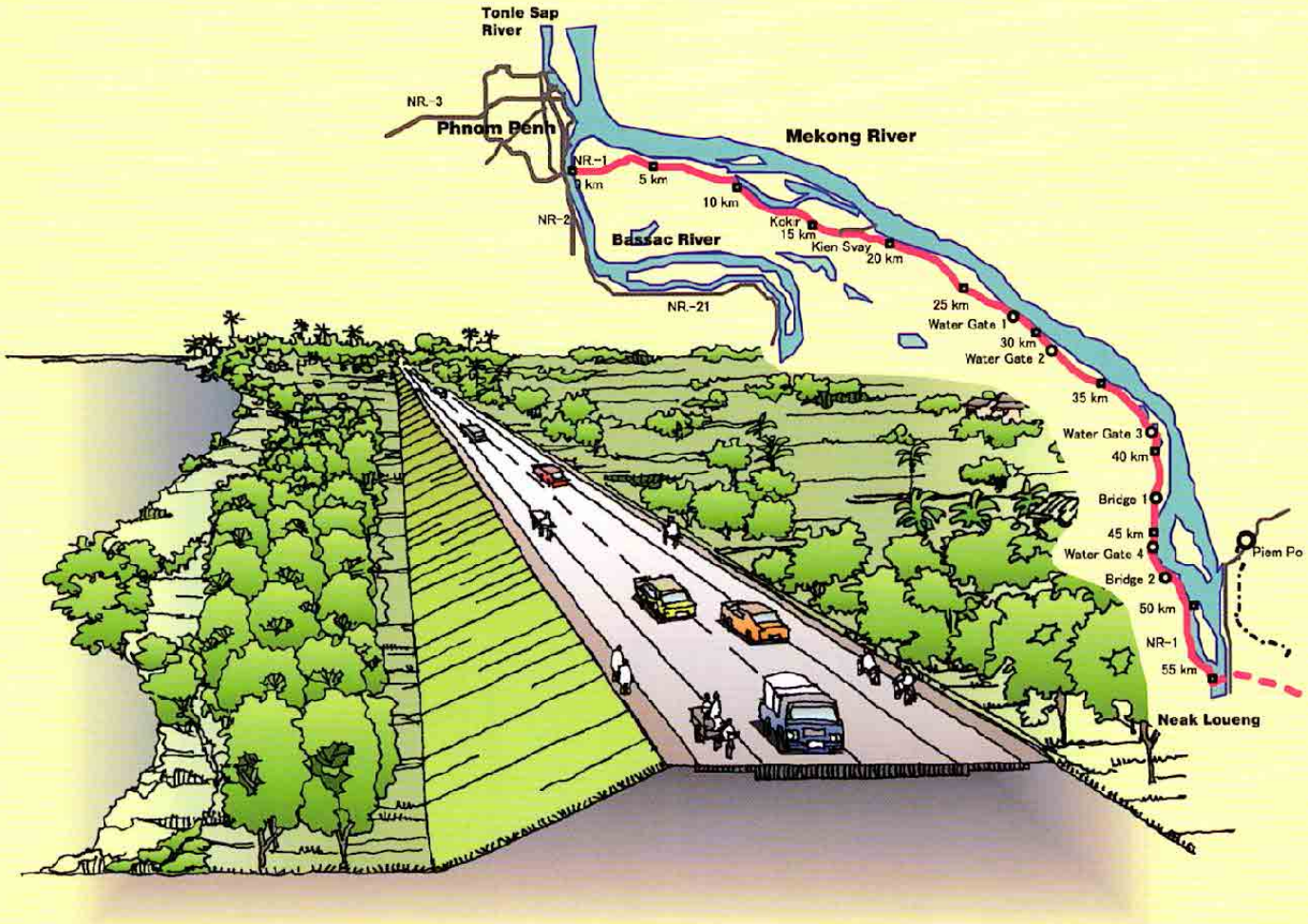
No.

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

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

THE FEASIBILITY STUDY ON
THE IMPROVEMENT OF NATIONAL ROAD No.1
(PHNOM PENH - NEAK LOUENG SECTION)
IN THE KINGDOM OF CAMBODIA

FINAL REPORT



SUMMARY

March 2003

PACIFIC CONSULTANTS INTERNATIONAL
KATAHIRA & ENGINEERS INTERNATIONAL

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The following foreign exchange rate was applied in the study:

US$ 1.0 = JP¥ 120 = Reil 3,990 (as of October 2002)

PREFACE

In response to the request from the Royal Government of the Kingdom of Cambodia, the Government of Japan decided to conduct the feasibility study on Improvement of National Road No.1 (Phnom Penh ~ Neak Loueng Section) in the Kingdom of Cambodia and entrusted the study to Japan International Cooperation Agency (JICA).

JICA dispatched a study team headed by Mr. Kenji Maruoka of Pacific Consultants International and consisting of Pacific Consultants International and Katahira & Engineers International to the Kingdom of Cambodia, three times between May 2002 and January 2003. In addition, JICA set up an Advisory Committee headed by Mr. Yukitoshi Fujishima of Japan Highway Public Corporation between May 2002 and January 2003, which examined the Study from specialist and technical point of view.

The team held discussions with the officials concerned of the Royal Government of the Kingdom of Cambodia and conducted field surveys at the study area. Upon returning to Japan, the team conducted further studies and prepared this final report.

I hope that this report will contribute to the promotion of this project and to the enhancement of friendly relationship between our two countries.

Finally, I wish to express my sincere appreciation to the officials concerned of the Royal Government of the Kingdom of Cambodia for their close cooperation extended to the team.

March 2003

Takao Kawakami
President
Japan International Cooperation Agency

March 2003

Mr. Takao Kawakami
President
Japan International Cooperation Agency

Letter of Transmittal

Dear Sir,

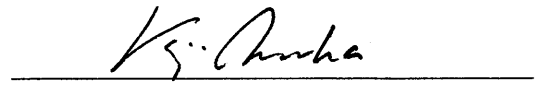
We are pleased to submit herewith the Final Report of "The Feasibility Study on Improvement of National Road No.1 (Phnom Penh ~ Neak Loueng Section) in the Kingdom of Cambodia".

The report contains the results of the study, which has been carried out by Pacific Consultants International in association with Katahira & Engineers International between April 2002 and March 2003. The report consists of four volumes, Summary, Main Report, Appendix, and Drawings.

The Summary briefly illustrates the findings in the study. The Main Report consists of 17 chapters and presents traffic demand forecast, engineering designs, road operation and maintenance plan, environmental conditions, project implementation plan, economic and financial analysis and conclusion and recommendations for the project implementation. It recommends that the institutional arrangements for project implementation should be organized as soon as possible.

We wish to express our greatest appreciation to officials of the Ministry of Public Works and Transport and the Royal Government of the Kingdom of Cambodia for their assistance extended to the Study Team, and also to the personnel of your Agency, the JICA Advisory Committee, the Ministry of Foreign Affairs, the Ministry of Land, Infrastructure and Transport, and the Embassy of Japan in the Kingdom of Cambodia. The Study Team sincerely hopes that the results of the Study will contribute to the improvement of road in Cambodia.

Yours faithfully,



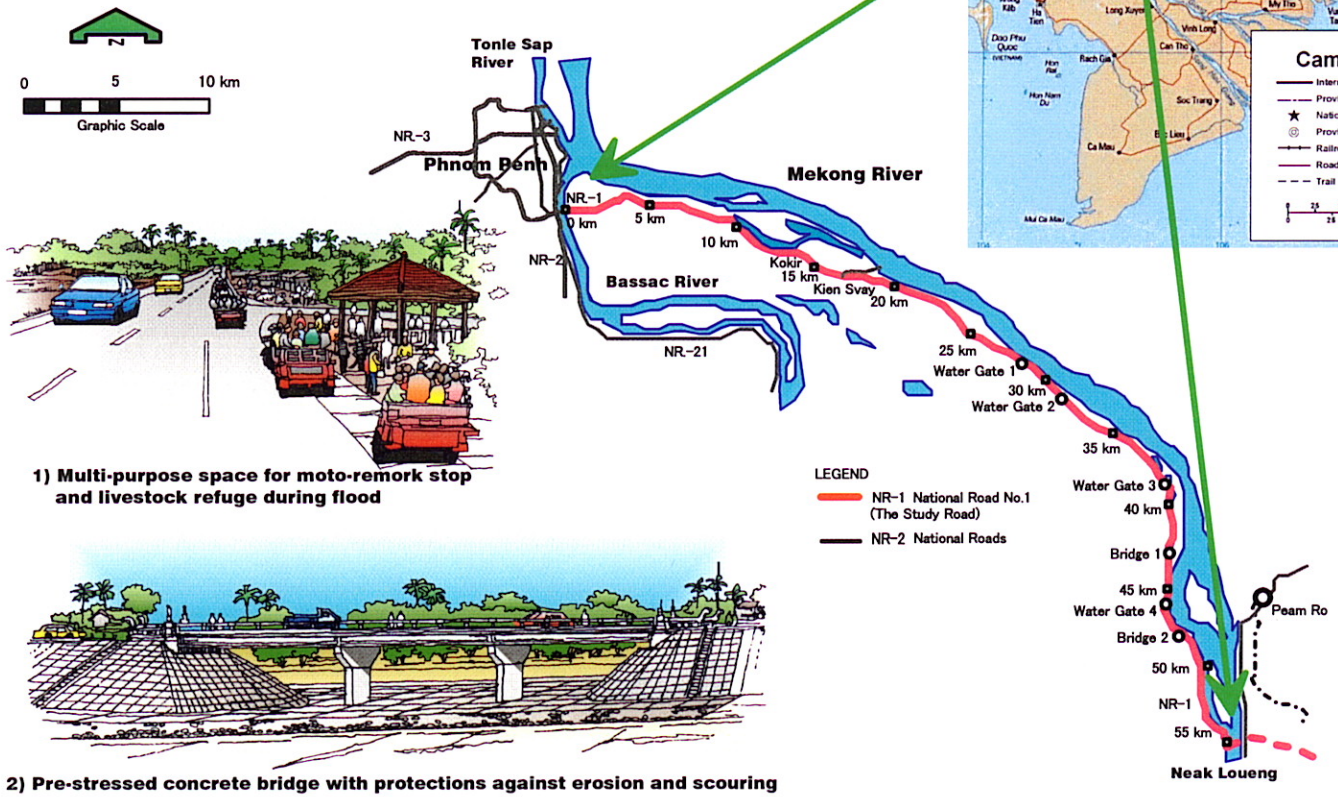
Kenji Maruoka
Team Leader
The Feasibility Study
on Improvement of National Road No.1
(Phnom Penh ~ Neak Loueng Section)
in the Kingdom of Cambodia

THE FEASIBILITY STUDY ON THE IMPROVEMENT OF

NATIONAL ROAD No.1

(PHNOM PENH - NEAK LOUENG SECTION)

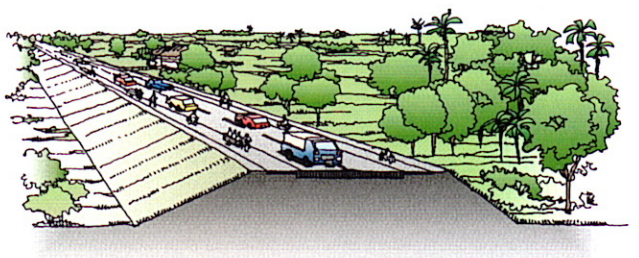
IN THE KINGDOM OF CAMBODIA



1) Multi-purpose space for moto-remork stop and livestock refuge during flood

2) Pre-stressed concrete bridge with protections against erosion and scouring

3) Road improvement in urban area considering traffic safety and future widening



4) Road improvement in rural area considering space for slow-moving vehicles

Deteriorated Pavement Condition

Deteriorated Old Colmatage Water Gate

Temporary Bridge at Cut-off Section

PROJECT AT A GRANCE

By improving a flood-free road to an all-weather standard;

1. **ensure road transport through a year**
2. **secure traffic safety and conserving environment**
3. **stimulate economic and social development**
4. **strengthen linkages between producing and consuming centers**
5. **encourage transition to market economy and poverty alleviation**

Photographs of Study Area (1/3)

Km 0+000: Origin point at Monivong Bridge South side

Bridge length: 270 meters, Width: Carriage-way 11 meters
Bridge type: Pre-stressed concrete box girder
Bridge is expected to be stabilized for heavy load.
Erosion at some locations of protection and approach road
Commercial Area at South side of bridge

Km 1+000: Commercial area at both side,
Traffic congestion due to lack of slow-vehicle lane
Pavement width 7 meters
Shoulder width: 2.0 to 3.5 meters with earth surface

Km 18+000: Road conditions of local area
Critical damage/destruction of road structure

Heavy Vehicles : Ratio of heavy vehicle (PCU) 13.9%,
(NR-1, C-1) over 25-ton truck 19.1%

Km 28+450: Newly constructed colmatage water gate
(Constructed by Japan Grant Aid, 2001)
Carriage-way: 13.5 meters on culvert

Photographs of Study Area (2/3)

Km 40+000: Road Conditions of local area
Critical damage: pothole/ broken road surface
Bumpy road condition
Pavement width 6 meters, shoulder width 2+2 meters

Km 42+850: Temporary steel bailey bridge

Cut off in year 2000 flood,
Bridge length 99 meters, width 4 meters,
limited live load 16 ton
ongoing improvement of piers and river-bed

Km 50+015: Old water gate,
constructed in Pol Pot Regime, 1976

Carriage-way width 5.8 meters
Defects and damages on concrete structure
Broken surface and concrete slab,
Steel plates are placed on road surface

Km 55+300: Terminal Plaza at Neak Loueng Ferry Port
and view on the Ferry

Photographs of Study Area (3/3)

Traffic accident of truck and motorbike
caused by not following traffic rules
(Km 18+000)

Traffic congestion with Moto-remork at commercial area
(Km 2+000)

National Road No.11 related Road to NR1
Critical erosion/ damage of existing paved road
Over flood on road in several past time

Colmatage water gate along the Bassac River
West to NR-1

Map of Study Area

ABBREVIATIONS

Authorities and Agencies

AASHTO	:	American Association of State Highway and Transportation Officials
ADB	:	Asian Development Bank
ASEAN	:	Association of South East Asian Nations
DPWT	:	Department of Public Works and Transport
FRMR	:	Fund for Repair and Maintaining of Road
JICA	:	Japan International Cooperation Agency
JRO	:	Japan Road Association
MEF	:	Minstry of Economy and Finance
MOE	:	Ministry of Environment
MoWRAM	:	Ministry of Water Resources and Meteorology
MPWT	:	Ministry of Public Works and Transport
NIS	:	National Institute of Statistics
PMU	:	Project Management Unit
RGC	:	Royal Government of the Kingdom of Cambodia
RMMO	:	Road Maintenance Management Organization
RSOJ	:	Road Structure Ordinance of Japan

