7.1-5.

On the other hand, Table 7.1-6 shows the existing pipe culverts and their current conditions (Refer to Appendix 7-1 for details). Similarly, silting-up phenomena are also seen in the pipe culverts. In addition, drainage capacity with various gradients for adopted dimension of pipes and drainage capacity on submerged flow are estimated as shown in Table 7.1-7 and Table 7.1-8 respectively. In conclusion, small pipes such as Φ50 ~ 80 to be upgraded by Φ100 and multiple-pipe one such as 3 ~ 5 pipes to be upgraded by box culvert is necessary from the viewpoint of flood disaster prevention.

Table 7.1-2 River Systems

No.	Drainage Facility	KP (Km)	River System						
1	Br06, Br8~Br10	39+800 ~ 41+700	Krang Ponley River	⇒ Reservoir	⇒ Krang Ponley River	⇒ *Br06, Br8~Br10*	⇒ Krang Bat River	⇒ Preaek Kmos River	⇒ Tonle Sap River
2	**Br07**	**KP40+400**	**Paddy Field (Tonle Sap River Side)**			⇒ ***Br07***	⇒ **Irrigation Canal**	⇒ **Br08, Br09**	
3	Br11	46+200	Pramat Creek			⇒ *Br11*	⇒ Pramat Creek	⇒ Preang Lake	⇒ Tonle Sap River
4	Br12, Bc06	48+400 ~ 49+100	Kat Preaek Creek	⇒ Leach Lake	⇒ Irrigation Canal ⇒	⇒ *Bc06* ⇒ *Br12, Bc06*	⇒ Irrigation Canal ⇒	⇒ Paddy Field ⇒ Floodplain	
5	Br13	49+700	Chheu Teal River		⇒ Anlong Toa Creek	⇒ *Br13*		⇒ Paddy Field	
6	Br15	58+300	Creek			⇒ *Br15*	⇒ Creek	⇒ Thurn Lake	
7	Br16	61+850	Pou Creek			⇒ *Br16*			⇒ Tonle Sap River
8	Br17	67+900	Tuek L'ak Creek			⇒ *Br17*		⇒ Roea Saen Lake	
9	Bc23	73+900	Thnuos Ta Saom Creek			⇒ *Bc23*	⇒ Sandah Creek	⇒ Cheng Danrei Lake	
10	Br19 ~ Br21	82+ 200 ~ 83+040	Chenng Kreav River + Krang Ta Mom Creek			⇒ *Br21*	⇒ Cheung Kreav River	⇒ Alum Lake	⇒ Tonle Sap River
11	Br24, Br25	101+001 ~ 106+670	Trapean Thum Creek + Preal River (Norther Side) Sna Leng Creek + Prong Creek (Southern Side)			⇒ *Br24*	⇒ Trapemg Kam River	⇒ Floodplain	
12	Br26, Br27	113+191 ~ 113+540	Khhang Tuol Creek + Kab Chen Creek			⇒ *Br26*	⇒ Si River	⇒ Floodplain	
13	Br28	116+697	Lea Pong Creek		⇒ Baribour River	⇒ *Br28*	⇒ Baribour River	⇒ Floodplain	
14	Br29	134+340	Chak Angkrang Creek			⇒ *Br29*	⇒ Preak Sokh Tuk Creek	⇒ Tonle Sap Lake	⇒ Tonle Sap River
15	Br30	135+910	Creek			⇒ *Br30*			
16	Br31, Br32	140+830 ~ 141+810	Tbol Creek			⇒ *Br32*	⇒ Russel Leat Creek	⇒ Tonle Sap Lake	⇒ Tonle Sap River
17	Br35, Br36	150+152 ~ 150+440	Creek			⇒ *Br35, Br36*	⇒ Floodplain	⇒ Tonle Sap Lake	⇒ Tonle Sap River
18	Br38	153+480	Phnou Creek + Kralanh Creek			⇒ *Br38*	⇒ Floodplain	⇒ Tonle Sap Lake	⇒ Tonle Sap River
19	Bc48	159+800	Preak Kampong Prak Creek			⇒ *Bc48*	⇒ Preak Kampong Prak Creek	⇒ Tonle Sap Lake	⇒ Tonle Sap River
20	Br39 ~ Br41	169+730 ~ 170+975	Thum Creek + Kampongla River			⇒ *Br41*	⇒ Chantok Creek	⇒ Tonle Sap Lake	⇒ Tonle Sap River

Source: Topograpic Maps (Scale: 1/100,000)

Note: Br and Bc mean bridge and box culvert respectively. Number means their grouping number.

Table 7.1-3 Existing Bridges

Province	Bridge No.		KP (Km)				Width	Span	Length	Bridge	Remarks
	PWRC	JICA*	PWRC	DPWT	JICA*	Drawing	(m)	(m)	(m)	Type	
Kampong Chhnang	Br5	Br05	38+538	N/A	*38+200*	*38+250*	10.75	4	8.2	RC Bridge	
	Br6	Br06	40+103	N/A	*39+800*	*39+760*	8.10	11.85	24.0	RC Steel Bridge	Bridge across Krang Ponley River
	Br7	Br07	40+979	N/A	*40+400*	*40+510*	9.20	15.4	15.4	RC Steel Bridge	*Flow Direction from Tonle Sap River Side*
	Br8	Br08	41+478	N/A	*40+900*	*40+905*	7.20	11.85	24.0	RC Steel Bridge	
	Br9	Br09	41+699	N/A	*41+100*	*41+100*	9.10	12	24.3	RC Steel Bridge	
	Br10	Br10	42+336	N/A	*41+700*	*41+730*	9.20	12	24.3	RC Steel Bridge	
	Br11	Br11	46+834	N/A	*46+200*	*46+220*	10.40	4	16.7	RC Bridge	Bridge across Pramat Creek
	Br12	Br12	49+045	N/A	*48+400*	*48+435*	10.60	5.1	21.0	RC Steel Bridge	
	Br13	Br13	50+328	N/A	*48+950*	*48+950*	9.10	11.95	24.2	RC Bridge	Bridge across Anlong Toa Creek
	Bc7	*Br13A*	51+914	N/A	*49+700*	*49+720*	9.10	12	12.0	RC Steel Bridge	
	Br14	Br14	58+991	N/A	*58+300*	*58+295*	9.20	12	12.0	RC Steel Bridge	Bridge across Pou Creek
	Br15	Br15	62+535	N/A	*61+850*	*61+830*	9.10	11.95	24.2	RC Steel Bridge	Bridge across Tuek L'ak Creek
	Br16	Br16	68+569	N/A	*67+900*	*67+890*	9.10	12	24.25	RC Steel Bridge	
		Br16A	*N/A*	*N/A*	*72+700*	*72+695*	*10.00*	*12.15*	*12.15*	RC Steel Bridge	
	Br17	Br17	83+030	N/A	*82+200*	*82+230*	10.20	21.45	21.45	PC Bridge	
	Br18	Br18	83+367	N/A	*82+300*	*82+510*	9.20	20.45	43.0	PC Bridge	
	Br19	Br19	84+204	N/A	*83+040*	*83+040*	10.30	13	26.5	PC Bridge	
	Br20	Br20	88+337	N/A	*85+800*	*88+780*	13.60	6	6.0	RC Bridge	Bridges acorss Trapemg River
	Br21	Br21	91+302	N/A	*91+300*	*90+970*	9.10	10.95	22.2	RC Steel Bridge	
	Br22	Br22	106+001	N/A	*106+300*	*106+230*	7.30	45.6	91.5	RC Steel Bridge	Bridges acorss Si River
	Br23	Br23	106+670	N/A	*106+900*	*106+910*	9.00	26.5	26.5	PC Bridge	
	Br24	Br24	113+191	N/A	*113+500*	*113+420*	10.10	15	15.0	PC Bridge	Bridge across Baribour River
	Br25	Br25	113+540	N/A	*113+900*	*113+750*	10.10	12	12.0	PC Bridge	Bridges acorss Preak Sokh Tuk Creek
	Br26	Br26	116+697	N/A	*116+600*	*116+900*	7.25	38.125	76.85	RC Steel Bridge	
Pursat	Br27	Br27	134+188	134+340	*134+200*	*134+340*	10.80	18.5	18.5	PC Bridge	Bridge across Russel Creek
	Br28	Br28	135+762	135+910	*135+800*	*135+910*	10.80	18.5	18.5	PC Bridge	
	Br29	Br29	140+715	140+830	*140+800*	*140+860*	10.80	18.5	18.5	PC Bridge	
	Br30	Br30	141+716	141+810	*141+800*	*141+895*	10.80	18.5	18.5	PC Bridge	
	Br31	Br31	146+885	147+045	*147+000*	*147+050*	10.80	18.5	18.5	PC Bridge	
	Br32	Br32	147+551	147+706	*147+700*	*147+715*	10.80	18.5	18.5	PC Bridge	
	Br33	Br33	150+009	150+152	*150+100*	*150+170*	10.80	18.5	18.5	PC Bridge	
	Br34	Br34	150+292	150+440	*150+500*	*150+460*	10.80	21.5	21.5	PC Bridge	
	Br35	Br35	151+210	151+365	*151+400*	*151+380*	10.80	18.5	18.5	PC Bridge	
	Br36	Br36	153+341	153+480	*153+600*	*153+470*	10.80	13.1	26.5	PC Bridge	Bridge across Tro Kor River
	Br37	Br37	169+558	169+730	*170+000*	*169+750*	10.80	26.5	26.5	PC Bridge	
	Br38	Br38	170+469	170+622	*170+900*	*170+680*	10.80	7.883	24.25	RC Steel Bridge	Bridge across Thlea Ma'am
	Br39	Br39	170+775	170+975	*171+200*	*170+990*	10.80	4.625	19.3	RC Bridge	Bridge across Chantok Creek

Source: Public Works Research Centr (PWRC), General Directorate of Public Works, Ministry of Public Works and Transport, Kingdom of Cambodia
Ministry of Public Work and Transportation, Director of Public work, Deputy Director of Road, DPWT, Pursat Province
** JICA Survey Team Carried out the inventory on Octover and November 2012.*

Table 7.1-4 Existing Box Culverts

Province	No. PWRC	No. JICA	KP (Km) PWRC	KP (Km) DPWT	KP (Km) JICA*	Length (m)	Dimension No. of Box×W×H (Design Height)	Condition
Kampong Chhnang	Bc3	Bc03	40+412	N/A	*40+053*	10.1	1×4.00×0.95 (1.00)	**Fair**
	Bc4	Bc04	45+263	N/A	*44+630*	10.0	1×4.00×0.85 (1.00)	**Good**
	Bc5	Bc05	47+484	N/A	*47+250*	16.8	1×1.00×0.80 (1.00)	**Good**
	Bc6	Bc06	49+560	N/A	*49+010*	12.5	1×4.00×0.70 (1.00)	**Good**
	Bc7	Bc07	51+914	N/A	*51+300*	15.2	3.30×2.10 + 3.40×2.40 + 3.30×2.10	**Good**
	Bc8	Bc08	54+317	N/A	*53+630*	10.4	2×3.00×1.30 (2.00)	**Bad**
	Bc9	Bc09	56+267	N/A	*55+600*	10.5	0.60×1.16 + 4.60×1.16 + 0.60×1.16	**Bad**
	Bc10		56+410	N/A	*55+700*	11.6	1×3.00×1.00	**Bad**
	Bc11		60+257	N/A	*59+600*	10.1	1×4.00×1.55 (2.00)	**Bad**
	Bc12		60+647	N/A	*59+920*	10.2	1×3.50×0.73 (1.00)	**Good**
	Bc13		61+893	N/A	*61+200*	10.4	2×2.00×1.74 (2.00)	**Fair**
	Bc14		63+386	N/A	*62+630*	9.5	4×1.30×2.00 (sluice gate)	**Good**
	Bc15		64+233	N/A	*63+520*	N/A	1×2.20×N/A	**Get Blocked**
	Bc16		65+280	N/A	*64+600*	12.7	1×1.00×0.62 (1.00)	**Poor**
	Bc17		65+791	N/A	*65+100*	10.5	1×2.00×0.23 (1.00)	**Bad**
	Bc18		66+645	N/A	*65+750*	12.0	1×1.90×0.62 (1.00)	**Poor**
	Bc19		69+964	N/A	*69+200*	10.5	1×2.00×0.73 (1.00)	**Good**
	Bc20		71+375	N/A	*70+200*	10.4	1×4.00×2.00	**Fair**
	Bc21		72+003	N/A	*71+300*	10.4	1×4.00×0.79 (1.00)	**Good**
	Bc22		73+056	N/A	*72+400*	12.2	1×3.90×0.70 (1.00)	**Good**
	Bc23		74+330	N/A	*73+900*	13.1	1×4.40×1.16 (2.00)	**Bad**
	Bc24		89+140	N/A	*88+500*	13.3	1×3.80×1.00	**Good**
	Bc25		108+244	N/A	*108+400*	12.1	1×3.80×0.80 (1.00)	**Good**
	Bc26		111+286	N/A	*111+500*	12.5	1×4.00×1.50 (2.00)	**Bad**
	Bc27		112+721	N/A	*112+900*	13.8	1×4.00×2.10 (2.50)	**Bad**
	Bc28		114+699	N/A	*114+900*	16.8	3.00×2.00 + 3.00×2.15 + 3.00×2.00	**Good**

Province	No. PWRC	No. JICA	KP (Km) PWRC	KP (Km) DPWT	KP (Km) JICA*	Length (m)	Dimension No. of Box×W×H (Design Height)	Condition
Kg. Chhnang	Bc29		114+809	N/A	*115+000*	13.6	2×2.85×2.00	**Good**
	Bc30		115+167	N/A	*115+320*	13.5	2×2.85×2.00	**Good**
	Bc31		120+749	N/A	*120+400*	12.1	2×3.00×2.00	**Poor**
	Bc32		124+845	N/A	*124+900*	12.2	3×3.00×1.50 (2.00)	**Poor**
	Bc33		127+722	N/A	*127+800*	12.3	3×3.00×2.00	**Good**
	Bc34		130+746	N/A	*130+900*	12.1	1×3.00×1.67 (2.00)	**Poor**
	Bc35		131+781	N/A	*132+030*	12.1	1×6.20×2.10	**Fair**
Pursat	Bc36		137+488	137+625	*137+700*	12.1	2×3.00×1.81(2.00)	**Good**
	Bc37		138+036	138+180	*138+200*	12.0	1×1.80×0.55 (1.00)	**Poor**
	Bc38		140+005	140+147	*140+120*	12.1	3×3.00×1.60 (2.00)	**Poor**
	Bc39		140+407	140+552	*140+500*	12.1	2×3.00×1.45 (2.00)	**Poor**
	Bc40		142+005	142+180	*142+200*	12.1	2×3.00×1.0 (2.00)	**Bad**
	Bc41		143+823	143+985	*143+980*	12.3	2×3.00×2.00	**Fair**
	Bc42		144+372	144+505	*144+500*	12.6	2×3.00×2.00	**Good**
	Bc43		149+671	149+823	*149+900*	12.2	1×2.00×2.00	**Good**
	Bc44		156+072	156+232	*156+300*	12.2	1×4.00×0.87 (1.00)	**Poor**
	Bc45		156+462	156+608	*156+700*	12.2	2×3.00×1.58 (2.00)	**Poor**
	Bc46		157+209	157+382	*157+450*	12.2	2×1.90 (2.00)×1.56 (2.00)	**Poor**
	Bc47		157+556	157+715	*157+800*	12.2	2×3.00×1.84 (2.00)	**Good**
	Bc48		159+599	159+773	*159+800*	12.2	3×3.00×1.45 (2.00)	**Poor**
	Bc49		160+859	161+350	*161+050*	12.2	3×3.00×1.20 (2.00)	**Bad**
	Bc50		162+850	163+038	*163+080*	12.2	2×1.85 (2.00)×1.60 (2.00)	**Poor**
	Bc51		164+514	164+678	*164+800*	12.2	3×3.00×1.90 (3.00)	**Bad**
	Bc52		166+588	166+773	*166+800*	12.2	1×4.00×2.00	**Fair**
	Bc53		169+858	170+040	*170+060*	12.3	1×4.00×1.15 (2.00)	**Bad**

Source: Public Works Research Centr (PWRC), General Directorate of Public Works, Ministry of Public Works and Transport, Kingdom of Cambodia
Ministry of Public Work and Transportation, Director of Public work, Deputy Director of Road, DPWT, Pursat Province
** JICA Survey Team Carried out the inventory on Octover and November 2012.*
Note: W and H means width and height respectively. N/A means data not available. The figures in parentheses means design hieght.

Table 7.1-5 Drainage Capacity by Current Dimension of Box Culverts

Province	No.	Location KP (Km)	Total Length (m)	Dimension	Capacity (m^3/s)				Province	No.	Location KP (Km)	Total Length (m)	Dimension	Capacity (m^3/s)			
					Gradient									Gradient			
				No. of Box × W × H	1‰	3‰	5‰	10‰					No. of Box × W × H	1‰	3‰	5‰	10‰
Kampong Chhnang	Bc03	40+053	10.1	1×4.00×0.95	3.0	5.2	6.7	9.4	Kg. Chhnang	Bc29	115+000	13.6	2×2.85×2.00	9.2	15.8	20.4	28.8
	Bc04	44+630	10.0	1×4.00×0.85	2.2	3.8	4.9	6.9		Bc30	115+320	13.5	2×2.85×2.00	9.2	15.8	20.4	28.8
	Bc05	47+250	16.8	1×1.00×0.80	0.3	0.6	0.7	1.0		Bc31	120+400	12.1	2×3.00×2.00	9.8	17.0	21.8	31.0
	Bc06	49+010	12.5	1×4.00×0.70	1.6	2.8	3.7	5.2		Bc32	124+900	12.2	3×3.00×1.50	10.2	17.4	22.5	31.8
	Bc07	51+300	15.2	3.3×2.1+3.4×2.4+3.3×2.1	18.0	31.3	40.4	57.2		Bc33	127+800	12.3	3×3.00×2.00	14.7	25.5	32.7	46.5
	Bc08	53+630	10.4	2×3.00×1.30	5.6	9.6	12.4	17.6		Bc34	130+900	12.1	1×3.00×1.67	3.0	6.7	8.7	12.2
	Bc09	55+600	10.5	0.6×1.16+4.6×1.16+0.6×1.16	4.5	7.8	10.1	14.4		Bc35	132+030	12.1	1×6.20×2.10	13.7	23.7	30.6	43.2
	Bc10	55+700	11.6	1×3.00×1.00	1.9	3.3	4.3	6.1	Pursat	Bc36	137+700	12.1	2×3.00×1.81	8.6	14.8	19.2	27.2
	Bc11	59+600	10.1	1×4.00×1.55	5.1	8.9	11.4	16.2		Bc37	138+200	12.0	1×1.80×0.55	0.4	0.8	1.0	1.4
	Bc12	59+920	10.2	1×3.50×0.73	1.5	2.6	3.3	4.7		Bc38	140+120	12.1	3×3.00×1.60	11.1	18.9	24.6	34.8
	Bc13	61+200	10.4	2×2.00×1.74	4.6	8.0	10.4	14.6		Bc39	140+500	12.1	2×3.00×1.45	6.4	11.2	14.4	20.2
	Bc14	62+630	9.5	4×1.30×2.00	4.4	7.6	10.0	14.0		Bc40	142+200	12.1	2×3.00×1.00	3.8	6.6	8.6	12.2
	Bc15	63+520	N/A	1×2.20×N/A	N/A	N/A	N/A	N/A		Bc41	143+980	12.3	2×3.00×2.00	9.8	17.0	21.8	31.0
	Bc16	64+600	12.7	1×1.00×0.62	0.2	0.4	0.5	0.7		Bc42	144+500	12.6	2×3.00×2.00	9.8	17.0	21.8	31.0
	Bc17	65+100	10.5	1×2.00×1.00	1.1	2.0	2.5	3.6		Bc43	149+900	12.2	1×2.00×2.00	2.8	4.8	6.2	8.7
	Bc18	65+750	12.0	1×1.90×0.62	0.6	1.1	1.4	2.0		Bc44	156+300	12.2	1×4.00×0.87	2.3	3.9	5.0	7.1
	Bc19	69+200	10.5	1×2.00×0.73	0.7	1.3	1.7	2.3		Bc45	156+700	12.2	2×3.00×1.58	7.2	12.4	16.0	22.8
	Bc20	70+200	10.4	1×4.00×2.00	7.2	12.5	16.2	21.7		Bc46	157+450	12.2	2×1.90×1.56	3.8	6.6	8.4	12.0
	Bc21	71+300	10.4	1×4.00×0.79	2.0	3.4	4.4	6.2		Bc47	157+800	12.2	2×3.00×1.84	8.8	15.2	19.6	27.8
	Bc22	72+400	12.2	1×3.90×0.70	1.6	2.7	3.5	5.0		Bc48	159+800	12.2	3×3.00×1.45	9.6	16.8	21.6	30.3
	Bc23	73+900	13.1	1×4.40×1.16	3.8	6.6	8.6	12.1		Bc49	161+050	12.2	3×3.00×1.20	7.5	12.9	16.8	23.4
	Bc24	88+500	13.3	1×3.80×1.00	2.6	4.5	5.8	8.2		Bc50	163+080	12.2	2×1.85×1.60	3.8	6.4	8.4	11.8
	Bc25	108+400	12.1	1×3.80×0.80	1.9	3.2	4.2	5.9		Bc51	164+800	12.2	3×3.00×1.90	13.8	23.7	30.6	43.5
	Bc26	111+500	12.5	1×4.00×1.50	4.9	8.5	10.9	15.5		Bc52	166+800	12.2	1×4.00×2.00	7.2	12.5	16.2	20.4
	Bc27	112+900	13.8	1×4.00×2.00	7.7	13.4	17.2	21.8		Bc53	170+060	12.3	1×4.00×1.15	3.4	5.8	7.5	10.7
	Bc28	114+900	16.8	3.0×2.0+3.0×2.15+3.0×2.0	14.7	25.5	32.7	46.5									

Note: W and H means width and height of box culvert respectively.

Table 7.1-6 Existing Pipe Culverts

Province	No. PWRC	No. JICA*	KP (Km) PWRC	KP (Km) DPWT	KP (Km) JICA*	Length (m)	Dimension (cm)	Condition
Kampong Chhnang	Pc6	Pc006	36+627	N/A	*36+300*	12.25	Φ100	*Poor*
	Pc7	Pc007	37+128	N/A	*36+800*	N/A	Φ100	*Good*
	Pc8	Pc008	39+095	N/A	*38+800*	11.80	Φ100	*Good*
		Pc009		N/A	*43+400*	12.30	2Φ100	
		Pc010		N/A	*50+400*	12.50	2Φ80	
	Pc9		51+026	N/A	*N/A*	N/A	Φ100	*Fair*
	Pc10	Pc011	51+620	N/A	*51+020*	12.60	3Φ100	*Poor*
		Pc012		N/A	*51+600*	N/A	Φ100	
	Pc11		51+723	N/A	*N/A*	N/A	3Φ100	*Worst*
	Pc12		52+176	N/A	*N/A*	N/A	2Φ100	*Good*
	Pc13		52+442	N/A	*N/A*	N/A	Φ50	*Poor*
	Pc14	Pc013	53+553	N/A	*52+900*	12.20	3Φ100	*Poor*
		Pc014		N/A	*53+300*	13.20	Φ40	
	Pc15		53+886	N/A	*N/A*	N/A	Φ50	*Poor*
	Pc16	Pc015	56+739	N/A	*56+080*	12.20	4Φ50	*Poor*
		Pc016		N/A	*56+120*	12.20	Φ100	
	Pc17		56+841	N/A	*N/A*	N/A	Φ50	
	Pc18	Pc017	58+308	N/A	*57+600*	12.30	Φ100	*Good*
	Pc19	Pc018	61+538	N/A	*60+900*	13.90	Φ100	*Good*
		Pc019		N/A	*62+900*	12.20	3Φ100	*Bad*
		Pc020		N/A	*63+200*	13.20	Φ40	*Get bocked*
	Pc20	Pc021	66+125	N/A	*65+420*	12.60	2Φ100	*Worst*
	Pc21	Pc022	66+772	N/A	*66+100*	12.30	2Φ100	*Bad*
	Pc22	Pc023	67+072	N/A	*66+400*	12.50	2Φ100	*Poor*
		Pc024		N/A	*68+200*	12.20	Φ60	*Poor*
	Pc23	Pc025	68+575	N/A	*68+978*	12.00	Φ50	*Good*
		Pc026		N/A	*68+992*	12.30	Φ100	*Good*
	Pc24		69+654	N/A	*N/A*	N/A	Φ80	
	Pc25	Pc207	69+667	N/A	*69+280*	12.10	3Φ50	*Poor*
		Pc028		N/A	*69+600*	12.10	2Φ100	*Good*
	Pc26	Pc029	70+952	N/A	*70+250*	12.20	4Φ50	*Bad*
	Pc27	Pc030	71+053	N/A	*70+700*	12.10	4Φ50	*Good*
	Pc28		73+371	N/A	*N/A*	N/A	Φ100	
		Pc031		N/A	*73+600*	12.50	Φ100	*Bad*
	Pc29	Pc032	74+564	N/A	*75+350*	11.30	Φ50	*Poor*
	Pc30	Pc033	76+060	N/A	*76+700*	12.50	Φ100	*Worst*
	Pc31		77+438	N/A	*N/A*	N/A	Φ80	
		Pc034		N/A	*78+500*	13.10	Φ100	*Fair*
	Pc32	Pc035	79+242	N/A	*79+900*	15.30	Φ80	*Poor*
	Pc33		80+844	N/A	*N/A*	N/A	2Φ100	
	Pc34	Pc036	81+792	N/A	*81+100*	12.20	4Φ100	*Poor*
	Pc35	Pc037	81+899	N/A	*81+200*	12.10	2Φ100	*Good*
		Pc038		N/A	*81+300*	12.20	4Φ100	*Poor*
	Pc36		82+040	N/A	*N/A*	N/A	2Φ80	
	Pc37		82+420	N/A	*N/A*	N/A	4Φ80	
	Pc38	Pc039	82+479	N/A	*81+700*	12.20	2Φ100	*Good*
		Pc040		N/A	*81+750*	12.00	Φ100	*Fair*
	Pc39	Pc041	82+586	N/A	*81+900*	11.70	Φ100	*Fair*
	Pc40	Pc042	82+684	N/A	*81+994*	11.20	Φ100	*Fair*
	Pc41	Pc043	82+929	N/A	*82+600*	11.10	Φ100	*Poor*
	Pc42	Pc044	83+220	N/A	*82+750*	11.00	Φ100	*Poor*
	Pc43	Pc045	83+465	N/A	*82+850*	11.00	Φ100	*Fair*
	Pc44	Pc046	83+564	N/A	*82+950*	11.10	Φ100	*Fair*
	Pc45		83+662	N/A	*N/A*	N/A	Φ100	
	Pc46		83+757	N/A	*N/A*	N/A	Φ100	
	Pc47		84+465	N/A	*N/A*	N/A	Φ60	
		Pc047		N/A	*84+700*	12.50	Φ120	*Good*
	Pc48		85+338	N/A	*N/A*	N/A	2Φ50	
	Pc49		86+496	N/A	*N/A*	N/A	Φ100	
		Pc048		N/A	*87+600*	14.00	3Φ100	*Poor*
	Pc50		88+597	N/A	*N/A*	N/A	3Φ60	
	Pc51		89+717	N/A	*N/A*	N/A	Φ50	
	Pc52		91+743	N/A	*N/A*	N/A	Φ60	
		Pc049		N/A	*92+300*	14.75	Φ100	*Poor*
		Pc050		N/A	*92+350*	14.70	Φ100	*Bad*
	Pc53		92+579	N/A	*N/A*	N/A	4Φ50	
	Pc54		92+660	N/A	*N/A*	N/A	Φ100	
	Pc55	Pc051	93+580	N/A	*93+400*	12.00	2Φ60	*Poor*
	Pc56	Pc052	94+006	N/A	*93+936*	16.00	Φ100	*Fair*
	Pc57		94+106	N/A	*N/A*	N/A	Φ100	
	Pc58		94+204	N/A	*N/A*	N/A	Φ100	
	Pc59		94+416	N/A	*N/A*	N/A	Φ100	
	Pc60		94+730	N/A	*N/A*	N/A	Φ100	
	Pc61	Pc053	95+084	N/A	*95+100*	14.80	Φ100	*Fair*
	Pc62		95+794	N/A	*N/A*	N/A	4Φ80	
	Pc63		95+973	N/A	*N/A*	N/A	4Φ80	
	Pc64		96+710	N/A	*N/A*	N/A	4Φ80	
		Pc054		N/A	*96+875*	17.20	4Φ80	*Poor*
	Pc65	Pc055	97+250	N/A	*97+400*	14.10	Φ100	*Fair*
	Pc66	Pc056	97+381	N/A	*97+500*	17.20	2Φ80	*Good*
	Pc67	Pc057	98+455	N/A	*98+600*	12.00	Φ100	*Poor*
	Pc68	Pc058	99+054	N/A	*99+300*	14.70	2Φ100	*Fair*
	Pc69	Pc059	99+518	N/A	*99+800*	14.50	2Φ100	*Good*
	Pc70		99+790	N/A	*N/A*	N/A	Φ80	
	Pc71	Pc060	100+166	N/A	*100+480*	13.50	2Φ80	*Bad*
	Pc72	Pc061	100+449	N/A	*100+700*	14.60	2Φ80	*Fair*
	Pc73	Pc062	101+094	N/A	*101+300*	14.60	2Φ80	*Fair*

Province	No. PWRC	No. JICA*	KP (Km) PWRC	KP (Km) DPWT	KP (Km) JICA*	Length (m)	Dimension (cm)	Condition
Kampong Chhnang	Pc74	Pc063	101+562	N/A	*101+800*	15.80	4Φ80	*Fair*
	Pc75	Pc064	101+837	N/A	*102+100*	16.20	2Φ80	*Poor*
	Pc76	Pc065	102+347	N/A	*102+600*	14.60	2Φ80	*Good*
	Pc77	Pc066	103+047	N/A	*103+300*	14.90	2Φ80	*Bad*
	Pc78		103+879	N/A	*N/A*	N/A	2Φ80	*Poor*
	Pc79	Pc067	110+536	N/A	*110+500*	14.7	Φ100	*Fair*
	Pc80	Pc069	112+361	N/A	*112+800*	14.5	3Φ120	*Fair*
	Pc81	Pc070	113+930	N/A	*114+400*	15.9	Φ80	*Bad*
	Pc82		114+965	N/A	*N/A*	N/A	5Φ100	
	Pc83		115+328	N/A	*N/A*	N/A	5Φ100	
	Pc84	Pc071	115+501	N/A	*115+700*	15.00	4Φ100	*Fair*
	Pc85	Pc072	115+702	N/A	*115+900*	15.00	5Φ100	*Fair*
	Pc86		115+983	N/A	*N/A*	N/A	2Φ80	
	Pc87		116+078	N/A	*N/A*	N/A	5Φ100	
	Pc88		117+131	N/A	*N/A*	N/A	4Φ100	
	Pc89	Pc073	117+470	N/A	*117+600*	13.40	2Φ80	*Fair*
	Pc90	Pc074	117+592	N/A	*117+700*	14.70	2Φ80	*Fair*
	Pc91	Pc075	117+917	N/A	*118+050*	14.80	3Φ100	*Bad*
	Pc92	Pc076	118+528	N/A	*118+600*	13.50	2Φ80	*Good*
	Pc93	Pc077	118+735	N/A	*119+200*	17.00	Φ100	*Fair*
	Pc94	Pc078	119+121	N/A	*120+800*	13.60	1Φ80	*Poor*
	Pc95	Pc079	119+382	N/A	*121+100*	14.70	2Φ80	*Bad*
	Pc96		120+749	N/A	*N/A*	N/A	Φ80	
	Pc97		121+006	N/A	*N/A*	N/A	2Φ80	
	Pc98	Pc080	121+662	N/A	*121+700*	14.70	Φ80	*Good*
	Pc99	Pc081	122+023	N/A	*122+100*	14.70	2Φ80	*Worst*
	Pc100	Pc082	122+407	N/A	*122+500*	14.70	2Φ80	*Get Blocked*
	Pc101		122+936	N/A	*N/A*	N/A	Φ80	
	Pc102		123+618	N/A	*N/A*	N/A	Φ100	
	Pc103	Pc083	123+926	N/A	*124+050*	13.20	Φ80	*Worst*
	Pc104	Pc084	124+511		*124+600*	16.20	2Φ100	*Good*
	Pc105		125+391	N/A	*N/A*	N/A	2Φ80	
	Pc106		125+602	N/A	*N/A*	N/A	2Φ80	
	Pc107		126+127	N/A	*N/A*	N/A	2Φ80	
	Pc108		126+162	N/A	*N/A*	N/A	4Φ50	
	Pc109	Pc085	126+203	N/A	*126+200*	14.70	2Φ100	*Bad*
		Pc086		N/A	*126+250*	12.10	2Φ80	*Poor*
		Pc087		N/A	*126+290*	12.60	2Φ100	*Fair*
	Pc110		126+669	N/A	*N/A*	N/A	4Φ100	
		Pc088		N/A	*126+800*	13.60	5Φ100	*Fair*
	Pc111	Pc089	127+159	N/A	*127+200*	14.50	3Φ80	*Fair*
	Pc112	Pc090	128+550	N/A	*128+600*	12.80	2Φ100	*Bad*
	Pc113	Pc091	129+180	N/A	*129+300*	12.70	2Φ80	*Fair*
	Pc114	Pc092	129+510	N/A	*129+600*	13.40	4Φ80	*Broken*
	Pc115		129+761	N/A	*N/A*	N/A	Φ100	
Pursat	Pc116	Pc093	136+935	137+090	*137+100*	11.80	2Φ100	*Poor*
	Pc117	Pc094	137+223	137+370	*137+300*	14.80	Φ100	*Poor*
	Pc118	Pc095	138+350	138+490	*138+400*	17.80	2Φ100	*Fair*
	Pc119		138+900	N/A	*N/A*	N/A	Φ80	
	Pc120	Pc096	139+579	139+050	*139+080*	15.00	Φ100	*Poor*
		Pc097		139+710	*139+700*	16.60	Φ100	*Poor*
				141+295	*N/A*	16.50	Φ100	
	Pc121	Pc098	142+321	142+490	*142+920*	14.00	Φ100	*Fair*
	Pc122		142+748	N/A	*N/A*	N/A	Φ80	
	Pc123		145+701	N/A	*N/A*	N/A	Φ100	
				145+390	*N/A*	14.70	Φ100	
				145+830	*N/A*	14.00	Φ100	
				147+262	*N/A*	16.00	2Φ80	
	Pc124	Pc099	147+828	147+980	*147+982*	13.40	2Φ100	*Good*
	Pc125		147+875	148+027	*N/A*	16.60	Φ100	
	Pc126		149+032	149+179	*N/A*	16.30	Φ100	
	Pc127	Pc100	151+709	151+953	*151+800*	15.00	Φ100	*Poor*
	Pc128	Pc101	152+448	152+593	*152+500*	16.00	Φ100	*Poor*
	Pc129	Pc102	152+788	152+935	*152+900*	13.00	3Φ100	*Fair*
	Pc130	Pc103	153+955	154+052	*154+070*	12.50	Φ060	*Good*
	Pc131		154+791	154+960	*N/A*	N/A	Φ100	
	Pc132	Pc104	154+856	155+010	155+010	12.50	2Φ100	*Poor*
	Pc133		155+274	155+444	*N/A*	12.00	Φ60	
	Pc134		158+005	N/A	*N/A*	N/A	3Φ120	
		Pc105		158+163	*158+200*	12.70	3Φ80 (Φ100)	*Good*
	Pc135	Pc106	158+642	158+817	*158+800*	12.50	Φ100	*Fair*
	Pc136	Pc107	159+395	159+565	*159+600*	12.60	2Φ100	*Worst*
	Pc137		159+720	N/A	*N/A*	N/A	2Φ100	
		Pc108		159+900	*159+900*	12.60	Φ100	*Bad*
	Pc138	Pc109	161+010	161+185	*161+300*	12.20	2Φ100	*Poor*
	Pc139	Pc110	161+481	161+650	*161+700*	12.60	4Φ100	*Bad*
	Pc140	Pc111	162+405	162+583	*162+700*	12.40	Φ100	*Poor*
	Pc141	Pc112	163+370	163+530	*163+600*	12.50	2Φ100	*Poor*
	Pc142		163+944	N/A	*N/A*	N/A	2Φ100	
		Pc113		164+110	*164+200*	12.40	Φ100	*Fair*
	Pc143	Pc114	165+143	165+332	*165+400*	12.50	2Φ100	*Poor*
	Pc144	Pc115	166+195	166+380	*166+500*	12.40	4Φ100	*Good*
	Pc145	Pc116	167+427	167+600	*167+700*	12.40	Φ100	*Poor*
	Pc146		168+281	N/A	*N/A*	N/A	Φ100	
		Pc117		N/A	*168+500*	12.40	Φ80	*Fair*
	Pc147		168+919	N/A	*N/A*	N/A	Φ100	
		Pc118		169+100	*169+200*	12.40	Φ100 (Φ80)	*Poor*

Source: Public Works Research Centr (PWRC), General Directorate of Public Works, Ministry of Public Works and Transport, Kingdom of Cambodia
Ministry of Public Work and Transportation, Director of Public work, Deputy Director of Road, DPWT, Pursat Province
** JICA Survey Team Carried out the inventory on Octover and November 2012. The figure in parentheses obtained from DPWT.*

Table 7.1-7 Drainage Capacity by Pipe Culverts

Gradient (‰)	Φ50		Φ60		Φ80		Φ100		Φ120	
	Velocity V (m/s)	Discharge Q (m^3/s)	Velocity V (m/s)	Discharge Q (m^3/s)	Velocity V (m/s)	Discharge Q (m^3/s)	Velocity V (m/s)	Discharge Q (m^3/s)	Velocity V (m/s)	Discharge Q (m^3/s)
1	0.61	**0.12**	0.69	**0.19**	0.83	**0.42**	0.96	**0.76**	1.09	**1.23**
2	0.86	**0.17**	0.97	**0.28**	1.18	**0.59**	1.36	**1.07**	1.34	**1.74**
3	1.05	**0.21**	1.19	**0.34**	1.44	**0.72**	1.67	**1.31**	1.89	**2.14**
5	1.36	**0.27**	1.54	**0.43**	1.86	**0.94**	2.16	**1.70**	2.44	**2.76**
10	1.92	**0.38**	2.17	**0.61**	2.83	**1.32**	3.05	**2.40**	3.45	**3.90**

Table 7.1-8 Drainage Capacity on Submerged Flow by Pipe Culverts

Water-level Difference Δh (m)	Φ50		Φ60		Φ80		Φ100		Φ120	
	Velocity V (m/s)	Discharge Q (m^3/s)	Velocity V (m/s)	Discharge Q (m^3/s)	Velocity V (m/s)	Discharge Q (m^3/s)	Velocity V (m/s)	Discharge Q (m^3/s)	Velocity V (m/s)	Discharge Q (m^3/s)
0.01	0.37	**0.07**	0.37	**0.10**	0.37	**0.19**	0.37	**0.29**	0.37	**0.42**
0.05	0.82	**0.16**	0.82	**0.23**	0.82	**0.42**	0.82	**0.65**	0.83	**0.94**
0.10	1.16	**0.23**	1.16	**0.33**	1.17	**0.59**	1.17	**0.92**	1.17	**1.33**
0.15	1.42	**0.28**	1.42	**0.40**	1.43	**0.72**	1.43	**1.12**	1.44	**1.62**
0.20	1.64	**0.32**	1.64	**0.46**	1.65	**0.83**	1.66	**1.30**	1.66	**1.87**
0.25	1.83	**0.36**	1.84	**0.52**	1.84	**0.93**	1.85	**1.45**	1.85	**2.10**
0.30	2.00	**0.39**	2.01	**0.57**	2.02	**1.10**	2.07	**1.59**	2.03	**2.30**
0.40	2.32	**0.45**	2.32	**0.66**	2.33	**1.17**	2.34	**1.84**	2.34	**2.65**
0.50	2.59	**0.51**	2.60	**0.74**	2.61	**1.24**	2.62	**2.05**	2.62	**2.96**

Note: Coefficient of inlet loss and coefficient of friction loss are applied as 0.4 and 0.1 respectively.

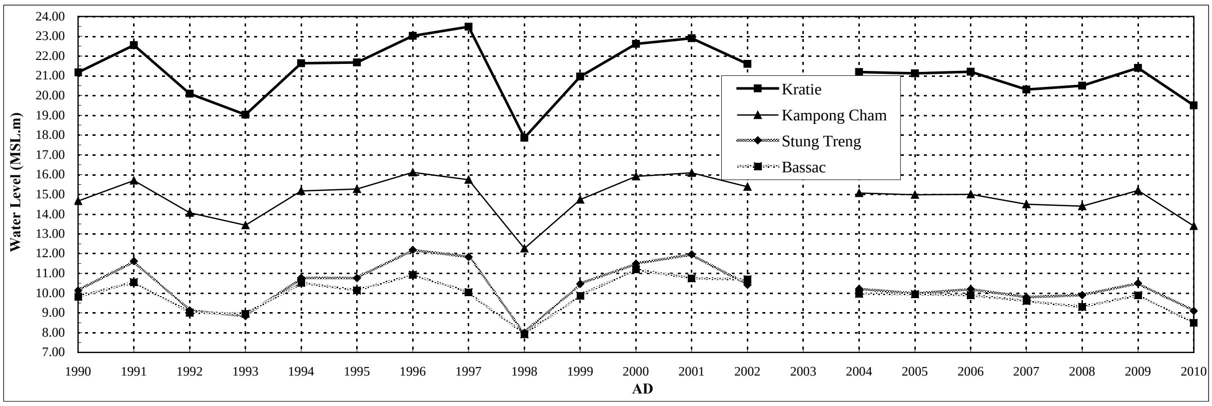
7.1.2 Water Level of Mekong River and Tonle Sap River

Annual maximum water level records at four gauging stations along the Mekong River in Cambodia are illustrated in Figure 7.1-2. It is understood that there is no obvious tendency of rising or lowering in flood water level throughout the last decade, except in year 1995.

Figure 7.1-3 illustrates the daily water levels of Tonle Sap River at Prek Kdam Gauging Station from 1st June up to 29th October i.e. rainy season. It is obvious that high water level (HWL) exceeded warning water-level (10m) in 2011 with the duration of one month (27th Sep~27th Oct). In addition, Figures 7.1-4 and 7.1-5 illustrate the Tonle Sap River Hyetograph updated at Prek Kdam (KP 31) and Kampong Luong (almost KP 154), respectively.

Furthermore, Table 7.1-9 summarizes the estimated maximum water level of the Tonle Sap Lake (1924-1959, 1995-2008). As a result, water level of 11.3 m (MSL) with return period of 10-yr by Log-Pearson III method widely used can be applied to the Project.

Accordingly, maximum flood level of 10.81 m (MSL) at Kampong Luong and 10.34 m (MSL) at Prek Kdam Bridge can be thus applied to the Project. Figure 7.1-6 illustrates the estimated flood level along NR 5.

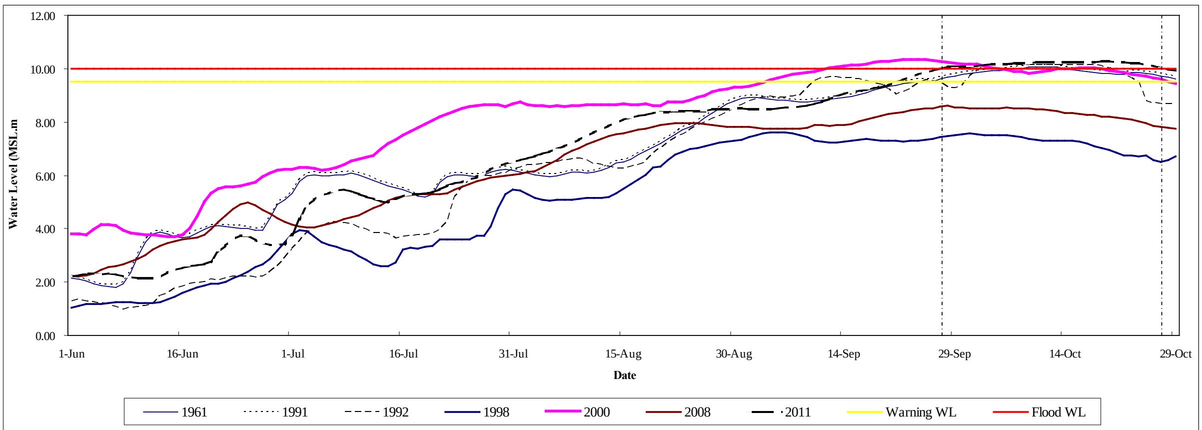


(Unit: MSL.m)

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 7.1-2 Annual Maximum Water Levels of Mekong River in Cambodia



Source: Mekong River Commission & Department of Water Resources and Meteorology, Ministry of Water Resources and Meteorology

Figure 1.1.1 Water Level at Prek Kdam Gauging Station

Figure 7.1-3 Water Levels at Prek Kdam Gauging Station (June ~ October)

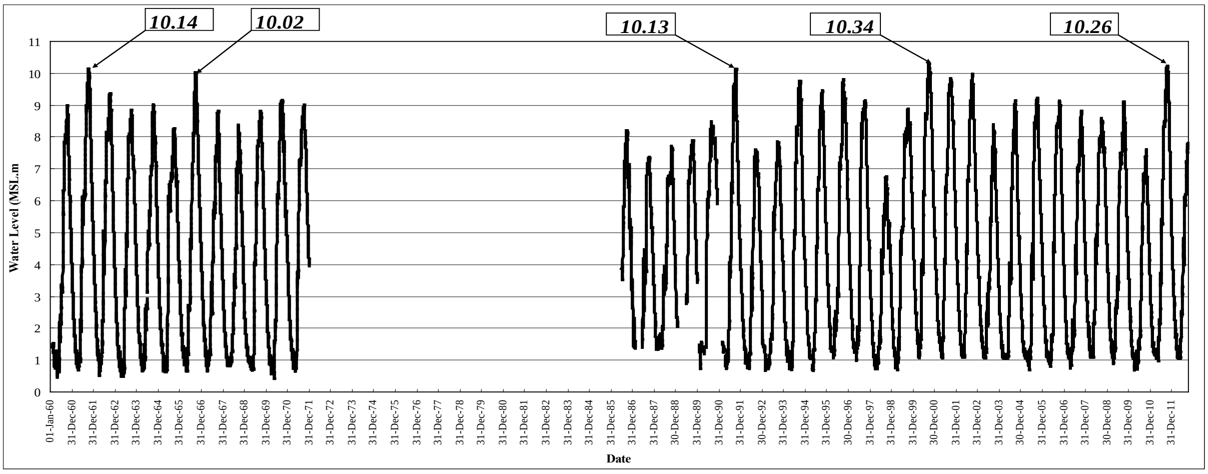


Figure 7.1-4 Tonle Sap River Hyetograph at Prek Kdam Gauging Station (1960 ~ 2011)

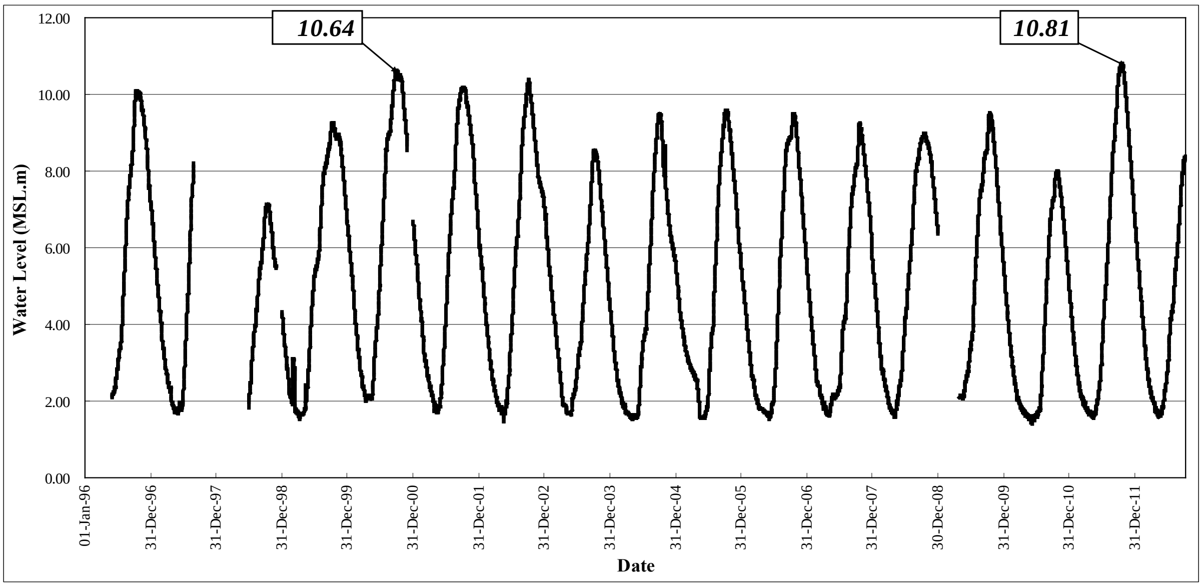


Figure 7.1-5 Tonle Sap Lake Hyetograph at Kampong Luong Gauging Station (1996 ~ 2011)

Table 7.1-9 Flood Water Revel Estimated by Different Method

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

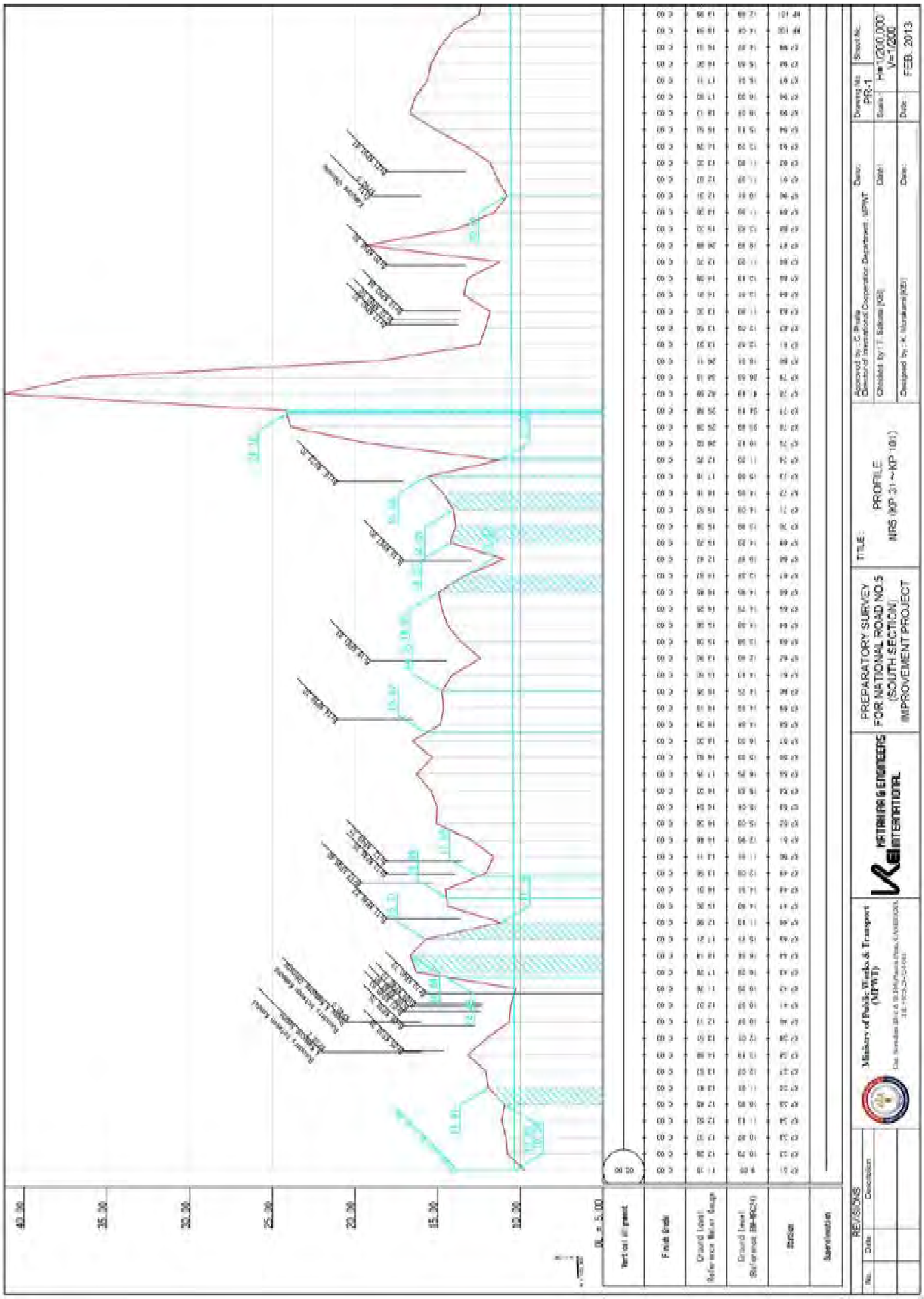


Figure 7.1-6 (1) Estimated Flood Level along NR 5 (1/2)

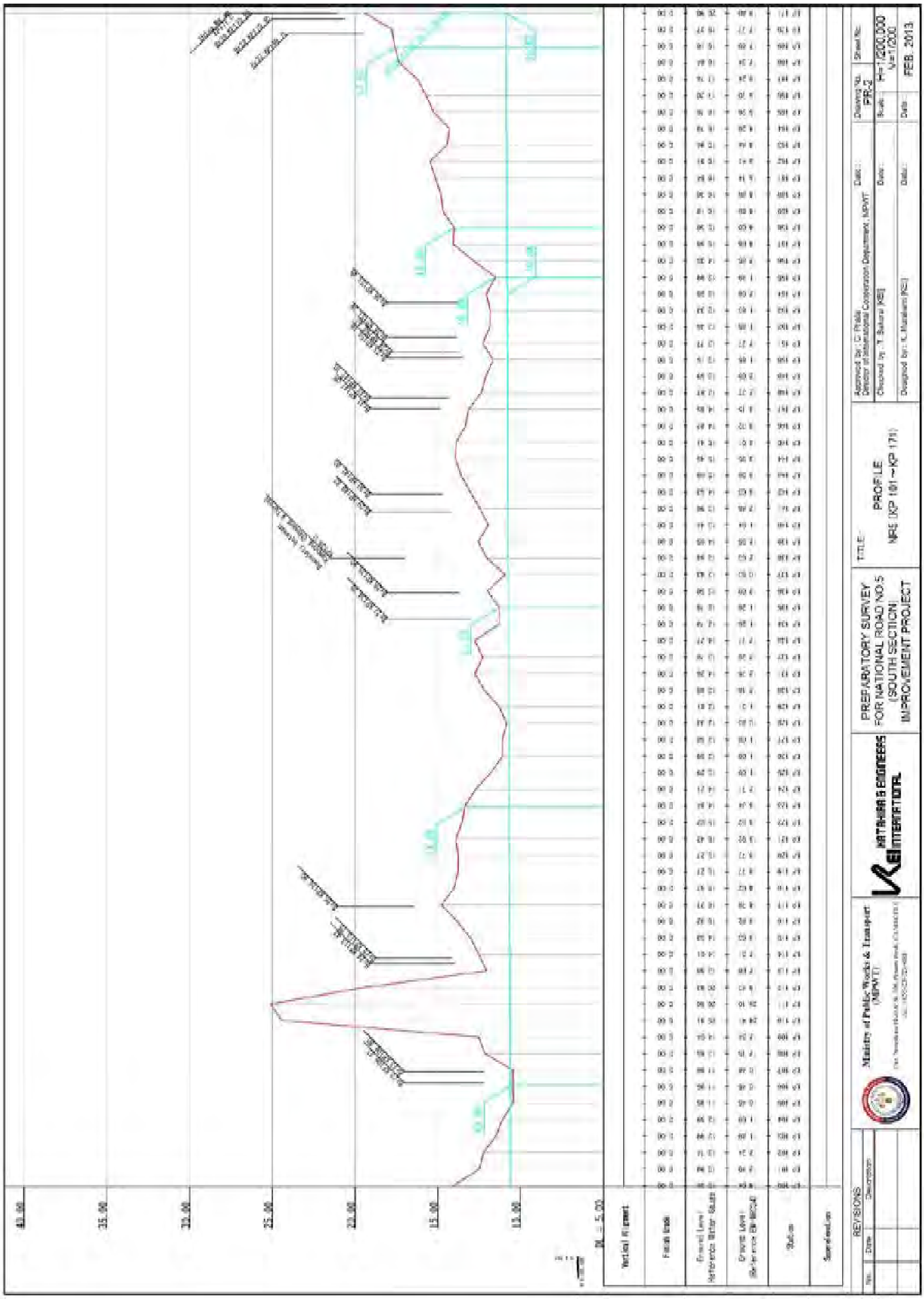


Figure 7.1-6 (2) Estimated Flood Level along NR 5 (2/2)

7.1.3 Information of Road Flood Condition

(1) Interview Survey on Information of Road Flood Condition

JICA Survey Team carried out interview survey to the residents living in, or close to, the flooded sites and/or flood-prone areas. (Refer Appendix 7-2: Inquiring Survey on Information of Flooding Conditions for details.) In addition, JICA Survey Team visited the DPWT offices in Kampong Chhnang and Pursat, respectively, to collect additional information on damaged and flood-prone sections. Table 7.1-10 summarizes the information/records on flood conditions along NR 5 obtained through such interview and those provided by DPWTs.

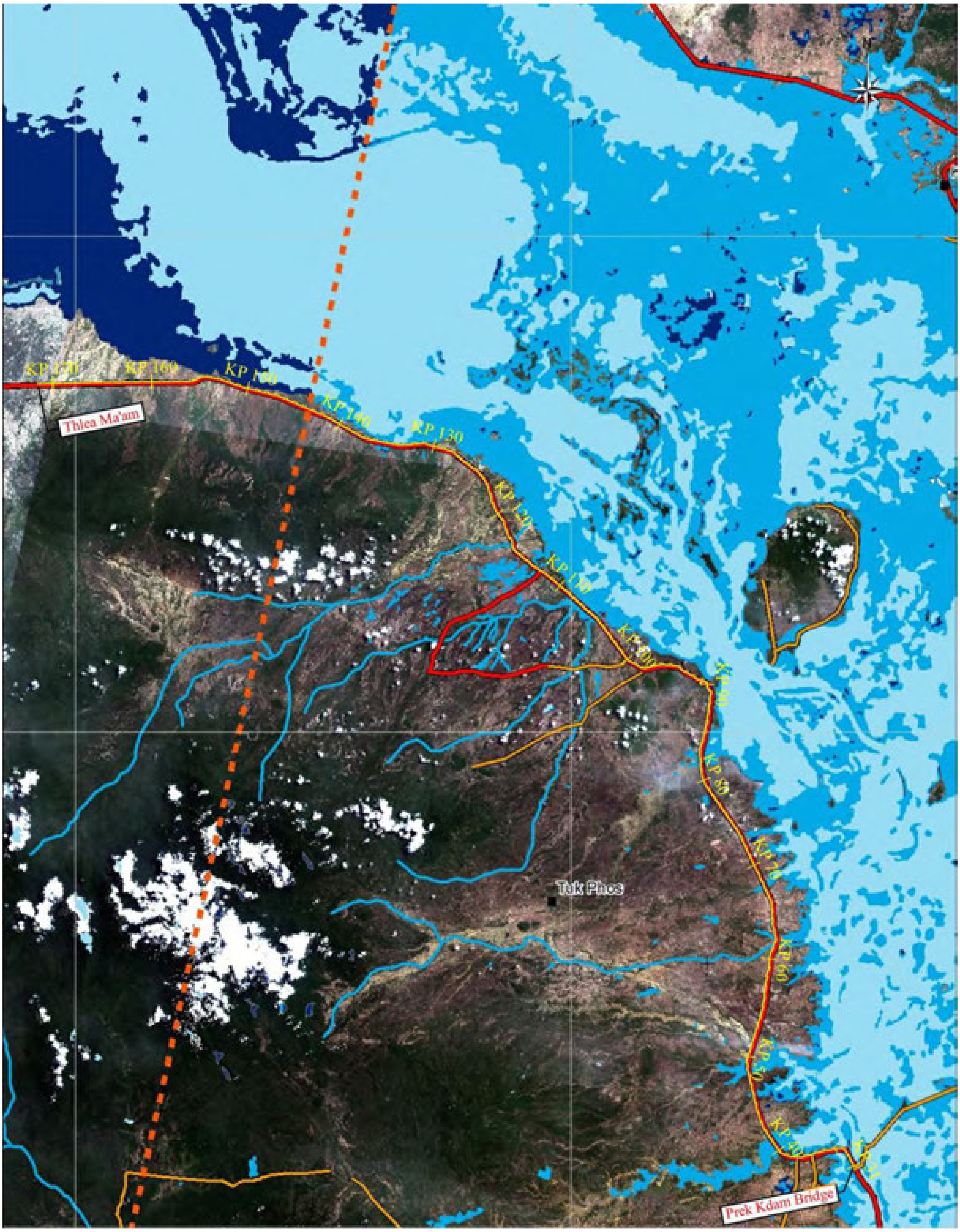
(2) Road Flood Condition through Satellite Image

In addition to the information obtained through the interview survey and inquiry to the Provincial DPWTs as mentioned above, satellite image was provided by MPWT. Figure 7.1-7 shows the overview of extent of 2011 flood disaster of Tonle Sap River along NR 5. From this satellite image, flooded road sections can be deciphered as summarized in Table 7.1-11. It is seen that the backing-up of the Tonle Sap River water severely breached the section between KP 40 and KP 43 and deeply/widely flooded up to mountain-ringed region. In fact, integrated flood disaster prevention needs to be taken for these breached sections in addition to the outcome of interview survey mentioned above.

Table 7.1-10 Information/Records on Road Flood Conditions

KP (Km)	Flood					Source
	Period	Level	Duration	Flow Direction	Frequency	
31+000	Oct ~ Nov-11	30 ~ 40cm	1 month	⇒Tonle Sap River	Seldom	JICA
35 ~ 36	N/A	Damaged by local heavy rain	N/A		Every year	JICA
42+700	Oct ~ Nov-11	10cm	1 month	⇒Mountain Side	Every year	JICA
43+000	*Oct ~ Nov 2002, Oct-Dec 2011*	*N/A*	*N/A*	*⇒Mountain Side*	*Every year*	*DPWT**
45+400	Oct-11	Shoulder flooded	3-4 days	⇒Mountain Side	Every year	JICA
45 ~ 46	N/A	Damaged by local heavy rain	N/A		Every year	JICA
47+500	Oct-11	30 ~ 40cm	3-4 days	⇒Mountain Side	Seldom	JICA
48+800	Nov-11	10cm	3-4 days	⇒Mountain Side	Seldom	JICA
55+000	Never flooded					JICA
57+500	Oct-11	5 ~ 10cm	12 hours	⇒Tonle Sap River	Every year	JICA
60+000	Oct-11	20cm	2-3 days	⇒Mountain Side	Every year	JICA
66 ~ 67	N/A	Poor maintenance on drainage canal at both sides	N/A	⇒Tonle Sap River	Every year	JICA
69 ~ 72	*Oct ~ Nov 2002, Oct-Dec 2011*	*N/A*	*N/A*	*⇒Tonle Sap River*	*Every year*	*DPWT**
69 ~ 70	N/A	Poor maintenance on drainage canal at both sides	N/A	⇒Tonle Sap River	Every year	JICA
74+000	Sep ~ Oct 2010 & 2011	40cm	1 week	⇒Tonle Sap River	Seldom	JICA
83+000	Aug ~ Sep-11	No flooding at road surface but houses along road were flooded	2 weeks	⇒Tonle Sap River	Seldom	JICA
90 ~ 91	*Oct ~ Nov 2002, Oct-Dec 2011*	*50 ~70cm (2011)*	*2 months (2011)*	*from Tone Sap River*	*Seldom*	*DPWT**
90+000	Sep-11	5 ~ 10cm	15 days	from Tone Sap River	Seldom	JICA
106+100	Sep-00	30cm	2 weeks	⇒Tonle Sap River	Seldom	JICA
135+000	*12-Aug*	*30cm*	*N/A*	*⇒Tonle Sap R.*	*Every year*	*DPWT***
155+000	Oct-10 (Sep-00)	1 ~ 2cm (10cm in 2000)	2-3 days (1 month in 2000)	⇒Tonle Sap River	Seldom	JICA
155 ~ 160	Aug ~ Oct	10 ~ 30cm	N/A	⇒Tonle Sap River	Every year	DPWT**

*Note: * Kampong Chhnang, DPWT, MPWT ** Pursat, DPWT, MPWT JICA means JICA Survey Team*



Source: Map produced 15-10-2011 by e-GEOS S.p.A (e-geos AN ASI/TELESPAZIO COMPANY)

Figure 7.1-7 Flooded Sections of NR 5 caused by Backwater of the Tonle Sap River

Table 7.1-11 Flooded Road Sections Deciphered from Satellite Image in 2011

Location (KP)	Bridge No.	Remarks
40 ~ 43	Br06, Br08, Br09, and Br10	Flow direction at Br07 generally is from Tonle Sap River side across NR-5 to mountain side. Total bridge length is 96.6m.
48 ~ 49	Br12, Br13, Br14	Total bridge length is 47.2m.
62	Br16	Length of Br16 is 24.2m.
68	Br17	Length of Br17 is 24.25m.
82 ~ 83	Br19, Br20, Br21	Length of Br20 is 43m. Total bridge length is 53.7m.
105 ~ 108	Br24, Br25	Length of Br24 is 91.5m. Total bridge length is 118m.
113 ~ 114	Br26, Br27	Total bridge length is 27m.
116 ~ 117	Br28	Length of Br28 is 76.85m.
134 ~ 136	Br29, Br30	Total bridge length is 37m.

7.1.4 Estimated Flood Discharge from Mountains

There are three factors which affect the runoff and the flood discharge from a catchment area served by a dam or culver, namely; i) rainfall and weather characteristics; ii) terrain characteristics; and iii) stream characteristics. Method of statistics and probability is applied to estimate the intensity of rainfall. This method is applicable for a catchment for which data of the highest annual floods are available over a period of at least 25 to 30 years. A probability of once in 50 years up to once in 200 years is used depending upon the catchment or the design life period of the target structure.

Basically, the hydrological component of design is concerned with the estimation of probable flood discharges brought about by rainfall of the above-mentioned watershed characteristics. Probable flood discharges or runoff produced in several drainage basins can be estimated using a number of available methods or formula.

“Rational method” is applied and provided it is possible to evaluate for the Project area concerned the various factors employed in the method from the hydraulic characteristics of the river or drainage canal such as cross sectional area, and slope of the stream allowing for velocity of flow or from the records available, if any, of discharges observed on the river or drainage canal at the site of the culvert, or at any other site in its vicinity. This method based on empirical formula has been widely utilized because of its simplicity and easy application by using the following equation.

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

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)

The drainage area, A, of each particular site was obtained by delineating the drainage boundaries defined by the ridges in the 1:100,000 scale topographic maps provided by MPWT and each one will be measured three times to achieve the average value using the polar planimeter.

To obtain the value of I, the time of concentration, t, is initially computed using the formula developed by Kirpich.

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

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)

Moreover, coefficient of runoff, C, is a function of the soil type and drainage basin slope.

A simplified table is shown below.

Table 7.1-12 Coefficients of Runoff

Type of Surface	Max Runoff Coefficient
Congested Urban Area	0.90
General Urban Area or Residential Area	0.75
Rocky Surface	0.90
Bare Clay Surface (faces of slips, etc.)	0.50
Forested Land (sandy to clay)	0.50
Mountain Terrain	0.30
Flattish Cultivated Areas (not flooded)	0.70
Upland & Plains	0.60
Steep or Rolling Grassed Area	0.80
Flooded or Wet Paddies	0.80
Ponds, Swamps, Reservoirs, Canal	1.00

Applying the above-mention conditions for the Project target area, Table 7.1-13 summarizes the estimated flood discharge for the grouping facilities mentioned above. Flow direction by flood at grouping No. 6 is originated from eastern mountains at the Tonle Sap River side.

Furthermore, it is always observed in the design of the bridge opening that the natural flow condition of the river/waterway should be respected or be kept unaltered as much as practicable. The principle is that any alteration to the channel causes the streamflow to make a corresponding response in order to maintain its equilibrium condition. This response to the streamflow, many times, is unpredictable especially during flood, and maybe destructive and catastrophic. Thus, the bridge length (opening) should correspond with the natural banks of the river, as much as possible.

The waterway opening of a bridge across a stream is generally set equal to the width of the riverbanks or can be obtained from the empirical regime formula for stable alluvial channels:

$$Ws = KQ^{1/2}$$

Where,

Ws : Waterway surface width (m)

K : Conversion constant (3.20 ~ 4.75)

Q : Flood discharge (m^3/s)

The larger value of K is used for shifting channels in sandy materials, but for relatively stable channels in more scour-resistant materials the lower value of K may be used. Further adjustment of the waterway opening width should be made on economic grounds after consideration of scour and other factors.

Moreover, the minimum span length of the bridge can be calculated using the following equation:

$$L = 20 + 0.005Q$$

Where,

L : Span Length (m)

Q : Flood Discharge (m^3/s)

Accordingly, the waterway opening and minimum span length for the whole bridges can be estimated by applying 60 mm of rainfall intensity adopted for North Section and thus as summarized in Table 7.1-13 for reference.

Table 7.1-13 Estimated Flood Discharge by Grouping Facilities

Grouping No.	Drainage Facilities	Drainage Area (Km²)	Coefficient of Runoff	Inflow Reach		Flow-down Reach		Estimated Flood Discharge (m^3/s)				
				Waterway Length (km)	Head* (m)	Waterway Length (km)	Head* (m)	Rainfall Intensity				
								60* mm/hr	70 mm/hr	80 mm/hr	90 mm/r	100 mm/r
1	Br05	44.1	0.30	16.2	35.0			221	257	294	331	368
2	Br06, Bc03, Br8~10, Bc04, Br11, Bc05	194.8	0.30	25.7	706.0	9.0	31.5	974	1,136	1,299	1,461	1,623
3	Br12, Bc06, Br13, Bc07	130.4	0.30	4.0	447.0	19.6	51.5	652	761	869	978	1,087
4	Bc08~10, Br15, Bc11~13, Br16, Bc14~18	86.2	0.30	11.5	165.0			431	503	575	647	718
5	Br18, Bc19~23	37.3	0.30	3.0	62.0			187	218	249	280	311
6	Pc030~033	3.2	0.50	1.0	45.0			27	31	36	40	44
7	Br19~21	162.1	0.30	3.6	1,497.0	20.0	92.0	811	946	1,081	1,216	1,351
8	Br22, Bc24	15.2	0.30	1.5	46.0			76	89	101	114	127
9	Br23	5.0	0.30	3.7	240.0			25	29	33	38	42
10	Pc047~054	3.8	0.50	2.1	166.0			32	37	42	48	53
11	Pc055~057	2.0	0.50	2.7	47.0			23	27	31	35	39
12	Pc058~064	2.0	0.50	2.7	19.0			17	19	22	25	28
13	Br24~25, Bc25~26	134.0	0.30	5.3	280.0	10.6	43.0	670	782	893	1,005	1,117
14	Bc27, Br26~27, Bc28~30	67.3	0.30	12.2	610.0	6.0	31.5	337	393	449	505	561
15	Br28, Bc31	239.7	0.30	27.2	1,744.0	7.0	29.4	1,199	1,398	1,598	1,798	1,998
16	Bc32~35	23.0	0.30	10.8	326.0			115	134	153	173	192
17	Br29~30, Bc36~39, Br31~32, Bc40~42, Br33~35, Bc43, Br36~37	79.8	0.30	5.5	442.0	4.0	13.5	399	466	532	599	665
18	Bc44~51	35.9	0.30	6.6	380.0	1.3	10.5	180	209	239	269	299
19	Bc52, Br39, Bc53, Br40~41	148.3	0.30	7.8	1,012.0	15.5	40.6	742	865	989	1,112	1,236

*Note: Head means water-level difference. * Flood discharges estimated by 60mm of rainfall intensty adopted for North Section will be thus aplied to the Project.*

Table 7.1-14 Estimated Waterway Opening and Minimum Span Length

Grouping No.	Drainage Facilities	Flood Discharge Q (m^3/s)	Waterway Opening (m)	Span Length (m)	Current Opening (m)
1	Br05	221	*48 ~ 71*	*21*	8
2	Br06, Bc03, Br8~10, Bc04, Br11, Bc05	974	*100 ~ 148*	*25*	112
3	Br12, Bc06, Br13, Bc07	652	*82 ~ 121*	*23*	49
4	Bc08~10, Br15, Bc11~13, Br16, Bc14~18	431	*66 ~ 99*	*22*	151
5	Br18, Bc19~23	187	*44 ~ 65*	*21*	42
6	Pc030~033	27	*17 ~ 25*	*20*	N/A
7	Br19~21	811	*91 ~ 135*	*24*	91
8	Br22, Bc24	76	*28 ~ 41*	*20*	10
9	Br23	25	*16 ~ 24*	*20*	22
10	Pc047~054	32	*18 ~ 27*	*20*	N/A
11	Pc055~057	23	*15 ~ 23*	*20*	N/A
12	Pc058~064	17	*13 ~ 19*	*20*	N/A
13	Br24~25, Bc25~26	670	*83 ~ 123*	*23*	155
14	Bc27, Br26~27, Bc28~30	337	*59 ~ 87*	*22*	108
15	Br28, Bc31	1,199	*111 ~ 164*	*26*	83
16	Bc32~35	115	*34 ~ 51*	*21*	42
17	Br29~30, Bc36~39, Br31~32, Bc40~42, Br33~35, Bc43, Br36~37	399	*64 ~ 95*	*22*	201
18	Bc44~51	180	*43 ~ 64*	*21*	51
19	Bc52, Br39, Bc53, Br40~41	742	*87 ~ 129*	*24*	78

Note: N/A means data not available in case of pipe culverts.

7.2 Topographical Survey

7.2.1 Objective

Topographical surveys on the selected routes of NR 5 (South Section), and Kampong Chhnang and Odongk bypass routes are conducted for preliminary road design and cost estimation.

(1) Existing Road (NR-5)

- Altitude of road surface: Necessary for measures against flood
- Cross section at 1 km interval: Necessary for preliminary design and estimation of earthwork volume
- To prepare topographic map: Used in design of section which the road centerline will be changed
- To design the section (KP32 to KP37) of changing road alignment

(2) Bypass

- To prepare topographic map: Used in design of Kampong Chhnang and Odongk bypasses

7.2.2 Contents

The topographical survey consists of the following parts.

Table 7.2-1 Summary of Contents

Section	Description	Quantities
Existing Road (NR-5)	Altitude of road surface at road center at interval 1 km	L=139 km
	Longitudinal and cross section surveys at bridge locations	4 no.
	Road centerline, longitudinal, cross section and topographical survey from KP32 to KP37	L=5 km
Kampong Chhnang Bypass	Road centerline, longitudinal, cross section and topographical survey at bypass route	L=12 km
	Longitudinal and cross section survey at bridge location	1 no.
Odongk Bypass	Road centerline, longitudinal, cross section and topographical survey at bypass route	L=4.9 km

7.2.3 Landmine Clearance

The landmine clearance has been 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 2 bypass routes 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 phase II started from January, 2013.

7.2.4 Detail and Output

Details and output of the topographical survey are shown in Tables 7.2-2 to 7.2-7.

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

Table 7.2-2 Survey Item for NR 5

Survey Item	Description
Control Point Setting	Setting Control Points approximately 5 km interval. Coordination and Elevation should be provided.
Longitudinal Survey	Longitudinal survey along center line by leveling, 1 km interval and changing points shall be surveyed. Each Control Points shall be confirmed by longitudinal survey.

Table 7.2-3 Output of the Survey for NR 5

Item	Description
Longitudinal Section	Scale: Horizontal 1/10,000, Vertical 1/100. Water level of river/canal shall be indicated.

(2) Topographical survey for Kampong Chhnang and Odongk bypass routes and the section from KP 32 to KP37 along NR-5 (Road Section).

Table 7.2-4 Survey Item and Output for Road Section

Survey Item	Description
Control Point Setting	Setting Control Points approximately 2 km interval. Coordination and elevation should be provided. 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 20 m interval, IP, BC, EC shall be set out.
Longitudinal Survey	Longitudinal survey along center line, 20 m interval and changing points shall be surveyed.
Cross Section Survey	Cross section survey interval 20 m, changing points within 30 m both side of road shall be surveyed
Peg Installations	Peg installations at bypass route, interval 20 m on the centerline, and 20 m both side 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 both side of road

Table 7.2-5 Output of the Survey for Road Section

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

(3) Topographical survey for bridge section at NR-5 and Kampong Chhnang bypass (Bridge Section)

Table 7.2-6 Survey Item for Bridge Section

Survey Item	Description
Longitudinal Survey	Longitudinal survey along center line, 10 m interval and changing points shall be surveyed. Within 50 m from center of bridge both side to be surveyed
Cross Section Survey	Cross section survey interval 10 m within 50 m both side from center of bridge along the road, changing points within 50 m both side of centerline shall be surveyed
Mapping	Survey houses, culverts, trees, objects and terrain within 50 m both side of road. Elevation of bore hole for soil investigation shall be surveyed.

Table 7.2-7 Output of the Survey for Bridge Section

Item	Description
Road Plan	Scale: 1/250. Contour Line 1 m each.
Longitudinal Section	Scale: 1/250. High Water level shall be indicated.
Cross Section	Scale: 1/200. Fence, house, canal etc shall be drawn.

7.2.5 Result of Survey

The results of the topographical survey are summarized below:

(1) Altitude of road surface survey for exiting road (NR-5)

There are not exact bench marks (BM) in Cambodia. Therefore, the Study Team checked 2 BMs along NR-5. One (1) of two (2) BMs is installed by Ministry of Water Resource and Metrology and the other one is installed by Mekong River Commission. But there is a difference of 1.5 m between both BMs. In this case, the Study Team adopted a low elevation BM to design the formation height because of the relation between road elevation and water flood level.

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

- ✓ KP39+800~KP42+200
- ✓ KP48+800~KP50+200
- ✓ KP55+500~KP56+500
- ✓ KP69+400~KP71+200
- ✓ KP104+800~KP107+200
- ✓ KP125+600~KP128+600
- ✓ KP133+600~KP135+400
- ✓ KP136+800~KP137+400

According to sub-clause 7.1.2, water level of Tonle Sap River is in the range of 10.34 m to 10.87 m. The topographical surveys data are shown in Figure 7.1-6 (1) and (2).

7.3 Geotechnical Investigation and Test Pitting for Confirmation of Utilities

Geotechnical Investigations were conducted for the following objectives;

i) To obtain the foundation conditions needed for the design of bridges

ii) To know the location of underground installed utilities such as water pipe along NR-5

Table 7.3-1 Objectives and Kinds of Soil Tests

Objectives	Kinds of Soil Test
Foundation Condition for Bridges	SPT, Physical Properties of Soil
Confirmation of Utilities	Test Pitting

7.3.1 Geotechnical Investigation for Bridges

A total of twelve (12) standard penetration test (SPT) borings were performed in the study area and also is planning in Kampong Chhnang Bypass route. The purpose of this geotechnical investigation is to provide soil data for preparing plans and specifications for the bridge foundations.

7.3.2 Geotechnical Characterization of the Study Area

The soil of Cambodia consists of decomposition of acidic soil and basic country rock, an alluvial thing of these deposition, ancient times, and modern times, etc. Geology of the study area is mostly a recent alluvium and pyroxene-hornfels and post Triassic granite are seen at a few spots.

(1) Boring Data

NR-5 (South Section) Project is running the southwest side of Tonle Sap River. Summary of borehole result is shown in Table 7.3-2.

