Ministry of Rural Development **Asian Development Bank**

MINISTRY OF RURAL DEVELOPMENT
KINGDOM OF CAMBODIA

Asian Development Bank: TA No 7199 - CAM

PREPARING THE PROVINCIAL/RURAL ROAD ASSET MANAGEMENT PROJECT

Final Report

March 2010

CURRENCY EQUIVALENTS
(As at September 2009)

Currency Unit	–	Riel
Rl 1.00	=	$ 0.00024
$ 1.00	=	Rl 4,150

Note: Cambodian Riel (RI) also has the acronym KHR

ABBREVIATIONS

AADT	Annual Average Daily Traffic
ADT	Average daily traffic
ADB	Asian Development Bank
ADO	Asian Development Outlook
BEC	Board of Engineers Cambodia
CBR	California Bearing Ratio
CC	Commune Council
CNCTP	Cambodia National Community of Transport Practitioners
CSF	Commune and Sangkat Fund
D&B	Design and Build
D&D	Decentralization and Deconcentration
DBST	Double Bituminous Surface Treatment
DCP	Dynamic Cone Penetrometer
DDIS	Detailed design, implementation and supervision consultant
DFID	Department for International Development (UK)
DOE	Department of Environment
EA	Executing Agency
ECI	Early Contractor Involvement
EIA	Environmental Impact Assessment
EIC	Engineering Institution of Cambodia (and see BEC)
EIRR	Economic Internal Rate of Return
EMP	Environmental Management Plan
EMMP	Environmental Monitoring and Management Plan
ESA	Equivalent standard axle (identical to ESAL)
ESAL	Equivalent Standard Axle Load
EWC	Extended Warranty Contracts
FDI	Foreign Direct Investment
FRMR	Fund for Road Maintenance and Repair
FWD	Four Wheel drive

GDP	Gross Domestic Product
GPS	Global Positioning Satellite (receiver)
GVW	Gross Vehicle Weight
HALO	A Trust dedicated to the removal of the debris of war
HDM4	Highway Development and Management Model
HGV	Heavy Goods Vehicle
HH	Household
IBRD	International Bank for Reconstruction and Development
IEE	Initial Environmental Examinations
IMF	International Monetary Fund
IPDP	Indigenous People Development Plan
IRC	Inter-Ministerial Resettlement Committee
IRI	International Roughness Index
IRR	Internal rate of return
ITC	Institute of Technology Cambodia
JICA	Japanese International Cooperation Agency
IDC	Interest during construction
ILO	International Labour Organisation
LRCS	Location Referencing Condition Survey
MAG	Mines Advisory Group
MEF	Ministry of Economy and Finance
MMS	Maintenance Management System
MPWT	Ministry of Public Works and Transport
MRD	Ministry of Rural Development
MOWRAM	Ministry of Water Resources and Meteorology
MUV	Manufactures Unit Value index
NCDM	National Committee for Disaster Management
NCS	National Committee Secretariat
NMT	Non-motorized transport
NPV	Net Present Value
NR	National Road
NRSC	National Road Safety Committee
NWRDP	North-Western Rural Development project
ODA	Official Development Assistance
PCU	Passenger Car Unit
PCSE	Passenger Car Space Equivalent
PDPWT	Provincial Department of Public Works and Transport
PDRD	Provincial Department of Rural Development

PIA	Poverty and Social Analysis
PIU	Project Implementation Unit
PM	Periodic Maintenance
PMU	Project Management Unit
PPTA	Project Preparation TA
PRIP	Provincial and Rural Infrastructure Project
PSA	Poverty and Social Assessment
PSC	Pre-Stressed Concrete
RGC	Royal Government of Cambodia
RID	Road Infrastructure Department
Rl	Riel
RM	Routine Maintenance
RMR	Routine Maintenance and Repair
RNDS	Road Network Development Study (JICA)
RoW	Right of Way
RP	Resettlement Plan
RSAP	Road Safety Action Plan
RTAVIS	Road Traffic Accident and Victim Information System
SBST	Single Bituminous Surface Treatment
SEACAP	South East Asia Community Access Programme
SEIS	Social and Environmental Impact Study
SEU	Socio-Economic Unit
TA	Technical Assistance
TOR	Terms of Reference
US$	United States Dollar
UCS	Unconfined Compressive Strength
UXO	Unexploded Ordnance
VOC	Vehicle Operating Costs
WB	World Bank
WFP	World Food Programme
WG	Working Group
WIM	Weigh in Motion (axle load measuring system)

NOTES

i. The fiscal year (FY) of the Government of Kingdom of Cambodia ends in December
ii. In this report, "$" refers to US dollars.

PREPARING THE PROVINCIAL/RURAL ROAD ASSET MANAGEMENT PROJECT

Contents

Executive summary

Maps

1 INTRODUCTION ... 1

2 ROAD UPGRADING ... 2

2.1 CANDIDATE ROADS ... 2
2.2 SELECTION CRITERIA ... 3
2.3 SELECTED TARGET ROADS ... 4
2.4 PROJECT DESCRIPTION ... 6
2.5 EXISTING PROJECT ROADS ... 6
2.5.1 Kampong Cham Province ... 6
2.5.2 Kampong Thom Province ... 8
2.5.3 Kampong Chhnang Province ... 9
2.5.4 Pursat Province ... 10
2.5.5 Battambang Province ... 10
2.5.6 Kampong Speu Province ... 11
2.5.7 Siem Reap Province ... 12

3 ROAD IMPROVEMENTS ... 13

3.1 ROAD DESIGN ... 13
3.1.1 Engineering surveys ... 13
3.1.2 Existing pavement strengths ... 14
3.2 EXISTING TECHNICAL SPECIFICATIONS AND DESIGN STANDARDS ... 14
3.2.1 Geometric design standards ... 14
3.3 DRAINAGE STRUCTURES ... 16
3.3.1 Design for repair or replacement ... 16
3.4 ROAD FURNITURE ... 20
3.4.1 Road safety considerations ... 20

4 TRAFFIC ... 21

4.1 INTRODUCTION ... 21
4.2 TRAFFIC SURVEYS ... 21
4.2.1 Classified Counts ... 21
4.2.2 Vehicle Types ... 22
4.2.3 Moving Observer Counts ... 23
4.2.4 Automatic Counts ... 23
4.3 ESTIMATES OF BASE YEAR TRAFFIC ... 23
4.3.1 24 Hour Adjustment ... 24
4.3.2 Daily Traffic Variation ... 24
4.3.3 Seasonal Variation ... 24
4.3.4 Derivation of Base Traffic Levels ... 25
4.3.5 Traffic Growth ... 27
4.3.6 Future Equivalent Standard Axle Loadings ... 31

5 PAVEMENT DESIGN ... 33

5.1 PAVEMENT DESIGN OPTIONS ... 35
5.2 CEMENT CONCRETE PAVEMENT TRIAL ... 37

6 CONSTRUCTION MATERIALS ... 39

6.1 SUBGRADE CORRECTION MATERIALS 39
6.2 EXISTING GRAVEL WEARING COURSE MATERIALS 39
6.3 AGGREGATES FOR ROAD PAVEMENTS 39
6.4 USE OF STABILIZATION 39
6.5 RECYCLING MATERIALS 40
6.6 AVAILABILITY OF CEMENT 40
6.7 AVAILABILITY OF LIME 40
6.8 SURFACING MATERIALS 40
6.9 ROAD MAINTENANCE 41

7 MINE/UXO RISK AND CLEARANCE 42

8 CAPACITY BUILDING 43

8.1 RURAL ROAD POLICY AND STRATEGY 45
8.2 ROAD ASSET MANAGEMENT SUPPORT 49
8.2.1 Road Inventory System 49
8.2.2 traffic statistics 49
8.2.3 MRD and PDRD Technical and planning capacity 49
8.2.4 Vehicle overloading control for rural roads 50
8.2.5 Planning and budget support 51
8.2.6 Professional associations 52
8.2.7 Registration of consulting and contracting firms 54
8.2.8 Formation of professional associations for firms 54
8.2.9 Support for THE local contractor industry 54
8.2.10 Contractor training 55
8.2.11 Decentralisation program for project implementation 56
8.3 ROAD SAFETY AND SAFEGUARDS PROGRAM 58
8.3.1 Road safety 58
8.3.2 MRD Social safeguards and environmental protection capacity 60
8.3.3 social safeguards capacity 61
8.3.4 environmental safeguards 61
8.4 CLIMATE CHANGE ADAPTION 61
8.4.1 Climate change Impacts on Cambodian Rural Roads 62
8.4.2 Climate Change Adaptation Component Activities 62
8.4.3 Disaster mitigation strategy 63
8.4.4 Flooding risks 63
8.5 GAPS IN DONOR COORDINATION 63

9 PROJECT COST ESTIMATES 66

9.1 FINANCIAL UNIT RATES 66
9.2 CIVIL WORKS COSTS AND PACKAGES 66
9.2.1 Civil works packages 67
9.3 CAPACITY BUILDING COMPONENTS 69
9.3.1 HIV/AIDs and Human trafficking Prevention program 71
9.3.2 Mines and UXO awareness 71
9.3.3 Preparation for a future project 71
9.4 PROJECT COST ESTIMATE 71
9.5 BASE COSTS 72
9.6 PHYSICAL AND PRICE CONTINGENCIES 72
9.7 INTEREST DURING CONSTRUCTION 72
9.8 CONSULTING SERVICES AND PROJECT MANAGEMENT 72
9.9 DETAILED COST ESTIMATE BY CATEGORY 72

10 PROJECT IMPLEMENTATION 74

10.1 EXECUTING AGENCY 74
10.2 DETAILED DESIGN AND SUPERVISION CONSULTANT 74

10.3 IMPLEMENTATION PLAN 74

11 ECONOMIC EVALUATION 76

11.1 GENERAL 76
11.2 EVALUATION CRITERIA 76
11.3 PRICES 77
11.4 EVALUATION MODELS 77
11.5 BENEFITS 79
11.5.1 Vehicle operating cost savings 79
11.5.2 Time savings 83
11.5.3 Residual values 85
11.5.4 Other potential benefits 86
11.6 PROJECT COSTS 87
11.6.1 Improvement costs 87
11.6.2 Road maintenance costs 89
11.7 ECONOMIC ANALYSIS 90
11.7.1 Results of the cost benefit analysis 90
11.7.2 Sensitivisy tests 92

12 REHABILITATION OF RURAL ROADS 94

12.1 BACKGROUND 94
12.2 PROBLEMS IN MAINTAINING LATERITE ROADS 97
12.2.1 Costs 97
12.2.2 Environmental and Health Issues 97
12.3 WHOLE LIFE CYCLE COSTING 98
12.4 ALTERNATIVE PAVEMENT AND SURFACES 100
12.4.1 Options Tested in the Region 100
12.4.2 Road Pavement performance 102
12.5 SEACAP PROJECT 102
12.6 PRESENT SITUATION 106

13 SOCIAL SAFEGUARDS 108

13.1 POVERTY AND SOCIAL ASSESSMENT 108
13.2 ENVIRONMENTAL EXAMINATION 112
13.2.1 Introduction 112
13.2.2 Description of the Environment 114
13.2.3 Institutional Requirements and Environmental Monitoring Program 120
13.2.4 Findings and Recommendations 121
13.2.5 Conclusion 121

14 DISCUSSION AND CONCLUSIONS 122

Appendices:

1. Poverty and Social Assessment Report
2. Rapid Environmental Assessment Report

Supplemental Appendices: Engineering surveys in 20 volumes, available on request

PREPARING THE PROVINCIAL/RURAL ROAD ASSET MANAGEMENT PROJECT

Executive summary

1. The project intends to improve approximately 505km of rural roads from gravel surfaced road standard (laterite roads) to bitumen sealed standard. The roads are located in seven provinces of Cambodia; five are in the Tonle sap region, namely Kampong Chhnang, Pursat, Battambang, Siem Reap and Kampong Thom. The remaining two are Kampong Speu and Kampong Cham to the southwest and northeast of Phnom Penh, respectively. The location of the project roads is shown on the maps given on the pages following this summary.

2. The target roads are all important local links that connect to the higher order network and they serve the rural communities giving access to agricultural areas district centres and markets and carry considerable traffic. The upgrading of these roads is consistent with ADB's strategy and with MRD's policy for rural road development and the strategy for the implementation of the policy. As such the social and economic well-being and opportunities of the local communities will be improved.

3. Many of these roads are being maintained by regravelling under MRD's normal construction and maintenance program. The engineering surveys show that the roads are generally built strongly and to a good standard. However, the lack of durability of many gravel-surfaced roads is a serious financial drain on the resources, with regravelling often being carried out after only three years because of high losses of gravel wearing course material through traffic and erosion. Upgrading the roads to bitumen sealed standard will increase the cost at construction but will reduce road maintenance and road user costs and thereby whole life costs are reduced.

4. The roads will be upgraded within their existing width. Although the widths are narrower in many cases than those now advised in the new draft MRD standards, it is considered they are adequate for the envisaged project. Road signage and safety measures have been included in the project to improve road safety.

5. A pavement design period of 15 years has been selected for the project roads. The new MRD draft technical standards provide a series of road pavement structural designs that are generally appropriate for this project. A chart is provided for the use of aggregate roadbases. It is also suitable for the use of stabilized road bases. Thus, two pavement design options are presented, aggregate bases and stabilized road bases. Where the traffic loading exceeds the limits of the MRD design standards, Overseas Road Note 31 has been used. ORN31 is in use internationally and by the MPWT and is a suitable alternative for this project, as necessary.

6. The use of stabilised materials will allow the best use of either the existing materials on the road by reprocessing them or the use of local materials (or both) rather than hauling high quality materials from remote quarry sources. For this reason and because of other advantages, the use of stabilized roadbase materials is the preferred option.

7. The roads will be sealed with a double bituminous surface treatment (DBST). This is more suitable for the actual conditions rather than a single bituminous surface treatment (SBST) as originally envisaged for the project. Although it is, obviously, more costly at the outset, it is more durable, being less prone to defects and has at least twice the service life (8 years). An SBST will be required after about 8 years in-service.

8. Capacity building programs have been included in the project to promote both the implementation of the project and the sustainable capability of the local contracting industry and that of the local population through the Commune Councils. Through a series of sub-contract systems and technical and management training methods, the skills necessary to

maintain the project roads will be imparted to the provincial contractors and at commune levels.

9. Sealed roads require maintenance during their service life. Importantly resealing with another SBST will be necessary. This demand will provide the impetus and incentive for local contractors to engage in the capacity building programs so they may compete for these later works.

10. Strong capacity building programs are also included to strengthen MRD and the PDRD's as they move, for the first time, towards a significant proportion of the networks they manage becoming sealed roads. They link MRD staff training to professional engineering organizations in Cambodia. This develops sustainable capacity within the country.

11. Contractors' skills must be developed for them to be able to undertake the construction and maintenance of paved roads. A system of accreditation can be adopted to make contractors more (or less) eligible for civil works contracts. The focus for training will be through MRD and the professional engineering Institution in Cambodia. Access to construction equipment and thereby full scale practical training will be provided.

12. Vehicle overloading is a very serious issue on some of the project roads and control is essential. Education and enforcement must be undertaken to stop vehicle overloading. The project will provide the impetus and means leading to effective control. However, in the pavement design it has been assumed that the existing levels of overloading are enduring. This approach is prudent and helps to ensure the civil works are durable.

13. The social safeguards and environment component of this TA study has emphasized the role of MRD in the development of Cambodia as well as road infrastructure MRD provides safe water supplies for rural communities. In undertaking this role, it is important that a social and environmental capacity is developed at MRD to provide a focal point for both development partner programs and MRD's own programs. The office should cooperate with the MoE and other Ministries on aspects of infrastructure development for the protection of communities and the environment. Capacity building support for this is included in the project.

14. Environmental impacts arising from the upgrading of the project roads are low and are largely limited to the activities during construction. The requirement for an environmental management plan is included in the project to mitigate this.

15. It has been estimated that the project will impact nearly 0.5million people. The roads traverse through 23 districts and 71 communes. The overall opinion of the people is that upgrading the roads is more than welcomed as it will increase their opportunities and access to services. It will also reduce dust. It should be noted however that there are concerns about vehicle speeds and accident rates increasing. Road safety provisions are included in the civil works and in the capacity building components. Social safeguards studies indicate that negative impacts are low, because the provision of sealed roads instead of gravel surfaced roads is generally seen as positive. Social impacts will be managed by appropriate plans that will be developed under the project. Because the roads are to be upgraded within their existing widths, resettlement planning is not a requirement.