Other Abbreviations

AC	:	Asphalt Concrete
AIDS	:	Acquired Immune Deficiency Syndrome
ALT	:	Alternative
ALEF	:	Axle Load Equivalency Factors
Ave	:	Average
B	:	Broadness
B/C	:	Benefit - Cost
BCD	:	Boundary Condition of Downstream
BCU	:	Boundary Condition of Upstream
BOD	:	Biochemical Oxygen Demand
Br	:	Bridge
BST	:	Bituminous Surface Treatment
CBR	:	California Bearing Ratio
CO	:	Carbon Monoxide
COD	:	Chemical Oxygen Demand
D	:	Depth
D	:	Diameter
DBST	:	Double Bituminous Surface Treatment
DCDP	:	Draft Cambodia Development Plan
e	:	Exponent
EIRR	:	Economic Internal Rate of Return
Elv or El	:	Elevation
EMP	:	Environmental Management Plan
ESAL	:	Equivalent Single Axle load
Fig	:	Figure
GDP	:	Gross Domestic Products
GL	:	Ground Level
H	:	Height
HIV	:	Human Immunodeficiency Virus
HV	:	Heavy Vehicles
HWL	:	Design High Water Level
IC	:	Interchange
i.e.	:	(Id est) that is
IEIA	:	Initial Environmental Impact Assessment
IS	:	Intersection
ISIA	:	Initial Social Impact Assessment
Km	:	Station of Inventory Survey of the Existing Road
L	:	Length
Ln	:	Natural Logarithm
LV	:	Light Vehicles
Max	:	Maximum
MC	:	Motorcycles

Min	:	Minimum
M_R	:	Resilient modulus (psi) (subgrade).
MSL	:	Mean Sea Level
[HN1]n	:	Roughness Coefficient
NA	:	Not Available
nos	:	Numbers
NO_2	:	Nitrogen Dioxide
NPV	:	Net Present Value
NR	:	National Road
NR-1	:	National Road No.1
OD	:	Origin and Destination
ODA	:	Official Development Assistnace
Org	:	Organization
PAPs	:	Project Affected Persons
Pave	:	Pavement
PC	:	Pedal-cycles
PC	:	Pre-stressed Concrete
Pk	:	Station of Existing National Road by MPWT
psi	:	(Performance) Serviceability Index
p_0	:	Initial Design Serviceability Index
p_t	:	Design Terminal Serviceability Index
Q or Q_0	:	Discharge Capacity
RC	:	Reinforced Concrete
Rd	:	Road
ROW	:	Right Of Way
SEDP	:	Socio-Economic Development Plan
SN	:	Pavement Structure Number
SO_2	:	Sulfur Dioxide
SS	:	Suspended Solids
St	:	Station of Proposed Centerline
S/W	:	Scope of Work
S_0	:	Combined Standard Error of the Traffic Prediction and Performance Prediction,
T	:	Time
TMP-PPMA	:	Transport Master Plan of the Phnom Penh Metropolitan Area
US or USA	:	United States of America
UXO	:	Unexploded Object
V	:	Velocity
VOC	:	Vehicle Operating Cost
W	:	Width
W/C	:	Weight-Capacity
WG	:	Water Gate
WL	:	Water Surface Elevation
W_{18}	:	Predicted Number of 18-kip
Z_R	:	Standard Normal Deviate,
⊿PSI	:	$p_0 - p_t$
ϕ□	:	Diameter
σ	:	Stress
σ ck	:	Concrete Compressive Strength
σ py	:	Steel Yield strength

Units

cm	:	Centimeter
dB	:	Decibel
ha	:	Hectare
hr	:	Hour
km	:	Kilometer
km^2	:	Square Kilometer
km/h	:	Kilometer per Hour
kN	:	Kilo Newton
kN/m	:	Kilo Newton per Meter
kN/m^3	:	Kilo Newton per Cubic Meter
L	:	Litter
m	:	Meter
m^2	:	Square Meter
M or mil	:	Million
min	:	Minute
mg/l	:	milligram per liter
mm	:	Millimeter
m/s	:	Meter per Second
m^3/s	:	Cubic Meter per Second
N/mm^2	:	Newton per Square Millimeter
pcu	:	Passenger Car Unit
pcu-hr	:	Passenger Car Unit – Hour
ppm	:	Parts per Million
Riel	:	Cambodian Currency
t	:	Ton
t/yr	:	Ton per Year
t/ha	:	Ton per Hectare
veh/day	:	Vehicles per Day
Veh	:	Vehicle
$	:	Dollar
%	:	Percent
°	:	Degree

PROJECT SUMMARY

1. COUNTRY	The Kingdom of Cambodia
2. NAME OF STUDY	The Feasibility Study on the Improvement of National Road No.1 (Phnom Penh–Neak Loueng Section) in the Kingdom of Cambodia
3. COUNTERPART AGENCY	Ministry of Public Works and Transport (MPWT)
4. OBJECTIVE OF STUDY	To carry out a feasibility study on the improvement of National Road No.1 (Phnom Penh–Neak Loueng Section) and transfer technology to Cambodian counterparts.

1. STUDY AREA Road section from Phnom Penh to Neak Loueng on National Road No.1, approximately 56km in length and inundation area

2. TARGET YEAR Year 2015

4. TRAFFIC DEMAND FORECAST 9,996～64,140 PCU/day

3. ECONOMIC FRAMEWORK

Population in Plain Region	Thousand	8,887
Per Capita GRDP	'000 Riels	1,440
Annual Growth Rate	%	6.0

5. OUTLINE OF FEASIBILITY STUDY AND PRELIMINARY DESIGN

(1) Flood Mitigation

- Hydraulic simulation was made to investigate flood condition of the study area. The design High Water Level (HWL) is set at the flood level of the maximum flood level of the year 2000. The free flow is set as 50cm for embankment and 100cm for bridges and box culverts.
- Inflow from main stream of the Mekong River to the inundation area on the right bank was studied to study the flood mitigation plan. The planned inflow was raised from 2,200m^3/s to 2,700m^3/s. This will lower the flood level of the Mekong River approximately 2～3.5cm more than present situation in the study area.
- The protection work for embankment slope is planned where the NR-1 faces to the Mekong River. It locates at 5 places and total length will be 3,800 meters. Revetment is planned for 900 meters in a place and green belt with 1:3-slope for 2,900 meters in four places.

(2) Road

- Proposed centerline is based on the existing centerline of NR-1. It satisfies geometrically design speed as 80km.
- As a result of alternative study, it is planned to provide space for future widening up to Kokir market and for slow-moving vehicles all along the study road. These spaces are to secure traffic safety and to correspond to the increase of the traffic demand in the future.

(3) Pavement

- NR-1 is planned to be improved with asphalt concrete. It is designed based on "AASHTO Guide for Design of Pavement Structures"
- Design CBR of 9 was used with improvement of subgrade by replacing the existing ground with a selected material.
- Five design sections were set based on the traffic demand forecast.

(4) Opening Structure

- PC (Pre-stressed Concrete) I-shaped simple girder is planned for superstructure of bridges after the alternative study. This type has advantage economically, in ease of construction, operation and maintenance.
- Gabion mat is planned for the protection of riverbed scouring and wet masonry for slope protection on each opening structure.

6. ROAD IMPROVEMENT PLAN

・Improvement of vertical alignment (higher than 2000 Flood level plus 50 cm) and pavement thickness
・New construction of asphalt concrete pavement whose structure consists of roadbed embankment including subgrade, sub-base course, base course and surface course
・Cross section of 7meter (3.5m/lane) through-traveled lanes with provision of space for slow-moving vehicles
・Provision of sidewalk and drainage together with street lighting up to the intersection to Tiger beer factory
・Provision of space for future widening up to Kokir Market
・Improvement of existing intersection to Tiger beer factory by channelization with traffic signal
・Existing two temporary bridges replaced by new pre-stressed concrete bridge with protection against erosion and local scouring and one new construction of bridge.
・Existing two pipe culverts replaced by new pipe culvert with protection against erosion
・Existing two water gates replaced by new box culvert with protection against erosion and new construction of nine box culverts.
・Protection of slope surface of road embankment: 900-meter long revetment and 2,900-meter long green belt
・Traffic safety measures by installing road markings, guard posts and rails, regulatory & warning signs, guide signs, kilometer posts and traffic signal at intersections
・Road related facilities such as moto-remork stops cum livestock refuge during flood, weighbridge station, and Road Station, etc.

7. Road Operation and Maintenance Plan

The road maintenance budget comes from "Fund for Repair and Maintaining of Road (FRMR)", and MPWT and provincial DPWT operate the maintenance and repair. The majority of the maintenance funds probably will be spent on emergencies by provincial level and leave very little for conventional maintenance activities.

It is indispensable to strengthen road maintenance capability and to cope with incremental demand brought about by the governmental policy of road improvement. It is suggested to increase the road maintenance fund by strengthening road user cost recovery practices and to draw up a long-term strategy for cost recovery from road users in order to secure the annual funds required for road maintenance.

8. PROJECT IMPLEMENTATION PLAN AND EVALUATIONS

(1) Project Implementation Plan and Cost Estimate

Total construction period is planned as 36 months. Implementation plan starts in 2003 and the study road will be improved in second half of 2007. Estimated construction cost is 38.338 million US dollars and project cost is 43.408 million US dollars.

(2) Economic Evaluation

The base EIRR for the project is 13.3%, with various sensitivity scenarios giving results that range from 8.4% to 19.1%.

(3) Environmental Evaluation

The IEIA (Initial Environmental Impact Assessment) concluded that there are neither substantial nor irreversible adverse environmental and social impacts arising from the Project. No additional land acquisition for road right-of-way is required because the project only involves the improvement of existing roads. The project will require resettlement of project affected person. It is suggested that due procedure for the resettlement action should be taken into practice by implementation organization without delay.

(4) Overall Evaluation

High priority should be given to the implementation of the project because the project will promote economic and social development and there is expectation of a sufficient economic return. The project will also contribute to improve NR-1 to flood-free road to an all-weather standard, enhance traffic safety and environmental conservation by well-designed paved road, integrate producing and consuming centers in terms of regional context and increase job opportunities for the local poor especially in the development corridor between Phnom Penh and Neak Loueng.

9. CONCLUSION AND RECOMMENDATIONS

It is concluded that the Study reveals high feasibility for the project implementation. Namely, the project has high technical feasibility, there is no substantial or irreversible adverse environmental impacts arising form the project, and the project is economically viable based on the economic analysis. It is recommended that the institutional arrangement for project implementation should be taken without interruption.

OUTLINE OF THE PROJECT

The Feasibility Study on Improvement of National Road No.1 (Phnom Penh – Neak Loueng Section) in the Kingdom of Cambodia

・Study period: Apr. 2002 - Mar. 2003
・Counterpart Agency: Ministry of Public Works and Transport,
The Royal Government of the Kingdom of Cambodia

1. Background of the Study

National Road No.1 (NR-1) covers about 166 km in Cambodia from Phnom Penh to Bavet (on the border to Vietnam that is the main crossing point to the southern part of Vietnam and 72 km to Ho Chi Minh City). This route is designated as Asian Highway No. A-1 as well as ASEAN Highway No. 1, and almost of all road traffic between Phnom Penh and Ho Chi Minh passes on this route.

NR-1 is divided into two sections:

- The section C-1 from Phnom Penh to Neak Loueng
- The section C-2 from Neak Loueng to Bavet, on the border to Vietnam

The ongoing ADB funded "Ho Chi Minh City to Phnom Penh Highway Improvement Project" in Cambodia aims to directly improve an arterial road located in the Plain Region, which covers the five provinces of Kandal, Prey Veng, Svay Rieng, Kampong Cham and Takeo and one municipality of Phnom Penh. The Plain Region has a population of 6.8 million (2002) that is more than 50% of the national population. It produces 54% of GDP, but occupies only 14% of national land.

The C-2 section (105 km length) is being improved with ADB assistance and financing and is scheduled to be completed by the year 2003. A feasibility study is being carried out for the C-1 section (56 km length) by this study in cooperation with JICA.

The target year of the plan is the year 2015, which accords with that of relevant studies and projects implemented by the Royal Government of the Kingdom of Cambodia

The influenced area has high development potential in terms of domestic production/ consumption as well as international trade/ investment. This area produces crops such as paddy, maize and vegetables as well as fisheries and livestock & poultry products that are mainly transported to Phnom Penh, the biggest consumption center. Accordingly, once NR-1 is improved, it will stimulate the development potential within the influence area, and high vehicle traffic generation is anticipated.

The expected roles and functions of NR-1 are as follows:

- To ensure road transport throughout the year by upgrading to a flood-free road to an all-weather standard.
- To secure traffic safety and conserve environment by separating slow-moving vehicles such as motorcycles and motorcycle trailer ("moto-remorks").
- To stimulate economic and social development by connecting major productive centers to urban centers to provide better market accessibility, allow more competition and stable prices as well as to increase job opportunities for the poor.
- To strengthen linkages between producing and consuming centers and between exploited resources and trading gateways by the improvement of the arterial road to an international standard. This will encourage the ongoing transition to market economy that has opportunities for reducing poverty.

2. Outline of the Project

2.1 Flood Mitigation

(1) Flooding Condition and Flood Damage

Flooding area by 2000 Flood around Phnom Penh, NR-1 (C-1 and C-2) and NR-11 was very large with about 40 to 50 km width around Phnom Penh and about 20 km width around Neak Loueng. This large flooding area can be divided into three zones as follows: Zone 1: Mekong River Main Stream, Zone 2: Left Bank Side Flood Plain, and Zone 3: Right Bank Side Flood Plain (Colmatage Area). NR-1 C-1 is included in the Zone 3.

It was estimated that the maximum water level was almost same as the road top in 2/3 of the sections with three overflows occurring along NR-1 C-1. Two artificial Cut-offs were installed during 2000 flood to save urban area of Phnom Penh city. The flood survey clarified that the flood damage composed of damage to houses, agriculture and others by 2000 Flood was almost the same as other floods. This means that flood damage of 2000 Flood was not increased by the two artificial Cut-offs of NR-1 C-1 made during 2000 Flood.

In order to clarify the hydraulic effect by the two artificial Cut-offs along NR-1 C-1, unsteady hydraulic simulation model was developed. Effects of lowering the maximum water levels at Phnom Penh and Neak Loueng during 2000 Flood by the artificial Cut-offs were estimated at 9 cm and 14 cm respectively. This lowering of the flood water level at Phnom Penh and Neak Loueng was very important because these 2 towns seemed to be saved from flooding, but they would have been flooded if the water level was a little higher.

(2) Flood Mitigation Plan

As a principle for constructing roads in a flood plain, the road should not be an obstacle to the flow of a flood. Based on this principle and the purpose of this project (which is to formulate an improvement plan for NR-1 C-1 to be all-weather road even during floods), the height of road embankments and openings along the NR-1 C-1 were planned.

Since there is no clear historical trend of increasing flood water level along NR-1(C-1), it is sufficient to set the Design High Water Level (HWL) at the same elevation as the maximum water level of 2000 Flood. In order to maintain safety against wave height and possible floating debris, 0.5 meter of freeboard for embankment and 1.0 meter are considered above the HWL.

Plan for Openings is made based on the inflow into the Colmatage area. The plan indicates that inflow should be increased by installing new openings. Based on the hydraulic simulation, it was estimated that the plan could further lower the flood water level at Phnom Penh and Neak Loueng 2.0 to 3.5 cm. Bridge is installed near the existing temporary bridges and box culverts and pipe culverts are to be distributed along the road since flood flow is a kind of lateral flow. Followings are outline of the plan.

Opening	Length/Size	Place
Bridges	Total length: 232 m (Br.1: 66m, Br.2: 100m and Br.3: 66 m)	3 places
New Box Culverts with stop log slots	W 2.0 m x H 5 to 6 m x 2 cells	6 places
New Box Culverts without stop log slots	W 2.0 m x H 5 to 6 m x 2 cells	3 places
Improvement of Pipe Culverts	D 1.0 m x 1 no.	2 places
Improvement of Old Water Gates (by Box Culverts)	W 2.0 m x H5.6 m x 2 cell, W 2.0 m x H5.8 m x 3 cell	2 places
JICA Water Gates	No change	4 places
Total		20 places

Note: W: width, H: height and D: diameter, Stop log slots are to be attached to the 6 box culverts for water use for agriculture.