Table 7.3-2 Summary of Borehole Result

Province	BH No	Bridge/River	KP (km)	No of Boreholes	Depth (m)	N-Value (Blows 30 cm)	Location
Kampong Chhnang	BH-1	Br.06	40.0	1	11.00 to 15.45	51 to 50	R 7.90 m
	BH-2	Br.10	42.0	1	13.00 to 18.45	56 to 50	R 6.00 m
	BH-3	Br.13	49.7	1	18.00 to 22.45	50	R 6.20 m
	BH-4	Br.16	67.8	1	16.00 to 19.45	50	R 6.20 m
	BH-5	Br.18	82.4	1	20.00 to 20.45	50	L 6.40 m
	BH-6	Br.22	106.2	1	20.00 to 20.45	50	R 5.30 m
	BH-7	Br.24	113.5	1	19.00 to 20.45	50 to 50	L 6.48 m
Pursat	BH-8	Br.28	135.9	1	22.00 to 25.45	71 to 49	R 4.00 m
	BH-9	Br.34	150.2	1	23.00 to 25.45	52 to 51	L 3.10 m
	BH-10	Br.36	153.5	1	22.00 to 25.45	41 to 46	R 6.00 m
	BH-11	Br.38	170.2	1	23.00 to 25.45	66 to 50	R 6.70 m
Kampong Chhnang Bypass	BH-12	Chrey Bak River	(1.1)*1	1	14.45 to 16.45	50	L Side
Total No of Bore holes				12			
Total Length of Borings				255.40 m			

**1: KP of Bypass Route*

The result of the investigation is summarized below:

Soil conditions comprise sediments of alluvial. The sediments at these locations typically comprise lean clay and clayey sand. The bearing layer is encountered at depths ranging from 10 m at KP 40 to as deep as 25 m at KP 170, further south towards the Phnom Penh from KP 40 to KP 106 is encountered the clay stone bedrock.

(2) Laboratory Test

The soil samples retrieved from soil borings were tested in accordance with ASTM Standard methods to determine the strength, classifications and compressibility of the soil. The laboratory-testing were as following items:

- Natural water content determination ASTM D-2216,
- Atterberg limit ASTM D-4318,

- Specific Gravity of Soil ASTM D-854 and ASTM C-128,
- Sieve Analysis ASTM D-421 and ASTM D-422,
- Wet Unit weight. Dry Unit weight
- Soil Classification ASTM D-2488.
- Unconfined compressive strength

7.3.3 Utilities

Various kinds of pre-existing utility traversed or paralleled the NR-5 in the widening areas. These utilities consisted of electric power lines, optic fiber cables, water supply pipes, and drainage facilities, all of which needed to remain in-service during construction. The rough amount of the major existing utilities which are identified within the study area is shown in Figure 7.3-1 and Table 7.3-3.

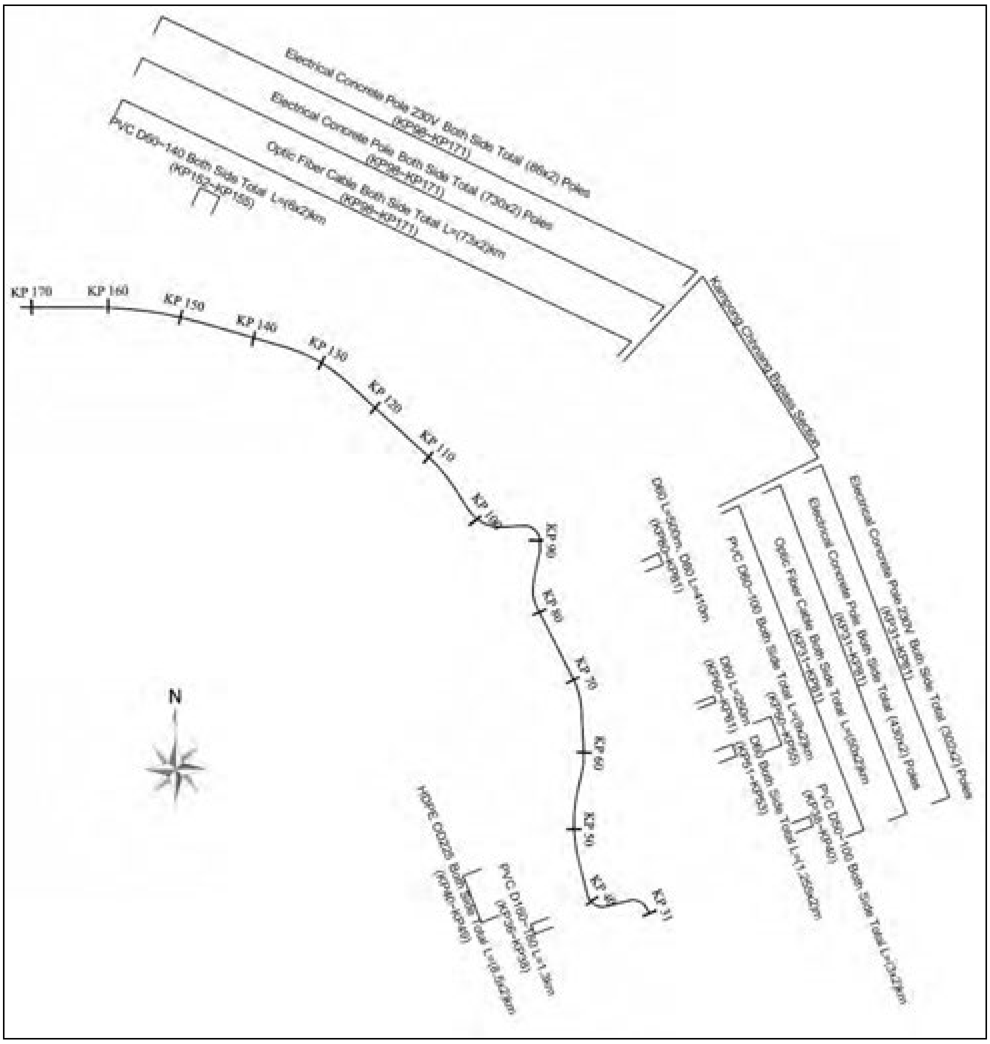


Figure 7.3-1 Existing Utilities

Table 7.3-3 Major Utility within the Study Area

Type of utility		Location	Side	From centerline	Q`ty	Owner/ Operator
1.Electricity						
Electrical concrete pole	230 kV	KP31 – KP81	L, R	15-20 m	302 no	*EDC
Electrical concrete pole (under construction)	230 kV	KP98 – KP171	L, R	15-20 m	86 no	EDC
2. Telecommunication						
Electrical concrete pole		KP31 – KP81	L, R	15 m	430 no	Metfone
Electrical concrete pole		KP98 – KP171	L, R	15 m	730 no	Metfone
Optic fiber cable		KP31 – KP81	R	5-10 m	50 km	**Telecom
Optic fiber cable		KP98 – KP171	R	5-10 m	73 km	Telecom
Optic fiber cable		KP31 – KP81	L	15-30 m	50 km	***CFO
Optic fiber cable		KP98 – KP171	L	15-30 m	73 km	CFO
3. Water supply						
PVC pipe	D160-180	KP36 – KP38	L	7-10 m	1.3 km	Private
PVC pipe	D60-100	KP38 – KP40	L, R	7-10 m	3.0 km	Private
HDPE pipe (under construction)	OD225	KP40 – KP49	R	15-20 m	8.5 km	Private
HDPE pipe (in the planning)	OD225	KP40 – KP49	L		8.5 km	Private
PVC pipe	D60-100	KP50 – KP55	L, R	10-15 m	9.0 km	Private
PVC pipe	D90-140	KP152 – KP155	L, R	12 m	6.0 km	Private
4. Drainage						
Concrete pipe	D60	KP51 – KP53	L, R	12 m	1,255 m	MPWT
Concrete pipe	D60	KP60 – KP61	R	12 m	250 m	MPWT
Concrete pipe	D60	KP80 – KP81	R	12 m	500 m	MPWT
Concrete pipe	D80	KP80 – KP81	R	12 m	410 m	MPWT
U-shape drain	U-0.6*0.5	KP81 – KP90	L		202 m	MPWT
U-shape drain	U-0.4*0.6	KP90 – KP91	L		108 m	MPWT
U-shape drain	U-0.8*0.8	KP90 – KP91	R		112 m	MPWT

** EDC: Electricite Du Cambodge*
***Telecom: Telecom Cambodia*
****CFO: Cambodia Fiber Optic Communication Network*

7.3.4 Test Pitting

Test pitting was carried out at 9 locations with the shape 1.0 m by 0.5 m and 1.5 m in depth. The Study Team also has done an interview with neighborhood residents along NR-5 about the utilities. The survey results of test pitting are shown in Table 7.3-4.

Table 7.3-4 Summary of Test Pitting

#	Location (Side)	Water Pipe( ) Depth (mm)	Optical Cable Depth (mm)	Dist. from Road Center (mm) *Up: Water Pipe Down: Optical Cable	Remark
No.1	KP38+010 (Mountain)	✓ (∅ 50) 300	-	7,700 -	
No.2	KP39+007 (Mountain)	✓ (∅ 60) 450	-	7,800 -	Beam (200 mm*450 mm)
No.3	KP39+005 (Tonle Sap)	✓ (∅ 50) 300	✓ 1,200	6,300 6,900	
No.4	KP39+600 (Tonle Sap)	✓ (∅ 50)*2 300	-	7,600 -	
No.5	KP39+600 (Mountain)	-	-	-	
No.6	KP53+010 (Mountain)	-	✓ 1,200	- 8,200	
No.7	KP53+010 (Tonle Sap)		✓ 1,100	- 5,400	
No.8	KP154+000 (Mountain)	✓ (∅ 60) 300	-	13,600 -	
No.9	KP154+000 (Tonle Sap)	-	-	-	

CHAPTER 8 PROBLEMS OF EXISTING ROAD CONDITION AND GENERAL SHCEME OF IMPROVEMENT

8.1 Problems of Existing Road Condition of South Section of NR 5

Based on the results of various surveys as cited above, the problems of current South Section of NR 5 can be summarized as below:

(1) Insufficient road width

- The width of existing pavement is 7.7 – 9.8 m. In view of the fact that the widths of Motorumocks or small agriculture tractors are 1.2 - 1.5 m, 9.8 m-wide pavement cannot provide with sufficient space for these slow vehicles, if central part of 3.5 m wide is used as the travel lane for 4 wheel vehicles.
- Forecasted traffic demand in 2030 on the section between Prek Kdam and Kampong Chhnang City exceeds 20,000 pcu/day.
- Thus, widening to 4 lanes will become necessary before year 2030.

(2) Weak pavement structure

- Existing pavement is DBST. Because of small bearing capacity of DBST, severe damages occur every year, especially after flood/inundation season.
- Because of potholes and other defects, vehicles are forced to slowdown. This is causing great economic loss.
- MPWT are spending considerable amount of fund in repair of damaged pavement every year. This is an avoidable financial burden to the Royal Government of Cambodia.
- Thus, improvement of pavement to asphalt concrete (AC) is needed.

(3) Vulnerability to inundation/flood

- Every year, many sections are inundated or flooded.
- Traffic is forced to slow down or stop due to inundation/flood, resulting in economic loss.
- Flood/inundation water reduces the bearing capacity of pavement structure, resulting in damages in pavement.

(4) Passing through Urbanized Areas

- Existing NR 5 is passing through many cities and towns, such as Kampong Chhnang and Odongk.
- This is not desirable not only from viewpoint of traffic congestion but also from viewpoint of traffic accident and air pollution.

Considering these problems, general scheme of the improvement of the South Section of NR 5 is proposed as presented in the following section:

8.2 General Scheme of Improvement of South Section

The scheme of improvement of South 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 proposal by the Survey Team to be used as the base for discussion between RGC and JICA:

8.2.1 Widening

It is proposed that the existing NR 5 is widened into 4 lanes considering the following facts:

(1) Traffic volume against capacity

In the Survey of the North Section, the Survey Team estimated the capacity of “opposed 2-lane with MC lanes” road to be around 24,000 pcu/day. (Please note that this ‘capacity’ is the capacity for smooth traffic flow.)

Later, the Survey Team obtained the traffic volume data observed on National Road No. 1 (NR 1) as shown in Table 8.2-1. The section of NR 1 from 0 km to 5 km has not been improved yet while the section from 5 km to Neak Loueng has been already widened to 2 lanes plus MC lanes. Thus, the traffic condition at 12 km + 500 is considered to indicate traffic condition of a ‘2-lane with MC lane’ road.

Table 8.2-1 Traffic Volume on National Road No. 1

Location		Traffic Volume (pcu/12hr.)	
Distance from Monivong Br.	Description of Roadside Area	Jul 2007	Sep 2011
1 km + 500	Urbanized area connected to Monivong Bridge	14,109	20,995
3 km + 500	Suburban area adjacent to the urbanized area	12,804	18,467
12 km + 500	Rural area near Kokir Market	7,793	11,596 (11,249)*

**Traffic volume at 12 km + 500 was estimated by multiplying [Traffic Volume at 1 km + 500] of Year 2011 by the ratio of [Traffic Volume at 12 km + 500] / [Traffic Volume at 1 km + 500] of Year 2007. Traffic volume of Year 2011 in parenthesis was estimated by using the ration of [Traffic Volume at 12 km + 500] / [Traffic Volume at 3 km + 500]*

Present traffic flow at point [12 km + 500] is reasonably smooth and can be considered to represent the boundary between ‘Level of Service (LOS) B’ and ‘LOS C’ designated in Highway Capacity Manual (HCM) 2000 of USA. Traffic volume/capacity ratio of the boundary between ‘LOS B’ and ‘LOS C’ is 0.44 (Free Flow Speed : 80 km/h). Thus, volume/capacity ratio at [12 km + 500] of NR 1 can be assumed to be around 0.5.

The actual traffic volume at [12 km + 500] in Year 2011 was not measured, and, thus, was estimated by multiplying [Traffic Volume at 1 km + 500] of Year 2011 by the ratio of [Traffic Volume at 12 km + 500] / [Traffic Volume at 1 km + 500] of Year 2007. The traffic volume of Year 2011 in parenthesis was estimated by using the ration of [Traffic Volume at 12 km + 500] / [Traffic Volume at 3 km + 500]. From this estimation, it can be assumed that the traffic volume at [12 km + 500] in Year 2011 is about 11,500 pcu.

	
Level of Service D: Traffic is flowing but speed is substantially lowered and traffic jam can occur if traffic volume increase a little.	**Level of Service C**: Traffic is flowing fairly smoothly although fast-going vehicle need to wait before passing slow-going vehicle.

Figure 8.2-1   Level of Service of Current Traffic on National Road No. 1

Considering the traffic volume/capacity ratio at ‘LOS C’ as described above, the capacity at [12 km + 500] can be estimated as follows:

11,500 / 0.5 = 23,000 (pcu/12 hr)

Using the ratio of [24 hr traffic volume / 12 hr traffic volume] observed in the North Section, the capacity for 24 hours can be estimated as;

23,000 x 1.28 = 29,440 (pcu/day) (rounded to 29,500 pcu/day.

This is an absolute capacity of a ‘2-lane with MC lane’ road. When traffic volume reach to this figure, severe traffic jam will occur. Adopting this absolute capacity, the traffic volume which allows reasonably smooth traffic flow is estimated as follows:

29,500 x 0.64 (upper limit for Level of Service C) = 18,890 pcu/day

Thus, based on the traffic volume and smoothness of traffic flow observed on the section of NR 1 with the cross section consisting of 2-lane with MC lanes, it is recommended to use 19,000 pcu/day as the practical capacity of ‘2-lane with MC lanes’ cross section.

The estimated traffic volume on Section I in year 2030 varies from about 20,000 pcu/day at the provincial boundary between Kampong Chhnang and Pursat to about 22,800 pcu/day in the north of Kampong Chhnang City, and more than 30,000 pcu/day at Prek Kdam. These figures exceed the practical capacity of ‘2-lane with MC lanes’ cross section as explained above.

(2)   Role of NR 5 and Modern Logistics

As discussed in Chapter 3, NR 5 is given a very important role in the road network of both Cambodia and GMS. Not only NR 5, NR 1 and NR 4 needs to be widened to 4-lane considering that these highways are vital to logistic system of Cambodia. Modern logistics require reliable transportation which can transport goods in the planned time. A ‘2-lane with MC lanes’ road 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 traffic accident occurs and one lane is blocked. Contrary, in case of full 4-lane, traffic can be operated even if one lane is blocked, by effectively utilizing remaining 3 lanes and shoulder. Thus, from this viewpoint, it is recommended that the whole section of NR 5 be widened to 4-lane.

(3) 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 case of the South Section, estimated traffic volume (20,000 pcu/day or more) is similar to that on the North Section which has been planned as 4-lane road. In addition, the section between Phnom Penh and Prek Kdam is being widened to 4 lanes. From viewpoint of consistency of road design standard, 4-lane cross section is recommended.

(4) Traffic Safety

Traffic safety is another aspect that needs to be considered in planning of arterial highways. Accident rate of NR 5 is the highest among the single-digit national highways. As stated in Section 4.8, NR 5 is the most hazardous single-digit national road. One of the cause of the accidents is overtaking. Widening to 4 lanes is expected to separate slow traffic and fast traffic, and thus, reduce the necessity of overtaking.

From viewpoint of traffic safety, it is proposed that traffics of opposed directions are separated. For this purpose, 3 m-wide median division with raised structure is proposed. This type of median division is in conformity with the criteria of Class 1 Road of ASEAN Highway Network.

For the reasons as sited above, it is proposed to widen the existing NR 5 into 4 lanes with 3 m-wide median division. Figure 8.2-2 shows the proposed typical cross sections of NR 5. The cross section will be discussed more in detail in Chapter 10.

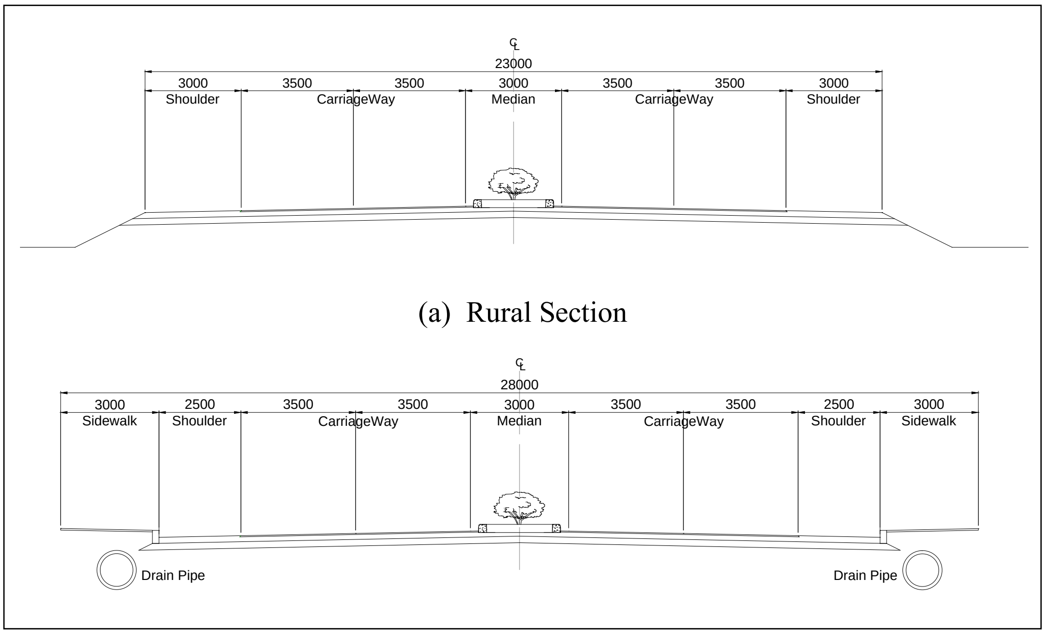


Figure 8.2-2 Proposed Typical Cross Section (4 Lanes)

8.2.2 Improvement of Pavement

The pavement of existing NR 5 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 asphalt concrete (AC). For these reasons, it is proposed to improve pavement type into AC. Detailed discussion on the structure of the pave is discussed in Chapter 9.

8.2.3 Countermeasure Against Flood/Inundation

To reduce or eliminate the frequent inundation on NR 5, the mechanism of the inundation needs to be understood. Three major mechanism of inundation are suspected:

- Flood water from the Tonle Sap Lake/River exceeds the road surface
- Dam up of the runoff of the rain water falling in the watershed along NR 5
- Rain water falling on the land adjacent to NR 5 where the ground level is close to or higher than that of surface of NR 5.

Main countermeasures to these causes are as follows:

- Raise road surface
- Increase the capacity of cross drainage (bridge and culverts)
- Provide new side ditch or strengthen the existing side ditch

Level of flood water of Tole Sap Lake/River has been analyzed as explained in Chapter 7. Insufficient capacity of cross drainage is also discussed in Chapter 7. In sufficient height of road surface relative to the adjacent land and/or defects of side ditches were identified through the site surveys. The proposed countermeasures for inundation are discussed in Chapter 10 Highway Design.

8.3 Plan of Kampong Chhnang and Odongk Bypasses

While the existing NR 5 is passing through many cities and towns, there are two sections where construction of bypass is proposed; Kampong Chhnang and Odongk. These bypasses are proposed (i) to avoid large scale resettlement which becomes necessary if the exiting NR 5 is to be widened, and (ii) to reduce/mitigate the traffic accidents and pollutions which are caused by through traffic passing through the urbanized area of the city/town.

(1) Route of Kampong Chhnang Bypass

The City of Kampong Chhnang is one of the major cities along NR 5, comparable to Battambang, Pursat and Sri Sophorn. The existing NR 5 becomes narrow and ‘bent’ when it passes the urbanized area of Kampong Chhnang. Widening of this section will necessitate resettlement of many houses/families. Even if widening can be done, there will still remain many locations where the alignment of existing NR 5 is bent, since NR 5 is a part of the urban street network. Thus, construction of bypass is more realistic and effective solution to the existing problems. Construction of Kampong Chhnang Bypass was proposed also in Road Network Master Plan of 2006.

(a) Preliminary Study of Alternative Routes

The alternative routes of Kampong Chhnang Bypass was preliminary studied in the Survey for the North Section.

DPWT of Kampong Chhnang Province had plans of three preliminary alternative routes shown as DPWT-1 to DPWT-3 in Figure 8.3-1. These routes are to widen the existing roads.

The JICA Survey Team proposed one alternative route shown as JICA-1 in Figure 8.3-1. JICA-1 is to construct a new road in the suburbs of Kampong Chhnang City. The main purposes of this route are;

- ➢ To avoid resettlement which becomes necessary if the existing road is to be widened as the case in the alternatives proposed by the DPWT,
- ➢ to avoid the urbanization of the roadside area in the future and secure the function of bypass, and
- ➢ secure sufficient space between the hemisphere of the existing urbanize area to allow future expansion of the urbanized area.

Also, shortening of the travel distance of through traffic is a important advantage of JICA-1 route.

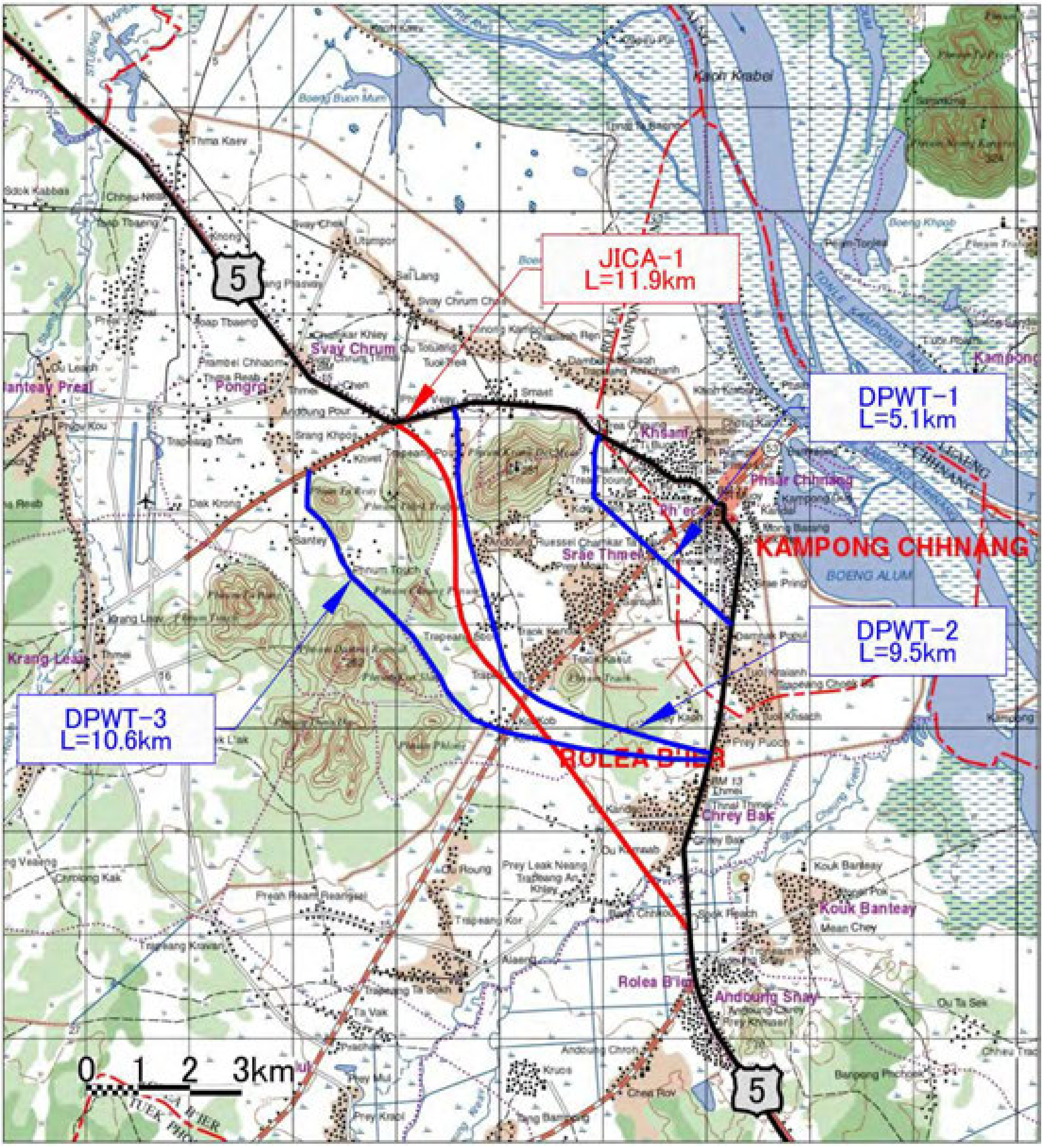


Figure 8.3-1 Alternative Routes of Kampong Chhnang Bypass

The advantages and disadvantages of these alternatives are compared in Table 8.3-1. As the result of comparative evaluation of these alternative routes, JICA-1 route was recommended by the JICA Team. After consultation among MPWT, DPWT of Kampong Chhnang Province and the JICA Team,

Table 8.3-1 Comparison of Alternatives of Kampong Chhnang Bypass

Alternatives		Alt-2: Bypass Construction			
		DPWT – 1 Route (L=4.9 km)	DPWT – 2 Route (L=9.6 km)	DPWT – 3 Ropute (L=10.6 km)	JICA- 1 Route (L=12.1 km)
Social Impact	Resettlement of Households/Houses	Many households/houses need to be relocated since the road to be widened is passing through an urbanized area.	Number of households/houses which needs to be relocated is less than that in DPWT-1 Route, since the road to be widened is located in the suburbs. Still considerable number of households/houses need to be relocated.	The road to be widened is located further away from the urbanized area of the city. Thus, the number of households/houses which need to be relocated is less than that in DPWT-2 Route.	Less than 10 houses need to be relocated at and near the intersection with the existing NR 5 in the north. Thus, the number of houses to be relocated is much less than those in DPWT Routes.
	Land Acquisition	Acquisition of additional land is necessary for widening of the existing road. In addition, acquisition of whole ROW is necessary for the section from the intersection with NR 53 to east which is newly constructed.	Same as DPWT-1 Route, in general. The area to be newly acquired becomes larger than in DPWT-1 Route since the length of newly constructed section is longer than in DPWT-1 Route.	Same as DPWT-1/DPWT-2 Routes. The area to be newly acquired becomes further larger than in DPWT-2 Route since the length of newly constructed section is longer than in DPWT-2 Route.	ROW over whole section length and whole road width needs to be newly acquired. Loss of agricultural land becomes larger than in other alternative routes.
	Acceptance by the Affected People	People living in the roadside lands usually welcome improvement of the road in front of their property (land) because of such reasons as improvement of quality of life (easier access to public services, reduction in dust and easier access to market etc) and increase in value of the land. Thus, improvement and/or widening of the suburban road is usually well accepted by the affected people.	Same as in DPWT-1 Route.	Same as in DPWT-1 Route.	Owner of the properties along the Bypass welcome construction of the Bypass because of such reasons as improvement of quality of life (easier access to public services, reduction in dust and easier access to market etc) and increase in value of the land.
Pollution/Living Environment	Noise, Vibration, Air Pollution	Through traffic is expected to divert to the Bypass. However, this will simply divert or distribute the source of noise, vibration and air pollution to the Bypass and not reduce them in total.	Through traffic will divert to the Bypass in the suburban area whose roadside is less populated, and noise, vibration and air pollution in the city center will decrease.	Through traffic will divert to the Bypass in the suburban area whose roadside is less populated, and noise, vibration and air pollution in the city center will decrease.	Through traffic will divert to the Bypass in the suburban area whose roadside is sparsely populated, and noise, vibration and air pollution in the urbanized area will decrease.
	Traffic Accident	Risks of traffic accident are	While traffic volume passing	While traffic volume passing	While traffic volume passing

Alternatives	Alt-2: Bypass Construction			
	DPWT – 1 Route (L=4.9 km)	DPWT – 2 Route (L=9.6 km)	DPWT – 3 Ropute (L=10.6 km)	JICA- 1 Route (L=12.1 km)
	expected to decrease since the road is traversing less-densely populated suburban area. However, the Bypass passes through residential area and degree of decrease in traffic accident is less than that in JICA-1 Route.	through the city center and traffic accident will decrease, there will be newly created risks of accidents on the Bypass. Total number of traffic accident is expected to decrease since the safety environment of the Bypass is more favorable than that of existing NR 5 in the city center.	through the city center and traffic accident will decrease, there will be newly created chances of accidents on the Bypass. Total number of traffic accident is expected to decrease since the safety environment of the Bypass is more favorable than that of existing NR 5 in the city center.	through the city center and traffic accident will decrease, there will be newly created risks of accidents on the Bypass. Total number of traffic accident is expected to decrease since the safety environment of the Bypass is more favorable than that of existing NR 5 in the city center.
Natural Environment/ Ecology	The section from the intersection with NR 53 to east which is newly constructed in the land which is mainly use for agriculture. This may cause interruption or separation of activity areas of biology.	The section from the intersection with NR 53 to east which is newly constructed in the land which is mainly use for agriculture. This may cause interruption or separation of activity areas of the biology.	The section from the intersection with NR 53 to east which is newly constructed in the land which is mainly use for agriculture. This may cause interruption or separation of activity areas of the biology.	The newly constructed Bypass may interrupt/separate the activity areas of the biology.
Road Function/Traffic Function	The proposed route traverses the periphery of existing urbanized area. Thus, it provides easier access to/from the city center. On the other hand, roadside area of the Bypass will be urbanized and the function as bypass may be lost in the near future.	The route is sufficiently away from the existing urbanized area and it is expected that the Bypass maintain the function of bypass for long future.	The Bypass utilizes the access road to Kampong Chhnang Airport. As a result the travel distance becomes longer than that in the existing NR 5.	Diversion of through traffic is fully attained. This is essential function of a bypass. The route is sufficiently away from the exiting urbanized area and it is expected that the Bypass maintain the function of bypass for long future. Further, the proposed route short-cut the existing NR 5 and travel distance is reduced.
Cost	Lowest next to Alt-1.	Larger than DPWT-1 and smaller than DPWT-2.	Largest among the DPWT Routes.	Larger than DPWT Routes because the length of the Bypass is longer than in DPWT Routes.
Overall Evaluation	**× Not recommended**	**× Not recommended**	**× Not recommended**	**◎ Recommended**

(b) Further Adjustment of the Agreed Route

After the Survey for the South Section started, the JICA Survey Team further reviewed this agreed route based on what were observed in the site survey and adjusted the route. Figure 8.3-2 shows the adjusted route of Kampong Chhnang Bypass. Main points of adjustment are as follows:

(i) Moved the intersection with the existing NR 5 in the south of Kampong Chhnang City to the north by about 1 km to secure a distance from the town of Rolea Bi'er.

(ii) Adjust the horizontal alignment of bypass near the above-mentioned intersection for smooth connection to NR 5.

(iii) Shift the horizontal alignment of bypass on the both side of the intersection with NR 53 to make the crossing angle as close as possible to 90 degree.

(iv) Shift the route at about 1.7 km south of the intersection with NR 5 in the northwest of Kampong Chhnang City to westwards by about 300 m to avoid the reservoir.

The adjusted route has been discussed with MPWT and DPWT, and was shown in the 1st Stakeholder Meeting held on 6 December 201. All the consulted parties supported the adjusted route.

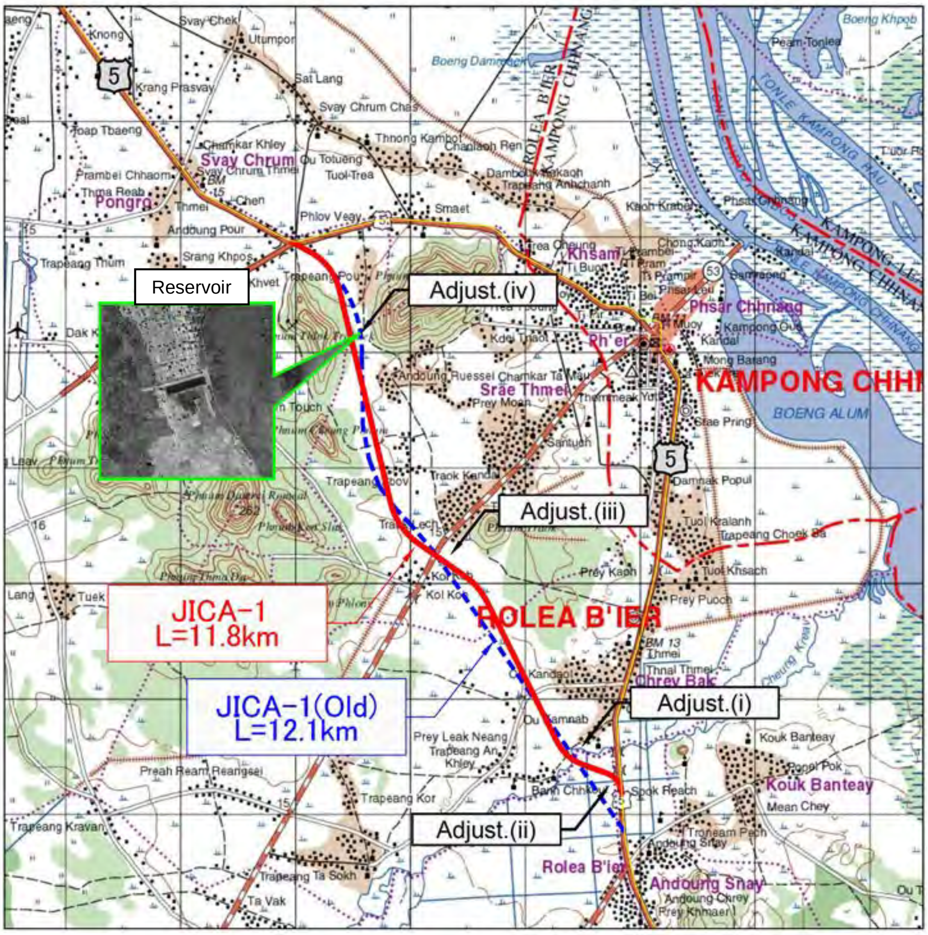


Figure 8.3-2 Adjusted Route of Kampong Chhnang Bypass

(2) Route of Odongk Bypass

Construction of Odongk Bypass was proposed by MPWT in the 1st Steering Committee held on 25 September 2012 to avoid large scale resettlement which becomes necessary if the existing NR 5 in the town of Odongk is to be widened. However, full site survey was not possible until late November because the many places on the possible alternative routes were covered by the flood water and could not be seen. The Survey Team conducted the first full site survey on 29 November 2012. By that time, most of the flood water had receded but many places were still covered by water. Thus, site survey became possible only in December 2012.

(a) Initial Study of Alternative Routes

Initially, several alternative routes as shown in the satellite image (Figure 8.3-3) were studied. These alternative routes were evaluated considering traffic function (shortening of travel distance/time and connection to important roads), extent of reduction in resettlement, easiness/difficulty of land acquisition, construction cost including protection against flood water and other technical aspects. Table 8.3-2 shows comparison of the initially proposed alternative routes. Special attention was paid to the following factors which are unique to Odongk Bypass:

(i) Historical heritage

One of the main concerns at this stage was historical heritage. Since the alternative routes traversing the southern side of the existing urbanized area pass near Phnom Odongk, old capital of Cambodia before Phnom Penh, possibility of encountering historical heritage is considered to be high, compared to the alternatives traversing the northern side of the urbanized area. Alternative-8 was planned to pass the southern area of Phnom Odongk to reduce the possibility of encountering historical heritage related to Phnom Odongk.

(ii) Connection to NR 51

The alternative routes passing the southern side of Odongk Town are directly connected to NR 51 which extends to NR 4 in the west of Phnom Penh. Thus these alternatives will contribute to establish a smooth transportation route of Thai border – Battambang - NR 51 - NR 4 – Sihanouk Ville without passing through congested Phnom Penh and its suburbs. Thus, these alternatives are very attractive from view point of nation-wide transport.

(iii) Flood

During the flood season, the area surrounding Odongk Town is flooded. Construction of highway embankment in flooded area need certain consideration in highway design, such as slope protection and soft ground treatment, some additional construction cost and adjustment of execution schedule of civil works. Thus, the length of section to be constructed in the flooded area should be as short as possible.

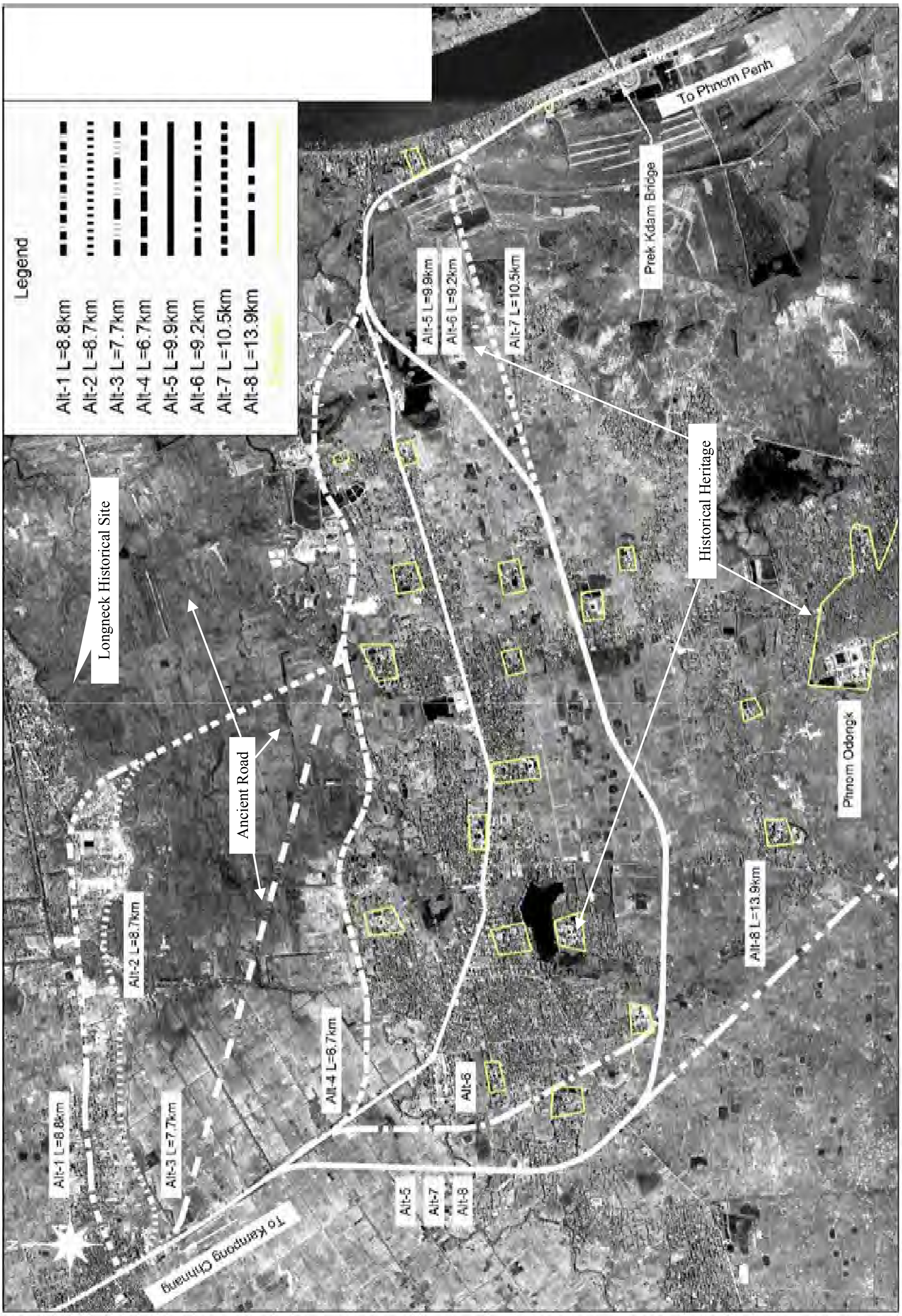


Figure 8.3-3 Alternative Routes of Odongk Bypass Initially Studied

Table 8.3-2 Comparison of Alternative Routes in Initial Study

Alternative		Traffic/Road Function	Length (km)	Land Acquisition/Relocation	Historical Heritage	Others
North of Odongk Town	Alt-1	・ North end section passes through town of Phsar Trach. Thus function as bypass is reduced. (D)	8.8	・ Considerable number of houses need to be relocated. (D)	・ Away from Phnom Odongk (A)	・ Considerable section needs to be constructed in flooded area (D)
	Alt-2	・ Does not pass urbanized area. (A) ・ Horizontal alignment is not smooth.	8.7	・ Large scale relocation is not required.		
	Alt-3	・ Does not pass urbanized area. (A) ・ Travel distance becomes shorter compared with the existing NR 5. (A)	7.7			・ Almost entire section needs to be constructed in flooded area (D)
	Alt-4	・ Pass hemisphere of urbanized area. Road side area will be urbanized & function of bypass will be reduced in near future. ・ Horizontal alignment is not smooth.	6.7			
South of Odongk T.	Alt-6	・ Direct connection to NR 51 (A) ・ Passes west hemisphere of urbanized area. Road side area will be urbanized & function of bypass will be reduced in near future. ・ Travel distance becomes longer than existing NR 5. (D)	9.2	・ Large scale relocation is not required.	・ High possibility of encountering historical heritage due to closeness to Phnom Odongk. (D)	
	Alt-7	・ Direct connection to NR 51 (A)	10.5			・ About 2 km-long section is constructed in flooded area (D)
	Alt-8	Direct connection to NR 51 (A)	13.9		・ Lower possibility of encountering historical heritage	

D: Disadvantage (substantial one only) A: Advantage (substantial one only)

(b) Initial Screening

After the above evaluation and comparison, Alt-1, Alt-2 and Alt-8 were discarded for the following reasons:

- Alt-1 and Alt-2 were evaluated to be less attractive than other alternative routes (have no particular advantages) and were discarded.
- Further examination of Alt-4 was temporarily haltered because it is too close to the existing urbanized area. Thus the road side of this route will be urbanized soon and the function as a bypass will be substantially lost.
- Alt-8 was found to have the following serious disadvantages and discarded:
  - Length of the bypass becomes excessively long (13.9 km).
  - Location of southern connection point with the existing NR 5 becomes south of Prek Kdam Bridge where the NR 5 is being widened under Chinese financial assistance.

(c) Further Examination of Alternatives

As the result of the initial examination and screening as stated above, three alternatives (Alt-3, Alt-5 and Alt-6) remained. These alternative routes were modified based on the information obtained through site surveys and discussions with MPWT, as well as the advice of Japanese experts on historical heritage who are cooperating with the Ministry of Culture and Fine Art (MCFA). This process of studying the route of Onongk Bypass is described in detail in Appendix 8-1.

(d) Proposed Route of Odongk Bypass

After discussions between MPWT and the Survey Team, as well as site surveys, the route of Odongk Bypass is proposed as shown in Figure 8.3-4. The main reasons that this route is proposed are as summarized below:

- Minimum impact to historical heritage: The proposed route crosses two ancient roads connected the historical site of Longveaek at the locations close to their ends near the urbanized area. According to MCFA, this is acceptable from viewpoint of conservation of historical sites provided proper survey on cultural asset is conducted before construction works start.
- Small number of houses which need to be relocated: The proposed route is to detour the densely populated area of Ondongk Town. Thus, large number of relocation of houses is not foreseen. This is most important in planning bypass route.
- Minimum construction cost: Compared to the initially proposed alternative routes, the length of proposed route is short, and increase of construction cost, compared with that of widening of corresponding section of the existing NR 5 is small.

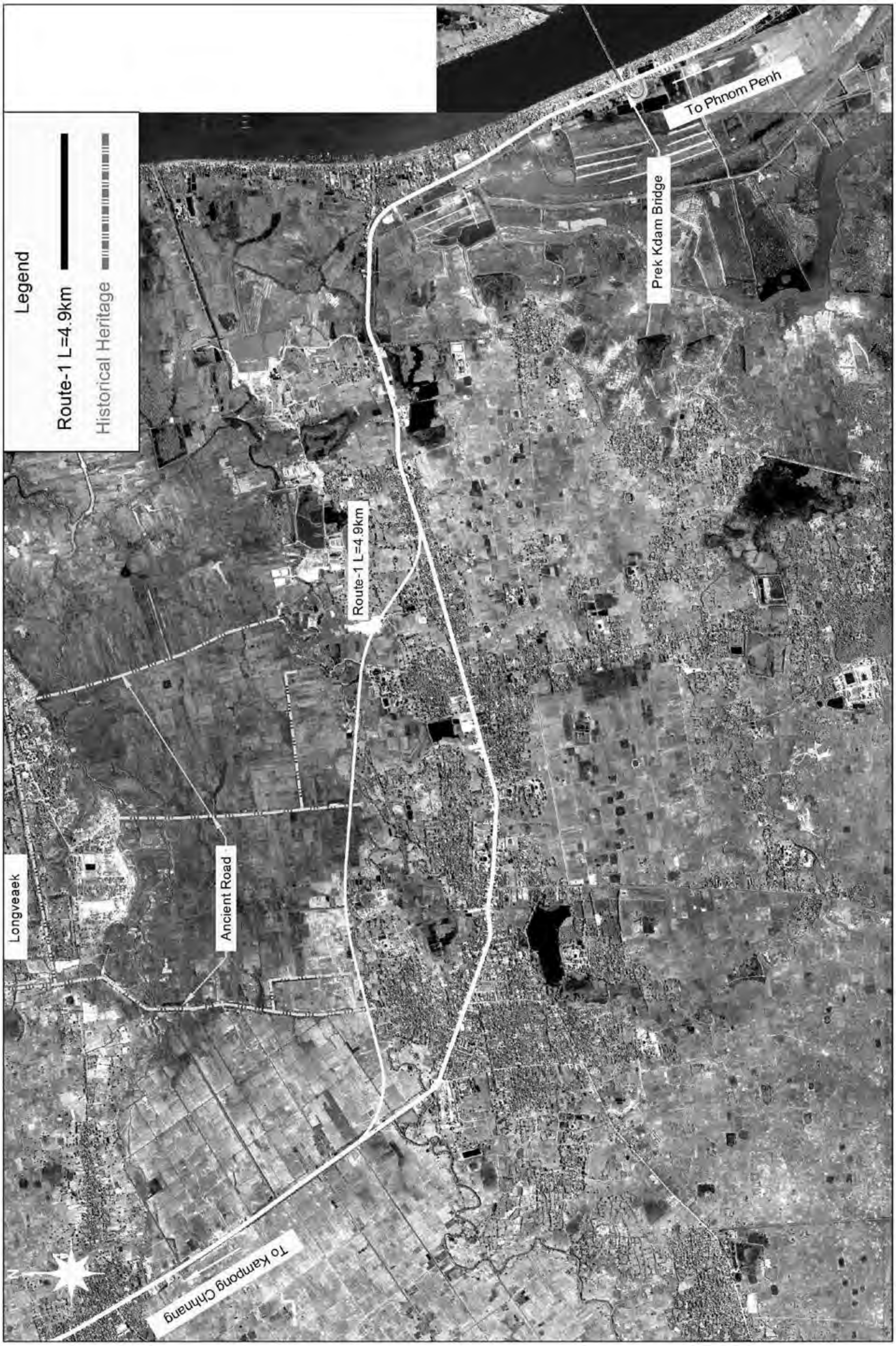


Figure 8.3-4 Proposed Route of Odongk Bypass

(e) Cost Implication

Construction cost of Odongk Bypass is one of the main factors in choosing between options of widening of the existing NR 5 or construction of the bypass. The estimated costs of bypass construction and widening of the existing NR 5 are compared in Tables 8.3-3 – 8.3-5:

Table 8.3-3 Comparison of Estimated Cost between Bypass and Widening of Existing NR 5

(US$ million)

Bypass Construction	Widening of NR 5	Difference
10.56	5.35	+5.31

Table 8.3-4 Comparison of Land Acquisition/Resettlement Cost

	Bypass Construction	Widening of Existing NR 5	Difference
Land Acquisition	176,000 sq. m US$ 0.775 million	None	
Resettlement/Relocation/ Other Allowance	20 main structures & some other structures US$ 0.65 million	272 AHs US$ 1.784 million	
Total	US$ 0.84 Million	US$ 1.78 million	US$ 0.94 million

Table 8.3-5 Comparison of Total Costs between Bypass and Widening of Existing NR 5

(US$ million)

Cost Item	Bypass Construction	Widening of Existing NR 5	Difference
Construction	10.56	5.35	+5.31
Land Acquisition & Resettlement	0.84	1.78	-0.94
Total Project Cost	11.40	7.13	+4.27

As for the total of construction cost and land acquisition/resettlement cost, bypass construction is larger by about US$ 4 million.

(f) Conclusion

It is proposed to construct Odongk Bypass, instead of widening the existing NR 5, considering the fact that

(i) the increase of project cost is estimated be within a acceptable range,

(ii) the negative social impact of resettlement for widening of existing NR 5 is considerably large,

(iii) long period and large effort are required for negotiation for resettlement, and considerable time is needed to actually relocate the houses, and

(iv) benefits of bypass construction (decrease in traffic congestion, traffic accidents and pollution in Odongk Town and smooth traffic on the bypass).

(3) Road Width of Bypass

As explained in Chapter 6 (Table 6.4-8 in P. 6-24), the traffic volumes on both of the two bypasses (if construction of bypass is opted at Odongk), in year 2030 are estimated to considerably exceed 20,000 pcu/day.

Table 8.3-6 Traffic Volume on Bypasses (Duplication of Table 6.4-1)

Area	Section	2012	2016	2021	2030
Kampong Chhnang	Bypass	6,232	10,472	13,819	22,220
	City Center (Survey Station No. 3)	6,625	8,753	11,226	17,238
Odongk	Bypass	9,100	13,822	18,181	21,380
	Center of Town	3,788	5,650	7,296	18,729

This estimation was made on assumption that the bypasses would be constructed in '2-lane with MC lane' cross section. In this estimation, it was assumed that bypasses are constructed as '2-lane with MC lane' cross section. Under such assumption, traffic was supposed flow into the city center (or center of town) because the traffic volumes on the bypasses are somewhat limited by the capacity of '2-lane with MC lane' road. Thus it is necessary to re-estimate the the traffic volume on the bypasses if the bypasses are constructed as 4-lane roads. Table 8.2-2 shows the result of re-estimation assuming that the bypasses are full 4-lane roads. As can be seen in the table, traffic volume on Odongk Bypasses is estimated to approach 30,000 pcu/day which justify construction of 4-lane bypasses. There is relative small change in traffic volume on Kampong Chhnang Bypass, but still it is more than 22,000 pcu/day which justify construction of 4-lane road.

Table 8.3-7 Re-Estimation of Traffic Volumes on Bypass

Area	Section	2012	2016	2021	2030
Kampong Chhnang	Bypass	6,232	10,472	13,819	22,354
	City Center (Survey Station No. 3)	6,625	8,753	11,226	17,104
Odongk	Bypass	9,100	13,822	18,181	28,917
	Center of Town	3,788	5,650	7,296	11,192

Considering the estimated traffic volume as discussed above, it is proposed that the two bypasses (Kampong Chhnang and Odongk) are constructed as 4-lane highway.

8.4 Section to be Improved

The South Section is divided into 5 sections as described below. Figure 8.4-1 shows the conceptual drawing of sections.

(a) Section I: Thlea Ma'am – Intersection of existing NR 5 and Kamopong Chhnang Bypass in the north of Kamopong Chhnang City

(b) Section II: Kampong Chhnang Bypass

(c) Section III: Intersection of existing NR 5 and Kampong Chhnang Bypass in the south of Kamopong Chhnang City

(d) Section IV: Town of Odongk (Selection of construction of bypass or widening of the existing NR 5 is to be made later)

(e) Section V: Odongk – Prek Kdam

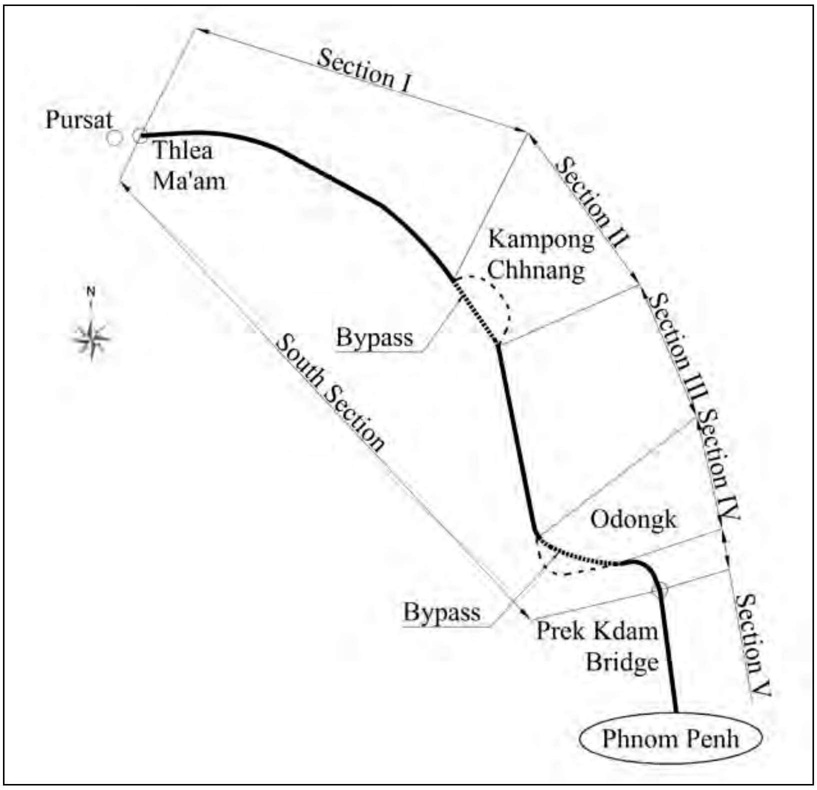


Figure 8.4-1 Section to be Improved

Sections I, III and V are proposed to be widened (into 4 lanes) as described in Subsection 8.2.2 below. Bypasses are proposed to be constructed around Kampong Chhinang and Odongk to avoid resettlement of large number of households/buildings.

However, option of Odongk Bypass may need further discussion between MPWT and MEF. The Survey Team has studied the possible alternative routes of the bypass on the satellite image, as well as at the site. The Survey Team also had discussions on the alternative routes with the relevant parties including MPWT, MEF and the Ministry of Culture and Fine Art (MCFA), and has come up with the recommendation as described in Subsection 8.2.4.

It is proposed that **the sections of existing NR 5 which will be parallel to the bypasses be excluded** in the sections to be improved following the precedent case of the North Section.

CHAPTER 9 HIGHWAY DESIGN

9.1 Highway Design of Improvement of Existing NR 5

9.1.1 Basic Design Policy and Design Criteria

Design of the North Section (Battambang – Serei Saophoan) of NR 5 was studied in the 'Preparatory Survey for National Road No.5 Rehabilitation Project' (hereinafter referred to as Survey on the North Section) conducted in 2011 – 12 and the preliminary design for the improvement of NR 5 and construction of two bypasses (Battambang Bp. and Serei Saophoan Bp.) was prepared. Since the South Section is another part of NR 5, the design policy for the South Section should be consistent with that of the North Section.

NR 5 is designated as Class I Road of Asian Highway Network. Thus, it is desirable to satisfy the design criteria of Asian Highway Class I Road. At the same time, NR 5 is an arterial national road of Cambodia and it needs to satisfy the Road Design Standard of Cambodia. Table 9.1-1 compares the design criteria of Asian Highway Class I and Road Design Standard of Cambodia. The table also shows the criteria recommended for the Project. These recommended criteria have been discussed and agreed between MPWT and JICA Team during the Survey of North section.

Table 9.1-1 Comparison of Design Speed and Criteria

Standard	Asian Highway	Cambodian Standard		Recommended	
Road Class	Class I	R5 (Rural)	U5 (Urban)	Rural	Urban
Design Speed	100 km/h (Flat)	100 km/h (flat)	50 km/h (type3)	100 km/h	50 km/h
Min. Curve Radius (Superelevation)	350 m (10%)	415 m (6%)	90 m (6%)	350 m (10%)	80 m (10%)

9.1.2 Recommended Cross-Sectional Composition

Table 9.1-2 compares the design criteria of cross-sectional composition.

Table 9.1-2 Comparison of Design Criteria

Items	Asian Highway	Cambodian Standard		Recommend
Road Class	Class I	R5 (Rural)	U5 (Urban)	
Lane Width	3.50 m	3.50 m		3.50 m
Shoulder Width	3.00 m (Flat)	3.00 m (Flat)	2.50 m (Type3)	3.00 m
Median Strip	3.00 m (Flat)	4.0 ~ 12.0 m (Flat)	2.0 ~ 4.0 m (Type3)	0.5 ~ 3.0 m
Cross Slope	2.0% (AC)	2.5 ~ 3.0% (AC)		2.0%
Shoulder Slope	3.0 ~ 6.0%	3 ~ 4% (sealed)	3%	
Vertical Clearance	4.5 m			4.5 m

As discussed in Chapter 8, it is proposed that existing NR 5 be widened to 4 lanes with raised median division.

For the sections passing through urbanized area where many vehicles are anticipated to park on street, 2.5 m-wide parking spaces are provided on the both sides. Figure 9.1-1 shows the proposed typical cross sections for rural and urban sections.

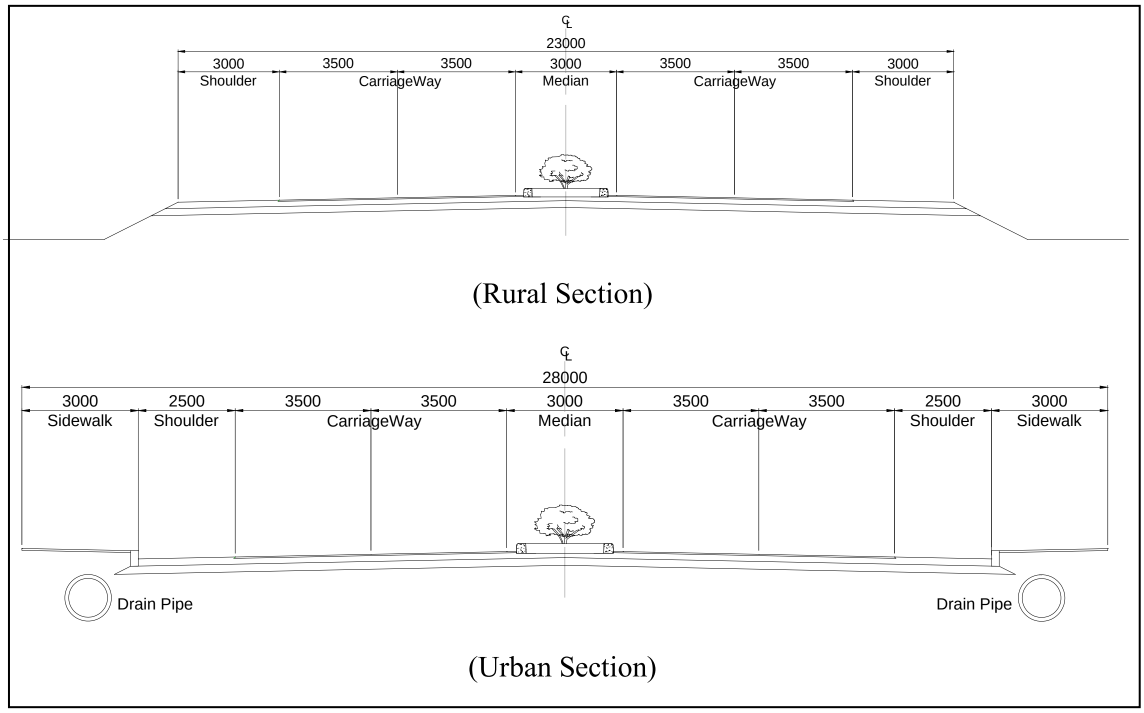


Figure 9.1-1 Proposed Typical Cross Section

9.1.3 Horizontal Alignment

(1) Applicable Design Criteria

As discussed in Subsections 9.1.1 above, design speeds and minimum radii of curve as shown in Table 9.1-3 are recommended for the Project. These recommended criteria were adopted in the North Section.

Table 9.1-3 Design Speed and Minimum Radius of Curve

	Applied Criteria	
Road Class	Rural	Urban
Design Speed	100 km/h	50 km/h
Min. Curve Radius (Superelevation)	350 m (10%)	80 m (10%)

At present, the speed limit for the ordinary (rural) sections of NR 5 is 60 km/h and that for urbanized section is 40 km/h. However, the above design speeds are proposed for this preliminary highway design considering the possibility of further improvement in the future such as grade separation at major intersections.

Through the site inspection, it was observed that the speed limit of 40 km/hr is currently applied on the urban section as listed below:

Table 9.1-4 List of Urban Sections Where Design Speed of 50 km/hr is Applied

KP	Length	Name of Location
KP31+000~KP31+700	700 m	Prek Kdam
KP35+000~KP39+800	4,800 m	Vihear Luong & Odongk
KP42+100~KP42+900	800 m	Phsa Trach
KP47+700~KP48+400	700 m	Anlog Tnaot
KP51+800~KP54+700	2,900 m	Kompomg Tralach & Chrak Romiet
KP60+000~KP60+800	800 m	Svay Kraom
KP79+400~KP81+000	1,600 m	Rlea B'ier
KP100+000~KP100+500	500 m	Svay Chrum
KP116+500~KP117+000	500 m	Phsar
KP118+000~KP118+700	700 m	Kam Prong
KP122+100~KP124+400	2,300 m	Popel & Ponley
KP140+600~KP141+300	700 m	Khsach Let
KP152+000~KP155+000	3,000 m	Kra Kor

Design speed of 50 km/hr is applied to these urban sections.

(2) Existing Horizontal Alignment of South Section

There are 73 curve sections and 95 bending points with small intersecting angles without curve between the straight lines along the South Section.

The radii of curve are generally small and some of them do not satisfy the requirement of design criteria. In addition, there are some curve sections where the lengths of curve are short and do not meet the design criteria. Such short curves require busy movement of steering wheel and are not preferable. Thus, these curve sections need to be improved to secure proper curve lengths.

(3) Improvement of Horizontal Alignment

(a) Small radius of curve

There are 14 curve sections where the existing curve radii are smaller than the minimum value of the design criteria. Table 9.1-5 shows the curve sections with substandard curve radii and proposed curve radii after improvement. It also shows distances of centerline shift due to the improvement. Examples of the improvements of curve sections are shown in Figures 9.1-2 and 9.1-3.

Table 9.1-5 Curves of Small Radii

IP	KP of IP	Land	Radii of Curve		Center Shift
			Exixting	Proposed	
4	33+106	Rural	170	600	70.4
5	33+911	Rural	150	400	7.0
28	49+770	Rural	200	550	5.0
38	58+671	Rural	300	800	3.2
40	59+485	Rural	250	850	3.0
104	104+413	Rural	300	750	3.2
110	110.923	Rural	250	1500	2.2
117	115+404	Rural	300	350	6.3
121	117+384	Rural	300	960	2.6
124	119+435	Rural	300	850	2.9
125	120+529	Rural	240	620	3.7
135	127+028	Rural	300	1400	2.0
142	130+335	Rural	200	420	4.8
143	132+310	Rural	300	1650	1.9

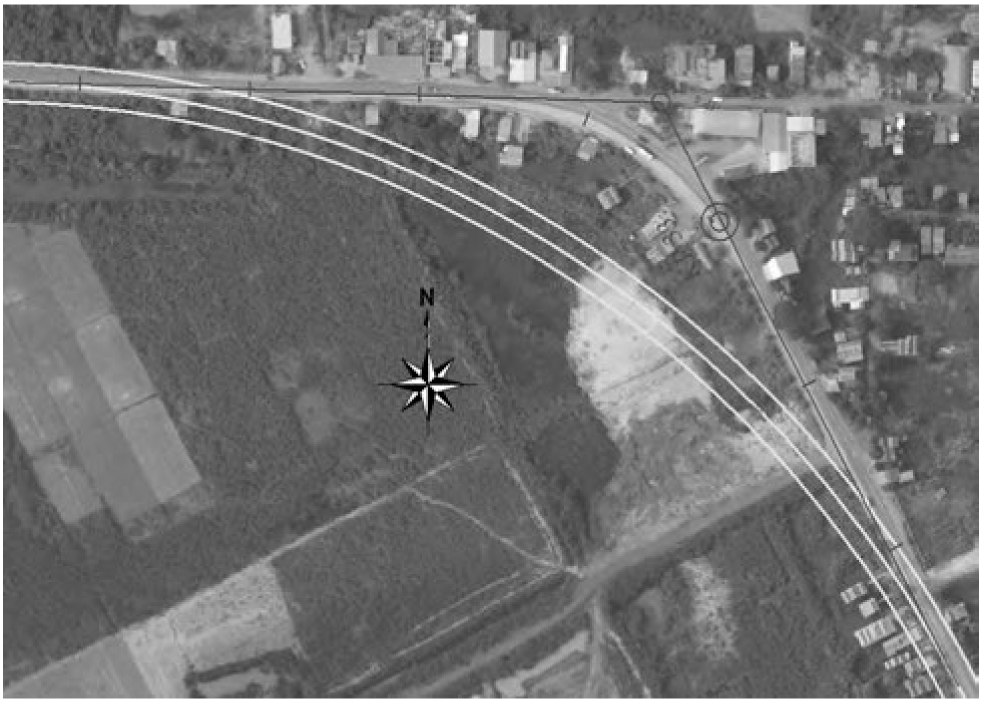


Figure 9.1-2 Proposed Alignment at KP 33 + 007 – KP33 + 186 (IP4)

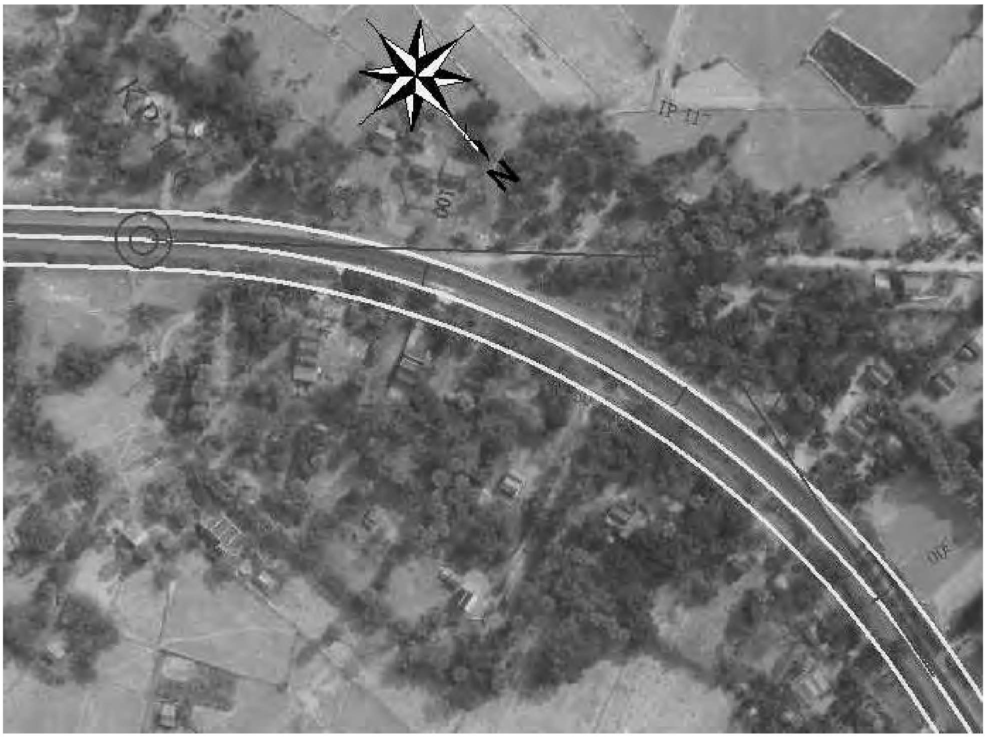


Figure 9.1-3 Proposed Alignment at KP 115 + 249 – KP 115 + 535 (IP117)

(b) Section with short curve length

There are 51 curve sections where the existing curve length is insufficient. The lengths of these curve sections are extended by introducing larger curve radii. Minimum curve lengths of 170 m and 80 m are secured for design speed of 100 km/hr (rural section) and 50 km/hr urban section), respectively.

(c) Bending alignment without curve

As stated above, there are 95 bending points with small intersecting angles without curve between the straight lines. Curves with sufficient lengths and relatively large radii are inserted between the two straight lines in order to secure smooth and comfortable travel of vehicles.

The plan with improve alignment is shown in Appendix 9-1.

9.1.4 Vertical Alignment and Height of Road Surface

South Section experienced inundation due to the flood which occurred in 2011 and pavement was severely damaged at many sections. The list of affected location is shown in Chapter 7. The team investigated the roadside condition and the direction of water flow by vertical alignment. The countermeasures for the flood and inundation were carefully studied and it is shown in Table 9.1-6.

Table 9.1-6 Countermeasures for Flood and Inundation

Location	Cause*	Countermeasure
KP34+000~KP36+000	3, low surface	Install side ditch from KP36 to 34
KP39+800~42+100	3, low surface	Rise embankment 1.5 meters
KP42+100~KP43+000	3, low surface	Install side ditch from KP43 to 42
KP43+000~KP46+200	3, low surface	Rise embankment 1.5 meters
KP46+500~KP48+400	3, low surface	Rise embankment 1.5 meters
KP49+000~KP50+400	3, low surface	Rise embankment 1.0 meter
KP55+500~KP58+000	3, low surface	Rise embankment 1.5 meters
KP59+000~KP61+000	3, low surface	Install side ditch form KP59 to 61, Bc13
KP65+900~KP67+900	3, low surface	Rise embankment 1.5 meters
KP68+800~KP72+700	3, low surface	Rise embankment 1.5 meters
KP74+000~KP78+000	3, low surface	Install side ditch from KP78 to 74
KP78+000~KP82+000	3, low surface	Install concrete ditch from KP78 to 82
KP112+000~KP113+000	3, low surface	Install side ditch from KP112 to 113
KP122+900~KP124+900	3, low surface	Install side ditch from KP122 to 124, Bc32
KP125+600~KP128+600	1, flood of Tonle Sap	Rise embankment 1.0 meter
KP133+600~KP134+000	3, low surface	Install side ditch form KP133 to134
KP136+800~KP137+800	1, flood of Tonle Sap	Rise embankment 1.0 meter
KP142+900~KP147+000	3, low surface	Rise embankment 1.0 meter
KP155+000	2, rain water from Mt.	Construction new box culvert
KP157+000~159+600	3, low surface	Rise embankment 1.0 meter
KP166+800~KP170+000	3, low surface	Install side ditch from KP170 to 167, Bc52

**Type of cause of inundation*

1: Flood of Tonel Sap Lake/River *2: Insufficient opening of cross drainage (bridges and culverts)*

3: Low height of road surface relative to the ground height adjacent road and/or inadequate drainage (side ditch)

As principle, the height of road surface is planned be raised so that the bottom of pavement structure shall be 50 cm higher than flood water level to protect the pavement. Also height of road surface needs to be raised to prevent the inundation and/or overflow during flood. Figure 9.1-4 shows the conceptual illustration of the minimum height of embankment above flood water level.

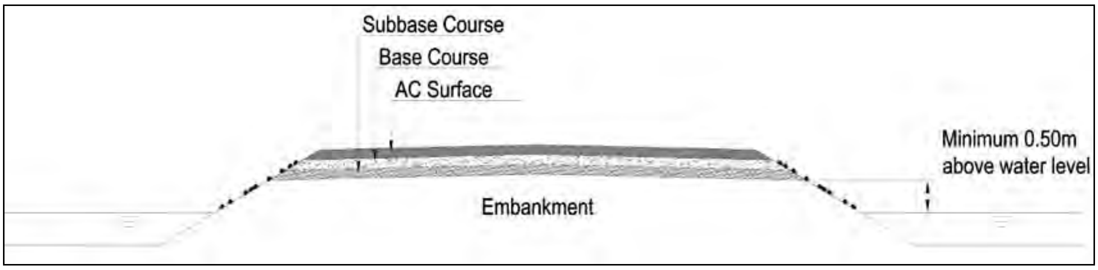


Figure 9.1-4 Conceptual Illustration of Minimum Height of Embankment

9.1.5 Pavement Design

(1) Existing NR 5

(2) Structure Number (SN)

Pavement structure is usually designed based on forecasted traffic load and CBR. AASHOTO's Pavement Design Manual is one of the textbooks of pavement design widely used in the world. In the design method presented in this Manual, the traffic load is converted from estimated traffic volume to cumulative 18-Kip Equivalent Single Axle Load (ESAL), using a parameter called 'Axle Load Equivalent Factor (ALEF)'.

(a) ALEF and ESAL

As a part of the Traffic Survey of this Preparatory Survey, the actual axle loads of heavy vehicles were surveyed utilizing the facility of the weighing station at KP 48 of NR 5 (See Section 5.4). The axle loads of 219 heavy vehicles travelling on both directions were measured. As the result of analysis, the average ALEF of heavy vehicle travelling on NR 5 was calculated to be 2.48/veh.

ESAL is obtained by multiplying ALEF with number of heavy vehicles passing the design section during the design period (usually 10 years). Thus,

ESAL = 2.48 x [Traffic Volume of Heavy Vehicle per Day] x 365 days/year x 10 years.

(b) Design of Pavement Structure for Existing NR 5

The pavement structure is designed with this load factor and following design conditions.

Table 9.1-7 Conditions of Pavement Design of NR 5

Item	Adopted Values
Design Period	10 years
Reliability	80%
Design CBR	12%
Traffic Load (W_{18}=Cumulative 18kip ESAL)	1.430×10^7 for Section III & V 9.813×10^6 for Section I
Structural Number (SN)	SN=3.57 for Section III & V SN=3.35 for Section I

After required SNs are obtained as described above, the pavement structure is designed considering the following aspects

Minimum Thickness of AC Layer

'Road Design Standard of Cambodia; Part 2: Pavement' designates standard pavement structures taking into account traffic volume and type of subgrade. According to these standard pavement structures, 150 mm-thick AC surface course is adopted for highways with large traffic volume of heavy vehicles, while 100 mm-thick AC surface course is adopted for highways with less traffic volume of heavy vehicles. Also, 150 mm-thick AC surface course is commonly adopted in many countries for highways with large volumes of heavy vehicles are anticipated. Thus, it is recommended to adopt 150 mm-thick AC surface course.

Use of Exiting Pavement Structure

Except the location where the embankment height is to be raised as the measure for inundation, the existing pavement shall be utilized as subbase course of designed pavement structure. It can reduce the construction cost and also mitigate the traffic disturbance. In addition, it can reduce industrial waste which would be produced by removal of the existing pavement. Thus, different pavement structures are proposed depending on whether or not the existing pavement is utilized. Table 9.1-8 and Figure 9.1-5 show the designed pavement structure.

Table 9.1-8 Designed Pavement Structure for NR 5

Layere	Thickness		
	Material	KP31~KP81	KP97~KP171
Surface & Binder	AC	15 cm	15 cm
Base	Stabilized gravel	15 cm	10 cm
Subbase	Crusher run	15 cm or ext.	15 cm or ext.

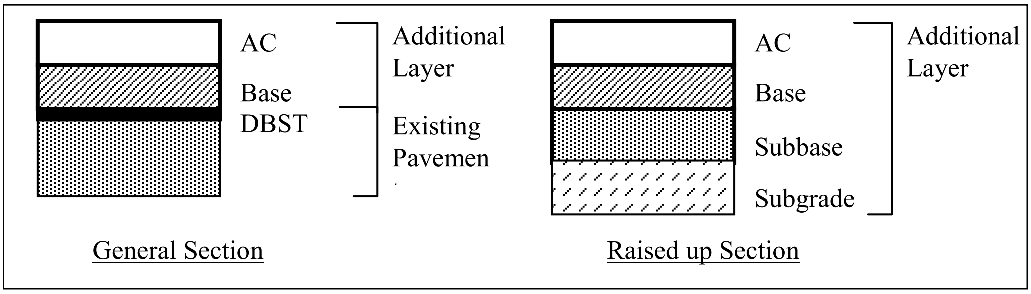


Figure 9.1-5 Pavement Structure for NR 5

(c) Design of Pavement Structure for Kampong Chhnang Bypass

Same design procedures are adopted in the pavement design for Kampong Chhnang Bypass. However, the traffic volume of heavy vehicles on the bypass was estimated in Chapter 6 in terms of pcu while the number of units of heavy vehicles is needed for calculation of the required SN. Thus, the estimated traffic volume on the bypass shown in pcu unit need to be converted to the number of units of heavy vehicles. Based on the estimation of counting station 3a, the ratio of heavy vehicle in pcu unit was calculated.

Table 9.1-9 Ratio of Heavy Vehicle

Station 3a	vechicle			pcu			HV/total
	MC	LV	HV	MC	LV	HV	
2012	15947	3569	1204	4784	4461	3612	0.281
2016	18961	6729	1708	5688	8411	5124	0.267
2021	24027	8875	2248	7208	11093	6744	0.269
2030	35686	14423	3575	10705	18028	10725	0.272

The ratio of heavy vehicle is approximately 27% in pcu unit at Kampong Chhnang. The traffic volume of bypass in pcu unit is converted to vehicle unit as shown in Table 9.1-10.

Using this ratio of heavy vehicles, the number of heavy vehicles on the bypass is calculated as shown in Table 9.1-11.

Table 9.1-10 Number of Heavy Vehicle on Bypass

Bypass	total pcu	HV (pcu)	HV (veh)	growth
2012	6232	1682.64	561	
2016	10472	2827.44	942	1.138
2021	13819	3731.13	1244	1.057
2030	22354	6035.58	2012	1.055

The subgrade of bypass is planned to be selected material obtained from borrowed pit. For this pavement design, CBR value is assumed to be 6%, which is common value for embankment material. Table 9.1-12 shows the design conditions of pavement for Kampong Chhnang Bypass. Table 9.1-13 and Figure 9.1-7 show the designed pavement structure for Kampong Chhnang Bypass.

Table 9.1-11 Conditions of Pavement Design for Kampong Chhnang Bypass

Item	Adopted Values
Design Period	10 years
Reliability	80%
Design CBR	6%
Traffic Load (W_{18}=Cumulative 18kip ESAL)	7.240×10^6
Structural Number (SN)	SN=4.14

Table 9.1-12 Designed Pavement Structure

Layer	Material	Thickness
Surface & Binder	AC	15 cm
Base	Stabilized gravel	15 cm
Subbase	Crusher run	25 cm

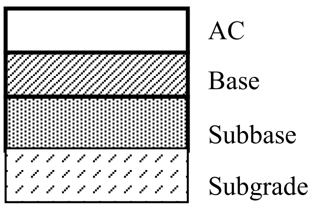


Figure 9.1-6 Pavement Structure

(d) Odongk Bypass

The pavement structure of Odongk Bypass is designed with procedures similar to that of Kampong Chhnang Bypass. Tables 9.1-15, 9.1-16 and 9.1-17 shows the estimated traffic volume, ratio of heavy vehicles and number of heavy vehicles on bypass, respectively. The ratio of heavy vehicle is approximately 37% in pcu.