16. It is estimated that the upgrading will cost between $56,000 and $105,000 per kilometre of road. Estimates of costs to undertake bridge replacements and drainage works and essential additional works such as raising embankments (within the existing width) to alleviate flooding or erosion protection works for example are included at a feasibility level. Of course, detailed design is essential.

17. The results of the evaluation for each road in terms of the EIRR and the NPV are expressed in 2009 values discounted at 12%. All the sections evaluated are viable, but with a wide range in the rates of return. The lowest EIRR is 12.5% and the highest is 67.3%, with the majority in the range 15% to 30%. The rates of return are correlated with traffic levels. All of those with an EIRR above 30% have a traffic level of more than 250 vehicles plus more

than 1,000 motorcycles per day. Those with EIRRs below 15% are those with low traffic and higher than average construction costs as a result of bridge or embankment work. Benefits have not been determined for these additional works, although they would occur, and so the roads are less marginal than appears from the HDM-4 output. When all road sections are combined and evaluated as a single project the EIRR is 31.6% and the NPV US$80.8 million.

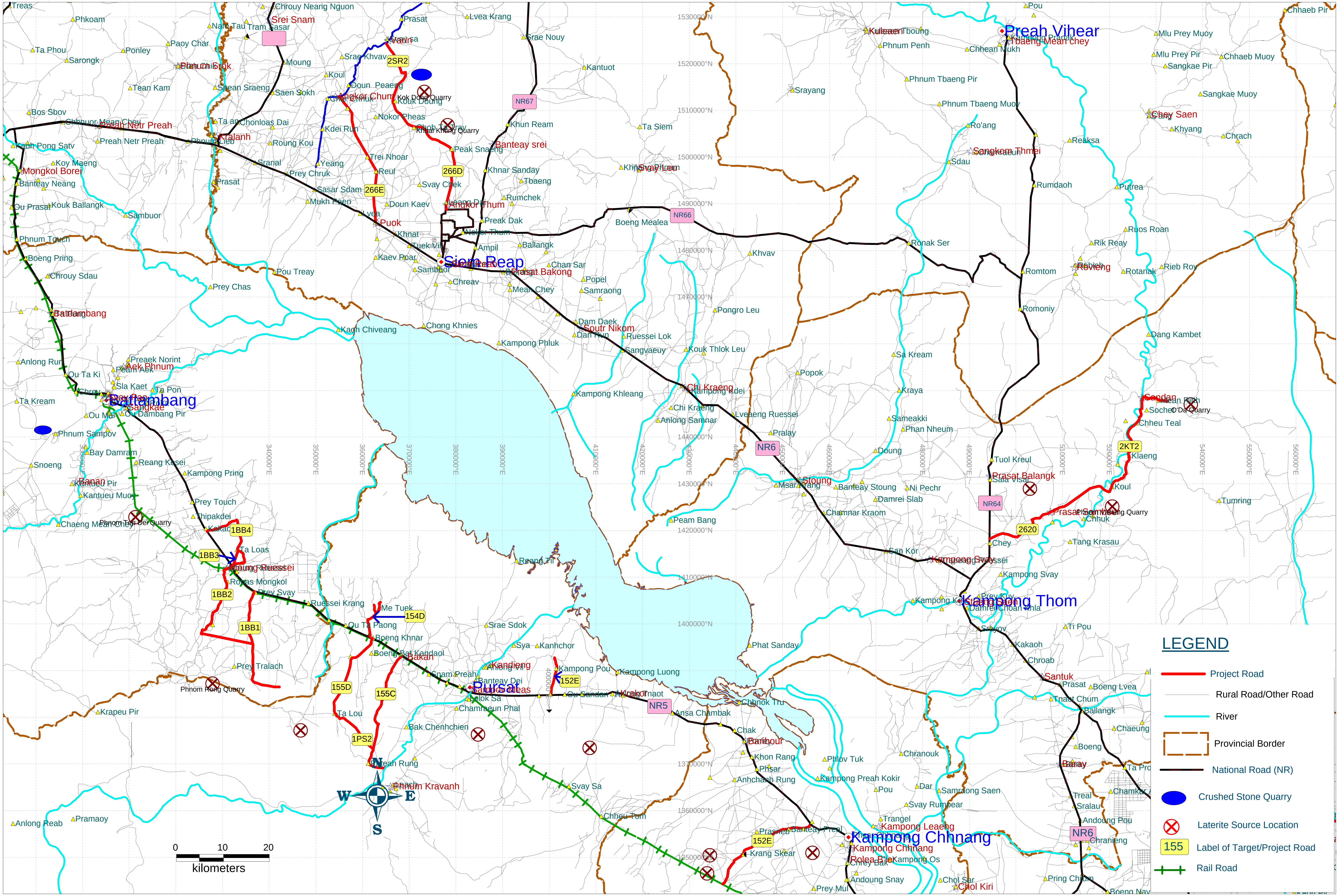
18. The Project is classified as environmental category B and an initial environmental examination (IEE) was conducted as part of project preparation in accordance with ADB Environment Policy (2002) and Environmental Assessment Guidelines (2003)

19. The environmental screening process for the project indicates that overall environmental impacts are acceptable because mitigation measures have been identified that are necessary yet sufficient to satisfy all environmental requirements in accordance with ADB requirements and Cambodian regulations. However, the IEE does not address issues associated with climate change that may be impacted upon by increased agricultural activity in the Project zone as a result of improved transport connectivity. This is an environmental issue that cannot be ignored but at present there is totally inadequate baseline data that would assist in the monitoring and evaluation of climate change.

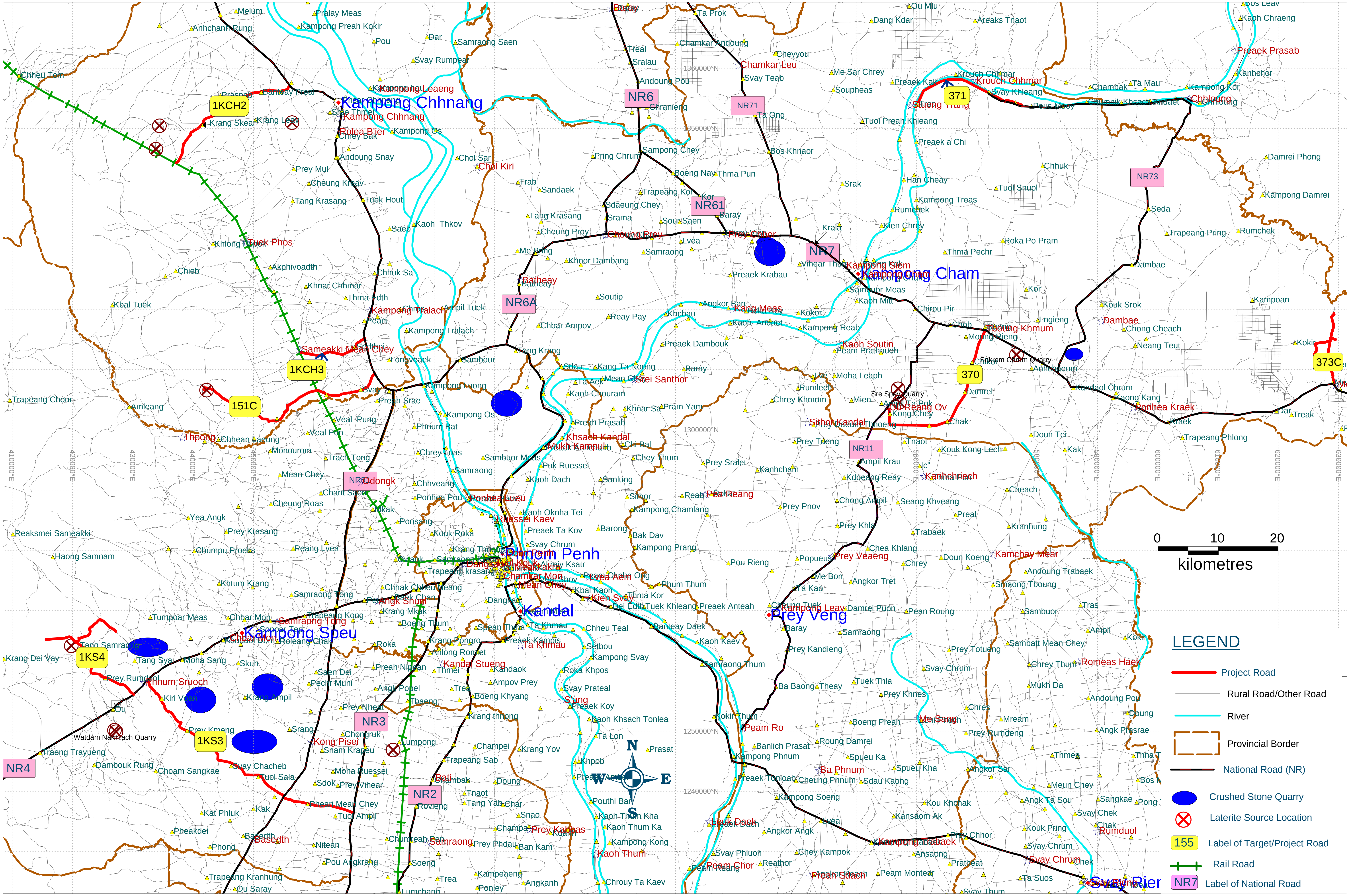
20. The potential environmental impacts, which appear to be greatest on the two roads in Kampong Thom – 2620 and 2KT2 - have been identified and mitigation measures provided. Implementation of the proposed mitigation measures and the monitoring program will reduce impacts to acceptable levels. Consequently, the IEE is regarded as sufficient and an EIA is not necessary.

21. Existing climate change projections supported by field observations highlight two major concerns related to current and future climate changes. Specifically, there appears to be an overall increase in average total annual rainfall and, this increase is poorly distributed over seasons, resulting in increased floods during the rainy season as well as increased drought incidence during the dry season. The adaptation component activities are focused on reducing the severity of climate change impacts on the infrastructure and to improve planning to prevent and respond to climate changes. Grant funding has been provided to the project to address climate change adaption requirements.

Map of Target Road Project in the Selected 7-Province
ADB-TA-7199-CAM: Provincial/Rural Road Asset Management Project



Map of Target Road Project in the Selected 7-Province
ADB-TA-7199-CAM: Provincial/Rural Road Asset Management Project



PREPARING THE PROVINCIAL/RURAL ROAD ASSET MANAGEMENT PROJECT

1 INTRODUCTION

1. The Government of Cambodia has requested the Asian Development Bank (ADB) to prepare the Provincial/Rural Asset Management Project. The objective of the project is to improve about 505kms of priority rural roads and establish capacity building programs for the Ministry of Rural Development (MRD). The length of the rural road network is approximately 28,000km or about 70% of the total road network of Cambodia. The remainder of the road network is under the responsibility of the Ministry of Public Works and Transport (MPWT). Only about 20% of the rural road network is in a fair to good condition and the remainder is in a poor condition, and is often seasonally impassable to motorised traffic. Virtually all of the rural road network at present is either gravel or engineered earth surfaced, or a simple track. Gravel and earth surfaces have often been found to have very poor durability under the climatic and traffic regime in Cambodia. They deteriorate rapidly and gravel losses are high, leading to a frequent need for reshaping and for regravelling to replace the lost material.

2. The project proposes the upgrading of 19 existing rural roads from gravel standard to a paved road standard. The provision of a durable paved road with a structural design life of 15 years will greatly reduce road maintenance costs and road user costs. Although it will be more costly to construct the upgrade, the whole life costs of the road will be lower. During the design life the road will require resealing to maintain the integrity and waterproofing function of the bituminous seal. At the end of the design life an engineered structural overlay will be required. A typical structural overlay would be an additional roadbase layer or a structural surfacing.

3. The project roads are located in seven provinces of Cambodia. Five of these are in the Tonle Sap region, namely Kampong Chhnang, Pursat, Battambang, Siem Reap, Kampong Thom and the remaining two are Kampong Speu and Kampong Cham located to the south east and north-east of Phnom Penh, respectively. The roads serve agricultural-based rural communities. A list of the project roads together with their individual lengths is given in Table 2.1.

4. The project also includes substantial elements for capacity building of MRD and for the rural roads sector to ensure the effective implementation of the project and sustainable change in the effectiveness of the delivery of services as guided by the MRD policy and strategy documents.

5. This final report describes each element of the scope of the project at feasibility stage; from a brief overview of present condition of the roads to a detailed presentation of the road improvements and the capacity building programs and social safeguards necessary for implementation. It also presents the costs which have been prepared in accordance with ADB guidelines. Engineering survey information is available as supplemental reports.

2 ROAD UPGRADING

6. The broad area for the project was prescribed in the ToR's for the project as being predominantly in the Tonle Sap region of Cambodia. In early discussions on the scope of the project, seven provinces were selected for further consideration. Five of these are in the Tonle Sap region, namely Kampong Chhnang, Pursat, Battambang, Siem Reap, Kampong Thom, and the remaining two are Kampong Speu and Kampong Cham located to the south east and north-east of Phnom Penh, respectively. Further discussions led to a list of candidate roads being prepared.

2.1 CANDIDATE ROADS

7. Discussions were held with the Provincial Departments of Rural Development (PDRD's) to obtain a prioritised list of roads within their individual provinces. A list of 38 roads with individual lengths varying from 3km to 66km was received, totalling 850kms. From the list of candidate priority roads and with consideration of ADB's objectives for the project a list of target roads was prepared for further examination. From the considerations given in the following paragraphs, and the guidance given in the consultant's ToR's a set of selection criteria were developed.

8. At present the networks of primary and tertiary roads are poorly and unreliably connected which presents a formidable challenge to the rural population because access to markets and services is restricted. Markets are limited to only those in the local area and there is little incentive to produce cash crops. Access to services especially health and education is also limited and often unreliable during the long, seven-month rainy season. Flooding of the land surrounding the roads is common place in some areas. While manageable flooding is necessary for rice growing, without adequate access through the provision of all weather roads, excessive flooding restricts the movement of people and goods.

9. The Tonle Sap region is potentially the most productive area of the country for agriculture and has received interventions in the road, agricultural sectors and other sectors from both multilateral donors including the ADB and from bilateral donors. It therefore, as a region, has the potential to produce the required benefits from the proposed investment in rural road infrastructure. Although outside the Tonle Sap region, the two provinces, Kampong Speu and Kampong Cham are in the central low land plains region of the country (to the south west and the north east of Phnom penh) and have a high agricultural potential. They are also among the poorest provinces in the country. Better road access would provide Kampong Speu with better access to markets both within the province and in Phnom Penh for example, and Kampong Cham is close to the Vietnam border and upgrading the roads would provide better access to both provincial and international markets in Vietnam.

10. Engineering considerations are that the roads selected for the project should be sufficiently engineered at the outset to enable upgrading to a paved road standard without widening, so that resettlement of road side communities and others was not required. It was recognized that once upgraded the roads could provide for the higher traffic speeds and therefore the upgrading should be considered with due regard to the safety of both road users and roadside communities. It is recognized that a road user and roadside community road safety program would be required within the project to mitigate this risk.

11. The upgrading of the selected roads should also not produce a negative impact on the local indigenous people, or on cultural, archaeological or tourist sites. While temporary environmental detractions would be managed through a suitable plan, long lasting negative impacts were to be avoided. Overall improvement of access to these sites should be viewed as a benefit in the selection of the roads.

12. It is necessary to achieve the threshold limit of 12% for the EIRR and to provide for the most project beneficiaries and, therefore, the selected project roads should be among the most highly trafficked rural roads within any particular province.

13. The strategy for rural road investments is focused on the understanding that rural road infrastructure is a prerequisite for reducing transport costs, improving access to markets, employment opportunities and to social services. Collectively, these reduce the poverty levels of the rural population.

2.2 SELECTION CRITERIA

14. The considerations were broken down into a list of selection criteria. These are given below.

15. For selection the roads must comply with the following:

- Connect to the existing paved road national and provincial network
- Support ADB's past, ongoing and future interventions for not only the roads sector but also for other sectors such as agriculture.
- Be consistent with MRD's priorities for rural development and decentralization
- Provide better access to services for remote rural communities and / or
- Provide the potential for higher economic growth by reducing transport costs for the movement of people and goods to markets and / or
- Provide the potential for economic growth through easier access to employment opportunities
- Be sufficiently engineered at the outset to enable upgrading to a paved road standard to be achieved without widening the road. Widening of structures (bridges) is seen as a necessary intervention with a positive benefit,
- not require resettlement of road side communities.
- not produce a negative impact on the local indigenous people,
- not produce a negative effect on the environment, other than the effects that occur during the construction period ,and which are to be managed through and environmental management plan
- not negatively affect cultural, archaeological or tourist sites. Improving access to these sites should be viewed as a benefit in the selection of the roads.
- be among the most highly trafficked rural roads within any particular province.
- achieve the threshold limit of 12% for the EIRR
- provide benefits for a large number of people living within the project area.