(3) Protection against Erosion and Scouring

Along NR-1 C-1, there are five places of total 3,800 meters where the road is facing the Mekong River and floodwater frequently attacks NR-1 C-1. In order to protect embankment slopes on the Mekong Side against erosion by waves or flow, revetment with wet masonry for the severest places between and Km 18+600 and 19+500 (900 meters) is planned. For other four places, gentle embankment slope (1:3) with green belt by swamp trees along the Mekong Side of the road for total 2,700 meters is planned

Protection for bridges and box culverts are necessary against erosion and local scouring by contraction flow with turbulence. The planned protection for bridge is composed of revetment with wet masonry around abutments and bed protection by gabion mats and boulders. Inlets and outlets of box culverts are also planned to be protected by revetment with wet masonry and gabion mats with boulders.

2.2 Road and Road Facilities

To design centerline horizontal alignment

i) to follow the centerline of the existing NR-1 C-1 section as much as possible
ii) to adjust irregular sections
iii) to adjust where the centerline does not satisfy the proposed criteria

As the study area is in very flat region, grades in general are less than 0.1%. Grades went up to about 1% for the approach section for the bridges and culverts.

Common features of cross section are listed as follows:

1) Design Speed: 80 km/h
2) Through-traveled lane width: 3.5 m/lane
3) Space for slow-moving vehicles: 2.5 meters
4) Crossfall (Through-traveled lane): 2%
5) Crossfall (Shoulder): :4%

Each section has different component of cross section referring the results of traffic survey.

Section	1	2	3	4	5	6	7
Chainage (St)	0+000 ~ 0+300	0+300 ~ 3+500	3+500 ~ 7+000	7+000 ~ 13+500	13+500 ~ 14+000	14+000 ~ 36+000	36+000 ~ 55+300
Type of Cross Section	I	II	II	III	IV	V	V

- Detail of Cross Section Unit: m

Type	Total Width	Soft Shoulder	Sidewalk	Hard Shoulder	Through-lane	Median	Through-lane	Hard Shoulder	Sidewalk	Soft Shoulder
I	24.0	-	2.5	2.0*	6.5	2.0	6.5	2.0*	2.5	-
II	24.0	-	2.5	2.5	3.5	7.0**	3.5	2.5	2.5	-
III	21.0	1.0	-	2.5***	3.5	7.0**	3.5	2.5***	-	1.0
IV	24.0	-	2.5	2.0*	6.5	2.0	6.5	2.0*	2.5	-
V	14.0	1.0	-	2.5***	3.5	-	3.5	2.5***	-	1.0

* Hard shoulder is for stopping lane.
** Median is space for future widening.
*** Hard shoulder is space for slow-moving vehicles.

To cope with the increased number and speed of vehicles after improvement and to secure safety, various safety measures are planned.

i) Installation of road markings
ii) Installation of guard posts on high embankment, guard rails on box culverts
iii) Installation of signals, regulatory & warning signs, guide signs, and kilometer posts
iv) Distribution of pamphlets to public to draw their attention for traffic safety

To enhance the function of the Study Road as well as to contribute to traffic safety, the following facilities were planned:

i) Installation of Moto-remork stops cum livestock refuge during flood
ii) Bus stop
iii) Pedestrian Bridge for traffic and pedestrian safety
iv) Weighing station to control over loaded vehicles for road maintenance.
v) Approach Slopes for Local Road to secure access for the local people
vi) Road Station for the amenity of road as well as to provide employment to the local people

2.3 Pavement Structure

"AASHTO Guide for Design of Pavement Structures" (AASHTO Standard) was used as the basic criteria for pavement design. Also, other criteria, such as "Asphalt Pavement Manual" by Japan Road Association (JRO) were referenced.

Design CBR of 9 was used assuming improvement of subgrade by placing a selected material of 30 cm thickness. Traffic demand forecast is used as traffic volume for the design. The study road is divided into five sections and each section is calculated to have required strength. The most economical structure of pavements (subrade, sub-base, base course and surface course) of pavement was selected. Table below show the structure of each section.

Section of Road	1	2	3	4	5
Station (St)	0.0 -3.5	3.5 - 7	7- 14	14 - 36	36 – end
Pk (MPWT)	5.6 – 9.1	9.1 – 12.6	12.6 – 19.6	19.6 – 41.6	41.6 - End
Total and Surface thickness	55cm, 10cm	52cm, 10cm	49cm, 10cm	59cm, 5cm	57cm, 5cm

2.4 Opening Structures

Opening structures are planned after flood mitigation plan. The plan has three bridges (superstructure: PC I-shaped splice girder, substructure: RC elliptic column, foundation: cast-in-situ RC), 11 box culvert (seven 2-cell with stop logs, one 3-cell with stop logs and three 2-cell without stop logs) and two pipe culverts (D: 1.0 meter). Type of bridge was selected concerning natural condition, construction cost, method and period, ease of maintenance. Box culverts has sufficient height and opening section for wild animals and live stocks to cross the study road safely through the culverts.

2.5 Road Operation and Maintenance System

The road maintenance budget comes from "Fund for Repair and Maintaining of Road (FRMR)". The fund will be used for routine and periodic maintenance and repair of the national, provincial and other roads under the management and responsibility of MPWT and other ministries. But the majority of the maintenance funds probably will be spent on emergencies by provincial level and leave very little for conventional maintenance activities. Both legal entities of Department of Public Works and Transport of province (DPWT) and Project Management Unit of MPWT (PMU) have similar problems as follows:

i) Shortage of road and bridge construction equipment and machinery
ii) Shortage of local engineers qualified in managing and supervising the operation of road and bridge construction equipment and machinery
iii) Lack of skilled construction equipment operators, mechanics, and electricians
iv) Lack of repair facilities and tools
v) Lack of managerial capability and research ability

Therefore, in order to secure the annual funds required for road maintenance, it is necessary to increase the road maintenance fund by strengthening road user cost recovery practices and to draw up a long-term strategy for cost recovery from road users. It is also necessary to ensure financing mechanism for road maintenance that are indispensable to strengthen road maintenance capability and to cope with incremental demand brought about by the governmental policy of road improvement:

3. Road Improvement Plan

The proposed road implementation is described as follows:

1) Improvement of vertical alignment (higher than 2000 Flood level plus 50 cm) and pavement thickness
2) New construction of asphalt concrete pavement whose structure consists of roadbed embankment including subgrade, sub-base course, base course and surface course
3) Provision of space for slow-moving vehicles
4) Provision of sidewalk and drainage together with street lighting up to the intersection to Tiger beer factory
5) Provision of space for future widening up to Kokir Market
6) Improvement of existing intersection to Tiger beer factory by channelization with traffic signal
7) Existing two temporary bridges replaced by new pre-stressed concrete bridge with protection against erosion and local scouring
8) Existing two pipe culverts replaced by new pipe culvert with protection against erosion
9) Existing two water gates replaced by new box culvert with protection against erosion
10) Construction of one new pre-stressed concrete bridge with protection against erosion and local scouring
11) Construction of nine new box culverts with protection against erosion
12) Protection of slope surface of road embankment: 900-meter long revetment and 2,900-meter long green belt
13) Traffic safety measures by installing road markings, guard posts and rails, regulatory & warning signs, guide signs, kilometer posts and traffic signal at intersections
14) Road related facilities such as moto-remork stops cum livestock refuge during flood, bus stops, pedestrian bridges, weighbridge station, approach slopes for local road and Road Station
15) Provision of space for toll plaza and administration office, if necessary

4. Project Implementation Plan

Construction planning is made to formulate project implementation plan. Construction method is selected and quantity estimation is carried out for main construction works. Construction time schedule is prepared based on following conditions

- Earth works: six months from November to April
- Asphalt pavement works: throughout the year.
- Sub structure works under HWL: six months from November to April.

Implementation takes 36 months in total. Project implementation plan is shown in table below.

	2003										2004												2005		2006		2007	
	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1st	2nd	1st	2nd	1st	2nd
Basic Design																												
Detail Design/ Preparation of tender Documents																												
Pre-qualification of Contractors Tendering/Tender Evaluation/ Signing of Contract																												
Construction																												

5. Economic Evaluation

Project cost is calculated based on quantity volume and construction plan of main construction works. The followings are the basic condition of cost estimation.

i) The cost is estimated in US dollar base considering the risk of fluctuation of exchange rate.
ii) The unit cost of each cost component is determined based on the economic conditions prevailing in October 2002 (US$ 1.0 = ¥ 120 = 3,990 Riel).
iii) Temporary facility cost, field expenses and over head are assumed to be 4%, 17% and 10% of direct construction cost.
iv) Detail engineering service and construction supervision service are assumed to be 4% and 6% of direct construction cost.
v) Survey and demolition cost for UXO is not estimated because it has already been carried out in most of the area of the study area.
vi) Compensation cost, relocation cost for utilities and cost on environmental measurement are estimated separately.
vii) Equipment cost is based on the local market price as far as they are available. The cost analysis is made in case of special equipment that is not available in Cambodia.

The basic condition of economic evaluation is as follows:

i) Traffic volume is based on the result of traffic demand forecast.
ii) Base case of the economic growth rate is set as 6%/yr
iii) Project life is assumed to be 20 years.
iv) Two tangible benefits are taken into account, which are Saving in travel time cost (time saving) and Saving in vehicle operation cost (VOC saving).
v) Discount rate is set as 12%
vi) Sensitivity test is made in different economic growth rate, construction cost, benefit amount and time savings.

EIRR of base case in calculated as 13.3%. The result of sensitivity test shows that EIRR in most of the cases are more than 12%. Therefore, implementation of the project road is justified

6. Environmental Evaluation

The IEIA was conducted in accordance with the environmental rules and regulations of Cambodia as well as environmental guidelines of JICA, and it concluded that there are neither substantial nor irreversible adverse environmental and social impacts arising from the Project. No adverse social impact is expected because the project only involves the improvement of existing roads and no additionally land acquisition for road right-of-way is required.

In the course of the Study, the activities designed to identify and predict the impact on the biogeographically environment and other matters was prepared based on the MOE's comments on IEIA. MPWT as the executing agency for the project has submitted the final report of IEIA to MOE, and due procedure was carried out in November 2002. MOE has issued an approval letter to the project.

Therefore, the environmental justification for the project is confirmed officially.

7. Conclusion and Recommendations

(1) Conclusion

The project will realize the strategic transport axis in East-south Asia as a part of Asian Highway No. A-1 by improvement of major arterial road to an all-weather international standard.

The significant benefits of the project are summarized as the enhancement of traffic safety and environmental conservation by well-designed paved road, the integration of producing 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 Phnom Penh and Neak Loueng. The project will also stimulate the development of the Asian Highway No. A-1 and induce incremental demand of domestic cargo as well as international trade to Vietnam.

i) It is recommended that the improvement of National road No. 1 C-1 Section (Phnom Penh - Neak Loueng L=56 km) be given the highest priority in the Second Socio-Economic Development Plan (SEDP-2) due to its necessity and urgency. The project's sufficient economic return is anticipated due to the higher traffic volumes.

ii) Well-designed bridges and culverts in the project will contribute to decreasing the floodwater level along NR-1(C-1) and at Phnom Penh, and accordingly flood risk will be reduced not only for NR-1(C-1) and Phnom Penh but also along NR-1(C-2) and NR-11 if 2000 Flood level should reoccur. By the inflow of floodwater to the Colmatage area through the planned openings, the water level inside the Colmatage area will slightly increase. However, no adverse impacts will affect agriculture in the Colmatage or the Bassac River.

iii) The proposed road improvement plan consists of appropriate flood mitigation measures, flood-free embankment level and strong as well as durable pavement structure. Accordingly it is technically feasible to cope with flood, floodwater and incremental demand of traffic and maintenance.

iv) The proposed plan will not require acquisition of land but evacuation of dwellers within Road Right-of-Way (ROW). According to prevailing procedure, 1,805 houses are located within tentative ROW of 30 meters, and they should move outside the tentative ROW. Since the permanent ROW is designated as 60 meters, it is socially feasible to vacate the land by a due procedure taken as the fair and just compensation to make Project Affected Persons (PAPs) resettled voluntarily outside the ROW.

(2) Recommendations

The following recommendations are made for the implementation of the project:

1) Appropriation of Funds for Project Implementation

It is recommended that the Government request a donor country to assist funding them, using bilateral ODA or a loan from a multi-lateral lending agency so as to alleviate the financial burden to the Government for the project implementation. The cost of compensation for resettlement and utility relocation, and the Government should appropriate the necessary funds for them in a timely manner.

2) Evacuation of Road Right-of-Way for the Project

It is necessary to evacuate PAPs from 30-meter wide ROW and to relocate utilities such as electricity and communication cables to proper locations before the construction works commence. These resettlement and relocation works require due and time-consuming procedures. Accordingly, it is recommended that such procedures should be taken in a timely manner to secure the necessary space for construction work.

3) Control of Development along NR-1(C-1)

It is recommended that any development within and along NR-1(C-1) should be effectively controlled to prevent indiscriminate activities and to facilitate the realization of project.

4) Maintenance of Detour Road at Cut-off No. 1 and No.2

Two temporary bridges at Cut-off No.1 and No.2 will be used until the construction work commences. Since it takes more than two years to start the construction work, it is necessary for MPWT to maintain detour roads and bridges properly.

5) Control of Over-loaded Trucks

It is recommended that action against over-loaded trucks should be taken immediately so that a weighbridge station at Cut-off No.2 be built to control over-loaded trucks.

6) Ensuring Financing Mechanism for Road Maintenance

To ensure financing mechanism for road maintenance, it is indispensable to strengthen road maintenance capability and to cope with incremental demand brought about by the governmental policy of road improvement. It is necessary to continue the follow up Road Maintenance Catch-up Program officially requested to Japan to realize the concept "Fee-for-Service" to contribute to increasing the road maintenance funds.

7) Improvement of Outlet Channel of Colmatage Water Gates

Outlet channels of Colmatage water gates constructed by Japan's grant aid are eroded partially by strong current. In order to utilize their flood mitigation function, it is recommended to improve the existing outlet channels including bank protection against erosion.

8) Countermeasure against the Bank Erosion of the Mekong River

It is recommended to conduct observation of the bank erosion every year, and provide some countermeasure beforehand, so that the bank erosion will not become a really serious problem to NR-1(C-1).

9) Study on Bridge over the Mekong River at Neak Loueng

It is necessary to deliberate a scheme for bridge crossings since considerable numbers of travelers are always exposed to risk and inconvenience. Therefore, it is recommended that a study on bridges over the Mekong River at Neak Loueng should be conducted.

(10) Comprehensive Study on Improvement of Chbar Ampov Intersection

Congested Chbar Ampov Intersection is one of major traffic bottlenecks on National Road No. 1 C-1 together with Neak Loueng Ferry and Kokir Market. Accordingly, it is desirable to improve it simultaneously if NR-1 C-1 is improved to a flood-free road to an all-weather standard. However, physical constraints are so severe and complicated that it is difficult to solve the problems only by an engineering design without the construction of 2nd Monivong Bridge.

It is recommended that the in-depth investigations and more comprehensive study covering Chbar Ampov Market, Kbal Ntal Intersection and its surroundings in Mean Chey District of Phnom Penh Municipality should be conducted for the improvement plan at Chbar Ampov Intersection.