Table 9.1-13 Estimated Traffic Volume (pcu)

Section	Traffic Volume			
	Year 2012	Year 2016	Year 2021	Year 2030
Bypass	9,100	13,822	18,181	28,917
Center of Town (Count. Sta. No.1)	3,788	5,650	7,296	11,192

Table 9.1-14 Ratio of Heavy Vehicle

Station 1	vehicle			pcu			HV/total
	MC	LV	HV	MC	LV	HV	
2012	5727	3788	1285	1718	4735	3855	0.374
2016	7710	5989	1914	2313	7486	5742	0.369
2021	9907	7894	2503	2972	9867	7509	0.369
2030	14993	12706	3908	4497	15882	11724	0.365

Table 9.1-15 Number of Heavy Vehicle on Bypass

Bypass	total pcu	HV (pcu)	HV (veh)	growth
2012	9100	3367	1122	
2016	13822	5114.14	1705	1.110
2021	18181	6726.97	2242	1.056
2030	28917	10699.29	3566	1.053

Table 9.1-18 shows the design conditions for pavement of Odongk Bypass.

Table 9.1-16 Conditions of Pavement Design of Odongk Bypass

Item	Adopted Values
Design Period	10 years
Reliability	80%
Design CBR	6%
Traffic Load (W_{18}=Cumulative 18kip ESAL)	1.293×10^7
Structural Number (SN)	SN=4.53

Likewise to the pavement of Kampong Chhnang Bypass, pavement structure with 150 mm-thick AC surface course is proposed.

Table 9.1-17 Designed Pavement Structure of Odongk Bypass

Layer	Material	Thickness
Surface & Binder	AC	15 cm
Base	Stabilized gravel	20 cm
Subbase	Crusher run	30 cm
Total Thickness		65 cm

9.1.6 Intersection

There are intersections with 2 digits National Road along the South Section. In the urban sections, many major streets are directly connected to NR 5. In rural sections, numerous minor roads are connected to NR 5. These minor roads are used for daily activities by the local residents. From a viewpoint of smooth and safe traffic on an arterial highway, such as NR 5, the access from those minor roads should be limited as much as possible. However, NR 5 is indispensable for the daily activities of the local residents and access from the minor roads cannot be limited.

The 3 m-wide shoulder is expected to function as the space for yield or stop for the traffic entering to NR 5 from the minor roads.

Typical design of intersection for major road and minor road are shown in Figure 9.1-10.

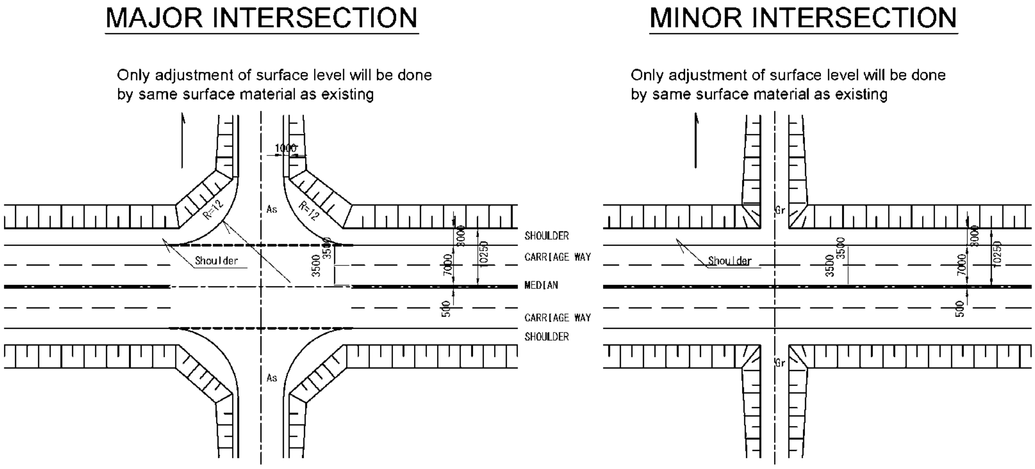


Figure 9.1-7 Typical Plan of Intersection

9.1.7 Appurtenances

(1) Drainage Facilities

South Section of NR 5 is passing through the slight rolling terrain and crosses many streams. The result of inventory survey conducted by the Survey Team, there are 49 box culverts and 90 pipe culverts on the existing South Section. All of those culverts are required to be extended to fit with widened road width, and also the headwalls are necessary to be newly constructed.

The typical cross section for commercial area shows mount up sidewalk and buried drainage pipe. The catch basin at proper interval and outlet facilities shall be considered during the detailed design stage.

The ditch along the section between KP78 and KP82 is planned to be lined by concrete. The grade of the road along this section is relatively steep and water flow is anticipated to erode the embankment and shoulders of the road for its high velocity. Some parts of earth ditch near outlet point may need to be protected against erosion by concrete or riprap.

Table 9.1-18 List of Side Ditch

Location	Length	Type
KP31+100~KP31+700	600 m	Concrete pipe
KP34+000~KP36+000	2,000 m	Earth ditch
KP38+650~KP39+250	600 m	Concrete pipe
KP42+100~KP43+000	900 m	Earth ditch
KP52+700~KP52+900	200 m	Concrete pipe
KP59+000~KP61+000	2,000 m	Earth ditch
KP74+000~KP78+000	4,000 m	Earth ditch
KP78+000~KP82+000	4,000 m	Rip rap
(KP80+400~KP80+800)	400 m	Concrete pipe
KP100+300~KP100+500	200 m	Concrete pipe
KP112+000~KP113+000	1,000 m	Earth ditch
KP116+700~KP116+800	100 m	Concrete pipe
KP122+900~KP124+900	2,000 m	Earth ditch
(KP123+200~KP123+700)	500 m	Concrete pipe
KP133+600~KP134+000	400 m	Earth ditch
KP141+000~KP141+200	200 m	Concrete pipe
KP153+500~KP154+000	500 m	Concrete pipe
KP166+800~KP170+000	3,200 m	Earth ditch

(2) Guardrail and Guide Post

Guardrails shall be installed in the following places:

- Section with an embankment height larger than 4 meters (to prevent vehicles fall down the embankment by accident)
- Twenty meter on the both sides of bridges (to prevent vehicles running into river or hitting the wall of bridge by accident)
- Ten meter on up-stream side of a heavy and sturdy structure, such as a traffic signal control box, located within 5 meter from the outside edge of shoulder.

The locations of box culvert are also hazardous if a vehicle run out of the road area. However, the height of culvert is much lower than bridge and the stream is narrow. The guide post, instead of guard rail, is to be placed for the caution to the drivers.

Figure 9.1-11 shows an example of the plane view of guard rail on the both sides of a bridge and Figure 9.1-12 shows an example of side view and plan view of guard rail.

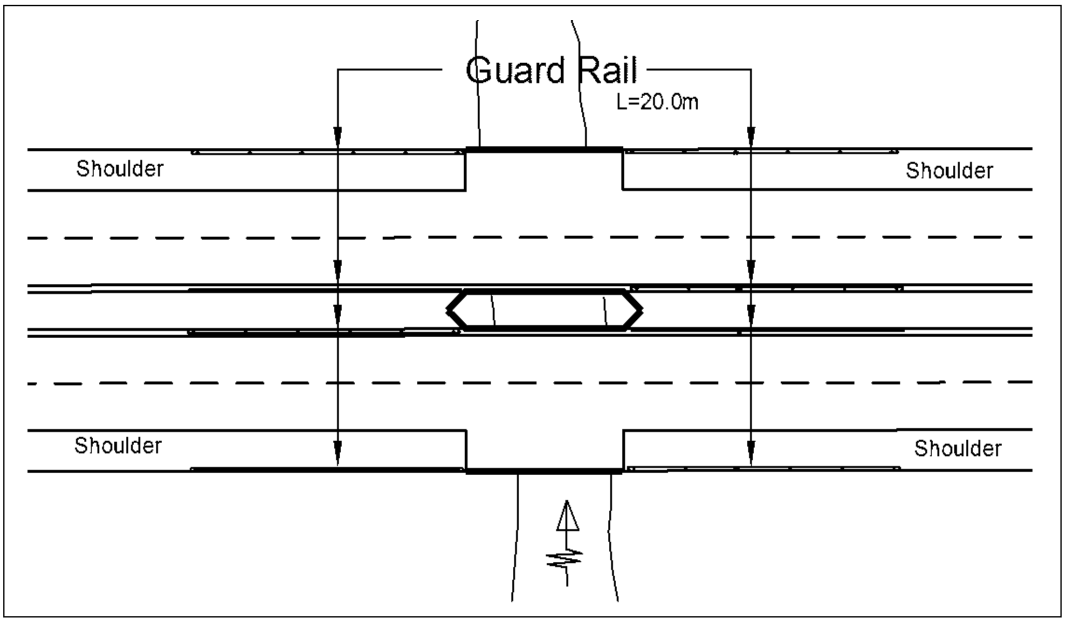


Figure 9.1-8 Plan of Guard Rail at Approach of Bridge

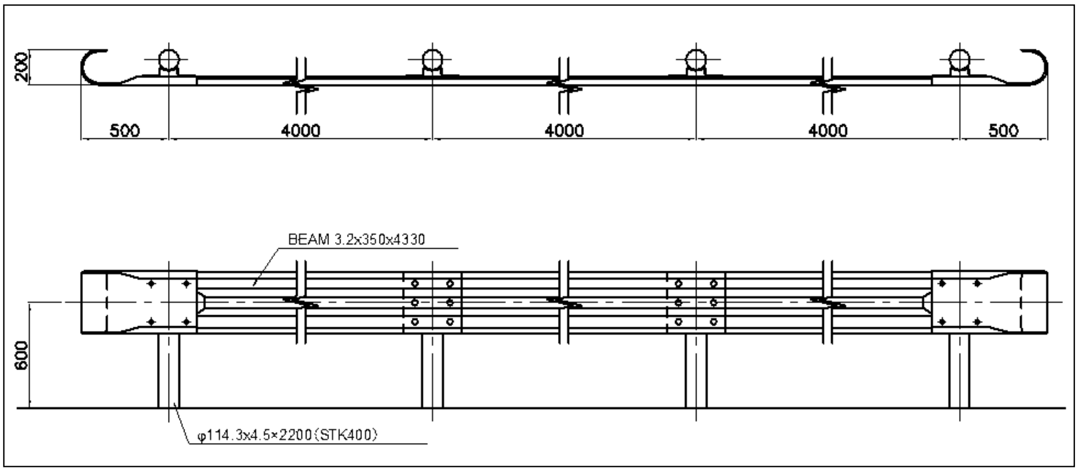


Figure 9.1-9 Example of Guard Rail

(3) Ramble Strip

Ramble strip is special pavement with rough surface which cause noise when vehicle passes it. It is placed in multiple strip across the carriageway to give drivers warning. Ramble strips shall be planned at entrance of town area, near school and markets, and other strategic locations.

Figure 9.1-10 Example of Ruble Strip

(4) Street Light

Lighting is provided at hazardous locations. During night, such hazardous locations need to be lighted and give good visibility to the drivers. Lighting is planned at the following locations:

- Major intersections
- Bridges

9.2 Highway Design of Kampong Chhnang Bypass

9.2.1 Cross Section

The design criteria of cross sectional composition of the Kampong Chhnang Bypass is as discussed in Subsection 9.1.1.

(1) Estimated Traffic Volume and Number of Lane

As discussed in Chapter 8, the estimated traffic volume on Kampong Chhnang requires the capacity of 4-lane. (Please see Subsection 8.2.2.)

(2) Consistency with Existing Section

After completion of the project, the bypass becomes the main route of NR 5. It means that the function of Asian Highway No. 1 divert to the bypass from existing route passing through Kampong Chhnang city center. Therefore, It is necessary to give the grade to the bypass same with general section of the South Section. Thus, the same cross section composition is designed for Kampong Chhnang bypass. Figure 9.2-1 shows the proposed cross section of Kampong Chhnang Bypass.

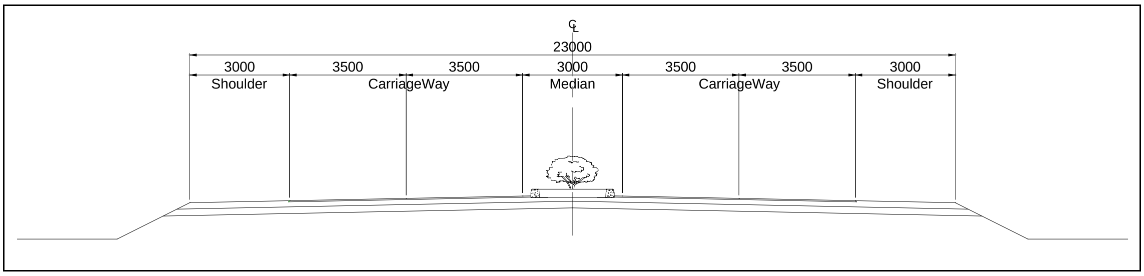


Figure 9.2-1 Proposed Typical Cross Section of Kampong Chhnang Bypass

9.2.2 Horizontal Alignment

As discussed in Chapter 8, JICA-1 route was selected. The design criteria was discussed in section 9.1.2.

Horizontal alignment was analyzed on the satellite photograph to satisfy the design criteria, avoiding the main control points such as houses, huts and a reservoir. The intersection angle with NR 53 was adjusted to nearly right angle. Topographic survey was conducted along this alignment.

As the result of topographic survey, no serious obstacle was found on the proposed route of the bypass. Thus, no further adjustment of alignment is necessary. Table 9.2-1 shows the elements of alignment of the bypass route. The total length of the bypass becomes 11.811 kilometers. The route of bypass is drawn on the topographic map and shown in Figure 9.2-2.

Table 9.2-1 IP & Elements of Curves

Station		Radius (m)	Curve Length (m)	Tangent (m)
0+261.171	IP 01	400	491.339	261.876
1+226.321	IP 02	800	609.941	320.655
4+528.082	IP 03	1,200	591.672	301.980
6+272.220	IP 04	1,200	865.953	452.800
10+940.845	IP 05	1,000	839.140	452.906

Figure 9.2-2 Route of Kampong Chhnang Bypass

The plan of Kampong Chhnang Bypass is shown in Appendix 9-2.

9.2.3 Vertical Alignment

The proposed route traverses mostly paddy areas. The paddy area is often covered by water for cultivation of rice and/or by accumulated rain water. The elevation of the existing ground along a few kilometer from the starting point is close the flood level of Tonle Sap River at Prek Kdam Bridge (10.34 m ASL) or lower. The embankment of the roadbed shall be sufficiently higher than the water level of paddy field so that the subgrade layer be not submerged and sufficient bearing capacity of subgrade be maintained during flood season.

Beginning Point

Intersection of Bypass Route & NR-53

Figure 9.2-3 Photo at Kampong Chhnang Bypass Route

According to the result of topographical survey, ground elevations along the route are approximately 9 to 24 m above sea level. While the surface levels of existing NR-5 at the starting point and end point of the bypass are 12.0 m and 15.3 m, respectively. According to the DPWT officials, no flood or overflow has been reported at these locations in the past.

Higher embankment is desirable from viewpoint of flood/inundation. However, higher embankment results in higher construction cost of embankment and wider land to be acquired. Considering these, the finishing grade (road surface) is set up at 12.60 m for the lowest section, while the level of flood water is assumed at 111.6 m. This allows the road surface to be higher than the assumed flood water level by 1.0 m. The embankment height in paddy area designed as described above becomes around 1.5 m in general. Certain embankment height is required also in order to secure sufficient coverage with embankment above pipe culverts for cross drainage. One and half meter embankment is sufficient from this viewpoint, in general.

The route of section in the vicinity of Sta.10+000 passes the edge of a hill. The maximum grade in this section is 0.556% which is well within the design criteria.

The surface level of a bridge near Sta.0+070 is planned to be 14.1 m. The vertical curve is provided on the approach to keep proper sight distance and driving comfort.

9.2.4 Pavement Design

Pavement design of Kamopong Chhnang was discussed in Subsection 9.1-5.

9.2.5 Drainage

The embankment of the bypass may act as a dike and block flow of water during the flood season. Especially, the bypass route traverses the paddy fields and it will be necessary to install sufficient cross drainage in order to provide adequate cross-sectional area for flow of water for the agriculture.

There are many cannels crossing the proposed bypass route. The direction of flood water flow is basically west to east (towards Tonle Sap Lake). Actual locations and diameters of cross drainage facilities (culverts) are to be designed in the detailed design stage. For larger streams, such as Chrey Bak River (Sta.1+070), bridge is to be constructed. The bridge planning is described in Chapter 10.

(1) Box Culvert

Box culverts are installed at comparatively wide water channels including irrigation channels. The schedule of box culvert is shown in Table 9.2-2.

Table 9.2-2 Schedule of Box Culvert

Km	No. of Cell	Width	Length
00+275	3-3 x 3	9.0	20.5
00+785	2-3 x 3	6.0	20.5
00+970	2-3 x 3	6.0	20.5
06+065	4-3 x 3	12.0	20.5
09+300	3-3 x 2	6.0	20.5

(2) Pipe Culvert

Pipe culverts are installed at small streams and also every 250 m interval with the design same as the North Section. The purpose of this is to minimize the difference of the water level on the both sides of the bypass. An in-depth study shall be undertaken at the detailed design stage.

9.2.6 Major Intersection

(1) Intersection with Existing NR 5

Intersections of the Bypass with the existing NR 5 are designed so that the main direction is for the Bypass and the traffic flow in the direction to the city center of Kampong Chhnang branches out from the Bypass. Figure 9.2-4 shows preliminary design of the northern intersection with the existing NR 5 as an example.

The capacity of the at-grade intersection as shown Figure 9.2-4 (with signal control) was calculated (see Appendix 9-1). The result of calculation showed that the degree of saturation in year 2030 is 0.67 which is within allowable level. Thus, an at-grade intersection can accommodate the traffic up to year 2030. However, in the long future, it may be necessary to construct flyover at the intersections of the bypass with the existing NR 5 to accommodate the increased traffic volume. Figure 9.2-5 shows an example of flyover to be constructed at the intersection.

(2) Intersection with NR 53

Another major intersection of Kampong Chhnang Bypass is the intersection with NR 53 which extends from the city center of Kampong Chhnang to southwest. This intersection can accommodate the traffic volume of year 2030 with the configuration of an at-grade intersection with signal control. Figure 9.2-6 shows preliminary design of the intersection with NR 53.

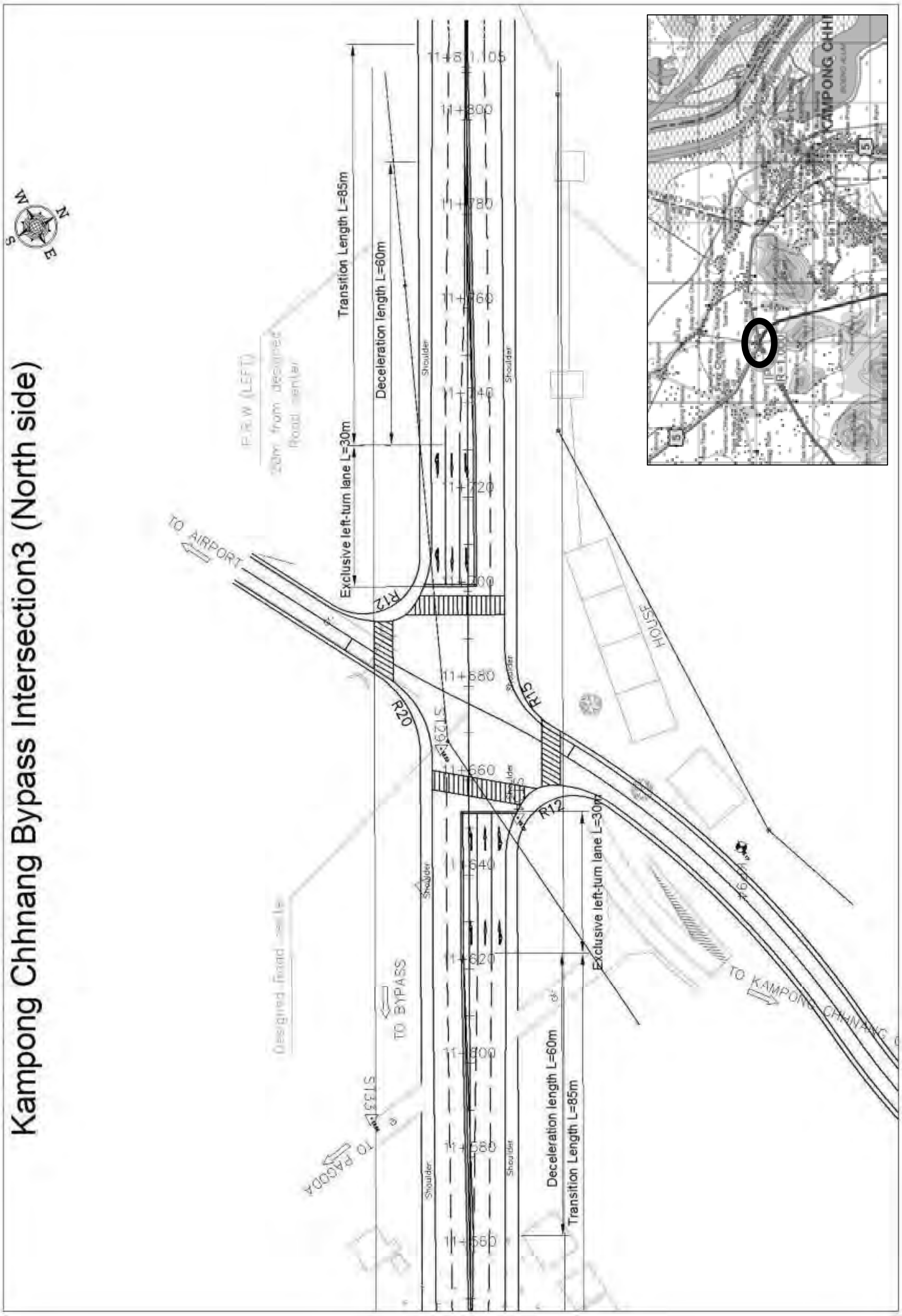


Figure 9.2-4 Northern Intersection of Kampong Chhnang Bypass

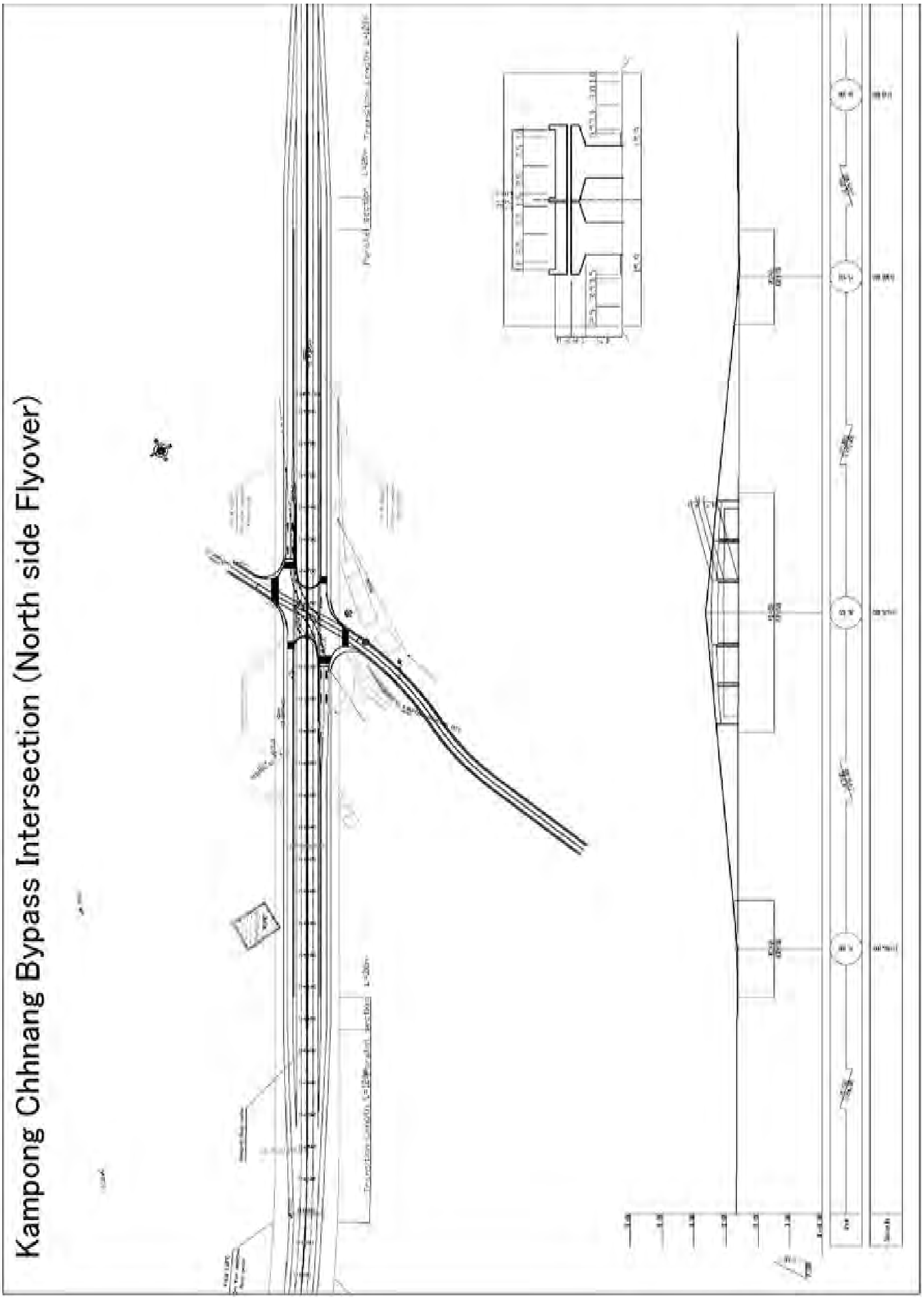


Figure 9.2-5 Example of Flyover for North Intersection of Kampong Chhnang Bypass

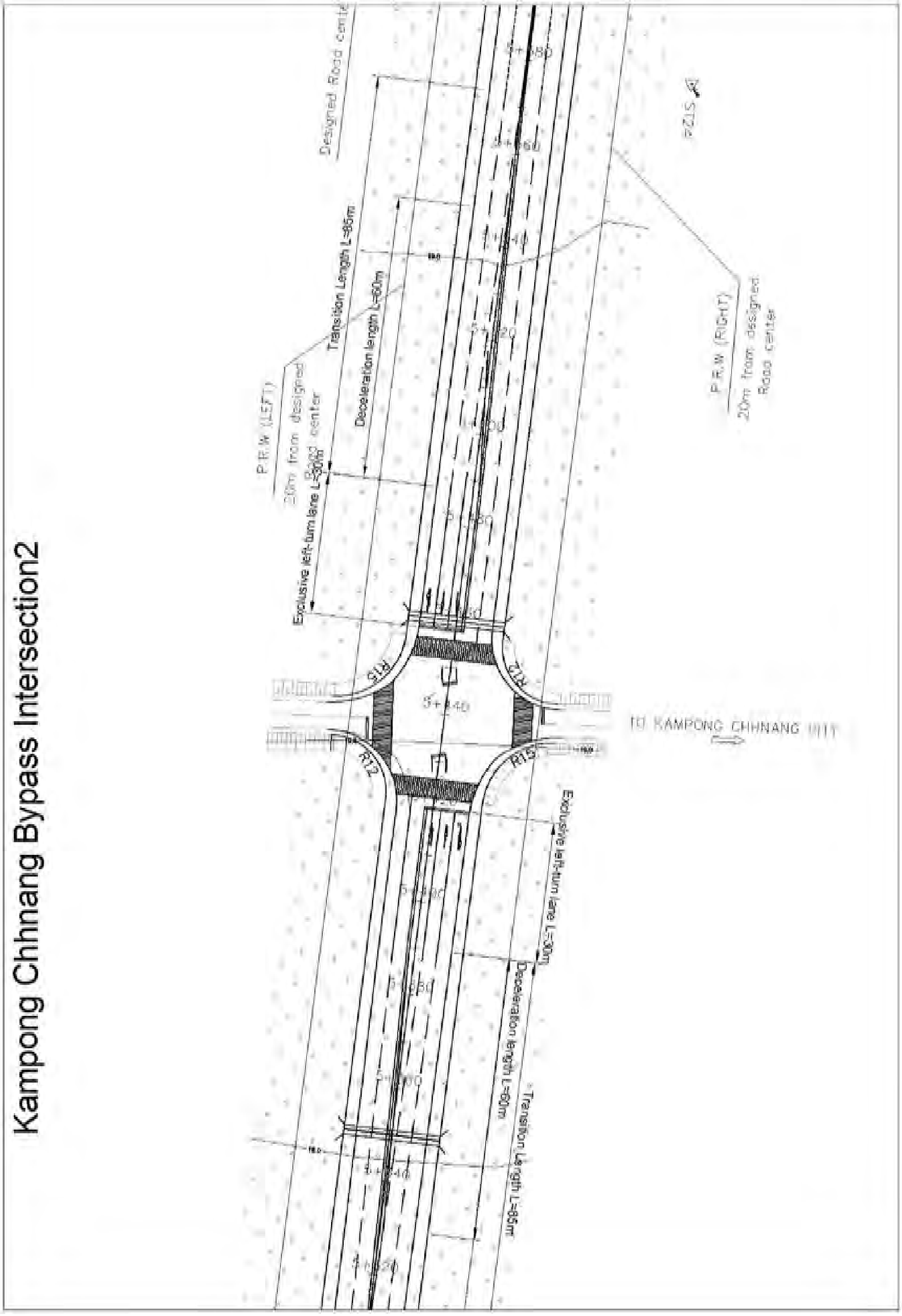


Figure 9.2-6 Preliminary Design of Intersection with NR 53

9.3 Planning of Odongk Bypass

9.3.1 Cross Section

(1) Design Criteria

The design criteria for cross sectional composition is discussed in section 9.1.1.

(2) Estimated Traffic Volume and Number

Similarly to those of Kampong Chhnang Bypass, these subjects are discussed in Chapter 8, and 4-lane cross section is proposed. (Please see Subsection 8.2.2.)

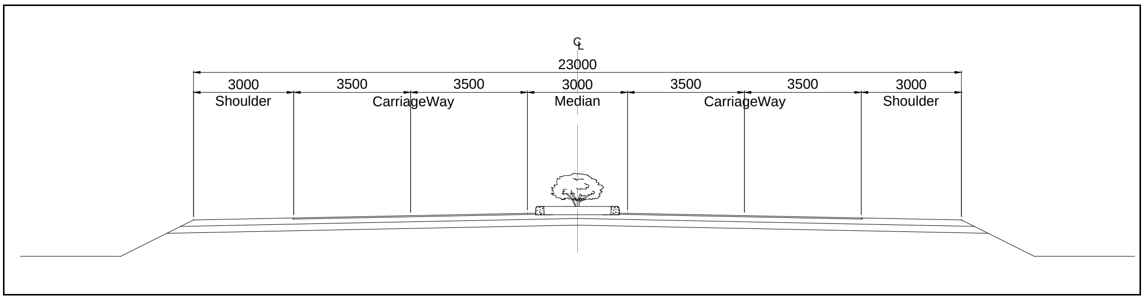


Figure 9.3-1 Proposed Typical Cross Section of Odongk Bypass

9.3.2 Horizontal Alignment

The bypass route has been selected as explained in Chapter 8. The design criteria was discussed in Subsection 9.1.2.

Horizontal alignment was planned on the satellite photograph, taking into account the flood water, the design criteria, and control points such as houses, huts, cemetery, temples and water streams.

This route was fixed after topographic survey along the route. The elements of alignment are as shown in Table 9.3-1 and total length of the bypass becomes 4.882 kilometers. The route of bypass drawn on the topographic map is shown in Figure 9.3-2.

Table 9.3-1 IP & Elements of Curves

Station		Radius (m)	Curve Length (m)	Tangent (m)
0+245.739	IP 01	500	456.807	245.739
1+053.072	IP 02	1,000	519.254	265.622
3+021.008	IP 03	2,000	661.903	334.006
4+571.556	IP 04	600	723.709	413.210

The plan of Odongk Bypass is shown in Appendix 9-3.

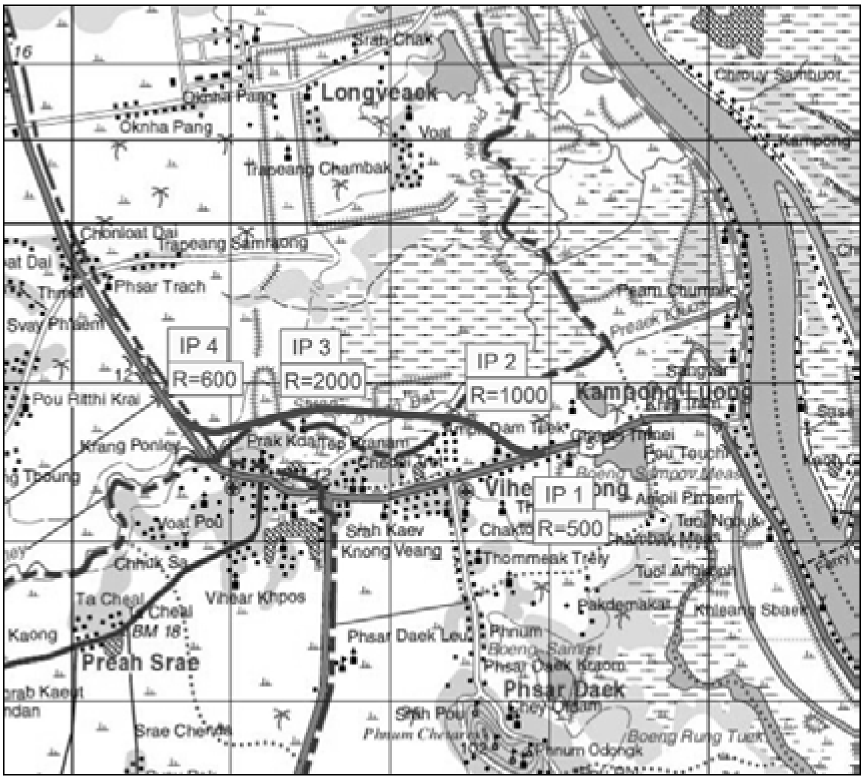


Figure 9.3-2 Route of Odongk Bypass

9.3.3 Vertical Alignment

The proposed route traverses swampy areas. The most of the route is covered by water during flood season. The embankment of the roadbed shall be sufficiently higher than usual level of flood water so that the subgrade layer is not submerged and sufficient bearing capacity of subgrade is maintained during flood season.

Based on the result of topographic survey, the elevation of road surface is designed at 11.0-11.8 meters above sea level. This road surface is to secure 0.5 m thick subgrade layer at the top of the embankment.

9.3.4 Pavement Design

The pavement design method for the bypass is the same as that of the South Section. and Kampong Chnang Bypass. It is discussed in Subsection 9.1.5.

9.3.5 Drainage

The embankment of the bypass will behave as a dike during the flood season and block water flow. Since the bypass route traverses the swampy area, it is necessary to install sufficient cross drainage in order to provide adequate cross-sectional area for discharge of flood water. Five (5) pipe culverts and nine (9) box culverts are planned on the bypass.

9.3.6 Intersection

Intersections of the Bypass with the existing NR 5 are designed so that the main direction is for the Bypass and the direction for the city center of Odongk branches out from the Bypass. Degree of saturation, if the it is constructed as an at-grade intersection with signal control is calculated as 0.7 for the traffic volume of year 2030.

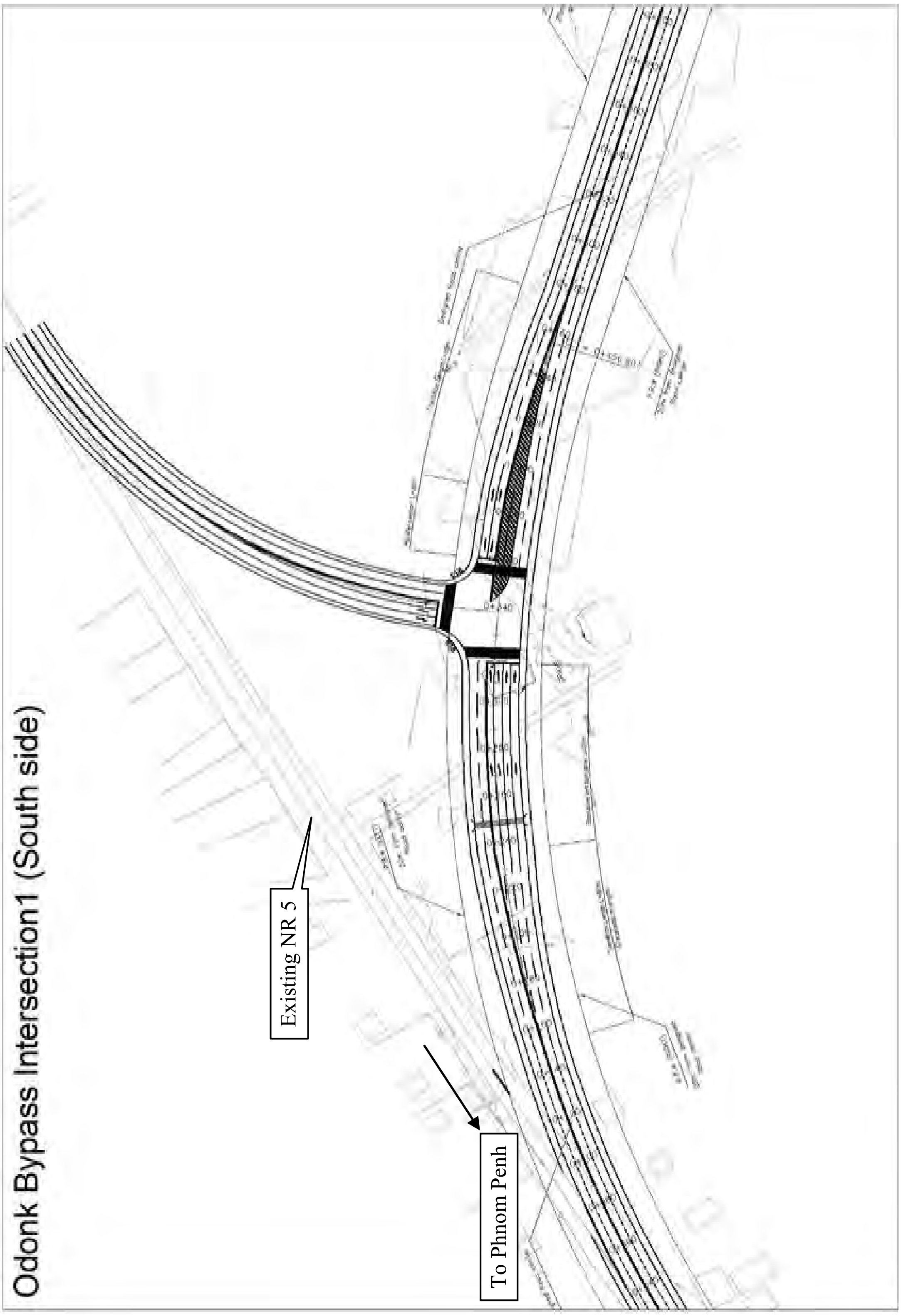


Figure 9.3-3 Intersection with Existing NR 5 (Eastern Intersection)

9.3.7 Slope Protection against Flood Water

The substantial portion of Odongk Bypass is constructed in the area where the ground surface is covered by the water during flood season (August – November). The velocity of flow of flood water is not so high and ordinary slope protection with vegetation (grass) is supposed to be sufficient. However, slope need additional short-term protection if embankment is completed shortly before the flood water rises. Placing sand bag filled with top soil collected in the nearby grass fields etc is tentatively proposed as the slope protection work for such purpose. Seeds of species of grass which are suitable to the local environment (conditions of soil, water, temperature etc) are contained in the locally collected top soil and grasses are expected to grow easily. Before the grasses grow sufficiently enough for slope protection, sandbag can function as slope protection. This method may be used in the section of the existing NR 5 or bypass as appropriate.

Figure 9.3-4 shows the concept of slope protection against flood water.

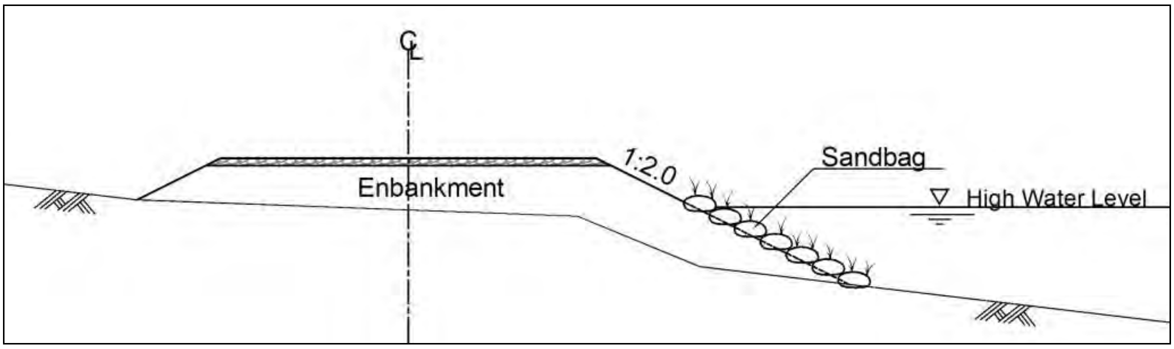


Figure 9.3-4 Conceptual Drawing of Sandbag Slope Protection

CHAPTER 10 BRIDGE PLANNING

10.1 General Design Policy and Design Criteria

10.1.1 Bridge Design Standard

(1) Design Standard

The Cambodian Road and Bridge Design Standard and Construction Specifications were established in 1999 and are to be used for the design and construction of all new roads and bridges and related rehabilitation works in the Kingdom of Cambodia. The design standards for bridges are:

- CAM PW 04-101-99 Bridge Design Code 1996 (the Base Document)
- CAM PW 04-102-99 Amendments and additions to the Base Document and to the Commentaries on the Cambodian Bridge Design Standard.

The Base Document is in fact the Australian Bridge Design Code 1996 and associated Commentaries. (Note that in Australia and New Zealand, the Australian Bridge Design Code 1996 has now been superseded by the Australian Bridge Design Code AS5100.)

The Base Document is an International Bridge Standard making use of modern limit state design philosophy. The amendments and additions to the Base Document reflect conditions in Cambodia from the viewpoint of loading (traffic, environmental and earthquake loads), design for durability and material requirements. A comparison of nominal traffic loading for a typical 20 m span pre-stressed concrete bridge is presented below. As can be seen the total maximum traffic load effects based on the Cambodian Bridge Design Standard are reasonably comparable to both AASHTO and JRA standards.

As a conclusion, Cambodian Standard is adopted in this survey.

Table 10.1-1 Comparison of Nominal Load Effects for 20 m span Bridge Cambodian, AASHTO and JRA Standards

Case	Load Standard	Single lane		Standard 10 m wide roadway bridge deck						
		Max Shear (kN)	Max Moment (kN-m)	Impact Factor	No. of Lanes	Load Mod. Factor *	Total Max Shear (kN)	Total Max Moment (kN-m)	Shear Factor	Moment Factor
1	CAM T44	358.3	1,639.2	0.35	3	0.80	1,161.0	5,311.0	1.00	1.00
2	CAM HLP 240	N/A	N/A	0.10	N/A	N/A	1,333.2	6,160.0	1.15	1.16
3	AASHTO LRFD HL-93	368.1	1,690.8	0.33	3	0.85	1,248.5	5,734.4	1.08	1.08
4	JRA L-Load	N/A	N/A	0.22	N/A	N/A	1,184.0	5,209.7	1.02	0.98

Note:
Case 1 & 2 : Cambodian Bridge Design Standard; Case 3 : AASHTO LRFD; Case 4 : JRA Specifications for Highway Bridges
** Load Modification Factor to account for multiple lane loading*

(2) Traffic Loading

The design traffic load specified in the Base Document consists of T44 Truck loading and L44 Lane loading.

The design T44 Truck load is a 44 tonne vehicle with five (5) axles and with maximum axle load of 9.8 tonnes (96 kN). One design truck can occupy one standard design lane width of 3.0 m. Refer to Figure 10.1-1. L44 Lane loading shall consist of the loads shown in Figure 10.1-2. The lane loading shall be assumed uniformly distributed over a 3 m Standard Design Lane. Only one tandem of concentrated loads shall be used per lane except that one additional tandem of concentrated loads of equal force shall be placed in each lane in one other span in such a position to produce maximum negative effect. L44 Lane loading does not apply for spans less than 10 m.

The Dynamic Load Allowance for T44 and L44 loadings shall be 0.35.

T44 Truck and L44 Lane loadings shall be assumed to occupy one Standard Design Lane of 3 m width.

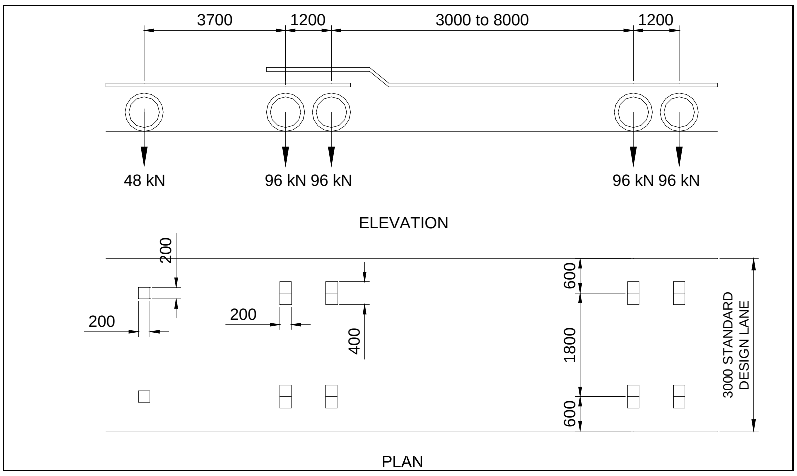
The number of Standard Design Lanes n shall be:

$$n = \frac{b}{3.1}$$

(rounded down to next integer)
where b = carriageway width (in meters) between traffic barriers

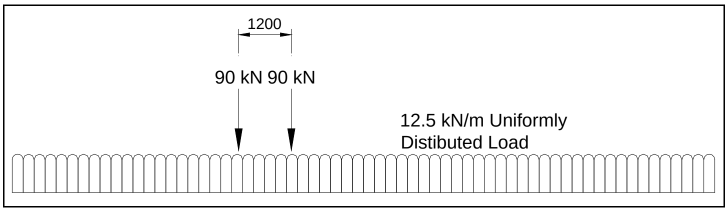
These Standard Design Lanes shall be positioned laterally on the bridge to produce the most adverse effect.

The design of bridges for the simultaneous application of road traffic loading and pedestrian loading is not required.



Source: MPWT, CAM PW 04-101-99 Bridge Design Code 1996

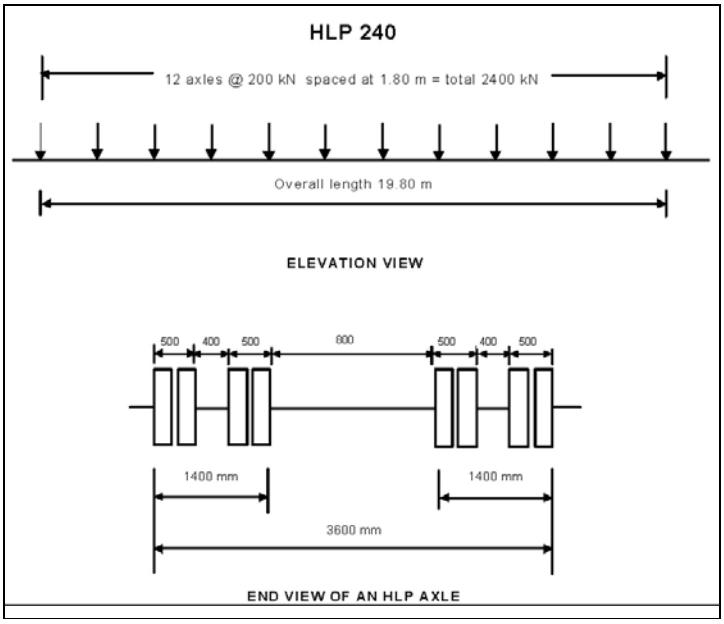
Figure 10.1-1 Design Truck Load T44



Source: MPWT, CAM PW 04-101-99 Bridge Design Code 1996

Figure 10.1-2 Design Lane Loading L44

Heavy Load Platform Loading HLP 240 shall be applied in accordance with the Cambodian Bridge Design Standard. The roads on which Heavy Load Platform Loading apply for bridge design generally will comply with design standards R6/U6, R5/U5 and R4/U4 of the Cambodian Road Design Standard Part 1 – Geometry. On this basis, bridges on National Road No. 5 will be required to support Heavy Load Platform Loading. The configuration of the HLP 240 axle loads is presented in Figure 10.1-3. Heavy Load Platform Loading HPL 240 shall be assumed to centrally occupy two (2) Standard Design Lanes. If the two Standard Design Lanes containing the Heavy Load Platform loadings are positioned such that one or more marked traffic lanes are unobstructed, then a loading of ½ of either the T44 Truck loading or L44 Lane loading shall be applied in those lanes.



Source: MPWT, CAM PW 04-101-99 Bridge Design Code 1996

Figure 10.1-3 Heavy Load Platform Loading

The load modification factors given below shall be applied to T44 Truck and L44 Lane Loading when loading Standard Design Lanes simultaneously. The modification factors shall not apply to Heavy Load Platform loadings.

Number of Standard Design Lanes Loaded	Load Modification Factor
1	1.0
2	0.9
3	0.8
4	0.7

A 70 kN single dual-tyred wheel load, with a contact area of 500 mm x 200 mm, shall be applied for all deck elements for which this loading is critical. This wheel load is designated as the W7 Wheel loading.

(3) Standard Bridges in Cambodia

Standard drawings for pipe culverts, box culverts and bridges have been prepared for MPWT approval under The Strengthening of Construction Quality Control Project, JICA.

With regard to bridges, plans are prepared for carriageway widths of 7 m, 8 m, 10 m, and 12 m for the following bridge types and spans:

- RC Flat Slab (RCS) with spans of 10 m, 12 m, 15 m and 18 m
- RC Deck Girder (RCDG) with spans of 12 m, 15 m, and 18 m
- Pre-tensioned Precast Plank hollow slab (PSC) with spans of 15 m, 18 m, 20 m and 25 m
- Post-tensioned Plank hollow slab with spans of 15 m, 18 m, 20 m and 25 m
- Post-tensioned Precast Concrete Deck Girder (PCDG) with spans of 18 m, 20 m, 25 m and 30 m

Features of these bridge types are as summarized below;

(i) Reinforced concrete flat slab

The reinforced concrete flat slab (RCS) bridge is the simplest form of construction applicable to short spans and offers the largest span/depth ratio of all the options, i.e. the deck slab is minimum thickness. This type of construction will therefore have minimal impact on the road profile. The deck is simply supported on a 30 mm thick cement mortar bed and is located with dowels.

(ii) Reinforced concrete deck girder

The reinforced concrete deck girder (RCDG) bridge is more economic for the longer spans in the range assigned. However this form of construction offers the smallest span/depth ratio of all the options, i.e. the deck construction is relatively deep. Such a relatively deep deck will have a significant effect on the road profile in cases where high flood level controls the deck elevation. The deck also requires the construction of diaphragms, both at the girder ends and in-span, to promote lateral load distribution. The deck is simply supported on rubber pads and is located with dowels.

(iii) Pre-tensioned precast plank hollow slab

The pre-tensioned precast plank hollow slab (PSC) bridge offers the advantages of precast construction, in terms of construction speed and construction quality control, and provides a large span/depth ratio for spans up to 25 m. This type of construction will therefore also have minimal impact on the road profile. The planks are pre-tensioned and incorporate voids, circular or rectilinear, to reduce weight. The planks are placed side by side to form the deck with the narrow gap filled with cement mortar. Once the mortar has gained sufficient strength, the planks are transversely post-tensioned using high tensile strength steel bars posted through holes in the planks and anchored in recesses at each side of the deck. The full depth planks do not require any in-situ concrete topping and can directly receive the pavement surfacing. The deck is simply supported on a 30 mm thick cement mortar bed and is located with dowels. This type of bridge deck has become the defector standard in Cambodia for short span bridges, with many examples already constructed ranging from 10 m span length.

(iv) Post-tensioned precast concrete deck girder

The post-tensioned precast concrete deck girder (PCDG) bridge spans up to 30 m in the standard established. This type can in fact be applied to spans up to 40 m or so and is economic for the longer spans in the range assigned. The precast concrete girders again offer advantages in terms of construction speed and construction quality control. The precast girders may or may not incorporate a part of the deck slab, with the reinforced concrete deck slab either totally or partially constructed in-situ. The deck slab may feature transverse prestress. The girders also require diaphragm to promote lateral load distribution. This form of construction however has a relatively small span/depth ratio, i.e. the deck construction is relatively deep. Such a relatively deep deck will therefore have a significant effect on the road profile in cases where high flood level controls the deck elevation. The deck is simply supported on elastomeric pads and is located with dowels.

Two types of reinforced concrete abutment are featured in the standard drawings:

・Stub Type

・Cantilever Type

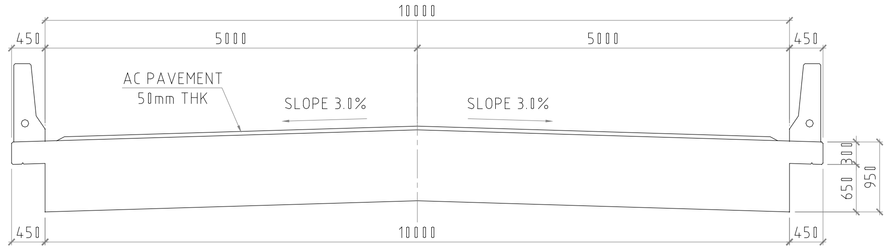
(v) Stub type abutment

The stub type abutment features a simple coping beam, providing a bearing shelf for the deck, supported on a single row of piles, with the wing walls hung off each side. This type is suitable for all the standard deck forms where the approach embankments are relatively low and where there is no threat of local scour attack.

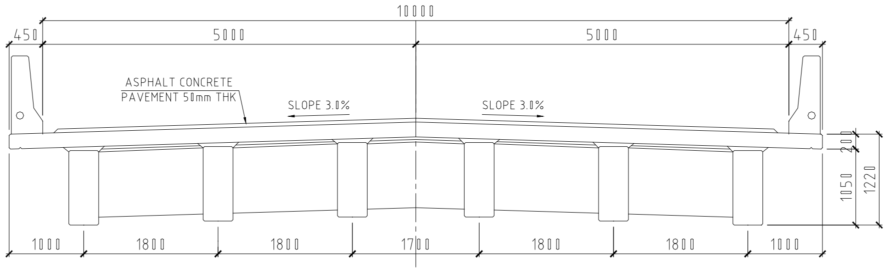
(vi) Cantilever abutment

The cantilever abutment is a substantial structure suitable for high approach embankment situations, or deep waterway locations, and where protection to local scour attack is required. The abutment comprises of a cantilever wall, providing a bearing shelf for the deck, supported on a pile cap with multiple rows of piles. The wing walls are hung off short counterforts at each side. The abutment can support large vertical and horizontal loads.

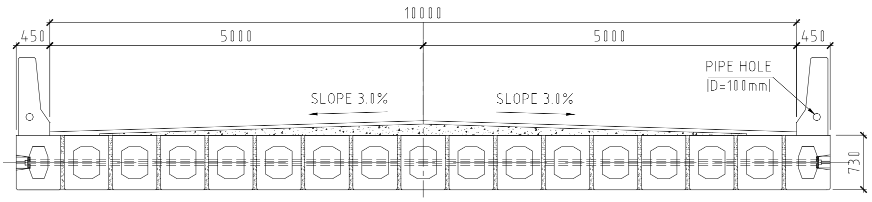
Refer to Figure 10.1-4 for typical sections of the proposed standard bridges (draft). Refer to Figure 10.1-5 for typical abutment layouts for the standard bridges. The standard bridges show a minimum freeboard of 80 cm to high water level.



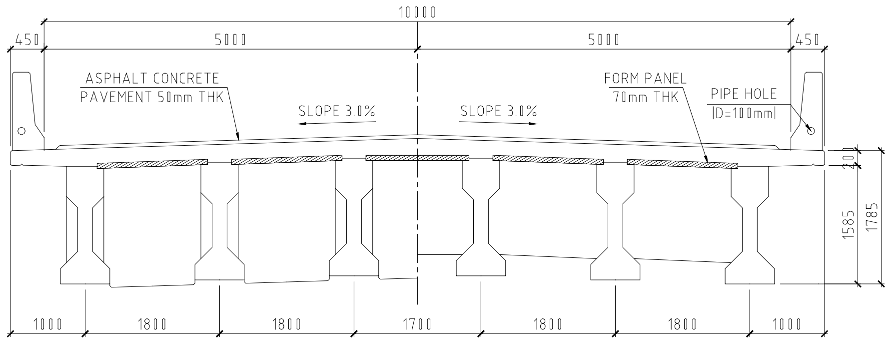
RC Flat Slab (RCS)



RC Deck Girder (RCDG)



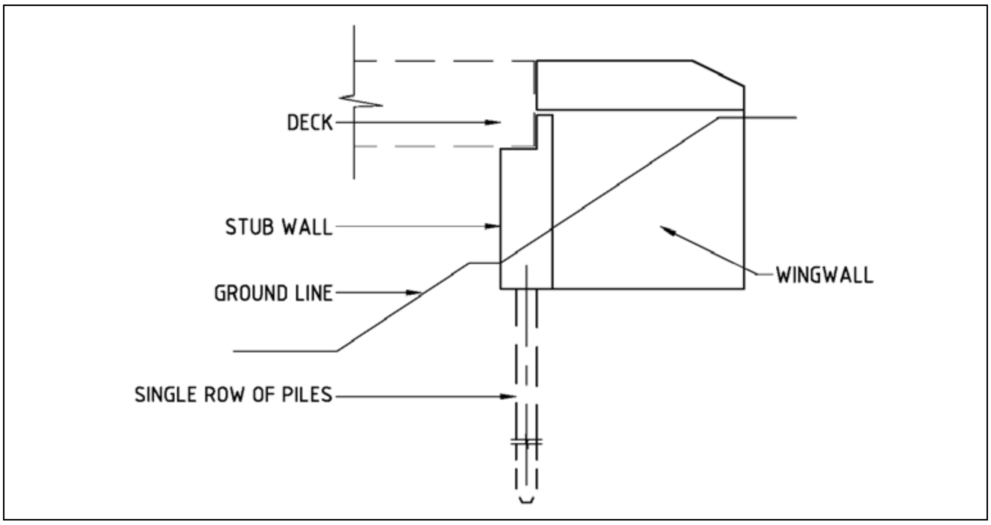
Pre-tensioned Precast Plank (PSC)



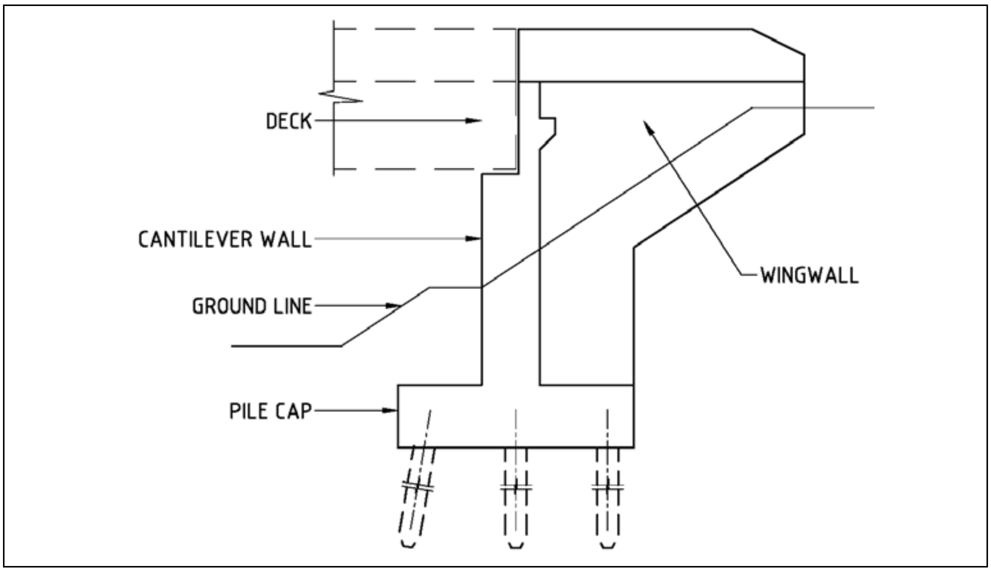
Post-tensioned Concrete Deck Girder (PCDG)

Source: MPWT, The Strengthening of Construction Quality Project, JICA

Figure 10.1-4 Standard Bridge Typical Sections for 10 m-Wide Carriageway



Stub Type Abutment



Cantilever Type Abutment

Source: MPWT, The Strengthening of Construction Quality Project, JICA

Figure 10.1-5 Standard Bridge Abutments

10.1.2 Design Criteria

The substantial carriageway width needed to accommodate a 4-lane road will require that all bridges on the South Section will either have to be widened or to be supplemented with an additional adjacent bridge. The bridges that have tangential road approaches are recommended to be equally widened on each side in order to maintain the tangent horizontal alignment of the existing road.

There are thirty seven (37) bridges on the South Section. Location of seven (7) bridges are out of proposed project section because of diverting to proposed bypass. Thus, thirty (30) bridges are required to be widened or to be supplemented with an additional adjacent bridge.

Figure 10.1-6 shows flow to select widening design. Widening design for each bridge is selected based on bridge location, bridge condition, road alignment, built year and result of site survey. Table 10.1-2 shows proposed bridge widening design for 4-lane.

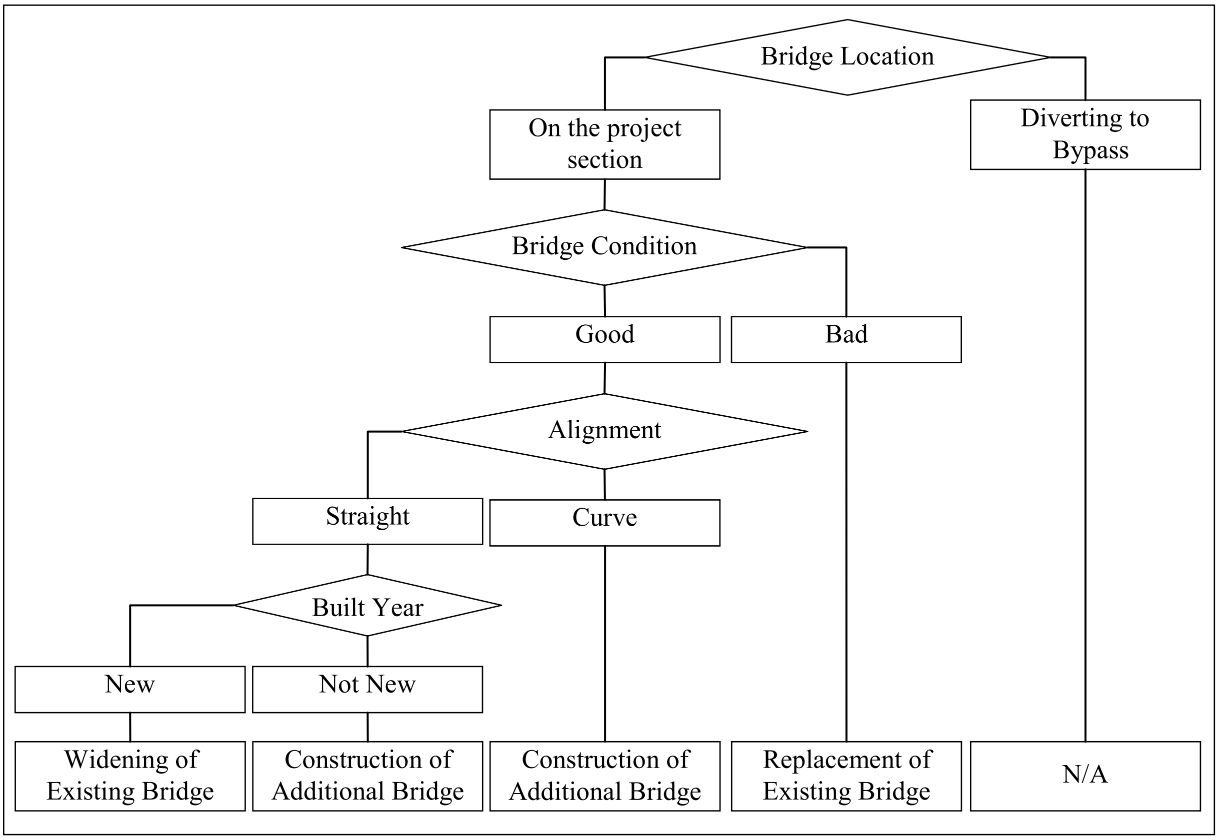


Figure 10.1-6 Flow to Select Widening Type

Table 10.1-2 Summary of Bridge Widening- Full 4-Lane Design

No.	Code	KP	Length (m)	No. of Span	Existing Type	4-Lane Widening Design
1	Br. 05	38.1	8.2	1	RCDG	N/A
2	Br. 06	39.7	23.9	2	Steel Girder	N/A
3	Br. 07	40.6	15.0	1	Steel Girder	Construction of Addition Bridge (LHS)
4	Br. 08	41.1	24.0	2	Steel Girder	Construction of Addition Bridge (LHS)
5	Br. 09	41.3	24.2	2	Steel Girder	Construction of Addition Beige (LHS)
6	Br.10	41.9	24.2	2	Steel Girder	Construction of Addition Bridge (LHS)
7	Br.11	46.2	16.2	4	RCDG	Replacement of Existing Bridge
8	Br. 12	48.4	21.0	4	Steel Girder & RC Rahmen	Construction of Addition Bridge (RHS)
9	Br. 13	48.9	8.5	1	RCDG	Replacement of Existing Bridge
10	Br.13’	49.7	24.0	2	Steel Girder	Construction of Addition Bridge (LHS)
11	Br. 14	58.3	12.1	1	Steel Girder	Construction of Addition Bridge (RHS)
12	Br. 15	61.9	24.2	2	Steel Girder	Construction of Addition Bridge (RHS)
13	Br. 16	67.8	24.2	2	Steel Girder	Construction of Addition Bridge (LHS)
14	Br.16’	72.7	12.1	1	Steel Girder	Construction of Addition Bridge (RHS)
15	Br. 17	82.2	15.0	1	PSC	N/A
16	Br. 18	82.4	41.2	2	Steel Girder	N/A
17	Br. 19	83.1	20.0	2	PSC	N/A
18	Br. 20	85.9	8.5	1	RCDG	N/A
19	Br. 21	90.9	22.2	2	Steel Girder	N/A
20	Br. 22	106.2	91.5	3	Steel Girder	Construction of Addition Bridge (LHS)
21	Br. 23	106.9	20.0	1	PSC	Widening of Existing Bridge
22	Br. 24	113.4	15.0	1	PSC	Widening of Existing Bridge
23	Br. 25	113.7	12.0	1	PSC	Widening of Existing Bridge
24	Br. 26	116.9	72.1	3	Steel Girder	Construction of Addition Bridge (RHS)
25	Br. 27	134.3	12.0	1	PSC	Widening of Existing Bridge
26	Br. 28	135.9	12.0	1	PSC	Widening of Existing Bridge
27	Br. 29	140.8	12.0	1	PSC	Widening of Existing Bridge
28	Br. 30	141.9	12.0	1	PSC	Widening of Existing Bridge
29	Br. 31	147.1	12.0	1	PSC	Widening of Existing Bridge
30	Br. 32	147.7	12.0	1	PSC	Widening of Existing Bridge
31	Br. 33	150.2	17.9	1	PSC	Widening of Existing Bridge
32	Br. 34	150.4	15.0	1	PSC	Widening of Existing Bridge
33	Br. 35	151.3	12.0	1	PSC	Widening of Existing Bridge
34	Br. 36	153.5	20.0	2	PSC	Widening of Existing Bridge
35	Br. 37	169.8	20.1	1	PSC	Widening of Existing Bridge
36	Br. 38	170.6	42.3	3	Steel Girder	Construction of Addition Bridge (RHS)
37	Br. 39	170.9	19.2	4	RCDG	Replacement of Existing Bridge

10.2 Replacement of Existing Bridge

Given the aged and deteriorated condition of the structure and insufficient carriageway width, it is proposed that three (3) bridges are replaced with a new 4-lane bridge. Existing bridge length of these bridges are 16.2 m, 8.5 m and 19.2 m. Type of new bridge is selected taking the following aspects into consideration, (i) to minimize impact on road profile, (ii) to ensure existing river clearance, and (iii) to ensure necessary waterway opening.

Chapter 7 of this report shows that water opening length around Br. 13 and Br. 39 is insufficient. Therefore, length of Br. 13 and Br. 39 need to be expanded.

Table 10.2-1 shows proposed plan of new bridges.

Table 10.2-1 Proposed Plan of Replacement Bridges

Code	KP	Existing Bridge		New Bridge		
		Type	Length (m)	Type	Length (m)	Number of Span
Br. 11	46.2	RCDG	16.2	PSC	20.0	1
Br. 13	48.9	RCDG	8.5	PSC	20.0	1
Br. 39	170.9	RCDG	19.2	PSC	30.0	2

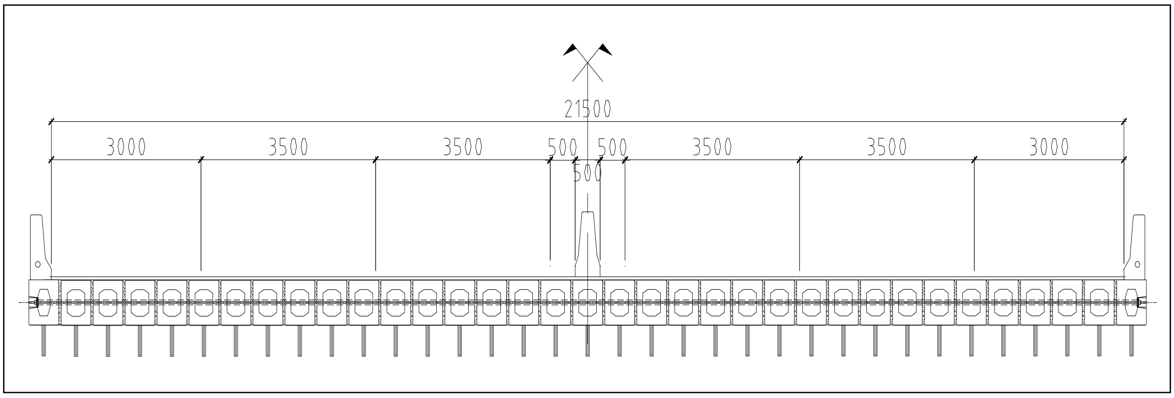


Figure 10.2-1 Typical Cross Section of Replacement Bridge

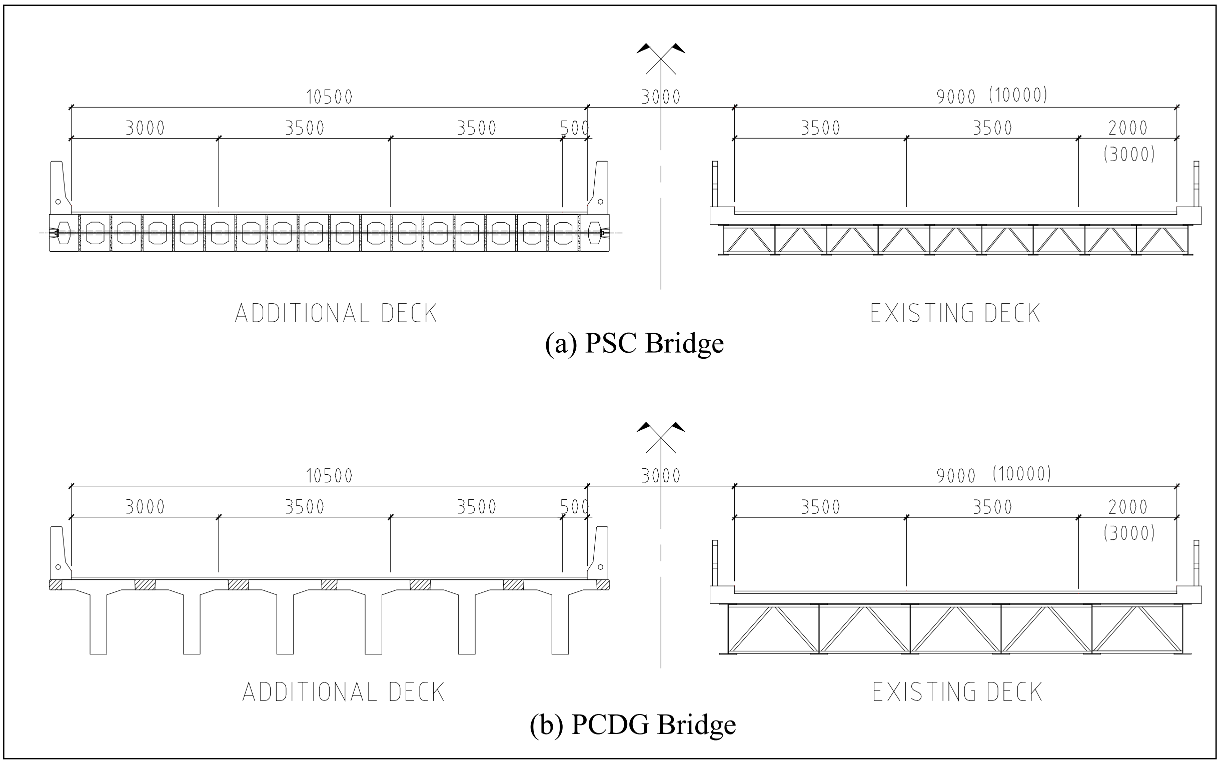
10.3 Construction of Additional Bridge

Thirteen (13) bridges are proposed to make use of the existing structure to accommodate one of the 2-lane carriageways and to construct an additional bridge to accommodate the other carriageway. Existing carriageway width are 9 m or 10 m. Existing 9 m width is less than required standard width of 10.5 m for a 2-lane. But the Survey Team proposes to keep the width of existing bridge. Because to expand width of existing bridge, reinforcement work for existing bridge will be required, and it will take large cost. And 9 m width carriageway is practicable for one direction of 4-lane road.

Type of additional bridges are selected taking the following aspects in to consideration, (i) to minimize impact on road profile, (ii) to ensure existing river clearance, (iii) to construct new pier on the same station with existing bridge, and (iv) to minimize the maintenance cost. Typical cross sections of a PSC bridge and a PCDG bridge are shown in Figure 10.3-1. An example of general view of PSC is shown in Figure 10.3-2. Other general views of bridges are shown in Appendix 10-1.

Table 10.3-1 Proposed Plan of Additional Bridges

Code	KP	Existing Bridge				Additional Bridge			
		Type	Length (m)	No. of Span	Width (m)	Type	Length (m)	No. of Span	Width (m)
Br. 7	40.6	Steel Girder	15.0	1	9.0	PSC	15.0	1	10.5
Br. 8	41.1	Steel Girder	24.0	2	9.0	PSC	25.0	1	10.5
Br. 9	41.3	Steel Girder	24.2	2	9.0	PSC	25.0	1	10.5
Br.10	41.9	Steel Girder	24.2	2	9.0	PSC	25.0	1	10.5
Br. 12	48.4	Steel Girder & RC Rahmen	21.0	4	10.4	PSC	25.0	1	10.5
Br. 13'	49.7	Steel Girder	24.0	2	9.1	PSC	25.0	1	10.5
Br. 14	58.3	Steel Girder	12.1	1	9.0	PSC	15.0	1	10.5
Br. 15	61.9	Steel Girder	24.2	2	9.0	PSC	25.0	1	10.5
Br. 16	67.8	Steel Girder	24.2	2	9.0	PSC	25.0	1	10.5
Br. 16'	72.7	Steel Girder	12.1	1	10.0	PSC	15.0	1	10.5
Br. 22	106.2	Steel Girder	91.5	3	9.1	PCDG	92.0	3	10.5
Br. 26	116.9	Steel Girder	72.1	3	10.1	PCDG	75.0	3	10.5
Br. 38	171.6	Steel Girder	42.3	3	10.1	PSC	48.0	3	10.5



(a) PSC Bridge

(b) PCDG Bridge

Figure 10.3-1 Typical Cross Section of Additional Bridge

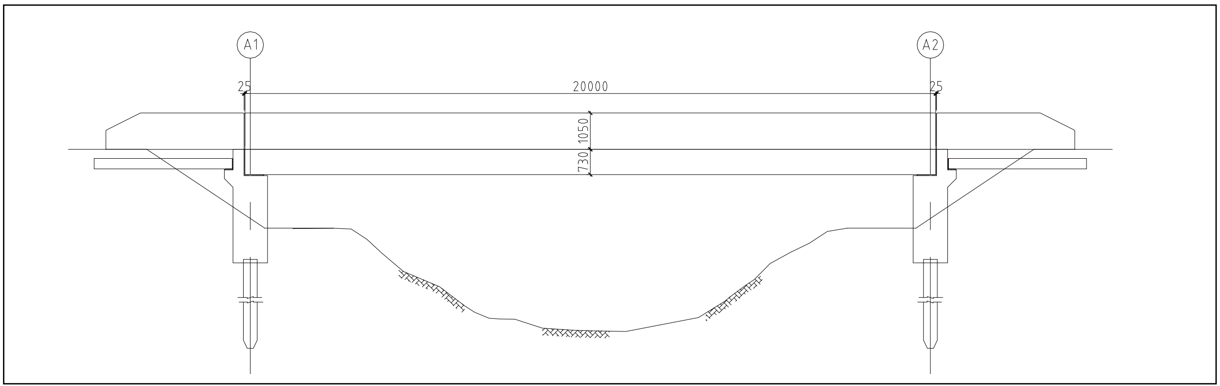


Figure 10.3-2 General View of PSC Bridge

10.4 Widening of Existing Bridge

Widening of existing bridge by adding deck slab and beam, as necessary, is proposed for 4-lane bridges. Substructure may also be widened. Such widening of bridge requires less cost because it does not demolish the existing structure but effectively utilize it. On the other hand, this method requires high-level engineering skill in execution.

This method has been practically adopted in some developed countries including Japan. On the other hand, there has been no such case in Cambodia. Thus, this Project (widening of NR 5) will become the pilot case for this method in Cambodia.

Adoption of the method requires employment of consultant(s) and contractor(s) who have sufficient experience in this method. Once this method is successfully introduced and disseminated in Cambodia, it will substantially reduce the cost of bridge widening which is foreseen in the future as further strengthening of the function of road network will become necessary to accommodate increased traffic demand which will, in turn, support future socio-economic development.

Fourteen (14) bridges of PSC deck are proposed to be widened by adding deck slab. The deck widening concept will therefore be substantially the same for all affected bridges. The deck widening concept will make use of similar section PSC units placed on extended substructure and transversely pre-stressed to the existing units of the deck Refer to Figure 10.4-1 for a typical cross-section of a widened bridge and Figure 10.4-2 for deck widening details.