2.3 SELECTED TARGET ROADS

16. The total length of the proposed target roads for the project is approximately 505km. The individual roads vary in length from 9km to 66kms. The total length of roads is shared fairly equally between the provinces. They comprise a mix of well established and frequently trafficked road links and a number of links that have just been improved to gravel road standard.

17. Thus, the existing condition of the project roads is very variable, ranging from those that have been regravelled and otherwise maintained to a good standard as recently as this year (2009) to roads that have not been maintained recently and are in a deteriorated condition with a very high road roughness values, and very little remaining wearing course gravel. Generally the project roads that have been recently maintained or improved, have a gravel wearing course that is, at present, about 250mm thick.

18. Some of these roads may carry less traffic than others at present, however they form important links to new or established centres and are often links that MRD has invested in recently. Collectively, the project roads will provide better access to essential services, reduce remoteness and increase economic opportunities. All the project roads link to a national or provincial road and provide access to the road network at large. With the exception of one link (NR64), the national road links are paved. For the exception it is understood that paving is proposed.

19. While many of the roads carry predominantly motor cycle traffic and light 4-wheeled vehicles, a few are trafficked by heavy vehicles, at least for part of their length.

20. The project roads have varying widths both within their length and between projects. The drainage structures are often narrower than the remainder of the road and the carriageway is restricted at these locations. This constricts flow but is tolerable given the types and volumes of traffic. Existing widths are between 4m and 6m and are usually about 5m.

21. The project will upgrade the roads within their existing widths. As such, resettlement is not required.

22. The roads to be upgraded traverse 23 districts and 71 communes. As such they will positively impact 560,000 people living in the project area.

Table 2.1 List of roads for improvement

Road No.	Province	District(s)	Name of Road	Length km	Provincial sub-total km
370	Kampong Cham	Tboung Khmum-Ou Reang Ov	Cheung Lang (Phsar Soung) -Ou Reang Ov	29.4	
371	Kampong Cham	Krouch Chhmar	Peus Pir-Kdol Leu (Trea)	20.8	
373C	Kampong Cham	Memot	Memot (National Road 7)-Kabbas	18.5	68.7
2620/2KT2	Kampong Thom	Prasat Sambour & Sandan	Prasat Sambour – Sandan[1]	66.2	66.2
1KCH2	Kampong Chhnang	Rolea B'ier - Tuek Phos	Phsar Pongro - Ra Krang Skear	25.3	
151C	Kampong Chhnang	Sameakki Mean Chey	Phsar Trach-Ra Tbeng Khpos	10.4	
151C	Kampong Chhnang	Sameakki Mean Chey	Wat Tbeng Khpos-Spean Our Tatep	6.7	
151C	Kampong Chhnang	Sameakki Mean Chey	Spean Our Ta Tep-Phnom Prah Theat	18.0	
1KCH3	Kampong Chhnang	Sameakki Mean Chey	Spean Pou - Ra Mean Nor	12.5	72.8
154D	Pursat	Bakan	Boeng Khnar-MeToeuk	11.1	
152E	Pursat	Kan Dieng	Kantuot - Kampong po	8.8	
155D	Pursat	Bakan	Boeng Khnar-Taluo	20.0	
155C	Pursat	Kravanh	Trapaing Chorng - Phtas Rung	22.4	
1PS2	Pursat	Bakan	Samraong - Talou	18.3	80.5
1BB1	Battambang	Moung Ruessei-Rukhakiri	Prey Svay - Prey Tralach Ruessei Krang	24.9	
1BB2	Battambang	Moung Ruessei-Rukhakiri	NR5 (railway) – Prek Chik – Chong Por	23.2	
1BB3 & 1BB4	Battambang	Moung Ruessei	Chrey - Taloas Kakoah	23.9	72.0
1KS3	Kampong Speu	Phnom Sruoch-Basedth	Phsar Trapeang Kraloeng-Phsar Pangkassei	45.4	
1KS4	Kampong Speu	Phnom Sruoch	Kiri Reaksmei - Dak Por	23.9	69.4
266E	Siem Reap	Puok- Angkor Chum	Puok- Angkor Chum	29.6	
266D & 2SR2	Siem Reap	Angkor Thum- Angkor Chum & Varin	Leang Dai - Svay Sa	46.2	75.8
Total length:					**505.4**

Note 1: From Sandan the project map shows the road to be upgraded is to the east of Sandan. It has been agreed that from the junction at Sandan town the road to the west should be upgraded for the same distance, including within Sandan town.

2.4 PROJECT DESCRIPTION

2.5 EXISTING PROJECT ROADS

23. Except where mentioned, all roads described as gravel roads have laterite surfaces. With two minor exceptions all road sections are in flat terrain. All the roads appear to provide all-weather access, although in some cases the roads are obviously difficult to pass through after heavy rain.

24. Motorcycles dominate traffic flow on all links. Estimates of daily totals were made from moving observer counts. The number of other motorised vehicles observed was too low on all links to make a reliable estimate of daily numbers by this method, but is probably in the range of 50 –100, with less than 50 in some cases. There are exceptions, for example Project road 1KS2 in Kampong Speu and Project road 266D/2SR2 in Siem Reap (see below for origins of the road numbering system). These have active quarry operations that are generating significant heavy truck and other traffic. There are also large numbers of bicycles on some road sections. Some roads have currently ongoing improvement works, which makes it difficult to get reliable base year traffic data.

25. These notes have been prepared during an inspection to obtain an overview of the project roads. Detail such as numbers of structures and traffic volumes for example have been up-dated as necessary by the formal surveys. However, the road lengths given in the title for the particular road have been updated by the information provided by the engineering surveys. The observations given below are ordered by province and project road.

26. Road numbering follows the national system prepared for national and provincial roads by MPWT in June 2009. as shown on a map and listed in the accompanying document provided at that time. It should be noted that the numbering of many roads is different compared with earlier versions of the map, and which are still in wide circulation. Where MPWT had not assigned a road number for the roads that will be upgraded under this project, the road number has been assigned under TA 7199 using the guidance given in the document prepared by MPWT. Therefore, the road numbering used to identify the project roads follows the national system.

27. It is understood that road numbering is essentially for the road user. As such, it does not determine which Ministry is responsible for the road, although it is clear that national roads are managed by MPWT the management of provincial roads is shared between MPWT and MRD. All the roads proposed for upgrading have been declared by MRD to be their assets.

2.5.1 KAMPONG CHAM PROVINCE

2.5.1.1 ROAD 370. CHEUNG LANG (SOUNG MARKET) -OU REANG OV DISTRICT (OREANG OV MARKET) 29.4KM

28. This road starts from NR7 at Soung market and heads south, before turning west and ending at Ou Reang Ov where it connects with NR11, which is sealed. It was upgraded as an ADB project road. The first 400m is sealed with a width of 5m, the remainder is a gravel road in generally fair to good condition, with speeds of 40-55km/h being achievable. The road is generally about 5m wide. It is much rougher for the last few hundred metres near NR11 where it has a stone surface. There is one bridge (19m long) and 11 box culverts with widths of 3.4m to 4m, and two box culverts with a width of 3.3m. There is very high population density along the road,

especially near the end points. Village development is very close to the alignment near the Soung end of the road. In other places the houses are further back from the road.

29. Towards Soung there is constant motorcycle traffic, with probably 2,500 per day, and a steady flow of other vehicles. Traffic is much lower in the central section, and increases again towards Ou Reang Ov and NR11.

2.5.1.2 ROAD 371. PEUS PIR - KDOL LEU (TREA) 20.8KM

30. This road is located on the southern bank of the Mekong River. It is a westward continuation of a road from Chhloung and Roka Khnaor that has already been sealed with a width of 6m. Kdol Leu is only 14km from the start. Thereafter the road continues south from Kdol Leu, mostly as a poor standard earth road, but with a new 4m wide gravel section from km 15.4 to km 16.4. In some places around Trea the road is narrow and in very bad condition, barely passable for vehicles. The road does not continue south to connect with NR7 just east of Kampong Cham town as it appears to on maps. The end point has been confirmed to be the ferry terminal near Trea at km 19.9. At the terminal, a vehicle ferry operates across the Mekong to Stueng Trang. From Stueng Trang there is a road south to Kampong Cham, the northern third of this road is not yet sealed, but is proposed for sealing.

31. The current condition of the road is very variable. There are some newly gravelled sections in good condition, with regravelling work ongoing in some places. Speeds are very variable, being only 10km/h – 15km/h in places where there is ongoing work. There are three bridges. At around km 6.5 there is an old 100m long Bailey bridge with a width of 3.8m. At km 9.6 there is an old 40m bridge with a width of 4m and at km 13.5 there is a very old 27m bridge with a width of 3.0m.

32. Near km 9.5 the road passes very close to the Mekong river, at a distance of between 10m and 30m from the road, and river bank sliding was noted. Some stabilization/ repair works are in progress.

33. There is almost continuous roadside activity and the road passes through a number of large villages. Traffic is probably at least 1,000 motorcycles a day, plus a few other vehicles. The current traffic probably includes some associated with ongoing maintenance work.

2.5.1.3 ROAD 373C. MEMOT (NR7) - KABBAS 18.5KM

34. This road starts from NR7 in Memot and heads north on a mostly straight alignment through rolling terrain used for rice growing and rubber plantations. It has been recently maintained (in May 2009) and is in very good condition. It is 6m wide. Speeds of 50-75km/h are possible. There is a cross roads at km 11. The main route appears to be the road to the left, but the project road continues straight ahead to the small village of Kabbas at km 12.3, where it stops as a dead-end link. When the PDRD were asked about the length being of 12.3km compared with the reported length of 19.6km they said that they wished to include two connecting links. One of these is a 5km section westwards from km 7.0 through Sangkae Chas to Sangkae Kai, where it stops. The other is a 1km section from km 7.2 eastwards to the small village of Triek, from where the road continues as an earth track. Both of these connecting links were also recently maintained. A new 16m bridge with a width of 6m is located at km 6.8.

35. The area around the road appears to have a very low population density; it passes through only one small village before reaching Kabbas. Traffic is higher than expected, with motorcycle traffic over 2,500 per day and numerous other vehicles. Traffic is much lower on the final 1.3km to Kabbas and on the two connecting links.

2.5.2 KAMPONG THOM PROVINCE

2.5.2.1 ROADS 2620/2KT2. NATIONAL ROAD 64 - PRASAT SAMBOUR – SANDAN 66.2KM

36. This road starts from NR64 about 15km north of Kampong Thom town. NR64 is currently unsealed but is proposed for sealing. From the start, the road heads in a north-easterly direction through Prasat Sambour. Up to that point the condition is mostly poor with speeds of 40km/h – 45km/h is possible. In some places the road is 8m wide, with the central section in bad condition and traffic normally using the sides of the road. Beyond Prasat Sambour the road is in better condition, and is about 6m wide. Speeds are 55km/h – 60km/h.

37. At km 28.5 there is a cross roads. At this point, the original route preferred by PDRD turns left, and continues on the left side of the Steung Sen river via Ngon for about 26km to Sandan. There is a 168m, 6m wide bridge, across the Steung Sen at Sandan. The road width varies from 4.5m to 6m and is generally in good to fair condition. The alignment is poor, with a number of bends with small radii. From Sandan the road continues as a gravel road in poor condition, about 6m wide. The end point indicated on the map is the village of Tboung Tuek, which is 58.5km from the start. Beyond Tboung Tuek, the road continues eastwards and then turns south. It appears to be part of a network of roads in the area. There also appears to be no reason to end the project at Tboung Tuek or km 66. Sandan would appear to be a more logical end point.

38. From km 28.5 there is an alternative route to Sandan. This route has been chosen for upgrading. This road continues straight ahead at the cross roads and crosses the Steung Sen at km 29.5 via a newly built 122m Bailey bridge that is 7m wide. The road continues to Sandan on the east side of the Steung Sen. It is mostly 5m wide and in fair condition. The area served appears to be more developed and with a higher population than the alternative route. It serves the large village of Chheu Teal. The difference in the length of the two alignments is about 100m.

39. From Sandan the project map shows the road to be upgraded is to the east of Sandan. It has been agreed that from the junction at Sandan town the road to the west should be upgraded for the same distance, including the length within Sandan town.

40. There are six bridges on the section to Prasat Sambour including one over 50m long, all are 4.3m wide. After Prasat Sambour there are three 6m wide bridges. On the alternative alignment there are eight bridges or box culverts plus the large bridge at Sandan. These bridges include some old bridges and a Bailey bridge with widths from 3m to 4m, plus three new 6m wide bridges. There are two 6m wide bridges on the alignment east of the Steung Sen.

41. The section between km 28.5 and Sandan to the east of the Steung Sen, is subject to flooding, and this year a length of approximately 4km was flooded for an extended period, ay one month. The alternative route to the west of Steung Sen is also liable to flood, although this year the flooded length was reported to be shorter, about 1km.

42. Up to Prasat Sambour, traffic is about 1,000 motorcycles a day plus a number of other vehicles. Traffic is slightly lower beyond there. Traffic appears to be much lower on the western alternative route than on the route east of the Steung Sen. There is very low traffic after Sandan.

2.5.3 KAMPONG CHHNANG PROVINCE

2.5.3.1 ROAD 1KCH2. PHSAR PONGRO-RA KRANG SKEAR 25.3KM

43. This road starts at NR5, about 7.5km north of Kampong Chhnang town, and ends at Krang Skear railway station, although there is no station, just a few buildings there. Local people reported that no train had been seen for a month. There appears to be no road beyond this point. The length was recorded as 24.5km. the alignment passes through Krang Skear village.

44. The road was upgraded in 2008 and has not yet been handed over to MRD by the contractor. It is in very good condition and 6m wide. It is mostly straight and level, with speeds of at least 55-60km/h, sometimes up to 75km/h being possible.

45. There are two new bridges on the first 6km; they are 25m and 30m long, respectively and both have a width of 4m and posted weight limits of 15 tonnes. In Krang Skear village, at about km 17, the road crosses an old irrigation barrage that is 38m long and 4m wide. At about km 19.5 a new 6m wide bridge is under construction.

46. Traffic appears to be about 750 motorcycles, plus a few other vehicles, per day up to Krang Skear village, and then lower for the remainder of the route. At the railway, people use small trolleys on the railway tracks to take produce out, saying there is no road transport available.

2.5.3.2 ROAD 151C COMPRISING PHSAR TRACH-RA TBENG KHPOS 10.4KM; WAT TBENG KHPOS-SPEAN OUR TATEP 6.7KM; AND SPEAN OUR TA TEP-PHNOM PRAH THEAT 18.0KM

47. Originally designated a three individual roads, these three contiguous sections of road form a link westwards from NR5 and are designated as Provincial Road 151C. The first part of the road was upgraded as an ADB project. It is mostly in fair condition with a width of 5m. Speeds are generally 25km/h to 40km/h. There are three bridges in the range of 12m - 15m long, with a width of 3.5m and a posted limit of 10 tonnes. The main centres along the road are Trapaeng Mts at km 17.3 and Svay Chuk at km 21. After Svay Chuk the road standard is lower. On this section there are two 20m bailey bridges, 3.8m wide. There is a small village at km 28, after which there is virtually no sign of traffic or activity before the end point. The end point is a temple on a hill top at km 35.5. The final few kilometres approaching it has a slight upwards gradient.

48. The traffic as far as Svay Chuk is about 750 motorcycles per day, plus a few other vehicles, with very low traffic beyond there.

2.5.3.3 ROAD 1KCH3. SPEAN POU - RA MEAN NOR 12.5KM

49. This road goes westwards from NR5 to the railway at Mean Nor, from where there are roads north and to the south, connecting with the project roads mentioned above (road 151C). It was upgraded as an ADB project and is 6m wide. Currently it is in very good condition, with maintenance works being completed at the time of this

survey. Speeds of 45km/h to 50km/h are possible. There are five bridges with lengths in the range 5 to 20m, all approximately 4m wide.

50. Traffic appears to be about 750 motorcycles per day, plus a few other vehicles.

2.5.4 PURSAT PROVINCE

2.5.4.1 ROAD 154D. BOENG KHNAR-ME TOEUK 11.1KM

51. The road starts from NR5 at Boeng Khnar and heads northwards. It was regravelled in 2008 and is in good condition, but the road is only 4m to 5m wide. There is a considerable roadside activity and speeds are typically only 30km/h to 40km/h. A portal restricts vehicle height to 2.5m (posted weight limit 6 tonnes). One box culvert at km 1.4 has a 4m wide wooden deck.