THE FEASIBILITY STUDY
ON
THE IMPROVEMENT OF NATIONAL ROAD NO.1
(PHNOM PENH - NEAK LOUENG SECTION)
IN
THE KINGDOM OF CAMBODIA

DRAFT FINAL REPORT

SUMMARY

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SUMMARY

SUMMARY

1. Background of the Study

National Road No.1 (NR-1) covers about 166 km in Cambodia from Phnom Penh to Bavet (on the border to Vietnam that is the main crossing point to the southern part of Vietnam and 72 km to Ho Chi Minh City). This route is designated as Asian Highway No. A-1 as well as ASEAN Highway No. 1, and almost of all road traffic between Phnom Penh and Ho Chi Minh passes on this route.

NR-1 is divided into two sections:

- The section C-1 from Phnom Penh to Neak Loueng
- The section C-2 from Neak Loueng to Bavet, on the border to Vietnam

The ongoing ADB funded "Ho Chi Minh City to Phnom Penh Highway Improvement Project" in Cambodia aims to directly improve an arterial road located in the Plain Region, which covers the five provinces of Kandal, Prey Veng, Svay Rieng, Kampong Cham and Takeo and one municipality of Phnom Penh. The Plain Region has a population of 6.8 million (2002) that is more than 50% of the national population. It produces 54% of GDP, but occupies only 14% of national land.

The C-2 section (105 km length) is being improved with ADB assistance and financing and is scheduled to be completed by the year 2003. A feasibility study is being carried out for the C-1 section (56 km length) by this study in cooperation with JICA.

The influenced area has high development potential in terms of domestic production/ consumption as well as international trade/ investment. This area produces crops such as paddy, maize and vegetables as well as fisheries and livestock & poultry products that are mainly transported to Phnom Penh, the biggest consumption center. Accordingly, once NR-1 is improved, it will stimulate the development potential within the influence area, and high vehicle traffic generation is anticipated.

The expected roles and functions of NR-1 are as follows:

- To ensure road transport throughout the year by upgrading to a flood-free road to an all-weather standard.
- To secure traffic safety and conserve environment by separating slow-moving vehicles such as motorcycles and motorcycle trailer ("moto-remorks").
- To stimulate economic and social development by connecting major productive centers to urban centers to provide better market accessibility, allow more competition and stable prices as well as to increase job opportunities for the poor.
- To strengthen linkages between producing and consuming centers and between exploited resources and trading gateways by the improvement of the arterial road to an international standard. This will encourage the ongoing transition to market economy that has opportunities for reducing poverty.

2. General Conditions

(1) Natural Conditions

1) Topography and Geology

Topography

Cambodia covers an area of 181,035 km^2 of which the total area of the cities/provinces of Plain Region (Phnom Penh, Kandal, Kampong Cham, Svay Rieng, Prey Veng, and Takeo) is 25,100 km^2. The geographical features of Cambodia can be classified with regard to terrain into Plains, Tonle Sap, Coastal, and Plateau and Mountain Regions.

Topography of Study Area is generally flat since the Project Road traverses the flat swampy hinterland of Mekong and other rivers. The highest point of Project Road is the beginning point in the commercial area on the eastern side of Monivong Bridge with an elevation of 11 meters above sea level; the lowest point is the ending point with elevation of 8 meters.

Geology

The project area lies on flat alluvial plain between the confluences at Phnom Penh city and downstream at Neak Loueng along the right bank of Mekong River.

The soils underlying the project area are generally sandy silt and clay with soft ground, and their bearing capacities are relatively low. For example, the bearing stratum for bridge foundation is as deep as GL -20 to -30 meters.

Accordingly, road structures shall be required with large-scale foundation. Poor bearing capacity of subsoil also results in shorter life period of pavement structures.

2) Meteorology and Hydrology

Climate

The climate of the study area is characterized by two pronounced seasons: wet season with frequent and heavy rainfall brought by southwest monsoon from mid-May to November and dry season from December to April influenced by northeast monsoon; there are short transitional periods in between these two seasons. The average annual rainfall in the study area is about 1,400 mm and the highest rainfall occurs in September (refer to Fig. S-2-1).

Annual average temperature in the study area is about 28°C with a minimum of 21°C in December and maximum of 34.6°C in April. Relative humidity varies from 67% in March to 84% in September. Monthly average wind speed ranges from 5.6 to 12.5 m/s and the highest wind speed is about 16-18 m/s.

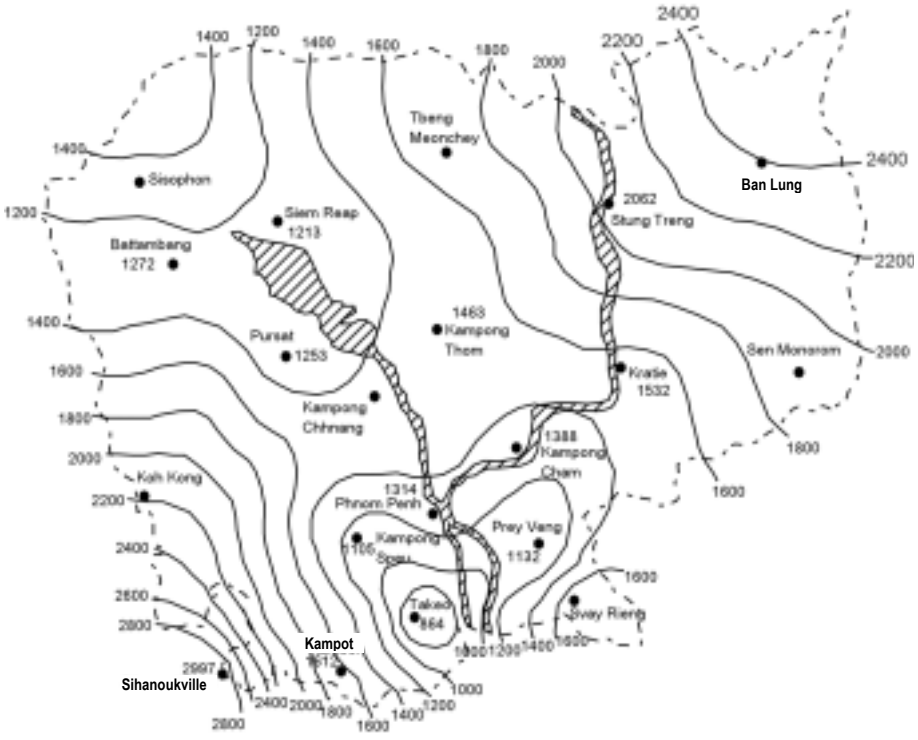


Fig. S-2-1 Distribution of Average Annual Precipitation in Cambodia

Mekong River

Mekong River is the longest river in south East Asia, originating in Tibet and flowing through China, Myanmar, Thailand, Laos, Cambodia and Vietnam. The length of the Mekong River is about 4,200 km, and its catchment area is 783,000 km^2. The Mekong River in Cambodia covers 154,895 km^2 and is composed of Mekong River Main Stream Basin (61,337 km^2), Tonle Sap River Basin including Tonle Sap Lake (79,310 km^2) and Bassac River Basin (14,248 km^2).

Water Level

Depending on the rainfall in the Mekong River Basin, water level of the Mekong River, Tonle Sap River and the Bassac River rises from end of May/June and peaks around end August/September. Then water level falls, and it becomes the lowest around February and March.

According to the annual maximum water surface level at Chrouy Changvar from 1894 to 2002, there is no clear tendency of increase of the maximum water surface level of floods (refer to Fig. S-2-2). However, data at Kampong Cham from 1960 to 2002 shows the tendency of increase of the maximum water surface level of floods within last decade. More intensive and comprehensive study will be required to clarify its cause and whether this will continue or not.

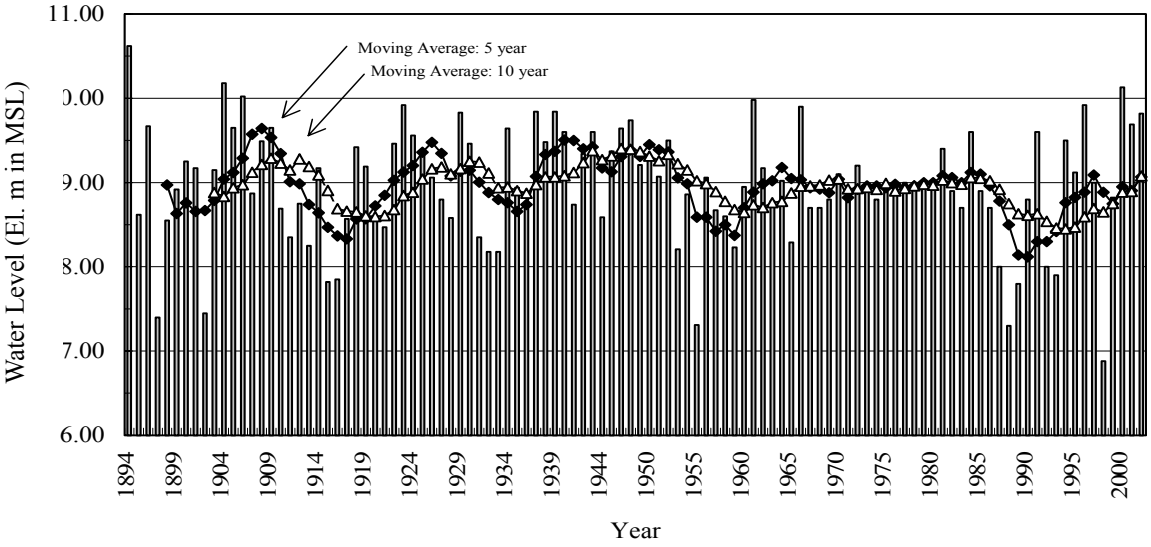


Fig. S-2-2 Annual Maximum Water Surface Level at Chrouy Changvar (1894 to 2002)

Major recent floods in and around Phnom Penh and NR-1(C-1) happened in 1996, 2000, 2001 and 2002. Among them, 2000 Flood was the severest flood around Phnom Penh and NR-1(C-1); the highest water level range was recorded as 10.13 meters at Chrouy Changvar to 10.18 meters MSL at Bassac Chaktomuk water level gauging stations located around Phnom Penh. 2000 Flood had different characteristics than other floods with two peaks and longer duration.

Return Periods of Floods

Frequency analysis was conducted on the annual maximum water level of floods. The calculated return periods of the 1996, 2000, 2001, and 2002 Floods around Phnom Penh and NR-1(C-1) were 8, 12, 6 and 6 years respectively.

For quasi-volume of the flood discharge, frequency analysis on the integration of flood water level between July and November was conducted. As a result, the return period of 2000 Flood of this quasi-volume becomes 23 years.

River Morphology including Bank Erosion

Trend of bank erosion of the Mekong River along NR-1(C-1) was studied by comparing the existing maps made in 1968 and 1996 (refer to Fig. S-2-3). By this comparison, four places were identified as the places with bank erosion. Among the four places, severest erosion happens between Km 18+000 to 26+000. It is recommended to conduct observation of the bank erosion every year, and provide some countermeasure beforehand, so that the bank erosion will not become a really serious problem to NR-1 (C-1).

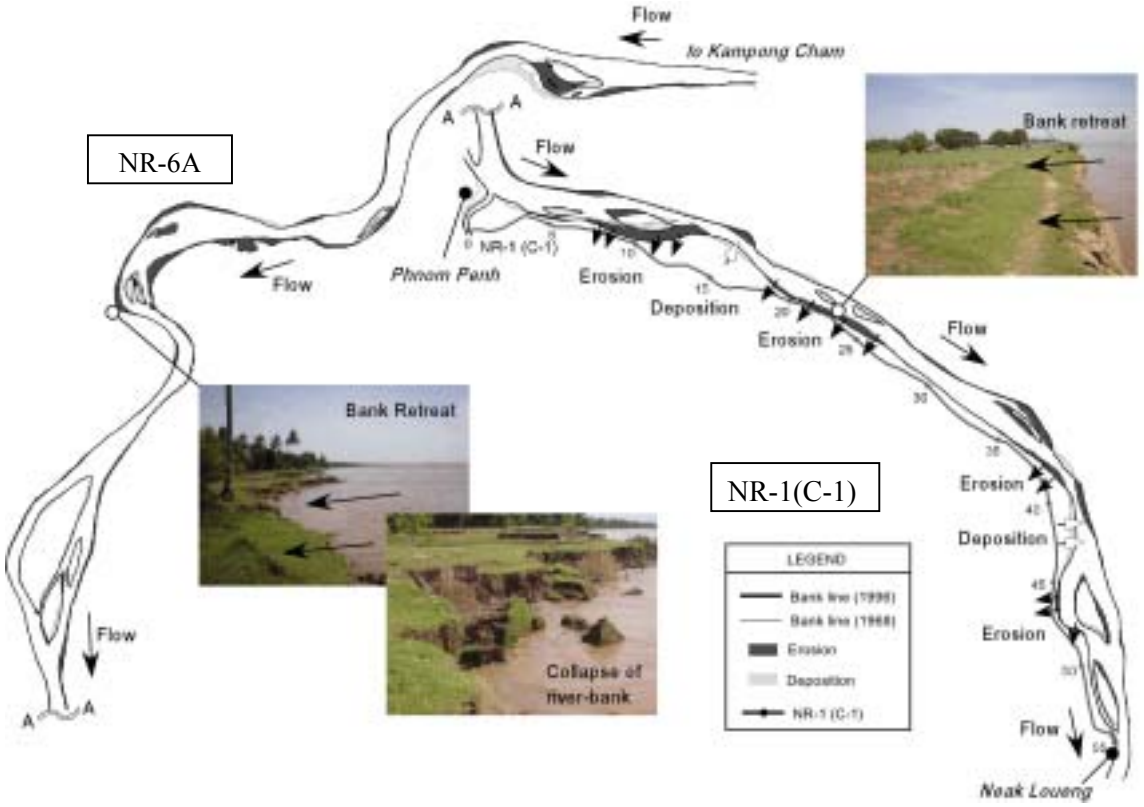


Fig. S-2-3 Trend of Bank Erosion along the Mekong River between Kampong Cham and Neak Loueng

3) Environment

Flora

There are a variety of plant species growing along NR-1. The important trees for commercial purposes are jackfruit, mango, coconut, tamarind, bamboo, etc.

There are 14 plant species used for fuel wood in local communities. Some species are natural to the inundated floodplains, and some are used for firewood and timber. Numbers of plants are cultivated or collected to supplement the village consumption of fruits and vegetables.

Seeds and fruits are collected and eaten from native plants such as lotus, persimmon and local wild grasses as well as a number of introduced species such as jujube and tamarind. Wild vegetables also present an important component of the local diet. Equally important are the local plants that provide fodder for livestock.

A wide variety of agricultural crops are cultivated within and around these wetlands and floodplain areas; also varieties of local rice are grown. The value of wetlands and floodplain ecosystems comes from the fact that they are multi-product producing systems.

Fauna, Bird species and Aquatic fishes

In the Study area, there are some common wildlife species, but it is a minor wildlife habitat. The flood plain and wetland areas are recognized as important for water-birds. A total of more than 70 bird species are reported in the project area. Most of these species are wetland birds and some forest-dwelling birds.

A total of more than a hundred species of fishes are inhabit the area, and most of these species are indigenous to Cambodia. Local people and fishermen balance their agricultural and fishing activities according to time and season.