Table 10.4-1 Proposed Plan of Widening Bridges

Code	KP	Existing Bridge				Widening Width (m)
		Type	Length (m)	Number of Span	Width (m)	
Br. 23	106.9	PSC	20.0	1	10.1	11.5
Br. 24	113.4	PSC	15.0	1	10.0	11.5
Br. 25	113.7	PSC	12.0	1	10.0	11.5
Br. 27	134.3	PSC	12.0	1	10.0	11.5
Br. 28	135.9	PSC	12.0	1	10.0	11.5
Br. 29	140.8	PSC	12.0	1	10.0	11.5
Br. 30	141.9	PSC	12.0	1	10.0	11.5
Br. 31	147.1	PSC	12.0	1	10.0	11.5
Br. 32	147.7	PSC	12.0	1	10.0	11.5
Br. 33	150.2	PSC	17.9	1	10.0	11.5
Br. 34	150.4	PSC	15.0	1	10.0	11.5
Br. 35	151.3	PSC	12.0	1	10.0	11.5
Br. 36	153.5	PSC	20.0	2	10.0	11.5
Br. 37	169.8	PSC	20.1	1	10.0	11.5

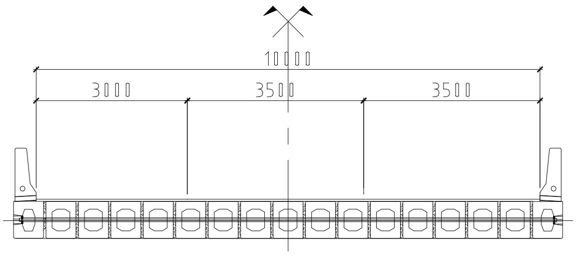
Two option are presented to achieve the extension of the transverse pre-stress for the PSC decks.

Option 1

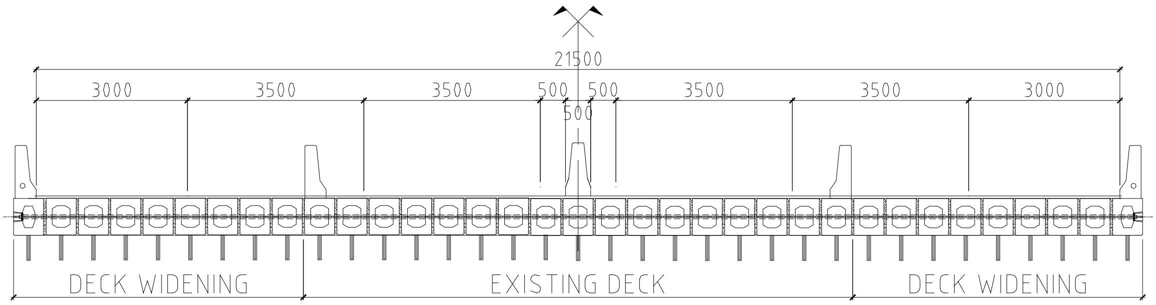
Option 1 proposes to break out the cement mortar at each anchorage recess and to use couplers to extend the pre-stressing bars. This option using couplers, may not be practicable as the length of existing threaded bar protruding beyond the anchor nut at each anchorage may not be long enough to develop sufficient pre-stress force with the coupler (extended length bars would have been used during construction to enable the pre-stressing operations and then cut back near the anchor nut) or the thread may have been damaged. A trial application of this technique is recommended prior to implementation should this option be selected.

Option 2

Option 2 proposes to construct separate superstructure connected by longitudinal joint. With this option, the additional deck can be constructed regardless of existing bridge condition. However trafficability is less preferable than Option 1, because longitudinal joint which appears on the road surface will be installed.

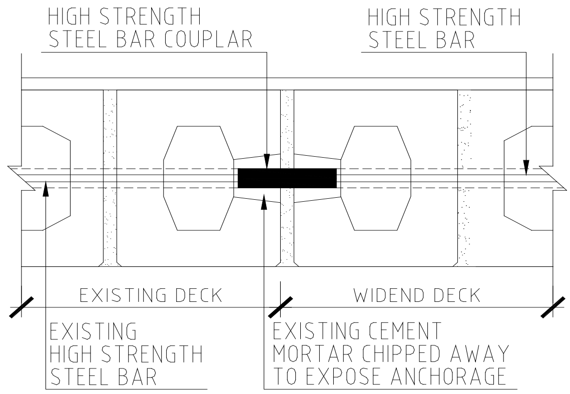


(a) Existing Condition of PSC Deck

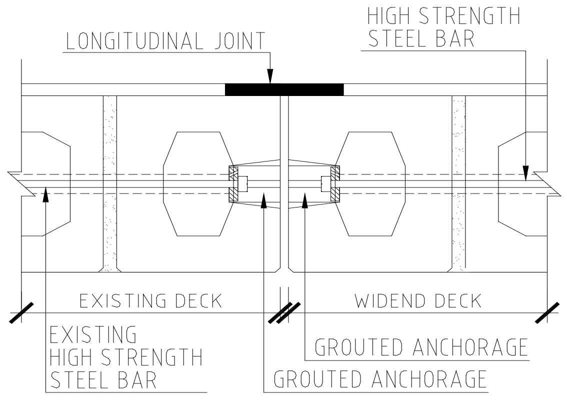


(b) Bridge Widening Condition

Figure 10.4-1 Typical Cross-Section of Widened Bridge for Full 4-Lane

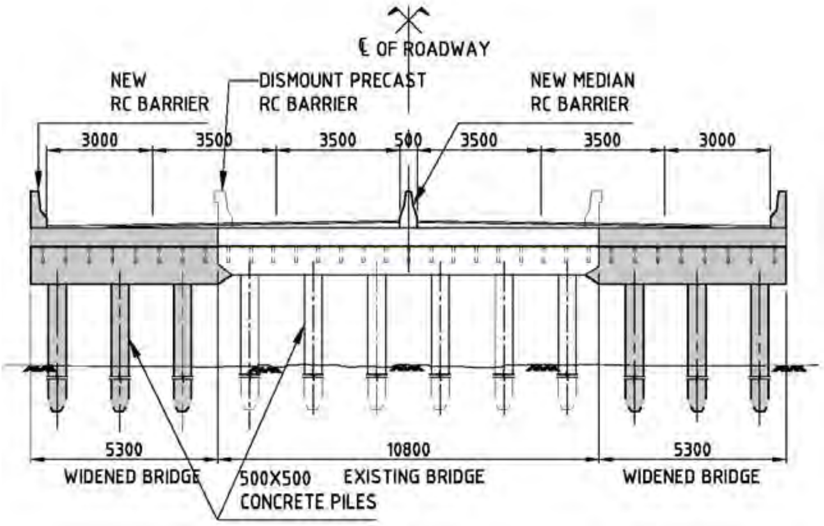


(a) Option 1 Transvers Pre-stress Extended with Couplers

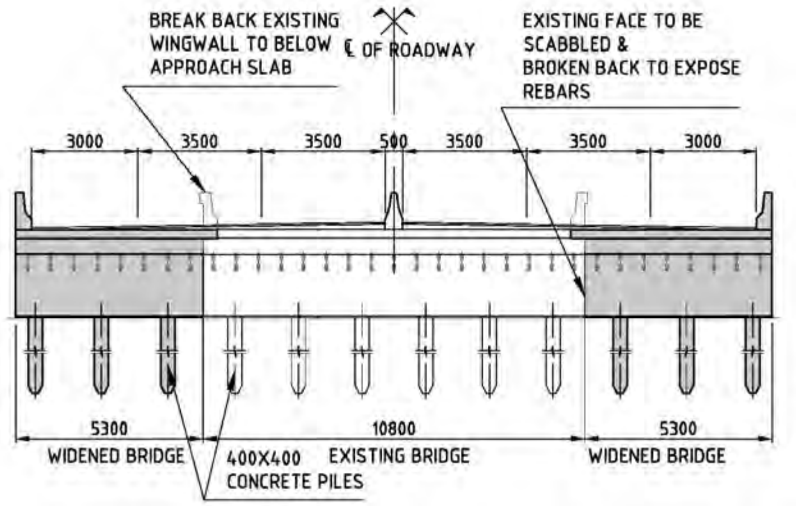


(b) Option 2 Longitudinal Joint

Figure 10.4-2 Deck Widening Connection Details for Full 4-Lane



a) Pier Widening



b) Abutment Widening

Figure 10.4-3 Typical Cross-Section of Substructure Widening for Full 4-Lane

10.5 Rehabilitation of Existing Bridge

Slope protection is damaged at five (5) bridges (Br. 7, Br. 13`, Br. 27, Br. 32, Br. 38). Stone masonry of these slope protection is sitting on sand back fill. It is suspected that sand under the stone was washed away by water flow in rainy season. The damaged part needs to be replaced with new slope protection. Figure 10.5-2 shows details of the proposed rehabilitation.

Br. 7 View on Pursat Side Abutment

Br. 13' View on Phnom Penh Side Abutment

Br. 38 View on Phnom Penh Side Abutment

Br. 38 View on Pursat Side Abutment

Br. 27 View on Pursat Side Abutment

Br. 32 View on Phnom Penh Side Abutment

Br. 32 View on Pursat Side Abutment

Figure 10.5-1 Damaged Slope Protections of Existing Bridges

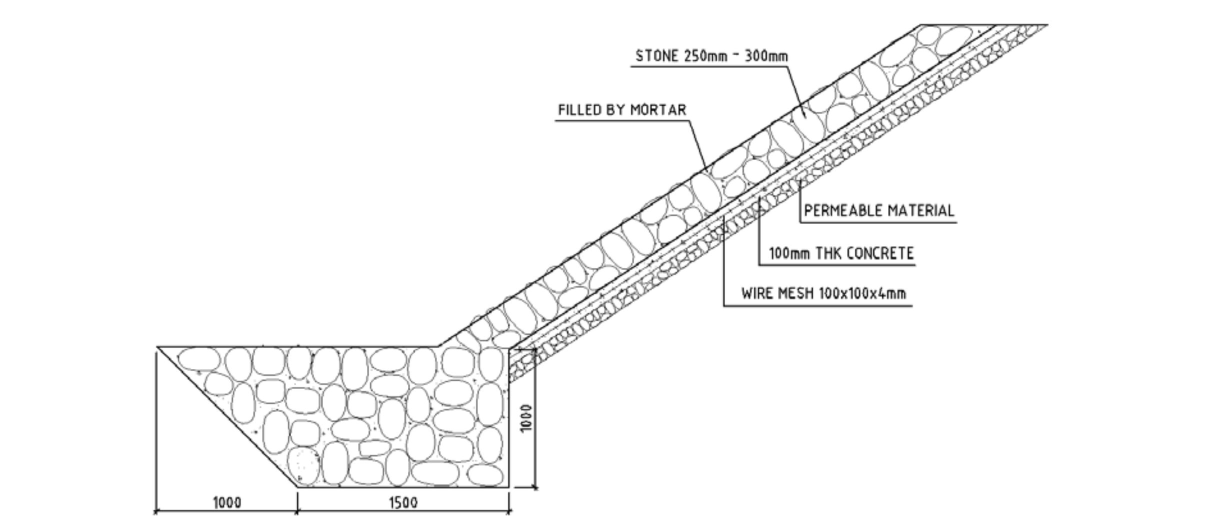
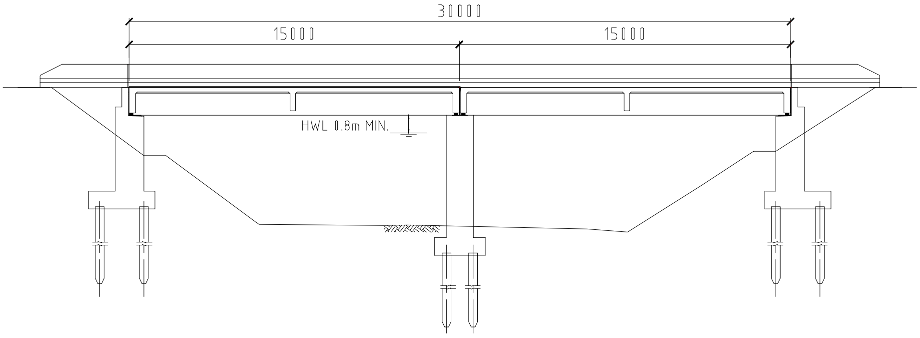


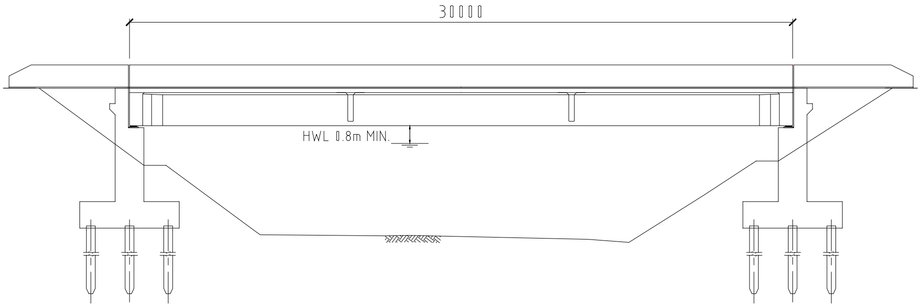
Figure 10.5-2 Repairing Method of Existing Slope Protection

10.6 Bridge on Bypass

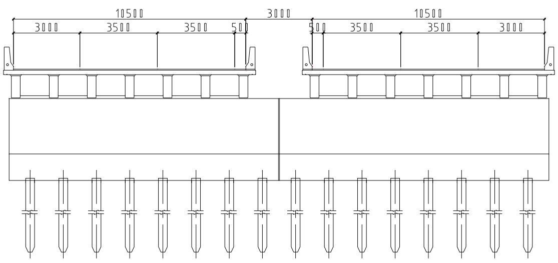
The proposed Kampong Chhnang bypass crosses a Chrey Bak River. The river is approximately 20 m in width at the crossing point. It is proposed a bridge in the order of 30 m-long be constructed to cross the river. Two alternative configurations for the bridge have been studied; a two-span RCDG structure and a single span PCDG structure. Figure 10.6-1 shows the typical sections of the two alternatives. Table 10.6-1 compares advantages and disadvantages of the two alternatives.



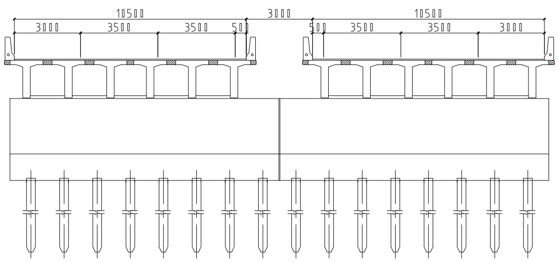
(a) Elevation of 2-Span RCDG Alternative



(b) Elevation of 1-Span PCDG Alternative



(c) Typical Section of RCDG Alternative



(d) Typical Section of PCDG Alternative

Figure 10.6-1 Elevation and Typical Section on the Bypass Bridge

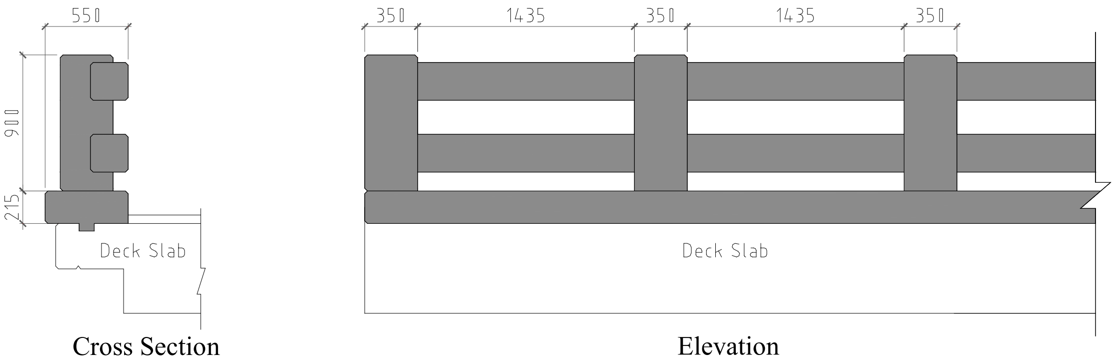
Table 10.6-1 Comparative Study of Alternatives for the River Bridge

1	2	3	4	5	6
Bridge Type	Total Length (m)	No. of Spans	Advantages	Disadvantages	Recommendation
RCDG	30	2	• Simplest form of construction • Precast RC girders can be lifted in using single small capacity cranes, without the need for launching gantries, working progressively from the river banks. • Least impact on the road profile	• Largest number of substructures to be constructed including one (1) piers required to be constructed in the river waterway • Scour hazard is greater than for the PCDG alternative • River channel is obstructed with a centrally placed pier • Longer construction period • Foundation costs are greater than for the PCDG alternative	2nd
PCDG	30	1	• Only two (2) abutments required as substructure. • River channel is substantially unobstructed • Shorter construction period • Foundations pose a lower scour hazard than the RCDG alternative • Girders provide greater support during construction to the in-situ concrete deck, requiring simpler formwork than the RCDG alternative	• Girders will require a launching gantry to put in place • Greatest depth of deck • Maximum impact on road profile	1st

10.7 Bridge Accessories

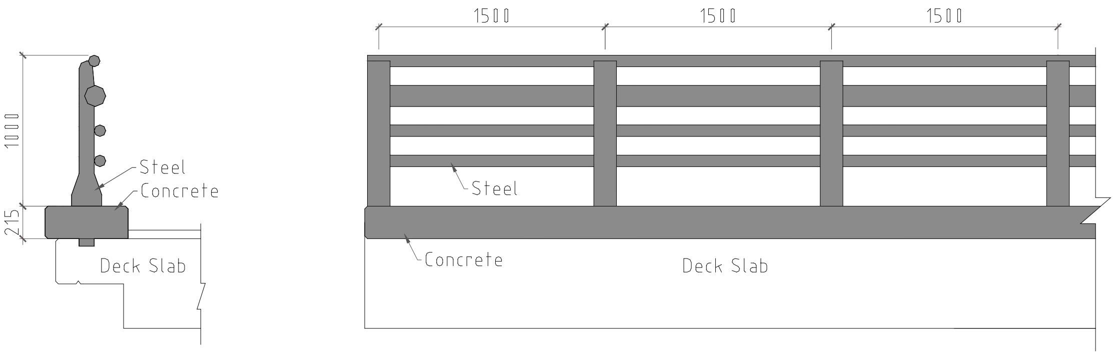
(1) Handrail

There are two (2) types of handrail which are concrete type and steel type. Concrete type handrail is heavier than steel type, but it does not need periodical painting. Thus, maintenance cost of concrete type handrail is lower than that of steel type. Concrete handrail has been proposed in “the Strengthening of Construction Quality Project” implemented by JICA. Figure 10.7-1 shows handrail.



Cross Section Elevation

(a) Concrete Type Handrail



Cross Section Elevation

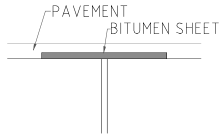
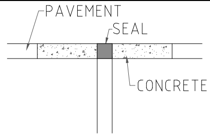
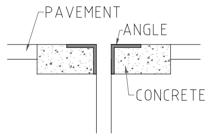
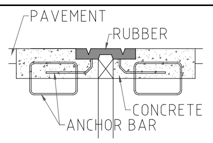
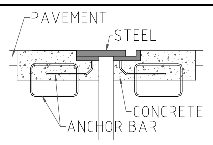
(b) Steel Type Handrail

Figure 10.7-1 Handrail

(2) Expansion Joint

Function of expansion joint is to secure smooth running for vehicles, allowing thermal expansion/contraction of bridge decks and beams. Expansion joints of existing bridge are steel angle type or joint less type. Table 10.7-1 shows five (5) types expansion joint.

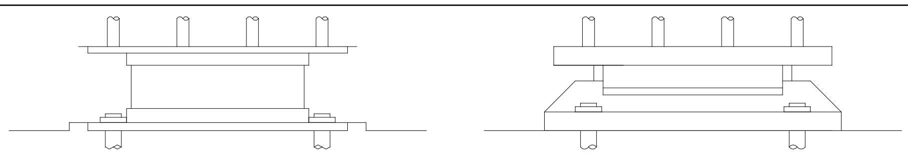
Table 10.7-1 Typical Type of Expansion Joint

Type	Movement (mm)	Type of Bridge	Cross Section
Joint Less Type	≦ 20	RC , PC	
Sealing Type	≦ 50	RC, PC, Steel	
Steel Angle Type	≦ 50	RC, PC, Steel	
Rubber Type,	20~100	RC, PC, Steel	
Steel Plate Type	20~1000	RC, PC, Steel	

Joint Less Type and Sealing Type and Steel Angle Type are proposed for the bridges on the South Section. Because movement of the planed bridges on the South Section are less than 50 mm, and these type expansion joints can be repaired without special parts or technique.

(3) Bridge Bearing

Bearing structure is classified to 2 types which are rubber type and steel type. Rubber type bearing is superior to steel type with regard to maintenance and seismo-resistance. Steel type is used for large movement bridge. Figure 10.7-2 shows cross section of rubber type bearing and steel type bearing.



(a) Rubber Type Bearing (b) Steel Type Bearing

Figure 10.7-2 Cross Section of Bridge Bearing

(4) Aseismatic Connector

There are many type of aseismatic connector. Anchor bar type aseismatic connector is proposed in “the Strengthening of Construction Quality Project” implemented by JICA. This type is suitable for new concrete bridge. Figure 10.7-3 shows anchor bar type aseismatic connector.

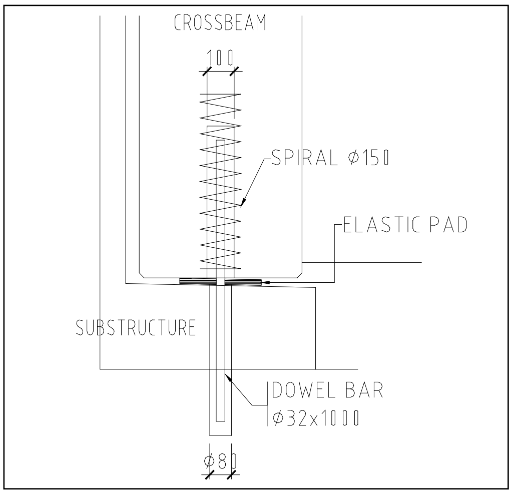


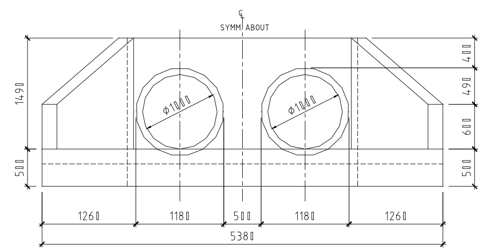
Figure 10.7-3 Anchor Bar Type Aseismatic Connector

10.8 Waterway Opening

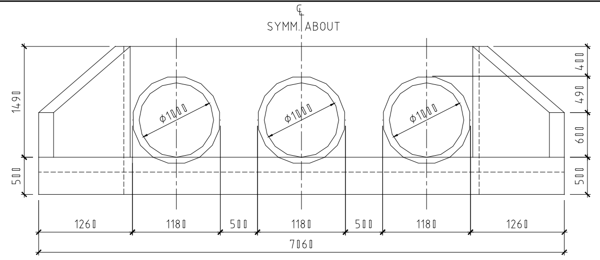
Existing waterway opening length in some sections are insufficient. These section need to be constructed additional waterway opening. Pipe culvert or box culver need to be constructed to make waterway opening in these sections. Figure 10.8-1 shows pipe culvert and box culvert.

Table 10.8-1 Estimated Waterway Opening

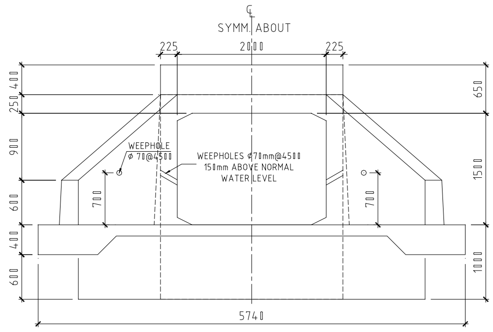
Grouping No.	Drainage Facilities	Waterway Opening (m)	Current Opening (m)	Stretched Bridge Length (m)	Insufficient Opening (m)	Note
1	Br. 05	48	8	-	40	Out of project area
3	Br. 12~13, Bc. 06~07	82	49	10 (Br13)	23	
5	Br. 14, Bc. 19~23	44	42	-	2	
8	Br. 20, Bc. 24	28	10	-	18	Out of project area
15	Br. 26, Bc. 31	111	83	-	28	
19	Br. 37~39, Bc. 52~53	87	78	10 (Br39)	-	



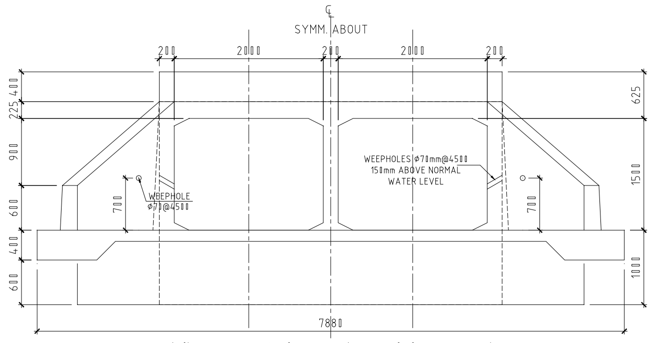
(a) Pipe Culvert (Double Type)



(b) Pipe Culvert (Triple Type)



(c) Box Culvert (Single Type)



(d) Box Culvert (Double Type)

Figure 10.8-1 Culvert

CHAPTER 11 COST ESTIMATION

11.1 Construction Cost

As described in Chapter 8, South Section is divided into 5 sections, shown in Figure 11.1-1 below. Table 11.1-1 details start and end point of each section with length.

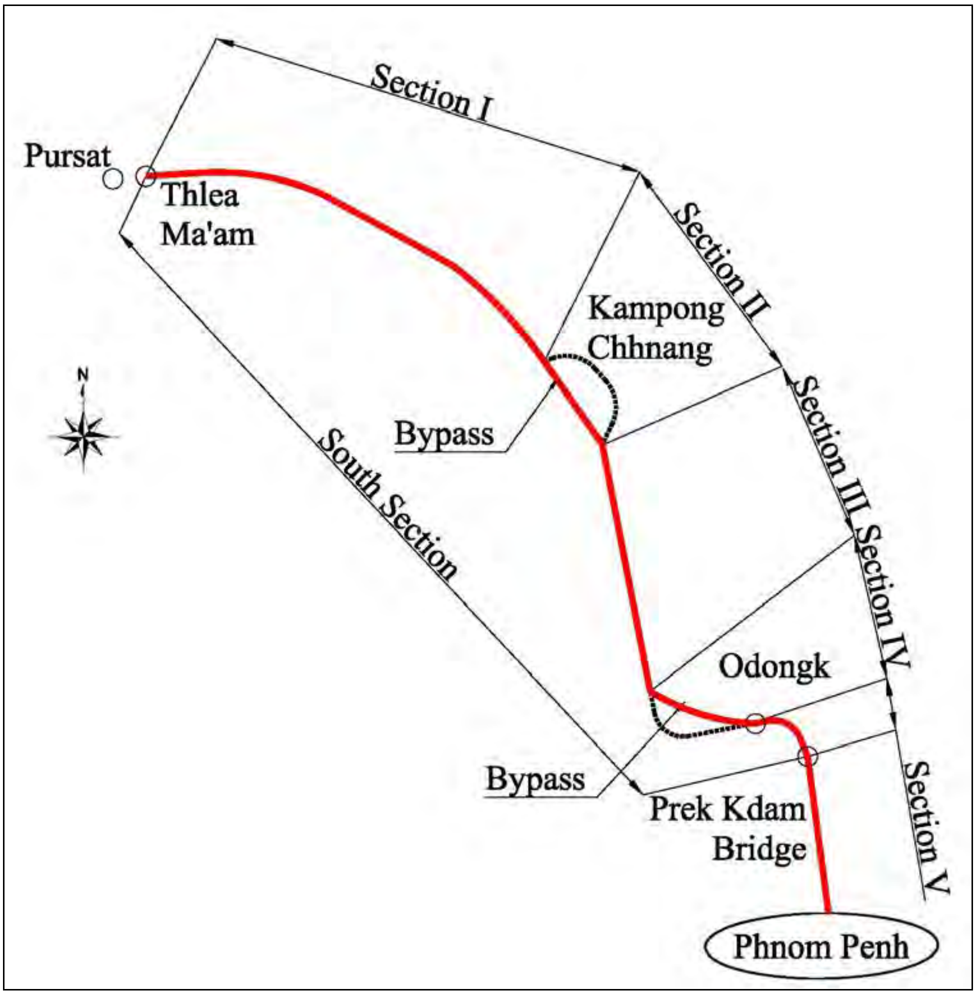


Figure 11.1-1 Map of Sections

Section I starts at Thlea Ma'am and ends at north of Kampong Chhnang City and Section II is Kampong Chhnang Bypass connecting NR 5 between north and south of Kampong Chhnang City. In same token, Section III starts at south of Kampong Chhnang City and ends at north of Odongk Town and Section IV is Odongk Bypass connecting NR 5 between north and east of Odongk Town. Section V starts at east of Odongk Town and ends at Prek Kdam Bridge. Start points and end points of these sections are as presented in the Table 11.1-1.

Table 11.1-1 Start Point and End Point of Sections

Section	Description	Start Point	End Point	Length (km)
I	Thlea Ma'am to Kampong Chhnang	Thlea Ma'am	Intersection of NR 5 with Kampong Chhnang Bypass in the north of Kamong Chhnang City	73.0
II	Kampong Chhnang Bypass	Intersection of Kampong Chhnang Bypass with NR 5 in the north of Kampong Chhnag City	Intersection of Kampong Chhnang Bypass with NR 5 in the south of Kampong Chhnag City	11.8
III	Kampong Chhnang to Odongk	Intersection of NR 5 with Kampong Chhnang Bypass in the south of Kampong Chhnang City	Intersection of NR 5 with Odongk Bypass in the north of Odongk Town	41.4
IV	Odongk Bypass	Intersection of Odongk Bypass with NR 5 in the north of Odongk Town	Intersection of Odongk Bypass with NR 5 in the east of Odongk Town	4.9
V	Odongk to Prek Kdam Bridge	Intersection of NR 5 with Odongk Bypass in the east of Odongk Town	Prek Kdam Bridge	4.3

The sections to be actually implemented are to be selected through the consultation between the Royal Government of Cambodia (RGC) and the Japan International Cooperation Agency (JICA) in the appraisal process of the Project.

11.1.1 Cost Estimate

The main points of estimation of construction cost are as listed below:

(a) Costs are computed in United State Dollars (US$). This is applied to both of Foreign Currency Portion and Local Currency Portion. Although official local currency is Khmer Riel (KHR), US$ is widely used in actual business and trades.

(b) Costs are computed with prices in the year 2013.

(c) Exchange rates of US$ 1 = JPY 97.9 (as of November 2013) are used for cost estimation, as necessary.

(d) Costs are computed for Section I, II, III, IV and V respectively.

(e) Costs of civil works are computed based on the basic rates collected in Cambodia and counterchecked with experiences in similar projects in the past in Cambodia after adjusting to fit to the Project.

(f) Materials and equipment not available in Cambodia, such as cement, reinforcement, pc strand, guardrails, street light, precast beam launching system and fuel are assumed to be imported into Cambodia.

Referring to the Chapter 9 and 10, scope of work and quantities of major works in each section are shown below.

Table 11.1-2 Work Scope in Each Section

Major works	Section I	Section II	Section III	Section IV	Section V
Road length	73.0 km	11.8 km	41.4 km	4.9 km	4.3 km
Road width	23.0 m & 28.0 m	23.0 m	23.0 m	23.0 m	23.0 m & 28.0 m
Pipe culvert	60 no.	40 no.	30 no.	5 no.	-
Box culvert	28 no.	5 no.	21 no.	9 no.	-
Bridge	18 no. to be rehabilitated	1 no. to be constructed	12 no. to be rehabilitated	-	-

In addition, two typical cross sections are adopted in Section I and V as explained in Chapter 9.

Table 11.1-3 Typical Cross Section Used in Section I and V

Type	Road width	Length
Rural Section	23.0 m	71 km in Section I, 41.4 km in Section III and 3.3 km in Section V
Urban Section	28.0 m	2 km in Section I and 1 km in Section V

Based on the consideration as stated above and quantities of work components taken off, unit prices for road works, culvert works and bridge works are computed. The unit prices thus estimated are as shown below.

Table 11.1-4 Unit Price of Works

Closed due to confidentiality

With the above data (quantities and rates), the construction costs are computed as below.

Table 11.1-5 Summary of Construction Cost

Closed due to confidentiality

For reference, major rates are compared with similar projects in the past and shown below. According to the comparison table, the rates in South Section are situated in-between. In addition, comparison of contractual components with similar projects in the past is provided in Section 11.8.

Table 11.1-6 Comparison of Basic Rates in Similar Projects

Closed due to confidentiality

11.2 Consultancy Services

Consultancy services are required to support the implementing agency in all phases of the Project, such as the engineering study stage, tender stage and construction stage.

It is recommended that the consultancy services in all phases of the Project shall be carried out by a consultant employed through the selection procedure of consultant as indicated in the Implementation Schedule of Table 12.3-2. It should be noted that arrangement of consultant shall be subject to the discussions between the RGC and JICA.

Major tasks to be undertaken by the consultant, including professional assignment schedule, are described below.

11.2.1 Major Tasks to be Undertaken by Consultant

(1) Scope of Work

Scope of work for consultant consists of the following tasks.

(a) Engineering study and basic/detail design

(b) Project Master Program

(c) Preparation of tender documents for construction

(d) Assistance to the Employer in bidding and bid evaluation

(e) Construction supervision

(f) Inspection for provisional hand over

(g) Inspection for final hand over

(h) Training to Cambodian engineers

(i) Research of cultural heritage, if any

(2) Detailed Task Requirements

Above tasks are undertaken in two major stages, namely, engineering study stage, and selection of contractors and construction supervision stage. Detailed task requirements of each stage are as listed below.

A. Engineering Study Stage

Task 1-1. Review the previous and on-going related studies and data collected.

Task 1-2. Conduct traffic survey.

Task 1-3. Analyze the traffic demand forecast and capacity requirement.

Task 1-4. Field survey and investigation

a. Alignment investigation, topographic survey and mapping.

b. Soil condition, geological data, water level and deep well impact.

c. River, canal, drainage networks, etc.

d. ROW adjacency.

e. Utilities survey.

f. Road traffic survey for traffic management planning during construction.

g. Hydrological survey.

h. Survey on cultural/historic heritage and archaeological survey.

Task 1-5. Assist the Employer in processing, monitoring and reporting on land acquisition

a. Resettlement plan and procedure for land arrangements.

b. Land acquisition plan and resettlement action plan (LAP/RAP).

c. LAP/RAP monitoring and report.

d. Temporary land arrangement.

e. Assist the Employer in public consultation.

Task 1-6. Prepare the construction arrangement plan

a. Land for construction activities (permanent and temporary).

b. Utilities relocation, removal or protection.

c. Traffic management plan and road detour/alternative road design.

d. Public relation and stakeholder socialization materials.

Task 1-7. Design standards and design criteria.

Task 1-8. Prepare detail design for civil works (road, structures etc.).

Task 1-9. Review road design in view of traffic safety.

Task 1-10. Review and update the project master program.

Task 1-11. Review the environmental impact assessment (EIA) and conduct supplemental EIA.

Task 1-12. Prepare tender documents including pre-qualification documents.

Task 1-13. Cost estimation by tender packages.

Task 1-14. Public relation.

Task 1-15. Training on design and tendering to Cambodian engineers.

Task 1-16. Research of cultural heritage, including review of archives during design stage

B. Selection of Contractors & Construction Stage

Task 2-1. Selection of contractors

a. Pre-qualification of bidders, including invitation for pre-qualification.

b. Tender call and pre-tender conference.

c. Tender evaluation and clarification.

d. Contract negotiations and contracting.

Task 2-2. Establish project management system.

Task 2-3. Review the contractors submittals and design interface.

Task 2-4. Site inspection and factory inspection.

a. Confirm to use/follow approved materials, drawings, working methods and schedule.

b. Confirm to follow approved quality control system.

c. Confirm to follow approved mitigation of environmental impact.

d. Confirm third party safety.

e. Confirm to follow health and safety plan.

f. Confirm to follow traffic management plan.

Task 2-5. Public relation during construction.

Task 2-6. Monitor environment management plan.

Task 2-7. Issue interim payment certificates.

Task 2-8. Review and report for alteration, variation and solution of disputes.

Task 2-9. Initiate meetings and reports.

Task 2-10. Review and inspect road in view of traffic safety.

Task 2-11. Inspect testing and as-built drawings at completion.

Task 2-12. Prepare guideline for HIV/AIDS protection activities.

Task 2-13. Inspect and report during defects liability period.

Task 2-14. Inspect testing for final hand over.

Task 2-15. Training to Cambodian engineers and administrators on tendering, contract management, construction management and maintenance of road.

Task 2-16. Research of cultural heritage at the commencement of construction

11.2.2 Consultant Assignment Schedule

Based on the tasks to be undertaken by the consultant, professional assignment schedule is proposed as shown in the Tables 11.2-1 and 11.2-2 for the engineering study and for the selection of contractors and construction supervision, respectively.

Table 11.2-1 Assignment Schedule for Engineering Study

	title	2015	2016	2017	2018	2019	2020	2021	2022	total
Basic Design, Detail Design and Preparation of Tender Document (International)										
1	Project Manager	8	-	-	-	-	-	-	-	8
2	Road & Pavement Expert	9	-	-	-	-	-	-	-	9
3	Structure Expert	8	-	-	-	-	-	-	-	8
4	Hydrological & Hydraulic Expert	8	-	-	-	-	-	-	-	8
5	Construction Planner	8	-	-	-	-	-	-	-	8
6	Cost Estimate Expert	7	-	-	-	-	-	-	-	7
7	Specification/Quality Management Expert	7	-	-	-	-	-	-	-	7
8	HIV/AIDS Protection Campaign Expert	2	-	-	-	-	-	-	-	2
9	Traffic Demand Forecast Expert	2	-	-	-	-	-	-	-	2
10	Traffic Safety Expert	1	-	-	-	-	-	-	-	1
11	Social Environment Expert	3	-	-	-	-	-	-	-	3
12	Natural Environment Expert	1	-	-	-	-	-	-	-	1
13	Capacity Development Expert	2	-	-	-	-	-	-	-	2
14	Cultural Heritage Research Expert	1	-	-	-	-	-	-	-	1
	Total	67	-	-	-	-	-	-	-	67
Basic Design, Detail Design and Preparation of Tender Document (Local)										
1	Deputy Project Manager	7.5	-	-	-	-	-	-	-	7.5
2	Civil Engineer - 1	9	-	-	-	-	-	-	-	9
3	Civil Engineer - 2	9	-	-	-	-	-	-	-	9
4	Civil Engineer - 3	9	-	-	-	-	-	-	-	9
5	Civil Engineer - 4	5	-	-	-	-	-	-	-	5
6	Geotechnical Engineer	6	-	-	-	-	-	-	-	6
7	Hydrological & Hydraulic Engineer	6	-	-	-	-	-	-	-	6
8	Traffic Management Engineer	6	-	-	-	-	-	-	-	6
9	Utilities Management Engineer	6	-	-	-	-	-	-	-	6
10	Cost Engineer - 1	5.5	-	-	-	-	-	-	-	5.5
11	Cost Engineer - 2	5	-	-	-	-	-	-	-	5
12	Specification Engineer	6	-	-	-	-	-	-	-	6
13	Quality Management / Safety Engineer	6	-	-	-	-	-	-	-	6
14	HIV/AIDS Protection Campaign Assistant	2	-	-	-	-	-	-	-	2
15	Traffic Demand Forecast Assistant	3	-	-	-	-	-	-	-	3
16	Social Environment Engineer	5	-	-	-	-	-	-	-	5
17	Natural Environment Engineer	1	-	-	-	-	-	-	-	1
18	Cultural Heritage Research Assistant	2	-	-	-	-	-	-	-	2
	Total	99	-	-	-	-	-	-	-	99

Table 11.2-2 Assignment Schedule for Selection of Contractors and Supervision

title		2015	2016	2017	2018	2019	2020	2021	2022	total
Tender Process and Construction Stage (International)										
1	Project Manager	4	11	11	11	10	1	1	-	49
2	Road & Pavement Expert	-	6	11	11	9	-	-	-	37
3	Structure Expert	-	6	11	11	9	-	-	-	37
4	Hydrological & Hydraulic Expert	-	3	12	-	-	-	-	-	15
5	Construction Planner	-	5	11	11	9	-	-	-	36
6	Cost Estimate Expert	-	6	11	11	9	1	-	-	38
7	Specification/Quality Management Expert	-	5	11	11	-	-	-	-	27
8	Traffic Safety Expert	-	-	-	-	1	-	-	-	1
9	HIV/AIDS Protection Campaign Expert	-	1	2	-	-	-	-	-	3
10	Social Environment Expert	-	4	1	1	-	-	-	-	6
11	Natural Environment Expert	-	2	1	1	-	-	-	-	4
12	Capacity Development Expert	-	2	2	2	1	-	-	-	7
13	Cultural Heritage Research Expert	-	2	-	-	-	-	-	-	2
Total		4	53	84	70	48	2	1	-	262
Tender Process and Construction Stage (Local)										
1	Deputy Project Manager	4.5	12	12	12	11	1	1	-	53.5
2	Civil Engineer - 1	-	6	12	12	11	-	-	-	41
3	Civil Engineer - 2	-	6	12	12	9	-	-	-	39
4	Civil Engineer - 3	-	3	12	12	9	-	-	-	36
5	Civil Engineer - 4	-	3	12	10	-	-	-	-	25
6	Geotechnical Engineer	-	4	12	10	-	-	-	-	26
7	Hydrological & Hydraulic Engineer	-	3	9	-	-	-	-	-	12
8	Traffic Management Engineer	-	3	9	6	-	-	-	-	18
9	Utilities Management Engineer	-	4	12	9	-	-	-	-	25
10	Cost Engineer - 1	1.5	9	12	12	11	1	-	-	46.5
11	Cost Engineer - 2	-	3	12	12	9	-	-	-	36
12	Specification Engineer	1	8	12	12	11	-	-	-	44
13	Quality Management & Safety Engineer	1	8	12	12	11	-	-	-	44
14	Resident Engineer for Section I	-	3	12	12	11	1	-	-	39
15	Deputy Resident Engineer for Section I	-	3	12	12	9	-	-	-	36
16	Resident Engineer for Section II - V	-	3	12	12	11	1	-	-	39
17	Deputy Resident Engineer for Section II - V	-	3	12	12	9	-	-	-	36
18	HIV/AIDS Protection Campaign Assistant	-	3	5	-	-	-	-	-	8
19	Social Environment Engineer	-	9	4	3	3	-	-	-	19
20	Natural Environment Engineer	-	2	1	1	1	-	-	-	5
21	Cultural Heritage Research Assistant	-	2	-	-	-	-	-	-	2
Total		8	100	208	183	126	4	1	-	630

11.2.3 Roles of Professional Staff

Roles of professionals are summarized in the Table below.

Table 11.2-3 Roles of Professionals

Professionals	Role of Professionals during Engineering Study, Selection of Contractors and Supervision
[International Professional]	
Project Manager	Overall management during engineering study, contractor selection and supervision stage
Road & Pavement Expert	Plan, survey, design and control on construction of road and pavement
Structure Expert	Plan, survey, design and control on construction of road structure
Hydrological & Hydraulic Expert	Plan, survey and design of hydrology and hydraulics of project site, including catchment area
Construction Planner	Plan and scheduling of overall construction (road and structure etc.)
Cost Estimate Expert	Calculation and analysis of project progress, costs and variations
Specification/Quality Management Expert	Compilation of specification and review & control on quality and safety
HIV/AIDS Protection Campaign Expert	Campaign and public relation on HIV/AIDS protection
Traffic Demand Forecast Expert	Conduct of traffic survey and computation of traffic demand forecast
Traffic Safety Expert	Review of traffic safety during design stage as well as construction stage prior to traffic opening
Social Environment Expert	Review of EIA, conduct of supplemental assessment during engineering stage and guide for monitor of environmental management plan during construction
Natural Environment Expert	Review of EIA, conduct of supplemental assessment during engineering stage and guide for monitor of environmental management plan during construction
Capacity Development Expert	Plan and conduct of training to Cambodian engineers
Cultural Heritage Research Expert	Review of archives of cultural heritage and conduct of field research on it during design stage and at the commencement of construction
[Local Professional]	
Deputy Project Manager	Overall management and assistance of project manager
Civil Engineer	Plan, survey, design and control on construction of road, pavement and structures Assisting the expert
Geotechnical Engineer	Plan, survey, design and review on plans submitted in regard to geotechnical matters Assisting the expert
Hydrological & Hydraulic Engineer	Plan, survey and design of hydrology and hydraulics of project site, including catchment area Assisting the expert
Traffic Management Engineer	Survey and plan of traffic management and review of those submitted Assisting the expert
Utilities Management Engineer	Survey and plan of utilities relocation etc. and review of utilities management plan submitted Assisting the expert
Cost Engineer	calculation & analysis of construction costs and assisting the expert
Specification Engineer	Compilation of specification and review & control on specification Assisting the expert
Quality Management & Safety Engineer	Compilation of requirements in regard to quality & safety and review & control on them Assisting the expert
Resident Engineer for Section I	Review on construction plan submitted and check & inspection on daily activities on site in Section I
Deputy Resident Engineer for Section I	Assisting resident engineer in Section I
Resident Engineer for Section II - V	Review on construction plan submitted and check & inspection on daily activities on site in Section II - V
Deputy Resident Engineer for Section II - V	Assisting resident engineer in Section II - V
HIV/AIDS Protection Campaign Assistant	Campaign and public relation on HIV/AIDS protection Assisting the expert
Traffic Demand Forecast Assistant	Conduct of traffic survey and assisting computation of traffic demand forecast
Social Environment Engineer	Assisting the expert for review of EIA, conduct of supplemental assessment during engineering stage and monitor of environmental management plan during construction
Natural Environment Engineer	Assisting the expert for review of EIA, conduct of supplemental assessment during engineering stage and monitor of environmental management plan during construction
Cultural Heritage Research Assistant	Assisting the expert for review of cultural heritage and conduct of field research on it during design stage and at the commencement of construction

11.2.4 Organization of Consultant

Consultant organization during the engineering study, selection of contractors and supervision stage are indicated below.

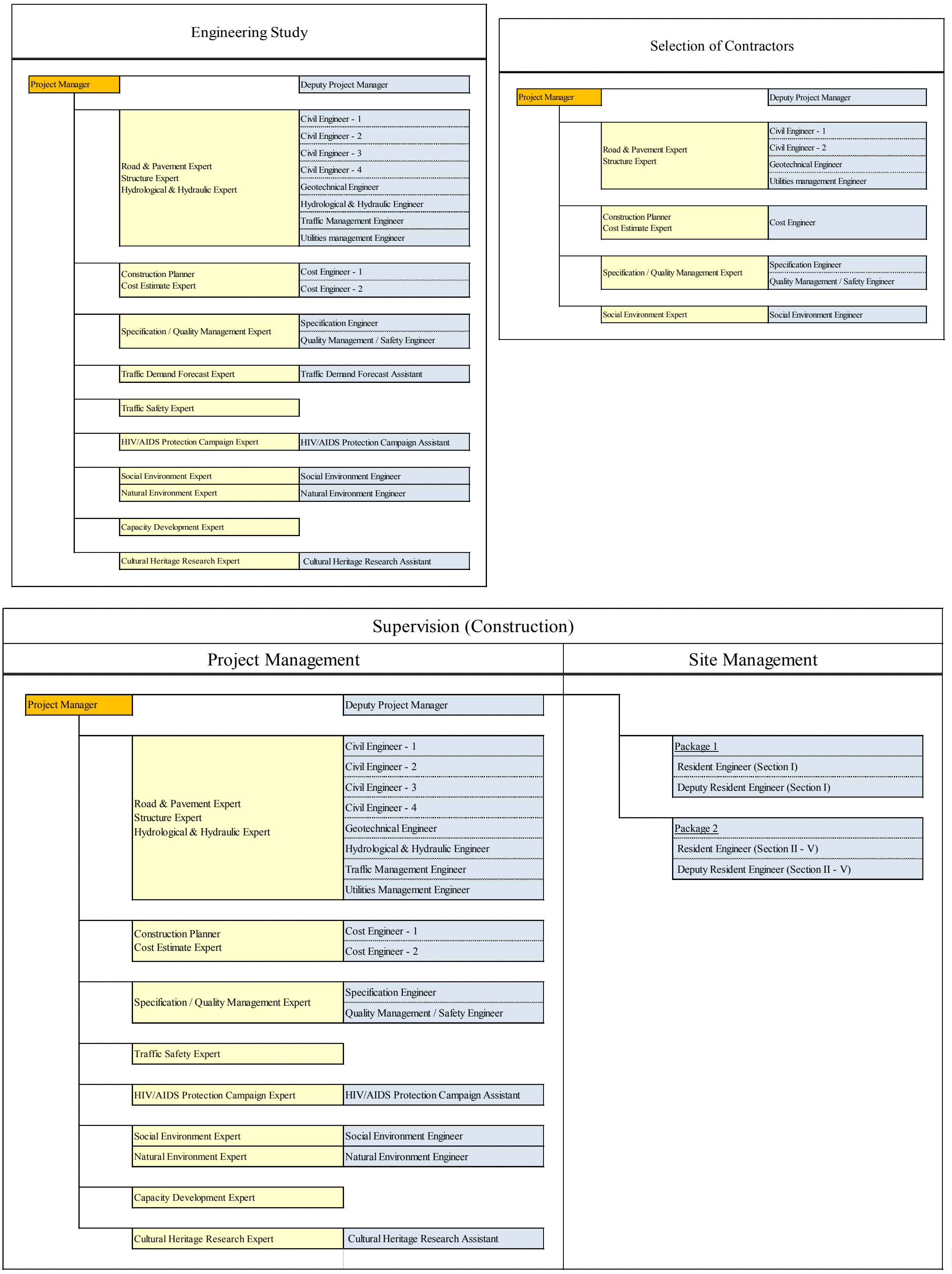


Figure 11.2-1 Organization of Consultant

11.2.5 Cost of Consulting Services

With the above schedule of professionals (international and local), costs of consulting services are computed.

In addition, it is recommended that training to technical and administrative staff in MPWT be conducted under the consultancy services in order to develop their capacity for designing, tendering, contract management, construction management and maintenance of roads as well as public relation and public consultation.

There are two schemes for the training, which are on the job training (OJT) etc. in Cambodia and technical training in developed countries, such as Japan. The former is the OJT and regular workshops during the engineering study, selection of contractors and supervision stage in Cambodia and the latter is proposed several times of overseas training. The cost for the latter is calculated assuming training in Japan with total 20 staff.

Total cost for consulting services including the training mentioned above is shown below.

Table 11.2-4 Cost of Consulting Services

Closed due to confidentiality

11.3 Cost Born by the RGC

Costs born by the Royal Government of Cambodia (RGC) are those for the following items.

(a) Land Acquisition and Resettlement Cost

(b) Utilities Relocation, Removal and/or Protection Cost

(c) Detection and Removal Cost of Mines and UXOs

(d) Taxes

(e) Administration Cost

It is to note that the above items shall be undertaken by the RGC and special attention shall be paid by the RGC and JICA (also by the consultant) not to hinder the progress of the Project due to insufficiency of budget for those items to be prepared by the RGC.

11.3.1 Land Acquisition and Resettlement Cost

Based on what is written in Chapter 16 and 17, the land acquisition and resettlement cost are estimated as shown below.

Table 11.3-1 Land Acquisition and Resettlement Cost

Closed due to confidentiality

11.3.2 Cost of Relocation, Removal and/or Protection of Utilities

Various utilities, such as electric and telephone cables with posts, have been installed along the National Road 5 and some of them need to be relocated for the Project, depending on the final design. Underground utilities such as water pipes, optic cables and electric cables are also found, being attached to the bridges. Photo 11.3-1 shows certain utilities hung at bridges. Hence, some of underground utilities need to be relocated and/or replaced for the Project, depending on the final design of the Project, too. Those buried near bridges (which shall be replaced or widened) definitely need to be removed and re-installed.

These utilities above ground and/or underground are detailed in Section 4.6.

Figure 11.3-1 Utilities at Bridges

The JICA Team has discussed the matters with the counterparts and it was confirmed as current practice in Cambodia that these relocations, removals and/or protections be carried out by relevant organizations with the Government fund, unless those were laid illegally.

It is difficult to compute the magnitude of this task in the Project at this stage and referring to the past results for utilities relocation, removal and/or protection in road widening projects, cost per km for the Project is allowed xxxxxxxxxxxxxx (similar to those in NR 1 phase 1 to 3) for whole stretch of NR 5 widening (Section I, III and V) and 10% of length of two bypasses (Section II and IV) because of new road.

Table 11.3-2 Utilities Relocation, Removal and/or Protection Cost

Closed due to confidentiality

11.3.3 Cost of Detection and Removal of Mines and UXOs

In accordance with the Minutes of Discussion on the Preparatory Survey for NR 5 Rehabilitation Project between JICA and MPWT, clearance of landmines and UXOs was carried out for Kampong Chhnanng Bypass (Section II) and Odongk Bypass (Section IV), whereas clearance has not been done for widening part of NR 5 between Thlea Ma'am and Prek Kdam Bridge (Section I, III and V). The clearance for Section I, III and V shall be carried out before construction work commence. The cost for this part is computed with same basis of Section II and IV carried out.

Table 11.3-3 Detection and Removal Cost of Mines and UXOs

Closed due to confidentiality

11.3.4 Taxes

In cost estimation for taxes, value added tax for the project are calculated and summarized as shown in Table 11.5-1.

11.3.5 Administration Cost

Organization of the Employer for the Project is being established, the details of which are described in Section 12.2.1. Because there may be cultural heritage around Odongk Town, cultural heritage research would be carried out and administrative matters in this regard shall be taken care with this organization.

Following the past cases of Yen Loan projects, the cost of administration is assumed at 1.64% of the total of construction cost, consultancy services and other costs.

11.4 Escalation

Escalation factors are applied to the project cost, as it is computed with the prices in year 2013.

(a) Different escalation factors are applied on the foreign currency portion and local currency portion although both are estimated in US$. xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx is used for foreign currency portion and xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx is used for local currency portion, considering the averaging price escalation in the past few years.

(b) Project cost is computed in US$ and the escalation factor for foreign currency is applied on the items directly related to international market prices like imported materials, fuel, major construction equipment and systems etc. and the escalation factor for local currency is applied on those related to domestic market prices like workers, earthwork and quarry material.

11.5 Summary of Project Cost

The summary of project cost computed in Sections 11.1 to 11.4, is shown below.

Table 11.5-1 Summary of Project Cost

Closed due to confidentiality

11.6 Annual Progress

Annual progress is calculated by expanding project cost to each year in accordance with the implementation schedule discussed in Section 12.3. Then, escalation factors for foreign currency xxxxxxxxxxx and local currency xxxxxxxxxxx are applied to the amount of each year.

Annual progress, after applying escalation factor, is shown below.

Table 11.6-1 Annual Progress

Closed due to confidentiality

It is to note that annual progress for the RGC will be heavy in the first few years due to land acquisition and resettlement and JICA Team reminds that sufficient budget shall be arranged by the

RGC in each year, particularly in the first few years. As land acquisition and resettlement are pre-requisite to commencement of construction, special attention on progress of land acquisition and resettlement in the years 2015 and 2016 shall be paid.

11.7 Repayment Schedule

JICA loan conditions applying to Cambodia are as follows.

- Interest rate : 0.01%
- Repayment period : 40 years
- Grace period : 10 years

As shown in Table 11.6-1 Annual Progress, loan will be commenced in the year 2015 and the total cumulative amount including interest at the end of grace period is calculated below.

Table 11.7-1 Loan Amount in Grace Period

Closed due to confidentiality

After the grace period, repayment shall be started with equal amount with interest and the amount per year is calculated with the following formula.

$$\text{Repayment per Year} = \frac{P \times I}{1-(1+I)^{-t}}$$

Where 'P' is total amount at the end of grace period, 'I' is interest rate and 't' is repayment period.

With the above formula, repayment is calculated approximately xxxxxxxxxxxxxxx per year in thirty years from 2025 till 2054.

11.8 Contract Package and Contract Conditions

There are five sections in the Project briefed in the Table 11.1-2 Work Scope in Each Section. Although there are differences between Section I, III and V and Section II and IV, as Section I, III and V is improvement of existing road and Section II and IV are new roads, components of each section are in common and consist of earthworks, pavement works and structural works (culverts and bridges). In view of volume and length of works (total is slightly more than 135 km) and considering all sections are continuous, JICA Team recommends that sections are to be separated to two packages. To make two packages separate in similar volume of the works, Package 1 consists of Section I only (total length 73 km) and Package 2 consists of Section II to V (total length 62 km). These are approximately similar size of volume in North Section of NR 5 (total length 83 km).

JICA team also recommends for conditions of contract to the above contract packages to use the General Conditions of Contract prepared by the International Federation of Consulting Engineers (Fédération Internationale des Ingénieurs-Conseils, or FIDIC) as a base. Other contractual components are recommended as follows.

- Construction period: 36 months
- Tender process: Prequalification then Tender
- Contract type: Bills of Quantity contract
- Payment terms: Advance payment 10 - 20% then Monthly payment with 10% retention
- Performance security: 10% of contract price
- Defect notification period: one year

As Table 11.1-6 in Section 11.1 shows the Comparison of Basic Rates with the Similar Projects, the contractual components of those similar projects are provided below as Table 11.8-1 and 11.8-2 for comparison to the above.

Table 11.8-1 (1) Comparison of Contractual Components in Similar Projects (1/2)

Funded country	Japan			
Project name	(1) Improvement of National Road No. 1 Phase 3	(2) Construction of Neak Loeung Bridge	(3) Flood Disaster Rehabilitation and Mitigation	
			NR 5 in Kampong Chhnang	Bridge in NR 11
Grant / Loan	Grant	Grant	Grant	
Construction period	November 2009 - June 2011 (20 months)	December 2010 - March 2015 (51 months)	January 2013 - January 2015 (25 months)	
Contract price	JPY 998 million	JPY 7,874 million	JPY 1,088 million	
Tender process	PQ / Tender	PQ / Tender	PQ / Tender	
Conditions of contract (CC)	CC for grant	CC for grant	CC for grant	
Scope of works	NR 1 rehabilitation: 9.1 km (car lane + bike lane) x 2	cable stayed bridge: 640 m approach bridge: 900 m + 675 m embankment: 840 m + 2,405 m	NR 5 rehabilitation: 2.2 km Street rehabilitation: 2.4 km Drainage way: 2.6 km	8 bridges
Contract type	Lump sum con tract	Lump sum contract	Lump sum contract	
Payment term	4 terms (40+30+20+10) % Advance/interim twice/completion	5 terms (3+29+33+28+7) % Each term 4 times of payment	4 terms (40+30+20+10) % Advance/progress 50%/ditto 85%/completion	
Performance security	10% of contract price	10% of contract price	10% of contract price	
Defect notification period	1 year	1 year	1 year	
Supervision	Consultant	Consultant	Consultant	

Source: Relevant documents in each project

Table 11.8-1(2) Comparison of Contractual Components in Similar Projects (2/2)

Funded country	Japan	Korea	ADB	China
Project name	(4) Sihanoukville Port SEZ Development	(5) Improvement of NR 31, 33, PR 117 and Kampot Bypass	(6) Improvement of National Road No. 5 Package No. 5F	Enlargement Project of NR 5 from Chruoy Changvar Bridge to Prek Kdam bridge
Grant / Loan	Loan	Loan	Loan	Loan
Construction period	September 2009 – August 2011 (700 days, about 23 months)	August 2011 – January 2014 (913 days, about 30 months)	October 2005 – September 2008 (36 months)	March 2012 – June 2015 (40 months)
Contract price	US$ 24.8 million & JPY 847 million (Total JPY 3,131 million)	KRW 27,216 million (US$ 24.9 million)	US$ 11.6 million	US$ 56.8 million
Tender process	PQ / Tender	PQ / Tender	Information not available	Information not available
Conditions of contract (CC)	FIDIC 1987 edition FIDIC 1999 edition D & B	FIDIC 1999 edition	FIDIC Fourth Edition 1987	No information available
Scope of works	Earthworks: 541,000 m^3 Pavement works: 88,666 m^2 Buildings	NR 31: rehabilitation 55 km NR 33: rehabilitation 36 km PR 117: rehabilitation 11 km Kampot bypass: new 4 km	NR 5: Improvement 47 km Bridge: 102 m (4 span) PC girder	NR 5:widening 30 km Bridges: 4 no Interchange: 1 no
Contract type	BQ contract	BQ contract	BQ contract	Lump sum
Payment term	Advance payment 10% Monthly payment with 10% retention	Advance payment 15% Monthly payment with 10% retention	Advance payment 15% Monthly payment with 10% retention	Information not available
Performance security	10% of contract price	10% of contract price	10% of contract price	Information not available
Defect notification period	365 days	548 days	364 days	Information not available
Supervision	Engineer	Engineer	Engineer	Supervisor

Source: Relevant documents in each project

11.9 Value Engineering

Value analysis and engineering (VA/VE) is a systematic method to improve the "value" of objects by using examination of function. In the field of value analysis and engineering, value is defined the ratio of function to cost; i.e. Value = Function/Cost.

Value can be, therefore, increased by either improving the function, reducing the cost or both. In construction, quality is usually specified in technical specification and therefore VA/VE is often meant to be achieved by lowering costs. However, to provide objectives with better function by even higher price may be within the meaning of VA/VE, as long as the value becomes higher.

Process of feasibility study is to select best option out of several ones and in this sense, feasibility study itself is similar to carry out VA/VE process and selection of best option is resulted from VA/VE.

In this study, items of VA/VE are summarized below.

Table 11.9-1 Items of Value Engineering

Item		Criteria	Chapter Reference
Road & pavement design	To select best option of typical cross section of road in Section I to V	Road geometry and future traffic demand	9
	To utilize existing material of sub-base course & base course into new design in Section I, III & V	Thickness & CBR of existing sub-base and base course	9
Bridge design	Widening of existing bridges instead of reconstruction	Cost, existing condition, constructability, and traffic management	10
	Additional bridge to construct next to existing bridges instead of reconstruction	Cost, existing condition, constructability, and traffic management	10
	Choice of pile foundation type for additional bridges in NR 5 and Kampong Chhnang Bypass. Use of either driven piles or bored piles.	Cost, soil conditions, river water depth, piling equipment requirements, and site access.	10
	Span configuration (number of spans and span length) for bridge in Kampong Chhnang Bypass	Cost, river width and water depth, soil conditions, girder launching equipment requirements, and site access	10

CHAPTER 12 IMPLEMENTATION PLAN

12.1 Execution Plan

12.1.1 Road Works

In this Project, there are two type of road works, which are widening of the existing road (Section I, III and V) and construction of bypasses around the city of Kampong Chhnang and the town of Odongk (Section II and IV).

Section I, III and V is to widen the existing NR 5 on both sides or either side to accommodate two lanes on both directions from one lane on both direction, by mainly filling road body. Since NR 5 is a part of major road network in Cambodia, hindrance to the traffic needs to be minimal during construction. Therefore, construction works should be carried out half by half to maintain traffic capacity similar to that of the existing road during construction.

On the other hand, works in Section II and IV are construction of new roads mainly in paddy field or vacant land, and construction of road is relatively straight-forward.

In either case, necessity of special technology is not anticipated.

Generally, construction of road is executed in the process as shown below:

(a) Work area is cleared and unsuitable material, if any, is removed.

(b) Embankment is constructed by filling soil in horizontal layers with specified thickness and compaction, and tests are conducted to confirm required dimension and quality.

(c) Slope is formed as specified and protected with sodding except those near river and swampy area where rip-rap are placed as the slope protection.

(d) Sub-grade is prepared before pavement structure is constructed.

(e) Sub-base course and base-course are spread and compacted as specified, and tests are conducted to confirm required dimension and quality.

(f) Asphalt concrete is laid on top of the base course as specified, and tests are conducted to confirm required dimension and quality.

Major materials needed for the road works of this Project are common embankment materials and quarry products for pavement works.

The JICA Team’s field survey indicated that embankment materials are obtainable from lands adjacent to, or near NR 5, although such materials are subject to laboratory tests before being used for embankment. It shall be spelt out in the specification during the engineering study that borrow areas for embankment material shall be leveled and drained off during implementation and after taking materials for embankment in order to keep dry conditions in the borrow areas. It shall also be included in the specification that dewatering system shall be facilitated during implementation to avoid muddy water to spill out from site.

Whereas for aggregates, there are two quarries near the city of Kampong Chhnang, producing aggregates for concrete, asphalt concrete, sub-base course, base course and crusher-runs for pavement works. JICA Team observes that these quarries are being managed well and tidied up in dewatering and surrounding road conditions. It also seems that capacity of those quarries is more than enough to supply materials to the Project. Hence, the quarries will certainly operate with high discipline after the Project. Locations of these quarries are shown in Figure 12.1-1 and quarry operation is indicated in Figure 12.1-2.

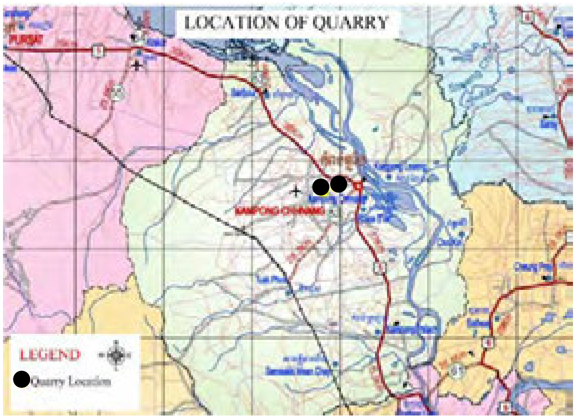


Figure 12.1-1 Location of Quarry

Figure 12.1-2 Quarry Operation

The JICA Team's survey indicated that there is no commercial asphalt plant in this region. However it was confirmed that several contractors in Cambodia possess movable asphalt plants. Capacities of these movable plants are 60 – 80 tons/hour. It is normal practice in Cambodia that these movable plants are mobilized and used for the project like NR 5 Improvement Project.

Process of road works for Section I, III and V allowing the flow of traffic is described below.

Filling works are carried out in one side first. After completion of filling up to existing road level and additional space for traffic to travel is available, traffic is shifted using newly filled space. Then filling on the other side is commenced. This practice is shown in Figure 12.1-3 below. If embankment needs to be filled higher than the existing road surface, the works shall be executed as shown in Figure 12.1-4.

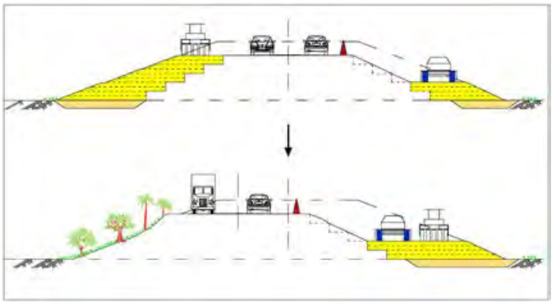


Figure 12.1-3 Embankment Works (1)

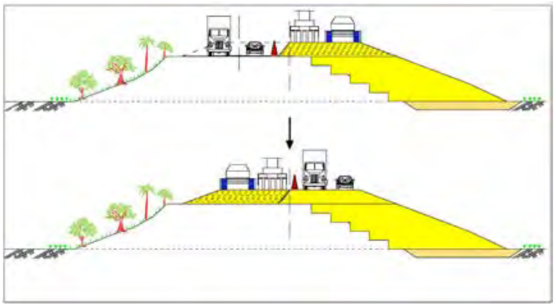


Figure 12.1-4 Embankment Works (2)

After embankment and sub-grade preparation is completed, sub-base course and base course works are carried out with the same manner as embankment, as one side is being carried out while the other side is maintained for traffic. These are shown in Figures 12.1-5 and 12.1-6, respectively.

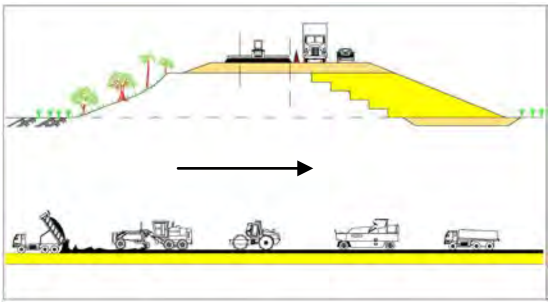


Figure 12.1-5 Sub-Base Course Works

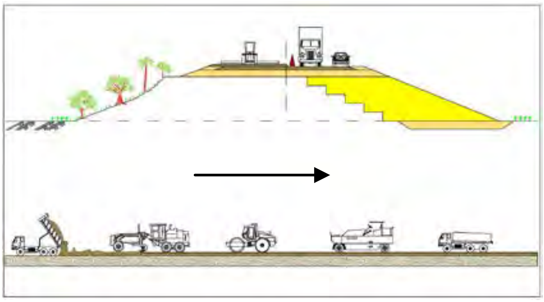


Figure 12.1-6 Base Course Works

Following the base course works, asphalt concrete works are carried out. The asphalt concrete works are also done in one side first, then done in the other side. These are shown in Figure 12.1-7 below.

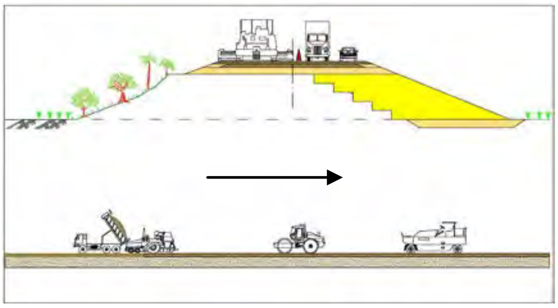


Figure 12.1-7 Asphalt Concrete Works

As for Kampong Chhnang Bypass and Odongk Bypass, the works can be executed without consideration for traffic except at intersections with existing roads, where certain measures are necessary to maintain traffics on the existing roads. It is also to note that there are swampy area expanded in certain area of the route of Odongk Bypass, and therefore extent of removal of unsuitable material and replacement with selected material shall be further investigated and designed during the engineering study.

12.1.2 Bridge Works

There are also two types of bridge works, which are rehabilitation to existing bridges (on the existing NR 5) and new bridge construction (on the bypass).

Three kinds of bridge works are planned as the rehabilitation of the bridges on the existing NR 5; construction additional bridges, widening of existing bridges and construction of new bridges after demolishing the existing bridges. These are described in Chapter 10 in detail and the basic aspects for construction plans are summarized in Table 12.1-1. It should be noted that temporary bridges for detour are required for Bridge 8, 11~16, 16' and 39 during replacement of existing bridge and temporary bridges for construction of additional bridge or widening of existing bridges are required for Bridge 22, 26, 36 and 38 because such works need work platform in river streams.

Table 12.1-1 Bridge Rehabilitation in Section I and III of NR 5

bridge ID		KP (km)	details of existing bridge					(two lanes x 2) scheme							remarks
			length (m)	c/way width (m)	super st. (m2)	span (no)	span length (m)	way of rehabilitation	sub st (no)	super st. (m2)	span x width (m2)	bridge removal	detour bridge	temp bridge	
1	Bridge 7	40.6	15.0	9.0	135.0	1	15.0	additional bridge to construct (LHS)	2	157.5	15*10.5	-	-	-	
2	Bridge 8	41.1	25.0	7.0	175.0	2	12.5	existing structure to demolish and new bridge to construct	2	525	25*21	to remove	required	-	
3	Bridge 9	41.3	25.0	9.0	225.0	2	12.5	additional bridge to construct (LHS)	2	262.5	25*10.5	-	-	-	
4	Bridge 10	41.9	25.0	9.0	225.0	2	12.5	additional bridge to construct (LHS)	2	262.5	25*10.5	-	-	-	
5	Bridge 11	46.2	20.0	10.1	202.0	4	5.0	existing structure to demolish and new bridge to construct	2	420	20*21	to remove	required	-	
6	Bridge 12	48.4	25.0	10.4	260.0	4	6.3	existing structure to demolish and new bridge to construct	2	525	25*21	to remove	required	-	
7	Bridge 13	48.9	20.0	10.2	204.0	1	20.0	existing structure to demolish and new bridge to construct	2	420	20*21	to remove	required	-	
8	Bridge 13'	49.7	25.0	9.1	227.5	2	12.5	additional bridge to construct (LHS)	2	262.5	25*10.5	-	-	-	
9	Bridge 14	58.3	15.0	9.0	135.0	1	15.0	existing structure to demolish and new bridge to construct	2	315	15*21	to remove	required	-	
10	Bridge 15	61.9	25.0	9.0	225.0	2	12.5	existing structure to demolish and new bridge to construct	2	525	25*21	to remove	required	-	
11	Bridge 16	67.8	25.0	9.0	225.0	2	12.5	existing structure to demolish and new bridge to construct	2	525	25*21	to remove	required	-	
12	Bridge 16'	72.7	15.0	10.0	150.0	1	15.0	existing structure to demolish and new bridge to construct	2	315	15*21	to remove	required	-	
13	Bridge 22	106.2	92.0	7.1	653.2	3	31-30-31	additional bridge to construct (LHS)	4	966	(31-30-31)*10.5	-	-	required	
14	Bridge 23	106.9	20.0	10.1	202.0	1	20.0	existing bridge to widen	2	230	20*11.5	-	-	-	connection to existing bridge is required
15	Bridge 24	113.4	15.0	10.0	150.0	1	15.0	existing bridge to widen	2	172.5	15*11.5	-	-	-	ditto
16	Bridge 25	113.7	12.0	10.0	120.0	1	12.0	existing bridge to widen	2	138	12*11.5	-	-	-	ditto
17	Bridge 26	116.9	75.0	7.1	532.5	3	27-21-27	additional bridge to construct (RHS)	4	787.5	(27-21-27)*10.5	-	-	required	
18	Bridge 27	134.3	12.0	10.0	120.0	1	12.0	existing bridge to widen	2	138	12*11.5	-	-	-	connection to existing bridge is required
19	Bridge 28	135.9	12.0	10.0	120.0	1	12.0	existing bridge to widen	2	138	12*11.5	-	-	-	ditto
20	Bridge 29	140.8	12.0	10.0	120.0	1	12.0	existing bridge to widen	2	138	12*11.5	-	-	-	ditto
21	Bridge 30	141.9	12.0	10.0	120.0	1	12.0	existing bridge to widen	2	138	12*11.5	-	-	-	ditto
22	Bridge 31	147.1	12.0	10.0	120.0	1	12.0	existing bridge to widen	2	138	12*11.5	-	-	-	ditto
23	Bridge 32	147.7	12.0	10.0	120.0	1	12.0	existing bridge to widen	2	138	12*11.5	-	-	-	ditto
24	Bridge 33	150.2	17.9	10.0	179.0	1	17.9	existing bridge to widen	2	205.85	17.9*11.5	-	-	-	ditto
25	Bridge 34	150.4	15.0	10.0	150.0	1	15.0	existing bridge to widen	2	172.5	15*11.5	-	-	-	ditto
26	Bridge 35	151.3	12.0	10.0	120.0	1	12.0	existing bridge to widen	2	138	12*11.5	-	-	-	ditto
27	Bridge 36	153.5	20.0	10.0	200.0	2	10.0	existing bridge to widen	3	230	20*11.5	-	-	required	ditto
28	Bridge 37	169.8	20.1	10.0	201.0	1	20.1	existing bridge to widen	2	231.15	20.1*11.5	-	-	-	ditto
29	Bridge 38	170.6	48.0	7.1	340.8	3	18-12-18	additional bridge to construct (RHS)	4	504	(18-12-18)*10.5	-	-	required	
30	Bridge 39	170.9	30.0	9.0	270.0	4	7.5	existing structure to demolish and new bridge to construct	3	630	30*21	to remove	required	-	

In summary, 30 bridges in Section I and III are to be rehabilitated as listed below:

Table 12.1-2 Summary of Bridges in Section I and III of NR 5

Way of rehabilitation		Bridge nos.
a	Additional bridge	7 nos. (Br. 7, 9, 10, 13', 22, 26, 38)
b	Existing bridge widened	14 nos. (Br. 23, 24, 25, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37)
c	Replace with new bridge	9 no. (Br. 8, 11, 12, 13, 14, 15, 16, 16', 39)

In Section II (Kampong Chhnang Bypass), there is one bridge to be newly constructed as described in Chapter 10 and the basic aspects are summarized in Table 12.1-3 below.

Table 12.1-3 Bridge Construction in Section II (Kampong Chhnang Bypass)

	bridge ID	KP (km)	length (m)	c/way width (m)	super st (m2)	span (no)	span length (m)	full four lanes scheme				remarks
								scheme	sub st (no)	super st (m2)	temp br (m2)	
1	Bridge 1	1.07	30.0	21.0	630.0	1	30.0	new bridge to construct	2	630	-	

Generally, bridge construction is executed in the process as described below;

- Piling works

  If required, preliminary test pile shall be constructed to confirm pile capacity prior to working pile constructions. Then working piles shall be commenced in the following procedures.

  a) Setting out pile positions

  b) Driving piles as per drawings with data (number of blow per each length etc.)

  c) At final depth, taking data (hammer height, settlement and rebound per blow etc.) for calculating pile capacity

  d) Re-driving, if required

  Some piles selected from working piles shall be tested to confirm the capacity and quality with either static load test or test by dynamic method.

- Sub structure

  Because all sub structures are near or in rivers or canals, temporary shoring shall be installed before excavation. Shoring is also necessary to minimize smearing of water in the river. Temporary shoring in general shall be watertight and well braced to sustain earth pressure during excavation. Typical shoring sketch (plan and section) is shown below.

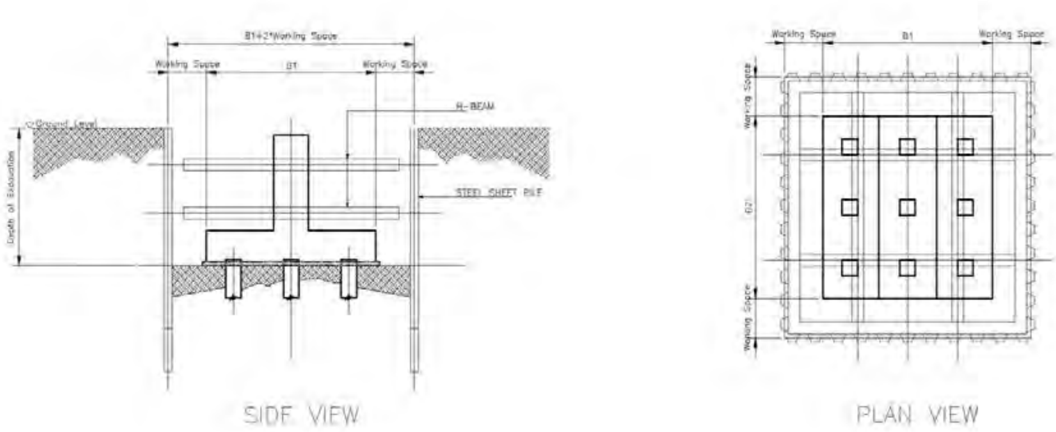


Figure 12.1-8 Schematic View for Structural Excavation

When excavation is completed, pile heads shall be treated as specified without damage to the piles and then lean concrete is placed. Following the lean concrete, reinforcing bars shall be arranged and forms be installed. Prior to placing concrete of footing, inspection shall be conducted and then concreting be done as per requirements in the specification.

Walls, columns and column heads shall be constructed with treatment of construction joint and firm scaffolding and supports shall be provided. All the while, concrete shall be cured with appropriate method in a period specified.

After properly backfilled, temporary shoring shall be removed carefully without damaging concrete structures.

- Super structure

  PCS (prestressed concrete slab) and PCDG (prestressed concrete deck girder) type shall be such that girders with tensioning is to be produced in casting yard, delivered to site, erected and then slab is to cast in-situ. Quality control of girders in casting, tensioning and grouting shall be done properly. Delivery and erection of girders shall be planned and carried out as per requirements spelled out in the specification.

  In case of the existing bridges (14 nos.) to be widened in Section I, III and V (Bridge 23 – 25 and 27 - 37), new PCS beams shall be added to the existing beams with due diligence, as described in Chapter 10.