52. The distance to Me Tuek is only about 7.7km. The original proposal was to continue the project to a school at Chen Tay, 11.6km from the start. This section is of a lower standard, mostly 3.5m to 4m wide and becomes a track towards the end. PDRD now say they would prefer to cut about 2km from this section, and include in the project a spur road from Me Toeuk to a road junction at Angkanh, a distance of about 1.8km. This spur road is currently an earth track in poor condition. A secondary school is under construction about 400m from Me Toeuk along the spur road.

53. Traffic flow as far as Me Toeuk was estimated at 1,000 motorcycles per day plus bicycles. No other vehicles were observed.

2.5.4.2 ROAD 155D. BOENG KHNAR-TALUO 20.0KM

54. The road starts from NR5 at Boeng Khnar and heads south to Taluo. The first 300m of the road is through a busy market area. The end point is a market and road junction at Taluo, at 19.3km. The road was upgraded in 2009, is 6m wide and mostly in good condition. It generally has a straight alignment and speeds are 50km/h to 65km/h.

55. There is one new bridge 6m wide, and two culverts or irrigation channels, with old wooden decks.

56. Traffic is estimated at about 750 motorcycles per day, with several other vehicles observed.

2.5.5 BATTAMBANG PROVINCE

2.5.5.1 ROAD 1BB1. NR5 (PREY SVAY) PREY TRALACH RUESSEI KRANG 24.9KM

57. Originally proposed as a U-shaped loop on the south side of NR5 with a length of 48km, the road to be upgraded is the western part of the link described below, a length of 24.9km.

58. The junctions with NR5 are about 7.5km and 17km east of Moung Ruessei. Work has recently been completed on the western side of the loop to provide a 7m wide earth embankment. This continues for about 25km to just beyond the village of Sdok Proveuk. Work is due to start soon on a 6m wide laterite surface on this section. It is reported that the upgrading is being carried out because a new district

has been created, and a new district HQ town will be established in the area. Currently the land around the road is used mostly for rice growing. The population density appears to be low. There is one 5.3m wide bridge (built in 2007) and a bridge is required at about km 11.5.

59. On the eastern section, from km 25 back to the end point at NR5, the road is a gravel road in variable condition. It is mostly about 3.5m wide on a 4.5m wide embankment. Some sections were maintained in 2007 and are in good condition, with speeds of 45km/h to 50km/h possible. Other sections are reported to have had no maintenance for ten years and are in bad condition, with speeds of 20km/h. This section has two new 5.3m wide bridges and a 30m long wooden bridge that is 3.9m wide.

60. Traffic is low throughout, probably about 750 motorcycles a day. Some contractor's vehicles are operating on the western section.

2.5.5.2 ROAD 1BB3 AND ROAD 1BB4 NR5 (CHREY) TALOAS KAKOAH 24.0KM

61. This project consists of two connected roads northeast of NR5, both starting at Moung Ruessei. The main section is a loop road of about 20km length that rejoins NR5 at Kakaoh, about 9km north-west of Moung Ruessei. The first 11.5km was upgraded in 2004 under an ADB project. It has a crushed stone 5m wide surface that is in good to fair condition, but has a rougher surface than the roads surfaced with lateritic gravels. Some sections have a poor horizontal alignment and speeds are about 35km/h to 40km/h. There is a lot of roadside activity. On the straighter sections speeds are about 50km/h. Beyond km 11.5, the next few kilometres are an earth/stone surface in very bad condition. Speeds are as low as 5 – 10km/h in places. Beyond that, it is a gravel road in fair condition, with a width of about 3.5 – 4m, and speeds are 35km/h to 40km/h. There are no bridges on the loop road. PDRD reported that they will upgrade the section of the road from km 11.5 to the end at Kakaoh as a high priority.

62. The other road starts at NR5 in Moung Reussei, about 600m north-west of the start of the main loop road. Apart from a 90 degree bend about 500m from the start, it is a straight road with a length of about 3.6km. It connects with the loop road at km 6.4 on the loop road. It was also part of the 2004 ADB project and has the same crushed stone surface mentioned above. There is a 7.5m long bridge that is 3.3m wide immediately before the 90 degree bend.

63. Motorcycle traffic appears to be highest on the 3.6km connecting road, at about 1,500 per day. It is about 1,000 per day on the ADB project improved section of the loop road, and much lower on the rest of the road. A total of three other vehicles were observed on the two roads over a one hour period.

2.5.6 KAMPONG SPEU PROVINCE

2.5.6.1 ROAD 1KS3. PHSAR TRAPEANG KROLOENG-PHSAR PANGKASSIE 45.4KM

64. This road provides a link between NR4 and NR3. It consists of two sections, separated by about 200m of NR51 at Svay Rumpea.

65. The 37.1km western section between Phnum Sruoch on NR4 and NR51 is in fair to poor condition, with poor drainage in places. The route appears to be made up of a series of roads in the local area network, with sharp bends at several points

when joining the next section. The width appears to vary between 5m and 6m. Average speed is 25km/h to 30km/h. There are some bad sections near Highway 51 with speeds of only 10km/h. There are eight bridges and two floodways. All of the bridges are less than 5m wide and most are only 3.5m wide. There is a large quarry located near the road about 3km west of NR51, but no associated vehicles were observed on the road.

66. The 12.3km eastern section, from NR51 to NR3, is mostly in fair condition and has a straight alignment, with speeds of 40km/h to 55km/h possible. The width is 6m. There is a private toll collection point for trucks. There are no bridges on this section.

67. Traffic appears to be higher on the eastern section, with about 1,500 motorcycles per day compared with less than 1,000 on the western section. A few other vehicles were observed.

2.5.7 SIEM REAP PROVINCE

2.5.7.1 ROAD 266E PUOK - ANGKOR CHUM 29.6KM

68. This road starts from NR5 just west of Puok market and heads north. For the first 500m it has a 4m wide concrete pavement. The rest of the road has a 5m gravel surface. It is reported to have been regravelled in 2008 as an ADB project and has a lime stabilised base, but now is in fair to poor condition. Speeds are 35km/h to 40km/h, lower in some places. At the end point it joins a sealed road.

69. There are 22 box culverts. All appear to be 5m long and 3.6m wide, with side walls. At about km 25, there is an 18m bridge, which is 4.5m wide,.

70. Traffic is estimated at 1,000 motorcycles a day plus a few other vehicles.

2.5.7.2 ROAD 266D AND 2SR2. LEANG DAI – SVAY SA 46.2KM

71. This road starts on the north side of the Angkor Wat area and heads north. It was built in 1998 as an ILO project and some sections were regravelled in 2004. Most of the road is in poor or bad condition having been damaged by the heavy trucks operating on the road from a quarry. The trucks are not allowed to use the first 2.5km of the road near Angkor Wat, and do not appear to operate north of the junction with the quarry access road at km 34. Some sections have been regravelled with crushed stone by the quarry. The width of the road is 5m – 6m. Speeds vary from 20km/h – 45km/h depending on condition. The alignment of the road could be significantly improved before the village of Doun Aem starting around km 34, but this would require a new bridge.

72. There are three floodways and four bridges, varying in length from 5m to 20m. The width of the bridges varies from 3.9m to 5.3m.

73. Relatively few motorcycles use the road; they are reported to use other roads because the project road is very dusty. Heavily loaded trucks, mostly 3-axle heavy trucks, from the quarry use the road for about 30km. North of km 34 no traffic was observed.

3 ROAD IMPROVEMENTS

3.1 ROAD DESIGN

3.1.1 ENGINEERING SURVEYS

74. Engineering surveys have been carried out on each of the roads proposed for improvement. These have included topographical, geological, and hydrological studies and measures of existing pavement strengths. The detail of the surveys is consistent with a feasibility study. More detailed studies must be carried out during the project implementation stage to provide the detailed design for civil works contracts. Traffic studies and social and environmental studies have also been carried out, as mentioned later in this report.

3.1.1.1 TOPOGRAPHICAL

75. Limited topographical surveys have been carried out commensurate with the accuracy required for a feasibility study. Start and end locations of the project roads have been established and GPS tracks were used to estimate road length. The odometer feature of the GPS units as well as the summation of distances between frequent individual GPS measurements such as those taken at structures were also used.

76. The widths of the existing roads were measured frequently including the widths at structures where the road often narrowed.

77. Typical existing road cross-sections were taken using optical leveling equipment at a minimum of three locations along each of the project roads.

3.1.1.2 GEOLOGICAL

78. Under the geological studies, the PDRD's provided the locations of the material sites that were in use in the vicinity of the project roads. These were sampled to obtain information on the quality of the materials. In addition, test pits were dug at three widely spaced locations on each of the project roads to determine the quality of the materials actually in place. The data obtained show that, where the gravel wearing course remains, as it does on most of the project roads, it is typically a reasonably well-graded plastic gravel, however the properties are variable from place to place. With suitable attention to material quality requirements, and generally minor improvements of the gravel wearing course materials as necessary, the existing gravel wearing course materials may be used as sub-base materials for the project roads.

79. The PDRD's information and an inspection of maps have provided the locations of the major aggregate quarries in the provinces and within the area of the project roads. These are shown in the maps presented in this report One major quarry exists within the provinces of Kampong Cham, Battambang, Kampong Speu and Siem Reap. The provinces of Kampong Thom, Kampong Chhnang, and Pursat do not have quarries and aggregates for construction purposes are hauled from neighbouring provinces.

80. The quarries are commercial enterprises and their materials are of suitable quality for use as well-graded aggregate base materials or single sized aggregate for bituminous surface treatments.

3.1.1.3 HYDROLOGICAL

81. The locations of all structures: pipe culverts; box culverts and bridges have been identified and logged using a hand held Global Positioning Satellite (GPS) receiver. Dimensions have been measured and an indication of the condition has been made. The dimensions of water courses have been estimated, and interviews have been held with the local communities to estimate whether or not there has been any flooding of the road historically. Photographs were taken of all structures.

3.1.2 EXISTING PAVEMENT STRENGTHS

82. The existing pavement strengths were determined using a Dynamic Cone Penetrometer (DCP). Tests were carried out at one kilometre intervals on each of the project roads. The tests were located at 1.5m from the centre of the road and measurements of strength were taken continuously to a depth of approximately 500mm below the surface. Through a calibration, the strengths are reported as measurements of California Bearing Ratio (CBR). Although the strengths of gravel surfaced roads near the surface are strongly related to the season of the year and recent rainfall, the strengths at depth are much less so. For established, existing roads they give an indication of the strength of the subgrade. The tests were carried out in July during the wet season. With caution not to overestimate the strength, the data obtained are suitable for an estimate of the subgrade strength for pavement design purposes at the feasibility stage of the project design. The data may be used with the pavement design chart(s) such as those given in Table 5.1. During the detailed design stage of the project the strength of the subgrade materials can be measured by testing samples in the laboratory as necessary to confirm the pavement design.

83. Generally the subgrades of the project roads are strong and they will provide a suitable foundation for the placement of the pavement.

3.2 EXISTING TECHNICAL SPECIFICATIONS AND DESIGN STANDARDS

3.2.1 GEOMETRIC DESIGN STANDARDS

84. MRD in association with SEACAP has prepared a set of geometric design standards suitable for the various classifications of road under its portfolio. These proposed design standards have been adopted for the project roads where possible, although because the project involves upgrading of existing roads without widening, the project roads may not be fully compliant with all the requirements of the standards. The proposed rural road classification in terms of traffic is shown inTable 3.1 and Table 3.2.

Table 3.1 Proposed classification of rural roads

Class	AADT of 4-wheeled vehicles	Width of running surface (m)	Sub class	PCUs of non 4-wheeled vehicles	Width of shoulders (m)	Total width (m)
RR 1	200 to 500	6.0	A	>300	1.5	9.0
		6.0	B	< 300	1.0	8.0
RR 2	100 to 200	5.0	A	> 300	1.5	8.0
		5.0	B	< 300	1.0	7.0
RR 3	30 to 100	3.5	A	> 300	1.5	6.5
		3.5	B	< 300	1.0	5.5
RR 4	5 to 30	3.0	A	> 300	1.0	5.0
		3.0	B	< 300	0.75	4.5
RR 5	< 5	2.5	A	>300	1.0	4.5
		2.5	B	<300	0.75	4.0

Source: MRD draft Technical Standards 2009

Table 3.2 List of Passenger Car Unit (PCU) values

Vehicle	PCU value
Bicycle	0.3
Animal cart; bicycle with trailer	0.4
Motor cycle	0.4
Motor cycle with trailer [1]	1
Passenger car	1
Light vehicle/van	1
Mini bus 4 tyres; pickup truck; Sarmlor [2]	1.1
Bus > 4 tyres	2.3
Light truck and Koyun[3] with 4 tyres	1.5
Medium truck 6 tyres	2
Heavy truck > 6 tyres	2.5

Source: MRD draft Technical Standards 2009

3.2.1.1 TYPICAL ROAD CROSS SECTIONS

85. A typical road section is shown in Figure 3.1. The Figure shows the seal extending over the road shoulder. The project roads are between 5.5 and 7m wide,

although many narrow through structures. (The typical width used for the individual roads are given in Table 5.2.)

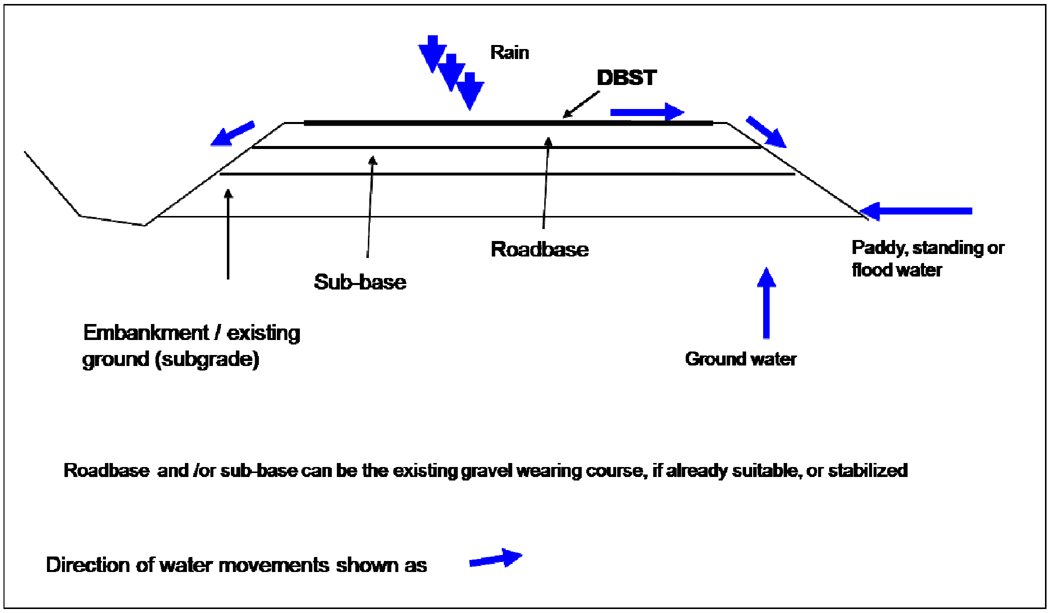


Figure 3.1 Typical road cross-section

3.3 DRAINAGE STRUCTURES

86. Details of the bridges and numbers of locations of the box and pipe culverts are given in Table 3.3. Further details are given in the supplementary Appendices.

3.3.1 DESIGN FOR REPAIR OR REPLACEMENT

3.3.1.1 BRIDGE REPLACEMENTS

87. Improvements to drainage structures and bridges are generally limited to those repairs required to provide reliable service for 15 years at least to match the planned design life of the pavements. Thereafter, further improvements can be undertaken along with structural improvements of the road pavement. Bridges have been designated for replacement if they are of timber construction or if they are other types of bridges and have been recorded as damaged in the engineering surveys. No new locations for bridges have been identified. Many of the bridges to be replaced are narrow. However, the replacement bridges have been planned with a width of 8m to provide good, safe movement for all road users now and in the longer term.

3.3.1.2 CULVERT REPLACEMENTS

88. Box and pipe culverts have been designated for replacement if they were recorded to be in fair, poor or damaged condition. A number of new locations for box or pipe culverts have been identified again based upon the engineering surveys. In particular, new drainage structures are to be provided where actual flooding had occurred based on interviews and observations and where it was reported that the flood waters were significantly higher on one side of the road than the other, such that the road was acting as a dam. A severe example is road 2620/2KT2 in Kampong

Thom province along the section of road to the east of Stueng Sen, where the Stueng Sen was in flood while the engineering surveys were in progress, and the differentials in water level on each side of the road were most evident. However, these measures are not enough alone to cope with flooding from the Stueng Sen and the road must be raised as discussed in paragraph 89 below. Another example is road 155C in Pursat province which was flooded over a length of 170m. It was reported that this road was not, historically, subject to flooding, but, as reported by the PDRD, recent agricultural developments have changed the patterns of water movements and culverts at new locations are required.