Natural Monuments and Protected Area

The Study area does not belong to the listed historical areas; there are no Angkorean or pre-Angkorean remains. It is mainly a residential village or agriculture area. There is no National park or Protected area also. There are four recreational areas along the Mekong River: Mohaleap, Kien Svay Khnong, Kien Svay Khau and Recreational Center.

Conditions of pollution level

- Water

  The amount of BOD in sampling stations 1 (2.4 mg/l), 2 (45.79 mg/l), 3 (4.1 mg/l) and 4 (46.12 mg/l) is lower than the Cambodian standard level of less than 80 mg/l, especially at stations 1 and 3. The amount of COD at stations 1 (42.28 mg/l), 2 (88.41 mg/l) and 4 (46.12 mg/l) is high, but it is still under the standard level of less than 100 mg/l stated in the sub-decree on Water Pollution Control. The amount of Suspended Solid (SS) at stations 1 (136 mg/l) and 4 (154 mg/l) is high; it exceeds the standard level of less than 120 mg/l. The amount of Fecal at station 1 (11,000 MPN/100ml) is quite high and over the standard level of less than 5,000 MPN/100ml; other stations are in the range 430 to 4,300 MPN/100mg. The highest level at station 1 was caused by polluting activities at sampling site near the cardboard factory and the boat port.

- Air Quality

  Sulfur Dioxide (SO_2): Concentrations of Sulfur Dioxide (SO_2) at all sampling stations are below the ambient air quality standard of 0.112 ppm. Concentrations vary between 0.0009 and 0.001 ppm for the rural areas and between 0.0018 and 0.014 ppm for urban areas. SO_2 concentrations in urban areas are generally higher than those in rural areas.

  Nitrogen Dioxide (NO_2): Concentrations of NO_2 at all sampling stations are below the ambient air quality standard of 0.052 ppm. Concentrations vary between 0.0304 and 0.0349 ppm for the rural area and between 0.0454 and 0.0494 ppm for urban area. NO_2 concentrations in urban area are generally higher than those in rural area.

  Carbon Monoxide (CO): Concentrations of CO at all sampling stations are below the ambient air quality standard of 17.21 ppm. Concentrations vary between 1.45 and 1.66 ppm for the rural area and between 2.08 and 3.75 ppm for urban area. CO concentrations in urban area are generally higher than those in rural area.

Noise level

The Noise levels at all sampling stations are below the standard (Residential area 60 dB(A) and commercial area 70 dB(A)) of the standard. Noise level varies between 54.0 and 78.4 dB(A) for the rural area and between 68.6 and 77.7 dB(A) for urban area. Maximum level of noise exists for a short time, made by cars and motorcycles, while the minimum level is rather constant most of the time.

(2) Social Conditions

The existing road traverses essentially rural areas except the first 3 km after Monivong bridge point and the ferry crossing at Neack Loueng, where agricultural land is interspersed with roadside villages and towns. The road from this point runs through flood land and is banked to rise up 3 to 6 meters. Buildings adjacent to the road are mostly built on concrete piles, and are typically single storey houses constructed of wooden floors and walls, and tilted roof. These serve both as shop and residence. Many storekeepers have extended their premises by encroaching onto the shoulder of the road by building wooden decks between the house and the road shoulder or sometimes mortaring part of the road shoulder.

There are two dense populated places: namely, Chbar Ampav market which is adjacent to Monivong Bridge and Kien Svay district town centering Kokir market. In addition, there are three urban areas, namely Kandal Leu, Kandal Kraom and Prek Ta Kaev villages.

Public facilities such as schools, hospitals and electric substations exist along the road. There are neither historical ruins related to Angkorean/pre-Angkorean era registered nor historical temple/monument. There are a lot of Buddhist temples located along the road as shown in Table S-2-1.

Table S-2-1 Main Cultural Assets and Religious Facilities

No.	Facility	Km Point	Remarks
1	Market	0+100	Chbar Ampov
2	Pagoda	1+200	Nirouth Rangsey
3	Pagoda	3+900	Chheu Teal Khpos
4	Market	6+000	Prek Aeng
5	Primary School	6+100	Prek Aeng
6	Pagoda	8+100	Muchheum Voan
7	Pagoda	9+000	Cham Pha
8	Pagoda	9+100	Chan Rangsey
9	Hospital	9+900	Kbal Kaoh
10	Primary School	10+300	Yok Bat
11	Pagoda	10+500	Kien Svay Khnong
12	Pagoda	11+200	Chitaram
13	Pagoda	12+200	Kien Svay Krau
14	School	12+200	Rasmey Sammaky
15	Market	13+600	Kokir
16	Hospital	13+900	Bang Aek Srok Kiensvay
17	Pagoda	14+300	Vanntamul
18	Pagoda	15+200	Slakaet
19	School	15+200	Slakaet
20	Pagoda	16+300	Sutharam
21	Pagoda	17+650	Dei Edth
22	School	17+700	Chey Voramann Ramon 7
23	Pagoda	18+700	Enn Prum Broey
24	School	20+500	Sdau Kanlang
25	School	35+100	Hun Sen Samrong Thum
26	Pagoda	39+600	Dei Dosh
27	Pagoda	49+200	Kampong Phnom
28	School	54+900	Kampong Chamlang

A water supply distribution system exists. However, some areas have private water supply and most people use water from groundwater or rivers and lakes. Electric power cables and optical fiber communication systems are installed along the road.

(3) Agriculture and Land Use

Crops and Cropping Pattern

Kandal Province is adjacent to Phnom Penh, and many crops such as rice, maize and vegetables are produced. Rice production is 239,780 t/yr, which is only 6% of the country total. However, unit production of rice of Kandal Province is 3.14 t/ha, which is much higher than the country average of 1.97 t/ha.

Cropping in the Study Area (Colmatage Area between the Mekong and Bassac Rivers) has two patterns: dry season paddy (including flood recession paddy) and dry season paddy with irrigation. Other crops are wet season paddy, and upland crops such as maize, vegetables etc. Dry recession paddy starts from December/January/February. Wet season paddy starts from May/June. Harvesting finishes before the coming of the floods.

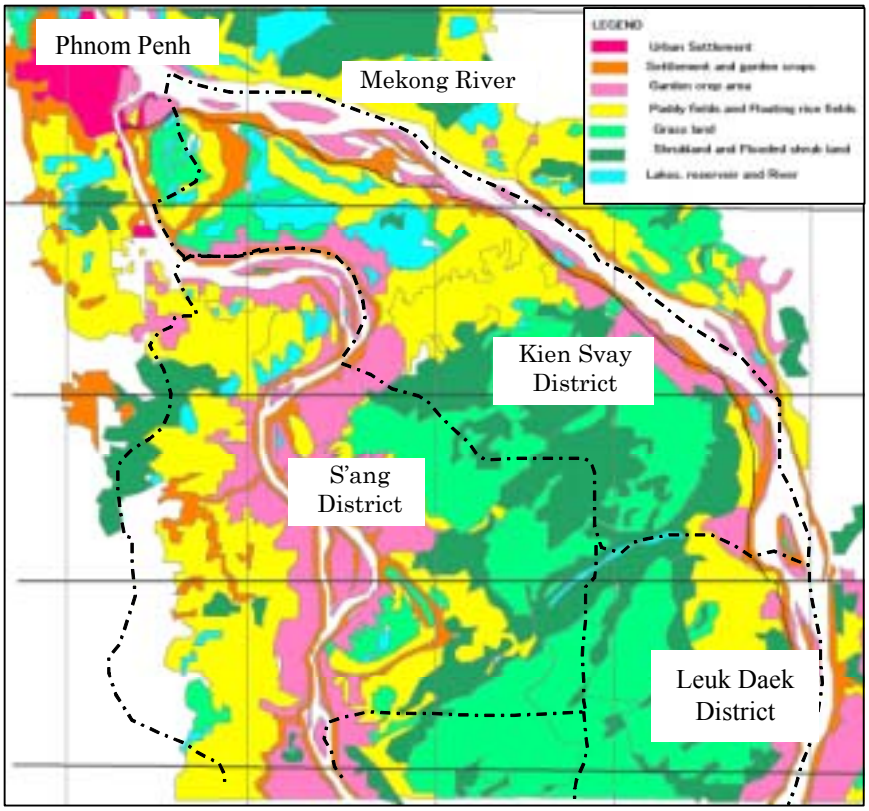


Fig. S-2-4 Land Use Map

Land use in the Colmatage Area is composed of wet land (such as grassland, shrub land & inundated shrub land), lakes/rivers covering 47.5% of the area, and agricultural land (including residential area such as paddy field, upland field and village area) covering 52.5% of the area (see Fig. S-2-4).

Colmatage Systems

There are 50 Colmatage Systems in the Colmatage Area: 12 systems along NR-1(C-1) and 38 systems along the left bank of the Bassac River. Among them, five systems are operating in the NR-1(C-1) side and 36 systems are operating in the Bassac River side. The purpose of the Colmatage Systems is to store floodwater, which flows into the Colmatage Area, to utilize the

stored water for irrigation during dry season, to distribute fertile soil containing nutrients to the surrounding paddy fields, etc., and to expand farmland by using the deposited silt in and around the Colmatage Canals.

Colmatage Systems (including water gates) are operated and maintained by farmers. Gates or canals will be opened after harvesting the wet season paddy. Gates or canals will be closed after floods to store water for irrigation. Some canals without gates are always opened under natural movement of surrounding river water level.

Flood Damage

According to the data of Kien Svay District in the Colmatage Area, wet season paddy could not be harvested in 2000 due to the flood. However, total production in 2000 (which consisted of only dry season paddy) was about 1.3 times of the production of 1999 when both wet season paddy and dry season paddy were harvested. It seems that 2000 Flood did not cause big damage to the farmers. Furthermore, as a result of interview survey by this Study, it was made clear that among the 47 villages in the Colmatage Area, annual income of 2000 decreased only in seven villages. Annual income of other villages was either no change (22 villages) or increased (18 villages). Based on this data, it can be said that the 2000 Flood produced almost no agricultural damage in the Colmatage Area.

Comments to the Openings (under the road such as culverts)

Farmers welcome openings along NR-1(C-1) to recover Colmatage Systems in combination with canals. All of the sites along NR-1(C-1) are possible sites for openings, if adverse impacts to the houses in and around the sites will not be caused by the openings.

(4) Road and Road Transport

Roads in Cambodia totaling 35,700 km consist of 44 National Roads (4,756 km), 124 Provincial Roads (5,700 km) and other Local Roads. National Roads consist of seven single digit primary roads (2,002 km) and 37 double digit secondary roads of No. 11 to 78a (2,754 km), while Provincial Roads consist of 124 triple digit roads of No. 101 to 339. Roads under jurisdiction of MPWT are 12,156 km in length and they are administratively classified into two categories as follows:

- National Road: National roads are intended to connect the capital to the provincial center, important population centers and important border crossings.
- Provincial Road: Provincial roads are intended to connect provincial centers to district centers to the extent these are not connected by National Roads.

There are two international road networks: namely, Asian Highway and ASEAN Highway. The former aims to assist member countries in developing road transport infrastructure in Asia and link Asia with Europe, thereby promoting regional and international cooperation for economic and social development, as well as opening up new potentials for international trade and tourism. The latter is to intensify cooperation in the development of trans-ASEAN transportation network as a trunk line or main corridor for the movement of goods and passengers in ASEAN.

National Roads No. 1 and No. 5 are designated as Asian Highway No. A-1 as well as ASEAN

Highway No.1, while National Roads No. 4, No. 6 and No. 7 are designated as Asian Highway No. A-11. Accordingly, the border crossing on NR-1, Bavet is designated as the main gate between Cambodia and Vietnam.

As shown in Fig. S-2-5, the arterial road network in the study area comprises National Roads of No.1, No.6 and No.7 as the primary national road, and that of No.11 and No. 21 as secondary national road.

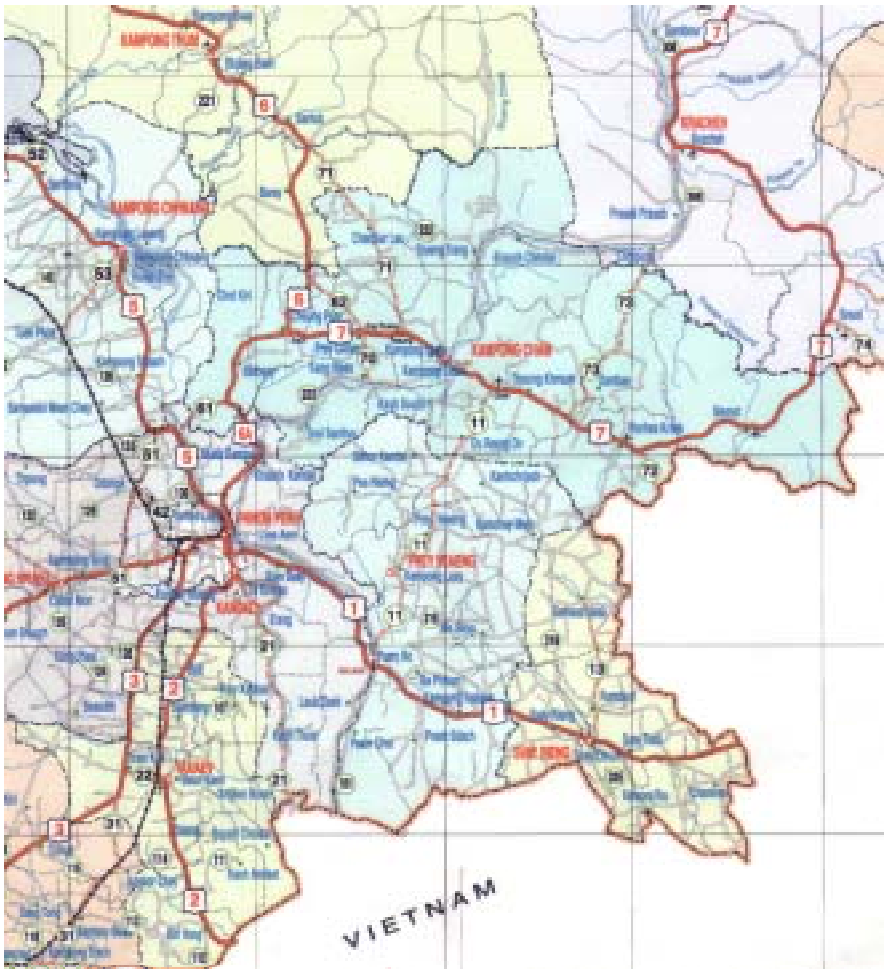


Fig. S-2-5 Arterial Road Network in the Study Area

In the international context, there are three routes connecting Phnom Penh to Ho Chi Minh as shown in Fig. S-2-6; the travel distance is 246 km on NR-1, 355 km on NR-6/7 and 421 km on NR-2.