12.1.3 Widening of Existing Bridge

Fourteen bridges are proposed to be widened as listed in Table 12.1-1. Widening of existing bridge is practiced in the developed countries such as Japan in recent years. The general process of widening is explained in Chapter 10. Details of bridge widening need to be designed and finalized by bridge design engineer and general contractor, respectively, with good experience in bridge widening works.

12.1.4 Other Structure Works

Pipe/box culvert works mainly consist of two kinds of works, earthworks and concrete works. Earthworks for culverts shall be executed in a manner similar to that described in Section 12.1.1 Road Works. Likewise, concrete works for culverts shall be executed in a manner similar to that described in Section 12.1.2 Bridge Works. In case of culverts in Section I, III and V, pipe/box culverts need to be extended as the road is widened, and these extension works shall be done in conjunction with embankment works stated in Section 12.1.1.

12.1.5 Traffic Management during Construction

When works for Section I, III and V are carried out allowing existing traffic, influence to the traffic needs be minimal. Therefore, traffic management is one of the most important tasks during construction, particularly in town areas. Basically, traffic capacity of road similar to that of existing condition should be provided during construction. This can be achieved by providing same carriageway width. But sometimes providing detours or alternative routes and other measure may be adopted in order to minimize interference to road users. The same principle shall be applied in constructing Kampong Chhnang Bypass (Section II) and Odongk Bypass (Section V) at intersections with the existing roads.

Figure 12.1-9 below shows a general flow chart for preparing traffic management plan.

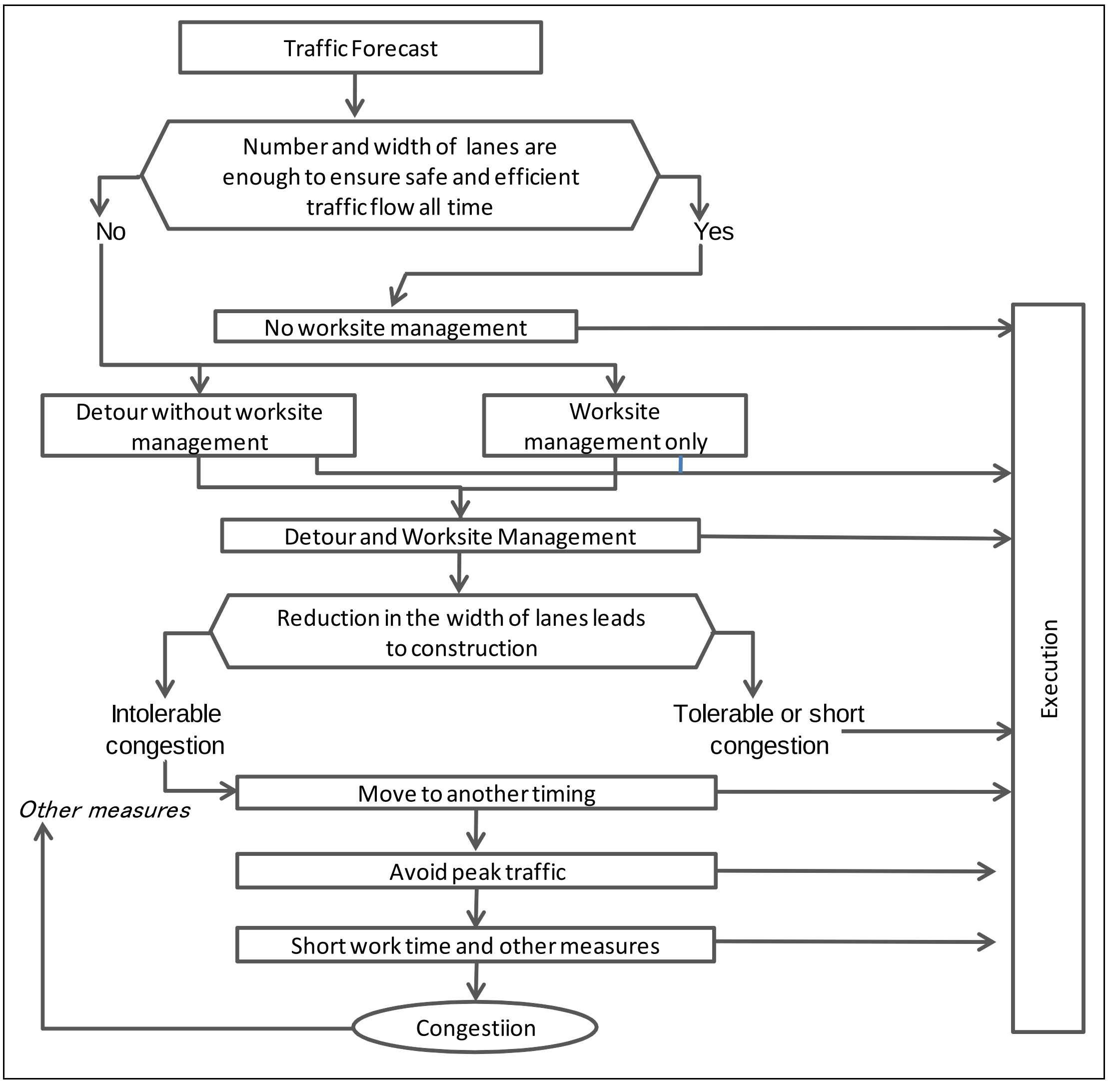


Figure 12.1-9 Flow of Traffic Management Plan

12.1.6 Utilities

Utilities such as electric cable, street light post, telephone line, optic fiber cable, water supply pipe and so on shall be checked thoroughly along the route prior to commencing construction. The following activities shall be conducted before, during and after construction.

(a) Contact relevant authorities to find out as-built documents and drawings for utilities

(b) Survey on actual locations of utilities above ground and underground on site, for latter using detectors

(c) Excavation of trial pits with certain interval to find out exact locations of utilities

(d) Temporary relocation, removal and/or protection to utilities, as required

(e) Reinstatement of utilities after construction works completed

As per experiences in the similar projects in Cambodia, relocation, removal, protection and reinstatement of utilities shall be carried out by relevant utility organizations or their designated companies. Those shall be under separate local contracts between the RGC and the utility organizations or those companies in order to avoid negative impacts on civil works for the Project.

12.2 Organization in Implementation

12.2.1 Employer

As requested by JICA, the Minister of Public Works and Transport has prepared a proposal to the Prime Minister in September 2011 that the Joint Coordinating Committee (JCC) to lead and manage the rehabilitation project of NR 5 as well as NR 1 (Asian Highway AH-1) under Japanese Loan be established and the proposal is being processed. The JCC will be organized with participation from the MPWT, the Ministry of Economy and Finance (MEF), the Council of Ministers and relevant provincial governments.

The Minutes of Discussions between the Royal Government of Cambodia (RGC) and Japan International Cooperation Agency (JICA) on the Project for Improvement of National Road No. 5 (Battambang – Sri Sophorn: North Section) under Japanese ODA Loan was signed in September 2012. Then, the Prakas No. 525 on the Establishment of Project management Unit (PMU) for the Implementation of the Project for Improvement of National Road No. 5 (Battambang – Sri Sophorn) under Japanese ODA Loan was issued in November 2012 and the PMU has been established for the North Section.

Similar PMU to the North Section shall be established for the South Section in due course, which is illustrated in the Figure 12.2-1 below, based on the above Prakas (No. 525).

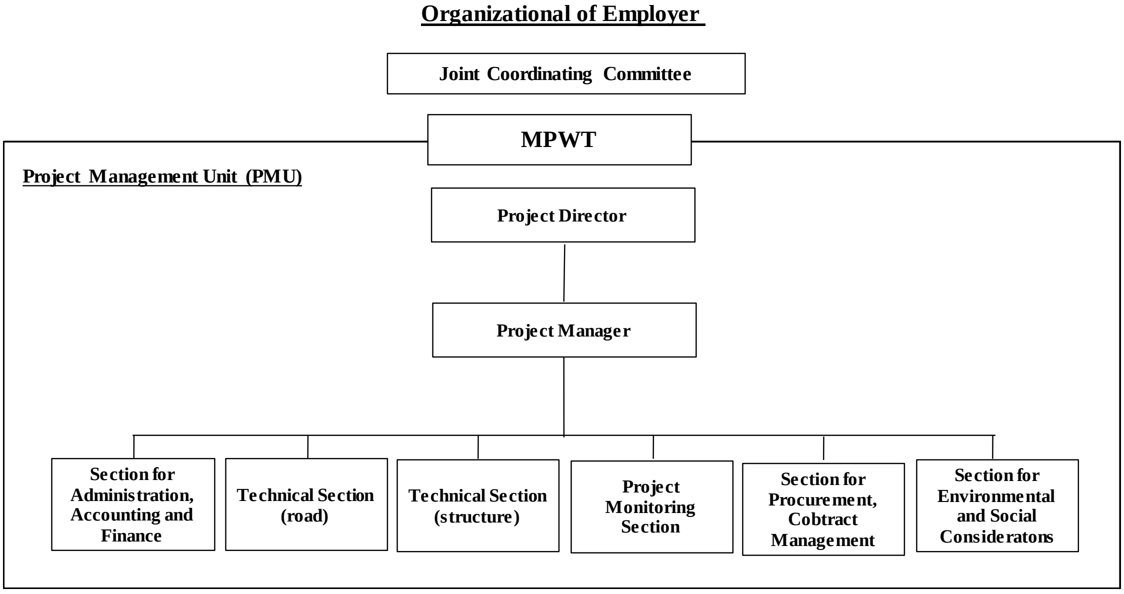


Figure 12.2-1 Organization of Employer

The JCC and PMU shall be established as soon as similar Prakas for the South Section is issued in order to have constructive and effective discussions and negotiations with JICA for loan agreement. The PMU during the engineering study and selection of contractors may be small organization and during construction stage shall be in full scale.

MPWT has certain experiences in procurement and project management under ADB and foreign country loans (e.g. China and Korea etc.) and other agencies have some experience in JICA loans like the Port Authority of Sihanoukville and Phnom Penh Water Supply Authority. Hence, it is thought that MPWT has certain level of knowledge and capability for project management and JICA Team recommends to enhance their capacity through trainings mentioned in Section 11.2.

12.2.2 Consultant

Consultant shall be selected after the loan agreement through the Guideline for the Employment of Consultants under Japanese ODA Loans and be contracted with the Employer in accordance with the contract concurred by JICA. Organizations of the consultant during the engineering services, the selection of contractors and supervision stage are indicated in Section 11.2.4.

12.2.3 Contractor

Contractor(s) shall be selected through the Guideline for the Procurement under Japanese ODA Loans and be contracted with the Employer in accordance with the contract recommended by JICA. As detail design and bill of quantities are prepared by the consultant, the conditions of contract between the Employer and the Contractor shall be the Bank Harmonized Edition of the General Conditions of Contract prepared by the International Federation of Consulting Engineers (Fédération Internationale des Ingénieurs-Conseils, or FIDIC). Under the FIDIC conditions, the relation between the Employer, the Consultant (the Engineer) and the Contractor are shown in the Figure 12.2-2 below.

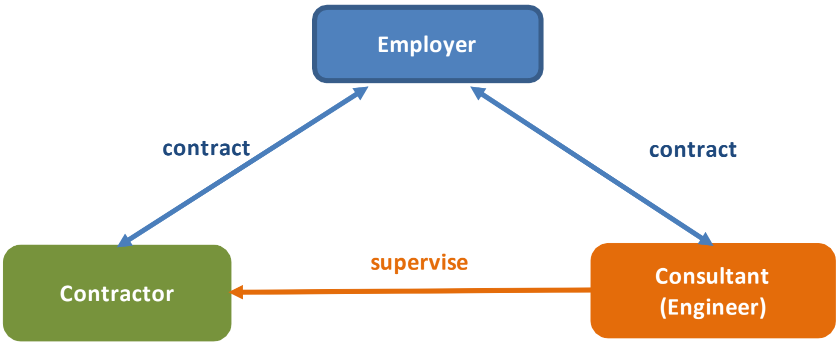


Figure 12.2-2 Relation of the Employer, Consultant and Contractor

12.3 Implementation Schedule

The JICA Team discussed with JICA and MPWT counterparts as well as various stakeholders of the Project and local consultants/contractors with regard to the implementation of the Project. Followings are the most probable schedule in each task considering the results of the above discussion.

(a) Feasibility study (FS)

The JICA Team has commenced the Survey in September 2012 and after incorporating Odongk Bypass, Draft Final Report and Final Report is submitted in July and December 2013.

(b) Royal Government of Cambodia (RGC) Action for Approval on FS

According to the interviews to staff in relevant departments in RGC regarding ODA loan, RGC needs to accept the FS and to prepare a formal request to Japanese Government. This task is estimated to take a few months.

(c) Negotiation of Loan Agreement

The standard processing time period for ODA loan project is set by the Japanese Government and a process will start as soon as receipt of formal request from RGC. The major activities for the process are as follows.

(i) Fact finding mission from JICA

(ii) JICA appraisal mission

(iii) Signing of loan agreement

Necessary time set in the standard process time period is nine months for the process and this is not easy to achieve, if referring to the experiences in the past. It is expected that signing on the loan agreement will be made in January 2014.

It means that this task will take 7 months.

(d) Selection of Consultant

There is standard schedule for the consultant selection, which consists of three major stages as follows;

(i) Short-listing or Expression of Interest and Request for Proposal Preparation Stage (approximately 2.6 months)

(ii) Proposal Stage (approximately 5.3 to 5.8 months)

(iii) Contract Negotiation and Signing Stage (approximately 2.6 months)

Total 10 – 11 months

Referring to the precedent projects in Cambodia under JICA, duration of selection of consultant varied from 10 months to 24 months and it took 10 months in the recent project (West Tonle Sap Irrigation and Drainage Rehabilitation and Improvement Project). Therefore, the JICA Team assumes that selection of consultant take 12 months by taking advance action prior to the formal loan agreement.

(e) Engineering Study and Supervision

Selected consultant shall carry out engineering study and tender process/evaluation for contractors followed by construction supervision.

The first task, the engineering study consists of basic design & detail design and preparation of tender documents. Usually the tender documents (pre-qualification document and tender document) will be compiled simultaneously with detail design or soon after basic design.

As the project is not very complicated, it is estimated that the engineering study, including the preparation of tender documents, be completed in 9 months, as 9 months period was allowed in the Final Report for the North Section of NR 5.

The tender process/evaluation for contractors usually consists of two stages; pre-qualification (PQ) stage and tender stage. The former starts during the detail design and the latter is commenced as soon as the detail design is completed. The duration of this task is discussed in (f) Selection of Contractors below. Supervision will follow the selection of contractors.

(f) Selection of Contractors

The selection of contractors starts from PQ stage and then proceeds to tender stage. The following task and duration will be in standard time frame in JICA.

(i)	Prequalification	3	months
(ii)	Preparation of tender document	3	months
(iii)	Tender period	2	months
(iv)	Tender evaluation	2	months
(v)	JICA concurrence to the evaluation result	1	month
(vi)	Contract negotiations	2	months
(vii)	JICA concurrence to contract	1	month

(viii)	L/C opening	1	month
	Total	15	months

According to the past experience in previous projects in Cambodia, average duration is much longer (approximately 19 months), however the above process could be believed to achieve in 15 months as stated above with due efforts of every party concern.

(g) Land Acquisition/Resettlement

The length of time required for the land acquisition and relocation is dependent mainly on the number of affected family. JICA has provided the technical assistance "Project on Capacity Enhancement of Environmental and Social Considerations for Resettlement". This technical assistance is expected to provide the positive effect to the land acquisition and relocation for NR 5 Project.

So far, most of the precedent project under Japanese ODA Loan has no problem on land acquisition and relocation, as land was cleared before the commencement of civil works in several projects in the past. According to the study at this stage, the JICA Team conclusion on the estimated necessary time is 19 months.

(h) Relocation, Removal and/or Protection of Utilities

Utilities relocation, removal and/or protection are able to explored after detail design is finalized, and those works shall be complete prior to commence construction works. Duration allowed for those works is therefore twelve months, and this could be achieved when the Employer manages well with all stakeholders.

(i) Detection and Removal of Mines/UXOs

The prerequisites of calculation of duration for detection and removal of mines/UXOs are as follows;

- Route to detect and remove mines and UXOs is Section I, III and V (South Section in NR 5) only, as Kampong Chhnang and Odongk Bypasses have been detected and removed during the FS.
- The detection shall be done in dry season. Water in paddy field and/or much water in the soil must be avoided.
- Soon after detection of landmines and UXOs, demining works shall be followed smoothly.
- There is no problem for detection and removal works with the land owners, after the completion of land acquisition.

The organization of detection and demining shall be the Cambodia Mine Action Center (CMAC). The necessary period for the detection on landmine and UXO is estimated to be around 4 months in dry season.

(j) Construction

There are two packages in this Project, which are Package 1: National Road 5 (Thlea Ma'am to Kampong Chhnang) (Section I) and Package 2: Kampong Chnnang Bypass (Section II), National Rad 5 (Kampong Chhnang to Odongk) (Section III), Odongk Bypass (Section IV) and National Road 5 (Odongk to Prek Kdam Bridge) (Section V). The scope of work in each package is shown below.

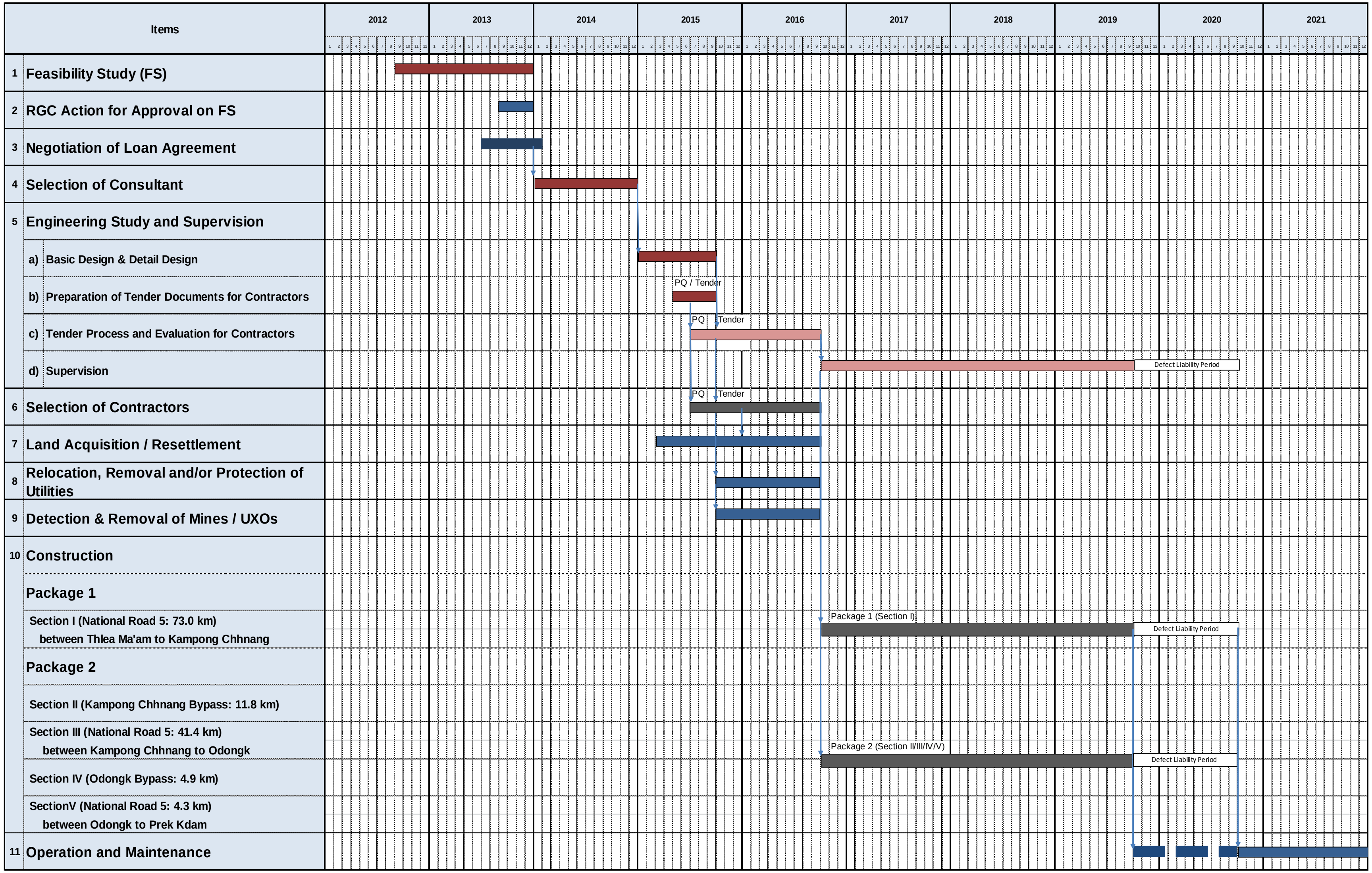
Table 12.3-1 Scope of Work of Contract Package

Description	**Package 1**	**Package 2**			
	Section I	Section II	Section III	Section IV	Section V
	NR 5 (Thlea Ma'am to Kampong Chhnang)	Kampong Chhnang Bypass	NR 5 (Kampong Chhnang to Odongk)	Odongk Bypass	NR 5 (Odongk to Prek Kdam Bridge)
Road length	73.0 km	11.8 km	41.1 km	4.9 km	4.3 km
Bridge no.	18 nos.	1 no.	12 nos.	-	-
Culvert no.	43 nos.	45 nos.	51 nos.	14 nos.	-

Based on the above and the execution plan, construction for both packages is estimated to take 3 years.

With the explanation in the above, the implementation schedule is drawn and prepared. The schedule is shown in Table 12.3-2 Implementation Schedule.

Table 12.3-2 Implementation Schedule for National Road 5 Rehabilitation Project



CHAPTER 13 MAINTENANCE AND OPERATION PLAN

13.1 Maintenance and Operation Cost

13.1.1 Organization in Charge of Road Maintenance

The functions of Ministry of Public Works and Transport (MPWT) are stipulated in the Sub-decree on the Organization and Function of MPWT and those of Department of Public Works and Transport (DPWT) in provinces and cities are stipulated in the Declaration on the Management and Process of DPWT. The important articles in the Sub-Decree and Declaration in respect of road maintenance are extracted and shown in Table 13.1-1 below.

Table 13.1-1 Functions and Duties of MPWT and DPWT with Respect to Maintenance

[**Sub-Decree**]

Article 3: MPWT has functions and duties as below;

(2nd Clause)

- Completion, maintenance and management of road, bridge, port, railway, maritime and state building infrastructure.

Article 11: General Department of Public Works and Transport is responsible for direction, introduction, following up and control of construction and maintenance of road and bridge infrastructure, public building construction and construction management, maintenance of national vestiges assigned by the Royal Government of Cambodia. General department is …

Article 12: Road Infrastructure Department (RID) is responsible for:

- Completion, maintenance, management and make regulation for business on road infrastructure, such as road, local road, ferry dock, ferry and urban street.
- For this responsibility, department has two functions.

a) Organize maintenance program and manage roads and bridges
  - Selecting data and utilizing data to understand road network.
  - Manage technical documents on roads and road network related documents.
  - Organize budget, divide follow-up means and control the maintenance.
  - Manage public properties, road transport, water transport and rail transport.

b) Manage road and bridge working site.
  - Study, manage and organize road and bridge maintenance program.
  - Organize budget, divide follow-up means and control road and bridge working site.
  - Assess complete working site.
  - Manage ferry docks and ferry.

Article 23: In the whole Cambodia, there are Provincial Departments of Public Works and Transport that is responsible for implementation and coordination with Ministry activities. Arrangement and operation of local organization is defined by other document.

[**Declaration**]

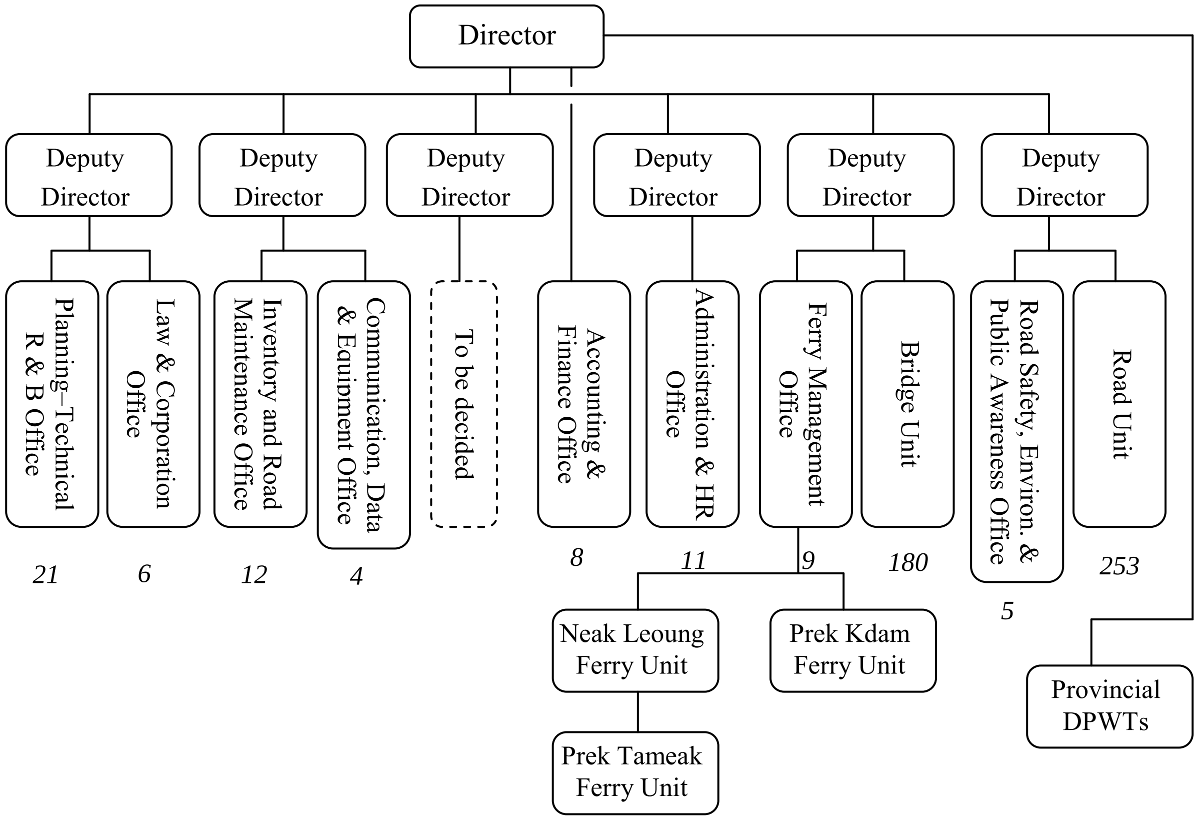
Article 1: This proclamation indicates the management and process of the base units under supervision of MPWT- so called Department of Public Works and Transport, Provinces and Cities has the following duties;

(4th Clause)

- Control and maintain all completed works of infrastructures, such as roads, bridges, ports, airports, drainage system, drainage & exhaust pipe stations, harbors, buildings, land plots.

Source: Sub-Decree 14 and Declaration 344, Cambodia

Referring to the above, it is noted that Road Infrastructure Department (RID) under General Department of Public Works and Transport in MPWT and DPWT are responsible for maintaining all roads and bridges in Cambodia. Figure 13.1-1 shows the organizational chart of RID, including number of staff (*italic*) in each office and unit this year. Table 13.1-2 shows number of staff in DPWT office along NR 5 this year.



Source: Road Infrastructure Department, MPWT

Figure 13.1-1 Organizational Chart of Road Infrastructure Department, MPWT

Table 13.1-2 Staff Number in DPWT along National Road 5

Province	Number of Staff
DPWT of Phnom Penh	297
DPWT of Kandal Province	139
DPWT of Kampong Chhnang	56
DPWT of Pursat Province	93
DPWT of Battambang Province	124
DPWT of Banteay Meanchey Province	63

Source: Road Infrastructure Department, MPWT

13.1.2 Practice of Road Maintenance and Operation

MPWT prepared and compiled four guidelines together with JICA experts in 2008 and the maintenance works are being carried out in accordance with those guidelines. Four guidelines are as listed below:

- Guideline for Regular Inspection
- Guideline for Supervision of Routine Maintenance
- Guideline for Supervision of Periodic Maintenance
- Guideline for Repairing Defects of Roads

According to the guidelines, road maintenance works are classified into three types; namely, routine, periodic and emergency.

Table 13.1-3 summarizes typical activities of each type of maintenance works.

Table 13.1-3 Typical Maintenance Activities

Type	Activity
Routine Maintenance	Clearing of pavement
	Mowing and maintenance of plants
	Clearing of ditches and culverts
	Repair of traffic signs and road markings
	Shoulder grading
	Pothole patching and crack sealing
	Repair of sealants and expansion joints of bridges
	Repair of cut and fill slopes
Periodic Maintenance	Re-graveling
	Resealing/surface dressing
	Overlay
	Maintenance of traffic signs and road markings
Emergency maintenance	Removal of debris or obstacles from natural causes
	Repair of damage caused by traffic accidents

Routine maintenance is planned based on regular (daily) inspection of the condition of road on the items as listed below:

- Pavement: potholes, cracks, ruts/settlements, deformations, local aggregate loss, edge break, scratches, bleeding etc.
- Cut and fill slopes
- Drainage
- Bridges: bottom, expansion joint etc.
- Other structures and facilities: markings, guardrails/handrails, signboards etc.

The results of regular inspection are categorized into three ranks as listed below.

Table 13.1-4 Rank of Defects

Rank A	Severe defects that may be harmful to traffic or structure and it requires urgent countermeasures.
Rank B	Defects that may be harmful to traffic or structure and it requires countermeasures but not urgent.
Rank C	Small defects that do not require countermeasures but it requires continuous observation.

The results of regular inspection are promptly reported to the operation office for follow-up maintenance works to be undertaken either continually throughout a year or at certain intervals every year.

Periodic maintenance is substantial repairs carried out at an appropriate time interval (every 3-year, 5-year, 8-year, 10-year etc.) based on the age, investment and initial design of the road. It could also be required when vehicle weight and traffic volume increased. It includes reconstruction, improvement, or rehabilitation works on any road section.

Emergency maintenance basically comprises works to restore road and road related facilities to their normal operating conditions after they are damaged by road accidents or natural causes. It is impossible to foresee the frequency, but such maintenance requires immediate action.

In addition to the above three types of maintenance, there is still another type of maintenance called 'preventive maintenance'. The term "preventive maintenance" refers to repair that addresses causes of deterioration leading to the need for costly rehabilitation work in future.

13.1.3 Necessity of Capacity Enhancement for Road Maintenance

In the past, actual works of road maintenance have been executed mainly by DPWT and the Army under contracts with MPWT. In this case, type of pavement has been mainly DBST or Macadam. DPWTs and the Army have capacity for such types of pavement but they are not supposed to have sufficient capacity for maintenance of AC pavement. Thus, a new system needs to be introduced for maintenance of roads with AC pavement, including to increase staff in the road maintenance office of MPWT and DPWT, and capacity enhancement for maintenance of AC pavement is necessary.

In this connection, it is the fact that technical cooperation project, the Strengthening Construction Quality Control Project (SCQCP) in MPWT has been completed in 2012 under JICA and the Follow-up to SCQCP are being implemented in MPWT this year. Another project, the Road Asset Management Project (RAMP) under ADB and WB are still being implemented in MPWT. As roads are currently being improved in Cambodia and AC pavement roads are increasing, it is highly needed to have capacity development project for AC pavement road maintenance in Cambodia. For this purpose, the project for strengthening of inspection and maintenance of roads and bridges will be commenced in MPWT under JICA near future and JICA Team recommends that such project shall start in due course and due time.

13.1.4 Budget for Road Maintenance and Operation Works

In the budget situation for road maintenance and operation works under MPWT, it is found that budget has been increased in recent years and the following table shows budget in each category of works under MPWT, including those in year 2013.

Table 13.1-5 Budget for Road Maintenance under MPWT

Unit: US$ million

Items	2007	2008	2009	2010	2011	2012	2013
Routine maintenance	5.7	8.8	17.1	17.9	16.1	15.8	20.0
Periodic maintenance	12.2	14.3	13.3	15.0	26.6	32.5	37.5
Emergency maintenance	1.6	1.9	2.4	2.9	3.7	4.0	5.0
Flood restoration works	2.4	2.4	0	0	0	23.7	0
Total	21.9	27.4	32.8	35.8	46.3	76.0	62.5

Source: Road Infrastructure Department, MPWT

As per discussion with staff in the road maintenance of Road Infrastructure Department (RID) under MPWT and in the Department of Public Works and Transport (DPWT) in Kampong Chnnang Province, it is found that there are budget for routine maintenance of road spent by MPWT as well as by DPWTs. The amounts of expenditure spent for routine maintenance in 2012 for paved roads are average US$ 2,900 /km.

13.1.5 Maintenance and Operation Cost

As described in Chapter 9 Highway Design, the design period of the pavement is 10 years. Thus, overlay of 5 cm thickness as the periodic maintenance becomes necessary every 10-year after completion. Also, routine maintenance needs to be implemented every year after completion.

Unit rate of future routine maintenance cost of the Project road is estimated at US$ 3,000 /km as the current unit rate of routine maintenance cost for asphalt concrete and DBST roads is slightly less than US$ 3,000. Hence routine maintenance cost for the Project in each year is estimated as follows:

Table 13.1-6 Routine Maintenance in Section I to V

Section	Unit Rate (US$ 1,000 /km)	Length (km)	Amount (US$ 1,000)
Section I	3	73.0	219
Section II	3	11.8	35
Section III	3	41.4	124
Section IV	3	4.9	15
Section V	3	4.3	13
Total			406

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

Table 13.1-7 Periodic Maintenance in Section I to V

Items	Unit Rate (US$)	Length (km)	Amount (US$1,000)
Section I			
Rural Area	US$ 14 /m^2 x 15.0 m x 1,000 = US$ 210,000 /km	71.0	14,910
Urban Area	US$ 14 /m^2 x 20.0 m x 1,000 = US$ 280,000 /km	2.0	560
Total of Section I			15,470
Section II	US$ 14 /m^2 x 15.0 m x 1,000 = US$ 210,000 /km	11.8	2,478
Section III	US$ 14 /m^2 x 15.0 m x 1,000 = US$ 210,000 /km	41.4	8,694
Section IV	US$ 14 /m^2 x 15.0 m x 1,000 = US$ 210,000 /km	4.9	1,029
Section V			
Rural Area	US$ 14 /m^2 x 15.0 m x 1,000 = US$ 210,000 /km	3.3	693
Urban Area	US$ 14 /m^2 x 20.0 m x 1,000 = US$ 280,000 /km	1.0	280
Total of Section V			973
Total of Section I - V			28,644

In summary, road maintenance and operation cost after completion is estimated in the price of 2013 as shown below.

・Routine maintenance: US$ 406,000/year
・Periodic maintenance: US$ 28,644,000/10-year

13.2 Annual Road Maintenance and Operation Cost

Road maintenance and operation costs after completion of the Project is calculated in the prices of 2013 as described in Section 13.1 above. Thus, escalation factor needs be applied in order to have annual cost in future years. Escalation factor is assumed as follows.

(a) Escalation factor in year 2014 to 2025: 1.3% and 2.8%/year for foreign and local currency portions, respectively, as stated in the Section 11.4.

(b) Escalation factor from year 2026: 0.6% and 1.5%/year for foreign and local currency portions, after twelve years growth with escalation in 1) above

(c) It is assumed that items directly related to international market prices like imported materials, fuel, major construction equipment and systems etc. are applied to the factor for foreign currency and those related to domestic market prices like workers, earthwork and quarry material to the factor for local currency.

Annual road maintenance and operation cost in each year is as shown in Table 13.2-1.

Table 13.2-1 Annual Road Maintenance and Operation Cost

Unit: US$1,000

Costs with 2013 price			Costs with escalation applied		
Routine maintenance	Periodic maintenance	Total	Routine maintenance	Periodic maintenance	total
406	-	406	456	-	456
406	-	406	464	-	464
406	-	406	472	-	472
406	-	406	480	-	480
406	-	406	489	-	489
406	-	406	497	-	497
406	-	406	501	-	501
406	-	406	505	-	505
406	-	406	510	-	510
406	28,644	29,050	514	36,279	36,793
406	-	406	519	-	519
406	-	406	523	-	523
406	-	406	528	-	528
406	-	406	532	-	532
406	-	406	537	-	537
406	-	406	542	-	542
406	-	406	546	-	546
406	-	406	551	-	551
406	-	406	556	-	556
406	28,644	29,050	561	39,562	40,123
406	-	406	566	-	566
406	-	406	571	-	571
406	-	406	576	-	576
406	-	406	581	-	581
406	-	406	586	-	586
406	-	406	591	-	591
406	-	406	596	-	596
406	-	406	602	-	602
406	-	406	607	-	607
406	28,644	29,050	613	43,216	43,829
406	-	406	618	-	618
406	-	406	624	-	624
406	-	406	629	-	629

CHAPTER 14 PROJECT EVALUATION

14.1 General

To measure the Project's operational and effectiveness conditions, appropriate indices are established based on the goals, objectives and functional characteristics of the Project. Improvement of the section of NR 5 between Thlea Ma'am and Prek Kdam Bridge, and construction of Kampong Chhnang Bypass and Odongk Bypass, have the direct objective of facilitating transportation of goods and passengers. As the result of improvement of traffic and transportation, the Project will contribute to socio-economic development of Cambodia as well as to promote regional development. With this concept, goals and objectives of the Project can be stated as follows:

・To facilitate transportation of goods and passengers (Direct objective)

・To mitigate road traffic congestion of roads in Kampong Chhnang City and Odongk Town.

・To promote regional development along National Road No. 5.

・To reduce road maintenance cost by improving the pavement structure.

・To secure a safety for pedestrian and a comfort for vehicles.

・To improve condition of environment pollution.

Based on these goals and objectives, indicators of the performance to be achieved during the Project life in specific and measurable terms are selected. Selected indices can, if measured, contribute to attaining better performance of the Project.

14.2 Evaluation Index

Performance of a project is usually evaluated in two aspects; degree of achievement of the targets in operation stage and their effectiveness. Degree of achievement in operation, in case of a road project, mainly refers to traffic volume. Effectiveness of a road project is degree of improvement of traffic conditions against increase of traffic demand.

<u>Selection of Operation and Effect Indicators</u>

Operation and effect indicators to evaluate and monitor the project performance and its effectiveness are selected as shown in Table 14.2-1. The indicators are divided into two; indicators for direct benefit accruing use of the road and those for indirect benefits which are brought about as the results of improvement in traffic/transport conditions.

Table 14.2-1 Performance Indicator with Project Operation and Effectiveness Measurement

Impact Indicators	Definition	Purpose of Indicator	Method of Measurement
1. Indicator for Direct Effect			
Traffic Volume	Average Traffic Volume (V) = $\Sigma Vi/\Sigma Km$ Where; Vi: traffic volume on each link in terms of PCU Km: Length on each link	To evaluate to what extent the movement of people and goods is encouraged.	Traffic Volume Counting
Reduction of traffic congestion	Vehicle congestion degree (V/C ratio) is mitigated. Average Congestion Degree (V/C) = $\Sigma V\text{-}Km/\Sigma C\text{-}Km$ Where; V-Km: traffic volume on each link in terms of PCU times length of each link C-Km: capacity on each link in terms of PCU times length of each link		Calculation of V/C ratio using the traffic volume measured in above.
Reduction of travel time	Average travel time required for the whole length of the project road	To evaluate the effect of road improvement on the traffic/transport and living environment, as well as public expenditure	Travel speed survey
Reduction of travel cost	Saving in total travel time cost for all vehicles running on the project road		Survey on the levels of bus charge and trucking charge
Reduction of traffic accident	Record of the number of traffic accidents		Accident statistics
Savings in road maintenance cost	Road maintenance cost is reduced from DBST to AC pavement.		Annual maintenance cost
Emission gas reduction	Reduction in vehicle emissions and vehicle noise can be lead to environmental benefits		Surveillance of NO_2
2. Indicator for Indirect Effect			
Promotion of regional development	Reduced transportation costs and the time cost saving for economic activities promote development of regional economic and industrial activities	To evaluate the extent of the regional development.	Population, Regional GDP, No. of factories, increase of job opportunity, etc.
Product market expansion	Product market is expanded owing to transport time reduction.		Distance between the place of production and place of consumption
Creation of employment opportunities with project construction	Employment opportunities will increase during the construction period.		Number of people locally employed during construction

14.3 Consideration on Indirect Benefits not Listed in the Table Above

In addition to the listed in Table 14.2-1 above, some more indirect benefits can be considered.

14.3.1 Promotion of Poverty Reduction

Poor people's inability to access jobs and services is an important element of the social exclusion that defines poverty. Regional and transport development can reduce poverty, by contributing to economic growth.

・During the construction period, poor people can work as unskilled construction workers

・After construction, this Project road will promote development of the region along the Project road by enhancing promotion of agriculture, industry and commerce. It is expected that job opportunities are increased in proportion with economic development.

14.3.2 Investment Promotion of Local and Foreign Firms

NR 5 is expected to promote economic activities such as foreign and domestic investment by providing efficient land transport to Phnom Penh. GMS regional economic cooperation is expected to create opportunities for various types of investments.

14.3.3 Relation to Transport Specialty Good and Tourist

Kampong Chhnang is a province well known for its fine clay pottery and they have tourist sport. With the road improvement, it is expected that the product market is expanded and increase in tourist and therefore is more active in the regions.

14.4 Operation and Effect Monitoring Plan

The operation and effect of the Project will be monitored by measuring impact indicators. The targets of the indictors are estimated in accordance with the planned monitoring timing as shown in Table 14.4-1.

Table 14.4-1 Operation and Effect Indicator

Indicators	Road	Original (2012)	Present (Year)	2 years after completion, projected as year 2022
Daily Traffic (PCU/day)	NR 5 main road	7,306		13,817
	Kampong Chhnang bypass	-		14,585
	Odongk bypass	-		19,363
Travel Time (minute)	-	(Existing NR 5 of Project Section): 135		(2 bypasses + Improved NR 5) 126

14.5 Economic Analysis

14.5.1 Objective

The main purpose of economic analysis for this survey is to show the effects of the road improvement of the project from viewpoint of national economy and it aims at evaluating the economic viability of the project implementation. Economic analysis estimates whether it is the project which benefits to national economy by analyzing the expenses consumption of the resources which national economy holds. The approach used for this follows the standard evaluation methodology for road improvement project.

14.5.2 Methodology

Economic evaluation conducted in terms of comparative analysis between benefits and costs. Benefits contain 1) time saving benefit and 2) vehicle operating cost saving benefit, while costs consist of construction cost, land acquisition cost and operation/maintenance cost. Indicators adopted here for economic evaluation are the conventional “Economic Internal Rate of Return (EIRR)”, “Benefit-cost ratio (B/C ratio)” and “Net Present Value (NPV) of the benefit”. Evaluation was conducted on the basis of transport demand forecast.

The benefit is regarded as various desirable effects given to the national economy when the project is implemented, and the cost is regarded as all national economical expenditure required for the project implementation concerned.

In order to evaluate the road projects from an economic view point, the following economic indicator were considered:

・The Net Present Value (NPV) of a given instrument is obtained by subtracting the present value of the costs from the present value of the future benefits. The benefits as well as the costs are discounted at the Opportunity Cost of capital. The investment is viable if the NPV is positive.

・The Economic Internal Rate of Return (EIRR) of a given project is defined as the discount rate at which the present value of benefits and the present value of costs are equal. It is a measure of the marginal efficiency of capital. For a project to be viable, the EIRR has to be greater than the Opportunity Cost of capital rate. Normally the NPV and EIRR will give the same indications of viability and priority ranking between projects.

・The benefit cost ratio (B/C ratio) refers to the ratio of the present value of the economic benefits stream to the present value of the economic cost stream. The investment is viable for the project if the B/C ratio is greater than 1.

(1) Implementation Plan of the Project and Evaluation Period

The economic analysis is based on the Project implementation schedule proposed in Chapter 12 as shown in Table 12.3-2. The evaluation period is assumed to be 30 years from 2020 to 2049 taking the service life of the Project into account.

Table 14.5-1 Project Implementation Schedule for Economic Analysis

	2015	2016	2017	2018	2019	2020	2021	2049
Bas Design and Detailed Design								
Tender Process								
Land Acquisition/Resettlement								
Construction								
South Section								
Kampong Chhnamg Bypass								
Odongk Bypass								
Operation and Maintenance								

(2) Evaluation Period and daily factor

Evaluation period is set as 30 years after opening to traffic. The annualized factor of the daily benefits is assumed to be 340 days per year taking into consideration the weekly variation in the volume of traffic on the roads.

(3) Discount rate

A discount rate of 12% is assumed, taking into account the opportunity cost of capital in Cambodia.

(4) "With Project" and "Without Project"

"With Project" covers the situation where the proposed road improvement and new bypass are implemented, and "Without Project" covers the situation where no such investment takes place. The quantified economic benefits, which would be realized from the implementation of the project, are defined as savings in vehicle travel costs (vehicle operating costs and vehicle travel time costs) derived from the difference between "With Project" and "Without Project".

The economic analysis procedure as illustrated in Figure 14.5-1 is employed in this survey. In order to estimate the benefit, traffic assignment to the road networks with and without the Project is considered.

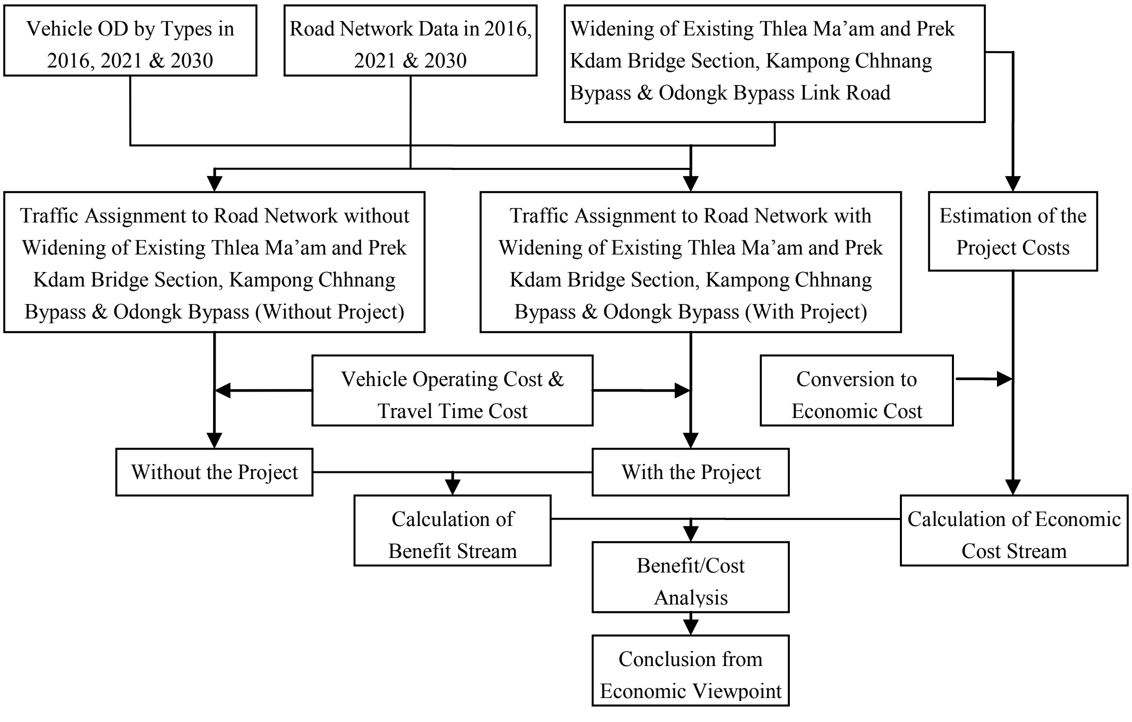


Figure 14.5-1 Procedure of Economic Analysis

14.5.3 Estimation of Economic Cost

Economic cost is a monetary expression of goods and services to be actually consumed for implementation of the Project. Also, economic cost is converted from financial cost by deducting tax portions and applying the standard conversion factor to the non-trade. Road user cost needs to estimate the travel costs in order to the Project. Travel costs consist of two component;

・Vehicle operating costs (VOC), is the physical costs of operating a vehicle such as consumption of fuel, lubricants, spare parts, deprecation, crew costs, and so on.

・Travel time costs (TTC), is the value of time spent in traveling that could be used in the other activities.

(1) Vehicle Operating Cost (VOC)

The VOC estimated in "the Preparatory Survey for National Road No. 5 Rehabilitation Project in the Kingdom of Cambodia" implemented by JICA in 2011-2012 was used as the basic reference for this survey. The VOC in this Survey was estimated considering consumer price in 2013. Inputs for vehicle operating costs required for calculating the VOC are as follows.

(a) Shadow wage rate (SWR)

The shadow wage rate (SWR) is an estimate of the economic price of labor. The labor divided into two categories: skilled, and unskilled corresponding to different degrees of scarcity. The shadow wage rate applied below the factors.

Table 14.5-2 Shadow Wage Rate

	Skilled	Unskilled
Shadow Wage Rate	1.00	0.50

Source: Cost-Benefit Analysis for development a practical Guide 2013

(b) Standard Conversion Factor (SCF)

The Standard Conversion Factor (SCF) is a standard method of incorporating, which converts domestic prices to border prices by adjusting, the distortions of prices in the domestic market. SCF used 0.90 in the Survey. It is usually adopting this range of figure.

(c) Vehicle Price

The vehicle price is estimated on the basis of average prices for new vehicles purchased from vehicle dealers. Most of vehicles are imported to Cambodia as second hand reconditioned vehicles. However, as second hand price is uncertain and depends on the frequency of use, a new vehicle prices are used in this Survey. For the purpose of calculating the economic price of each vehicle taxes and import duties have been subtracted from the retail price. The resulting economic price includes elements of Cost Insurance and Freight (CIF) price, retailer's margin.

Table 14.5-3 Vehicle Prices and Characteristics

Type	Fuel Type*	Km per driven (Annual Km)	Service Life	Financial Price (US$)	Economic Price (US$)
Motor Cycle	P	10,000	10	1,500	936
Car	P	30,000	10	40,000	23,250
Pick-Up	P	30,000	10	30,000	21,360
Mini Bus	P	30,000	10	47,500	33,428
Big Bus	D	70,000	10	83,000	58,420
Light Truck	D	60,000	8	32,000	22,535
Medium Truck	D	100,000	12	85,000	59,808
Heavy Truck	D	100,000	12	108,000	75,988

Fuel Type : P: Petrol D: Diesel
Source: Car dealers

(d) Tire Cost

The economic costs of tires assessed in the same way as vehicle prices. A suppliers in Phnom Penh were surveyed to assess general prices of different types (motorcycle, passenger car, bus and truck) of tire. New tires are subject to import duty, and VAT, the rate of which varies depending on type of tire. Custom Import duty is principally charged at 15% of the CIF value of the tire. The rate of VAT and special tax are 25% and 15% for all types of tire (Special tax for motorcycle tire is tax free). For the purpose of calculating the economic price of each vehicle tire, taxes and import duties have been subtracted from the retail price. The resulting economic price includes elements of CIF price, retailer’s margin.

Table 14.5-4 Tire Cost

Type	No. of Tire	Financial Price (US$)	Economic Price (US$)
Motor Cycle	2	44.0	35.9
Car	4	224.0	149.3
Small Bus	4	292.0	194.7
Large Bus	6	2,280.0	1,520.0
Light Truck	4	700	466.7
Medium Truck	6	1,770	1,180.0
Heavy Truck	10	3,800	2,533.3

Source: Retail shop

(e) Fuel and Lubrications

Fuel and lubricants prices estimated based on a survey of market prices. There are a number of suppliers in Cambodia operating competitively. Fuels are subject to import duty, special tax, and VAT. For the purpose of calculating the economic price of fuel and lubricants, these taxes and import duty subtracted from the retail price. The resulting economic price includes elements of CIF price, customs import duty, value added tax and retailer’s margin.

Table 14.5-5 Fuel and Tire Cost

Type	Financial Price (US$) / liter	Economic Price (US$) / liter
Gasoline Regular	1.27	1.03
Diesel	1.20	0.98
Lubricant (motorcycle)	3.60	2.93 (0.8ℓ)
Lubricant (4 wheels or more)	7.50	6.11

Source: Retail shop

(f) Spare Parts Cost

Spare parts costs are as applied 1% of the vehicle price (economic price).

(g) Maintenance Labor Cost

The maintenance costs estimated based on a survey of the average monthly cost of skilled supervisors and mechanics. Average working hours applied 200 hours per month.

Table 14.5-6 Maintenance Labor Cost

	Motor Cycle	Car	Pick-up	Mini Bus	Large Bus	Light Truck	Medium Truck	Heavy Truck
Wages per month								
Supervisor	400	400	400	400	400	400	400	400
Mechanic	150	150	150	150	150	150	150	150
Owner	0	0	0	0	0	0	0	0
Maintained by (%)								
Supervisor	10	25	25	25	50	25	50	50
Mechanic	40	50	50	50	50	50	50	50
Owner	50	25	25	25	0	25	0	0
Maintenance hours per year	40	70	70	250	300	250	300	350
Average hourly rate for services (US$)	20.0	61.3	61.3	218.8	412.5	218.8	412.5	481.3
Shadow wage rate factor	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Economic Price (US$)	20.0	61.3	61.3	218.8	412.5	218.8	412.5	481.3

(h) Crew Cost

The crew costs estimated based on a survey of unit costs per drivers and conductors or assistants, number of staff per vehicle, and number of hours per vehicle. In Cambodia, unit costs for drivers are estimated at around US$150 to $300 per driver depend on the type of vehicle, while unit cost for conductors or assistants are estimated to be one half of the average monthly cost of skilled supervisor and semi-skilled worker respectively.

Table 14.5-7 Crew Cost

	Motor Cycle	Car	Pick-up	Mini Bus	Large Bus	Light Truck	Medium Truck	Heavy Truck
Number of drivers	0.2	0.25	0.5	1	1	1	1	1
Average monthly wage rate	150	250	250	250	300	250	300	300
Working Hour	200	200	200	200	200	200	200	200
Average hourly rate for driver	0.150	0.313	0.625	1.250	1.500	1.250	1.500	1.500
Skilled wage factor – Semi - skilled	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Driver cost (Economic)	0.150	0.313	0.625	1.250	1.500	1.250	1.500	1.500
Number of conductors	0	0	0	0.5	1	1	1	1
Average monthly wage rate	0	0	0	125	150	125	150	150
Working Hour	200	200	200	200	200	200	200	200
Average hourly rate for conductor	0.000	0.000	0.000	0.313	0.750	0.625	0.750	0.750
Skilled wage factor – Unskilled	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Conductor cost (Economic)	0.000	0.000	0.000	0.156	0.375	0.313	0.375	0.375
Total Crew Cost	0.150	0.313	0.625	1.406	1.875	1.563	1.875	1.875

(i) Depreciation

Depreciation cost can be expressed as a percent of new vehicle cost and is given by the following formula:

Vehicle per 1,000 veh-km = DEP/New vehicle prices

A vehicle is a medium-term asset. The purchase cost represents an investment which yields services over several years. The market value of the asset declines with both the passage of time and with amount and type of usage.

It is this loss of market value that represents vehicle depreciation. The vehicle depreciation per km is a function of the average annual depreciation and annual utilization.

DEP = ADEP/AKM

Where: ADEP: Average annual depreciation, expressed as % of average new vehicle cost

ADEP: (1 / LIFE)*100

LIF is average vehicle service life

AKM: Average number of kilometers driven per vehicle per year

(j) Insurance Cost

Insurance cost was assumed to be 1% or 3% of vehicle price.

(k) Overhead Cost

Overhead cost was calculated at 10% of the sub-total of the VOC. Based on the above mentioned discussion and estimations the basic vehicle operating costs are calculated and are shown in Table 14.5-8.

Table 14.5-8 Vehicle Operating Cost by Vehicle Type

Unit US$/1,000 km

Type	Item	Motor Cycle	Car	Pick-up	Mini Bus	Large Bus	Light Truck	Medium Truck	Heavy Truck
Distance related VOC	Fuel cost	309.3	3,093.1	3,093.1	4,021.0	13,733.7	10,006.0	19,619.6	32,372.4
	Lubricant cost	5.9	73.3	91.7	122.2	1604.2	366.7	1833.3	1833.3
	Tire cost	17.9	112.0	112.0	146.0	2128.0	560.0	2360.0	5066.7
	Maintenance cost	9.4	232.5	213.6	334.3	584.2	225.3	598.1	759.9
	Depreciation cost	0.6	14.4	13.2	20.6	36.1	17.4	30.8	39.1
	S-total	343.0	3,525.3	3,523.5	4,644.2	18,086.2	11,175.4	24,441.8	40,071.4
	Overhead cost	0.0	0.0	352.4	464.4	1,808.6	1,117.5	2,444.2	4,007.1
	Total	343.0	3,525.3	3,875.9	5,108.6	19,894.8	12,293.0	26,886.0	44,078.5
Time related VOC	Crew cost	90.0	234.4	468.8	2,250.0	3,281.3	2,500.0	3,750.0	4,500.0
	Maintenance cost	20.0	61.3	61.3	218.8	412.5	218.8	412.5	481.3
	Insurance cost	28.1	697.5	640.8	334.3	584.2	225.3	598.1	759.9
	Depreciation cost	0.3	7.7	7.1	11.1	19.4	9.4	16.6	21.1
	S-total	138.4	1,000.9	1,177.9	2,814.1	4,297.4	2,953.5	4,777.2	5,762.2
	Overhead cost	0.0	0.0	117.8	281.4	429.7	295.3	477.7	576.2
	Total	138.4	1,000.9	1,295.7	3,095.6	4,727.1	3,248.8	5,254.9	6,338.4
Total		481.4	4,526.1	5,171.6	8,204.2	24,621.9	15,541.8	32,140.9	50,416.9
VOC/1000 km		48.1	150.9	172.4	273.5	351.7	259.0	321.4	504.2

(2) Travel Time Cost (TTC)

Travel time costs (TTC), also referred to as Value of Travel Time (VTT) is to the cost of time spent on transport. It includes costs to work and businesses of the time their employees and vehicles spent on travel. If the alternative activity can have monetary value assigned to it, this can be used as a part of road user cost in the economic appraisal of the projects, particularly road improvement projects.

In order to estimate the travel time costs, the average wage approach method is taken into consideration. The wage rates of vehicle occupants are assessed and then their average rate is estimated to reflect the value of time of occupants in different vehicles. An assessment of number of passengers in working time and non-working time is made for each vehicle type. The TTC for working time is then taken as the estimated wage rate. The TTC for non-working time is not taken into account in this study.

Unit costs were converted to unique passenger vehicle cost averaged by share of volume of each type of vehicle, which were forecasted by the Study. Converted and calibrated unit VOC in 2012, 2021 and 2030 are shown in Table 14.5-9.

Table 14.5-9 Forecast of Time Value Per Vehicle

Unit: US$/hour

	Motorcycle	Light Vehicle	Bus	Truck
Vehicle occupancy (Person)	1.8	3.5	18.0	2.0
2012	0.49	6.31	6.89	1.24
2021	0.70	9.00	9.83	1.77
2030	1.41	17.99	19.66	3.53

(3) Construction Cost, Maintenance Cost and Land Acquisition Cost

The cost of construction, maintenance and land acquisition presented in Chapter 12 and Chapter 13 are used in the economic evaluation. Some basic presumptions assumed in the economic analysis are as follows:

・Escalation factor : Price escalation is not taken into account for construction cost, maintenance cost and land acquisition cost.

・Tax and import duty : Value added tax and import duty are excluded from cost.

・Land acquisition cost : Land acquisition cost is included.

14.6 Economic Evaluation

(1) Cost Benefit Analysis

The result of the economic analysis is shown in Table 14.6-1. The economic analysis is based on the annual user's benefit and cost estimate shown in before Table 14.5-8, construction of

Thlea Ma'am and Prek Kdam Bridge (4-lanes but inner city of Kampong Chhnag and Udongk section are not improved)) and Kampong Chhnang Bypass (4-lanes) and Odongk Bypass (4-lanes) are evaluated in terms of EIRR, BCR and NPV with assumed operation period of 30 years.

Evaluation of the economic viability is undertaken through these three approaches and using discount rate of 12.0%. Compared with such large value of discount rate, it can be said that economic viability is estimated at a feasible level.

Table 14.6-1 Result of Economic Analysis

Indicator	Result
EIRR	20.7
B/C	3.10
NPV（ Million US$）	*****

***** Closed due to confidentiality

The cost-benefit analysis stream are the 30 year project life is shown in Table 14.6-2.

Table 14.6-2 Cost Benefit Stream of the Project

Unit: x 1,000 US$

SQ	Year	Project Cost	Maintenance Cost	Total Cost	Saving VOC	Saving Value of Time	Benefit	Net Benefit	Discount Cash Flow (at 12%)		
									Cost	Benefit	Net Benefit
	2015	*****		*****				*****	*****	*****	*****
	2016	*****		*****				*****	*****	*****	*****
	2017	*****		*****				*****	*****	*****	*****
	2018	*****		*****				*****	*****	*****	*****
	2019	*****		*****				*****	*****	*****	*****
1	2020	*****	395,850	*****	*****	*****	*****	*****	*****	*****	*****
2	2021	*****	395,850	*****	*****	*****	*****	*****	*****	*****	*****
3	2022		395,850	395,850	711.89	18,461,708.5	18,462,420.4	18,066,570.4	179,062.4	8,351,461.4	8,172,399.0
4	2023		395,850	395,850	1,453.01	25,390,946.3	25,392,399.3	24,996,549.3	159,877.2	10,255,564.2	10,095,687.0
5	2024		395,850	395,850	2,503.89	33,215,637.5	33,218,141.4	32,822,291.4	142,747.5	11,978,794.8	11,836,047.3
6	2025		395,850	395,850	3,127.73	42,028,352.5	42,031,480.2	41,635,630.2	127,453.1	13,533,011.7	13,405,558.6
7	2026		395,850	395,850	4,766.87	51,930,319.2	51,935,086.0	51,539,236.0	113,797.4	14,930,096.2	14,816,298.8
8	2027		395,850	395,850	5,707.70	63,032,187.2	63,037,894.9	62,642,044.9	101,604.8	16,180,257.5	16,078,652.7
9	2028		395,850	395,850	14,825.42	75,454,858.0	75,469,683.5	75,073,833.5	90,718.6	17,295,703.6	17,204,985.0
10	2029		28,323,750	28,323,750	16,564.79	89,330,384.8	89,346,949.6	61,023,199.6	5,795,600.4	18,282,156.1	12,486,555.7
11	2030		395,850	395,850	134,136.58	209,605,898.6	209,740,035.2	209,344,185.2	72,320.3	38,318,720.3	38,246,400.0
12	2031		395,850	395,850	139,904.45	220,086,193.6	220,226,098.0	219,830,248.0	64,571.7	35,923,647.1	35,859,075.4
13	2032		395,850	395,850	145,920.35	231,090,503.2	231,236,423.6	230,840,573.6	57,653.3	33,678,276.5	33,620,623.2
14	2033		395,850	395,850	152,194.92	242,645,028.4	242,797,223.3	242,401,373.3	51,476.2	31,573,251.4	31,521,775.2
15	2034		395,850	395,850	136,062.26	254,777,279.8	254,913,342.1	254,517,492.1	45,960.9	29,597,166.5	29,551,205.7
16	2035		395,850	395,850	141,912.94	267,516,143.8	267,658,056.8	267,262,206.8	41,036.5	27,747,244.9	27,706,208.4
17	2036		395,850	395,850	172,684.39	280,891,951.0	281,064,635.4	280,668,785.4	36,639.7	26,015,233.5	25,978,593.8
18	2037		395,850	395,850	180,109.82	294,936,548.6	295,116,658.4	294,720,808.4	32,714.0	24,389,181.5	24,356,467.5
19	2038		395,850	395,850	161,018.18	309,683,376.0	309,844,394.2	309,448,544.2	29,209.0	22,862,784.4	22,833,575.5
20	2039		28,323,750	28,323,750	167,941.96	325,167,544.8	325,335,486.8	297,011,736.8	1,866,028.2	21,433,786.2	19,567,757.9
21	2040		395,850	395,850	202,398.05	338,174,246.6	338,376,644.6	337,980,794.6	23,285.2	19,904,433.1	19,881,147.9
22	2041		395,850	395,850	179,209.02	351,701,216.4	351,880,425.5	351,484,575.5	20,790.4	18,481,044.8	18,460,254.4
23	2042		395,850	395,850	215,976.74	365,769,265.1	365,985,241.8	365,589,391.8	18,562.8	17,162,358.2	17,143,795.3
24	2043		395,850	395,850	191,231.97	380,400,035.7	380,591,267.7	380,195,417.7	16,573.9	15,935,077.7	15,918,503.7
25	2044		395,850	395,850	197,542.63	395,616,037.1	395,813,579.8	395,417,729.8	14,798.2	14,796,807.8	14,782,009.6
26	2045		395,850	395,850	204,061.53	411,440,678.6	411,644,740.2	411,248,890.2	13,212.7	13,739,846.8	13,726,634.2
27	2046		395,850	395,850	210,795.56	427,898,305.8	428,109,101.3	427,713,251.3	11,797.0	12,758,386.6	12,746,589.6
28	2047		395,850	395,850	217,751.82	445,014,238.0	445,231,989.8	444,836,139.8	10,533.0	11,847,034.0	11,836,501.0
29	2048		395,850	395,850	224,937.63	462,814,807.5	463,039,745.1	462,643,895.1	9,404.5	11,000,781.1	10,991,376.6
30	2049		28,323,750	28,323,750	193,633.81	395,616,037.1	395,809,670.9	367,485,920.9	600,811.1	8,396,023.2	7,795,212.1
	Total	*****	95,659,200	*****			*****	*****	*****	*****	*****

***** Closed due to confidentiality

(2) Sensitive Analysis

A sensitivity analysis is conducted to see the influence of fluctuation of benefit and construction cost. Sensitivity analysis is made on the cases with +10% in the cost and -10% in the benefit.

These changes in cost and benefit are supposed to represent unfavorable scenarios. The results of the sensitivity analysis are shown in Table 14.6-3.

As the results of sensitivity analysis, even if the worst case which the benefits are decreased in 10% and the project costs are increased in 10% is occurred, the project EIRR of the all cases exceeds over the opportunity of capital in Cambodia of 12%. The implementation of the project is economically feasible from view point of national economy.

Table 14.6-3 Results of the Sensitivity Analysis

Case		Economic Indicator	Benefits		
			-10%	Base Case	10%
Costs	-10%	NPV (US$ million)	*****	*****	*****
		B/C	3.10	3.45	3.79
		EIRR (%)	20.7%	21.6%	22.5%
	Base Case	NPV (US$ million)	*****	*****	*****
		B/C	2.79	3.10	3.41
		EIRR (%)	19.8%	20.7%	21.5%
	10%	NPV (US$ million)	*****	*****	*****
		B/C	2.54	2.82	3.08
		EIRR (%)	19.0%	19.9%	20.7%

***** Closed due to confidentiality

14.7 Conclusion

The significant benefits of the project are summarized as the enhancement of traffic safety and environmental conservation by well-designed Asphalt paved road; the integration of production and consuming centers in terms of regional context; and the reduction of transport cost to provide better market accessibility for more competition toward low prices and to increase job opportunities for the local poor especially in the development corridor between Thlea Ma’am and Prek Kdam.

The project will also stimulate the development of the Asian Highway No. AH1 and induce incremental demand of domestic cargo as well as international trade to Thailand.

CHAPTER 15 NOTES FOR IMPLEMENTATION AS JAPANESE ODA LOAN PROJECT

Through the long experiences of implementation of Japanese ODA loan projects, JICA has found many important points which need attention from the view point of smooth implementation of projects as well as to fully achieve the objectives of projects. Among those points, some are pertinent to this Project. Some important points were raised in the Survey for the North Section.

MPWT established the Project Management Unit for the North Section in November 2012 to manage the Project (see Section 12.2). The PMU is currently preparing procurement of the consultant services for the detailed design (DD) and construction supervision (C/S). The experience of implementation of Japanese Yen loan project will be accumulated within this PMU through implementation of the Project of North Section. It is expected that the Project of the South Section can be more effectively managed by the PMU than the North Section. However, the notes for implementation of Japanese Yen loan project is reiterated here to draw attention to important points.

15.1 Start-up Stage

Start-up delay is one of the focused areas identified in “2011 Joint Country Portfolio Performance Review (JCPPR)” held on April 28 and 29, 2011, jointly by Ministry of Economy and Finance (MEF), Asian Development Bank (ADB), Japan International Cooperation Agency (JICA) and the World Bank. There are some issues discussed in JCPPR such as recruitment of consultant, project launch workshop and project administration manual. Three issues are focused here.

15.1.1 Land Acquisition, Relocation and Mitigation Plan for Affected Families

The issue “Land Acquisition, Relocation and Mitigation Plan for Affected Families” is one of the most important points in the start-up stage. Many projects have faced difficulties with this issue. JICA has tackled with this issue based on its guidelines. However, some projects such as National Road No. 1 and Neak Loeang Bridge have received criticism on this issue.

So far, most of the precedent projects under Japanese ODA Loan have no problem on land acquisition and relocation. In the projects of ‘Sihanoukville Port’, ‘Phnom Penh Water’ and ‘Telecom Cambodia’ land acquisition was completed before the commencement of civil works. For the most recent project under Japanese ODA Loan, West Tonle Sap Irrigation and Drainage Rehabilitation and Improvement Project, this issue would not be so serious because almost of land has already acquired. However, now only EDC cannot prepare the necessary land for the construction of transmission lines. The delay of land acquisition is affecting the schedule of construction.

JICA is providing technical assistance on this issue through the Project on Capacity Enhancement of Environmental and Social Considerations for Resettlement. Under this project, Basic

Resettlement Procedures (BRP) is expected to be established by the end of March 2012. The result of this technical assistance project would be very helpful for the NR 5 project. It is expected that the problem of land acquisition and resettlement could be mitigated with the good collaboration between the two projects.

15.1.2 Internal Approval Procedures

In the JCPPR, the development partners indirectly pointed this issue. There are two major points; delay in decision making and insufficient capacity of staff regarding the project implementation procedures.

For the Japanese ODA loan projects, not only the decision in project executing agency but also that of MEF is necessary. Sometimes the final decision needs long time because of the long decision making line in the authorities.

So far, there have been ten Japanese ODA loan projects implemented in Cambodia. For MPWT, this is the first project financed by Japanese ODA loan. It is necessary for MPWT staff to familiarize themselves with the procedures of project implementation under Japanese ODA loan.

Also, provision of a procurement specialist by JICA, if implemented, is expected to be effective to assist MPWT in approval procedure.

15.2 Procurement Stage

The delays in procurement procedures was also pointed out in the JCPPR. JCPPR identified four issues; enhancing procurement capacity, strengthening governance and building capacity of staff in public procurement, strengthening and streamlining procurement oversight and monitoring, ensuring reasonableness and reliability of cost estimates. In case of Japanese ODA Loan projects, two issues among the issues, enhancing procurement capacity and strengthening and streamlining procurement oversight and monitoring are important points.

JCPPR proposed some measures for this issue. The main points are; strengthening and streamlining the Procurement Review Committee and the quality control of procurement document. It is recommended that JICA consider the following measures:

(i) Use of Sample Procurement Documents prepared by JICA

(ii) Procurement Seminars to not only MPWT but also Procurement Review Committee members including representatives of MEF.

JICA sometimes extends technical assistance to the implementing agency for smooth procurement. The objective of the procurement assistance is to develop the capacity of the executing agency in the employment of project consultants including, among others, the following:

(i) Preparation of a short-list of consultants

(ii) Finalization of TOR

(iii) Preparation of request for proposal including LOI, etc.

(iv) Preparation of technical proposal evaluation criteria

(v) Proposal evaluation and report preparation

(vi) Contract negotiations

Employment of Competent Consultant and Good Contractor

In the procurement stage, most important thing is to employ competent consultant and good contractors. Competent consultants and good contractors, in many cases, can prevent many risks, such as poor work quality, delay in progress and cost overrun, from occurring.

To recruit a good consultant, weight of financial proposal in the evaluation of proposal with QCBS needs to be as small as possible. In case of consultant services, low price becomes possible only with low-priced experts who often do not have required skill/knowledge/experience.

Offering large-size contract packages is generally believed to be one of practical measures for employing good contractors. In addition to this, diligent prequalification and bid evaluation are also important. However, it is a fact that there have been several cases in the past where contractors with poor ability were employed. Employment of a competent consultant can prevent to certain extent the problem caused by a contractor with poor capacity.

15.3 Construction Stage

In the construction stage, the development partners including JICA faced some delay and difficulties. The major problems are insufficient quality of civil works and construction safety.

15.3.1 Construction Quality Control

Quality control is utmost important aspect in road construction/rehabilitation. However, MPWT has suffered in the past from substandard quality and consequent premature deterioration of roads which resulted in unexpectedly high maintenance cost and hindrance to traffic. Figure 15.3-1 shows examples of roads where quality is poor.

Photo 1: NH48 Near Koh Kong (in 2010)

Photo 2: NH7 Near Kratie (in Apr., 2009)

Figure 15.3-1 Examples of Road with Poor Quality

The JICA Team considers employment of competent consultant and good contractors is the key to successful quality management. The followings are possible measures for employing good contractors:

(1) Packaging

In order to attract qualified international constructors, the most important point is the size of contract. It is recommended to make the size of procurement package as much as possible.

(2) Pre-qualification

In order to achieve the quality of civil works, PQ condition is important factor. It would be necessary to incorporate the following conditions in addition to the fundamental conditions; experience in large scale civil work contract, experience in the project financed by Japanese ODA loan, experience of the contract which is based on the sample document of JICA, experience of the FIDIC contract.

(3) Local Competitive Bidding

In order to keep the quality of civil works, it is recommended to avoid LCB except for small package. As pointed out in the JCPPR, in Cambodia, the capacity of local constructor is still limited.

(4) Two-Envelope Bidding

In order to select qualified international contractor, it is necessary to use Two-Envelop Bidding following the JICA guidelines. The specification for and evaluation of technical proposal are important points.

15.3.2 Construction Safety

Here the term construction safety refers to two kind of safety; safety of workers and safety of the third party which is traffic and people around the work site.

It is one of the main concerns of JICA in Japanese loan projects that projects are implemented without accidents. Construction safety tends to be given little attention, if not neglected, in many developing countries and it has been the case also in Cambodia. However, with rapid socioeconomic development, safety is becoming one of the important issues. Thus, diligent attention needs to be given this aspect.

Examples of measures for enhancing safety may include the following:

(i) Detailed specification for safety measures in bidding documents

(ii) Strict condition in technical specification on the experience on construction safety

(iii) Continuous training and seminars for MPWT staff, such as the “Seminar on Safety Management and Quality Management of Infrastructure Projects in Cambodia” on Feb. 21, 2011, organized by JICA

(iv) Use of result of study on Construction Safety Management of ODA Projects implemented by the Overseas Construction Association of Japan, Inc. (OCAJI)

Competent consultant and good contractors usually can considerably contribute to both types of safety for worker and third party because good site management is the base of such safety. It should be noted that safety measures often needs some cost. Thus, cost for required safety measures need to be reflected in the cost estimation.

15.4 Operation and Maintenance Stage

15.4.1 Budget for Operation and Maintenance

In 2010, maintenance budget was increased from US$ 32.8 million in 2009 to US$ 35.8 million (9% increased). This budget will be allocated for the maintenance of the following structures:

1. Routine Maintenance US$ 17.9 Million

1.1 National and provincial road (A/C) US$ 7.9 Million

1.2 National and provincial road (Laterite) US$ 5.9 Million

1.3 Traffic inspection US$ 0.1 Million

1.4 Culvert construction at key infrastructure US$ 4.0 Million

2. Periodic Maintenance US$ 15.0 Million

3. Emergency maintenance US$ 2.9 Million

However, the above budget is not sufficient for the maintenance works. So far, the large scale maintenance and improvement works have been financed by Development Partners' assistance. This Project is to improve the pavement type of NR 5 from DBST to AC, and is expected to reduce annual maintenance cost. However, rehabilitation of AC pavement becomes necessary every 10 years in usual practice and MPWT needs to prepare relatively large fund for this pavement rehabilitation.

15.4.2 Traffic Safety

This Project is to widen the carriageway of existing NR 5 and separate slow traffic, such as motorcycles and moto-rumoks, and high-speed traffic, such as passenger cars. As a result, the chances of traffic accidents are expected to be reduced in general.

On the other hand, there is a possibility that some pedestrians cannot respond to the increased speed of vehicles, especially that of high-speed vehicles, and may commit miss judgment when crossing the road and hit by a vehicle. Thus it is recommended that campaign to raise awareness of roadside residents against increased vehicle speed be implemented as the road improvement approach to completion. Also so-called '3Es' (engineering, education and enforcement) should be practiced.

15.4.3 Enforcement against Overloaded Trucks

It is widely known that overloaded trucks severely damage pavement. Thus, enforcement against overloaded trucks is indispensable to secure expected life period of pavement and achieve expected project benefit.

The locations of weighing station on National Road No.5 are;

(i) Lung Vek (Kampong Chhnang 048+000),

(ii) Kleang Moeung (Pursat 191+800),

(iii) Anlung Vil (Battambang 282+000), and

(iv) Koun Domrei (B. Meanchey 389 + 000).

Effective operation of these weighing stations is expected to substantially reduce overloaded trucks. MPWT should continue its effort, with cooperation of traffic police, for effective operation of weighing stations.

CHAPTER 16 ENVIRONMENTAL AND SOCIAL CONSIDERATION

16.1 Legal, and Administrative Framework

16.1.1 Legal Framework

(1) Law on Environmental Protection and Natural Resource Management

"Law on Environmental Protection and Natural Resource Management (Preah Reach Kram/NS-RKM-1296/36)" was enacted in November, 1996 and is the main legal instrument in governing the environmental protection and natural resource management in Cambodia. The purposes are as follows:

- To protect and promote environmental quality and public health through the prevention, reduction, and control of pollution,
- To assess the environmental impacts of all proposed projects prior to the issuance of a decision by the Royal Government,
- To ensure the rational and sustainable conservation, development, management, and use of the natural resources of the Kingdom of Cambodia,
- To encourage and enable the public to participate in environmental protection and natural resource management,
- To suppress any acts that cause harm to the environment.

The Article 6 and 7 in the Chapter 3 regulate environmental impact assessment system in Cambodia.

Article 6:

"An environmental impact assessment (EIA) shall be conducted on every project and activity of the private or public, and shall be approved by the Ministry of Environment before being submitted to the Royal Government for decision. This assessment shall also be conducted for existing activities that have not yet been assessed for environmental impacts. The procedures of the process for environmental impact assessment shall be defined by sub-decree following a proposal of the Ministry of Environment. The nature and size of the proposed projects and/or activities (proposed and existing) both private and public, that shall be subject an environmental impact assessment which shall be defined by sub-decree following a proposal of the Ministry of Environment"

Article 7:

"All investment Project Applications and all proposed State projects shall be subject to an initial Environmental Impact Assessment and/or Environmental Impact Assessment as specified in article 6 of this law. The Ministry of environment shall review and provide recommendations on the initial Environmental Impact Assessment and/or environmental impact assessment to the competent bodies within period determined by the Law on Investment of the Kingdom of Cambodia."

(2) Sub-decree on Environmental Impact Assessment Process

"Sub-decree on Environmental Impact Assessment Process (Anukret/72ANK-BK/11Aug99)" was prepared in August, 1999. The main objectives of this sub-decree are as follows:

- To determine an Environmental Impact Assessment (EIA) process for every private and public project or activity. The assessment shall be reviewed by the Ministry of Environment prior to submission to the Royal Government for a decision.
- To determine the type and size of the proposed private and public projects and activities, including existing and ongoing activities subject to the process of EIA.
- To encourage public participation in the implementation of the EIA process and take into account their input and suggestions in the process of project approval.

EIA requirements for proposed projects are mentioned in the Chapter 3 (Article 6 ~ 13).

Article 6:

"A Project Owner must conduct Initial Environmental Impact Assessment (IEIA) in order to comply with the EIA requirement as stated in the annex of this sub-decree."