3.3.1.3 FLOOD PREVENTION

89. A 4km section of road 2620/2KT2 was severely flooded in September/October 2009. Flood waters were expected to reach levels of 0.65m above the existing level of the road in places, and may have exceeded these levels. To rectify this situation the project has planned that the road should be raised by up to 1m over a 4km length. The existing sideslopes are shallow at about 1:4 (vertical to horizontal) and the road can be raised within its existing width by steepening the sidelopes. Slope protection has been planned under the project using hard engineering and bioengineering at severe and less severe locations, respectively. It will be evident that detailed design is required to accurately design suitable remedial measures for the flooded sections of road, and this process is essential at the detailed design stage.

90. If the scope of works to prevent flooding of the road are determined to be beyond this project, because of the cost of the works required, the detailed design engineers should consider upgrading the section to the west of the Stung Sen from km 28.5 to Sandan. The western section also floods but it is understood to a lesser extent, affecting about 1km. Two factors should be considered for this road: (i) it is important to ensure access to Sandan for disaster alleviation purposes (as evidenced this year) and (ii) the eastern route (as currently selected for improvement) serves more population centres. Both the east and west sections of the road were surveyed under this feasibility stage of the project and data is available for the western section in the Supplemental appendices.

3.3.1.4 EROSION PROTECTION

91. Erosion is severe on two roads. Road 371 in Kampong Cham is adjacent to the Mekong river for most of its length. The engineering surveys recorded that it was within 10metres of the road over a length of 340m and within 20m to 30m of the road for a length of approximately 1.5km. Sliding of the road sideslopes was reported and minor repair works were in progress at the time of the surveys. The project has made a financial provision for gabion boxes and gabion mattresses in this area over a length of up to 350m and for bio engineering to be carried out as necessary over other areas that are at risk. However the situation is severe and careful consideration will be needed at detailed design to decide actual works that can be carried out. The Road 1KS2 in Kampong Speu province has also suffered extensive erosion. In this case because of the release of flood waters from an earth dam. The existing gabion mattresses have been undermined and severely damaged. Provision has been made to repair or replace the erosion protection measures and provide bio engineering solutions to stabilize the ground at less severe locations.

92. Erosion is evident on many roads to a greater or lesser extent. Often it is caused by the localized concentration of water because of a particular defect in the existing road which can be readily rectified during the upgrading process. However it

is expected that the sealing of roads cause far greater surface runoff than from gravel-surfaced roads and the potential for erosion may be greater. Good engineering practice and attention to detail will mitigate these effects. Grass cover can be expected to grow on most sideslopes.

3.3.1.5 PROVISION OF CONCRETE SIDE DRAINS

93. Concrete "U" shaped and covered side drains are required at a number of locations on some of the project roads where open unlined side ditches are not suitable. These have been planned for roads 373C, 1KCH2, 151C, 155D AND 1KS3, for lengths of approximately 250m for each road where the road passes through market areas.

94. The civil works to be undertaken are conventional; comprising concrete works using either precast materials, or those manufactured on site. The use of bio engineering has been introduced as a low-cost method of stabilizing road slopes that are at risk and where natural grass cover is not adequate.

95. Other than where maintenance, repair or replacement of the drainage structures including ditches is required, the civil works will be carried out from within the width of the existing road.

Table 3.3 Structures

Road No.	Province	Name of Road	Road Length	Bridges				Box culverts			Pipe culverts		
				Existing		Repair/ replace		Exist-ing	Repair /replace	New Location	Exist/ ing	Repair/ replace	New location
			Km	No.	Length m	No.	Length m	No.	No.	No.	No.	No.	No.
370	KC	Cheung Lang (Phsar Soung) -Ou Reang Ov	29.4	1	19			13	3		46	3	
371	KC	Peus Pir-Kdol Leu (Trea)	20.8	3	163	2	70	2	1		1	1	1
373C	KC	Memot (National Road 7)-Kabbas	18.5	1	17						17		
2620/2KT2	KT	Prasat Sambour - Sandan	66.2	8	317			8	0	6	72	3	6
1KCH2	KCH	Phsar Pongro - Ra Krang Skear	25.3	3	102			2			36	2	
151C	KCH	Phsar Trach-Ra Tbeng Khpos	10.4					2	1		13	2	
151C	KCH	Wat Tbeng Khpos-Spean Our Tatep	6.7	2	17						9		
151C	KCH	Spean Our Ta Tep-Phnom Prah Theat	18.0	3	69			2			19	2	
1KCH3	KCH	Spean Pou - Ra Mean Nor	12.5	3	37			3			11	3	
154D	PS	Boeng Khnar-MeToeuk	11.1					2			16	3	
152E	PS	Kantuot - Kampong po	8.8										
155D	PS	Boeng Khnar-Taluo	20.0	2	30	1	12	2	2		15	1	
155C	PS	Trapaing Chorng - Phtas Rung	22.4	1	20	1	20	1	1	2	35	1	
1PS2	PS	Samraong - Talou	18.3	1	9	1	9	1	1		20	1	
1BB1	BB	Prey Svay - Prey Tralach Ruessei Krang	24.9	1	7				3		13	1	
1BB2	BB	NR5 (railway) – Prek Chik – Chong Por	23.2								35	4	
1BB3 & 1BB4	BB	Chrey - Taloas Kakoah	23.9						5		24	14	
1KS3	KS	Phsar Trapeang Kraloeng-Phsar Pangkassei	45.4	4	73				16	1	17	3	1
1KS4	KS	Kiri Reaksmei - Dak Por	23.9	3	114				5	1	33	1	
266E	SR	Puok- Angkor Chum	29.6	1	20				23		31	2	
266D & 2SR2	SR	Leang Dai - Svay Sa	46.2	3	58				15		34	3	
Totals			**505.4**	**40**	**1073**	**5**	**111**	**105**	**17**	**9**	**497**	**48**	**8**

3.4 ROAD FURNITURE

3.4.1 ROAD SAFETY CONSIDERATIONS

96. The road accident rates in Cambodia are high and considerably higher than those in neighbouring countries. Driver behavior is often poor and the road safety knowledge of road users is lacking.

97. Paving the project roads will often lead to increases in vehicle speeds. Also, many of the existing road drainage structures or bridges are narrower than the sections of the same road without structures and so the passage of vehicles is restricted. These conditions reduce road safety.

98. The project roads have inadequate signage and that which is in place is often found to be in a poor state of repair. Repairs or replacement of existing road furniture and safety signage will be undertaken as necessary, and additional road signage will be provided to aid road safety. At some locations, traffic calming measures will be undertaken to improve road safety.

99. Road marking will be provided at locations where the line of sight is restricted. Provision of road edge marking on the approach to structures and other objects has been included to guide the road user. Painting of structure and obstacles has also been included to make them more visible. In the detailed design consideration should be given to providing carriage way markings to guide 4-wheeled vehicles towards the road centre (for narrow roads) and leave a marked area for vulnerable road users. It will also help to keep heavy vehicles closer to the centre of the road and away from the outer shoulders where less lateral support is provided to the road structure and the risk of shear deformation is greater.

100. The southern end of Road 371 in Kampong Cham including the village of trea is narrow and passes through a densly populated area with houses very close to the road. Extra road safety provisions have been made for this length including traffic calming and longitudinal pedestrian barriers where necessary to limit direct access to the road. It will be essential to limit vehicle speeds along this length of road.

4 TRAFFIC

4.1 INTRODUCTION

101. All of the roads included in the study are open to traffic and the majority have unrestricted access for the whole year. Benefits from upgrading will therefore be predominantly from road user cost savings. The accuracy of an appraisal of such roads is very dependent on the accuracy of the estimates of the base year traffic level and the future growth in traffic. Considerable effort was therefore made to determine traffic levels accurately for each road. Although a number of the roads have been improved under donor assisted projects, and therefore subject to some form of appraisal, no previous traffic count data for the roads could be located. For this study, manual classified counts were carried out on all roads, in many cases at more than one site, to provide the main source of traffic information. In addition, moving observer and automatic counts were also carried out.

102. Following the usual conventions, traffic levels are expressed in terms of daily traffic flows. When expressed as total traffic over 24 hours the term Average Daily Traffic (ADT) is used. When seasonal variations are taken into account the term Annual Average Daily Traffic (AADT) is used. Estimates of AADT were used as the basis of the economic appraisals.

4.2 TRAFFIC SURVEYS

4.2.1 CLASSIFIED COUNTS

103. Manual, classified traffic counts identifying different vehicle types, were carried out on all project roads for two days. The standard procedure was to carry out the count over a 12-hour period, from 6AM to 6PM. Often the count commenced during the day, to enable close supervision of the initial counting. In these cases counting was carried out over three days, with counting on the third day continuing up to the time that counting commenced on the first day. Thus, there was always 24 hours of counting between the hours of 6AM to 6PM. A minimum of one site was used on each road. Additional sites were used where there was believed to be a difference in traffic flow along the road; for example on either side of a large village or a major road junction. The locations of the sites were chosen as points where traffic levels were believed to be typical of the whole road, or section of road, being covered by the count. Sites near the start or end points, or any other junctions with motorable roads, were avoided. Care was taken to avoid locations near markets, schools or any other site where there may be large numbers of motorcycles and bicycles making very short distance journeys not typical of the whole length of the section. However, for practical reasons sites needed to be in villages or immediately adjacent to them, and often the amount of non-motorised traffic recorded was clearly above general levels along the road. This was particularly the case for bicycles, which are used by large number of children going to/from school. The results were adjusted to compensate for this, and produce an estimate of average non-motorised traffic levels along the while section length. Traffic was recorded separately for each hour. There is evidence that daily variations are not significant, and so counting did take place on Saturdays and Sundays in some cases. (An exception to this is bicycle traffic associated with journeys to/from school as discussed below.) In the case of four of the sites a second two-day count was undertaken to verify the traffic level indicated by the first count.

4.2.2 VEHICLE TYPES

104. A more extensive vehicle classification system than that used for some other studies was adopted to enable the characteristics of vehicle types used in the economic evaluation to be specified more accurately. The vehicle categories identified in the counts were:

Non-motorised

- Bicycle - All two and three-wheeled non-motorised vehicles, including cyclos and those used for carrying freight.
- Animal Cart - All animal drawn-vehicles (Ox-carts, Buffalo-carts, horse and cart).

Motorised

- Motorcycle - Motorcycles, scooters and any other 2-wheeled motorised vehicles, but not those with trailers. Motorcycle traffic dominates vehicle movements on virtually all roads.
- Motorcycle with Trailer - Motorcycles with a trailer (remoque), or any 3-wheeled motorised vehicle, used for freight or passenger transport.
- Car - This type includes sedan cars and station wagons (but not 4-wheel drive vehicles) with a maximum of 7 seats.
- 4-wheel Drive Vehicles - All four-wheel drive (FWD) vehicles, such as Toyota Landcruiser or Mitsubishi Pajero, with a maximum of 7 seats.
- Pick-up - Vehicles such as the Toyota Hi-lux designed for use as light freight vehicles, but are also used for private transport as an alternative to sedan cars. They are also known as utilities. Very small trucks are also included in this category, being distinguished from the Light Truck category in having only single wheels on the rear axle. If it appeared that a pick-up was being used for private passenger transport, especially a twin-cab model, it was counted as a Car or a 4-wheel Drive Vehicle as appropriate. If converted for public transport use, with seats and a canopy or roof over the rear section, it was counted as a Minibus.
- Minibus - The minibus type is typically an 8-12 seat vehicle, such as the Mercedes MB 140D (now replaced by the Sprinter), sometimes referred to as a microbus or van.
- Bus - All buses with more than 16 passenger seats. They are distinguished from the Minibus type by having dual-wheel on the rear axle. (Very few buses operate on rural roads in Cambodia.)
- Small Koyun/Etan - Small tractors made into a road vehicle by attaching a single-axle trailer, or small, slow moving, locally-made trucks.
- Large Koyun/Etan - Locally-made trucks that typically have low capacity engines not always designed for motor vehicles. These are much slower than conventional vehicles and are normally only used for short distance freight movements.
- Light Truck - These are trucks with a payload of up to 4 tonnes. They have two axles and dual-wheels on the rear axle. If converted for passenger transport and carrying passengers they were counted as buses.

- Medium Truck - These are larger trucks than the light truck, but also have two axles and dual-wheels on the rear axle. They have a carrying capacity up to 10 tonnes. Although sometimes difficult to distinguish from the Light Truck in traffic counts most are much larger. There are significant differences between these two types, especially in terms of axle loads, and it is considered desirable to obtain information on the numbers of each for use in feasibility and pavement design studies.
- Heavy Truck - All 3, 4 or 5-axle rigid trucks, articulated trucks and truck-trailers. A large range of such vehicles operates in Cambodia but most have a similar ESA, and numbers are very low on most of the study roads, thus a single category was considered to be appropriate.

105. If any vehicle did not meet one of the above descriptions, it was recorded as the vehicle type it was closest to in appearance and size (for example an ambulance would be recorded as a Minibus). The only exceptions were graders, rollers and other equipment used in road construction or maintenance. These were excluded, but all other vehicles were included even if they did not match exactly one of the types shown on the form. Pedestrian movements can be included in an HDM-4 analysis, with benefits related to higher walking speeds on improved roads. However, it is difficult to determine appropriate levels of traffic and the benefits are minor, so pedestrian traffic was not included.

4.2.3 MOVING OBSERVER COUNTS

106. Moving observer counts were made during the initial field surveys, recording the levels of motorcycle traffic and the total of all other motorised traffic traveling in the opposite direction at approximately 5km intervals along the roads. Traffic levels were too low for these to be used as an indicator of the overall level of traffic, but they could be used as a guide to levels of motorcycle traffic, and of the variation of traffic flow along each road. Their main use was in planning the manual classified counts, in particular identifying where more than one count site was required and in providing information on the vehicle types in use on the study roads.

4.2.4 AUTOMATIC COUNTS

107. The Consultants have also undertaken some traffic surveys using an automatic counter. The equipment, which can be buried beneath the surface of gravel roads, detects vehicle movements by monitoring the disturbance that passing vehicles cause to the earth's magnetic field. It was used to record total hourly traffic levels for a continuous period of seven days. The counter is not designed to record motorcycle movements, but does so when a motorcycle passes directly over the counter. The results therefore include all four-wheel vehicles and some motorcycles. Because traffic levels are dominated by motorcycles the results are not reliable as an indicator of total traffic flows, but the results can be used as an indicator of daily variation and of the relative levels of day-time and night-time traffic.

4.3 ESTIMATES OF BASE YEAR TRAFFIC

108. A number of adjustments were made to survey data to estimate the 2009 traffic flows on the Study Roads in terms of annual average daily traffic (AADT) to serve as the base year traffic figures.

4.3.1 24 HOUR ADJUSTMENT

109. The counts were for 12 hours and estimates of night-time traffic were required to adjust the results to a 24 hour basis. The ratio to adjust a count of less than 24 hours to an ADT basis is normally higher for inter-urban roads than on rural roads, and on high traffic roads compared with low traffic roads. When the 12-hour count results are for the period between 6AM and 6PM the 24/12 adjustment factor for rural roads is normally in the range 1.1 to 1.3. It is rarely above this, but can be as low as 1 in some cases. The Northwestern Rural Development Project[1] carried out some 24-hour counts and from these assumed a factor of 1.1. The 24-hour automatic count results indicated that a factor of 1.1 to 1.2 was consistent over a period of seven days. A factor of 1.11 has been applied, which is consistent with an assumption that 90 percent of traffic occurs in the 12 hours between 6AM and 6PM.

4.3.2 DAILY TRAFFIC VARIATION

110. Traffic counts are often carried out over a continuous period of seven days. The reason for this is that daily traffic levels often vary in a regular pattern, reflecting the distribution of activities relating to work, trading and recreation over a week. When this occurs, extending traffic counting periods progressively towards seven days results in increasing levels of accuracy of an estimate of ADT as more of the daily peaks and lows are included in the count period. Increasing the count period beyond seven days continues to improve the accuracy, but the rate of improvement is less. In this study the emphasis was on counts at different locations to determine changes in traffic patterns along study road sections rather than on long counts at one location. The only seven-day counts were those using an automatic counter. The results showed that the daily variation is random and there is no reason to adjust for the days of the week on which counting took place, even if these were Saturdays and Sundays. The automatic counts did not record bicycle traffic, and this would be expected to show daily variation as much of it is associated with journeys to/from school, but it is not considered important in terms of the impact on viability or on road design, and so was not taken into account in planning the traffic counts.