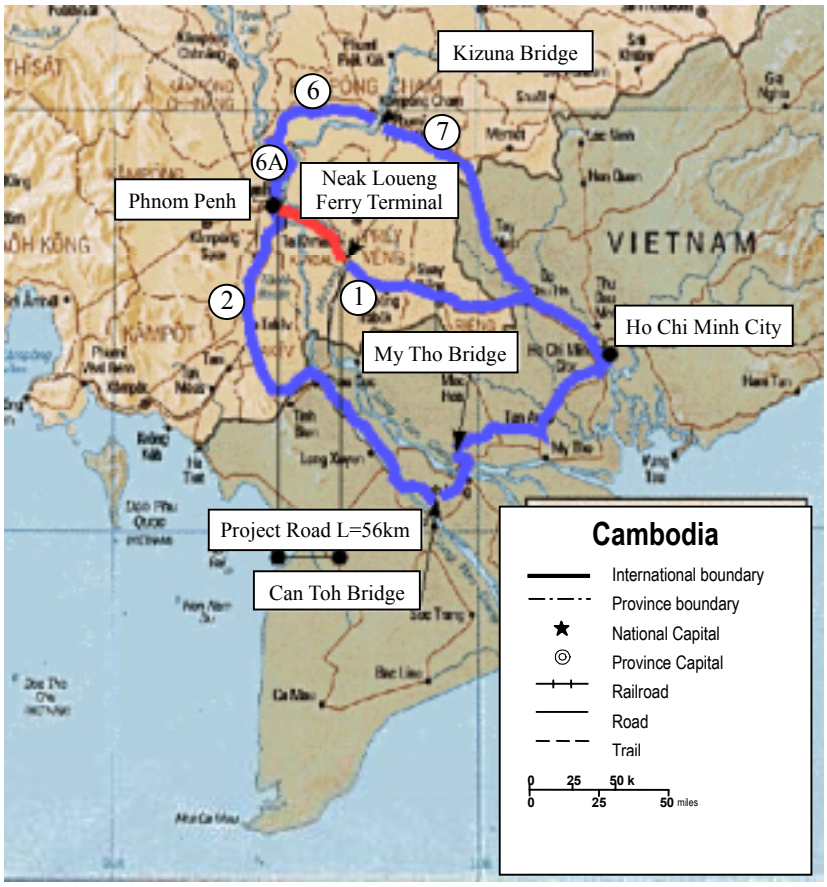


Fig. S-2-6 Existing Routes to Ho Chi Minh City

Due to the salient feature of the road network in the study area, it is very difficult to find an alternative route by road when the route is disrupted by flooding and road traffic is interrupted. The main reasons are as follows:

1) The road network is very low grade.
2) The Mekong River and its tributaries sever the road route because of only one bridge crossing the Mekong River.

(5) Traffic Condition

a. Traffic Volume Counts (Cordon Line Survey)

As shown in Fig. S-2-7, 24-hr traffic counts indicate that daily traffic volume on NR-1 is about 16,000 with 24/12-hr ratio of 1.18, and peak hour ratio of 0.14 for C-1 section (NR-1_1), and only 4,000 with 24/12-hr ratio of 1.11, and peak hour ratio of 0.17 for C-2 section (NR-1_2).

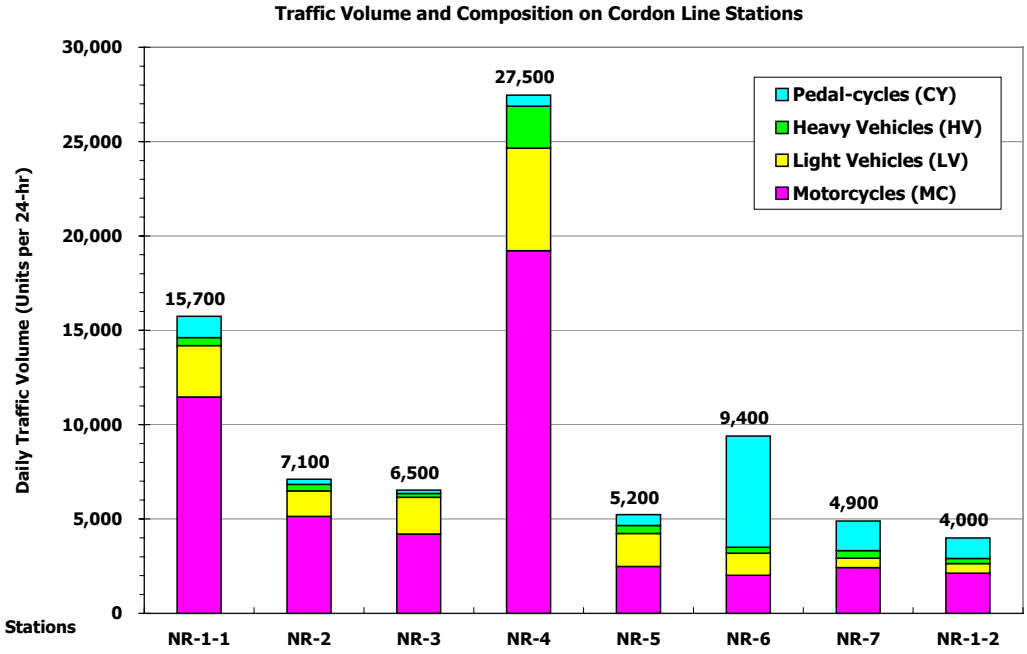


Fig. S-2-7 Traffic Volume and Composition on Cordon Line Stations

b. Trip Mode

As shown in Fig. S-2-8, trip modes (excluding "by Walk") indicate that major mode is "Motorbike" (57.8%), followed by "Private Car" (11.1%), "Bicycle" (10.1%), and "Motorcycle Trailer" (6.2%). Other light vehicles, such as "Mini Bus" and "Light Truck" make up 4.8% and 4.2%, respectively. Heavy vehicles, such as "Bus", "Heavy Truck", and "Trailer Truck" make up only 0.2%, 4.8%, and 0.9%, respectively.

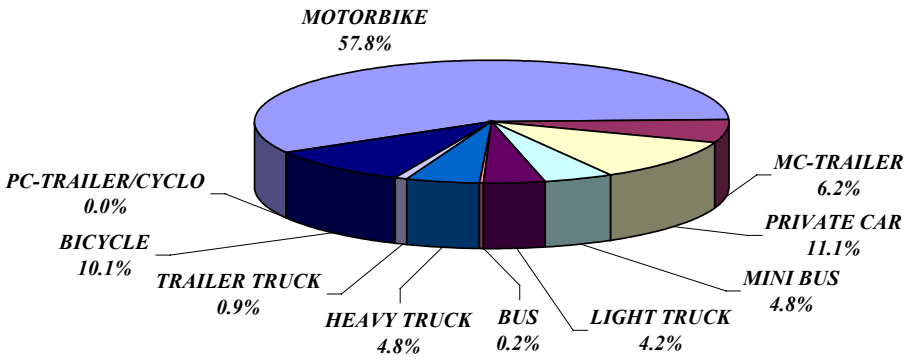


Fig. S-2-8 Trip Mode on National Road Network Users (excluding "by Walk")

c. Origin and Destination (OD)

As shown in Fig. S-2-9, vehicle OD data indicate that almost 45% of vehicles crossing cordon lines have origin or destination in Phnom Penh. Second major origin or destination is Kandal (31%), followed by areas along NR-4 and Kampong Cham with around 8% and 6% share, respectively. Areas beyond Mekong River along NR-1 has around 5% share.

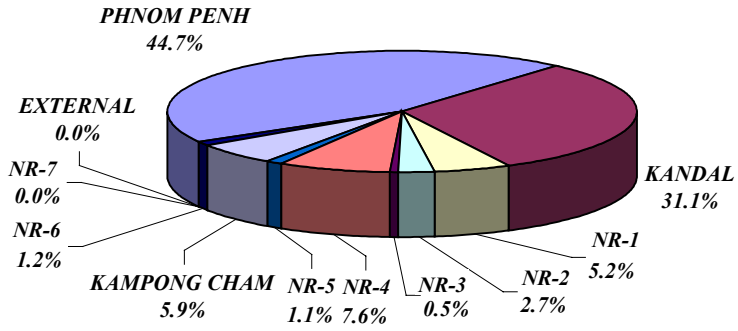


Fig. S-2-9 Trip Origin and Destination on NR-Network Users (Vehicle OD)

d. Travel Speed

As shown in the Table S-2-2 and Fig. S-2-10, the travel speed survey indicate that average speed on NR-1-C-1 section (Chbar Ampov ~ Prek Tonloab) is 37.2 km/hr as a whole; thus, average travel time becomes 1.48 hr (89 min).

Table S-2-2 Average Travel Speed on NR1-C1 Section

Section	Direction	Morning	Daytime	Evening	Average	Description (Distance in km)
Whole	N-Bound	36.2	37.3	38.1	37.2	Chbar Ampov – Prek Tonloab (0.0 km - 55.0 km)
	S-Bound	37.9	38.0	35.8	37.2	

Unit: km/hr

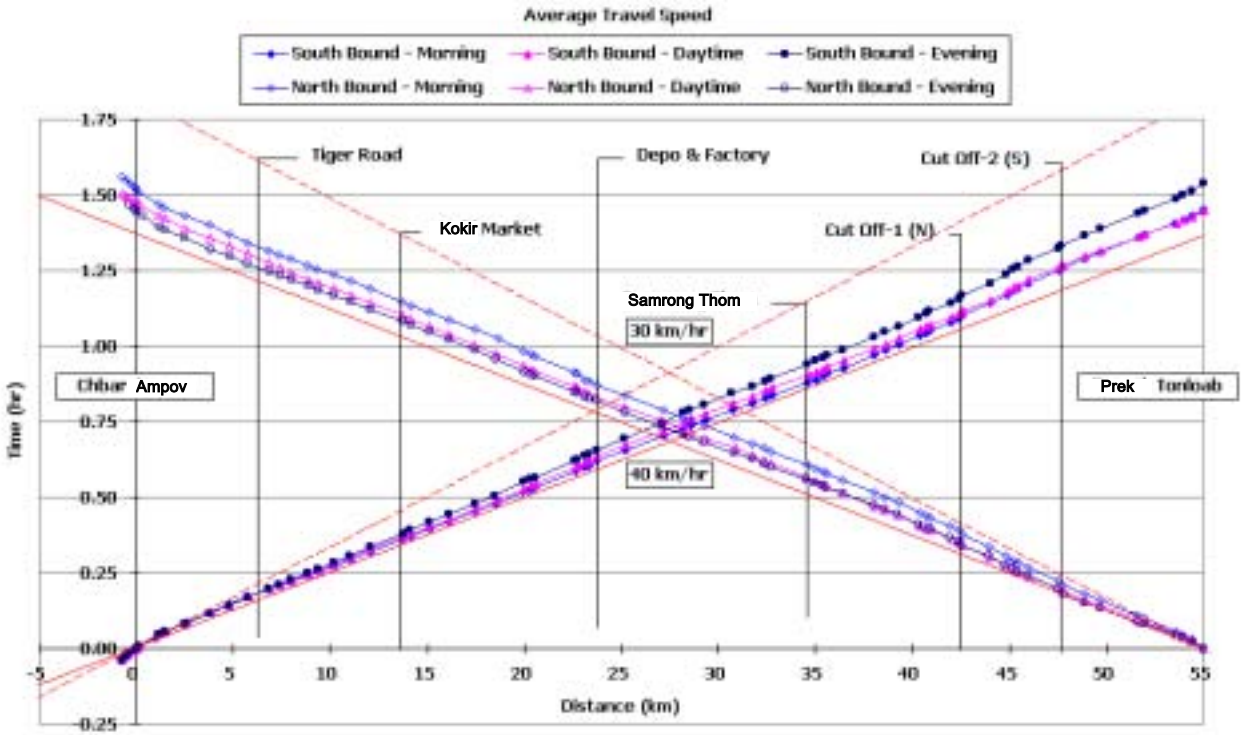
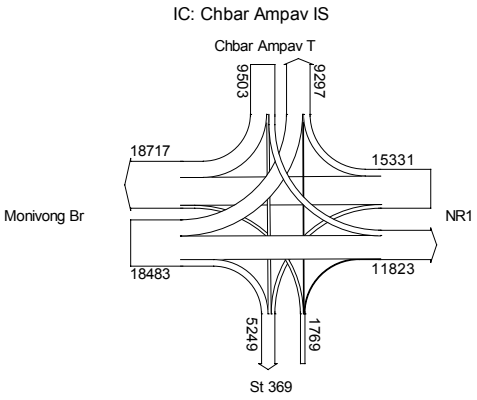


Fig. S-2-10 Average Travel Speed

e. Intersection Traffic Movement Counts

As shown in the Fig. S-2-11, Chbar Ampov Intersection (East End of Monivong Bridge) handled approximately 128,000 vehicles (45,000 pcu) in daytime 12-hr. Of this total, 112,000 units (28,000 pcu) are MC totaling 87% (62% for pcu), followed by LV with 10,000 units (13,000 pcu) totaling 8% (28% for pcu).



Total (in Veh.Units)		Out-Bound				Total
		North	East	South	West	
In-Bound	North	32	6,401	3,369	23,105	32,906
	East	8,125	34	3,602	25,424	37,186
	South	1,517	1,165	3	3,588	6,273
	West	22,641	19,972	8,821	277	51,711
Total		32,316	27,573	15,794	52,394	128,076

Total (in PCU)		Out-Bound				Total
		North	East	South	West	
In-Bound	North	8	2,128	922	6,454	9,513
	East	2,599	24	1,474	11,259	15,356
	South	392	375	1	1,004	1,772
	West	6,304	9,320	2,855	91	18,571
Total		9,303	11,847	5,252	18,809	45,211

Fig. S-2-11 12-hr Traffic Volume and Movement at Chbar Ampov Intersection

f. Cargo Movement Survey (Loading Weight & Capacity)

As shown in Fig. S-2-12, net loading of each type of cargo-vehicle calculated by discarding empty movements indicate that they have tendency of "*Overloading*". Net loading weight-capacity (W/C) ratios are 2.08 for light truck, 1.55 for heavy truck, 1.40 for trailer truck, and 1.56 as a whole.

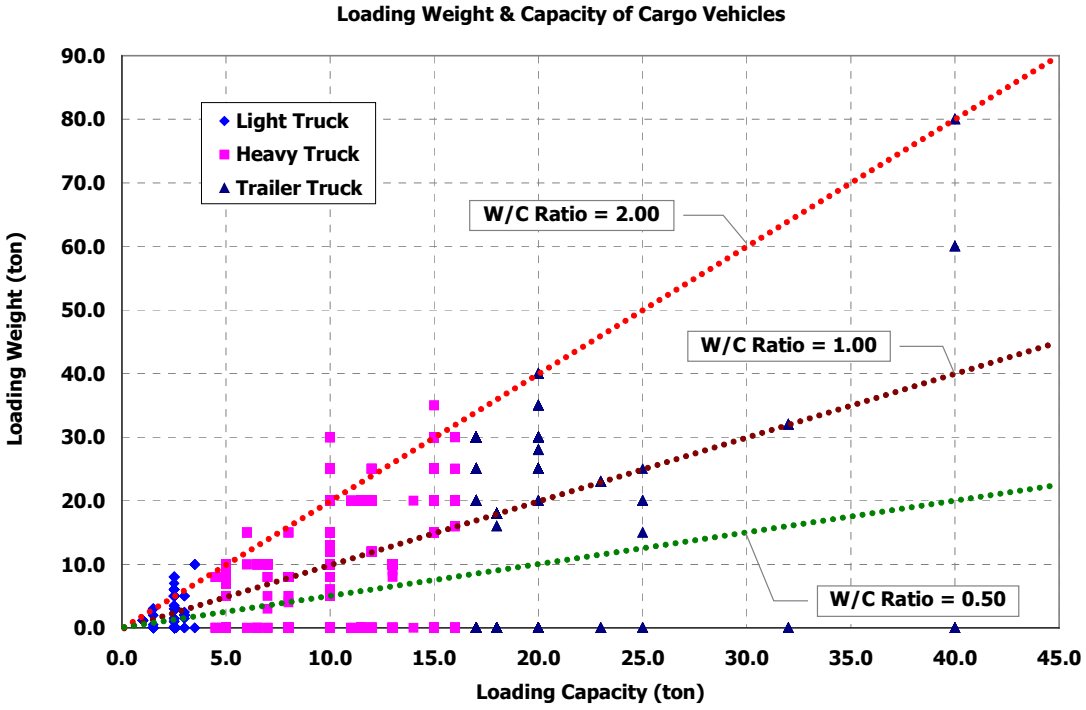


Fig. S-2-12 Loading Weight and Capacity of Cargo Vehicles (Interview Base)

(6) Road Facilities

Alignment

The existing alignment is horizontally favorable with relatively large curve radii except the stretch that sharp curves with small radii exist at Km 13+500-18+000 (Pk 19.1-23.6) and Km 32+600-32+800 (Pk 38.2-38.4).