Article 8:

"A Project Owner must apply to the MOE for reviewing their full report of EIA report and Feasibility Study, in case a project tends to cause a serious impact to the natural resources, ecosystem, health and public welfare."

Article 11:

"A Project Owner must cover all the fee's services for reviewing and monitoring upon their project. These service fees shall be approved by the Ministry of Economy and Finance following the proposal of the MOE. The said fee shall be incorporated into the national budget."

According to this sub-decree, the types of projects and criteria for mandating IEIA/EIA are stipulated as summarized in Table 16.1-1. National Road construction project with length over 100 km is required an IEIA or EIA. Therefore, this project needs to conduct the IEIA or EIA.

Table 16.1-1 List of Projects and its Criteria Required IEIA/EIA in Cambodia

No.	Type and Activities of Projects	Size/Capacity
A.	INDUSTRIAL	
B.	AGRICULTURE	
C.	TOURISM	
D.	INFRASTRUCTURE	
1.	Urbanization development	All sizes
2.	Industrial zones	All sizes
3.	Construction of bridge-roads	>= 30 Tones weight
4.	Buildings	Height >= 12 m or floor >= 8,000 m^2
5.	Restaurants	>= 500 Seats
6.	Hotels	>= 60 Rooms
7.	Hotel adjacent to coastal area	>= 40 Rooms
8.	National road construction	>= 100 Kilometers

No.	Type and Activities of Projects	Size/Capacity
9.	Railway construction	All sizes
10.	Port construction	All sizes
11.	Air port construction	All sizes
12.	Dredging	>= 50,000 m^3
13.	Damping site	>= 200,000 people

Source: Sub-Decree on Environmental Impact Assessment Process (1999)

(3) General Guideline for Conducting Initial and full Environmental Impact Assessment Reports

"Prakas (Declaration) on General Guideline for Conducting Initial and full Environmental Impact Assessment Reports" was prepared in September, 2009 and guides the preparation of IEIA or EIA report for the project owner.

(4) Protected Area Law

"Protected Area Law" was enacted in January 2008. This law defines the framework of management, conservation and development of protected areas. The objectives of this law are to ensure the management, conservation of biodiversity, and sustainable use of natural resources in protected areas.

(5) Sub-Decree on Water Pollution Control

"Sub-Decree on Water Pollution Control (No:27 ANRK.BK)" was prepared in April 1999. The purpose of this sub-decree is to regulate the water pollution control in order to prevent and reduce the water pollution of the public water areas so that the protection of human health and the conservation of bio-diversity should be ensured.

(6) Sub-Decree on Solid Waste Management

Sub-Decree on Solid Waste Management (No:36 ANK/BK) was enacted in April, 1999. The purpose of this sub-decree is to regulate solid waste management in a proper technical manner and to provide safety precautions in order to ensure the protection of human health and the conservation of biodiversity.

(7) Sub-Decree on Control of Air Pollution and Noise Disturbance

Sub-Decree on Control of Air Pollution and Noise Disturbance (No:42 ANK/BK) was enacted in June, 2000. The purpose of this sub-decree is to protect the quality of the environment quality and public.

(8) JICA Guidelines

JICA has prepared "Guidelines for Environmental and Social Considerations, April 2010" as the referential guidelines for environmental and social considerations. According to the guidelines, JICA classifies development projects into four categories with regards to the extent of environmental and social impacts, and taking into account the outlines, scale, site and other conditions. The four categories are as follows:

- Category A: Proposed projects are likely to have significant adverse impacts on the environment and society.

➢Category B: Proposed projects are classified as Category B if their potential adverse impacts on the environment and society are less adverse than those of Category A projects.

➢Category C: Proposed projects are classified as Category C if they are likely to have minimal or little adverse impact on the environment and society.

➢Category FI: A proposed project is classified as Category FI if it satisfies all of the followings:

- JICA's funding of JICA-REDP is provided to a financial intermediary or executing agency;
- The selection and appraisal of the components is substantially undertaken by such an institution only after JICA's approval of the funding, so that the components cannot be specified prior to JICA's approval of funding (or project appraisal); and
- Those components are expected to have a potential impact on the environment.

National Road No. 5 Rehabilitation Project (Prek Kdam Bridge - Thlea Ma' Am section) to be implemented is classified as "Category A".

16.1.2 EIA Schedule

According to Sub-decree on EIA Process, National Road No. 5 Rehabilitation Project needs to conduct the EIA study and EIA report needs approval of the Ministry of Environment (MOE). Figure 16.1-1 shows general flow of approval of the EIA.

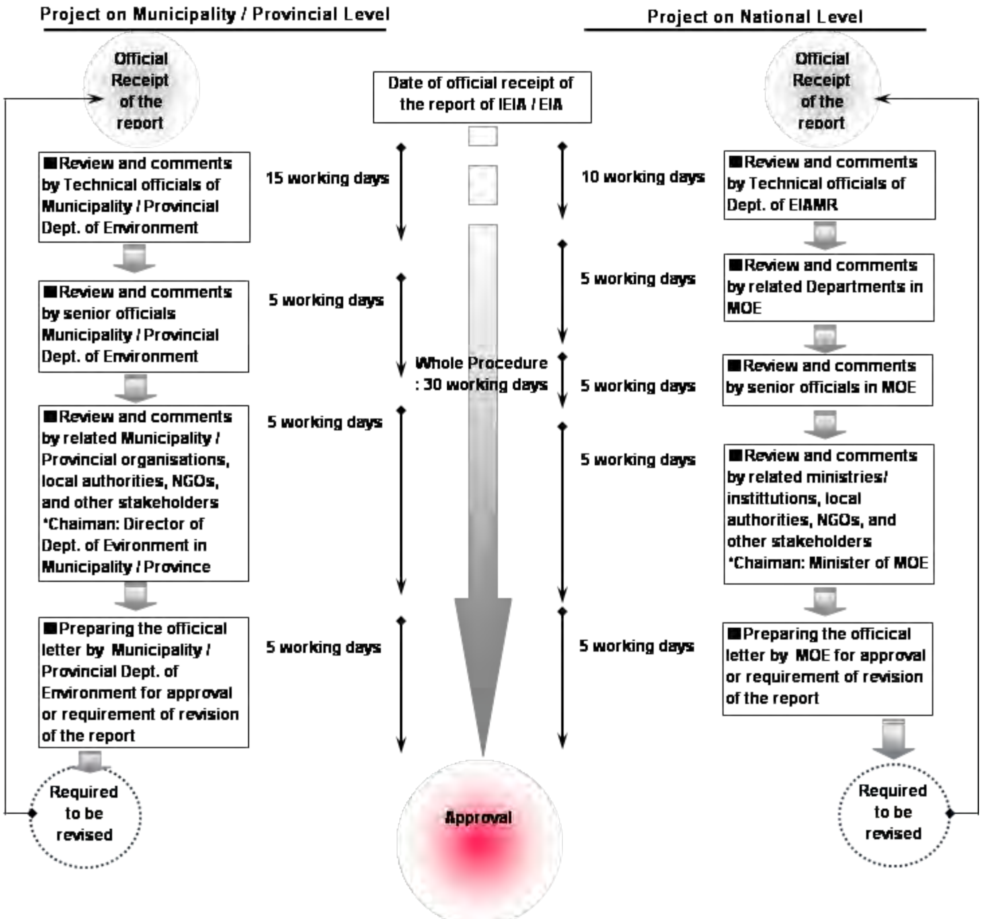


Figure 16.1-1 IEIA/EIA Approval Procedure

Table 16.1-2 shows the schedule of EIA study for this Survey:

Table 16.1-2 Tentative Schedule of EIA Procedure

Year	2012		2013										
Month	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Contract with EIA Consultant	▲												
Meeting with MOE (1)	▲												
Literature Survey by Consultant	▬	▬											
Holding of public meetings		▲											
Internal Meeting in Japan and preparation of final technical TOR				▲									
Fixing on conceptual alignment				▲									
Field Survey, EIA Study and Reporting by Consultant					▬	▬	▬						
Submission of First Draft EIA to JICA survey team								▲					
Review of First Draft EIA by JICA survey team								▬					
Additional Survey in Rainy Period									▬				
Submission of Draft EIA Report to JICA survey team									▲				
Meeting with MOE (2)										▲			
Submission of Final EIA Report to MOE										▲			
Review of EIA report by MOE										▬	▬		
Approval on EIA report											▲		

16.1.3 Institutional Framework

The Department of Environmental Impact Assessment (DEIA) in MOE and Municipality/ Provincial Department of Environment (DE) are in charge of review and making comment on the IEIA or EIA report of public/private project each on national level and municipality/provincial level following the general guidelines. MOE and Municipality/Provincial DE are also responsible to prepare the official letter for approval or require the project's owner for revision of the IEIA or Full EIA report. Figures 16.1-2 and 16.1-3 show organizational structure of DEIA in MOE and Provincial/Municipal Environmental Department (PMED), respectively.

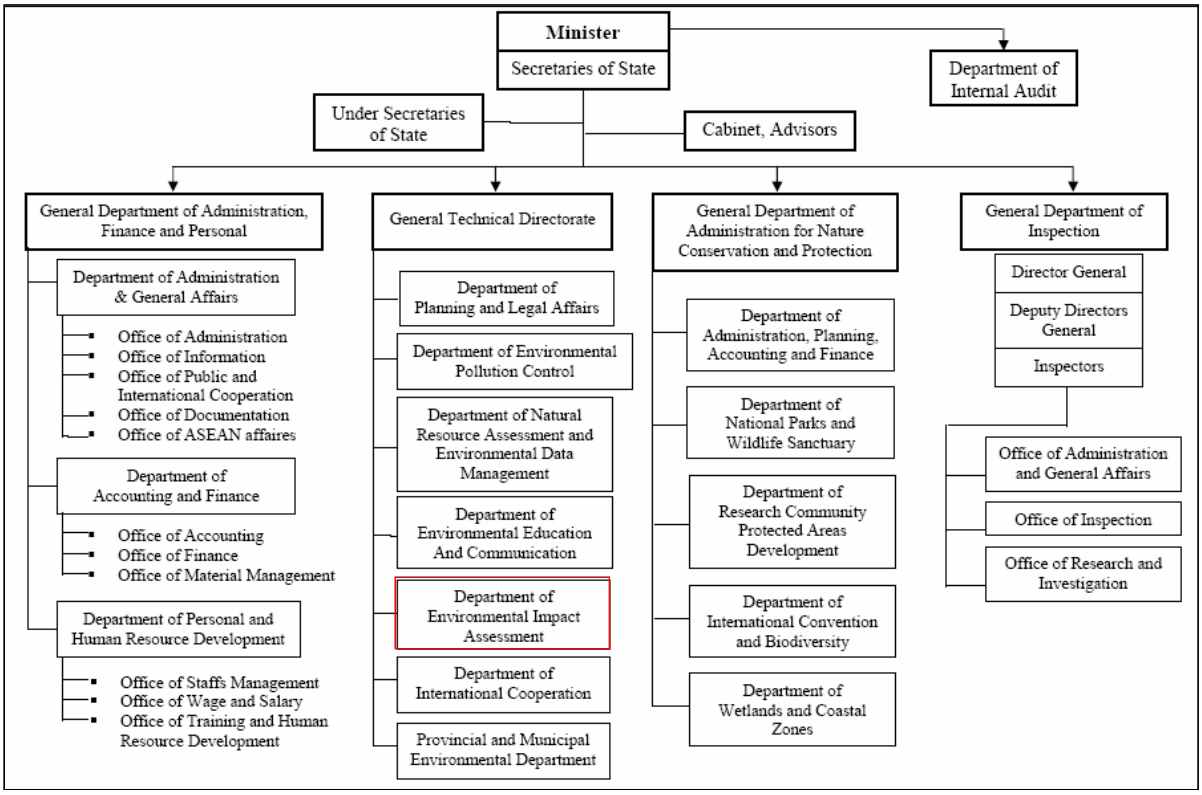


Figure 16.1-2 Organization Chart of MOE

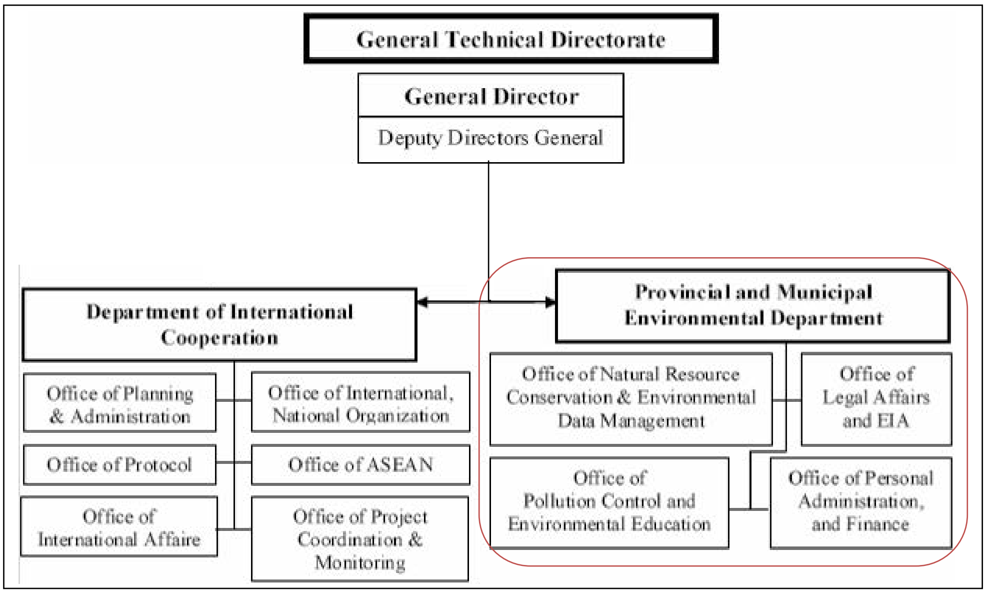


Figure 16.1-3 Organizational Structure of PMED

16.1.4 Environmental Standard

(1) Air Quality

Sub Decree on Air and Noise Pollution Control (1999) provides the maximum allowable limits for ambient air pollutants.

Table 16.1-3 Ambient Air Quality Standard in Cambodia

No.	Parameter	1 Hour Average mg/m^3	8 Hour Average mg/m^3	24 Hour Average mg/m^3	1 Year Average mg/m^3
1	Carbon monoxide (CO)	40	20	-	-
2	Nitrogen dioxide (NO_2)	0.3	-	0.1	-
3	Sulfur dioxide (SO_2)	0.5	-	0.3	0.1
4	Ozone (O_3)	0.2	-	-	-
5	Lead (Pb)	-	-	0.005	-
6	Total Suspended Particulate (TSP)	-	-	0.33	0.1

Source: Sub Decree on Air and Noise Pollution Control (2000), Annex 1

(2) Noise

Sub Decree on Air and Noise Pollution Control (2000) provides the maximum allowance of noise level in public and residential area.

Table 16.1-4 Maximum Permitted Noise Level in Public and Residential Area (dB(A))

No.	Area	Period of time		
		From 6:00 to 18:00	From 18:00 to 22:00	From 22:00 to 6:00
1	Quiet areas - Hospitals - Libraries - School - Kindergarten	45	40	35
2	Residential area: - Hotels - Administration offices - House	60	50	45
3	Commercial and service and mix area	70	65	50
4	Small industrial factories intermingling in residential areas	75	70	50

Remark: This standard is applied to control of noise level of any source of activity that emitted noise into the public and residential area.

Source: Sub Decree on Air and Noise Pollution Control (2000), Annex 6

(3) Water Quality

Tables 16.1-5 and 16.1-6 show Cambodian standards for water quality in public water areas for bio-diversity conservation. Table 16.1-7 shows the water quality standard for discharging water into public water areas.

Table 16.1-5 Water Quality Standard for Bio-Diversity Conservation (for River)

No	Parameter	Unit	Standard Value
1	pH	mg/l	6.5 – 8.5
2	BOD5	mg/l	1 – 10
3	Suspended Solid	mg/l	25 – 100
4	Dissolved Oxygen	mg/l	2.0 - 7.5
5	Coliform6	MPN/100 ml	< 5000

Source: Sub-decree on water pollution control (1999), Annex 4

Table 16.1-6 Water Quality Standard for Bio-Diversity Conservation (for Lakes and Reservoirs)

No	Parameter	Unit	Standard Value
1	pH	mg/l	6.5 – 8.5
2	COD	mg/l	1 – 8
3	Suspended Solid	mg/l	1 – 15
4	Dissolved Oxygen	mg/l	2.0 - 7.5
5	Coliform	MPN/100 ml	< 1000
6	Total Nitrogen	mg/l	1.0 – 0.6
7	Total Phosphorus	mg/l	0.005 – 0.05

Source: Sub-decree on water pollution control (1999), Annex 4

Table 16.1-7 Standard for Discharging Wastewater into Public Water Area

No.	Pollutant	Unit	Allowable Limit	
			Protected Public Water	Public Water Area & Sewer
1	Temperature	Degrees C	<45	<45
2	pH	-	6 - 9	5 - 9
3	BOD5 (5 days at 20°C)	mg/l	<30	<80
4	COD	mg/l	<50	<100
5	Total Suspended Solids	mg/l	<50	<80
6	Total Dissolved Solids	mg/l	<1,000	<2,000
7	Grease and Oil	mg/l	<5.0	<15
8	Detergents	mg/l	<5.0	<15
9	Phenols	mg/l	<0.1	<1.2
10	Nitrate (NO_3)	mg/l	<10	<20
11	Chlorine (free)	mg/l	<1.0	<2.0
12	Chloride (ion)	mg/l	<500	<700
13	Sulfate (as SO_4)	mg/l	<300	<500
14	Sulfide (as Sulfur)	mg/l	<0.2	<1.0
15	Phosphate (PO_4)	mg/l	<3.0	<6.0
16	Cyanide (CN)	mg/l	<0.2	<1.5
17	Barium (Ba)	mg/l	<4.0	<7.0
18	Arsenic (As)	mg/l	<0.10	<1.0
19	Tin (Sn)	mg/l	<2.0	<8.0
20	Iron (Fe)	mg/l	<1.0	<20
21	Boron (Bo)	mg/l	<1.0	<5.0
22	Manganese (Mn)	mg/l	<1.0	<5.0
23	Cadmium (Cd)	mg/l	<0.1	<0.5
24	Chromium (Cr^{+3})	mg/l	<0.2	<1.0
25	Chromium (Cr^{+6})	mg/l	<0.05	<0.5
26	Copper (Cu)	mg/l	<0.2	<1.0
27	Lead (Pb)	mg/l	<0.1	<1.0
28	Mercury (Hg)	mg/l	<0.002	<0.05
29	Nickel (Ni)	mg/l	<0.2	<1.0
30	Selenium (Se)	mg/l	<0.05	<0.5
31	Silver (Ag)	mg/l	<0.1	<1.0
32	Zinc (Zn)	mg/l	<1.0	<3.0
33	Molybdenum (Mo)	mg/l	<0.1	<1.0

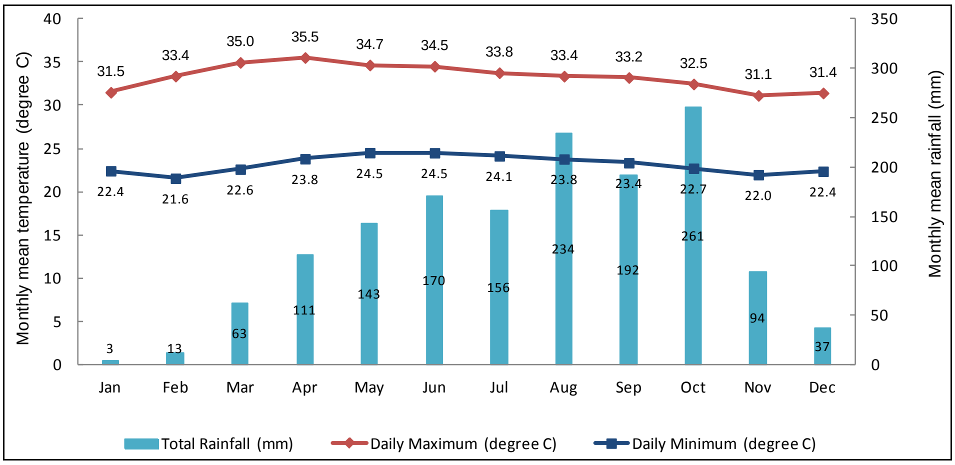
No.	Pollutant	Unit	Allowable Limit	
			Protected Public Water	Public Water Area & Sewer
34	Ammonia (NH_3)	mg/l	<5.0	<7.0
35	DO	mg/l	>2.0	>1.0
36	Polychlorinated Biphenyl	mg/l	<0.003	<0.003
37	Calcium	mg/l	<150	<200
38	Magnesium	mg/l	<150	<200
39	Carbon Tetrachloride	mg/l	<3	<3
40	Hexachloro Benzene		<2	<2
41	DDT		<1.3	<1.3
42	Endrin		<0.01	<0.01
43	Dieldrin		<0.01	<0.01
44	Aldrin		<0.01	<0.01
45	Isodrin		<0.01	<0.01
46	Perchloro Ethylene		<2.5	<2.5
47	Hexachloro Butadiene		<3	<3
48	Chloroform		<1	<1
49	1,2- Dichloro Ethylene		<2.5	<2.5
50	Tricholoro Ethylene		<1	<1
51	Trichloro Benzene		<2	<2
52	Hexachloro Cyclohexene		<2	<2

Source: Sub-decree on water pollution control (1999), Annex 2

16.2 Natural Environment

16.2.1 Climate

The Project Area is located in tropical monsoon zone. The climate consists of dry season and rainy season. The dry season is from November to April. During dry season, monsoon wind blows from the north bringing cold air from Siberia. Rainy season is from May to October. During rainy season, wind blows from southwest of country bringing moisture from Indian Ocean and make rainfall which is vital for agricultural activities. The annual difference in temperature is a narrow range of 4 ~ 5 degrees Celsius.



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

Figure 16.2-1 Monthly Mean Temperature and Rainfall in Pursat

16.2.2 Land Use and Forest Area

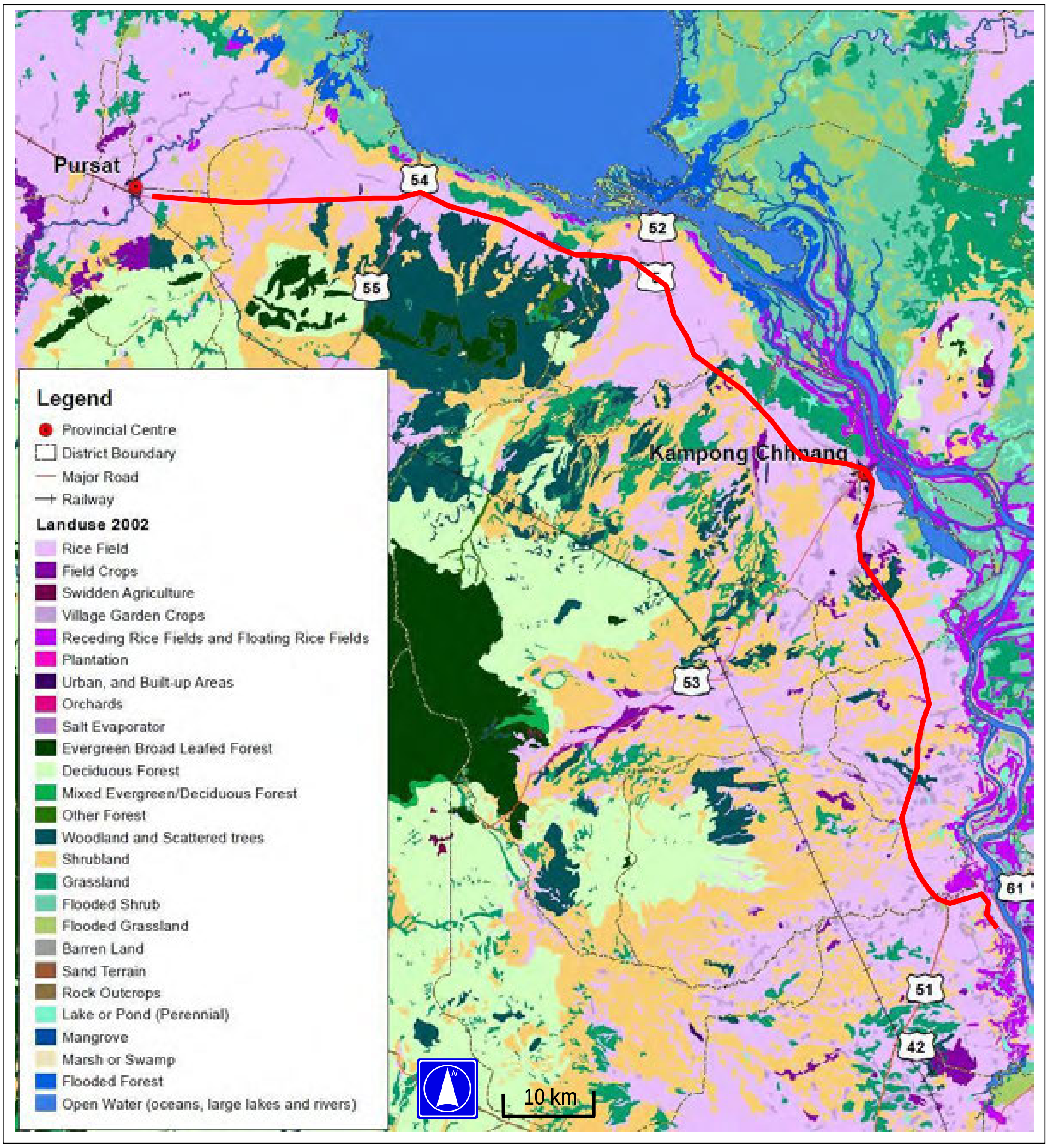
The land use around the project area is mostly rice field, shrub land or urban area. There are no considerable natural vegetation areas including forest around the project area. Several community forests with small area have remained in very limited areas. Flooded forest zone with 10 ~ 30 km width exists around Tonle Sap Lake located to the east of National Road No.5 (NR 5). The area between the target section of NR 5 and flooded forest is mostly agricultural land.

Community forests:

Community forests are defined by "Sub-Decree (No: 79 Or Nor Krar. Bor Kar) on community forestry management, 2003". Forestry Administration is the main implement organization of the sub-decree. Community forests are state forests subject to an agreement to manage and utilize the forest in a sustainable manner between the Forestry Administration and a local community or organized group of people living within or nearby the forest area that depend upon it for subsistence and customary use. The distance between the target section of NR 5 and the community forest is approximately 300 m at the nearest point.

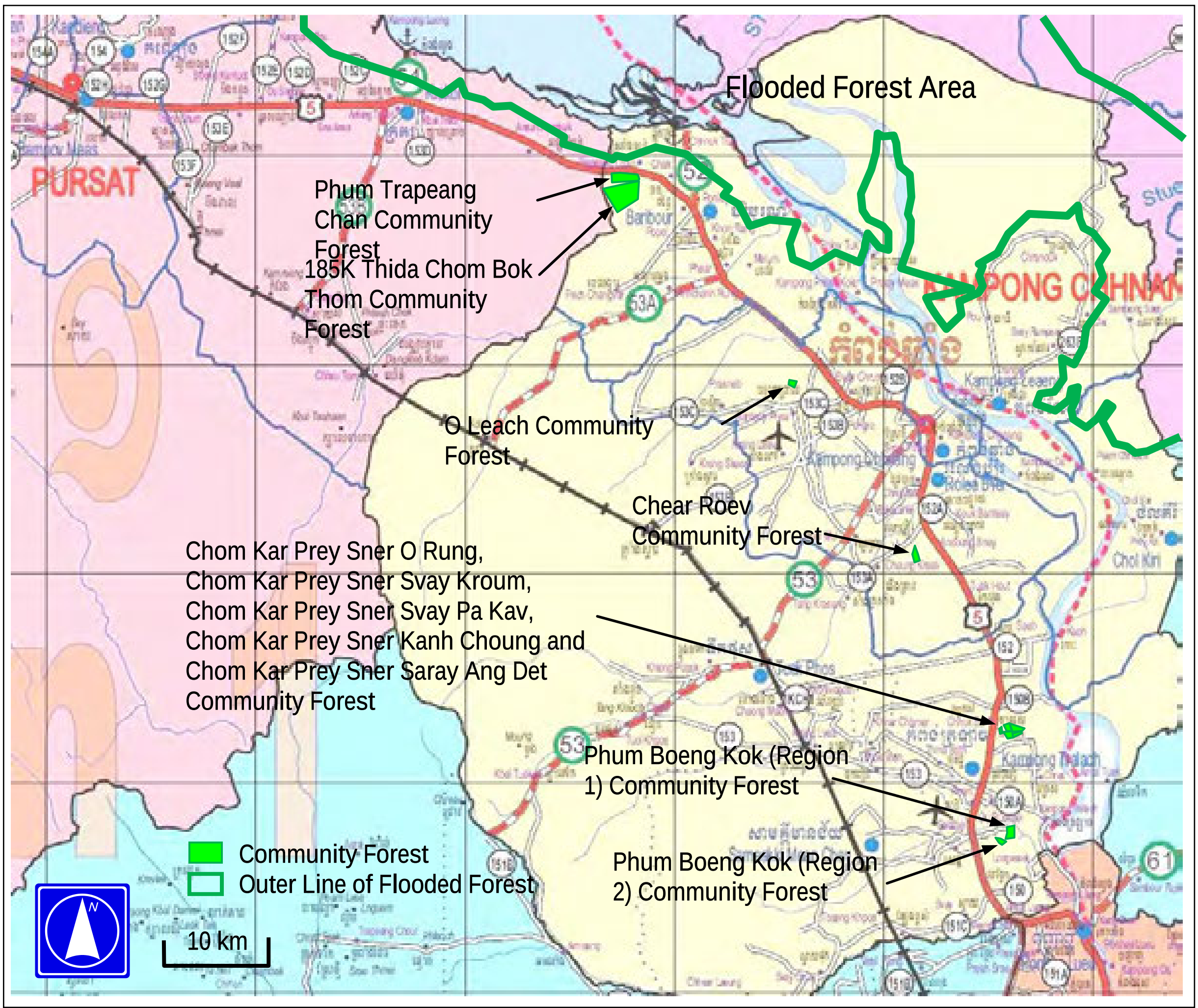
Flooded forest:

The flooded forest is defined by "Sub-decree (Prakas No. 197) on flooded forest, 2011" as a protected forest. Provincial governments and Tonle Sap Authority are the main implement organizations of the sub-decree. The forest has 647,406 hectares of ecologically-rich flooded forest surrounding Tonle Sap lake. The forest is protected against damaging activities caused by excessive exploitation, shifting cultivation, imports of harmful forest vegetation and wildlife species, and so on. The distance between the target section and the forest is approximately 1 km at the nearest point.



Source: The Atlas of Cambodia National Poverty and Environment Maps 2007

Figure 16.2-2 Land Use around Project Area



Source: Open Development Cambodia

Figure 16.2-3 Community and Flooded Forest around Project Area

16.2.3 Protected Area

In Cambodia, protected conservation areas cover around 4.6 million hectares. There are 7 national parks, 10 wildlife sanctuaries, 3 protected landscape areas, 3 multiple use management areas and 7 protected forests (Source: Cambodia Environment Outlook 2009).

In general, Right of Way (ROW) and its surrounding area of NR 5 has been already cultivated and developed for human activities with variety of land use form, such as agricultural land, residential area, commercial spots, and so on. Therefore, the target section of NR 5 is not included in the protected areas for natural environment. However, a portion of the target section runs alongside the line of buffer zone or transition zone in “Tonle Sap Biosphere Reserve (TSBR)”.

In the meeting held between the officials of the Ministry of Environment (MOE) and the JICA Survey Team confirmed that the ROW (30 m width) of NR 5 is defined as the outside of TSBR, and therefore, additional environmental approvals are not required for implementation of the project.

Tonle Sap Biosphere Reserve (TSBR):

TSBR is defined by “Royal-Decree on The Establishment and Management of Tonle Sap Biosphere Reserve, 2001”. Cambodia National Mekong Committee is the main implement organization of the Decree. The reserve is approximately 1.4 million hectares, designated by UNESCO in 1997 and includes the lake and most of the surrounding area bordered by NR 5 and 6. TSBR has been classified into the core area, buffer zone and transition zone. MOE is responsible for the modification of zoning.

Core Area: The core areas are defined likewise national park or wildlife sanctuary, which are devoted to long term protection and conservation of natural resources and ecosystem, in order to preserve flooded forest, fish, wildlife, hydrological system, and natural beauty. MOE is responsible for the management and preparation of protection and conservation plan for the core areas. There are 3 core areas (Boeng Chhmar, Preak Torl and Stung Sen) in TSBR. These core areas are listed in “Protected Area Law, 2008”. The distance between the target section and the core areas is approximately 15 km at the nearest point.

Buffer Zone: The buffer zone is subject to experimental research and discovery of method for the management of flooded forest, fishery, agriculture, housing settlement, land use, water resources, navigation and tourism to ensure their sustainability, increased production, while preserving the environmental quality and fish. Its boundary corresponds to the outer boundary of the Tonle Sap Multiple-Use Area.

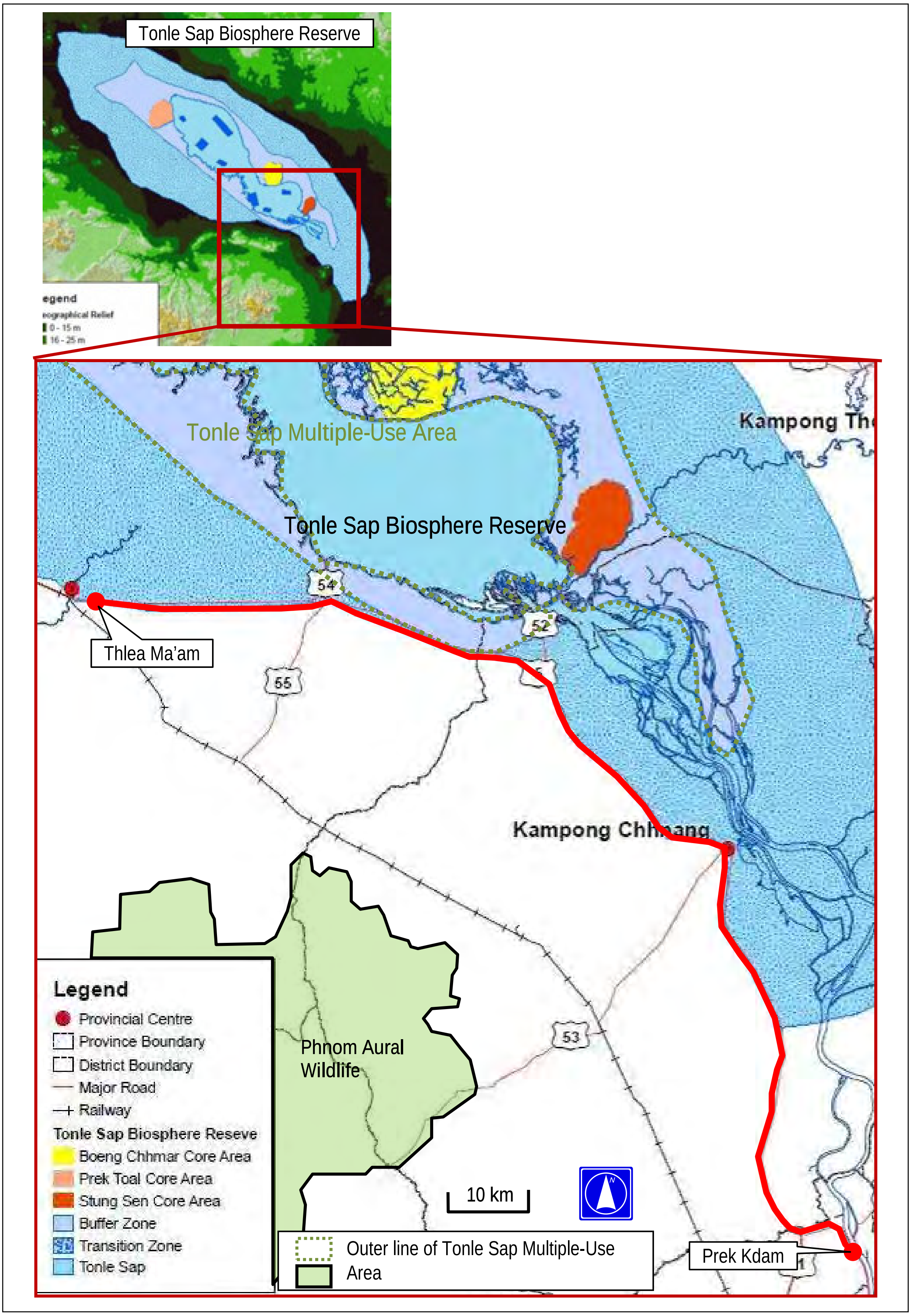
Transition Zone: The flexible transition area is the integrated economic zone, which is managed for the sustainable agriculture, human settlement and land uses, without having adverse effects on the flooded forest, water quality and soils of the region around the Tonle Sap Lake. The area is limited between the outer boundary of the buffer zone and NR 5, and NR 6.

Tonle Sap Multiple-Use Area:

Tonle Sap Multiple-Use Area is defined by “Protected Area Law, 2008”. MOE is the main implement organization of the Law. The Multiple-Use Area is an area in land and/or water territories, which is rich in natural resources that are intact and require management activities to ensure long-term protection and maintenance of biological resources and ecosystem. In the meantime, it provides natural products and services for use to meet the community needs. A portion (approximately 5 km long) of the target section runs alongside the line of the area.

The major environmental issues in TSBR are as follows:

- Loss of fishery resources due to over fishing and use of destructive and illegal fishing practices
- Clearance of flooded forest due to agricultural development and increase in demand for fuel-wood by local people
- Water contamination due to increase in domestic wastewater, especially around Siem Reap area
- Increase in erosion and sedimentation due to forest cover decline



Source: The Atlas of Cambodia National Poverty and Environment Maps 2007

Figure 16.2-4 Protected Area around Project Area

16.2.4 Ecosystem

In order to obtain available information on the ecosystem along the project road, the JICA Survey Team visited the relevant organizations including MOE, WWF, IUCN and Wildlife Conservation Society. However none of these organizations have not conducted ecological surveys in and around the project area, the useful information on fauna and flora is few. To identify fauna and flora species, direct observations and interview surveys to local people were conducted in March and July, 2013. Wetlands, reservoirs and shrub lands located within around 250 m area from the road center, which potentially have high biodiversity, were intensively surveyed besides the roadside area. The water quality in these wetland and reservoirs were also surveyed.

(1) Outline

The ecosystem around the project area is developed on the following land use:

- Paddy field and vegetable or fruit farm
- Residential or urban area
- Natural river or channel
- Wetland, reservoir or flood plain
- Sparse woodland or shrub land

Starting from Prek Kdam (Direction from Phnom Penh) until Thlea Ma'Am, the ending of the project area, agricultural ecosystem (paddy field and farm) covers most of the project area including the buffer and transition zone of TSBR. There are Odongk town, Kampong Chhnang city and Baribour town as major urban areas, and many residential areas of small communities on both sites of the NR 5 are found. Agricultural channels are also found through the whole project area. A major flood plain is located on the left hand side prior to reaching Odongk town. This flood plain is used as fish farm by local people during dry period. A considerable wetland with high biodiversity is located around Ou Prong River crossing point to the northwest of Kampong Chhnang city (see Figure 16.2-5, Water 7 point). Small shrub lands are found on both sites from Odongk town to Kampong Chhnang city, which are mainly owned by developers. Major shrub lands are found on both sites in the northwest suburb of Kampong Chhnang city.

Mass migration routes of mammals, reptiles and insects were not identified around the target section in as a result of the literature and field surveys.

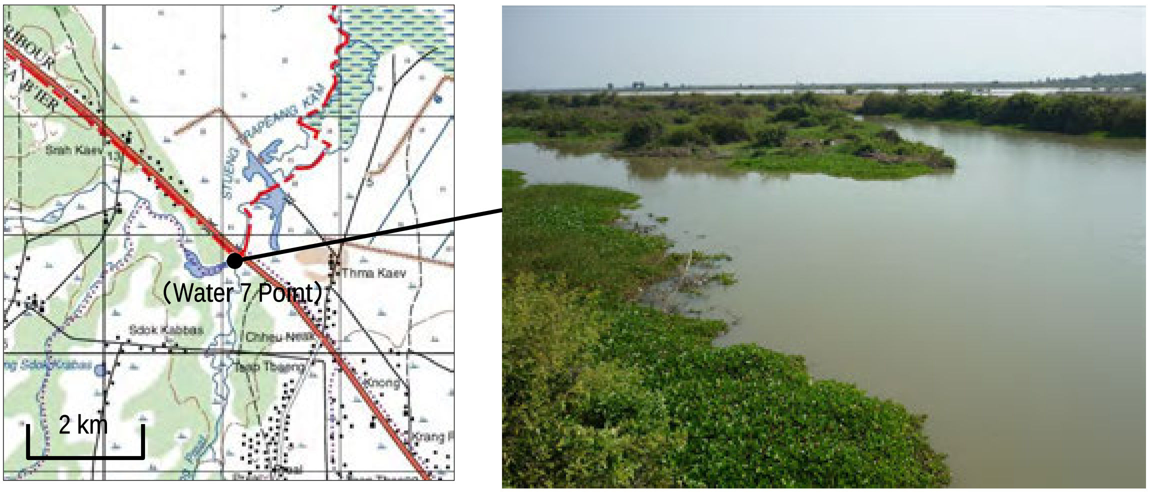


Figure 16.2-5 Wetland around Ou Prong River Crossing Point

(2) Agricultural Area

Agricultural ecosystem (paddy field and farm land) are observed along the project area. Starting from Prek Kdam (Direction from Phnom Penh) untill Thlea MA'am, the ending of the project area, paddy fields are found on both sides, starting from PK 39 + 829 m on both sides of the NR No.5. The ending point of the paddy field on the right side is at KP 148 + 517 m ~ 149 + 729 m and that of the left hand side is at KP 148 + 517 m ~ 149 + 955 m. In between, there are many locations were also observed. Meanwhile, farm land, cashew farm, was found at KP 130+ 790 m ~ 131 + 930 m on the left hand side while its ending point is located at KP 145 ~ 145 + 578 m on both sides.

Table 16.2-1 Detailed Locations of Paddy Field and Farm Land

Type of Land Use	Location Right side (Northeast)	Location Left side (Southwest)
Paddy Field	KP 39 + 829 m ~ 41+ 799 m	KP 39 + 829 m ~ 41+ 799 m
	KP 48 + 500 m ~ 50 + 756 m	KP 43 + 152 m ~ 44
	KP 55 + 869 m ~ 56 + 704 m	KP 48 + 500 m ~ 49 + 462 m
	KP 61 + 852 m ~ 63 + 535 m	KP 60 + 814 m ~ 61 + 218 m
	KP 64 + 114 m ~ 65 + 846 m	KP 61 + 852 m ~ 65 + 846 m
	KP 66 + 520 m ~ 67	KP 69 + 332 m ~ 71 + 931 m
	KP 69 + 332 m ~ 71 + 627 m	KP 81 + 146 m ~ 82 + 882 m
	KP 81 + 146 m ~ 82 + 882 m	KP 112 + 735 m ~ 113 + 395 m
	KP 148 + 517 m ~ 149 + 729 m	KP 129 ~ 129 + 525 m
	-	KP 148 + 517 m ~ 149 + 955 m
Farm Land	-	KP 130+ 790 m ~ 131 + 930 m
	KP 145 ~ 145 + 578 m	KP 145 ~ 145 + 578 m

Note: KP = Kilometer Post

(3) Residential and Urban Areas

Odongk town, Kampong Chhnang and Baribour towns were observed as major urban areas. These areas are very active in daily economic activities. Many residential areas of small communities on both sites along the project area were found.

Table 16.2-2 Detailed Locations of Residential Area

Type of Land Use	Location Right side (Northeast)	Location Left side (Southwest)
Residential area	KP 31 ~ 31+ 706 m	KP 31 ~ 31+ 706 m
	KP 31+ 925 m ~ 33 + 507 m	KP 32+ 736 m ~ 33 + 240 m
	KP 34 + 801 m ~ 39 + 829 m	KP 34 + 801 m ~ 39 + 829 m
	KP 41 + 799 m ~ 48+ 500 m	KP 41 + 799 m ~ 43+ 152 m
	KP 50 + 756 m ~ 55 + 869 m	KP 44 ~ 48 + 500 m
	KP 56 + 704 m ~ 61 + 852 m	KP 49 + 462 m ~ 60 + 814 m
	KP 63 + 535 m ~ 64+ 114 m	KP 61 + 218 m ~ 61 + 852 m
	KP 65 + 846 m ~ 66 + 520 m	KP 65 + 846 m ~ 67 + 758 m
	KP 67 ~ 67 + 758 m	KP 68 + 98 m ~ 69 + 332 m
	KP 68 + 98 m ~ 69 + 332 m	KP 71 + 931 m ~ 81 + 146 m
	KP 71 + 627 m ~ 81 + 146 m	KP 98 + 100 m ~ 105 + 118 m
	KP 98 + 100 m ~ 105 + 338 m	KP 107 + 457 m ~ 112 + 735 m
	KP 107 + 457 m ~ 112 + 735 m	KP 149 + 955 m ~ 171
	KP 114 ~ 130 + 790 m	KP 114 ~ 129
	KP 131 + 930 m ~ 134 + 110 m	KP 129 + 525 m ~ 130 + 790 m
	KP 134 + 565 m ~ 145	KP 131 + 930 m ~ 134 + 110 m
	KP 145 + 578 m ~ 148 + 517 m	KP 145 + 578 m ~ 148 + 517 m
	KP 149 + 729 m ~ 171	KP 134 + 565 m ~ 145

(4) Natural River and Channel

Agricultural channels and small rivers are found though the project area. These channels and most of the small rivers usually dry up during the dry season. It is notable that during the rainy season, the small rivers have direct and/or indirect connections with the Tonle Sap Great Lake.

(5) Wetland and Flood Plain

A considerable wetland with high biodiversity is located at KP 105 + 338 m ~ 107 + 457 m (Right site or Northeast) and KP 105 + 118 m ~ 107 + 457 m (Left side or Southwest) around Ou Prong River crossing point to the northwest of Kampong Chhnang town. The starting point of flood plain is located at KP 31+ 706 m ~ 31+ 925 m on the right hand side and at KP 31+ 706 m ~ 32 + 736 m of the left hand side prior to reaching Odongk town. The ending point of the flood plain is located on both sides at KP 67 + 758 m ~ 68 + 98 m. This flood plain is used as fish farm by local people during dry period.

Table 16.2-3 Locations of Flood Plain and Wetland

Type of Land Use	Location Right side (Northeast)	Location Left side (Southwest)
Flood Plain	KP 31+ 706 m ~ 31+ 925 m	KP 31+ 706 m ~ 32 + 736 m
	KP 33 + 507 m ~ 34 + 801 m	KP 33 + 240 m ~ 34 + 801 m
	KP 67 + 758 m ~ 68 + 98 m	KP 67 + 758 m ~ 68 + 98 m
Wetland	KP 105 + 338 m ~ 107 + 457 m	KP 105 + 118 m ~ 107 + 457 m

(6) Shrub Land

Major Shrub lands are found at KP 112 + 735 m ~ 114 on the right hand side and KP 113 + 395 m ~ 114 on the left hand side, while its ending point is at KP 134 + 110 m ~ 134 + 565 m on the right hand side.

Table 16.2-4 Locations of Major Shrub land

Type of Land Use	Location Right side (Northeast)	Location Left side (Southwest)
Shrub land	KP 112 + 735 m ~ 114	KP 113 + 395 m ~ 114
	KP 130+ 790 m ~ 131 + 930 m	KP 134 + 110 m ~ 134 + 565 m
	KP 134 + 110 m ~ 134 + 565 m	-

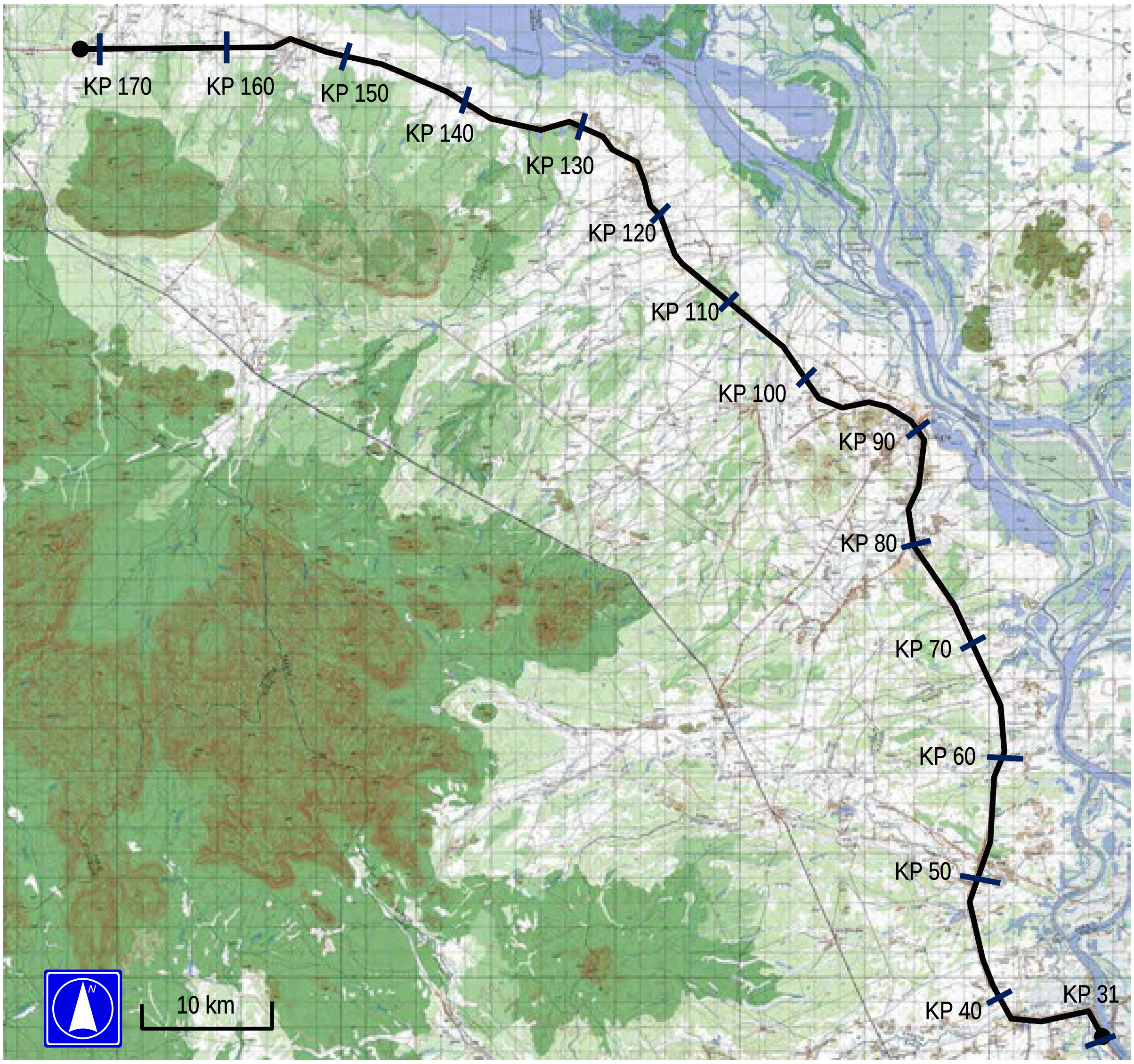


Figure 16.2-6 Location of Main Kilometer Post (KP)

(7) Flora

Because the target section of NR 5 do not run through forest areas, the trees along the road are roughly divided roadside trees artificially planted within approximately 7 m on both sides from the road center line and garden trees in private lands. Eucalypt trees are major roadside tree species in rural areas. Big or middle size trees including Rain tree and Banyan tree are located on the roadsides in build-up areas and create esthetic effects and the shade to pedestrians. These trees will be required to be cut down for the widening works except for the bypass sections. Main garden trees are shown in Table 16.2-5. The garden trees with in the ROW will be the compensated assets. Main roadside trees are shown in Table 16.2-6. Based on direct observations, 117 floras including vine (climbing plant) were found along the project area and the Kampong Chhnang Bypass. The list of flora species is presented in Appendix 16-2. Some of the plants could not be identified either scientific name or family name. Endangered and/or rare flora species were not identified along the target section in this survey.

Table 16.2-5 Main Garden Tree Species

No.	Local Name	English Name	Scientific Name
1	Tnaot	Palm Tree	*Borassus flabellifer*
2	Svay	Mango Tree	*Mangifera indica*
3	Khnol	Jack Tree	*Artocarpus heterophyllus*
4	Tiep	Custard Apple Tree	*Annona squamosa*
5	Doung	Cocunut Tree	*Cocos nucifera*
6	Trabaek	Guava Tree	*Psidium guajava*
7	Teuk Dah Ko	Milk Tree	*Chrysophyllum cainito*
8	Putrea	Jujube Tree	*Zizyphus mauritiana*
9	Totuem	Pomegranate Tree	*Punica granatum*
10	Chek	Banana Tree	*Musa spp.*
11	Pring	Jambolan Tree	*Eugenia spp.*
12	Svay Chan Ti	Cashew Tree	*Anacadium occidentale L.*

Table 16.2-6 Main Roadside Tree Species

Location Right Side	Tree Name	English Name	Location Left Side	Tree Name	English Name
KP 32 + 934 m	Ampil Barang	Rain tree	KP 32 + 730 m	Ampiltoeuk	Manila tamarind
KP 34 + 157 m	Ampil Barang	Rain tree	KP 32 + 720 m	Chek	Eucalypt tree
KP 35 + 36	Tnaot	Sugar Plam	KP 46 + 120 m	Acacia	
	Putrea	Jujube tree	KP 57 + 90 m	Breng Khyal	Eucalypt tree
KP 36 + 37	Ampil	Tamarind tree	KP 58 + 270 m	Breng Khyal	Eucalypt tree
	Tnaot	Sugar palm		Acacia	
KP 37 + 375 m	Chhat	Indian almond	KP 60 + 61	Acacia	
KP 38 + 39	Teuk Dah Kou	Milk fruit		Angkanh	
	Chhat	Indian Almond		Breng khyal	Eucalypt tree
KP 39 + 175 m	Acacia		KP 66 + 67	Chhat	Indian almond
KP 44 + 160 m	Breng Khyal	Eucalypt tree		Ampilbarang	Rain tree
KP 57 + 120 m	Breng Khyal	Eucalypt tree		Svay chanty	Cashew tree
KP 59 + 625 m	Porpealkhae	Eucalypt tree		Acacia	
KP 60 + 85 m	Breng Khyal	Eucalypt tree	KP 68 + 132 m	Putrea	Jujube tree
KP 65 + 66	Acacia		KP 73 + 188 m	Tnoat	Sugar palm
	Breng khyal	Eucalypt tree	KP 74 + 805 m	Roluoanhi	
KP 66 + 38 m	Acacia		KP 75 + 76	Trasek	
KP 67 + 470 m	Svay Chanty	Cashew tree		Roluoanhi	
KP 68 + 69	Thkouv			Breng khyal	Eucalypt tree
	Acacia		KP 79 + 80	Tnaot	Sugar palm
KP 69 + 70	Tnaot	Sugar palm		Ampil	Tamarind tree
	Breng khyal		KP 80 + 81	Loeurng Reach	Golden Shower tree
KP 74 + 405 m	Ampil toeuk			Chhat	Indian almond
KP 75 + 192 m	Tnaot	Sugar palm	KP 81 + 82	Angkanh	
KP 76 + 257 m	Tnaot	Sugar palm		Acacia	
KP 81 + 82	Acacia			Breng khyal	
	Breng khyal		KP 100 + 101	Thkouv	
KP 98 + 99	Putrea	Jujube tree		Chras	Albizia tree
	Ampil Barang	Rain tree		Breng khyal	Eucalypt tree
KP 100 + 101	Loeurng Reach	Golden Shower tree	KP 105 + 106	Breng khyal	Eucalypt tree
	Maysak	Teak tree		Acacia	

Location Right Side	Tree Name	English Name	Location Left Side	Tree Name	English Name
	Krangaok	Peacock flower	KP 106 + 333 m	Breng khyal	Eucalypt tree
KP 101 + 102	Breng khyal	Eucalypt tree		Acacia	
	Ampil barang	Rain tree	KP 107 + 108	Breng khyal	Eucalypt tree
	Trasek		KP 108 + 109	Kor	Kapok tree
	Putrea			Thkouv	
KP 103 + 104	Breng khyal			Breng khyal	Eucalypt tree
	Acacia			Acacia	
KP 105 + 106	Thkouv			Trasek	
	Acacia			Poutea	Jujube tree
KP 108 + 740 m	Thkouv		KP 109 + 110	Putrea	Jujube tree
KP 110 + 700 m	Breng khyal			Acacia	
KP 111 + 112	Breng khyal			Maysak	Teak tree
KP 114 + 115	Breng khyal		KP 110 + 111	Acacia	
	Acacia			Ampilbarang	Rain tree
KP 115 + 116	Acacia			Trabaek	Guava tree
KP 116 + 353 m	Breng khyal	Eucalypt tree		Trabaekprey	Queen flower
	Acacia		KP 111 + 112	Putrea	Jujube tree
KP 117 + 118	Breng khyal	Eucalypt tree		Breng khyal	Eucalypt tree
	Acacia		KP 112 + 113	Chamriek	
	Thkouv			Svay chanty	Cashew tree
KP 118 + 119	Thkouv			Breng khyal	
	Acacia		KP 113 + 114	Acacia	
	Ampil barang	Rain tree		Breng khyal	Eucalypt tree
	Trabaekprey	Queen flower	KP 114 + 115	Breng khyal	Eucalypt tree
KP 119 + 120	Thkouv			Acacia	
	Trasek			Kor	Kapok tree
	Trabaek	Guava tree		Putrea	Jujube tree
KP 120 + 121	Pring	Jambolan tree	KP 115 + 116	Breng khyal	Eucalypt tree
	Thkouv			Acacia	
KP 122 + 117 m	Breng khyal			Chamriek	
KP 123 + 670 m	Chhat	Indian almond	KP 117 + 118	Breng khyal	Eucalypt tree
KP 124 + 125	Trabaekprey	Queen flower		Acacia	
	Putrea	Jujube tree		Phkar Krangoak	Peacock flower
	Chhat	Indian almond		Pring	Jambolan tree
KP 125 + 126	Trabaek	Guava tree	KP 118 + 119	Breng khyal	
	Trabaekpry	Queen flower		Ampilbarang	Rain tree
	Breng khyal	Eucalypt tree		Ounh Mounh	Cassia grandis
	Tnoat	Sugar palm		Chamriek	
	Thkouv			Trabaek	Guava tree
	Putrea	Jujube tree	KP 119 + 120	Chamriek	
KP 126 + 127	Thkouv			Kor	Kapok tree
	Putrea	Jujube tree		Angkanh	
KP 127 + 474 m	Putrea	Jujube tree		Ampilbarang	Rain tree
KP 128 + 129	Tnoat	Sugar palm		Chhat	Indian almond
	Putrea	Jujube tree		Putrea	Jujube tree
	Chamriek		KP 120 + 121	Thkouv	
	Trabaek	Guava tree		Tnaot	Sugar palm
	Ampilbarang	Rain tree		Svay Chanty	Cashew tree
KP 129 + 130	Tnoat	Sugar palm		Ampil	Tamarind tree

Location Right Side	Tree Name	English Name	Location Left Side	Tree Name	English Name
	Putrea	Jujube tree		Ampilbarang	Rain tree
	Krasang			Pring	Jambolan tree
	Pring	Jambolan tree		Trasek	
	Trasek			Putrea	Jujube tree
KP 132 + 855 m	Svay Chanty	Cashew tree	KP 122 + 123	Acacia	
KP 133 + 886 m	Thkouv			Chhat	Indian almond
KP 143 + 54 m	Brengkhyal			Doung	Coconut tree
KP 151 + 670 m	Ampilbarang	Rain tree	KP 123 + 204 m	Mien	Logan tree
KP 155 + 156	Acacia			Chhat	Indian almond
	Tnoat	Sugar palm	KP 124 + 125	Doung	Coconut tree
	Por	Banyan tree		Ampilbarang	Rain tree
KP 156 + 157	Acacia			Putrea	Jujube tree
KP 158 + 780 m	Tnoat	Sugar palm		Toeukdas Kou	
	Por	Banyan tree		Chhat	Indian almond
	Chamriek		KP 125 + 126	Thkouv	
KP 159 + 950 m	Chheuteal			Putrea	Jujube tree
	Acacia			Trabaek	Guava tree
KP 160 + 161	Ampilbarang	Rain tree		Pring	Jambolan tree
	Prengkhyal			Trasek	
	Pring	Jambolan tree		Trakiebktam	
KP 161 + 830 m	Acacia			Tnoat	Sugar palm
KP 162 + 163	Pring	Jambolan tree		Svay	Mango tree
	Ampilbarang	Rain tree	KP 126 + 127	Russei Srok	Bamboo
KP 163 + 164	Acacia			Ampilbarang	Rain tree
	Poutrea	Jujube tree	KP 128 + 129	Pring	Jambolan tree
KP 164 + 165	Tbaeng			Acacia	
	Acacia			Ampilbarang	Rain tree
KP 166 + 906 m	Tnoat	Sugar palm		Thkouv	
KP 167 + 450 m	Tnoat	Sugar palm		Putrea	Jujube tree
KP 169 + 170	Tnoat	Sugar palm	KP 129 + 130	Pring	Jambolan tree
	Pring	Jambolan tree		Trasek	
KP 170 + 171	Poutrea	Jujube tree		Putrea	Jujube tree
	Ampil	Tamarind tree		Tnoat	Sugar palm
	Phkar Krangoak	Peacock flower		Ampilbarang	Rain tree
	Prengkhyal			Trabaek	Guava tree
	Acacia				

Only on Left Side					
Location	Tree Name	English Name	Location	Tree Name	English Name
KP 130 + 131	Kor	Kapok tree	KP 160 + 161	Acacia	
	Chamriek			Tnoat	Sugar palm
	Tnoat	Sugar palm		Acacia	
KP 132 + 813 m	Svay Chanty	Cashew tree	KP 161 + 162	Ampilbarang	Rain tree
	Chamriek			Acacia	
KP 135 + 136	Acacia		KP 162 + 163	Chrey	
	Putrea	Jujube tree		Trasek	
	Chamriek			Tnoat	Sugar palm
KP 137 + 138	Svay chanty	Cashew tree		Acacia	
	Breng khyal	Eucalypt tree	KP 163 + 164	Breng khyal	Eucalypt tree

Only on Left Side					
Location	Tree Name	English Name	Location	Tree Name	English Name
	Kor	Kapok tree		Acacia	
KP 138 + 284 m	Thkouv		KP 164 + 165	Acacia	
KP 140 + 141	Phkar Krangoak	Peacock flower		Thlork	
	Ampilbarang	Rain tree		Trabaekprey	Queen flower
	Ampiltoeuk	Manila tamarind	KP 165 + 166	Ampilbarang	Rain tree
KP 141 + 142	Tnoat	Sugar palm		Pring	Jambolan tree
	Ampilbarang	Rain tree	KP 167 + 168	Tnoat	Sugar palm
	Acacia			Phkar Krangoak	Peacock flower
KP 142 + 615 m	Acacia			Acacia	
	Thkouv			Poun	
KP 143 + 350 m	Putrea	Jujube tree	KP 168 + 169	Ampilbarang	Rain tree
KP 146 + 147	Acacia			Tnoat	Sugar palm
KP 147 + 148	Acacia			Ampil	Tamarind tree
	Tnoat	Sugar palm	KP 169 + 170	Tnoat	Sugar palm
	Svaychanty	Cashew tree		Chambak	
KP 155 + 156	Tnoat	Sugar palm	KP 170 + 171	Ampilbarang	Rain tree
	Trasek			Ampil	Tamarind tree
	Chrey			Tnoat	Sugar palm
KP 156 + 157	Tnoat	Sugar palm		Breng khyal	Eucalypt tree
KP 159 + 950 m	Pring	Jambolan tree		Acacia	

(8) Fauna

Fauna here refers to fish species, reptiles and amphibians, and bird species that can be found through their presences passing by the project area. Based on the information obtained from the interviews of local people, the results are shown in Table 16.2-7. The information on inhabitants of Croaker (middle size fish), Cobra, Python, Soft Shell Turtle and Terrapin (fresh water turtle) as rare species was reported in most of the interviewed locations. However, the habitats of these species were not specified along the target section in this survey as a result of the direct observations.

Fish Species

33 main fish species were found through family-scale fishing activities at rivers and streams crossing the project area. Most of those fish species were found during the rainy season. However, some of the species could not be written in English. It is notable that wetlands in the eastern side of the transition zone in TSBR along the project area including small rivers have direct and/or indirect connections with the Tonle Sap Great Lake in particular during the rainy season.

Mammals, Reptiles, and Amphibians

8 Mammals, 7 Reptiles, and 5 Amphibians were mainly identified and reported.

Birds

26 main birds were reported by local people. Their habitats were unknown. What the local

people observed was that those birds migrated from other areas and passed by the project area. During the rainy season, more birds were observed. This may be concluded that one of their habitats is from the flooded forests of the Great Lake where is to the east of NR 5.

Table 16.2-7 List of Main Fauna

No.	Local Name	English Name	Scientific Name	Identified Location	IUCN Red List Classification
I- Fish and crustacean species					
1	Trey Bra Kae		*Pangasius conchophilus*	Paddy Field, River, Wetland and Flood Plain	LC
2	Trey Bra Kchao		*Pangasius bocourti*	River, Wetland and Flood Plain	LC
3	Trey Bra Thom	Sutchi Catfish	*Pangasiano donhypophthalmus*		N/A
4	Treypor	Spot Pangaasius	*Pangasius larnaudii*		LC
5	Trey Andaeng Roeng	Walking Catfish	*Clariasbatrachus*		N/A
6	Trey Andaengtun	Black Skin Catfish	*Clariasmeladerma*		N/A
7	Trey Andat Chke	Whitelip Sole	*Achiroides Leucorhynchos*		N/A
8	Trey Chhkaok		*Cyclocheichthys enoplos*		N/A
9	Trey Chhpin	Goldfin Tinfoil Barb	*Hypsibarbus malcolmi*		LC
10	Trey Proloung	Hoven's Carp/Mad Barb	*Leptobarbus hoevenii*		N/A
11	Trey Deap/Trey Chdau	Giant Snakehead	*Chnna mucropeltes*		N/A
12	Trey Domrey	Marble Goby	*Oxyeleotris marmorata*		LC
13	Trey Ka-Ek	Black Sharkminnow	*Labeo chrysophekadion*		LC
14	Trey Kaes		*Micronemacheveyi*		N/A
15	Trey Kahe	Goldfoil/Tinfoil Barb	*Barbonymus schwanenfeldii*		LC
16	Trey Kampulbai/ Trey Chhkaok Kda	Papillocheilus Ayuthiae	*Cosmochilus harmandi*		LC
17	Trey Kanhchrouk	Skunk Botia	*Yasuhikotakia morleti*		LC
18	Trey Khchoeung	Frecklefin Eel	*Trey chonluanh moan*		N/A
19	Trey Khman	Hampala Barb	*Hampala macrolepidota*		LC
20	Trey Kray	Clown Featherback	*Chitala ornata*		LC
21	Trey Krolang/Trey Prul	Small Scale Mud Carp	*Cirrhinus mucrolepis*		N/A
22	Trey Kromorm	Butter Catfish	*Ompokbimaculatus*		N/A
23	Trey Kros	Pla Rong Mai Tub	*Osteochilus microcephalus*		LC
24	Trey Krum		*Osteochilus melanopleurus*	River, Wetland and Flood Plain	N/A
25	Trey Krus	Dusky Face Carp	*Osteochilus lini*		LC
26	Trey Phtuok/Trey Ros	Snakehead Murrel	*Channa striata*		LC
27	Trey Proma	Boeseman Croaker	*Boesemania*		NT
28	Trey Sanday/Trey	Wallago	*Wallagoattu*		N/A

No.	Local Name	English Name	Scientific Name	Identified Location	IUCN Red List Classification
	Kropoit				
29	Trey Slat	Bronze Featherback	*Notopterus notopterus*		LC
30	Trey Stuok		*Wallagoleerii*		N/A
31	Trey Ta Oan		*Ompokhypophthalmus*		N/A
32	Trey Chhlaing	Asian Redtail Catfish	*Hemibagrusnemurus*		N/A
33	Trey Khcha		*Hemibagruswyckioides*		N/A
II- Mammals					
1	Skar Touch	Small Asian Mongoose	*Herpestes javanicus*	Wetland, Flood Plain, and Kampong Chhnang Bypass area	LC
2	Kdan Nhaeng	Lesser Mouse deer	*Tragulus javanicus*		DD
3	Tunsay Kul	Burmese Hare	*Lepus pequensis*		N/A
4	Kanthuek	Northern Treeshrew	*Tupain belangeri*		N/A
5	Kambrok Por	Variable Squirrel	*Callosciurus erythraeus*	Kampong Chhnang Bypass area	LC
6	Chhlous	Red Muntjac	*Muntiacus muntjak*		LC
7	Sam Pouch Vor	Small Indian Civet	*Viverricula indica*		LC
8	Chrouk Prey	Wild Pig	*Sus scrofa*		LC
III- Reptiles					
1	Pous Vek Dom Bouk	Indochinese Spitting Cobra	*Naja siamensis*	Paddy Field, Wetland, Flood Plain and Kampong Chhnang Bypass area	VU
2	Kam Broma	East Asian Porcupine	*Hystrix brachyura*	Wetland and Flood Plain	LC
3	Pous Vek Krobei	Monocled Cobra	*Naja kaouthia*		LC
4	Pous Thlan Touch	Burmese Python	*Pyfthon Molurus bivittaftus*		VU
5	Pous Thlan Thom	Reticulate Python	*Python reticulatus*		N/A
6	Kan Theay	Asiatic Soft Shell Turtle	*Amyda cartilaginea*		VU
7	An Deurk Srae	Rice field terrapin	*Malayemys subtrijuga*		VU
IV- Amphibians					
1	Kingkuok	Common Asian Toad	*Bufo melanosttrictus*	All the interviewed location	N/A
2	Hing	Common Asian Bullfrog	*Kaloula pulchra*		LC
3	Kangkeb	Paddy Frog	*Fejevarya limnocharis*		N/A
4	Kangkebkob	Regulose Bullfrog	*Hoblobatrachus rugulosus*		N/A
5	Kanhchanhchek	Common Tree Frog	*Polypedates leucomystax*		LC
V- Birds					
1	Bakou	Common Hoopoe	*Upupa Epops*		LC
2	Popustoek	Little Grebe	*Tachybaptus ruficollis*		LC
3	Populchampusthum	Thick-Billed Green Pigeon	*Treron curvirostra*		LC
4	Populchoeung	Yellow-Footed Green Pigeon	*Treron phoenicoptera*		N/A
5	Chochatkrem	Common Kingfisher	*Alcedo atthis*		LC
6	Porltouk	Blue-Eared Barbet	*Megalaima australis*		LC

No.	Local Name	English Name	Scientific Name	Identified Location	IUCN Red List Classification
	Thngaskhmao			Wetland and Flood Plain	
7	Porltouk Kbal	Lineated Barbet	*Megalaima lineata*		LC
8	Porltouk Ambuk	Coppersmith Barbet	*Megalaima haemacephala*		LC
9	Chek Tum	Black-Naped Oriole	*Oriolus chinensis*		LC
10	Ka Ek	Large-Billed Crow	*Corvus macrohynchos*		N/A
11	Meam Touch Prey	Asian Barred Owlet	*Glaucidium cucloides*		N/A
12	Sek Sourm	Alexandrine Parakeet	*Psittacula eupatria*		LC
13	Sek Sork	Red-Breasted Parakeet	*Loriculus vemalis*		N/A
14	Kvaek	Black-Crowned Night Heron	*Nycticorax nycticorax*		LC
15	Ngeav Kork	Stork-Billed Kingfisher	*Halcyon capensis*		N/A
16	Antep Toing	Greater Racket-Tailed Drongo	*Dicrurus paradiseus*		LC
17	Kok Krourng	Intermediate Egret	*Egretta intermedia*		N/A
18	Kok Kmao Thleurm Andeurk	Black Bittem	*Bupetor flavicollis*		N/A
19	La Out Thom	Greater Coucal	*Centropus sinensis*		LC
20	Mean Toek Kmoa	Common Moorhen	*Gallinula chloropus*		LC
21	Mean Toek Troung Sor	White-Breasteed Waterhen	*Amauromis phoenicurus*		N/A
22	Preab Srok	Rock Pigeon	*Columba livia*		LC
23	Pror Voek	Lesser Whistling Duck	*Dedrocygna javanica*		N/A
24	Tror Ses Knorng Plerng Toch	Common Flamedback	*Dinopium javanense*		LC
25	Tavao	Common Koel	*Eudynamys scolopacea*	Wetland and Flood Plain	N/A
26	Teav Kiev	Indian Roller	*Coracias benghalensis*		LC

Note: LC = Least Concern, NT = Near Threatened, VU = Vulnerable, N/A = Not Available in IUCN Red List
9 concentric interview points were set up along the target section.
Most of the fauna species were mostly reported at all the interviewed locations
Source: Interview with local people in March and July, 2013

(9) Effects of Flood

In the project area, some parts (KP 31 – 36, KP 48 – 52, KP 91 – 93, KP 96 – 116) used to get flooded in 2000. On the positive side, floods can distribute large amounts of water and suspended river sediment over large areas. The sediment helps replenish valuable topsoil components to lands which are useful for agricultural productivity. On the negative side, flood disrupts physical infrastructures in urban areas and people’s daily livelihoods in particular in rural areas. If it is severe enough, toxic materials (paints, pesticides, gasoline, etc.) can release into the local environment.

16.2.5 Environmental Quality and Pollution

(1) Scope of Survey

Environmental quality and pollution survey was conducted by a local consultant (KEY CONSULTANTS CAMBODIA Ltd.) in May and July, 2013. The survey method and location is shown in Table 16.2-8, and Figure 16.2-7 and 16.2-8. Terms of Reference for the environmental quality and pollution survey is given in Appendix 16-1 for reference.

Table 16.2-8 Survey Method of Environmental Quality and Pollution Survey

	Survey Items	Survey Time and Measuring Period	Survey Points
Air Quality	・PM 10μm ・PM 2.5μm ・NO_2 ・SO_2	・One day after three consecutive days with no rain in March, 2013, except for holiday and rainy day ・One day in early July, 2013, except for holiday ・24 hours in a low	・5 cross-sections ・Total 10 Points (1 roadside point + 1 point for measuring background on each cross-section)
Noise and Vibration Survey	・Equivalent continuous A-weighted sound pressure Level (LAeq) ・Vibration Level	・One day in March, 2013, except for holiday and rainy day ・24 hours in a low	・Same points as Air Quality Survey
Water Quality	・pH ・Biochemical Oxygen Demand (BOD) ・Chemical Oxygen Demand (COD) ・Total Suspended Solids (TSS) ・Total Coliform	・One day after three consecutive days with no rain in March, 2013, except for rainy day ・One day in early July, 2013	・Surface water such as reservoir, channel and river around project site ・Total 10 Points
Waste	・Official waste management system of cities and towns along the road ・Outline of major illegal waste dumping sites	-	・Both sides of the target road including Kampong Chhnang Bypass

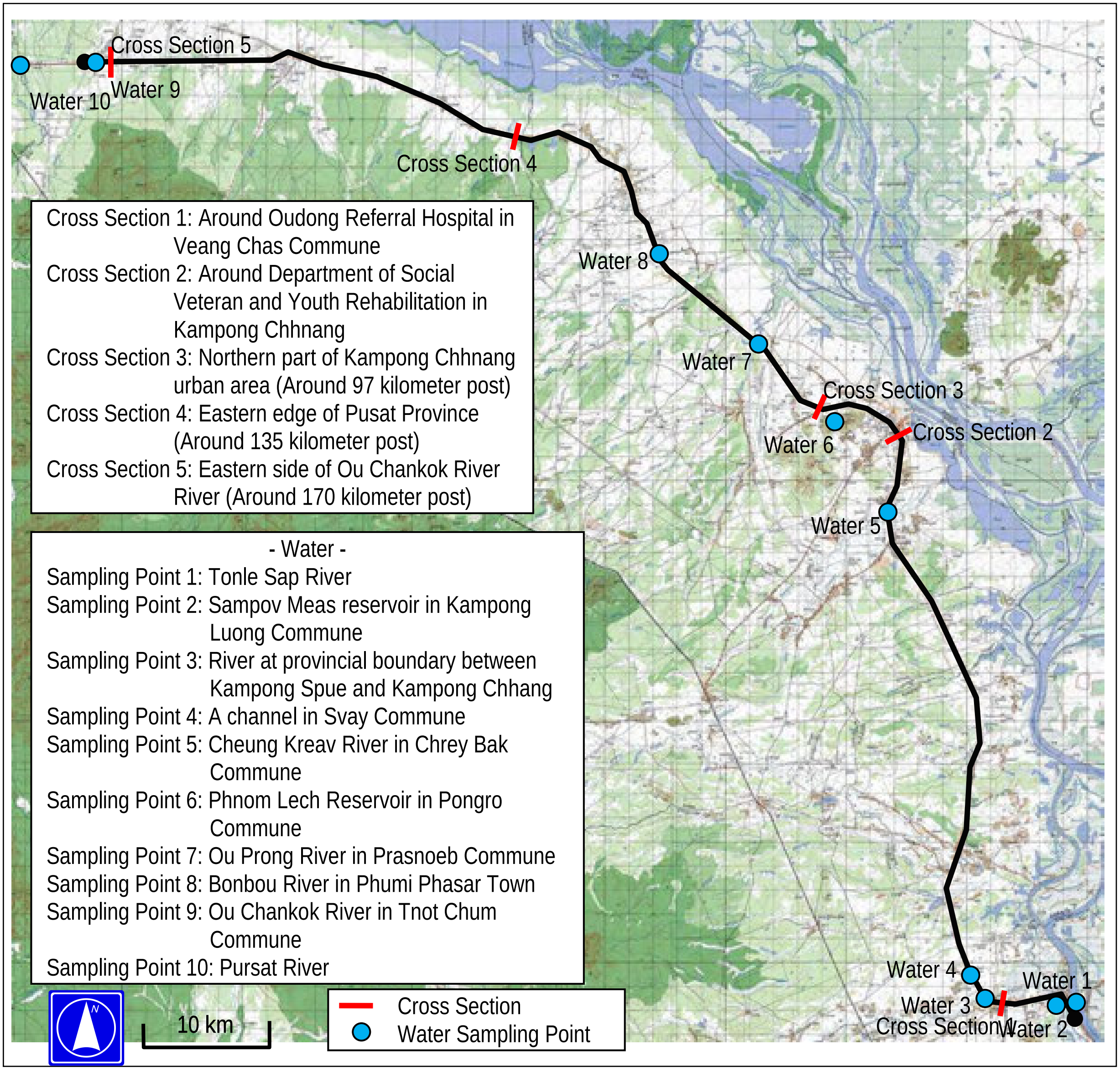


Figure 16.2-7 Location Map of Environmental Quality and Pollution Survey

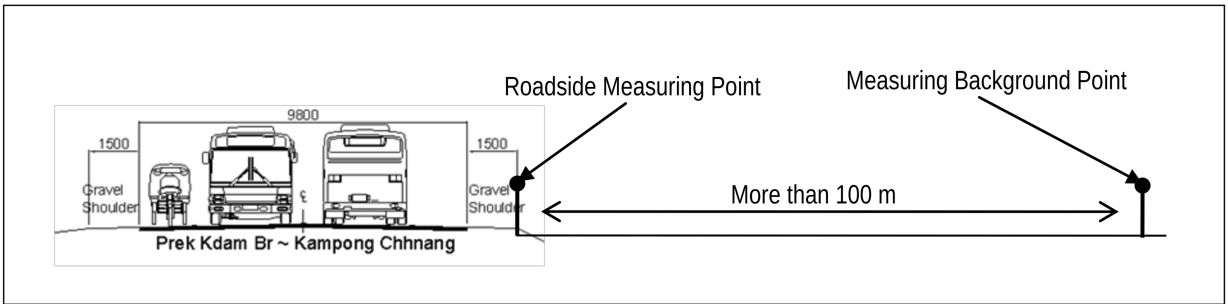


Figure 16.2-8 Schematic Illustration of Cross-Sectional Configuration of Measurement Point

(2) Air Quality

The air quality surveys were conducted from 14 to 26 March, 2013 as dry period and from 1 to 12 July, 2013 as rainy period The result of the air quality survey is shown as in Table 16.2-4. Generally, NO_2 and SO_2 were lower than the MOE's standards. PM (Particulate Matter) 2.5 was also lower than WHO's standard. However, PM 10 levels were found to be higher than the WHO's standard at most of the points independently of roadside or background points in dry period. These are due to the following matters:

Cross section 1	During the air sampling period there was a medium air current in the afternoon
Cross section 2 and 3	During the air sampling period there was a strong air current along the road in the afternoon.
Cross section 4 and 5	During the air sampling period there was also a strong air current either day time or night time.