4.3.3 SEASONAL VARIATION

111. Seasonal patterns to traffic need to be considered in producing an estimate of AADT. The major seasonal influences are usually crop harvesting, causing peaks in traffic flows, and rainfall, disrupting traffic on unsealed roads and reducing traffic levels over much of the road network. The peaks of traffic in harvest seasons may be predominantly caused by passenger vehicles rather than those transporting crops; the increased traffic reflecting more movement of labour and generally increased activity at that time.

112. Continuous automatic counting carried out on National roads does show a seasonal pattern; with peak traffic in January/February and low traffic in August/September. Some of this is likely to be caused by rainfall, with the impact of rainfall on road condition, and hence on traffic level, probably higher on unsealed and flood-prone roads directly affected. However, there is no direct evidence of the amount of seasonal variation in traffic levels on the project roads.

[1] Ministry of Rural Development – Northwestern Rural Development Project – ADB Loan 1862-CAM (SF) – Report on Provision of Appropriate Pavement Designs and Socio-Economic Evaluation of Rural Road Improvement from Gravel to Durable Surfaced Road - Intech Cambodia - March 2006

113. These factors show that traffic levels are usually below the AADT during the period July to November, with lowest traffic levels in August when traffic is on average 80 per cent of the AADT. Most of the traffic counts for this study were carried out in August, with a second phase in September, and a seasonal adjustment factor of 1.2 was applied to derive an estimate of the AADT from the traffic count results.

4.3.4 DERIVATION OF BASE TRAFFIC LEVELS

114. From the information referred to above base year traffic levels were estimated for each section of road. A summary of the traffic data is shown in Table 4.1 with more detailed information showing traffic by vehicle type shown in Table 4.2. In all cases the traffic level is an estimate of the traffic over the designated section for the year 2009. Traffic levels are shown in terms AADT, that is vehicles per day, with the total traffic flow in terms of PCUs also shown in Table 4.1. The PCU values for each vehicle type are as shown in the previous chapter (see Table 3.2).

Table 4.1 Base Year Traffic Summary (AADT)

Road and Count Site No. and Road Name		Non-motorised	Motor-cycle	Vehicles	Total PCU
370	Tbong Khmum - Ou Reang Ov	97	3,435	445	2,079
371	Peus Pir - Kdol Leu (Trea)	63	1,795	60	811
373C	Memot (NR7) - Kabas	3	1,482	115	757
2620	NR62- Prasat Sambour (Chamres Village)	17	1197	296	863
2KT2	Chamres Village - Sandan Town (East River)	30	659	158	449
2KT3	Chamres Village - Sandan Town (West River)	62	861	87	466
1KCH2	Phsar Pong Ror-Ra Krang Skear	53	1,164	133	695
151C.1	Phsar Trach-Tbeng Khpos	55	2,298	228	1,332
151C.2	Wat Tbeng Khpos-Spean Our Tatep	42	1,007	97	569
151C.3	Spean Our Tatep-Phnom Prah Theat	121	1211	76	634
1KCH3	Spean Pour-Ra Meanor	38	749	115	497
154D	Boeng Khnar - Metoeuk	26	738	51	394
152E	NR5 (Beung Kantout) - Kampong Po	54	753	87	428
155D	Boeng Khnar-Taluo	60	1,488	134	807
155C	NR5 (Trpaing Chorng) - Bord Rumdoul (Phtah Roung)	26	563	46	289
1PS2	Talou - Samraong Village	27	740	94	419
1BB1	NR5 (Prey Svay) - Sdok Praveuk	52	1,090	269	857
1BB2	NR5 (Railway) - Prek Chik - Chong Por	35	485	214	570
1BB3.1	NR5 (Chrey) - Talas - Karkos	42	556	87	356
1BB3.2	NR5 (Chrey) - Talas - Karkos	46	523	59	314
1BB4	NR5 (Chrey) - Talas - Karkos	74	1,259	137	737
1KS3.1	Phsar Traepang Kraleung - Phsar Pang Kassey	16	756	142	508
1KS3.2	Phsar Traepang Kraleung - Phsar Pang Kassey	52	1,805	295	1,181
1KS4.1	Samki Reaksmey - Dak Por	23	679	91	485
1KS4.2	Samki Reaksmey - Kraing Thum	4	170	23	108
266E	Puok- Angkor Chum	66	1,392	285	948
266D	Leang Dai - Svay Sor	128	1,341	538	1,344
2SR2	Leang Dai - Svay Sor	34	295	58	209

Table 4.2 Base Year Traffic Data by Vehicle Type (AADT)

Road and Count Site No. and Road Name		Bicycle	Animal Cart	Motor-cycle	3-Wheel	Car	Jeep/ 4WD	Pick-up	Mini-bus	Bus	Koyun/Etan		Truck		
											Small	Large	Light	Med	Heavy
370	Tbong Khmum - Ou Reang Ov	91	6	3,321	113	51	33	54	45	0	167	1	53	28	13
371	Peus Pir - Kdol Leu (Trea)	59	4	1,784	11	24	5	5	18	0	0	0	7	0	1
373C	Memot (NR7) – Kabas	3	0	1,466	16	8	9	28	3	0	30	0	27	10	0
2620	NR62- Prasat Sambour (Chamres Village)	17	1	1174	23	77	29	39	65	17	11	29	20	7	3
2KT2	Chamres Village - Sandan Town (East River)	29	1	657	2	70	14	35	10	1	7	3	16	1	0
2KT3	Chamres Village - Sandan Town (West River)	58	3	852	9	17	7	15	34	1	1	1	9	0	1
1KCH2	Phsar Pong Ror-Ra Krang Skear	46	8	1,139	25	13	1	1	5	0	101	1	1	10	1
151C.1	Phsar Trach-Tbeng Khpos	51	4	2,119	179	54	24	16	27	1	14	27	57	4	3
151C.2	Wat Tbeng Khpos-Spean Our Tatep	35	7	986	21	5	9	5	2	0	15	0	55	1	5
151C.3	Spean Our Tatep-Phnom Prah Theat	115	6	1195	17	15	7	7	7	5	15	1	17	0	2
1KCH3	Spean Pour-Ra Meanor	35	3	680	69	27	15	8	8	0	21	5	31	0	0
154D	Boeng Khnar – Metoeuk	26	0	705	33	5	5	3	3	0	17	0	18	1	0
152E	NR5 (Beung Kantout) - Kampong Po	52	1	730	23	10	8	35	16	0	2	11	3	1	0
155D	Boeng Khnar-Taluo	58	2	1,470	18	21	3	40	4	0	26	5	19	1	15
155C	NR5(Trpaing Chorng)Bord Rumdoul (Phtah Roung)	25	1	559	3	13	5	10	2	0	13	1	3	0	0
1PS2	Talou - Samraong Village	26	1	731	9	28	6	23	12	0	6	0	16	3	0
1BB1	NR5 (Prey Svay) - Sdok Praveuk	45	7	1,048	42	42	7	29	4	0	129	4	32	11	11
1BB2	NR5 (Railway) - Prek Chik - Chong Por	23	12	370	115	25	12	25	5	0	105	19	15	3	5
1BB3.1	NR5 (Chrey) - Talas – Karkos	42	1	540	16	16	6	9	4	0	35	3	11	0	1
1BB4	NR5 (Chrey) - Talas – Karkos	73	2	1,228	31	13	3	11	4	0	71	6	26	3	0
1BB3.2	NR5 (Chrey) - Talas – Karkos	45	1	511	12	5	4	0	0	0	33	0	17	0	0
1KS3.1	Phsar Traepang Kraleung - Phsar Pang Kassey	5	11	745	11	18	7	17	13	0	51	32	0	0	5
1KS3.2	Phsar Traepang Kraleung - Phsar Pang Kassey	49	3	1,771	34	49	21	39	44	1	13	5	33	82	9
1KS4.1	Samki Reaksmey - Dak Por	15	8	565	114	7	3	1	1	1	31	0	41	6	1
1KS4.2	Samki Reaksmey - Kraing Thum	2	3	161	9	3	0	0	1	0	16	0	3	0	0
266E	Puok- Angkor Chum	64	3	1,373	19	40	31	68	12	0	31	13	83	1	6
266D	Leang Dai - Svay Sor	116	12	1,299	43	85	57	88	0	4	97	61	58	89	0
2SR2	Leang Dai - Svay Sor	28	7	291	4	11	9	5	0	0	9	0	11	9	2

4.3.5 TRAFFIC GROWTH

115. To assess the benefits of road improvements and to determine appropriate pavement design it is necessary to establish future traffic levels on the project roads. In this study traffic levels have been projected from the base year of 2009 for a period of 23 years to 2031. This is to provide a 20 year benefit period for all projects. In order to assess benefits of road improvement projects future traffic must be considered in three categories:

- Normal Traffic that would use the project road if no improvement were made,
- Generated Traffic that occurs only as a result of the improvement to the road,
- Induced Traffic that only arises because of the local development
- Diverted Traffic that changes from another route (or mode of transport) as a result of the improvement.

4.3.5.1 NORMAL TRAFFIC

116. Normal traffic flows are likely to increase over time as a result of growth in population and economic activity. Previous growth is commonly used as a basic indicator of normal growth, but there are no historical traffic data for the study roads with which current count results can be compared. Fuel sales and vehicle registrations can often be used as indirect indicators of traffic growth, but are not applicable in this case because the majority of vehicles operate in urban areas and on national roads, where growth patterns may be different from those on rural roads. Also registration data for Cambodia are clearly incomplete.

117. It is possible to forecast future traffic by relating traffic growth to predicted economic growth, as measured by gross domestic product (GDP). The demand for transport is related to the output of the economy that produces it. Traffic is almost invariably positively correlated with GDP, and traffic growth with GDP growth. The general relationship is as follows:

Q=k(real GDP)e

118. where Q is some measure of demand for transport, k is a constant and the exponent 'e' is the elasticity of demand for transport with respect to GDP. Elasticity is the proportional change in demand per unit change in real GDP, so an elasticity of 1.5 implies a 15 percent growth in travel demand in response to a 10 percent increase in real GDP. (As the determinant used is GDP, this implicitly includes population growth, and it is not necessary to consider population growth and increases in income per head separately, as is often done in traffic forecasting.)

119. Elasticities in developing countries typically range from 1 to 2, with the higher rate applying to personal passenger traffic. Higher rates sometimes occur during periods of increasing personal vehicle ownership which, in the case of motorcycle traffic, is currently happening in rural areas of Cambodia. Elasticities tend to fall as economies develop, but this is unlikely to be a significant (and quantifiable) effect over the period in question. The elasticities assumed are :

Motorcycle Traffic	2.0
Other Passenger Traffic	1.5
Freight Traffic	1.2

120. Because the roads included in the study are essentially rural roads, serving predominantly local traffic, regional variations in growth rates will affect traffic growth. However, it was not considered realistic to obtain growth rates on a regional or provincial level, and national rates have been used. Following a period of rapid growth, largely a result of expansion in industrial production, the Cambodian economy achieved approximately 5.5 percent growth in GDP in real terms in 2008. There has been a marked change in 2009. Household consumption is expected to fall as a result of lower real incomes and reduced wage employment. Private investment, which was very dependent on foreign direct investment (FDI), has also slowed. The number of tourists arriving in Cambodia in the first two months of 2009 was 2 percent below that of 2008, with occupancy rates in major hotels well below 40 percent. Public consumption and investment, and segments of the informal economy, are expected to offset the impact of the global environment. Also agriculture has continued to sustain growth, and is the only major sector doing so. However, agriculture remains vulnerable to climatic uncertainties and lower prices of various commodities (for example cassava and rubber). According to World Bank forecasts, the economy is expected to contract by 1 percent in 2009, mainly as a result of the global recession, in particular from the impact on garment exports. In the *Asian Development Outlook (ADO) 2009* the ADB originally forecast that the GDP of Cambodia would grow by 4 percent in 2009, but in September 2009 this forecast was changed to a contraction by 1.5 percent, very similar to the World Bank forecast. It is probable that the areas served by the Study Roads have not suffered from the international recession as much as urban areas but the national growth rate has been used as a predictor of traffic growth.

121. Future growth rates, especially in the short term, are difficult to predict in the current economic circumstances. Because the downturn is largely the result of external factors, the recovery is largely conditional on a restoration in growth abroad. The World Bank forecasts that growth in 2010 could be in the 0-4 percent range if external demand recovers, and the evidence by August 2009 was that a number of major economies have already returned to growth. The revised forecast made by the ADB in September 2009 is that growth in 2010 will be 3.5 percent, only slightly lower than the forecast of 4 percent made earlier in the ADO. Both agencies consider that beyond 2010 historical growth rates are likely to be achieved. An average growth rate of 3 percent has been used for the period 2009-12, with annual growth of 6 percent for the next five years, dropping to 5 percent after 2017.

122. Using the above estimates of GDP growth and elasticities the assumed traffic growth rates are set out in Table 4.3.

Table 4.3 Normal Traffic Growth Rates

	2009-12	2012-17	2017 onwards
Motorcycles	6.0	12.0	10.0
Passenger Vehicles	4.5	9.0	7.5
Freight Vehicles	3.6	7.2	6.0

123. Traffic growth can be affected by a change in the vehicle types used or the loading patterns following significant improvements to the road. Such changes

cannot be incorporated in a standard HDM-4 analysis and no allowance for such changes has been made in the growth rates. However, non-motorised traffic has been assumed not to grow above present levels, reflecting that the growth in motorised traffic includes an element of transfer from non-motorised vehicles.

4.3.5.2 GENERATED TRAFFIC

124. Generated traffic arises because road improvement makes a journey more attractive as a result of travel cost and/or time reduction. Normally it is assumed that there must be a reduction in VOC of approximately 25 percent before there is measurable generated traffic. In the case of upgrading unpaved roads to sealed standard there are normally sufficient reductions for generation to occur. The standard approach to estimating generated traffic is to use demand relationships. The price elasticity of demand for transport is the responsiveness of traffic to a decline in transport costs. It has been measured in road appraisal studies in developing countries and found to fall in the range -0.6 to -2.0, with an average of about -1.0. This means that a one per cent decrease in transport costs leads, on average, to a one per cent increase in traffic. Evidence suggests that the elasticity of demand for passenger transport is above one, with that for freight transport usually much lower.

125. The economic benefit arising from this traffic is calculated as half the benefit to an equal amount of normal traffic. In theory, generation should be determined from costs expressed in financial rather than in the economic terms used for the calculation of project benefits, but the difference in percentage terms is small.

126. For the Project roads the cost reduction following improvement depends largely on the condition of the existing road, measured by roughness. Given the normal maintenance procedures in Cambodia this is expected to vary greatly over time; from low roughness immediately after periodic maintenance, increasing to high roughness over a period of three to four years before the next periodic intervention. At times the very high roughness will produce VOC reductions of more than 50 percent. This would suggest that generated traffic could be up to 50 per cent of normal traffic levels. However, it is important to note that the theoretical response in terms of increased demand for travel, and hence in traffic levels, depends not on the total VOC but on the perceived cost reduction. This is mainly the cost of fuel, plus the value of time, in the case of private vehicles. In the case of public transport it is the fare reduction, again plus the value of time. The impact of cost reduction on travel demand will therefore be less than the theoretical response.

127. It is also important to note that any calculation of increased traffic due to road improvement should be based on total journey costs, and not just that part of the cost incurred on the road under study. This will vary according to the origin and destination of each trip, but where travel on the roads is part of a longer journey there will be a reduction in the overall journey cost saving, and in the amount of traffic generation.

128. It is probable that the shorter journey time and increased comfort also contributes to higher passenger travel demand, but this effect cannot be separated from the price effect. In fact, the true price elasticity is almost certainly less than one; if it were one or above the traveller would be deciding to spend all of the cost saving on additional trips. Almost certainly if more trips are made the traveller is not just reacting to a lower price, but also to a superior service. However, it is not a problem that this effect is incorporated in the estimate of demand elasticity, as any additional trips are given the same value in the evaluation. But if the generation of passenger

trips following the sealing of roads is as much a response to quality of service as the cost reduction, the level of generated traffic will not be closely related to the reduction in cost, and it is not useful to attempt to calculate a precise relationship. A general allowance for generated traffic will be as accurate.