Embankment

(i) Low embankment height

Existing road elevation is lower than the design flood water level of 2000 Flood at several locations such as Km 18+500-19+500 (Pk 24.1-25.1), Km 43+700-44+400 (Pk 49.3-50.0), Km 46+000-48+000 (Pk 51.6-53.6) and Km 49+400-50+600 (Pk 55.0-56.2). On these sections, the flood water overflowed the road surface and caused traffic disruption.

Narrow road width

(ii) Insufficient width of roadt

Widths of the top of embankment at some locations are less than 9.0 meters, which is considered to be minimal for an undivided 2-lane road (7.0 m-wide carriageway plus 1.0 m-wide shoulder on the both sides). At these locations, vehicles have to slow down their speed to pass each other. This is typically seen from Km 30+000 towards Neak Loueng.

Embankment slope
protected by vegetation

(iii) Erosion on the embankment slope

The existing slopes are usually well protected by vegetation. At some points, the grade of the slope is rather steep near the top of embankment (about 1 : 1.5) and become flatter (about 1 : 2.0) towards the toe of slope. These slopes may have been eroded by flood water or water running down the slope from the road surface. Slope protection is necessary in road improvement.

Pavement

(i) Poor pavement condition

Pavement condition of the majority portion of NR-1(C-1) is judged to be “Bad” or “Very Bad”. There is no section where pavement condition was judged to be “Good”. Only 3% is judged as “Fair”. The following types of pavement damages are commonly observed.

Cracks: Often, surface condition of the pavement is acceptable with regard to the smoothness of the ride and travel speed; however, extensive cracks are observed. Unless repaired immediately, these cracks will further develop resulting in potholes.

Potholes: When the cracks further develop, the material of pavement is lost, leaving holes 5 to 20 cm deep. Vehicles have to substantially slow down to avoid these potholes.

Destroyed pavement: In a very severe case, surface course of bituminous material is completely lost leaving only gravel or earth surface. This is typically seen along the section Km 18+000-19+000 (Pk 23.6-24.6)

Crack are developing

Destroyed pavement at Km 18+000-Km 19+000

Previously repaired pothole

Another case of damaged pavement

(i) Insufficient pavement strength

The structure of the existing pavement is basically macadam type with thickness varying from 15 to 30 cm. Compared to the volume and axle load of the heavy vehicles passing on the road, the strength of the existing pavement is deemed insufficient. Insufficient pavement strength results in deterioration of pavement and proper maintenance/ rehabilitation becomes indispensable.

(ii) Insufficient width

Width of pavement, except the vicinity of Chbar Ampov Market, is generally 5 to 6 meters. This pavement width is deemed insufficient for undivided 2-lane arterial road. In addition to insufficient width, slow-moving vehicles such as moto-remorks and moto-dops stop for passengers on road, and this interrupts vehicle smooth movement.

Road Surface Drainage Facility

Road surface drainage facility is practically non-existent even in the urbanized sections. Puddles on the shoulder are observed along urbanized sections where embankment height is

nil. Puddles are also often observed on unpaved shoulder along rural sections. These waters seep into granular pavement materials and subgrade, and reduce baring capacities of these materials.

Bridge, Culvert and Watergate

(i) There are Bailey bridges near Km 42+800 (Pk 48.4) and Km 48+000 (Pk 53.6) where the road embankment was excavated to release the water of Mekong River during the Flood of Year 2000. The structure of these bridges is of temporary nature and vehicle weight limit of 16 tons is being implemented. Accordingly, these bridges can not cater for heavy trucks. Also the widths of these bridges are 4-meter and 4-wheel vehicles can not pass on the bridges.

(ii) There are old water gates at Km 41+040 (Pk 46.6) and Km 50+015 (Pk 55.7). The widths of these culverts are 5.8 and 6.5 meters and 4-wheel vehicles have to slow down to pass on these culverts. Also, the deck slab of the culvert at Km 50+015 is severely damaged and a steel plate is being placed as a temporary cover.

Traffic Control and Traffic Safety

(i) There is no traffic signal between Phnom Penh and Neak Loueng. Traffic signals are needed along the urbanized sections such as near Chbar Ampov Market and Kokir Market where the traffic is congested and many pedestrians cross the road.

(ii) There are 27 units of traffic signs between Phnom Penh and Neak Loueng. They are mainly signs to indicate school zones. There is no warning/information sign for approaching town or speed limit sign. There are no pavement markings, guard rails or other traffic control/safety facilities. When the road is improved and travel speed of the vehicles increases, traffic control/safety facilities need to be appropriately installed.

Utilities

Telecommunication cable (optic fiber) is located approximately 6.5 meters from the centerline on the right side and approximately 60 cm from the ground surface along the entire section. There are electric poles from Km 0+100-20+400 (Pk 5.7-27.0). They are generally located along the edge of the shoulder, either on the both sides or one side of the road. These utilities need to be relocated before the construction works.

(7) Bridge and Structures

There are 10 structures on the project road: six water gates, two temporary bailey bridges and two pipe culverts. These 10 structures are listed below with four other locations (No.1, 6, 7 and 14) which used to have opening structures in the past. These four structures were found from interviews with local inhabitants during this study.

Table S-2-3 List of Existing Structures on the Project Road

No	Station (Km)	Structure Name	Dimension		Type (span arrangement, number of gates)
			Length(m)	width(m)	
1*	20+640	Sdau Kanlang	Interview		Pipe culvert in the past.
2	24+000	Prek Loueng Culvert	0.50	10.50	ϕ 0.5 m (Steel)
3	24+840	Rohat Kchal Culvert	1.00	12.50	ϕ 1.0 m (RC)
4	28+450	Prek Pol Water Gate	10.10	20.00	3 Gates (by Japan's grant aid)
5	31+120	Prek Yourn Water Gate	10.10	23.50	3 Gates (by Japan's grant aid)
6*	32+800	Prek Ta Kaev	Interview		Pipe culvert in the past.
7*	36+900	Spean Dek	Interview		Steel bridge in the past.
8	38+923	Prek Chrey Water gate	10.10	23.50	3 Gates (by Japan's grant aid)
9	41+040	Prek Samrong Thom Water Gate	7.80	8.50 (6.50)	2 Gates
10	42+830	Pou Miev Bridge	99.00	5.70 (4.00)	3 Spans (Bailey Bridge)
11	45+776	Kokir Thom Water Gate	10.00	20.00	3 Gates (by Japan's grant aid)
12	47+967	Khbal Chrouy Bridge	66.00	5.50 (3.80)	2 Spans (Bailey Bridge)
13	50+040	Kampong Phnom Water Gate	7.70	8.50 (5.60)	3 Gates
14*	52+100	Spean Wat	Interview		Steel bridge and pipe culverts in the past

* Locations from interview.

The study team carried out an inventory survey on the 10 existing structures. The outline of the results is as follows:

Two bailey bridges (No.10 and 12) were installed at the places of artificial cut-offs during 2000 flood to recover road function. These bridges are for temporary use. Protection works (Gabion mat) was ongoing as of June 2002.

Four water gates (No.4, 5, 8 and 11) were constructed for Colmatage and irrigation system with the assistance of Japan's grant aid in 2002. Carriageway width (13.5 meters) meets the Asian Highway standard and stability is very high.

Survey results of other four structures (No.2, 3, 9 and 13) are listed below.

Table S-2-4 Results of Inventory Survey on the Existing Structures

No	Structure Name	Outline
2	Prek Loueng Culvert Constructed in 1965	Steel pipe ϕ 0.5m. It is a drainage pipe in flood seasons with small discharge capacity. Mud fills inside the pipe. Position of steel pipe is settled, and scouring around inlet and outlet.
3	Rohat Kchal Culvert Constructed in 1979	Concrete pipe, ϕ 1.0m with wing wall. The concrete has poor quality with cracks, etc. It is a drainage pipe in flood seasons with small discharge capacity.
9	Prek Samrong Thom Water Gate Constructed in 1977	It is seriously damaged with many cracks, spalling, honeycomb, lime-water leakage and exposed re-bars. The flow from Mekong main flow in the rainy season is very limited due to the embankment of timber factory on the upstream.
13	Kampong Phnom Water Gate Constructed in 1976	Slab was damaged and the concrete was striped out. Top surface is covered by steel plates and bottom is filled with concrete. Lots of scale, spalling, honeycomb, cracks and expose re-bars are visible. There is exposure of aggregate all over the concrete surface. Water flow exists only in flood season.

Based on the inventory survey, soundness evaluation was executed to identify the necessity of repair or replacement of the existing structures. The rating details are shown below.

Table S-2-5 Rating of Soundness Evaluation for Existing Structures

Durability	Load Capacity	Functionality			Rating
		Deformation/deflection	Carriageway Width	Flow Section	
No damage/defects	more than 20 t	No deformation/deflection	Wider than Criteria	More than Flood Mitigation Plan	**4 (A)**
Inspection is required	-	Small deformation/deflection	-	-	**3 (B)**
Detailed inspection is required	-	Big deformation/deflection	-	-	**2 (C)**
Urgent repair and/or replacement work is required	less than 20 t	Severe deformation/deflection	Narrower than Criteria	Less than Flood Mitigation Plan	**1 (D)**

There are no as-built drawings for existing structures except four new water gates (No. 4, 5, 8 and 11). Therefore, stability of the structures without as-built drawings is judged based on the inventory survey. The results of overall evaluation are listed below.

The strength of slab is roughly calculated for two water gates (No.9 and 13) applying "T-20" loading system of Japanese standard. The arrangement of reinforcing bars is assumed from exposed re-bars and data of similar structures. The result indicates that the slab does not have sufficient strength for heavy loaded vehicles to go across.

Moreover, the results of axle load survey shows that there are many overloaded trucks. This could cause serious defection or damage to the existing structures in the near future.

13. Km 50+040 Kampong Phnom Water Gate Scale, exposed re-bars and refilled concrete on the bottom surface of slab

Table S-2-6 Overall Evaluation of Soundness on the Existing Structures

Evaluation Items			Structure Number								
			2	**3**	**4**	**5**	**8**	**9**	**10**	**11**	**12**	**13**
Durability	Degree of damages & defects of structure		2	2	4	4	4	1	2	4	2	1
Load Capacity	Heavy vehicle axle load more than 20 t				4	4	4			4		
	Heavy vehicle axle load less than 20 t		1	1				1	1		1	1
Functionality	Deformation/deflection		4	4	4	4	4	3	2	4	2	3
	Carriageway width	Sufficient for future traffic			4	4	4			4		
		Insufficient for future traffic	1	1				1	1		1	1
	Opening width	Sufficient for flood flow			4	4	4			4		
		Insufficient for flood flow	1	1				1	1		1	1
Total Evaluation Point			9	9	20	20	20	7	7	20	7	7
Overall Evaluation			C	C	A	A	A	D	D	A	D	D

A: Sound (17-20 points) B: Fairy Sound (13-16 points) C: Unsound (9-12 points) D: Dangerous (5-8 points)

Two pipe culverts (No.2, 3), two water gates (No.9, 13), and two bailey bridges (No.10, 12) should be replaced and/or repaired urgently. However, it is difficult to widen or repair the existing structures. New opening structures should replace all these structures. The table below shows the reasons for the replacement.

Detailed study on other locations (No.1, 6, 7, 14) indicates that No. 6 and 7 are appropriate for construction of new openings but No. 1 and 14 are judged as inappropriate locations due to the presence of local residences.

Table S-2-7 Reasons to Replace the Existing Structures

Type of Structure	Structure No	Reasons	Proposed New Structure
Pipe Culverts	2, 3	Insufficient soundness, carriageway (6.5 & 6.7 m), and flow section. Poor quality of concrete.	Pipe or Box culvert
Water Gates	9, 13	Insufficient soundness, carriageway (6.5 & 5.8 m). Poor quality of concrete. Connecting new and over-aged concrete	Water gate (Box Culvert)
Bailey Bridges	10,12	Insufficient soundness, carriag way (4.0 m), strength, stability. Loading limitation of 16 t Bailey bridge is for temporary use.	Bridge

3. Socio-economic Framework

(1) Socio-economic Framework

1) Existing Condition

Since the Cambodian economy shifted to the market-oriented economy, it has continued its strong recovery although there were some difficulties in 1997 and 1998. It recorded an annual growth rate of 5.7% during the period of 1993 and 2001. Estimated per capita GDP in 2001 was 1.02 million Riels in current prices, a marginal increase from 2000. In real terms, per capita GDP in Cambodia Riels has shown modest annual growth of around 3% over the past 3 years.

In current prices, the agriculture sector in 2001 accounted for 37% of GDP compared with 46% in 1993. The industrial sector continued to grow, nearly doubling from 12% in 1993 to 21.9% in 2001, due to rapid expansion in the textile, wearing apparel and footwear industry, and construction activity. Although tourist oriented service sectors grew significantly, the expansion of the industry sector has swamped this; the service sector contribution to GDP remains at around 35%.

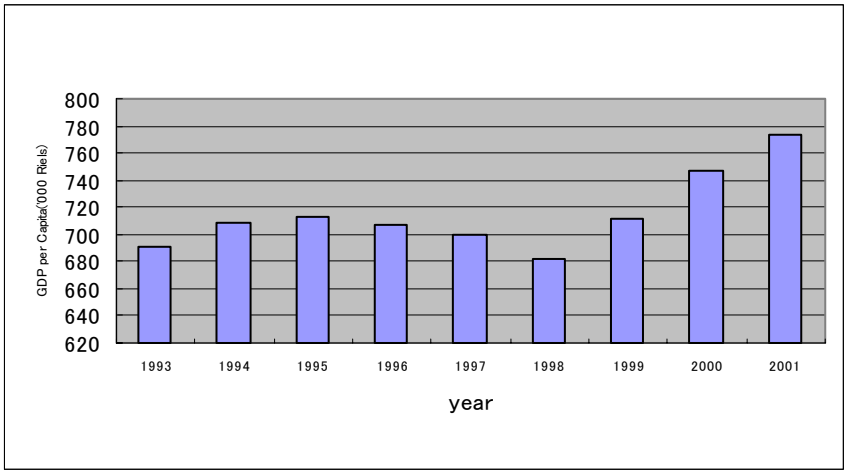


Fig. S-3-1 GDP / Capita in 1993 Constant Riel

According to the "General Population Census 1998", Cambodia has a population of 11.44 million in 1998, consisting of 5.51 million males and 5.93 million females. Number of households in the country is 2.19 million so that an average household size is 5.2 persons.

The population is expected to increase from 13.10 million in 2001 to 18.09 million in 2015 with an average annual growth rate of 2.3%.