Moreover, because the air sampling was conducted in March, 2013, or in end of dry period, the current air coincidently occurred at all the sampling locations, the air current brought some dusts into the atmosphere and then may deposit into air samples. As a result, the PM 10 concentration levels may increase.

On the other hand, PM 10 levels in rainy period were less than the WHO's standard at most of the points due to near-daily rainfall. The PM 10 levels at the 2 roadside points were higher than the WHO's standard. Suspended particulate matter in vehicle emission gas may cause the increase in PM 10 in addition to the high background level.

Table 16.2-9 Result of Air Quality Survey during Dry Period

Location	Ambient Air Pollution Concentration (mg/m^3)							
	NO_2		SO_2		PM 2.5		PM 10	
Survey Month	Mar.	Jul.	Mar.	Jul.	Mar.	Jul.	Mar.	Jul.
Cross Section 1 Roadside Point	0.021	0.007	0.009	0.002	0.016	0.012	0.014	0.043
Cross Section 1 Background Point	0.011	0.004	0.004	0.001	0.004	0.004	0.104	0.026
Cross Section 2 Roadside Point	0.018	0.008	0.013	0.005	0.017	0.010	0.107	0.054
Cross Section 2 Background Point	0.011	0.005	0.008	0.003	0.012	0.006	0.066	0.039
Cross Section 3 Roadside Point	0.009	0.004	0.006	0.003	0.015	0.013	0.080	0.036
Cross Section 3 Background Point	0.006	0.004	0.004	0.002	0.006	0.003	0.075	0.025
Cross Section 4 Roadside Point	0.025	0.010	0.019	0.006	0.016	0.011	0.129	0.041
Cross Section 4 Background Point	0.007	0.005	0.006	0.003	0.007	0.011	0.077	0.013
Cross Section 5 Roadside Point	0.019	0.008	0.010	0.004	0.010	0.015	0.127	0.068
Cross Section 5 Background Point	0.007	0.004	0.003	0.002	0.003	0.003	0.076	0.027
Standards of the MOE or WHO	0.1		0.3		0.02*		0.05*	
	(24 Hours)		(24 Hours)		(24 Hours)		(24 Hours)	

Note: No Cambodian Standards for PM2.5 and PM10 The asterisk (*) refers to WHO's Standards

(3) Noise and Vibration

Noise levels at the roadside points of the 5 surveyed cross sections were a bit lower than the MOE's standard during day time and were higher than that of the standard during night time. At the background points, the noise levels were lower than the standard during the day time and were a bit lower than that of the standard during the night time (Figure 16.2-9 to 16.2-13). The details of the results are presented in Appendix 16-3. Higher noise level during the night time is mostly due to friction sound of road surface and tires by high speed vehicles and urban noise around the monitoring points.

All vibration levels at the roadside and background points of the 5 cross sections were lower than "Request Limit Concerning Automobile Noise in Japan" either day time or night time (Figure 16.2-14 to 16.2-18). The details of the results are presented in Appendix 16-3. Because threshold level of vibration sense is generally 55 dB, the vibration levels at roadside have no impact on the local residence.

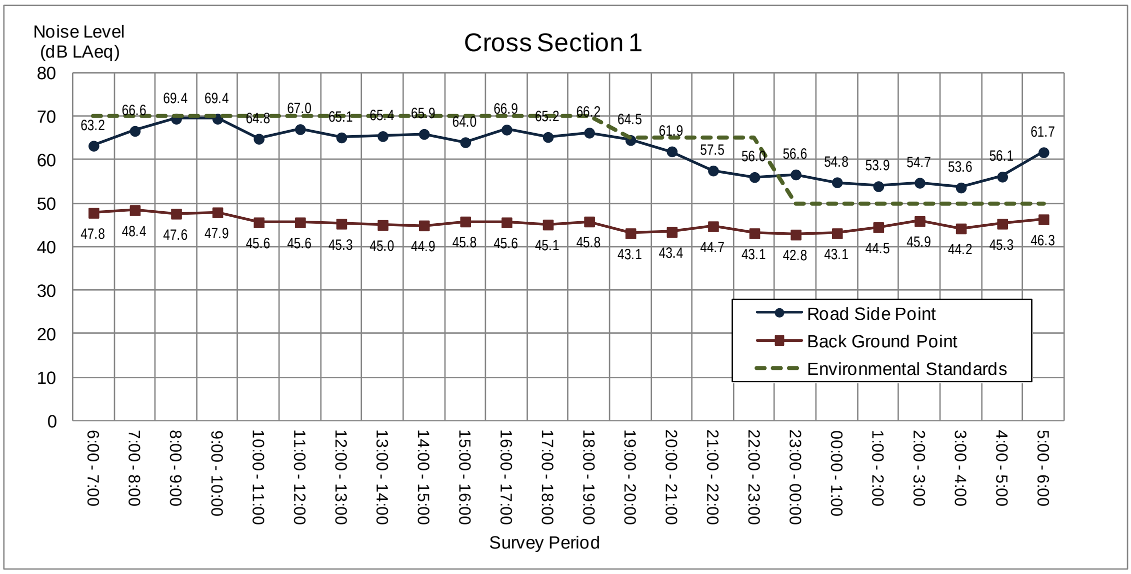


Figure 16.2-9 Result of Noise Survey (1)

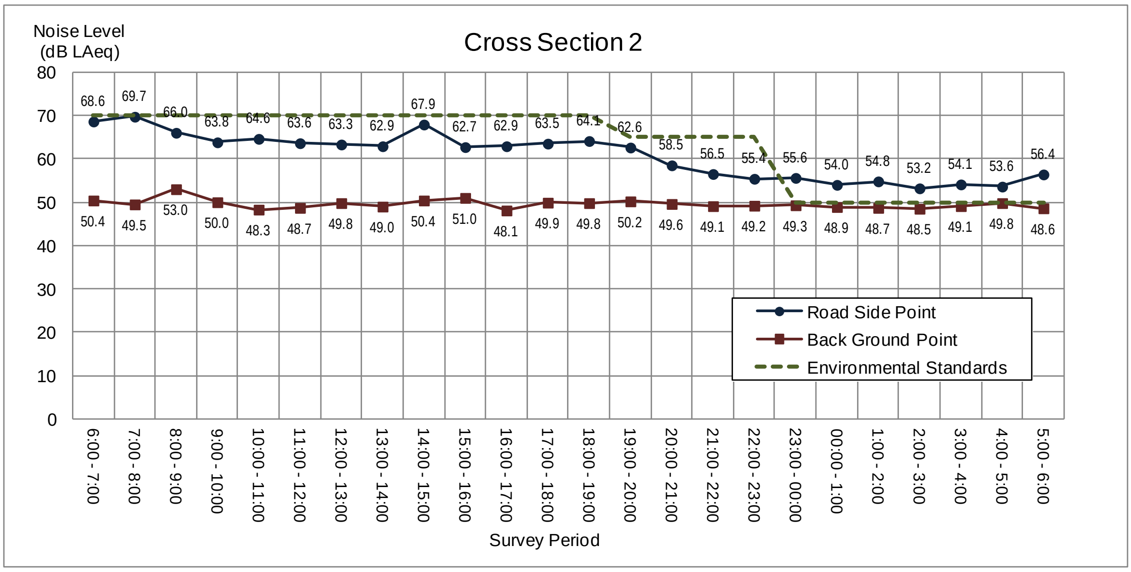


Figure 16.2-10 Result of Noise Survey (2)

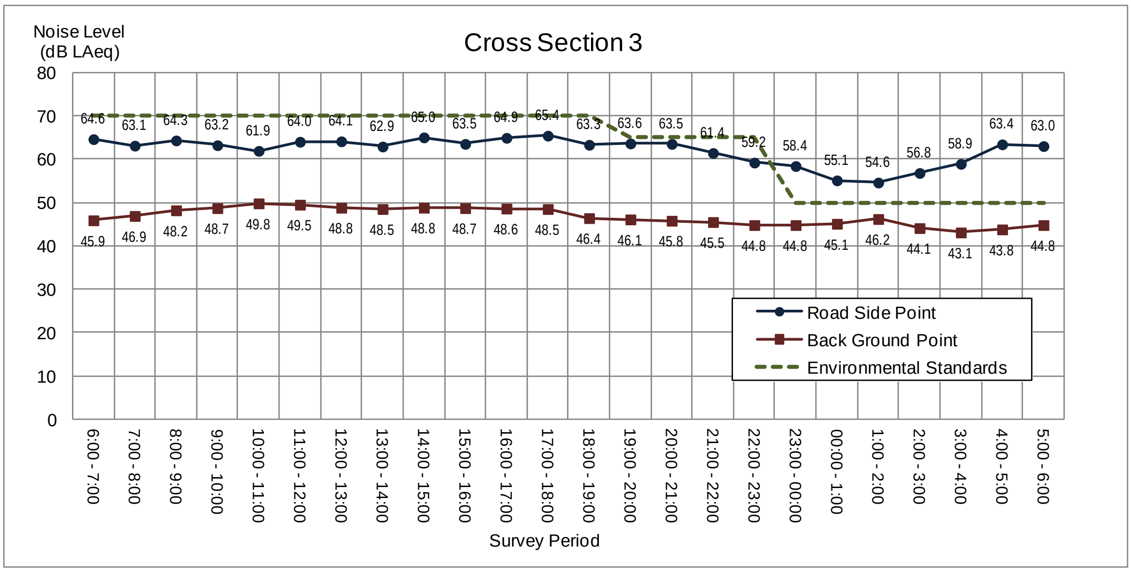


Figure 16.2-11 Result of Noise Survey (3)

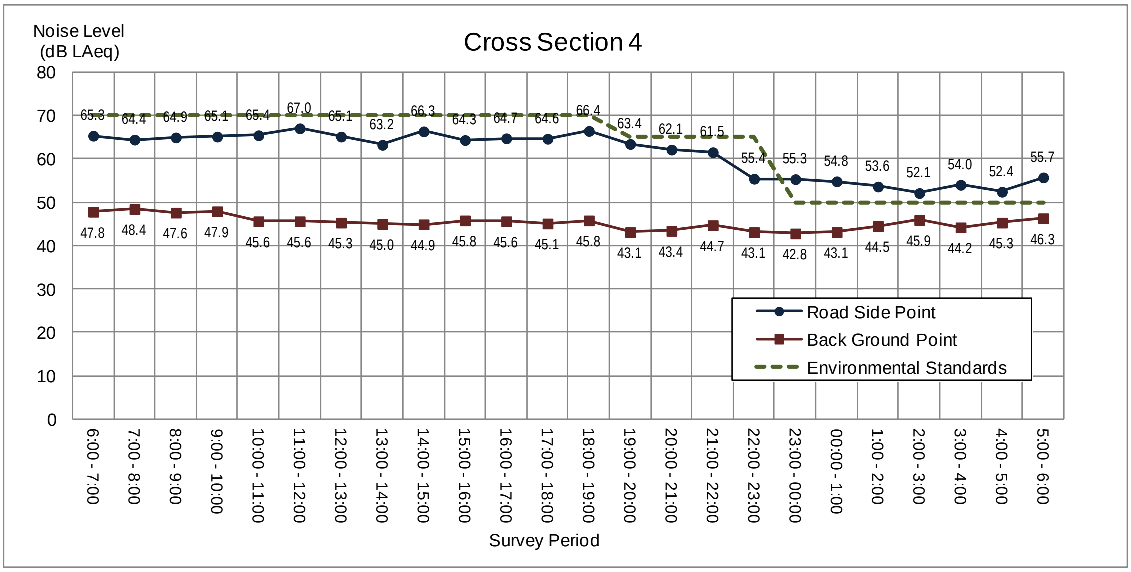


Figure 16.2-12 Result of Noise Survey (4)

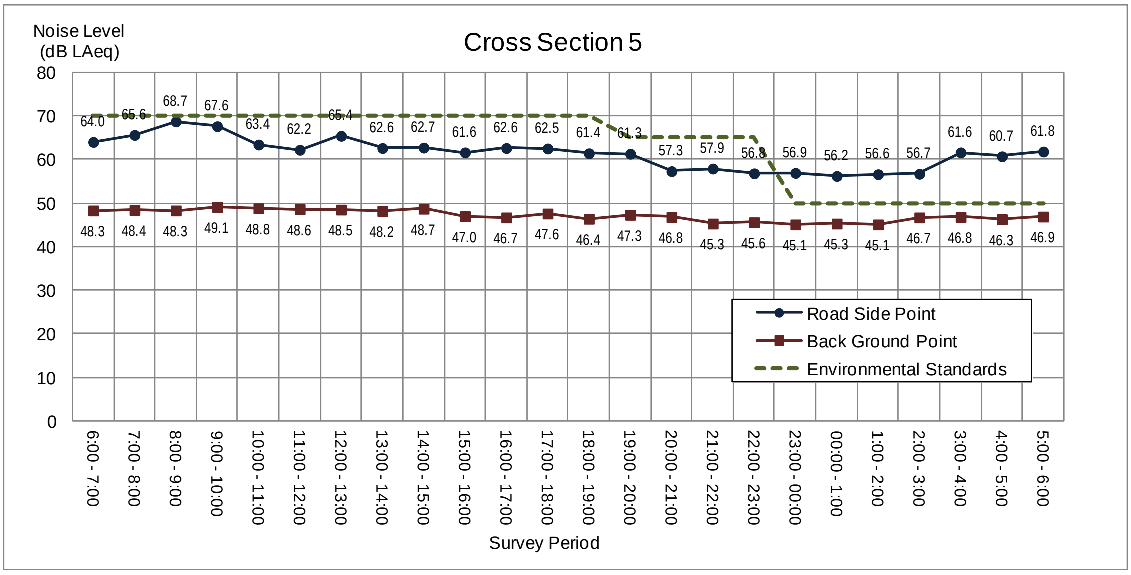


Figure 16.2-13 Result of Noise Survey (5)

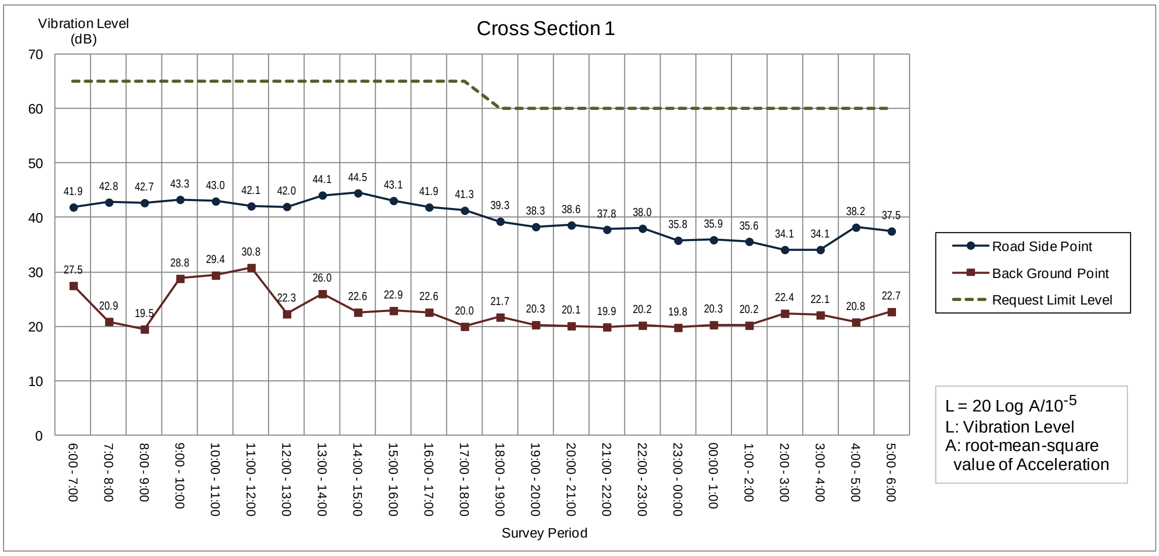


Figure 16.2-14 Result of Vibration Survey (1)

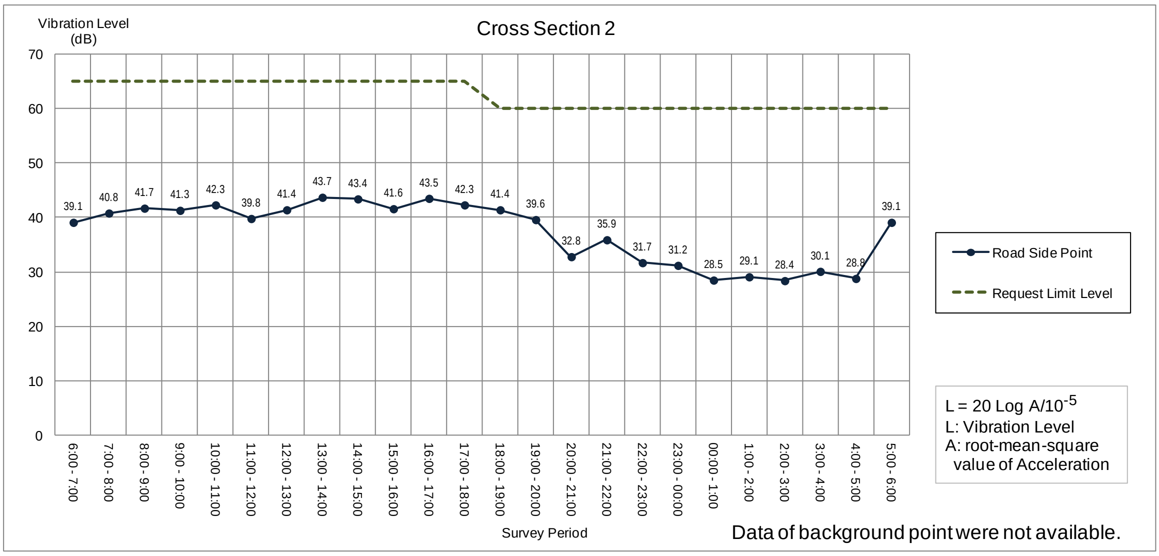


Figure 16.2-15 Result of Vibration Survey (2)

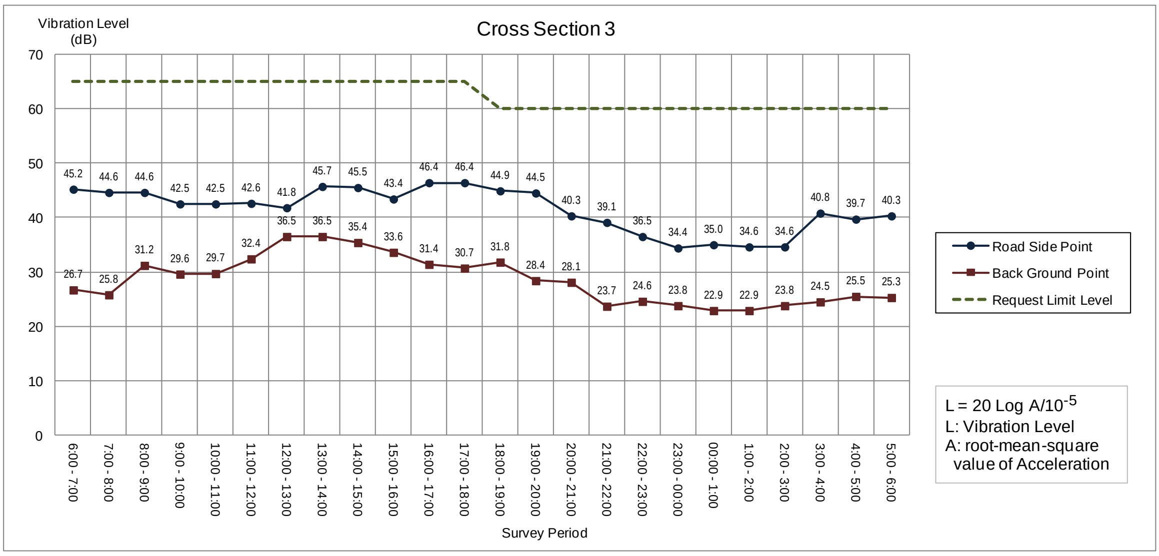


Figure 16.2-16 Result of Vibration Survey (3)

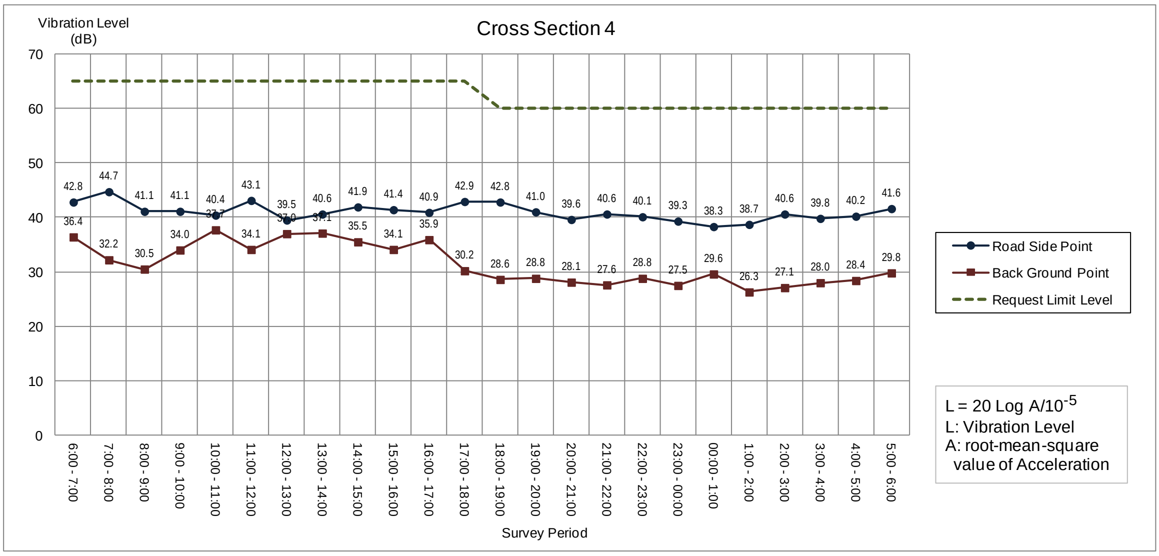


Figure 16.2-17 Result of Vibration Survey (4)

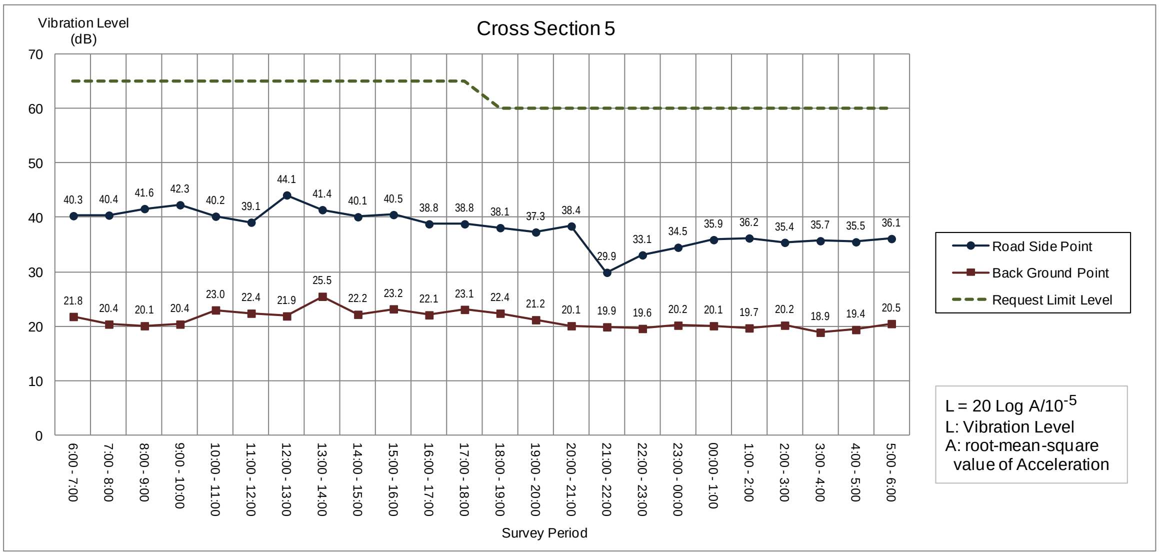


Figure 16.2-18 Result of Vibration Survey (5)

(4) Water Quality

The water sampling was conducted on 22 March and 5 July, 2013. The result of water quality analysis is shown in Table 16.2-5. The pH levels at all the water sampling locations were in the MOE's standard. The TSS in dry and rainy period was found to be higher than the MOE's standard at 4 water sampling locations: River at Provincial Boundary, A channel in Svay Commune, Cheung Kreav River and Ou Chankok River. The TSS levels in the rivers during rainy period have a tendency to rise. The high TSS levels may be due to re-suspended sediments eroded from the bottom of the rivers. The TSS levels are generally considered that with a concentration less than 20 mg/l to be clear, between 40 and 80 mg/l tends to appear cloudy, and over 150 mg/l usually appears dirty. The BOD levels were in range of the standard. The COD level of the river at provincial boundary during dry period was higher than the standard. This may be due to the sampling location surrounded by residential area, and disposing wastewater into the river. It is notable that the higher the COD, the higher the amount of pollution in river. The BOD and COD in Tonle Sap River descend during rainy period. The Total Coliform levels in some rivers and a reservoir heavily exceeded the standard. This is due to agricultural runoff and animal manures washed out by rain or flowed in through drainages from upstream areas to the rivers and streams.

Table 16.2-10 Result of Water Quality Survey during Dry Period

No.	Location	Survey Month	Temp (Deg. C.)	pH	TSS (mg/l)	BOD (mg/l)	COD (mg/l)	Total Coliform (MPN/100 ml)
1	Tonle Sap River**	Mar.	32.4	7.0	86	2.25	5.00	2,400
		Jul.	33.5	7.6	162	0.70	1.57	15,000
2	Sampov Meas Reservoir*	Mar.	32.5	7.7	112	1.25	3.92	74
		Jul.	32.5	7.8	94	1.06	1.76	94
3	River at Provincial Boundary**	Mar.	31.6	7.4	110	3.00	10.19	2,400
		Jul.	31.4	7.5	398	2.59	4.70	4,300
4	A channel in Svay Commune**	Mar.	31.2	7.6	338	3.60	6.27	930
		Jul.	32.2	7.5	398	2.70	4.90	2,300
5	Cheung Kreav River**	Mar.	30.1	6.9	132	2.20	5.35	4,600
		Jul.	30.1	6.9	396	3.95	5.88	4,300
6	Phnom Lech Reservoir*	Mar.	30.6	8.2	66	1.25	5.48	4,600
		Jul.	31.6	7.4	110	2.95	7.84	300
7	Ou Prong River**	Mar.	30.3	6.5	60	1.20	2.17	2,400
		Jul.	31.1	6.5	74	2.85	6.27	74
8	Bonbou River**	Mar.	29.7	6.8	76	0.85	1.98	110,000
		Jul.	28.7	6.9	318	2.65	4.70	2,400
9	Ou Chankok River**	Mar.	29.8	6.5	142	2.40	7.05	110,000
		Jul.	28.4	6.9	416	3.95	5.49	430
10	Pursat River**	Mar.	30.9	7.5	78	2.65	3.74	46,000
		Jul.	28.8	7.0	198	1.35	3.72	430
Standard of the MOE				6.5 – 8.5	25 – 100	1 – 10	1 – 8	*<1,000 or **<5,000

Note: Total Coliform Standard in Reservoir <1,000 and Total Coliform Standard in River <5,000

(5) Waste

It was common to see people throwing away their wastes into side drains and on road shoulders. In an attempt to know more in-depth, some of those people were asked and then reported that their disposed wastes would disappear either by water flow or somebody else would clean up the wastes due to public areas. As a result, many illegal wastes disposal sites were found and usually observed at bridges, near the rest areas, and at the end of urban areas. There were 11 major illegal wastes disposal areas were noticed. Main sources of the illegal waste disposal are from residents, vendors, and passengers.

Table 16.2-11 Illegal Wastes Disposal along the Project Area

No	PK No.	Location	Condition	Source
1	31	Prek Kdam	Wastes were disposed on the road shoulder. Wastes composition consisted of organic, plastic, recyclable, and toxic wastes. Burning such wastes was a common practice.	Restaurants, business houses, vendors, passengers and residents.
2	35	Near gate to Odongk mountain	Wastes were disposed on the road shoulder. Wastes composition consisted of organic and plastic. Burning the wastes was a common practice of vendors and some households.	Vendors from the market in front of Odongk Mountain gate and some residents
3	41 – 42	Trach market	Wastes were disposed on the road shoulder. Waste composition mostly consisted of organic product. Burning such wastes was a common practice of vendors.	Vendors from the market
4	46 – 48	Poar Village	Wastes were disposed on the side drain. Wastes composition mostly consisted of plastic product. Burning such wastes was a common practice.	Residents and restaurants
5	60	Thnol Toteung market	Wastes were disposed on the road shoulder. Plastic waste dominated among other wastes. Burning the wastes was a common practice.	Vendors and residents
6	66	Saeb Village	Wastes were disposed on the road shoulder. Plastic waste dominated among other wastes. Burning the wastes was a common practice.	Vendors and residents
7	80 – 81	Near the Prey Khmer market	Wastes were disposed on the road shoulder. Plastic waste dominated among other wastes. Burning the wastes was a common practice.	Local residents and passengers.
8	104	Thmor Keo Village	Wastes were disposed into the side drain. Plastic waste dominated among other wastes. Burning the wastes was a common practice.	Vendors and residents
9	117	Psar Village	Wastes were disposed on the road shoulder. Plastic waste dominated among other wastes. Burning the wastes was a common practice.	Vendors from the market and local residents
10	127	Near Chork primary school	Wastes were disposed on the road shoulder. Plastic and organic wastes dominated among other wastes. Burning the wastes was a common practice.	Restaurants
11	141	Koal market	All of wastes were generated from the market and some residents and were then burnt. Plastic products were much more than other wastes.	Vendors and some of households around this area.

16.3 Social Environment

16.3.1 Administrative Boundary

The project, section from Prek Kdam to Thlea Ma'Am, covers three (3) provinces of Kandal, Kampong Chhnang, and Pursat. Under the three provinces, there are six (6) districts where existing NR 5 is going across.

As lower administrative division under each district, thirty five (35) communes might be traversed by the existing road and proposed two bypasses. Figure 16.3-1 NR 5 (South Section) and Administrative Boundary (1) and Figure 16.3-2 NR 5 (South Section) and Administrative Boundary (2) describe administrative boundary along the project area, followed by the list of local authorities concerns (Table 16.3-1).

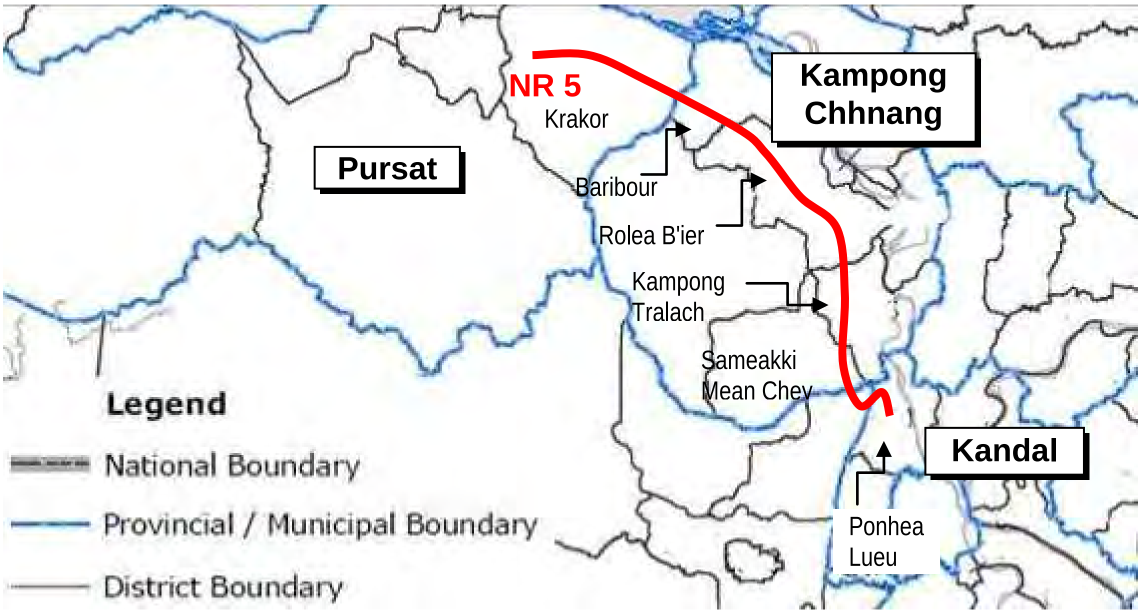


Figure 16.3-1 NR 5 (South Section) and Administrative Boundary (1)

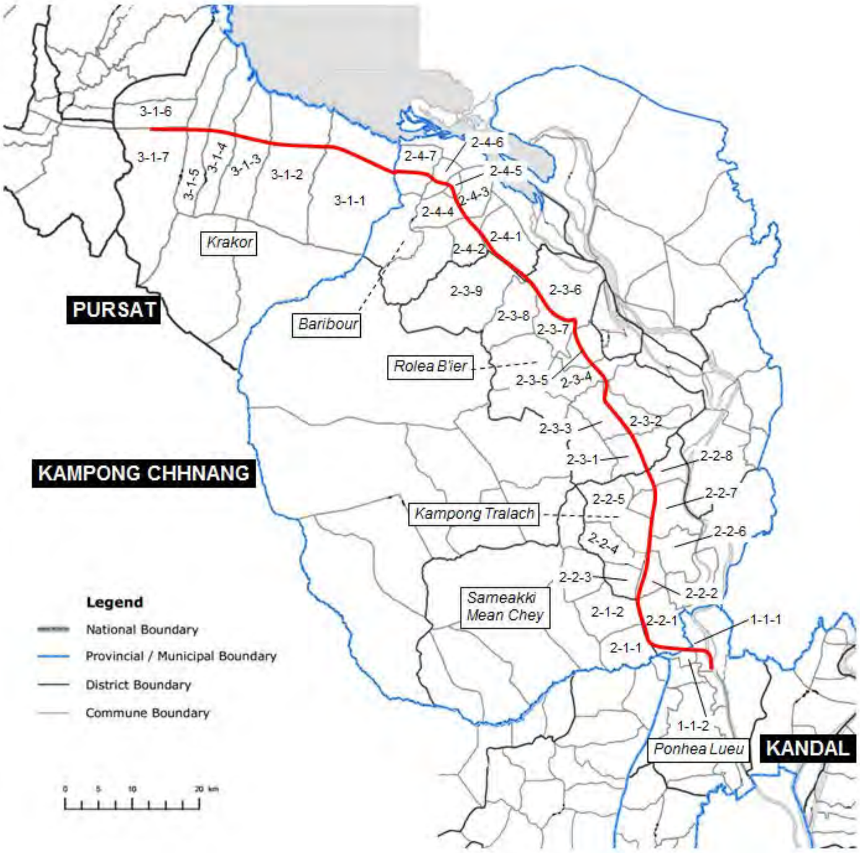


Figure 16.3-2 NR 5 (South Section) and Administrative Boundary (2)

Table 16.3-1 Provinces, Districts, and Communes in the Project Area

Province		District		Commune		House holds	Popu lation
1	Kandal	1-1	Ponhea Lueu	1-1-1	Kampong Luong	2,108	10,694
				1-1-2	Vihear Luong	1,461	7,396
2	Kampong Chhnang	2-1	Sameakki Mean Chey	2-1-1	Svay	2,360	10,546
				2-1-2	Sedthei	1,414	7,905
		2-2	Kampong Tralach	2-2-1	Longveaek	1,526	7,243
				2-2-2	Ou Ruessei	1,845	8,229
				2-2-3	Peani	1,527	7,183
				2-2-4	Thma Edth	988	4,444
				2-2-5	Chhuk Sa	1,958	8,470
				2-2-6	Chres	2,081	9,216
				2-2-7	Ta Ches	2,440	11,486
				2-2-8	Saeb	1,459	6,871
		2-3	Rolea B'ier	2-3-1	Tuek Hout	1,638	7,757
				2-3-2	Andoung Snay	1,207	5,588
				2-3-3	Rolea B'ier	1,805	7,673
				2-3-4	Chrey Bak	2,240	10,128
				2-3-5	Srae Thmei	2,396	10,614
				2-3-6	Svay Chrum	2,950	13,217
				2-3-7	Pongro	1,711	7,284
				2-3-8	Banteay Preal	955	3,983
				2-3-9	Prasnoeb	1,200	5,171
		2-4	Baribour	2-4-1	Melum	889	3,814

Province		District		Commune		House holds	Popu lation
				2-4-2	Phsar	1,251	5,317
				2-4-3	Khon Rang	1,597	6,985
				2-4-4	Popel	1,126	5,095
				2-4-5	Ponley	1,674	7,275
				2-4-6	Chak	680	2,856
				2-4-7	Trapeang Chan	1,132	5,080
3	Pursat	3-1	Krakor	3-1-1	Asna Chambak	1,412	6,915
				3-1-2	Kbal Trach	1,653	8,137
				3-1-3	Anlong Tnot	2,071	9,606
				3-1-4	Sna Ansa	1,010	4,570
				3-1-5	Ou Sandan	1,069	4,633
				3-1-6	Boeng Kantuot	1,282	5,700
				3-1-7	Tnot Chum	2,395	11,620

Source : General Population Census of Cambodia 2008, National Institute of Statistics, Ministry of Planning

** The data of "Household" and "Population" in above table describes total number of whole commune (not exclusive to project affected areas). Figures are based on the result of "General Population Census of Cambodia 2008, National Institute of Statistics, Ministry of Planning"*

16.3.2 Population

The latest population census was implemented in 2008 as "General Population Census of Cambodia". Based on the census, population and household data on three provinces which is located in the project area, are assembled in Table 16.3-2 Population and households in the project related provinces. "Sex ratio" and "Average house hold size", the total number of person who is living in a household, are almost same among three provinces.

Table 16.3-2 Population and Households in the Project Related Provinces

Province	Population			Sex Ratio (Male/ Female)	House holds	Average Household Size
	Total	Male	Female			
Kandal	1,265,280	612,692	652,588	93.9%	258,393	4.9
Kampong Chhnang	472,341	227,007	245,334	92.5%	101,260	4.6
Pursat	397,161	192,954	204,207	94.5%	83,745	4.7

Data Source: General Population Census of Cambodia 2008, National Institute of Statistics, Ministry of Planning

Table 16.3-3 shows ratio of population and households in and vicinities of the project comparing to whole province. The result indicates that Kampong Chhnang and Pursat Province have relatively large direct impacts from the project, and Kandal Province occupies limited area in the project site.

Table 16.3-3 Ratio of Project Related Population and Household

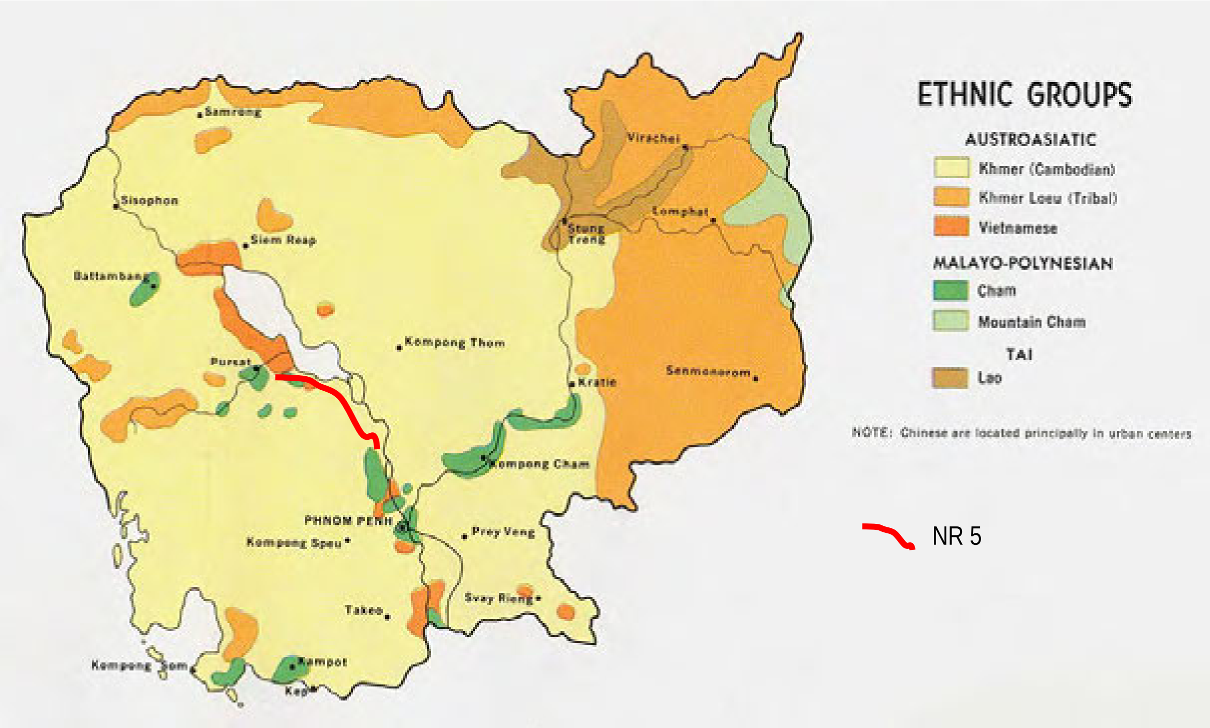
Province	Population			Household		
	(1)Whole Province	(2) Project Vicinity	Ratio (2)/(1)	(1)Whole Province	(2) Project Vicinity	Ratio (2)/(1)
Kandal	1,265,280	18,090	1.4%	258,393	3,569	1.4%
Kampong Chhnang	472,341	232,560	49.2%	101,260	50,460	49.8%
Pursat	397,161	51,181	12.9%	83,745	10,892	13.0%

Data Source: General Population Census of Cambodia 2008, National Institute of Statistics, Ministry of Planning

** (2) Project Vicinity covers communes where NR 5 crossing and/or facing to*

16.3.3 Ethnic Group

Figure 16.3-3 is the distribution map of ethnic groups in Cambodia. Focusing on the survey area, Cham people (green color) lives along Tonle Sap River, especially from Phnom Penh to Prek Kdam, the starting point of the project (south section). On the other hand, Vietnamese (orange color) lives lakeside area in Pursat Province. Some of them live on floating village (e.g. Kampong Luong) and their livelihood has connection to aquatic products from Tonle Sap Lake.



Source: Map of Cambodia with detail of ethnic group distributions (1972), Texas University Library

Figure 16.3-3 Ethnic Groups in Cambodia

As a whole country, more than 90% population belong the ethnic group of Khmer. They are followers of Buddhism and speak Khmer language. In and vicinities of the project site, Cham people and Vietnamese immigrant are observed as small groups. In general, Cham and Vietnamese can understand Khmer language, however, they keep their own language, religion, and other social behaviors.

Figure 16.3-4 Khmer Monks at Odongk Pagoda

Cham people are known as ethnic Muslims originated from the Kingdom of Champa which had gone to ruin in 19th century. Cambodia is one of the areas in Indochina where Cham people resettled after they lost their home country. The number of Cham population is said around 220,000 and most of them are living along Mekong River and Tonle Ssp. They speak Cham Language and usually have mosque as a religious and community center. Their major occupations are fishing, farming and businesses. Some scattered mosques are observed along the project area of NR 5.

Figure 16.3-5 Cham's Mosque along NR 5

Vietnam people in Cambodia have different origin and most of them are living along Vietnam border and inland water area where they feed themselves with fishing. Around 95,000 Vietnamese are living in Cambodia. They speak Vietnamese and their religion varies from Buddhism to Christianity. Their major occupations are small business such as barbershop in urban and fishing in rural. It is estimated that there are not so much Vietnamese population in the project area.

Figure 16.3-6 A Vietnamese at Tonle Sap Floating Village

16.3.4 Gender

(1) Key Factors

According to United Nations Development Plan (UNDP) in Cambodia, key facts about gender equality in Cambodia are described as below;

(a) Cambodia ranks 99 out of 145 countries on the Gender Inequality Index (GII) in the Human Development Report 2011. GII is a new measurement replacing the Gender-related Development Index (GDI) and Gender Empowerment Measure (GEM).

(b) Over the past decade, there have been improvements on the status of women in Cambodia. Yet, they remain less visible in public sphere. Women comprise 34 percent of civil servants and hold 22 percent of seats in the National Assembly.

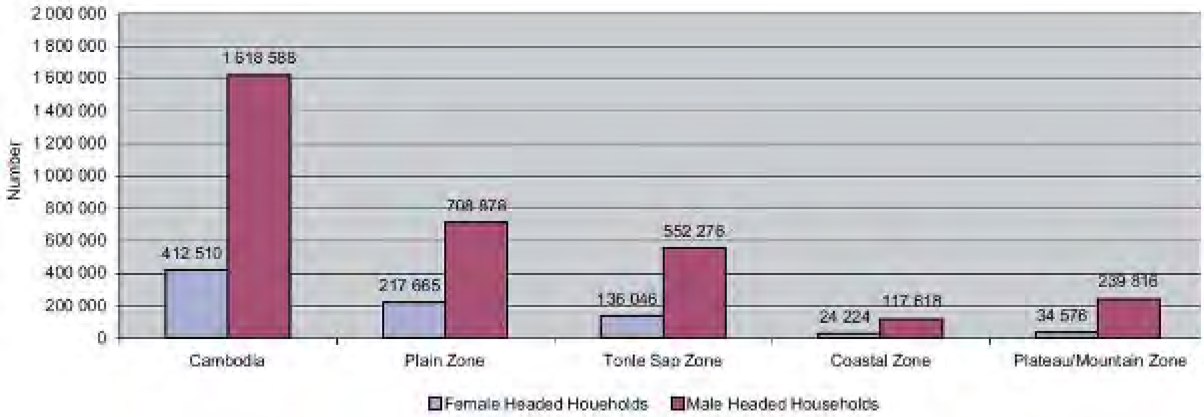
(c) Almost the same number of boys and girls attend school until the age of 14. However, fewer girls continue in higher education. Adult literacy rates are also unequal: only 70.9 percent of adult females are literate, compared to 85.1 percent of their male peers.

(d) The number of men and women in the total workforce is almost the same (49.4 percent women). However, more women are self-employed or unpaid family workers (83 percent of female employment vs. 76 percent of male employment). This informal economy provides low, irregular income and unstable employment. More importantly, because many tend to operate unregistered, there is little or no access to organized markets, credits and training institutions and to other public services.

(e) Like many other countries in East Asia, Cambodia has the Law on Prevention of Domestic Violence and Protection of Victims. Despite the law, 22.5 percent of married women experienced violence within their homes and up to 89 percent do not report the incident, according to a survey by Ministry of Women's Affairs in 2009.

(2) Statistics from Census (2008)

Based on the result from Census (2008), in rural area including Tonle Sap Zone, around 20% of agricultural household is female headed (Figure 16.3-7).

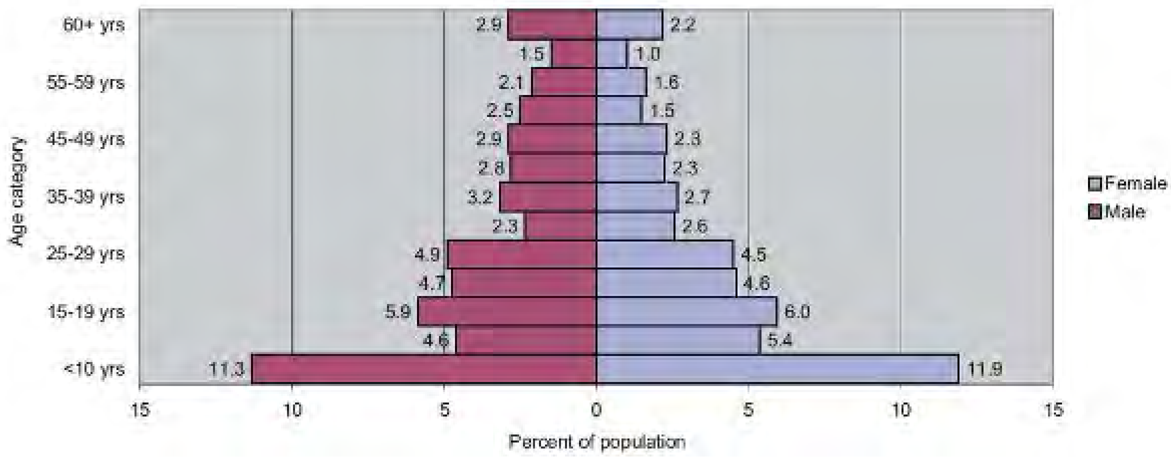


Source: National Gender Profile of Agricultural Households, 2010 (Based on the 2008 Cambodia Socio-Economic Survey), FAO & NIS, Ministry of Planning

Figure 16.3-7 Number of Male and Female Headed Household

According to the survey by FAO & NIS, the median age of the agricultural household heads is 46 years old, and male heads have a lower median age than female heads.

Figure 16.3-8 shows age pyramid in agricultural area in Cambodia.

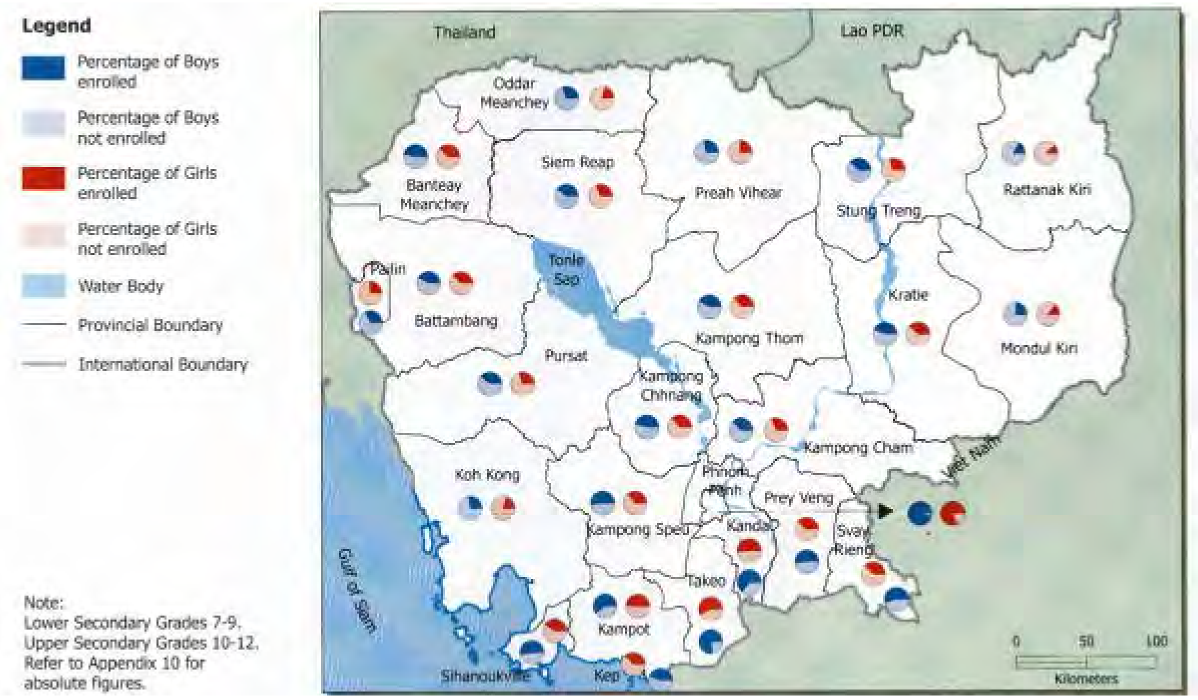


Source: National Gender Profile of Agricultural Households, 2010 (Based on the 2008 Cambodia Socio-Economic Survey), FAO & NIS, Ministry of Planning

Figure 16.3-8 Age Pyramid in Agricultural Area

(3) Gender in Education

As a gender indicator, enrollment ratio shows slightly defference between boys and girls (Figure 16.3-9). Among the provinces where NR 5 (South Section) acrosses, Pursat is the lowest enrollment ratio. Boys can study at lower secndary school many more than girls in all provinces. This situation causes differences of illiteracy between male and female.



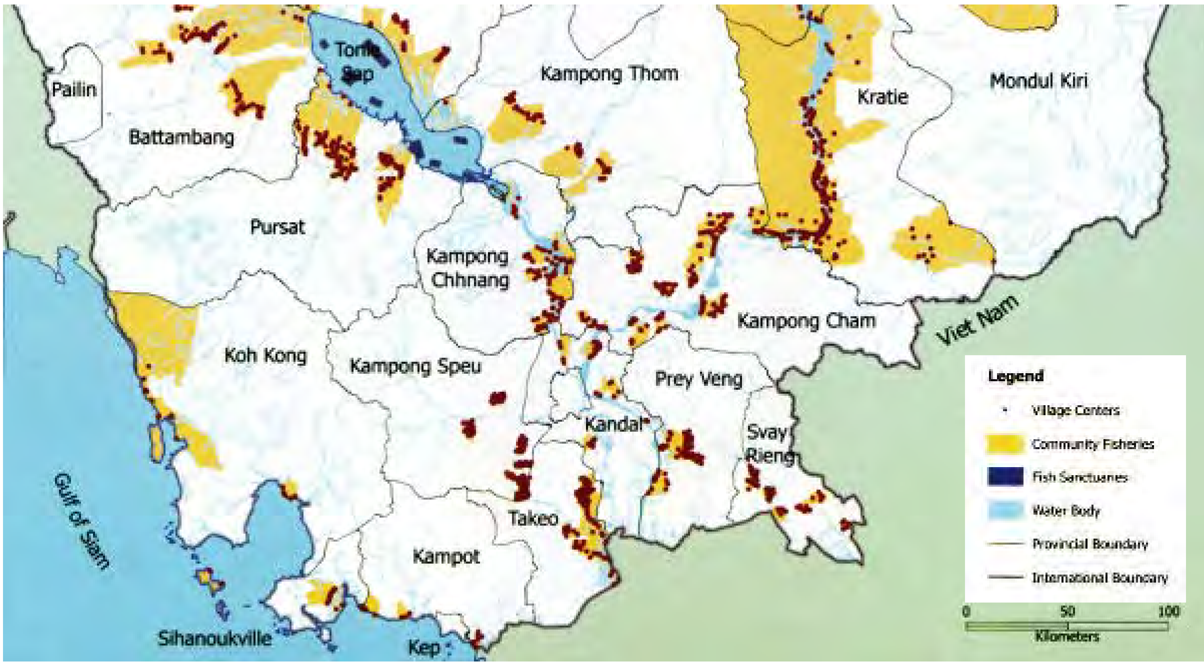
Source: The Atlas of Cambodia, National Poverty and Environment Maps, Save Cambodia's Wildlife (2006)

Figure 16.3-9 Lower Secondary (age 7-9) School Enrollment Status

16.3.5 Community Fishery (CF)

Community Fishery (CF) was proposed and developed under the ADB's initiative to realize the sustainable natural resources management in Tonle Sap Lake. Traditional tendering for fishing lots caused violence and other unfavorable social problems after 1993. As a result, Government tried to introduce CF with aims of ecosystem management, fishery resource management, poverty reduction, and so on.

CF has been set entire country except Mondulkiri Province, and there are some CFs area along NR 5 in Kampong Chhnang and Pursat Provinces (Figure 16.3-10). Some part of unloaded fishes and swamp small animals are transported to neighboring local market or far consumption area including Phnom Penh through NR 5.



Source: The Atlas of Cambodia, National Poverty and Environment Maps, Save Cambodia's Wildlife (2006)

Figure 16.3-10 Community Fishery Distribution

(a) Fishermen in Tonle Sap River (b) Unloaded Fish from Tonle Sap Lake

Figure 16.3-11 Fishery in Tonle Sap Lake

16.3.6 Culture and Tourism

NR 5 is the main access route to cultural and historical places and tourism zones as below;

(1) Longveak and Odongk Area

Odongk and Longveak area is located around 40 km north west of Phnom Penh. This area was the old capital city of Cambodia after the Angkor era. Longveak area in Kampong Chhnang Province is in the north side of existing NR 5 and there is several ancient path between present Odongk town area. In the south side of existing NR 5, there is Odongk Mountain (or Phnom Oudong) in Kandal Province. Pagodas at the top and around the hill are popular day-trip site from Phnom Penh for both domestic and foreign visitors. Odongk Mountain is located from around one kilometer south from Odongk market area of existing NR 5.

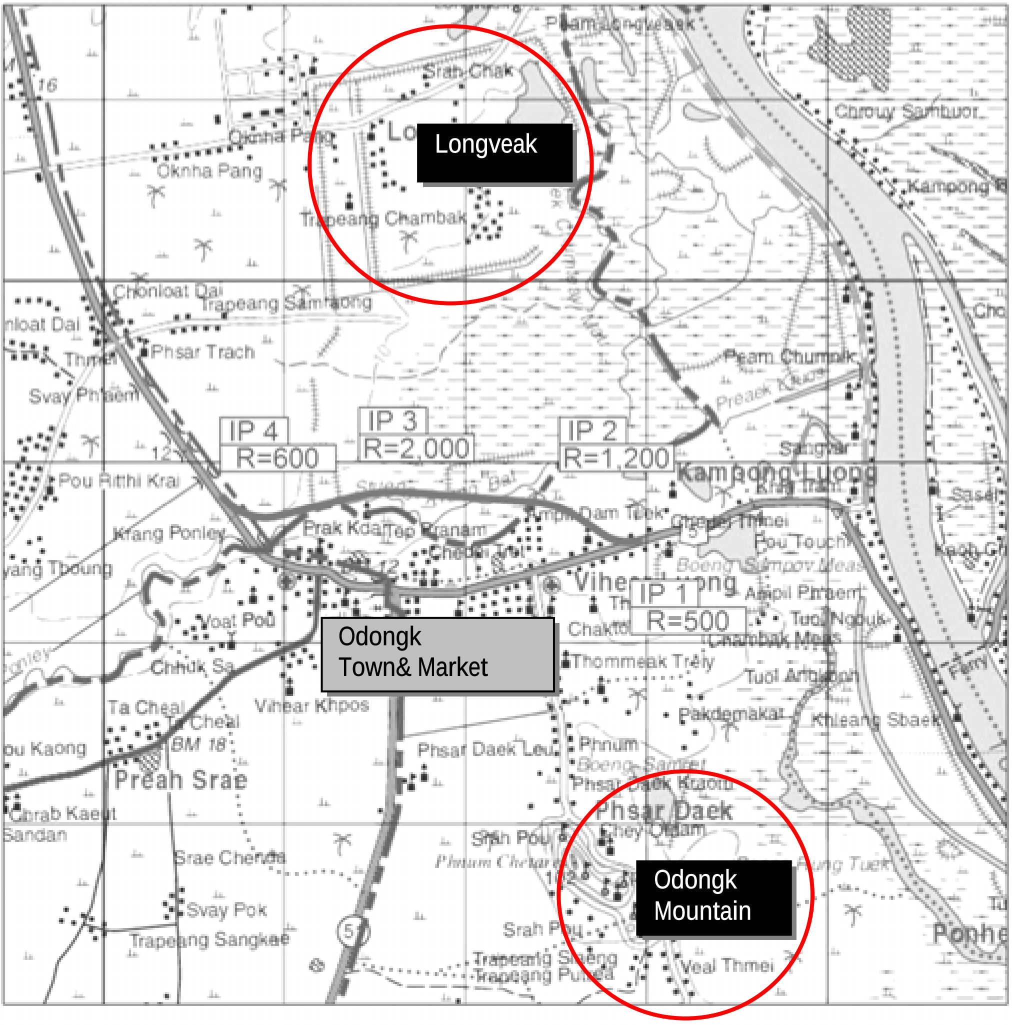
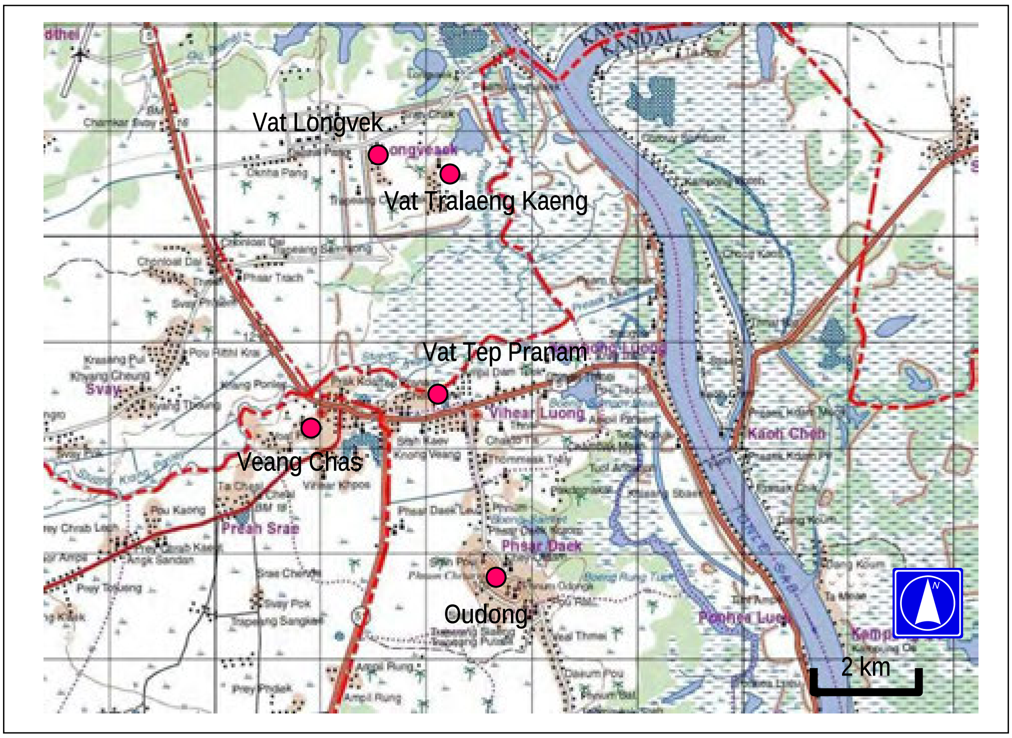


Figure 16.3-12 Cultural Heritage in Longveak and Odongk Area (1)

Figure 16.3-13 Typical Culture and Tourism Spots : Odongk Pagoda



Source: Sambor Prei Kuk et le bassin du Tonle Sap

Figure 16.3-14 Cultural Heritage in Longveak and Odongk Area (2)

(2) Tonle Sap Ecotourism

Rich aquatic ecosystem of Tonle Sap Lake and rivers can attract foreign tourist. Kampong Chhnang Port has a small floating jetty for tourist boats and visitor can enjoy cursing. Floating villages where Vietnamese living, fish cultivation, and flooded forest are the important tourism resources. There are some other points where people can access to Tonle Sap floating village and ecosystem along NR 5 (South Section).

Figure 16.3-15 Typical Culture and Tourism Spots : Eco Tourism in Tonle Sap Lake (Kampong Chhnang)

16.4 Result of Environmental Scoping

To identify potential impacts on the environment during the pre-construction, construction and operation stages of the project, the environmental scoping has been formulated for the target section of NR 5 and selected Bypass plan. The result of the environmental scoping is shown in Table 16.4-1. The scoping items rating at “A-“, “B-“ and “C” are assessed in this section.

Table 16.4-1 Result of Environmental Scoping

No.	Impact Item	Assessment		Potential Impact/Reason
		Pre-Construction/ Construction Phase	Operation Phase	
Environmental Pollution				
1	Air pollution	B-	B±	**Construction Phase:** ・ Dust and emission gas caused by construction works ・ Dust in borrow pit or quarry site **Operation Phase:** ・ Increase of air pollutants in vehicle exhaust gas due to increase of traffic volume. ・ Decrease of air pollutant due to reduction in fuel consumption of vehicles caused by mitigation of traffic congestion and increase in vehicle speed.
2	Water pollution	B-	C-	**Construction Phase:** ・ Turbid water caused by construction works ・ Accidental massive leaking of fuel or oil ・ Turbid water from borrow pit or quarry site **Operation Phase:** ・ Turbid water from borrow pit or quarry site
3	Waste	B-	C-	**Construction Phase:** ・ Construction waste **Operation Phase:** ・ Illegal dumping of solid waste
4	Soil pollution	C-	B-	**Construction Phase:** ・ Accidental massive leaking of fuel or oil **Operation Phase:** ・ Leaking of fuel, oil and harmful cargo by traffic accident
5	Noise and vibration	B-	B-	**Construction Phase:** ・ Noise and vibration caused by construction works ・ Noise and vibration in borrow pit or quarry site **Operation Phase:** ・ Increase in noise level caused by vehicles
6	Ground subsidence	C-	D	**Construction Phase:** ・ Subsidence near road **Operation Phase:** ・ No impact
7	Offensive odors	B-	C-	**Construction Phase:** ・ Offensive odors caused by construction works **Operation Phase:** ・ Exhaust gas from vehicles with incomplete combustion
8	Bottom sediment	C-	C-	**Construction Phase:** ・ Accumulation of filled soil eroded into rivers or streams by rainfall ・ Erosion in borrow pit or quarry site

No.	Impact Item	Assessment		Potential Impact/Reason
		Pre-Construction/ Construction Phase	Operation Phase	
				Operation Phase: ・ Sedimentation of debris caused by collapse of road slope on riverbed ・ Erosion in borrow pit or quarry site
Natural Environment				
9	Protected areas	C-	C-	**Construction Phase:** **Operation Phase:** ・ Impact on “Tonle Sap Biosphere Reserve”
10	Ecosystem	B-	C-	**Construction Phase:** ・ Loss of roadside vegetation ・ Impact on agricultural ecosystem ・ Impact of turbid water caused by bridge construction on aquatic life **Operation Phase:** ・ Impact of change of surface water flow in embankment sections on remote aquatic ecosystem
11	Hydrology	C-	C-	**Construction Phase:** ・ Alteration of water flow in river or stream by construction works **Operation Phase:** ・ Impact caused by newly constructed embankment on surface water flow
12	Geographical features	B-	D	**Construction Phase:** ・ Change of topography in bypass or embankment sections ・ Change of topography in borrow pit or quarry site. **Operation Phase:** ・ No impact
Social Environment				
13	Resettlement/ Land Acquisition	A-	D	**Pre-Construction Phase:** ・ Resettlement and additional land acquisition **Construction Phase:** ・ Temporal lease of land for construction yard **Operation Phase:** ・ No impact
14	Poor people	B-	B-	**Pre-Construction Phase:** **Operation Phase:** ・ Impact of resettlement and loss of business opportunity on poor people
15	Ethnic minorities and indigenous peoples	C-	D	**Pre-Construction Phase:** **Operation Phase:** ・ Impacts on Ethnic Cham and Vietnamese **Operation Phase:** ・ No impact
16	Local economies, such as employment, livelihood, etc.	B±	B±	**Pre-Construction Phase:** ・ Impact of land acquisition and resettlement on livelihood of Project Affected Persons **Construction Phase:** ・ Creation of job opportunities to local people ・ Impacts of bridge construction on local fishery **Operation Phase:** ・ Contribution to local economies

No.	Impact Item	Assessment		Potential Impact/Reason
		Pre-Construction/ Construction Phase	Operation Phase	
				· Widening gap in local economy
17	Land use and utilization of local resources	B-	B+	**Construction Phase:** · Change of land use in bypass sections **Operation Phase:** · Development of economy and social condition · Contribution to utilization of local resources
18	Water usage	B-	C-	**Construction Phase:** · Impact on existing agricultural cannels **Operation Phase:** · Impact caused by newly constructed embankment or culverts on surface water flow
19	Existing social infrastructures and services	B-	B±	**Pre-Construction Phase:** · Relocation or protection of existing utilities **Construction Phase:** · Temporary traffic congestion **Operation Phase:** · Improvement of access to social services · Spilt of local communities or widening disparity
20	Social institutions such as social infrastructure and local decision making institutions	C-	C-	**Construction Phase:** **Operation Phase:** · Spilt of local communities or widening disparity in bypass section
21	Misdistribution of benefits and damages	C-	B-	**Pre-Construction Phase:** **Construction Phase:** · Misdistribution of benefit **Operation Phase:** · Misdistribution of benefit between new bypass and existing NR 5 (old route)
22	Local conflicts of interest	D	D	**Construction Phase:** **Operation Phase:** · No impact
23	Cultural heritage	C-	C-	**Construction Phase:** · Impact on Longveaek remains **Operation Phase:** · Impact of tourism development on religious value
24	Landscape	B-	C-	**Construction Phase:** · Loss of road side trees **Operation Phase:** · Impact of embankment road on paddy field scene
25	Gender	C-	C-	**Construction Phase:** **Operation Phase:** · Impact on street women's venders
26	Children's rights	D	B±	**Construction Phase:** · No impact **Operation Phase:** · Traffic accident of children due to more traffic volume and faster vehicle speed · Improvement of safety by widening footpath
27	Infectious diseases such as	B-	D	**Construction Phase:** · Infection risks of HIV/AIDS

No.	Impact Item	Assessment		Potential Impact/Reason
		Pre-Construction/ Construction Phase	Operation Phase	
	HIV/AIDS			**Operation Phase:** ・ No impact
28	Working conditions (including occupational safety)	B-	D	**Construction Phase:** ・ Dust and emission gas caused by construction works ・ Deterioration of sanitary conditions **Operation Phase:** ・ No impact
29	Accidents	B-	B±	**Construction Phase:** ・ Traffic accident surrounding of construction site **Operation Phase:** ・ Improvement of traffic safety by road widening and vehicle separation ・ Traffic accident due to more traffic volume and faster vehicle speed
Other				
30	Trans-boundary impacts or climate change	B-	B±	**Construction Phase:** ・ Generation of CO_2 from construction equipment **Operation Phase:** ・ CO_2 emission from vehicles

A+/-: Significant positive/negative impact is expected.
B+/-: Positive/negative impact is expected to some extent.
C+/-: Extent of positive/negative impact is unknown. (A further examination is needed, and the impact could be clarified as the study progresses)
D: No impact is expected
** Impact Items refer to "JICA Guidelines for Environmental and Social Considerations April 2010"*

16.5 Alternative Analysis

16.5.1 South Section of NR 5

(1) Alternatives

Three alternatives are proposed, considering the objectives of road improvement and adverse impacts both to natural and social environment:

(a) Objective and adverse impacts of the Project

The primary objective of road improvement is **securing smooth and safe traffic**, by coping with anticipated increase in traffic demand. This will induce development of economic activity and regional development. Smooth and safe traffic will also improve access to social services such as school and medical service. Another main objective is to **reduce the maintenance cost** which is currently large because of fragile pavement structure.

The most probable adverse impact is **resettlement of houses and households** required for securing the necessary land for widening. Another adverse impact is the **cost needed to improve the road**. The cost of road improvement needs to be met either by the national fund or the financial assistance of foreign donors, or both, which can otherwise be used for other purposes.

(b) Alternative

Three alternatives are proposed, considering the objectives of road improvement and adverse impacts both to natural and social environment:

(i) Alternative-1: Improvement of pavement from existing DBST into asphalt concrete (AC)

The main objectives of this alternative are (i) to eliminate necessity of resettlement of houses/households, and (ii) reduce the maintenance cost of the road. Thus, only the pavement is improved and the road is not widened.

(ii) Alternative-2: Widening into 4-lane and improvement of pavement into AC

The objectives of this alternative are (i) to secure sufficient traffic capacity which can accommodate increased future traffic, and (ii) reduce the maintenance cost.

(iii) Alternative-3: Widening to the ‘opposed 2-lane + MC lane on both sides’ cross section and improvement of pavement into AC

The objectives of this alternative are (i) to secure the traffic capacity which can accommodate the future traffic demand up to around year 2030, (ii) reduce the number of houses/households to be relocated, and (iii) reduce the cost of construction cost. This alternative is proposed because this type of cross section has been practically adopted in some arterial national roads, including NR 1 (Phnom Penh – Neak Loueng Section) and NR 5 (Sri Sophorn – Poipet Section).

Figure 16.5-1 shows the typical cross sections of these alternatives.

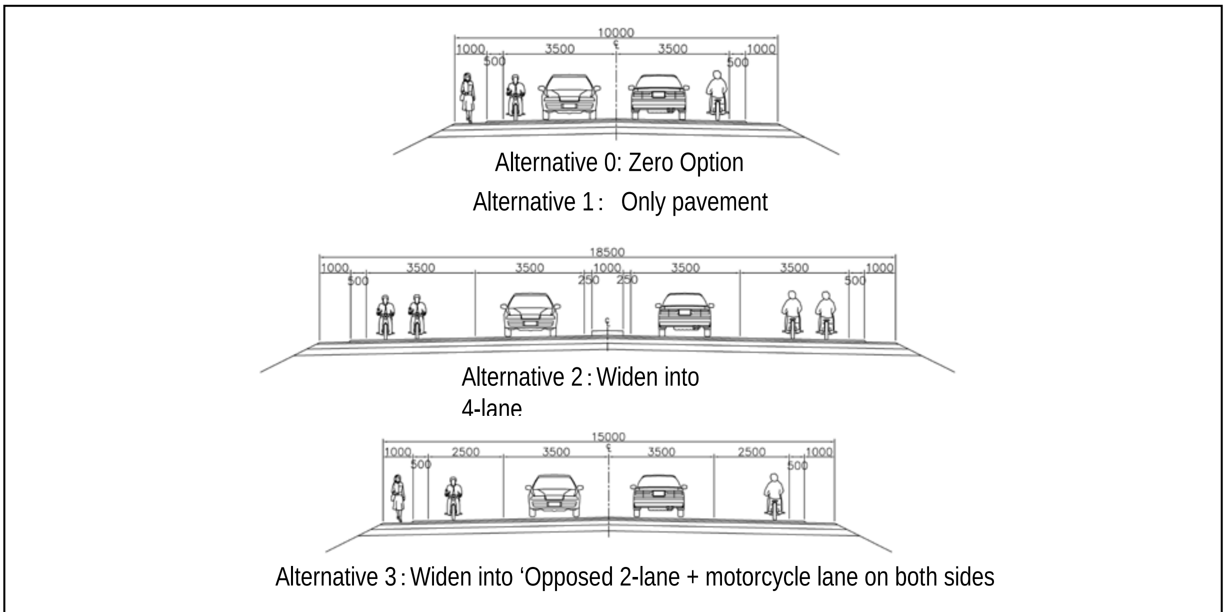


Figure 16.5-1 Typical Cross Section of Alternatives

(2) Items of Evaluation

Items of evaluating the alternatives are proposed as below, considering the objectives and adverse impacts of the Project:

(i) Social impact

Social impact, or resettlement of houses and households the impacts which needs diligent consideration. Thus, magnitudes of resettlement is adopted as one of the evaluation items.

(ii) Impact to natural environment

A road project may give some impact to natural environment. Thus this items is considered in evaluation of alternatives.

(iii) Impact to living environment/pollution

When traffic demand is not met, traffic congestion occurs and exhaust gas will increase. Thus, pollution is proposed as one of the evaluation items.

(iv) Traffic safety

Safe traffic is one of the most important aspects in road transport. Thus traffic safety is adopted as one of the evaluation items.

(v) Road/transport function

This refers to the performance of road whose function is to accommodate the traffic and serve for smooth, reliable and fast movement of people and goods. Strengthening of such function is the basic objective of the road improvement.

(vi) Construction cost/maintenance cost

This includes two sub-items. It is expected that improvement of the pavement can reduce the maintenance cost while such improvement need construction cost of the new pavement.

Table 16.5-1 compares advantages and disadvantages of these alternatives and “zero option”.

Table 16.5-1 Comparison of Alternatives of Improvement of Existing NR 5

Alternatives	Alt-0：Zero Option; No action	Alt-1：Existing road width is maintained; Only pavement is improved into asphalt concrete (AC).	Alt-2：Widen into 4-lane; pavement is improved into AC.	Alt-3：Widen into ‘Opposed 2-lane + motorcycle lane on both sides; pavement is improved into AC
Objective	Maintain the existing conditions. No impact to social & natural environment. No construction cost is required.	Resettlement is not required. Pavement is improved so that maintenance cost can be reduced.	Secure sufficient traffic capacity and smooth traffic. Improve traffic safety by slow traffic & fast traffic.	Reduce construction cost and number of households/houses to be relocated, securing required traffic capacity.
Social Impact				
Resettlement	No resettlement required.	Same as Alt-1.	Large number of households/houses	Considerable number of (less than in Alt-2)

Alternatives	Alt-0：Zero Option; No action	Alt-1：Existing road width is maintained; Only pavement is improved into asphalt concrete (AC).	Alt-2：Widen into 4-lane; pavement is improved into AC.	Alt-3：Widen into 'Opposed 2-lane + motorcycle lane on both sides; pavement is improved into AC
				households/houses need to be relocated.
Separation of Local Community	There is no change in conditions for crossing of road except new difficulty due to increase in traffic volume.	Same as Alt-1.	Crossing of road becomes difficult due to increase of road width and increase of vehicles speed.	Same as Alt-2 except that the degree of difficulty of crossing due to widening of road width is less than that in Alt-2.
Influence to Socio-Economic Activities and Regional Development	Sound growth of socio-economic activities is hampered, resulting in impedance in regional development, caused by traffic congestion.	Same as Alt-0.	Smooth traffic is secured resulting in growth in socio-economic activities and regional development. Increased job opportunities for local laborers and increase demand for consumer goods contributes to increase in gross income of the region.	Same as Alt-2 in principle; however, there is a possibility that traffic congestion start earlier than in Alt-2 and socio-economic activities and regional development will be hampered.
Impact to Natural Environment	Exiting conditions are maintained and no impact to natural environment is anticipated.	Only pavement structure is changed and practically no impact to natural environment is anticipated.	Since the main work is widening of an existing road, no large impacts are anticipated.	Same as Alt-2.
Impact to Living Environment /Pollution	There is a high possibility of traffic jam as traffic volume increase in future. When traffic jam occurs, travel speed is decreased and frequency of stop & start increases, resulting in increase in emission of pollutant.	Same as Alt-0.	Increased traffic demand in future will be accommodated and traffic jam will be substantially reduced resulting in prevention of crease of emitted pollutant is prevented. On the other hand, increased traffic capacity will induce traffic demand and increase total emission of pollutants.	Same as Alt-2 in principle; however, smaller traffic capacity than in Alt-2 will result in traffic jam and increase of emitted pollutants starting at earlier time in future.
Impact to Traffic Condition				
Road/ Transport Function	Smooth traffic cannot be secured due to traffic jam which will occur as traffic volume increase in future.	Same as Alt-0.	Smooth traffic can be secured owing to sufficient traffic capacity.	Same as Alt-2 in principle; however, traffic jam will start to occur at earlier time in future than in Alt-2 because traffic capacity is smaller than Alt-2.
Traffic Safety	High risk of traffic accident due to narrow road width which	Same as Alt-0: Risk of accident increases due to higher travel speed	Slow traffic, such as agricultural tractor, and fast traffic, such as	Slow traffic and fast traffic are separated and risk of accident is

Alternatives	Alt-0：Zero Option; No action	Alt-1：Existing road width is maintained; Only pavement is improved into asphalt concrete (AC).	Alt-2：Widen into 4-lane; pavement is improved into AC.	Alt-3：Widen into 'Opposed 2-lane + motorcycle lane on both sides; pavement is improved into AC
	forces travelling in the opposite lane when overtaking.	which becomes possible owing to improved road surface.	passenger car, are separated resulting in less risk of accident. Also, risk of head-on collision is decreased since necessity to travel in the opposite lane for overtaking is greatly reduced. On the other hand, risk of accident may increase due to increased travel speed of vehicles.	decreased, although to less extent than in Alt-2.
Construction Cost/ Maintenance Cost	No construction cost is required while maintenance cost remains large due to vulnerable pavement.	Cost for improvement of pavement is required. On the other hand, maintenance cost is reduced since pavement becomes durable.	Costs for resettlement, civil works of widening, pavement etc are required. On the other hand, maintenance cost is reduced owing to improved durability of pavement.	Same as Alt-2 in principle; costs for resettlement, widening, pavement etc are smaller than in Alt-2 due to narrower road width.