129. In addition to generated traffic of the type discussed above there are also additional trips made if any road closure during the rainy season is eliminated or reduced following upgrading. The benefits to such additional trips are valued in the same way as generated trips, and so are best included as generated traffic. Most of the study roads have already been upgraded to all-weather condition in terms of surface condition, drainage and structures, but some wet season closures can be expected. The average number of days during for which roads will be closed is difficult to determine, and some closures may still occur after sealing as a result of flooding. Also the number of additional trips will vary according to the degree to which temporary road closure, or difficult road conditions, can be anticipated. In some cases additional trips will be made before the rainy season to avoid the difficult conditions, so that all-year access will not necessarily lead to more traffic on an annual basis. In other words, road improvement will lead to a change in the timing of some trips, and only a limited increase in the total number of trips.

130. In order to allow for the significant increase in traffic which occurs following road improvement to sealed standard in some cases, a general traffic increase of 30 percent has been assumed in the case of cars and other light vehicles, and 15 per cent in the case of motorcycles. Generation in freight traffic theoretically occurs only if the reduction in transport costs has sufficient impact on prices of goods to induce consumers to buy more goods. Given the low proportion of transport cost to the value of goods normally carried by a truck it is unlikely that the impact will be more than one or two per cent of retail prices of goods, even if the full transport saving is passed on to consumers. However, freight traffic is normally observed to increase following sealing of roads and it has been assumed that there will be an additional 10 percent freight traffic.

131. The effect of generation is sometimes assumed not to occur in full for a number of years, as road users adjust to the new situation following road improvement. For simplicity all generation has been assumed to occur in the first year after improvement. Generated traffic has been assumed to grow at the same rate as normal traffic.

4.3.5.3 INDUCED TRAFFIC

132. Induced traffic can occur when road improvement leads to new or expanded activities that produce additional traffic being established in the area served by the road. Often induced traffic is considered to be a component of generated traffic, and there is overlap between them, which can lead to double counting if induced traffic benefits are calculated. Theoretically induced traffic is different, being a proxy for producer surplus that can occur when the reduction in transport costs associated with road improvements is large enough to induce an increase in agricultural production in the zone of influence of the road. It can also be related to the opening up of new tourist facilities or industries.

133. No specific schemes were identified in the areas served by the roads, and because the project will involve upgrading, rather than new roads providing road access to areas for the first time, the reduction in transport costs in such cases is not considered to be large enough to change agricultural production patterns and

produce extra traffic. Therefore no additional induced traffic has been included in the projections.

4.3.5.4 DIVERTED TRAFFIC

134. Traffic will normally travel on the quickest or cheapest route available, which may not necessarily be the shortest. Improvements to the road system may cause existing traffic to divert to another route if it becomes quicker or cheaper than the route currently being used. The benefits arising from such diversion must be calculated separately from those relating to normal and generated traffic. With most roads included in this study there is no possibility of traffic diversion, but in some cases it needs to be considered. Road No. 266E Puok – Angkor Chum in Siem Reap Province will provide a shorter sealed road route to Angkor Chum from Siem Reap town and Puok than via NR 5 and a provincial road. However, the distance saving will be small and speeds will be lower, so no diversion is expected. Road No. 1KS4 Kiri Reaksmei – Dak Por in Kampong Speu Province will provide a shorter route between Dak Por and Kampong Speu town than the alternative route via a rural road, NR 46 and NR 4. However, Road No. 1KS4 is significantly shorter and the existing condition is good, so that it is believed to be currently carrying almost all traffic on that route, and no additional diversion is expected. There are two possible alignments for road No. 2KT2, the second half of the road from Prasat Sambour to Sandan in Kampong Thom Province beyond km 28.5. The alternative routes are east or west of the Steung Sen River. The eastern route has been chosen as it carries slightly more traffic and serves directly a much larger population in the villages along the alignment. The two routes are almost exactly the same length, and if the eastern alignment is sealed it would attract traffic from the western alignment. Traffic counts were carried out on both routes, and it was assumed that 50 percent of traffic, representing through traffic to Sandan, would divert from the western route.

135. Two roads in Kampong Chhnang, No. 1KCH2 and 1CCH3 end at the Phnom Penh to Battambang railway. The railway is currently operating at a very low level with only an intermittent service. Some freight is carried unofficially on the railway track on small motorised trolleys. There is an ongoing major project to rehabilitate the railway, including an extension to reconnect it to the Thai rail system. It is difficult to predict the impact of this on road traffic on the two roads concerned and no adjustment has been made to the traffic estimates to allow for diversion to or from the railway.

4.3.6 FUTURE EQUIVALENT STANDARD AXLE LOADINGS

136. No specific axle load surveys were carried out for the study. Data from automatic weigh-in-motion (WIM) surveys carried out on national roads and the results of surveys carried out for the Northwestern Rural Development Project were used. A basic set of equivalent standard axles (ESA) values have been used at this stage of the study. These are shown in Table 4.4. Specific values may be required for trucks on the southern part of Road No. 266D/2SR2 Leang Dai – Svay Sa in Siem Reap Province because of the very heavily loaded large three-axle trucks associated with a quarry operating on most of the route. The ESAs of trucks are much higher and more variable than for other vehicle types. In the case of other vehicle types, axle loads are sufficiently low that it is acceptable to use an estimated value for the ESA for each vehicle type.

Table 4.4 ESA by Vehicle Type

Car	Jeep/ 4WD	Pick-up	Minibus	Bus	Koyun/Etan		Truck		
					Small	Large	Light	Med	Heavy
0.00	0.01	0.05	0.04	0.7	0.05	0.2	0.2	0.80	3.5

The cumulative total ESAs for 10, 15 and 20 years after opening the roads to traffic after upgrading are shown in Table 4.5. These are shown in millions of ESAs and are for total traffic in both directions. They are based on traffic flows that include the growth rates and traffic generation factors referred to above.

Table 4.5 Cumulative ESA Values (millions)

Road and Count Site No. and Road Name		10 years	15 years	20 Years
370	Tbong Khmum - Ou Reang Ov	0.53	0.95	1.51
371	Peus Pir - Kdol Leu (Trea)	0.04	0.06	0.10
373C	Memot (NR7) – Kabas	0.10	0.17	0.27
2620	NR62- Prasat Sambour (Chamres Village)	0.25	0.44	0.70
2KT2	Chamres Village - Sandan Town (East River)	0.05	0.08	0.14
2KT3	Chamres Village - Sandan Town (West River)	0.05	0.09	0.15
1KCH2	Phsar Pong Ror-Ra Krang Skear	0.10	0.17	0.28
151C.1	Phsar Trach-Tbeng Khpos	0.20	0.35	0.56
151C.2	Wat Tbeng Khpos-Spean Our Tatep	0.18	0.32	0.50
151C.3	Spean Our Tatep-Phnom Prah Theat	0.09	0.16	0.26
1KCH3	Spean Pour-Ra Meanor	0.05	0.09	0.15
154D	Boeng Khnar - Metoeuk	0.03	0.06	0.09
152E	NR5 (Beung Kantout) - Kampong Po	0.04	0.06	0.10
155D	Boeng Khnar-Taluo	0.36	0.64	1.01
155C	NR5 (Trpaing Chorng) - Bord Rumdoul (Phtah Roung)	0.01	0.02	0.03
1PS2	Talou - Samraong Village	0.05	0.08	0.13
1BB1	NR5 (Prey Svay) - Sdok Praveuk, Pretralach Commune	0.36	0.64	1.02
1BB2	NR5 (Railway) - Prek Chik - Chong Por	0.20	0.36	0.56
1BB3.1	NR5 (Chrey) - Talas - Karkos	0.05	0.09	0.14
1BB4	NR5 (Chrey) - Talas - Karkos	0.07	0.13	0.21
1BB3.2	NR5 (Chrey) - Talas - Karkos	0.03	0.05	0.08
1KS3.1	Phsar Traepang Kraleung - Phsar Pang Kassey	0.16	0.28	0.45
1KS3.2	Phsar Traepang Kraleung - Phsar Pang Kassey	0.64	1.15	1.82
1KS4.1	Samki Reaksmey - Dak Por	0.11	0.19	0.31
1KS4.2	Samki Reaksmey - Kraing Thum	0.01	0.01	0.02
266E	Puok- Angkor Chum	0.27	0.48	0.77
266D	Leang Dai - Svay Sor	0.62	1.10	1.75
2SR2	Leang Dai - Svay Sor	0.10	0.18	0.28

5 PAVEMENT DESIGN

137. The technical standards developed by MRD in association with SEACAP also present a series of pavement design tables for both bitumen surfaced roads and concrete roads as well as for roads surfaced with a gravel wearing course. These tables are quite comprehensive and provide good guidance for roads with low cumulative traffic loading levels as suitable for this project. The table for pavement structures with unbound roadbases is shown in Table 5.1. However, the pavement structures do not include one with a stabilized roadbase, which as shown below is a pavement option for this project. The pavement design chart is suitable for stabilized road bases instead of unbound aggregate road bases and either pavement type may be used with the same chart.

138. The pavement design table provides for either a DBST surfacing or for an Otta seal. The Otta seal is similar to a DBST except that it uses a graded gravel instead of a single sized stone. Selection is based on local availability of the materials. Neither of them provide any structural strength. Both, however, are more durable than an SBST. Under this project, a DBST has been selected instead of a SBST, because it provides a more suitable surfacing with a far longer initial life (before resealing is necessary) and is particularly suited for the roads with higher traffic volumes or those with high cumulative traffic loading. A DBST may also be more durable where vehicles are turning sharply and at intersections. It also provides a better surface texture (far less open textured) for the wide range of road user types travelling on the project roads. The roads are relatively narrow and so the DBST will be applied over the full width of the road including the shoulders to prevent vulnerable users migrating to a “better” surface nearer to the road centre where the higher speed 4-wheeled vehicles will travel.

139. A conventional DBST will be used with a larger stone applied to the first layer of bitumen and a smaller stone applied for the second layer of bitumen. TRL ORN3 or the UK equivalent (TRL RN39) should be used in preference to other design guides. The selection of either of these design guides is to ensure that the most appropriate stone sizes are used for each layer because the stone is expected by design to embed into the surface of the road base during its life in service and smaller stone sizes are more appropriate for harder roadbases such as stabilized bases than larger stone and conversely large stones are usually more suitable for aggregate bases where greater embedment is expected. Lack of embedment will lead to early stone loss and an excess embedment will lead to low surface texture and less skid resistance. The design guides describe the use of a device to measure the hardness of the surface during the design phase which is not indicated in other design guides.

140. Paved roads require a different pavement structure to gravel-surfaced roads. For gravel roads a relatively thick layer (say 250mm) of gravel is required to both provide a structural layer that is thick enough to protect the subgrade from traffic and is thick enough to tolerate some of the gravel being worn away over time and still perform reasonably well. Defects are corrected by routine maintenance and regravelling is carried out periodically to replace the lost gravel. However, the wearing course gravel is not usually of a suitable roadbase quality to be simply surfaced with a bituminous seal. Clearly, because of the bituminous surfacing, defects in paved roads cannot be simply reshaped and compacted as they can for gravel-surfaced roads. They are expected to remain as built for many years until they are upgraded further. The wearing course material provided for gravel roads is

generally similar to the sub-base material used for a paved road. However, a much thinner layer is generally required for paved roads carrying light traffic on the same subgrade. A roadbase of stronger material is required for a paved road to provide better load spreading so that defects so often seen in gravel roads do not occur.

141. The measurements of strength made during this project and confirmed through material sampling and laboratory testing carried out as part of the detailed design stage will provide the subgrade strength information for design. Details of the cumulative Equivalent Standard Axle Loading (ESAL's) are provided in Table 4.4. Together these data provide the input values to be used in the pavement design table(s).

142. Usually the cumulative equivalent standard axles in the more heavily loaded direction is used for the pavement design for the whole width of the pavement. Because of the widths of the existing roads, which are generally quite narrow, it can be expected that the wheel paths in each direction will overlap with those in the opposite direction especially for the truck traffic which is the most important category for pavement loading. In this situation, the cumulative traffic loading in both directions has been used as the estimate. However there are two exceptions in the pavement design table (see Table 5.2) where the road width is adequate and the traffic in only the most heavily loaded direction is used for design. It is also true that channeling of heavy traffic on very narrow roads can lead to additional loading as mentioned in TRL's Overseas Road Note 31 (ORN31) (TRL, 1993). If this is perceived to be a significant risk at detailed design stage, the pavement engineer should take this into account and make adjustments to the estimated cumulative traffic loading and then increase the thicknesses of the pavement layers, as necessary.

143. Where the number of ESAs exceeds the limits of the tables, the pavement design is based on ORN31. ORN31 is in use internationally in tropical and sub-tropical countries. It is suitable for use in Cambodia and the pavement design tables are in use by MPWT.

144. The estimates of cumulative equivalent standard axles have not taken into account the very heavy overloading caused by particular vehicle types namely those used by quarry operators. It has been assumed that the overloading control will be effective and these vehicles will not be permitted to travel on the project roads. This decision has been taken because it cannot be economic or within the scope of the project to design for such vehicles. If this assumption is not correct the roads cannot be built using the pavement designs in this report. The esa's of such vehicles when overloaded is estimated to be approximately 50esa per vehicle, whereas legally loaded they would be 4esa's per vehicle.

145. The materials quality to be used in the respective pavement layers are CBR80% for the roadbase and CBR25% for the sub-base. Where a "fill" is required its strength requirement is CBR10%. The CBR should be measured in the laboratory in the soaked condition at the appropriate density. Where a stabilized road base is used the strength of the material required is a minimum of 2.5MPa as measured in the Unconfined Compressive Strength Test (UCS). Stabilized materials must conform to the requirements of internationally accepted durability tests such as those given in the British Standard BS1924.

Table 5.1 Structures with unbound or stabilized road bases

Subgrade CBR%	Layer	Cumulative traffic in mesa					
		0.02	0 05	0.10	0.3	0.5	1.3
S1 = 2%	Surface	DBST or Otta					
	Roadbase (mm)	125	150	150	150	150	200
	Sub-base (mm)	150	150	150	200	200	225
	Fill (mm)	200	225	250	300	350	325
S2 = 3, 4%	Surface	DBST or Otta					
	Roadbase (mm)	125	125	150	150	150	200
	Sub-base (mm)	125	150	150	200	200	225
	Fill (mm)	150	175	150	200	250	225
S3 = 5 -7%	Surface	DBST or Otta					
	Roadbase (mm)	125	125	125	125	150	175
	Sub-base (mm)	100	125	150	150	150	175
	Fill (mm)	75	100	100	100	175	175
S4 = 8 -14%	Surface	DBST or Otta					
	Roadbase (mm)	125	125	125	150	150	175
	Sub-base (mm)	100	125	150	175	200	225
S5 = 15 -29%	Surface	DBST or Otta					
	Roadbase (mm)	100	100	125	150	150	175
	Sub-base (mm)	75	100	100	100	125	150
S6= >30%	Surface	DBST or Otta					
	Roadbase (mm)	100	100	125	150	150	175

Source: MRD draft Technical Standards 2009, title has been modified to indicate it is also suitable for stabilized roadbases.

5.1 PAVEMENT DESIGN OPTIONS

146. One of two options will be selected for the roadbase on the individual project roads, or within lengths of a project road. These are an unbound graded stone or a

stabilized roadbase; to be constructed over the full width of the existing road. Both are technically suitable from a pavement structural point of view. Figure 5.1 and Figure 5.2 show the technical differences between each option. Although one roadbase option may be chosen in favour of another, and indeed the stabilized road base by far provides a greater function than the aggregate roadbase under the conditions prevailing under this project, and so is preferred. However, the choice must be made primarily on an economic basis.