2) Socio-economic Framework

Based on a number of lessons during First Five Socio-Economic Development Plan (SEDP-1), the Second Five Socio-Economic Development Plan (SEDP-2) was formulated in 2001. The National development objectives set up in the SEDP-2 are as follows:

- Economic growth that is broad enough to include sectors where the poor derive a livelihood
- Socio and cultural development
- Sustainable use of natural resources and sound environmental management

In order to achieve the above-mentioned objectives, the targets of the macro-economic indicators set up in the SEDP-2 are as follows:

Table S-3-1 Target of Key Indicators of SEDP-2

	2001	2002	2003	2004	2005
Real GDP Growth (%)	6.0	6.0	6.0	6.5	6.5
Per Capita GDP (US$)	275	295	317	341	359
Growth of Agriculture (%)	3.5	3.5	3.5	3.5	3.5
Growth of Industry (%)	7.0	7.0	7.0	7.0	7.0
Growth of Services (%)	8.0	8.0	8.0	8.0	8.0

Source: SEDP-2

The above mentioned framework up till 2005 is integrated into in the study.

The Government has tentatively formulated the Draft Cambodia Development Plan (DCDP) 2001-2020. Since the future GDP growth rate proposed in DCDP 2001-2020 (7.5%/yr) is optimistic estimation judging from the historical trend and future potential, it is assumed that the GDP growth rate proposed in DCDP is employed as high growth scenario.

Based on the historical trend of the GDP growth of Cambodia, the annual growth rate is expected to increase from 5 to 7% per annum. Past trend analysis shows that the estimated economic growth rate would be about 6%. This case is the so called “Medium Growth Scenario”, and it is selected for use as the future macro-economic framework for future traffic demand forecast.

The current high growth rate of the GDP of Cambodia results in too much concentration of investments to the garment and footwear-manufacturing. However, such investments may not be expected to continue to the manufacturing sector for coming decade. This may become “Low Growth Scenario” (4.5%/yr).

These two scenarios (high and low growth scenarios) will be examined in sensitivity analysis in the economic evaluation.

Table S-3-2 Economic Growth Prospects under Trend based Scenario (Medium Growth)

	1996-2000	200-2005	200-2010	2011-2020	(SEDP-2)
Real GDP Growth (%)	5.1	6.0	6.0	6.0	(6.2)
Primary sector (%)	2.0	3.2	3.2	3.2	(3.5)
Secondary sector (%)	16.8	12.4	10.2	9.6	(7.0)
Tertiary sector (%)	3.6	8.0	4.8	4.2	(8.0)

Source: Study Team's Estimation

As for the population projection, future population of both national and provincial levels is basically employed after careful examination of population projections made by the National Institute of Statistics (NIS).

According to the NIS, the population is projected using the PEOPLE computer program. The elements used in the model are age structure, fertility rate, mortality rate, and migration between city/province. The future population projected is as follows:

Table S-3-3 Population Projection by Year

Year	Population (000)	Annual Average Growth Rate (%)
2001	13,099	-
2002	13,433	2.5
2005	14,454	2.5
2010	16,245	2.4
2015	18,091	2.2
2020	19,918	1.9

Source: Population Projections 2001 – 2021, NIS

(2) Traffic Demand Forecast

a. Trip Production

Trip production rate obtained from TMP-PPMA[1] was utilized to set up the control total of initial trip generation and attraction of the Study Area. As shown in Table S-3-4, total trip production from adjacent districts along NR-1(C-1) section will increase from 718,000 in 2002 to 981,000 trips per day in 2015 (2015/2002 = 1.37) along the lines of its population growth (2015/2002 = 1.28).

[1] Transport Master Plan of the Phnom Penh Metropolitan Area, DPWT-MPP & JICA in 2000

Table S-3-4 Projected Populations and Trip Productions by Large Traffic Zone

Population (Unit: 1,000 Persons)

Year	2002	2005	2010	2015
PP	1,233	1,387	1,657	1,932
KD-1	306	325	359	392
KD-2	417	444	490	536
KD-3	88	93	103	112
KD-4	102	108	119	131
KD-5	109	116	128	140
KD-6	209	222	246	268
PV	1,060	1,110	1,192	1,263
SR	541	570	620	667
KCM	1,837	1,952	2,146	2,333
NR-2	896	945	1,030	1,114
NR-3	636	675	742	813
NR-4	1,070	1,177	1,369	1,576
NR-5	1,920	2,059	2,313	2,588
NR-6	2,445	2,651	3,019	3,411
NR-7	566	619	714	815
TTL	13,434	14,454	16,245	18,091

Trip Production (Unit: 1,000 Person Trips per Day)

Year	2002	2005	2010	2015
PP	3,478	3,995	4,871	5,795
KD-1	718	780	879	981
KD-2	1,012	1,099	1,239	1,382
KD-3	206	224	252	281
KD-4	239	260	293	326
KD-5	256	278	313	349
KD-6	492	534	602	671
PV	2,491	2,664	2,920	3,157
SR	1,271	1,369	1,519	1,666
KCM	4,317	4,685	5,257	5,832
NR-2	2,107	2,269	2,523	2,786
NR-3	1,495	1,619	1,819	2,033
NR-4	2,514	2,825	3,355	3,941
NR-5	4,511	4,942	5,666	6,471
NR-6	5,747	6,363	7,396	8,528
NR-7	1,329	1,486	1,749	2,038
TTL	32,181	35,391	40,651	46,237

Legend:

PP: Phnom Penh KD-1~6: Kandal along NR-1~6 PV: Prey Veng

SR: Svay Rieng KCM: Kampong Cham NR-2~7: Provinces along NR-2~7

Trip Production Rate: 2002 = 2.35, 2005 = 2.40, 2010 = 2.45, 2015 = 2.50 Adjustment Rate: Urban = 1.20, Rural = 1.00

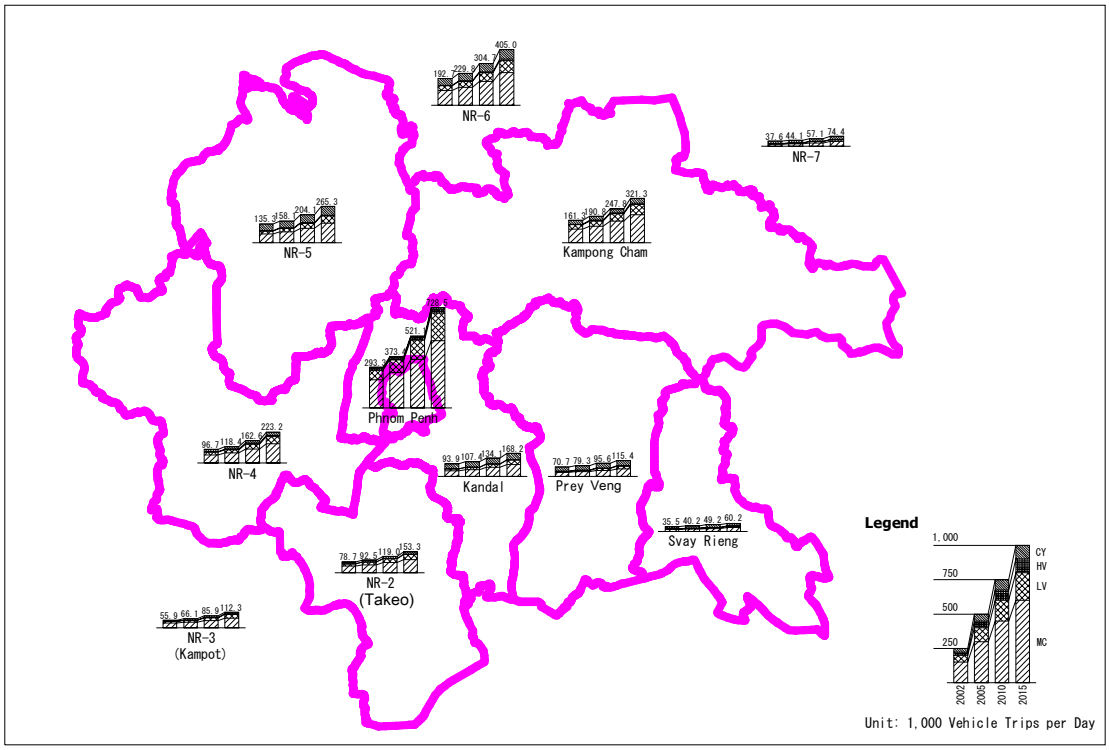


Fig. S-3-2 Vehicle Trip Productions by Large Traffic Zone (Regional Base)

b. Results of Traffic Demand Forecast

According to the traffic demand forecast analysis, in the "With Project" case, average travel speed along NR-1(C-1) section will be kept at level of around 50 km/hr in 2015

against present level of 34.4 km/hr (2015/2002=1.43). Even traffic demand will increase from 7,300 pcu in 2002 to 16,700 pcu per day (2015/2002 = 2.28), and total vehicle time also will be kept at adequate level of 18,700 pcu-hr in 2015 from 11,800 pcu-hr in 2002 (2015/2002=1.59). Total time saving by the Project will reach about 8,600 pcu-hr per day against "Without Project" case, and this is consistent with annual time saving by over three million pcu-hr in 2015.

Table S-3-5 Results of Traffic Demand Forecast along NR-1(C-1) Section

Strada	from		to	Length	Daily Traffic Volume (pcu)				Average Speed (km/hr)				Average VCR			
Link	Sta.		Sta.	(km)	2002	2005	2010	2015	2002	2005	2010	2015	2002	2005	2010	2015
A	0.0	~	3.5	3.5	29,024	36,046	50,427	64,140	39.7	39.0	39.9	39.1	0.48	0.59	0.56	0.71
B	3.5	~	7.0	3.5	13,142	16,100	23,157	29,646	40.0	40.0	50.0	40.0	0.44	0.54	0.39	0.49
C	7.0	~	14.1	7.1	8,917	10,739	15,847	20,676	40.0	40.0	50.0	50.0	0.30	0.36	0.35	0.46
D	14.1	~	25.2	11.1	5,252	6,243	9,496	12,142	30.0	40.0	60.0	60.0	0.26	0.21	0.21	0.27
E	25.2	~	36.3	11.1	4,740	5,668	8,559	10,964	30.0	40.0	60.0	60.0	0.24	0.19	0.19	0.24
F	36.3	~	46.8	10.5	4,378	5,254	7,917	10,167	30.0	40.0	60.0	60.0	0.22	0.18	0.18	0.23
G	46.8	~	55.4	8.6	4,335	5,207	7,752	9,996	30.0	40.0	60.0	60.0	0.22	0.17	0.17	0.22
Total & Average				55.4	7,307	8,856	12,993	16,672	34.4	39.7	51.0	49.3	0.30	0.28	0.27	0.34
Index (2002=1.00)					1.00	1.21	1.78	2.28	1.00	1.15	1.48	1.43	1.00	0.93	0.89	1.15

Strada	from		to	Length	Capacity-Length (pcu-km)				Vehicle-Length (pcu-km)				Vehicle-Time (pcu-hr)			
Link	Sta.		Sta.	(km)	2002	2005	2010	2015	2002	2005	2010	2015	2002	2005	2010	2015
A	0.0	~	3.5	3.5	213,750	213,750	315,000	315,000	101,584	126,161	176,495	224,490	2,560	3,237	4,423	5,741
B	3.5	~	7.0	3.5	105,000	105,000	210,000	210,000	45,997	56,350	81,050	103,761	1,150	1,409	1,621	2,594
C	7.0	~	14.1	7.1	211,500	211,500	317,250	317,250	62,865	75,710	111,722	145,764	1,572	1,893	2,234	2,915
D	14.1	~	25.2	11.1	222,000	333,000	499,500	499,500	58,301	69,301	105,401	134,772	1,943	1,733	1,757	2,246
E	25.2	~	36.3	11.1	221,000	331,500	497,250	497,250	52,379	62,627	94,575	121,151	1,746	1,566	1,576	2,019
F	36.3	~	46.8	10.5	210,000	315,000	472,500	472,500	45,969	55,167	83,129	106,754	1,532	1,379	1,385	1,779
G	46.8	~	55.4	8.6	174,000	261,000	391,500	391,500	37,717	45,298	67,445	86,963	1,257	1,132	1,124	1,449
Total & Average				55.4	1,357,250	1,770,750	2,703,000	2,703,000	404,812	490,614	719,815	923,654	11,761	12,349	14,121	18,745
Index (2002=1.00)					1.00	1.30	1.99	1.99	1.00	1.21	1.78	2.28	1.00	1.05	1.20	1.59

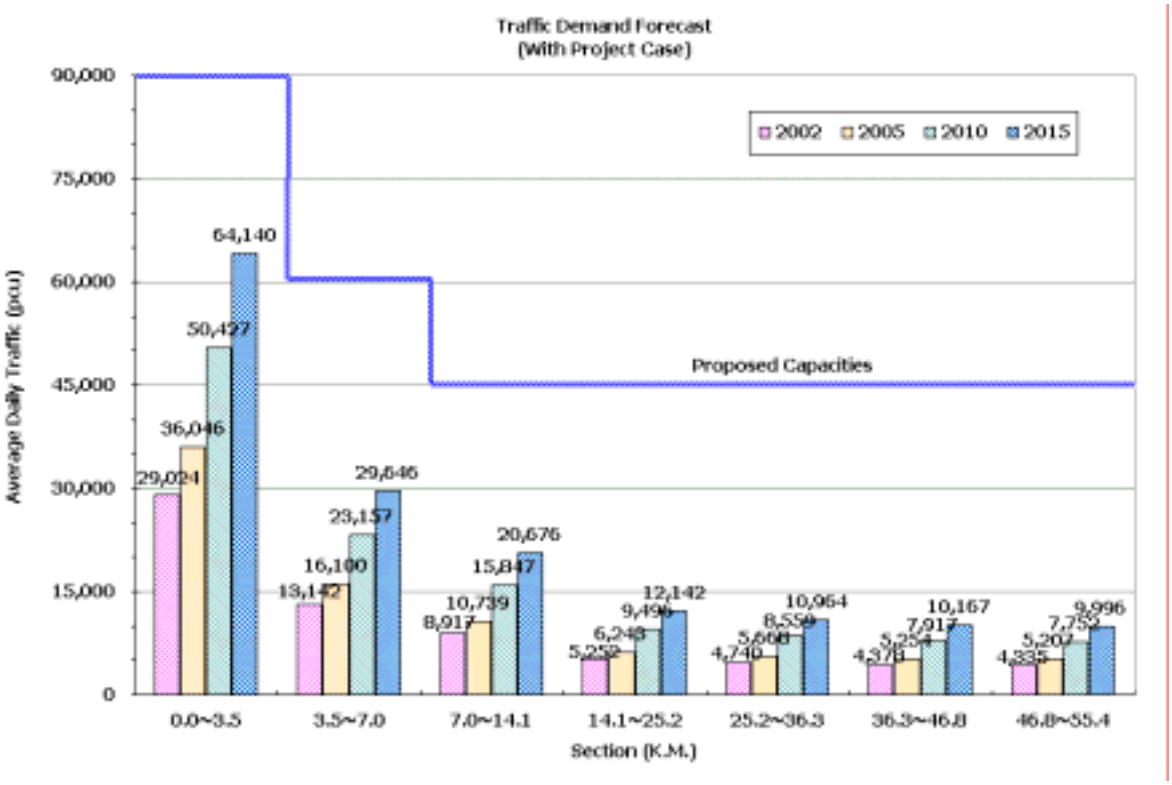


Fig. S-3-3 Results of Traffic Demand Forecast along NR-1(C-1) Section