(3) Overall Evaluation

Overall Evaluation of each alternative is summarized below:

・ **Alternative-0 (Zero Option):**

While this option causes minimum or no negative impacts with regard to social impact (resettlement) and construction cost and causes no impact to natural environment, it will not solve the problems associated with traffic congestion which lead to hampered socio-economic activities and regional development, as well as increase in risk of traffic accident and pollution.

・ **Alternative-1 (Improvement of pavement only):**

Similarly to Alternative-0, this alternative causes minimum or no negative impact with regard to social impact (resettlement) and construction cost and causes no impact to natural environment, it will not solve the problems associated with traffic congestion which lead to hampered socio-economic activities and regional development, as well as increase in risk of traffic accident and pollution. **Thus, the objectives of the Project are not met with this alternative.**

・ **Alternative-2 (Widening into 4 Lanes)**

While this Alternative causes the largest negative impact with regard to social impact (resettlement) and construction cost, it is expected to promote socio-economic activities and regional development and reduce future risk of traffic accident and pollution to the maximum degree among the alternatives. It should be noted that increase in traffic capacity may induce a new demand in road traffic and cause increase in the total emission of pollutants.

While there remains the possibility of impact to the natural environment, it is expected to be small. Negative impact of resettlement is unavoidable in this alternative and need diligent mitigation measures (compensation and other measures).

Another negative impact of Alternative-2 is split of local communities. This is caused by widening of the road width and increase of vehicle speed which make crossing of road difficult. This negative impact can be mitigate to certain degree by providing facilities which assist safe crossing, such as pedestrian crossing road marking, ruble strip on pavement surface and traffic signs to reduce vehicle speed (please see (4) Ramble Strip' in Subsection 9.1.7 'Appurtenances)

The government Cambodia has accumulated experiences in resettlement and is expected to practice it best effort to mitigate the negative impacts. **This alternative is expected to fully achieve the objectives of the Project by eliminating traffic congestion** which will occur unless some measure is taken.

・ **Alternative-3 (Widening into 2 Lanes + Motorcycle Lane)**

This alternative has an advantage that the degree of negative social impact (resettlement) is smaller than that in Alternative-2. It can accommodate increased traffic demand up to less than 10 years after completion of the Project. Thus, widening into full 4-lane will be needed over sections of considerable length within 10 years after completion of the Project. **Thus, this Alternative cannot fully achieve the objectives of the Project.**

The evaluation stated above are summarized in the Table below:

Table 16.5-2 Summary of Evaluation

Alternative	Alternative-0	Alternative−1	Alternative - 2	Alternative - 3
Main Advantage	No resettlement is required	No resettlement is required	Smooth traffic is secured. (Main objective of Project is achieved.)	Smooth traffic is secured for about 10 years after completion of the Project. Number of houses/ households to be relocated is less than those in Alternative-2.
Main Disadvantage	Traffic jam due to future increase in traffic demand and retardation in development in socio-economic activities.	Traffic jam due to future increase in traffic demand and retardation in development in socio-economic activities.	Large number of houses/households need to be relocated.	Large number of houses/households, although less than in Alternative-2, needs to be relocated. Widening will become necessary within about 10 years after completion of the

Alternative	Alternative-0	Alternative-1	Alternative - 2	Alternative - 3
				Project.
Overall Evaluation	Not recommended because the objectives of the Project are not achieved.	Not recommended because the objectives of the Project are not achieved.	Recommended with condition that due consideration is given to mitigation of negative impacts.	Recommended only when the fund needs to be minimum.

Recommendation:

As stated above, Alternative-2 is evaluated to achieve the objectives of the Project. On the other hand it requires considerable extent of resettlement which needs diligent mitigation measures including adequate compensation and restoration of income and other aspects of resettled people. Thus, Alternative-2 was recommended by the JICA Survey Team, with condition of proper mitigation measures be taken for negative impacts as discussed above. After discussions among relevant organizations including MPWT, DPWT and JICA Team, Alternative-2 was adopted.

16.5.2 Bypass Construction

(A) Kampong Chhnang Bypass

(1) Objective and adverse impacts of bypass construction

The main objectives of constructing bypass are as follows:

- To avoid large scale resettlement which becomes necessary if the exiting NR 5 is to be widened,
- To reduce/mitigate the traffic accidents and pollutions which are caused by through traffic passing through the urbanized area of the city/town, and
- To induce desirable form of urban development

While construction of a bypass brings about favorable impact on traffic flow, traffic safety, pollution and urban development, it is possible that it causes some adverse impacts. First, it needs new acquisition of considerable area of land (mainly rice fields), as an adverse impact. Also, construction of road embankment in rice field may cause some impact on ecology and natural environment.

(2) Alternatives of Bypasses

Alternative routes and their comparison are described in detail in Section 8.3, Chapter 8. The followings are summary of the reasons of alternatives to be proposed.

- DPWT of Kampong Chhnang Province had plans of three preliminary alternative routes shown as DPWT-1 to DPWT-3 in Figure 8.3-1. These routes are to widen the existing roads.
- The JICA Survey Team proposed one alternative route shown as JICA-1 in Figure 8.3-1.

JICA-1 is to construct a new road in the suburbs of Kampong Chhnang City. The main purposes of this route are;

- To avoid resettlement which becomes necessary if the existing road is to be widened as the case in the alternatives proposed by the DPWT,
- To avoid the urbanization of the roadside area in the future and secure the function of bypass, and
- To secure sufficient space between the hemisphere of the existing urbanize area to allow future expansion of the urbanized area.

Also, shortening of the travel distance of through traffic is a important advantage of JICA-1 route.

(3) Evaluation Item

Evaluation items are proposed in similar consideration with that of improvement of the existing NR 5. However, some of the evaluation items are altered with other ones considering the objectives of bypass construction:

(i) Land acquisition

Bypass is constructed as a new road, and thus, need substantial area of land. Thus, this is proposed as one of the evaluation items.

(ii) Acceptance by the affected people

Owners of houses or lands along the road generally prefer the road in front of their properties be improved since the value of their properties increased by the road improvement. Thus, improvement of existing road is well accepted by the affected people.

(iii) Noise, vibration and air pollution

One of the objectives of bypass construction is to divert the through traffic and reduce traffic volume passing through the urbanized area. As the result, noise, vibration and air pollution in the urbanized area are reduced. New noise etc is created along the bypass but the bypass passes the area remote from the existing urbanized area and impact to the people are reduced. Considering these, noise, vibration and air pollution is proposed as one of the evaluation items.

(iv) Traffic accident

Likewise to the case of noise, vibration and air pollution, traffic accident is expected to be reduced due to reduction in the through traffic which passes through the urbanized area. New risks of traffic accident are originated on the bypass. Thus, traffic accident is adopted as one of the evaluation items.

(v) Impact on natural environment

Construction of a completely new road in agricultural land may cause some impacts to natural environment. Thus it is proposed as one of the evaluation items.

(vi) Road/traffic function

Likewise to improvement of exiting NR 5, strengthening of the road/traffic function is one of the most important objectives of bypass construction. Thus it is adopted as one of the evaluation items.

(vii) Contribution to development of socio-economic activities and local economy

Similarly to improvement of existing NR 5, construction of a bypass is expected to contribute to development of socio-economic activities and local economy through improved traffic/transport conditions. These include the following:

- Easier access to public services for the people living along/near the bypass,
- Improvement of transportation of agricultural products, especially produced in the area along the bypass,
- Easier access of the local products to the markets through improved transportation.

Thus, this item is adopted as one of the evaluation items.

(viii) Construction cost

Likewise to improvement of exiting NR 5, construction cost is one of the negative impact, and thus, proposed as one of the evaluation items.

Table 16.5-2 summarizes the comparison of advantages and disadvantages of the main alternatives “Kampong Chhnang Bypass”.

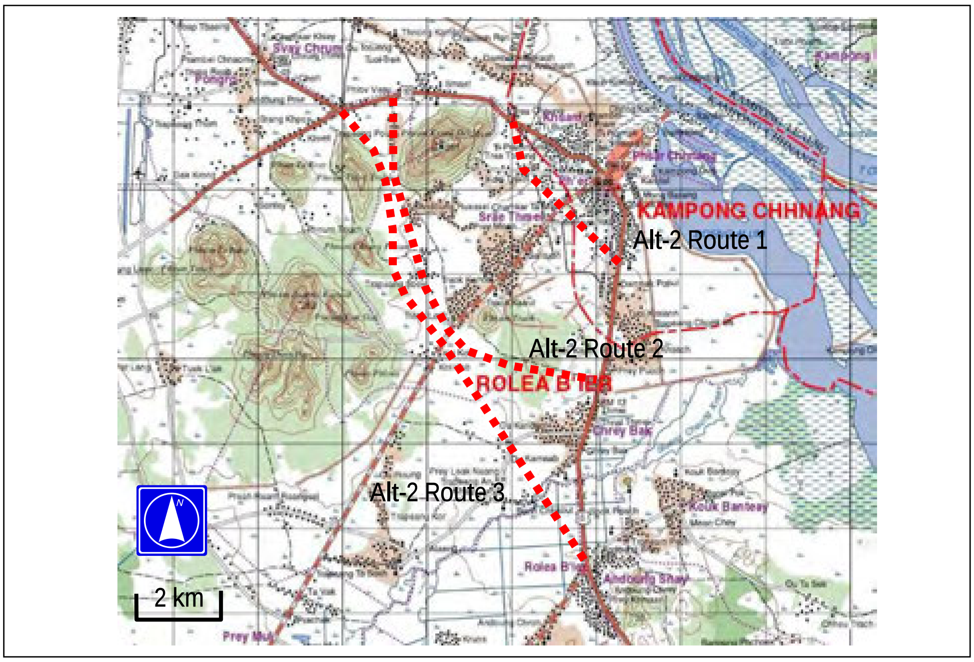


Figure 16.5-2 Location of Proposed Kampong Chhnang Bypass Route

Table 16.5-3 Comparison of Alternatives of Kampong Chhnang Bypass

Alternatives	Alt-1: Widening of Existing NR 5	Alt-2: Bypass Construction		
		Route 1 (L=4.9 km)	Route 2 (L=9.6 km)	Route 3 (L=12.1 km)
Resettlement of Households/ Houses	Many households/ houses need to be relocated since NR 5 is passing through an urbanized area.	Many households/ houses need to be relocated since the road to be widened is passing through an urbanized area.	Number of households/ houses which needs to be relocated is less than that in Route 1, since the road to be widened is located in the suburbs. Still considerable number of households/houses need to be relocated.	Less than 10 houses need to be relocated at and near the intersection with the existing NR 5 in the north. Thus, the number of houses to be relocated is much less than those in Route 1 and 2.
Land Acquisition	No land acquisition is necessary since the land within 30 m from the road center has been designated as the right of way (ROW).	Acquisition of additional land is necessary for widening of the existing road. In addition, acquisition of whole ROW is necessary for the section from the intersection with NR 53 to east which is newly constructed.	Same as Route 1, in general. The area to be newly acquired becomes larger than in Route 1 since the length of newly constructed section is longer than in Route 1.	ROW over whole section length and whole road width needs to be newly acquired. Loss of agricultural land becomes larger than in other alternative routes.
Acceptance by the Affected People	People living in the roadside lands usually welcome improvement of the road in front of their property (land) because of such reasons as improvement of quality of life (easier access to public services, reduction in dust and easier access to market etc) and increase in value of the land. However, in case that the road is already wide and paved, they may oppose to road improvement.	People living in the roadside lands usually welcome improvement of the road in front of their property (land) because of such reasons as improvement of quality of life (easier access to public services, reduction in dust and easier access to market etc) ansince the value of the land becomes higher. Thus, improvement and/or widening of the suburban road is usually well accepted by the affected people.	Same as in Route 1.	Owner of the properties along the Bypass welcome construction of the Bypass since the value of the land becomes higher.
Noise, Vibration, Air Pollution	Through traffic passes through the city center, resulting in increased noise, vibration and air pollution.	Through traffic is expected to divert to the bypass. Noise and vibration in the city center will decrease. However, this will simply divert or distribute the air pollution sources to the bypass and not reduce them in total.	Through traffic will divert to the Bypass in the suburban area whose roadside is less populated, and noise, vibration and air pollution in the city center will decrease.	Through traffic will divert to the Bypass in the suburban area whose roadside is sparsely populated, and noise, vibration and air pollution in the urbanized area will decrease.

Alternatives	Alt-1: Widening of Existing NR 5	Alt-2: Bypass Construction		
		Route 1 (L=4.9 km)	Route 2 (L=9.6 km)	Route 3 (L=12.1 km)
Traffic Accident	Through traffic passes through the city center and risks of traffic accident will increase as the traffic demand will grow in the future.	Risks of traffic accident are expected to decrease since the road is traversing less-densely populated suburban area. However, the Bypass passes through residential area and degree of decrease in traffic accident is less than that in Route 3.	While traffic volume passing through the city center and traffic accident will decrease, there will be newly created risks of accidents on the Bypass. Total number of traffic accident is expected to decrease since the safety environment of the Bypass is more favorable than that of existing NR 5 in the city center.	Same as in Route 2.
Impact on Natural Environment	No substantial change is anticipated since the project is to widen the road which has been existing for long time.	The section from the intersection with NR 53 to east which is newly constructed in the land which is mainly use for agriculture. This may cause interruption of migration routes or separation of habitat of wildlife.	The section from the intersection with NR 53 to east which is newly constructed in the land which is mainly use for agriculture. This may cause interruption of migration routes or separation of habitat of wildlife.	The newly constructed Bypass may interrupt/ separate the activity areas of the biology.
Road Function/ Traffic Function	Travel speed of vehicles is forced to slowdown by congestion, signals at intersections and other obstacles, resulting in reduction in efficiency of transport. In addition there are many bends in the existing NR 5 in the urbanized area of Kampong Chhnang which forces further slowdown of traffic.	The proposed route traverses the periphery of existing urbanized area. Thus, it provides easier access to/from the city center. On the other hand, roadside area of the Bypass will be urbanized and the function as bypass may be lost in the near future.	The proposed route is sufficiently away from the existing urbanized area and it is expected that the Bypass maintain the function of bypass for long future.	Diversion of through traffic is fully attained. This is essential function of a bypass. The route is sufficiently away from the exiting urbanized area and it is expected that the Bypass maintain the function of bypass for long future. Further, the proposed route short-cut the existing NR 5 and travel distance is reduced.
Contribution to development of socio-economic activities and local economy	Practically no improvement from the current condition. May be worsened due to traffic congestion in the city center.	The Bypass passes through the urbanized area and little positive impact on transport of agricultural product, while business opportunities along the bypass will increase owing to increased traffic.	Transport/traffic condition of the people along the Bypass will be improved and socio- economic activities of the people along the Bypass will be promoted. Transportation of agricultural products will be improved to certain degree since the Bypass is close to agricultural land.	Access to/from NR 5 for the people living southwestern side of the current urbanized area will be substantially improved through the Bypass and also the transportation of agricultural products will be improved.

Alternatives	Alt-1: Widening of Existing NR 5	Alt-2: Bypass Construction		
		Route 1 (L=4.9 km)	Route 2 (L=9.6 km)	Route 3 (L=12.1 km)
Construction Cost	Volume of required works is less than other alternatives, and the cost is a minimum price among the alternatives.	Lowest next to Alt-1.	Larger than Route 1.	Larger than Route 1 and 2 because the length of the Bypass is longer than in Route 1 and 2.

(4) Overall Evaluation

Overall evaluation of each alternative is summarized below:

- **Alternative-1 (Widening of Exiting NR 5):**

This alternative requires large scale resettlement which is very difficult to implement. Also, many problems which are anticipated in the future due to increase of traffic volume, such as traffic accidents and pollution will not be solved. The existing NR 5 has many bents (corners) where it passes the city center of Kampong Chhnang, and traffic has to slow down even after the road is widened. Thus it substantially reduces the degree of achievement of Project objectives.

- **Alternative-2, Route-1:**

The largest disadvantage of this route is that it passes the existing urbanized area of Kampong Chhnang City. It requires resettlement of considerable number of households/houses. The one of the main objective of bypass construction is to minimize resettlement. Route-1 is evaluated to be very unfavorable from the viewpoint of resettlement. Also, when the bypass will be completed, the road side area is already densely populated and various factors of ‘side friction’ to traffic (obstacles which hamper smooth and safe traffic, such as traffic from the crossing streets) will exist resulting in imperfect function of bypass. Thus, this route is evaluated not to fully achieve the objective of the bypass construction.

- **Alternative-2, Route-2**

The northern half section of Route-2 uses the existing road by widening it. Thus, resettlement of considerable number of households and houses, although less than that in route-1, become necessary. Another drawback of this route is it is close to the existing urbanized area of the city. With expansion of the urbanized area in the future, the roadside of the bypass will be densely populated and the function of bypass will be substantially lost. Thus, the objectives of bypass construction will not be fully attained.

- **Alternative-2, Route-3**

This route traverses agricultural area outside of the current urbanized area. The number of houses to be resettle is estimated to be in the order of magnitude of 10. Since this route keeps sufficient distance from the existing urbanized area, the function of bypass is expected to be maintained for long time. Still another advantage of this route is that it can shorten the travel distance of through traffic compared to that in the existing NR 5 which curves when it passes Kampong Chhnang City. Thus, this route best achieves the objectives of bypass construction. One of the major disadvantage of this route is that it passes thorough the agricultural area and there is a possibility of impact to the natural environment, including separation of activity areas of animals (fauna). Although existence of large mammals was not found in the field survey, there is a possibility that various reptiles, amphibious and fishes are living in the area. Separation of activity areas of such animals can be mitigated to certain extent by providing sufficient number of bridges and/or culverts which will minimize the change of flow of the surface water (through rivers and channels).

The evaluations stated above are summarized in the table below:

Table 16.5-4 Summary of Evaluation of Alternatives Routes of Odongk Bypass

Alternatives	Alt-1: Widening of Existing NR 5	Alt-2: Bypass Construction		
		Route 1	Route 2	Route 3
Main Advantage	No substantial impact to natural environment is anticipated. No agricultural land is lost.	No land acquisition is required.	Land acquisition is required only for the section from intersection with NR 57 to southeast.	Number of houses/ households to be relocated is minimum. Function of bypass will be maintained in long future. Travel distance of through traffic is shortened.
Main Disadvantage	Large number of houses/households need to be relocated.	Large number of house/households need to be relocated. Bypass of function will be lost in the future as the urbanized area will expand.	Considerable number of houses/households need to be relocated on the section from intersection with NR 57 to northwest.	Considerable area of agricultural land will be lost.
Overall Evaluation	Not recommended in view of large number of houses/households which need to be relocated.	Not recommended in view of that large number of houses/households which need to be relocated and the function as a bypass will be lost in near future.	Not recommended in view of that considerably large number of houses/households need to be relocated.	Recommended in view of little number of houses/households to be relocated and the long time period when the function of bypass will be maintained.

Recommendation:

Considering that this route best achieves the objectives of bypass construction, this route (alternative) was recommended. After discussions among relevant organizations including MPWT, DPWT and JICA Team, Alternative-2, Route-3 was adopted. It should be noted that sufficient number of bridges and/or culverts need to be provided not to substantially change the current flow of surface water and pass for aquatic animals.

(B) Odongk Bypass

(1) Objective and adverse impacts of bypass construction

Objectives and adverse impacts of Ondong Bypass are same as those of Kampong Chhnang Bypass.

(2) Alternatives of Bypasses

Alternative routes and their comparison are described in detail in Section 8.3, Chapter 8. Eight (8) alternative routes were initially proposed. Figure 16.5-3 show the general locations of alternative routes of Odongk Bypass. However, all of these routes were found to be unfeasible due to various reasons, including impact to historical heritage. After consultation between MPWT and the JICA Survey Team, a new route passing the north periphery of the town was selected as the proposed route.

(3) Evaluation Item

Evaluation items same to those of Kampong Chhnang Bypass are adopted. Table 16.5-3 summarizes the comparison of advantages and disadvantages of the main alternatives "Odngk Bypass".

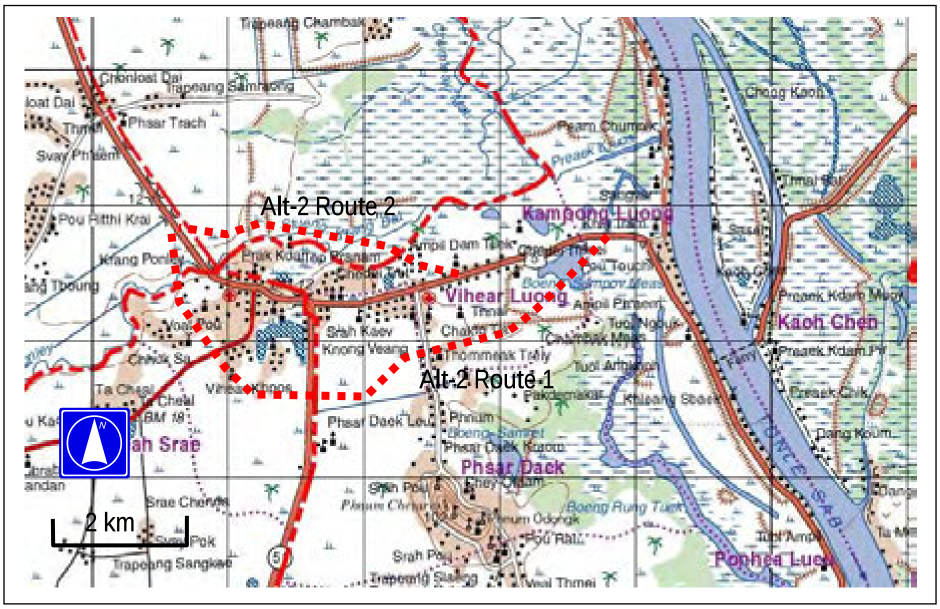


Figure 16.5-3 Location of Proposed Odongk Bypass Route

Table 16.5-5 Comparison of Alternatives of Odongk Bypass

Alternatives	Alt-1: Widening of Existing NR 5	Alt-2: Bypass Construction	
		Route 1 South of Odongk Town (L=9.9 km)	Route 2 North of Odongk Town (L=4.9 km)
Resettlement of Households/ Houses	Many households/houses need to be relocated since NR 5 is passing through an urbanized area.	Large scale relocation is not required.	Large scale relocation is not required.
Land Acquisition	No land acquisition is necessary since the land within 30 m from the road center has been designated as the right of way (ROW).	Acquisition of additional land is necessary for widening of the existing road.	Same as Route 1, in general. The area to be newly acquired becomes smaller than in Route 1 since the length of newly constructed section is shorter than in Route 1.
Acceptance by the Affected People	People living in the roadside lands usually welcome improvement of the road in front of their property (land) because of such reasons as improvement of quality of life (easier access to public services, reduction in dust and easier access to market etc). However, in case that the road is already wide and paved, they may oppose to road improvement.	Owner of the properties along the Bypass welcome construction of the Bypass since the value of the land becomes higher.	Same as in Route 1.
Noise, Vibration, Air Pollution	Through traffic passes through the city center, resulting in increased noise, vibration and air pollution.	Through traffic will divert to the Bypass in the suburban area whose roadside is sparsely populated, and noise, vibration and air pollution in the urbanized area will decrease.	Same as in Route 1.
Traffic Accident	Through traffic passes through the city center and risks of traffic accident will increase as the traffic demand will grow in the future.	While traffic volume passing through the city center and traffic accident will decrease, there will be newly created risks of accidents on the Bypass. Total number of traffic accident is expected to decrease since the safety environment of the Bypass is more favorable than that of existing NR 5 in the city center.	Same as in Route 1.
Impact on Natural Environment or others	No substantial change is anticipated since the project is to widen the road which has been existing for long time.	The proposed route has high possibility of encountering historical heritage due to looseness to Phnom Odongk.	The proposed route is away from Phnom Odongk
Road Function/Traffic	Travel speed of vehicles is forced to slowdown by	The proposed route directly connects to NR 51 (A) and	Pass hemisphere of urbanized area. Road side area will be

Alternatives	Alt-1: Widening of Existing NR 5	Alt-2: Bypass Construction Route 1 South of Odongk Town (L=9.9 km)	Alt-2: Bypass Construction Route 2 North of Odongk Town (L=4.9 km)
Function	congestion, signals at intersections and other obstacles, resulting in reduction in efficiency of transport. In addition there are many bends in the existing NR 5 in the urbanized area of Odongk Town which forces further slowdown of traffic.	passes west hemisphere of urbanized area. Road side area will be urbanized & function of bypass will be reduced in near future. Travel distance becomes longer than existing NR 5.	urbanized & function of bypass will be reduced in near future. Horizontal alignment is not smooth.
Construction Cost	Volume of required works is less than other alternatives, and the cost is a minimum price among the alternatives.	Larger than Route 2 because the length of the Bypass is longer than in Route 2.	Lowest next to Alt-1.

16.6 Environmental Impacts and Mitigation Measures

16.6.1 Prediction of Environmental Pollution

(1) Prediction of Air Pollution and CO_2 Emission

According to the traffic demand forecast estimated in this survey, the total traffic demand in the each forecasted station in 2016 will increase by 144 ~ 179 percent as Passenger Car Unit from the traffic volume in 2012. Air pollutants and CO_2 emitted by the vehicle traffic will also increase. The total emission volume of SPM (Suspended Particulate Matter), NOx (Nitrogen oxide) and CO_2 emitted by the vehicle traffic from the whole of the target road (139 km long) in 2016 and 2021 is estimated in case of “With Project” and “Without Project” at a preliminary level. Because the project will not complete in 2016, the emission volume of “ in 2016” and “With Project” is estimated as an assumption.

The “total emission volume” is calculated as:

$$BR_i = \sum_j \sum_l (Q_{ijl} \times L_l \times \beta_j) \times 365 \div 1{,}000{,}000$$

where:

BR i	: Total Emission Volume in case of development i (ton/year)
Qi j l	: Traffic Volume in case of development i, link l and vehicle type j (number/day)
Ll	: Length of link l (km)
β *j*	: Emission factor by vehicle type j (gram/ (number*km))
j	: vehicle type
l	: link

Source: Objective Evaluation Index by Ministry of Land, Infrastructure, Transport and Tourism, Japan, 2003

The emission factors are calculated on the basis of “Grounds for the Calculation of Motor Vehicle Emission Factors using Environment Impact Assessment of Road Project etc. (Revision of FY 2010, National Institute for Land and Infrastructure Management, Japan”. The details of the used calculation method are presented in Appendix 16-4.

The result of traffic volume forecast, average vehicle travel speed and emission factors to estimate the total emission volume are shown in Table 16.6-1.

Table 16.6-1 Traffic Volume, Average Vehicle Speed and Emission Factors

Item	Motorcycle	Light Vehicle	Heavy Vehicle
Traffic Volume in 2012 (Present Condition, Without Project) (number*km/day)	516,555	343,847	143,948
Traffic Volume “Without Project” in 2016 (number*km/day)	742,995	653,802	204,952
Traffic Volume “With Project” in 2016 (number*km/day)	799,277	625,598	197,719
Traffic Volume “Without Project” in 2021 (number*km/day)	954,629	863,563	269,810
Traffic Volume “With Project” in 2021 (number*km/day)	1,032,145	825,601	260,096
Average Vehicle Speed in 2012 (Present Condition, Without Project) (km/hr)	50	50	50
Average Vehicle Speed “Without Project” in 2016 (km/hr)	49	49	49
Average Vehicle Speed “With Project” in 2016 (km/hr)	58	58	58
Average Vehicle Speed “Without Project” in 2021 (km/hr)	47	47	47
Average Vehicle Speed “With Project” in 2021 (km/hr)	58	58	58
Emission Factor SPM in 2012 (Present Condition, Without Project) (g/ (number*km))	0.00048	0.00159	0.04118
Emission Factor SPM “Without Project” in 2016 (g/ (number*km))	0.00049	0.00162	0.04179
Emission Factor SPM “With Project” in 2016 (g/ (number*km))	0.00045	0.00150	0.03753
Emission Factor SPM “Without Project” in 2021 (g/ (number*km))	0.00051	0.00169	0.04314
Emission Factor SPM “With Project” in 2021 (g/ (number*km))	0.00045	0.00150	0.03755
Emission Factor NOx in 2012 (Present Condition, Without Project) (g/ (number*km))	0.017	0.058	1.138
Emission Factor NOx “Without Project” in 2016 (g/ (number*km))	0.018	0.059	1.152
Emission Factor NOx “With Project” in 2016 (g/ (number*km))	0.016	0.054	1.076
Emission Factor NOx “Without Project” in 2021 (g/ (number*km))	0.018	0.061	1.186
Emission Factor NOx “With Project” in 2021 (g/ (number*km))	0.016	0.054	1.076
Emission Factor CO_2 in 2012 (Present Condition, Without Project) (g-CO_2/ (number*km))	41.1	136.9	667.9
Emission Factor CO_2 “Without Project” in 2016 (g-CO_2/ (number*km))	41.4	137.8	673.6
Emission Factor CO_2 “With Project150” in 2016 (g-CO_2/ (number*km))	39.5	131.6	635.5
Emission Factor CO_2 “Without Project” in 2021 (g-CO_2/ (number*km))	42.0	140.0	686.4
Emission Factor CO_2 “With Project150” in 2021 (g-CO_2/ (number*km))	39.5	131.6	635.7

** Source: CO_2 Emissions from Fuel Combustion Highlight, 2012 by International Energy Agency*

The result of estimation of the total emission volume is shown in Figure 16.6-1. The total emissions of SPM, NOx and CO_2 in 2021 in case of "Without Project" increase approximately twice as large volume as in 2012. On the other hand, the volumes of SPM, NOx and CO_2 in case of "With Project" are approximately 16, 13 and 9 percent less than "Without Project" ones, respectively.

The CO_2 emission in 2016 in case of "Without Project" increases approximately 34,000 ton/year from the emission in 2012. The increasing amount is approximately equal to 2.3% of the CO_2 emission (1.5 million ton *) from the road transport sector in 2010.

Because the emissions factors will change in the future due to improvement in vehicle efficiency, the recalculation should be considered at the future stage.

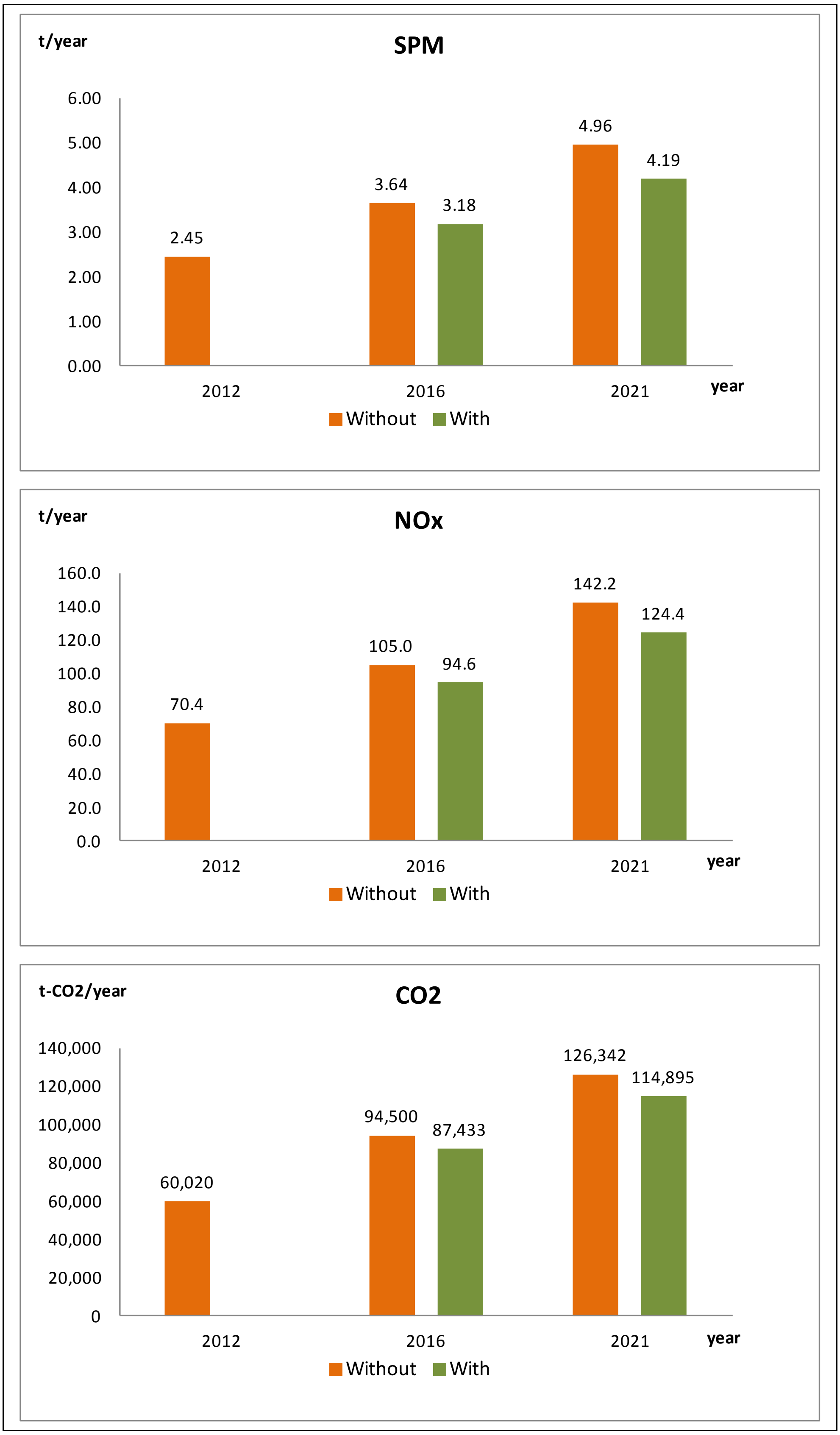


Figure 16.6-1 Result of Estimation of Total Emission Volume

Air pollutant levels of SPM and NO_2 emitted by vehicles during operation phase on the roadside are predicted by using a ambient air pollution dispersion model (Plume Model) on the basis of “Environmental Impact Assessment Technique for Road Project No.383-400, June 2007, National Institute for Land and Infrastructure Management, Japan”. Plume Model is a general dispersion model used in case of more than 1 m/s wind velocity. The details of the used model are presented in Appendix 16-4.

Because the wind data in the project site are insufficient to calculate pollutant levels of a day and each station forecasted the traffic volume, the pollution levels of the forecasted station No. 2 mentioned in “Chapter 6 Traffic Forecast” in this report (Southern suburb of Kampong Chhnang), where is forecasted the most traffic volume at the peak traffic volume hour in the target section, in 2021 after completion of Kampong Chhnang Bypass, are only calculated as the worst case.

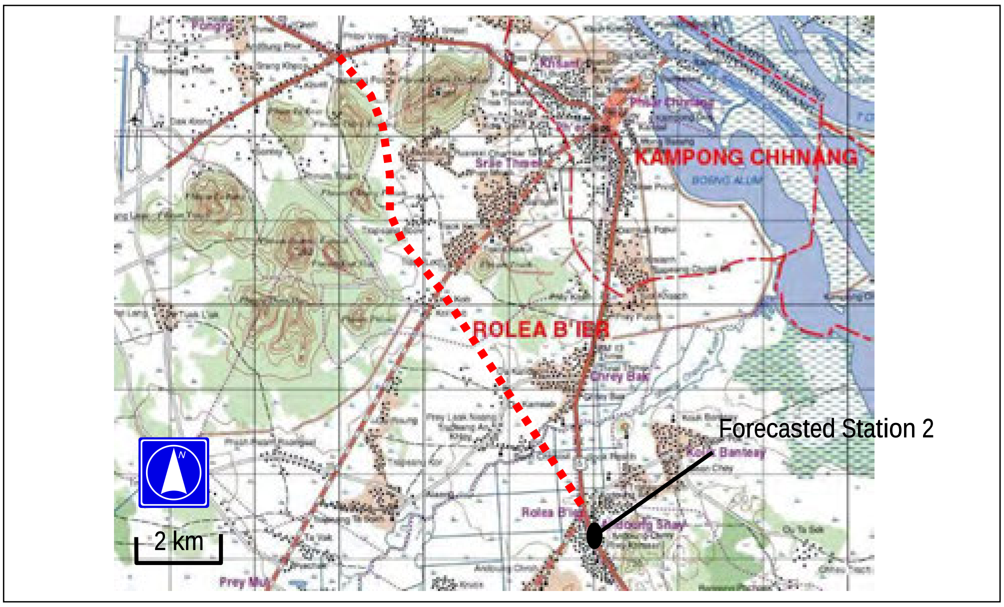


Figure 16.6-2 Point Predicted Air Pollutant Level

The result of air pollutant levels caused by vehicle emission on the roadside is shown in Table 16.6-2. The predicted NO_2 level in north-northwest wind is almost same as the deference of NO_2 levels between “Roadside Point” and “Background Point” at Cross Section 3 (Northern suburb of Kampong Chhnang), where there are no air pollution sources except for vehicles, in the air quality survey results (see Table 16.2-4). The predicted pollutant levels are very low and these contribution amounts to ambient air quality will not be considerable concentration.

Table 16.6-2 Predicted Air Pollutant Level Caused by Vehicle Emission on Roadside

Parameter	North-northwest wind (2 m/s) (Along road direction)	East-northeast Wind (2 m/s) (Right angle to road direction)	Cambodia Ambient Air Quality Standard
SPM (mg/m^3)	0.00025	0.0000075	0.05* (PM10, 24 Hour)
NO_2 (mg/m^3)	0.0040	0.000121	0.3 (1 Hour)

The asterisk (*) refers to WHO's Standards

(2) Prediction of Noise Level

According to the noise survey, the levels along the target road are less than the environmental standards in the daytime. However, in the future, the noise levels may rise by the environmental standard due to increased traffic volume and speed. The level of the forecasted station No. 2 that is a same point as "Air Pollution" in this report in 2021 is predicted by a brief calculation method of LAeq under simple condition in "ASJ RTN-Model 2008 by The Acoustical Society of Japan". The details of the used calculation method are presented in Appendix 16-4.

The result of noise levels caused by vehicle traffic at the end point of road (roadside), on 15 m line from road center and borderline between the ROW and private land are shown in Table 16.6-3. The predicted noise levels on the roadside are higher than the standards during all day. The noise level on 15 m line from road center is same as the standard during 6:00 ~ 18:00. The noise levels on the borderline are lower than the standards during 6:00 ~ 22:00. The noise level during 22:00 ~6:00 is 8 dB higher than the standard. However, actual noise levels around houses located along the road become lower than the predicted levels depending on the distance to road.

Table 16.6-3 Predicted Noise Level Caused by Vehicle Traffic on Roadside

Time	6:00 to 18:00	18:00 to 22:00	22:00 to 6:00
Predicted Noise Level (dB) at end point of road (12.75 m from road center)	71	67	62
Predicted Noise Level (dB) on 15 m line from road center	70	66	61
Predicted Noise Level (dB) on borderline (30 m from road center)	67	62	58
Cambodia Maximum Noise Level Standard (Commercial and service and mix area) (dB)	70	65	50

16.6.2 Impact and Mitigation

The potential impacts by the magnitude are shown in Table 16.6-4, 16.6-5 and 16.6-6. The recommended mitigation measures for each identified impact are also presented in these Tables.

(1) Significant or Large Impact Items

Table 16.6-4 Impacts and Mitigation Measures (Significant Impact)

Item	Impact	Mitigation
Social Environment		
Resettlement/ Land Acquisition	**Pre-Construction Phase:** ・ Resettlement and additional land acquisition will be required. ・ Affected households including partial asset losses may be more than 2,000. **Construction Phase:** ・ Additional small scale land acquisition and resettlement may be required. ・ Temporal lease of land will be required for construction yard. **Operation Phase:** ・ Additional physical resettlement and land acquisition will not be required.	**Pre-Construction Phase:** ・ Authorities concerned shall prepare and strictly implement a proper Resettlement Action Plan (RAP) and Land Acquisition Plan (LAP) (see Chapter 17 Resettlement Action Plan). **Construction Phase:** ・ Authorities concerned shall implement the RAP and LAP. ・ The contractor shall provide proper compensation for construction yards to land owners or users. **Operation Phase:** -

(2) Substantial Impact Items

Table 16.6-5 Impacts and Mitigation Measures (Substantial Impact)

Item	Impact	Mitigation
Environmental Pollution		
Air pollution	**Construction Phase:** ・ Operation of construction equipment will generate dust and emission gas. ・ Traffic congestion in construction site will cause increase in exhaust gas from vehicles. ・ Dust will occur in borrow pit or quarry site. **Operation Phase:** ・ In the future, total amount of air pollutant caused by vehicle exhaust gas due to increment of vehicle will increase. In 2021, the total emission will increase approximately twice as large volume as in 2012. ・ On the other hand, the amount is expected to be reduced due to improved traffic efficiency compared to without project.	**Construction Phase:** ・ The contractor shall prepare and strictly implement dust control measures such as periodical water spray. ・ The contractor actively uses electrically-powered equipment. ・ The contractors shall maintain their construction equipments in adequate working conditions. ・ The contractors shall keep clean road surfaces. ・ The driver of construction vehicles comply with speed limits to minimize road dust. ・ The contractor and supervision consultant shall provide prior notification to the local community on the schedule of construction activities. ・ The contractor shall prepare and strictly implement a traffic management plan around construction site. ・ The supervision consultant shall monitor dust, exhaust gas and complaint from the local people. ・ If the local residents and pedestrians complain about the dust and gas, the supervision consultant and contractors should reconsider the construction technique and method. **Operation Phase:** ・ The regulations on fuel quality and importing old cars are to be prepared by MOE in the future. ・ Emission gas control shall be strictly implemented. ・ A relevant agency shall monitor air quality on roadside.

Item	Impact	Mitigation
Water pollution	**Construction Phase:** ・ Turbid water caused by construction works is likely to affect existing surface water resources. ・ Human wastewater will cause surface water contamination. ・ In case of accidental massive leaking of fuel or oil, water pollution including ground water may occur. ・ In case of inadequate management in borrow pit or quarry site, turbid water from borrow pit or quarry site by rainfall may cause surface water contamination. **Operation Phase:** ・ Considerable water pollution is unlikely to occur. ・ In case of inadequate management or recovery in borrow pit or quarry site, turbid water from borrow pit or quarry site by rainfall may cause surface water contamination.	**Construction Phase:** ・ Construction works in and around rivers, streams, reservoirs or channels shall be concentrated in dry period. ・ The contractors shall maintain their construction equipments in adequate working conditions. ・ To reduce turbid water, steel sheet pile construction method should be selected in bridge construction works as necessary. ・ The contractor should consider installation of cofferdam as necessary. ・ The contractor shall strictly control waste oil and other waste. ・ The contractors will be prohibited from washing the construction tools along the rivers, streams, reservoirs and other public water to prevent further pollution. ・ In construction works in and around rivers streams, reservoirs or channels, the supervision consultant and contractor should monitor and control the turbid water as necessary. ・ The wastewater septic tank facility in the workers camp and/or other necessary locations shall be properly maintained. ・ The supervision consultant shall monitor water quality. ・ The contractor and supervision consultant shall take into account the environmental impacts such as water contamination caused by turbid water and soil erosion in selection of borrow pit and quarry site. ・ The contractor shall prepare and strictly implement an environmental management plan including adequate drainage to avoid accumulation of stagnant water and vegetation recovery plan in borrow pit or quarry site. ・ In case of development of new borrow pit or quarry site, necessary approvals from environmental authorities shall be obtained prior to the operation. ・ In case of purchase from quarry firm, a task on the environmental management should be included in the contract. **Operation Phase:** ・ MPWT shall monitor environmental condition in abandoned borrow pit or quarry site. ・ If the condition has risk of soil erosion in borrow pit or quarry site, MPWT should consider the countermeasures.
Waste	**Construction Phase:** ・ Construction waste caused by construction works and general waste from construction office will	**Construction Phase:** ・ The contractor shall prepare and strictly implement a proper waste management plan including waste due to demolish works.

<table>
<tr><th>Item</th><th>Impact</th><th>Mitigation</th></tr>
<tr><td></td><td>be generated.
・ Solid waste due to demolish works of facilities in the ROW will generate.
Operation Phase:
・ Illegal dumping of solid waste may increase along the newly constructed bypass.</td><td>・ The waste management plan should be approved by the local relevant authority in advance of construction works.
・ The contractors shall provide temporary sanitation facilities such as portable toilets and garbage bins to ensure that the domestic wastes to be generated by the construction personals.
・ The solid waste should be separated into hazardous, non-hazardous and reusable waste streams and store temporary on site.
・ Office building for construction contractor shall be provided with toilets and septic tanks to handle domestic sewage.
・ The contractor shall consider and implement proper re-use plans of the construction waste.
・ The supervision consultant shall monitor the waste disposal
・ The local relevant authority should maintain closely consultation with the contractor on the collection of garbage.
Operation Phase:
・ A relevant agency should monitor and control illegal dumping.</td></tr>
<tr><td>Noise and vibration</td><td>Construction Phase:
・ Construction works is likely to increase in the noise and vibration level.
・ Noise and vibration will occur in borrow pit or quarry site.
Operation Phase:
・ In the future, noise level caused by vehicle driving will increase. In 2021, the noise level will be same as the standards during 6:00 ~ 18:00. The levels during 18:00 ~ 22:00 and 22:00 ~6:00 are 1 dB and 11 dB higher than the standard, respectively.
・ On the other hand, noise levels along roadside are expected to be reduced due to widening and improved smooth surface compared to without project.
・ In the future, vibration level caused by vehicle driving will increase. However, because the present vibration levels at the roadside are lower than “the threshold level of vibration sense”, serious impact of vibration on the local people is unlikely to occur in road sections with good surface condition.</td><td>Construction Phase:
・ A proper work schedules should be prepared not to concentrate the construction equipment at a certain point for long time.
・ The contractors shall maintain their construction equipments in adequate working conditions.
・ Construction works with heavy noise and vibration shall be prohibited during night (10:00 pm - 6:00 am) to avoid noise disturbance in residential, commercial and other noise-sensitive areas.
・ The contractor selects quiet equipment and working methods as much as possible.
・ The contractor and supervision consultant shall provide prior notification to the local community on the schedule of construction activities.
・ The supervision consultant shall monitor noise, vibration and complaint from the local people in construction site, borrow pit and quarry site.
・ If the local residents and pedestrians complain about the noise and vibration, the supervision consultant and contractors should reconsider the construction technique and method.
Operation Phase:
・ The proper countermeasures to reduce noise and vibration such as slow speed in curve sections should be included in the plan and design.
・ A relevant agency shall monitor noise and vibration on roadside.
・ If the noise level reaches a significant level such as</td></tr>
</table>

Item	Impact	Mitigation
		exceeding the environmental standards, the relevant agency should consider mitigation measures on noise control.
Natural Environment		
Protected areas	**Construction Phase:** ・ Because the distance between the target section of NR 5 and the core areas is sufficient long, the impacts on the core areas are unlikely to occur. ・ Because the construction works will be limited within the ROW of NR 5 or the outside of "Tonle Sap Biosphere Reserve (TSBR)", the direct impacts on natural resources in the buffer or transition zone of TSBR are unlikely to occur. ・ Rivers or streams that have direct and/or indirect connections with TSBR will be temporarily disturbed by construction works. ・ Road widening will require loss of existing vegetation along the buffer or transition zone of TSBR. **Operation Phase:** ・ Because natural tree clearing and change of river flow will not be required, direct impacts on the natural resources are unlikely to occur. ・ The project is unlikely to cause new environmental issues or deteriorate existing issues in TSBR. ・ However, because a portion of the target road runs alongside the line of the buffer zone in TSBR, indirect impacts on some components in TSBR may occur sometime in the future.	**Construction Phase:** ・ Vegetation loss for land clearing should be minimal and in limited areas of the ROW. ・ To identify impacts on aquatic life and consider the mitigations, the supervision consultant should staff specialists on fauna or ecosystem as necessary. **Operation Phase:** ・ Relevant agencies should monitor the environmental conditions along the target section in the buffer zone or transition zone. ・ If troubles of some sort occur, the agencies should consider the countermeasures.
Ecosystem	**Construction Phase:** ・ Vegetation in roadside including trees will be lost by widening works. However, tree clearing of community or flooded forest will not be required. ・ Agricultural ecosystem will be lost or disturbed by construction works. ・ Turbid water caused by bridge construction is likely to affect aquatic life. ・ Ecosystem in wetland around Ou Prong River crossing point may be	**Construction Phase:** ・ Vegetation loss for land clearing should be minimal and in limited areas of the ROW. ・ The contractor and supervision consultant shall prepare and strictly implement vegetative restoration plans such as tree planting and sowing on road side. ・ The supervision consultant shall consider impacts of alien species in the vegetative restoration plans. ・ The contractor and supervision consultant shall prepare and strictly implement proper construction plans to minimize disturbance in existing agricultural cannels and reservoirs.

Item	Impact	Mitigation
	disturbed by the construction activity. **Operation Phase:** ・ Because the target road mostly passes through well developed area such as agricultural land and urban area, impact on biodiversity is unlikely to occur. ・ Because the distance between the target road and Tonle Sap lakeside is approximately 4 km at the nearest point, direct impact on ecosystem in Tonle Sap Lake is unlikely to occur. ・ If the embankment sections choke off or change existing surface water flow, impact on remote aquatic ecosystem may occur.	・ The supervision consultant shall monitor water quality including turbidity. ・ Construction works in and around rivers, streams, reservoirs or channels shall be concentrated in dry period. ・ To reduce turbid water, steel sheet pile construction method should be selected in bridge construction works as necessary. ・ To identify impacts on aquatic life and consider the mitigations, the supervision consultant should staff specialists on fauna or ecosystem as necessary. ・ The contractor should consider installation of cofferdam as necessary. **Operation Phase:** ・ To maintain existing surface flow condition, locations of existing bridges and culverts should not be changed. ・ The proper countermeasures to maintain existing surface flow condition in embankment sections should be included in the design such as sufficient cross-section area of flow and culverts with sufficient flow capacity.
Hydrology	**Construction Phase:** ・ Water flow in the rivers or streams may be altered during construction works. But the impact will be temporary and in limited area. **Operation Phase:** ・ Because some project sites are located in flood plain, impact caused by newly constructed embankment on surface water flow may occur.	**Construction Phase:** ・ The contractor and supervision consultant shall prepare and strictly implement proper construction plans to minimize disturbance in rivers and existing agricultural cannels. **Operation Phase:** ・ To maintain existing surface flow condition, locations of existing bridges and culverts should not be changed. ・ The proper countermeasures to maintain existing surface flow condition in embankment sections should be included in the design such as sufficient cross-section area of flow and culverts with sufficient flow capacity.
Geographical features	**Construction Phase:** ・ Topography will be changed in bypass or embankment sections on a small scale. ・ Topography will be changed in borrow pit and quarry site. **Operation Phase:** ・ Impact on geographical features is unlikely to occur.	**Construction Phase:** ・ The contractor and supervision consultant shall take into account the environmental impacts such as soil erosion and mudslide in selection of borrow pit and quarry site. ・ The contractor shall prepare and strictly implement an environmental management plan including adequate drainage to avoid accumulation of stagnant water and vegetation recovery plan in borrow pit or quarry site. ・ In case of purchase from quarry firm, a task on the environmental management should be included in the contract. **Operation Phase:** -

Item	Impact	Mitigation
Social Environment		
Poor people	**Pre-Construction Phase / Construction Phase / Operation Phase:** ・ Some of the poor people who do not have their own land living within Right of Way or Provisional Road Width will be affected by resettlement and lose their business opportunity.	**Pre-Construction Phase / Construction Phase / Operation Phase:** ・ Authorities concerned shall prepare and strictly implement a proper RAP and LAP including fair compensating methods.
Local economies, such as employment, livelihood, etc.	**Pre-Construction Phase:** ・ Land acquisition and resettlement may cause livelihood degradation of Project Affected Persons (PAPs). ・ Road widening will require acquisition of agricultural lands as agricultural resources. However, the required land will be very small to the total agricultural land. **Construction Phase:** ・ Construction will create job opportunities to local people. ・ Bridge construction works may have impacts on local fishery. **Operation Phase:** ・ Reduction of travel time will contribute to local economies and promote tourism. ・ Change of access to local resources may widen gap in local economy. ・ If the embankment sections choke off or change existing surface water flow, impact on local fishery may occur.	**Pre-Construction Phase:** ・ Authorities concerned shall prepare and strictly implement a proper RAP and LAP including fair compensating methods. ・ Proper compensations including recovery fee for roadside agricultural lands should be provided to the land owners or users. **Construction Phase:** ・ The contractor shall prepare and strictly implement a fair hiring plan of local people as construction worker. ・ The contractor should give priority to the PAPs in hiring local people. ・ The contractor and supervision consultant shall provide prior notification to the local community and fisherpersons on the schedule of construction activities and restricted areas, especially in bridge construction works. ・ The contractor and supervision consultant should periodically hold sufficient local stakeholder meetings in the pre-construction stage and during construction works, and establish mutual understanding with the PAPs as necessary. **Operation Phase:** ・ The local government should monitor local economy and livelihood. ・ If troubles of some sort occur, the local government should consider the countermeasures.
Land use and utilization of local resources	**Construction Phase:** ・ Bypass sections will require change of land use, mainly from agricultural land to ROW. **Operation Phase:** ・ Especially in bypass sections, land use along NR 5 will be changed and be developed economically and socially. ・ Improved transportation will contribute to effective utilization of local resources.	**Construction Phase:** ・ The contractor and supervision consultant shall provide prior notification to the local community on the schedule of construction activities. ・ The contractor and supervision consultant should periodically hold sufficient local stakeholder meetings in the pre-construction stage and during construction works, and establish mutual understanding with the PAPs as necessary. **Operation Phase:** ・ The local government should monitor local economy and land use. ・ If troubles of some sort occur, the local government should consider the countermeasures.

Item	Impact	Mitigation
Water usage	**Construction Phase:** ・ Existing agricultural cannels located in roadside will be affected by widening works. ・ Existing wells within the ROW of bypass sections will be lost. **Operation Phase:** ・ Newly constructed embankment or culverts may change surface water flow.	**Construction Phase:** ・ The contractor and supervision consultant shall provide prior notification to users of agricultural cannels on the schedule of construction activities. ・ The contractor and supervision consultant should periodically hold sufficient local stakeholder meetings in the pre-construction stage and during construction works, and establish mutual understanding with the PAPs as necessary. ・ The proper countermeasures to reduce impact on present water usage should be included in the construction plan. ・ Water supply systems or additional wells should be provided to owners and users of the lost wells. **Operation Phase:** ・ The proper countermeasures to reduce impact on present water usage should be included in the road design. ・ Relevant agencies should monitor water usage and flow. ・ If troubles of some sort occur, the agencies should consider the countermeasures.
Existing social infrastructures and services	**Pre-Construction Phase:** ・ Relocation or protection of existing utilities, such as electric poll, water pipe and optical fiber cable will be required. **Construction Phase:** ・ Temporary traffic congestion in construction site including NR 5 and other rural roads will occur. **Operation Phase:** ・ Access to social services will be improved. ・ Road crossing of pedestrians and livestock will become harder due to widening. ・ Spilt of local communities or widening disparity may occur in bypass section.	**Pre-Construction Phase:** ・ Detailed survey on existing utilities should be conducted in the planning stage. ・ The contractor and supervision consultant should periodically hold sufficient meetings with the utility owners in every stage and establish mutual understanding. ・ Proper relocation plans should be prepared and strictly implemented in advance of contraction works. **Construction Phase:** ・ The contractor and supervision consultant shall provide prior notification to local people and drivers on the schedule of construction activities, and location, time and type of traffic restriction. ・ The contractor shall prepare and strictly implement a traffic management plan around construction site. **Operation Phase:** ・ The proper countermeasures to support road crossing of pedestrians and livestock, such as crosswalk or road traffic sign to inform livestock crossing should be considered on the basis of site survey in the detail design stage. ・ The supervision consultant should review the countermeasures to support road crossing of pedestrians and livestock in the construction phase. ・ Relevant agencies should monitor the utility and local communities.

Item	Impact	Mitigation
		・ If troubles of some sort occur, the agencies should consider the countermeasures.
Misdistribution of benefits and damages	**Pre-Construction Phase / Construction Phase:** ・ Considerable misdistribution of benefit is unlikely to occur. ・ In case of unfair hiring of construction worker, misdistribution of benefit may occur. **Operation Phase:** ・ After the traffic flow is changed to new bypass, some shops along existing NR 5 (old route) will lose their business opportunity, while shops set up along bypass will make profit.	**Pre-Construction Phase / Construction Phase:** ・ The contractor shall prepare and strictly implement a fair hiring plan of local people as construction worker. **Operation Phase:** ・ The local government and supervision consultant shall provide prior notification to the shop owners on schedule of the bypass project in early stage.
Cultural heritage	**Pre-Construction Phase / Construction Phase:** ・ Proposed Odongk bypass will have minor impacts on Longveaek remains. **Operation Phase:** ・ Road improvement will promote tourism and worship to religious heritage. Religious value may be spoiled by tourism development.	**Pre-Construction Phase / Construction Phase:** ・ Authorities concerned shall conduct a proper archeological survey and preserve the record in advance of construction works. ・ Archeological fragments found during construction works should be stored in proper facilities. **Operation Phase:** ・ Relevant agencies should monitor the cultural heritage. ・ If troubles of some sort occur, the agencies should consider the countermeasures.
Landscape	**Construction Phase:** ・ Vegetation at existing roadside including high trees will be lost by widening works, and cause change of landscape. **Operation Phase:** ・ Because there are no protected scenic view areas in and around the target section and roadside vegetation will be recovered for a short period due to the warm and rainy climate, considerable impact on landscape is unlikely to occur.	**Construction Phase:** ・ Vegetation loss for land clearing should be minimal. ・ The contractor and supervision consultant shall prepare and strictly implement vegetative restoration plans such as tree planting and sowing on road side. **Operation Phase:** -
Children's rights	**Construction Phase:** ・ Considerable impact only on children's rights is unlikely to occur. **Operation Phase:** ・ Road improvement may cause traffic accident of children due to more traffic volume and faster vehicle speed. ・ Traffic venerable people including children can be separated safely from main vehicle lane.	**Construction Phase:** - **Operation Phase:** ・ A relevant agency shall monitor and control vehicle speed to reduce traffic accident. ・ Local educational institutes should conduct traffic safety training to children.

Item	Impact	Mitigation
Infectious diseases such as HIV/AIDS	**Construction Phase:** ・ Infection risks of HIV/AIDS may be increased among construction workers and local business offering food and entertainment. **Operation Phase:** ・ Considerable impact on infectious diseases is unlikely to occur.	**Construction Phase:** ・ The contractor shall prepare and strictly implement educational program on infection risks for construction workers. ・ The educational program should be included in the construction contract. **Operation Phase:** -
Working conditions (including occupational safety)	**Construction Phase:** ・ Dust and emission gas caused by construction works may affect workers health. ・ Sanitary conditions around construction site may get worse due to waste from workers and toilet. **Operation Phase:** ・ Considerable impact on working conditions is unlikely to occur.	**Construction Phase:** ・ The contractor shall prepare and strictly implement dust control measures such as periodical water spray. ・ The contractors shall maintain their construction equipments in adequate working conditions. ・ The contractors shall provide temporary sanitation facilities such as portable toilets and garbage bins to ensure that the domestic wastes to be generated by the construction personals. ・ The solid waste should be separated into hazardous, non-hazardous and reusable waste streams and store temporary on site. ・ The supervision consultant shall monitor the waste disposal. **Operation Phase:** -
Accidents	**Construction Phase:** ・ Traffic accident may occur surrounding of construction site **Operation Phase:** ・ Traffic safety including pedestrians will be improved by road widening and vehicle separation ・ Traffic accident due to more traffic volume and faster vehicle speed may increase ratio of traffic accident.	**Construction Phase:** ・ The contractor shall prepare and strictly implement a traffic management plan around construction site. **Operation Phase:** ・ The proper countermeasures to reduce traffic accident should be included in the road design. ・ A relevant agency shall monitor and control vehicle speed to reduce traffic accident. ・ The local government should conduct traffic safety campaigns.

(3) No or Unknown Impact Items

Table 16.6-6 Impacts and Mitigation Measures (No or Unknown Impact Items)

Item	Impact	Mitigation
Environmental Pollution		
Soil pollution	**Construction Phase:** ・ Soil pollution caused by construction works will not occur normally. ・ Because the target road mostly passes through agricultural land, accidental massive leaking of bitumen, fuel and oil may cause agricultural soil pollution. **Operation Phase:** ・ Impact on soil quality is unlikely to occur.	**Construction Phase:** ・ Because the surplus soil containing contaminated materials may cause negative impact on drainage condition in agricultural land, the proper disposal site should be selected. ・ Bitumen, diesel and waste oil shall be handled and stored carefully to prevent leakage or spill. Waste oil shall be collected, stored in drums and disposed at a site approved by the local relevant authority ・ Waste oil storage shall be in drums, raised off

Item	Impact	Mitigation
		the ground, covered to keep rain out and surrounded by a bund to contain any spills and simplify clean up. **Operation Phase:** -
Ground subsidence	**Construction Phase:** ・ Subsidence near the road due to added soil weight may occur. ・ Because there are soft ground areas along the proposed bypass, subsidence near the road due to the soil weight filled on the rice field may occur. **Operation Phase:** Because the expected load on road will not be too heavy, impact on ground subsidence is unlikely to occur.	**Construction Phase:** ・ Detailed soil investigations should be conducted at subsidence-prone locations in the planning stage. ・ In the detailed design stage, the detailed geological surveys should be conducted. ・ The proper structure design and construction technique should be considered on the basis of the survey results. ・ The supervision consultant and contractor should monitor the ground subsidence. ・ If the ground subsidence occurs, the consultant and contractors should reconsider the construction technique. **Operation Phase:** -
Offensive odors	**Construction Phase:** ・ Because construction equipment causing offensive odors will not be used in the construction works, impact of offensive odors on the local people and workers is unlikely to occur. **Operation Phase:** ・ Because vehicles with incomplete combustion are few, impact of offensive odors on the local people is unlikely to occur.	**Construction Phase:** - **Operation Phase:** -
Bottom sediment	**Construction Phase:** ・ Filled soil may be eroded by heavy rain and flow into rivers or streams, and be accumulated at the bottom of rivers or streams. However, the impact is likely to be small and in only limited areas. **Operation Phase:** ・ Because the whole target section is very flat, filling sections are unlikely to collapse and cause debris and sedimentation on riverbed. ・ Erosion in borrow pit or quarry site by rainfall is likely to be small, short and in only limited areas.	**Construction Phase:** - **Operation Phase:** -
Social Environment		
Ethnic minorities and indigenous peoples	**Pre-Construction Phase / Construction Phase:** ・ Road widening may cause resettlement or other impacts on Ethnic Cham and Vietnamese living along NR 5.	**Pre-Construction Phase / Construction Phase:** ・ Authorities concerned shall prepare and strictly implement a proper RAP and LAP including fair compensating methods.

Item	Impact	Mitigation
	Operation Phase: ・ Impact on ethnic minorities is unlikely to occur.	**Operation Phase:** -
Social institutions such as social infrastructure and local decision-making institutions	**Construction Phase / Operation Phase:** ・ Because of improvement project of existing road, considerable impact on social institutions is unlikely to occur. ・ Spilt of local communities or widening disparity may occur in bypass section.	**Construction Phase / Operation Phase:** ・ The local government should monitor community relationship around the road. ・ If troubles of some sort occur, the local government should consider the countermeasures.
Gender	**Construction Phase / Operation Phase:** ・ Impact on street venders, especially women, may occur.	**Construction Phase / Operation Phase:** ・ The contractor and supervision consultant should hold sufficient meetings with local people including street venders in the pre-construction stage and during construction works, and establish mutual understanding with the PAPs as necessary.
Other		
Trans-boundary impacts or climate change	**Construction Phase:** ・ Trans-boundary impacts will not occur. ・ Operation of construction equipment will generate CO_2. However, the amount of CO_2 emission will be an extremely few level to climate change. **Operation Phase:** ・ In the future, total amount of CO_2 emission from vehicles will increase. In 2016, the total CO_2 emission volumes will increase approximately 50% from the volumes in 2012. ・ On the other hand, because of improved traffic efficiency, the amount may be reduced compared to without project.	**Construction Phase:** ・ The contractor actively uses electrically-powered equipment. ・ The contractors shall maintain their construction equipments in adequate working conditions. **Operation Phase:** ・ MPWT should conduct educational campaigns to reduce CO_2 emission from transportation sector. ・ Relevant agencies should estimate total amount of CO_2 emission from transportation sector.

16.7 Environmental Management Plan

16.7.1 Introduction

The Environmental Management Plan (EMP) provides institutional arrangement, environmental monitoring plan during construction and operation, and training and staffing. The EMP objectives are to show the tasks which will be implemented by relevant governmental institutions at local, provincial and national levels and to suggest parameters need to be monitored in the project phases. It should be noted that the EMP is considered as an operational document that will be frequently updated by the project owner/ the MPWT with assistance/advice from a supervision consultant to reflect on-site project activities.

16.7.2 Institutional Arrangement

Implementation of the EMP will be carried out by the project owner, the MPWT, in cooperation with governmental institutions at national, provincial and local levels.

At the national level, the MPWT will cooperate with Department of EIA and Department of Pollution Control of the MOE, Department of Hydrology and River Works of Ministry of Water Resources and Meteorology, the Ministry of Land Management, Urban Planning and Construction and Inter-Ministerial Resettlement Committee of the Ministry of Economic and Finance.

At the provincial level the MPWT will closely work with its departments, Provincial Department of Environment, Provincial Department of Water Resources and Meteorology, Provincial Department of Land Management Urbanized Planning and Construction, related governmental departments and local authorities in all the relevant provinces.

At local level, the MPWT will work with local authorities for the facilitation, controlling, and solving of any social conflicts that may happen in the project area.

16.7.3 Environmental Monitoring Plan

Environmental monitoring plan (EMoP) is one of the vital processes of the EMP. It is included items to be monitored by project phase, location, frequency, and responsible unit. The EMoP can help to adjust potential problems that might result from the project activities and allow prompt implementation of effectively corrective measures. It aims at assessing environmental conditions, monitoring the effective implementation of mitigation measures, and warning significant deteriorations in environmental quality for further prevention action. The monitoring results will be a practical document for the MPWT to maintain compliance with environmental laws and regulations, work safety, and appropriate implementation of the mitigation measures.

Implementation of the EMoP will cover the construction and operation phases of the project. This summarizes what important parameters will be monitored and how frequent will be for measurements. Table 16.7-1 shows suggested EMoP need to be monitored.

Table 16.7-1 Monitoring Form (Draft)

Construction Stage :

Item	Location	Parameter / Means of Monitoring		Result (Average / Max / Total, etc.)	Standard (Legal / International Standard)	Frequency	Remarks
Air quality	Construction site	Visual inspection of mechanical condition and exhaust gas				Every day before working	
	Construction site	Visual observation of dust				Every day	
	Storage facilities for dust generating materials						
	Boundary of ROW nearest to construction site	SPM10			0.05 mg/m^3 (WHO, average 24h)	2 times in dry season and 2 times in rainy season	
		SPM2.5			0.02 mg/m^3 (WHO, average 24h)		
		SO_2			0.30 mg/m^3 (MOE, average 24h)		
		NO_2			0.10 mg/m^3 (MOE, average 24h)		
Water Quality	Rivers including Ou Prong River, streams, reservoirs and other public water bodies where construction works are executed.	Visual observation				Every day	
		pH			6.5-8.5 (MOE)	When any pollution is suspected	
		TSS			25-100 (mg/l) (MOE)		
		BOD			1-10 (mg/l) (MOE)		
		COD			1-8 (mg/l) (MOE)		
		Other items (as required)					
Noise	Boundary of land plot nearest to the construction site	Noise Level			60 dB (06:00-18:00) 50 dB (18:00-22:00) 45 dB(22:00-06:00) (MOE, residential area)	- When noise/vibration level exceeding the Cambodian standards is suspected - When local residents complain	
Vibration		Vibration Level			65 Hz (05:00-17:00) 60 Hz (17:00-05:00) (Lab. MOE)		
General waste	Waste storage at construction site	Slurry and other construction waste	Discharged amount			Every day	
			Recycled amount				
			The way of recycle				
			Treated amount				
			Location of final disposal site				
		General waste	Discharged amount				
			Recycled amount				
			The way of recycle				
			Treated amount				
			Location of final disposal site				

Item	Location	Parameter / Means of Monitoring		Result (Average / Max / Total, etc.)	Standard (Legal / International Standard)	Frequency	Remarks
Subsidence	Subsidence-prone locations along the Project road	Visual inspection and interview to the local people				1 time/week to 1 time/month depending on situation	
Hydrology	Rivers, streams and reservoirs where construction works are executed	Visual inspection on volume and speed of water flow				Every day	
Ecosystem	Along NR-5	- Visual observation of animals and plants - Interview with relevant agencies including environmental NGOs				Every half year (1 time in dry season and 1 time in rainy season)	
	Odongk bypass						
	Kampong Chhnang bypass						

Service Stage :

Item	Location		Parameter / Means of Monitoring	Result (Average / Max / Total, etc.)	Standard	Frequency	Remarks
Air quality	BTB-KP 300	Road side	SPM10		0.05 mg/m^3 (WHO, average 24h)	2 times in dry season and 2 times in rainy season	
		200 m away from road side					
	BTB Bypass intersection with NR-57	Road side					
		200 m away from road side					
	BMCH-KP 356	Road side					
		200 m away from road side					
	BTB-KP 300	Road side	SPM2.5		0.02 mg/m^3 (WHO, average 24h)		
		200 m away from road side					
	BTB Bypass intersection with NR-57	Road side					
		200 m away from road side					
	BMCH-KP 356	Road side					
		200 m away from road side					
	BTB-KP 300	Road side	SO_2		0.30 mg/m^3 (MOE, average 24h)		
		200 m away from road side					
	BTB Bypass intersection with NR-57	Road side					
		200 m away from road side					
	BMCH-KP 356	Road side					
		200 m away from road side					

Item	Location		Parameter / Means of Monitoring	Result (Average / Max / Total, etc.)	Standard	Frequency	Remarks
	BTB-KP 300	Road side	NO_2		0.10 mg/m^3 (MOE, average 24h)		
		200 m away from road side					
	BTB Bypass intersection with NR-57	road side					
		200 m away from road side					
	BMCH-KP 356	Road side					
		200 m away from road side					
Noise	BTB KP 300, ROW boundary		Noise Level		60 dB (06:00-18:00) 50 dB (18:00-22:00) 45 dB(22:00-06:00) (MOE, residential area)		
	BTB Bypass intersection with NR-57, ROW boundary						
	BMCH-KP 356, ROW boundary						
Vibration	BTB KP 300, ROW boundary		Vibration Level		65 Hz (05:00-17:00) 60 Hz (17:00-05:00) (Lab. MOE)		
	BTB Bypass intersection with NR-57, ROW boundary						
	BMCH-KP 356, ROW boundary						
General waste	Along the road and public gathering		Discharged amount			Surveyed 1 time per year based on the data of institution for garbage collection.	
			Recycled amount				
			The way of recycle				
			Treated amount				
			Location of final disposal site				
Subsidence	Building and other structure in BTB Province		Rising up of building is visually inspected			2 times in dry season and 2 times in rainy season	
	Building and other structure in BMCH Province						
Ecosystem	Along NR-5		- Visual observation of animals and plants - Interview with relevant agencies including environmental NGOs			Every half year (1 time in dry season and 1 time in rainy season)	
	Odongk bypass						
	Kampong Chhnang bypass						

WHO: World Health Organization, MOE: Ministry of Environment (Cambodia)

***Remarks; Past trend and current status including remedial measures if necessary*

Table 16.7-2 Suggested Monitoring Item and Responsible Agency

Items	Implementation Agency	Supervision Agency
Construction Phase		
Air quality	Supervision Consultant and Construction Contractor (Analysis: Department of Pollution Control of the MOE : DPC)	MPWT
Water Quality	Supervision Consultant and Construction Contractor (Analysis: DPC)	MPWT
Noise	Supervision Consultant and Construction Contractor (Analysis: DPC)	MPWT
Vibration	Supervision Consultant and Construction Contractor (Analysis: DPC)	MPWT
General waste	Construction Contractor	Supervision Consultant
Subsidence	Construction Contractor	Supervision Consultant
Hydrology	Supervision Consultant and Construction Contractor (Analysis: DPC)	MPWT
Ecosystem	Supervision Consultant and Construction Contractor (Analysis: DPC)	MPWT and MOE
Service Stage		
Air quality	MPWT and Provincial authority (Analysis: DPC)	MOE
Noise	MPWT and Provincial authority (Analysis: DPC)	MOE
Vibration	MPWT and Provincial authority (Analysis: DPC)	MOE
General waste	Provincial authority	MPWT
Subsidence	Provincial authority	MPWT
Ecosystem	Provincial authority	MPWT, MOE and Cambodia National Mekong Committee

Note: DPC = Department of Pollution Control of the MOE

16.7.4 Training and Staffing

(1) Participants

In order to assist the project construction phase smoothly, trainings will be provided for few engineers from the MPWT and the MOE due to their limitations in site monitoring and management and environmental knowledge. List of the proposed trainees is shown as in Table 16.7-2. Training contents will be developed by highly-qualified trainers. The trainings should be commenced before or at early of the construction phase.

Table 16.7-3 List of the Proposed Trainees

No	Institution	Number of trainees	Engineers Involved
1	The MPWT	4	Engineers for site monitoring and management
2	The MOE	2	Environmental technicians/engineers

(2) Training Budget

The training budget is responsible by the MPWT. Each training session will provide 2 days in class and 2 days for field practice. The trainees for site monitoring and management will work closely with the construction engineers to learn day to day on site monitoring and management. The trainees or environmental technicians/engineers can assist the construction engineers to do daily environmental monitoring and evaluation the contractor performance in compliance with the EMP in the EIA report and other environmental safeguards stated in the construction contract. The detailed cost estimate for the trainings is shown in Table 16.6-3.

16.7.5 Organization for EMP

The proposed draft organization chart of the EMP in the construction phase is shown in Figure 16.7-1.

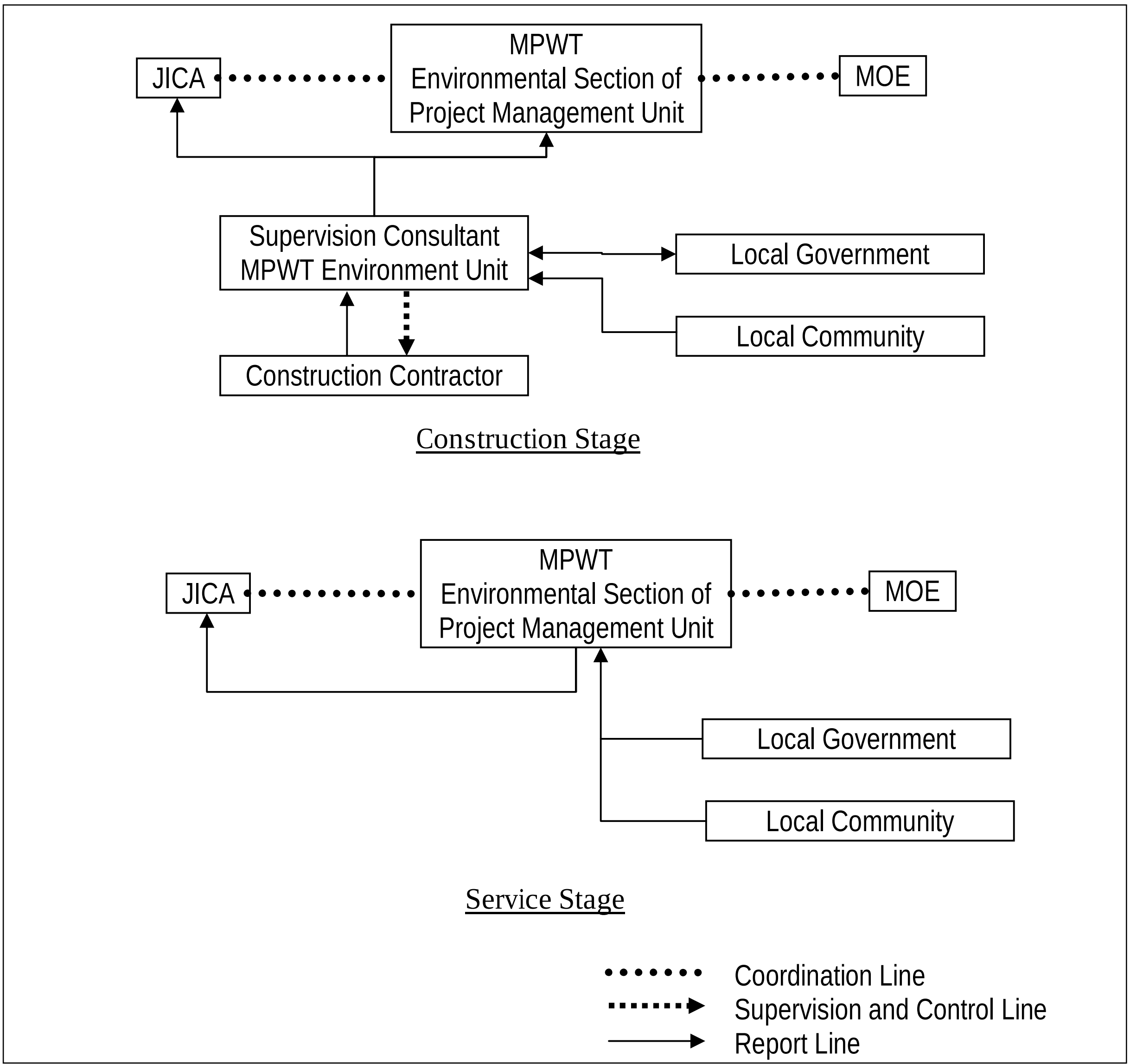


Figure 16.7-1 Proposed Organization for EMP

16.7.6 Cost Estimation of EMP

The cost estimation for EMP such as environmental monitoring cost and training coast is shown in Table 16.7-3.

Table 16.7-4 Cost Estimation for EMP

No	Description	Unit	Quantity	Unit Rate	Total Cost Estimate in US$
I. Environmental Monitoring					
1	Air quality (Constriction Stage)	Sample	4	1,400	5,600
2	Air quality (Service Stage)	Sample	12	1,400	16,800
3	Water Quality (Constriction Stage)	Sample	4	700	2,800
4	Potable pH Meter	LS	1	100	100
5	Potable Turbidity Meter	LS	1	1,900	1,900
6	Noise and Vibration (Constriction Stage)	Sample	4	800	3,200
7	Noise and Vibration (Service Stage)	Sample	12	800	9,600
				Sub-Total	40,000
II. Training Fee					
1	Training course on environmental management and field practice	Course	1	1,500	1,500
2	Training course on site monitoring and field practice	Course	1	1,500	1,500
3	Training course on general site management	Course	1	1,500	1,500
4	Transportation for the field practices	Time	3	400	1,200
5	Training materials and snacks for all the courses	Lump Sum	1	450	450
				Sub-Total	6,150
III. Training Allowance					
-	-	-	-	Daily Stipend Allowance (US$)	-
1	Engineers from the MPWT	Man-Day	4	100 x 4 Days	1,600
2	Engineers from the MOE	Man-Day	2	100 x 4 Days	800
				Sub-Total	2,400
				Grand Total	**48,550**

Note: Daily stipend allowance included food, accommodation and transportation.
Venue fee is included for the training courses.