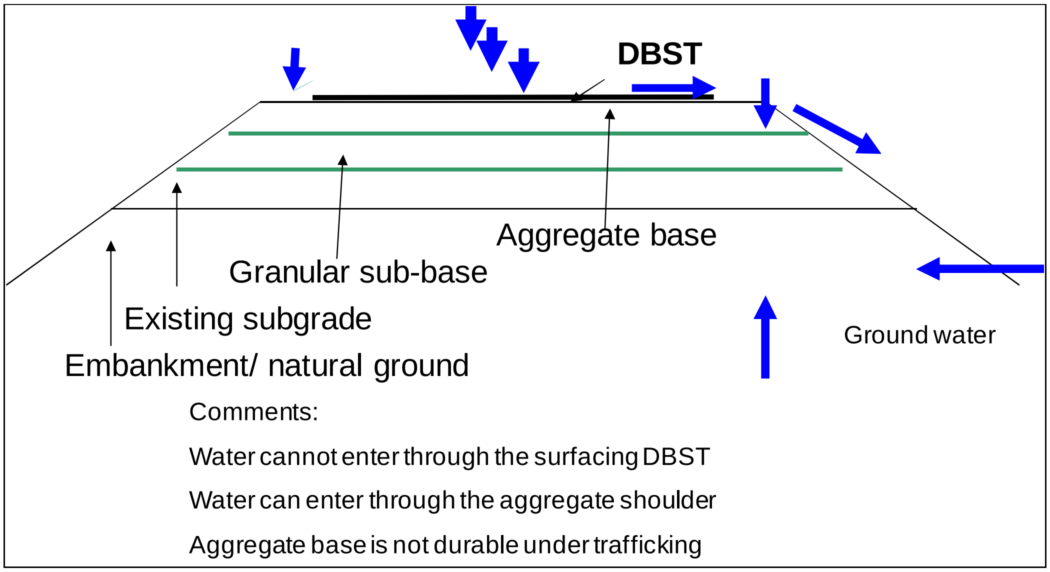


Figure 5.1 Road cross-section for an aggregate base

147. Option 1: where graded aggregates are available from existing quarries located at economic haulage distances from the job site and where there is not an existing recently placed thick gravel wearing course of, say, 250mm, material for an aggregate roadbase will be sourced from the quarries and hauled to the job site. The aggregate base will be placed to give a compacted thickness of between 100mm to 200mm in accordance with the pavement design.

148. Option 2: where a thick and strong gravel wearing course has been placed and still exists in sufficient depth, the upper 125mm of the gravel wearing course will be ripped and reprocessed with a stabilizer to improve its strength. Thus, the existing material recycled with an additive rather than using new materials. However if the quantity of gravel is insufficient some new materials from local material sites may be required to make up quantities. The stabilizer is most likely to be cement or lime, as appropriate for the type of existing material. Essentially, the mixed material is watered and re-laid and compacted in a similar fashion to that used for the aggregate base and other layers as described above.

149. It should be remembered that a good quality aggregate can be stabilized using a small addition of cement to provide a strong and stiff roadbase for the full width of the road including the very outer edge of the pavement.

150. The overriding principle is that the total pavement with an improved subgrade if required conforms to the thicknesses and strengths given in the pavement design table (Table 5.1) and the materials qualities given in paragraph

145. If the pavement design requires the use of ORN31, because the traffic exceeds the limits of the MRD design chart, the pavement structures and materials quality given in ORN31 must be adhered to. These are similar to those used in the MRD design chart.

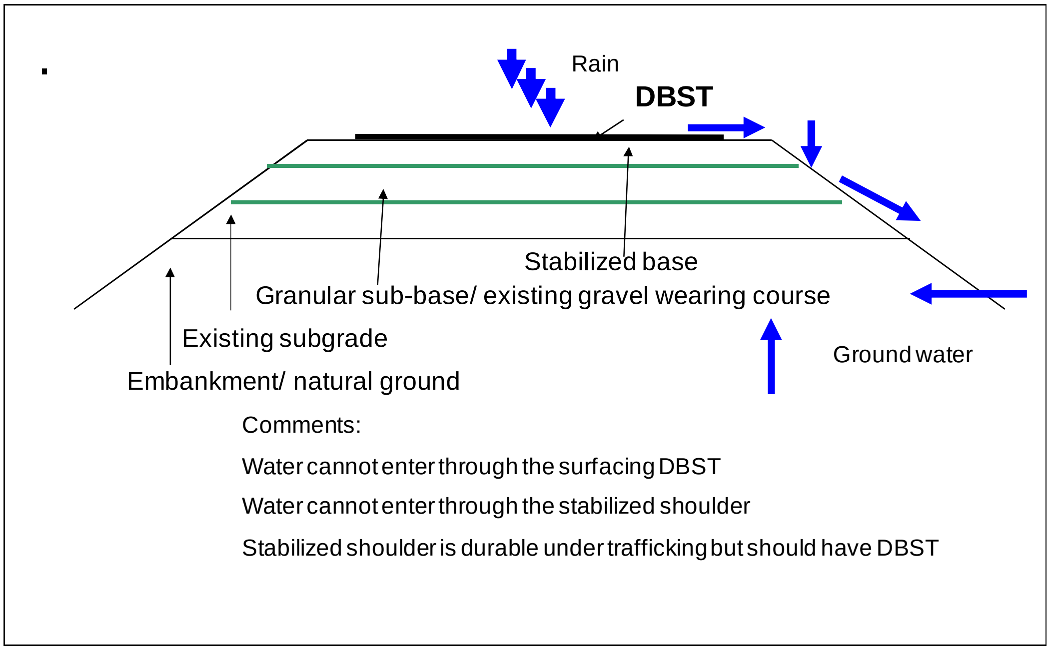


Figure 5.2 Road cross-section for a stabilized roadbase

5.2 CEMENT CONCRETE PAVEMENT TRIAL

151. It is appropriate to undertake a pavement trial using cement concrete pavement under the project to extend the pavement options for future projects and to increase the capability to include this pavement type which is suitable under certain conditions. It also lends itself to labor intensive construction methods. The climate in Cambodia, with low seasonal temperature variations suggests that concrete pavements such as those used in the Philippines where unreinforced concrete is laid as a continuous strip during a day and then joints are cut within 24hrs to a shallow depth in the slab at about 4.6m intervals transverse to the line of the road. The slab then cracks to the full depth at the cut and aggregate interlock alone provides the essential load transfer between slabs. This avoids the need for dowel connections between slabs. (Clearly, if the concrete is formed in isolated single bays dowel load transfer bars will be necessary.) Although bamboo reinforced concrete has been trialed extensively in Cambodia, subsequent investigations carried out under SEACAP have shown that bamboo is not suitable in this application and does not strengthen the concrete. The detailed design for the concrete trial should be developed by the implementation consultants.

152. A suitable location for the concrete pavement trial is along the narrow section of road 371 near the village of Trea where the trial is likely to ease construction difficulties along narrow lengths of road, and where a local labour force is potentially available.

Table 5.2 Outline pavement designs

Road No.	Province	Name of Road	Road Length	Road width	Existing gravel wearing course thickness	Subgrade CBR for design	ESA for pavement design	Design guide	Pavement thicknesses		
									Fill	Sub-base	Roadbase
			Km	m	Mm	%	Millions		mm	mm	mm
370	KC	Cheung Lang (Phsar Soung) -Ou Reang Ov	29.4	6	250	S4	1.3	MRD	0	225	175
371	KC	Peus Pir-Kdol Leu (Trea)	20.8	6	50	S4	0.1	MRD	0	150	125
373C	KC	Memot (National Road 7)-Kabbas	18.5	7	100	S3	0.3	MRD	100	150	125
2620/2KT2	KT	Prasat Sambour - Sandan	66.2	6 - 7	200	S3	0.1	MRD	100	150	125
1KCH2	KCH	Phsar Pongro - Ra Krang Skear	25.3	6	200[2]	S4	0.3	MRD	0	175	150
151C	KCH	Phsar Trach-Ra Tbeng Khpos	10.4	6	300	S4	0.5	MRD	0	200	150
151C	KCH	Wat Tbeng Khpos-Spean Our Tatep	6.7	6	300	S4	0.5	MRD	0	200	150
151C	KCH	Spean Our Ta Tep-Phnom Prah Theat	18.0	6	200	S4	0.5	MRD	0	200	150
1KCH3	KCH	Spean Pou - Ra Mean Nor	12.5	6.5	200	S4	0.3	MRD	0	175	150
154D	PS	Boeng Khnar-MeToeuk	11.1	6	350[2]	S4	0.1	MRD	0	150	125
152E	PS	Kantuot - Kampong po	8.8	5.5	100[2]	S3	0.1	MRD	100	150	125
155D	PS	Boeng Khnar-Taluo	20.0	7	100[2]	S4	1.3	MRD	0	225	175
155C	PS	Trapaing Chorng - Phtas Rung	22.4	5.5	300	S3	0.2	MRD	75	100	125
1PS2	PS	Samraong - Talou	18.3	5.5	200	S4	0.1	MRD	0	150	125
1BB1	BB	Prey Svay - Prey Tralach Ruessei Krang	24.9	7	260	S3	0.5	MRD	175	150	150
1BB2	BB	NR5 (railway) – Prek Chik – Chong Por	23.2	7	0	S3	0.5	MRD	175	150	150
1BB3 & 1BB4	BB	Chrey - Taloas Kakoah	23.9		120	S3	0.3	MRD	100	150	125
1KS3	KS	Phsar Trapeang Kraloeng-Phsar Pangkassei	45.4	6 - 7	50- 270	S3	T3	ORN31[1]	125	150	175
1KS4	KS	Kiri Reaksmei - Dak Por	23.9	7	150- 600	S4	0.3	MRD	100	150	125
266E	SR	Puok- Angkor Chum	29.6	6 – 7	150	S4	0.5	MRD	0	200	150
266D & 2SR2	SR	Leang Dai - Svay Sa	46.2	6	150	S3	T4	ORN31[1]	125	175	200

Note 1 ORN31 design uses Chart 8: stabilized base and stabilized sub-base. Note 2: the material is a sandy clay rather than a gravel

6 CONSTRUCTION MATERIALS

6.1 SUBGRADE CORRECTION MATERIALS

153. Where essential, the subgrade will be repaired by placing and compacting suitable local material or low quality material from material sites. Often this will not be necessary. Construction equipment will be the same as that routinely used for this operation. Material will loaded from local sources using excavators and bucket loaders and hauled to the job site in large tipper trucks, where the material will be dumped, spread with a motor grader, watered as necessary and compacted using large compaction equipment. The compaction equipment may include steel wheeled rollers, pneumatic tyred rollers and large vibrating rollers.

6.2 EXISTING GRAVEL WEARING COURSE MATERIALS

154. Where new sub-base material is required it will be sourced from relatively local and established material sites. The material is often a lateritic gravel, which is commonly found in the project area. The method of supply and placement will be similar to that used for the subgrade. The material requirements for sub-base materials are similar to those in use for the gravel wearing course, so these operations are very similar to those currently used for periodic maintenance of the gravel roads.

6.3 AGGREGATES FOR ROAD PAVEMENTS

155. Aggregate quarries have been identified in the engineering surveys. These quarries produce both single sized stone for general construction purposes, road surfacing aggregate, concrete works, and an “all-in” graded aggregate for use as aggregate base course for roads. Haulage distances to some of the project roads are considerable and it is likely that the stabilization of more local materials will be preferred. Reducing the haulage of heavy materials in large quantities also reduces traffic to the network at large and, importantly, along the project roads. Suitable construction processes must be employed to ensure contractors or suppliers do not travel excessively on the newly completed roads or indeed unnecessarily on the rural network.

156. Aggregates for surface treatments are discussed further in paragraph 165.

6.4 USE OF STABILIZATION

157. For processing with cement it is likely that bagged cement will be spotted on the ripped surface at suitable and frequent locations, these are then opened, raked over the surface and then blended into the raw material using an agricultural plough, or a motor grader in the conventional way. In using these processes, constraints are placed on the operations to prevent the spread of cement or lime, for example, being blown off the job site by the wind.

158. For processing with bagged lime the methodology will be similar to that used for cement. However it may be possible to use a lime slurry (lime with water) instead of dry lime which overcomes dust problems. It may also be appropriate to batch the material at an established plant and deliver the mix to the job site, but this is unlikely as it would mean removing the existing material to the batching plant and returning it mixed to the job site.

6.5 RECYCLING MATERIALS

159. Pavement option 2 above provides for recycling existing materials (with cement or lime) and so saves on the provision of new materials.

160. It may be possible to use large specialist recycling machines that rip the existing material, blend in the stabiliser and water as necessary and re-lay it ready for compaction. These machines virtually eliminate the presence of dry stabiliser on the surface for any extended period during construction and can dramatically increase the rate and quality of the construction process.

6.6 AVAILABILITY OF CEMENT

161. Cement is available from two cement factories in Cambodia so it is expected that importation will not be necessary.

6.7 AVAILABILITY OF LIME

162. The lime to be used will be either slaked lime (calcium hydroxide) or quick lime (calcium oxide). For the latter, precautions must be taken to avoid health hazards from contact with the lime and from the heat produced as it hydrates on the job site. Both forms of lime are commonly used for road construction and are also used for agricultural purposes to reduce the acidity of soil, for example. Two small scale lime production businesses are in operation in Cambodia, one in Battambang province and the other in Kampot province, however, imported lime may be required to maintain supply levels.

6.8 SURFACING MATERIALS

163. Prime coat: a prime coat of bitumen will be sprayed onto the surface of the road to prepare for the bituminous treatment. This is a low viscosity bitumen which penetrates the top 10mm of the road surface, binds it and provides a key for the bituminous surfacing.

164. The bituminous surfacing will comprise a DBST. Bitumen will be spayed over the prime from a purpose-built bitumen distributor. The bitumen will be a straight run or a bitumen emulsion. The bitumen emulsion is bitumen blended with water at a specialist facility of the supplier and is delivered and laid cold. The straight run bitumen is supplied cold or hot and may be blended by the contractor or the supplier. It is laid hot. Both are conventionally used for road surfacings. For the straight run bitumen, the volatiles are rapidly evaporated. For the bitumen emulsion, the water is evaporated but more slowly.

165. Aggregate stone for the surfacing will be sourced from existing quarry suppliers and hauled to the job site. The surfacing aggregate is immediately spread over the laid bitumen from specialist road chipping spreaders and the surface is rolled using compaction equipment, and opened to public traffic. Initially traffic movements and speed are controlled to prevent stone chippings being removed. Any excess surfacing stone should be collected and removed by the contractor.

166. All the processes involved in providing the surfacing are those conventionally used for road construction.

6.9 ROAD MAINTENANCE

167. The intention is to provide a road with a structural life of 15 years. Thereafter, it will require either a strengthening layer (say 125mm of aggregate base or a further stabilized layer) and a new surfacing or a structural surfacing or both depending upon the requirements and economics pertaining at that time.

168. During the planned structural life, a DBST will require another seal (an SBST) as a maintenance treatment after about eight years in service. It should then provide good service for a further 8 years. The actual service life is strongly dependent on the quality control at construction.

169. If quality control is good, then the only maintenance required ought to be limited to simple tasks such as grass cutting, minor edge repairs and culvert cleaning. Any defects in the roadbase, which should be isolated and rare, may give rise to potholes which can be repaired by patching using crushed stone for roads with unbound aggregate bases, or local materials mixed with the appropriate stabilizer (cement or lime) for both those roads with aggregate bases and those with stabilized bases.

170. A good quality and timely reseal is vital for the long term performance of the project roads. Delays caused by lack of technical support or lack of funds would be detrimental to this process. For this reason, the technical requirements for the resealing and the funding for the civil works should be identified and quantified through the preparation for a future project component of this project, as described in 9.3.3.

171. Defects in the aggregate base can be repaired by patching using crushed stone for those roads with aggregate bases, or local materials mixed with the appropriate stabilizer (cement or lime).

172. Surfacing defects can be repaired using small scale equipment such as a small bitumen tank and hand lance for spraying and a supply of aggregate chippings. The use of bitumen emulsions is much preferred because it is sprayed cold and is safer to use. Stabilized roadbases crack naturally after construction. Over time transverse cracks may appear at the surface in stabilized roadbases. These can be readily sealed using bitumen emulsion and a hand-lance or by other simple application methods.

7 MINE/UXO RISK AND CLEARANCE

173. A land mine or unexploded ordnance risk is widespread in Cambodia including the provinces in which the proposed project will be conducted. The works are to upgrade existing roads and much of the work will be carried out within the width of the existing roads. Nevertheless a risk remains. Deep seated mines may be exploded by heavy construction equipment and shallow ordnance may be uncovered during the works. Maps exist to give a first indication of the level of risk and many areas will have already been cleared by the Cambodian authorities and other organizations. The experts in Cambodia must be engaged to determine the level of risk for any particular project road or area and advise on the need for clearance. During detailed design the implementing consultants will engage such experts and commission, through the civil works contractors, any clearance works that are required. Clearance must be carried out by expert firms who will certify that areas are cleared.

174. Construction activities attract the attention of the local communities and children frequently watch the works from nearby. For these and other reasons a public information program will be undertaken within the local communities to prepare and advise them of the risks. The workers of the implementing consultants and the civil works contractors as well as others associated with the project will also be taught and advised of the risks.

8 CAPACITY BUILDING

175. The MRD was established in its current form in 1994 as shown in Figure 8.1 and the Department of Rural Roads (DRR) was formed in 2001 under the Directorate of Technical Affairs. The organizational structure of the DRR is shown in Figure 8.2. The offices of MRD and the DRR are at the same site in Phnom Penh. MRD and DRR have received capacity building support under previous ADB interventions such as the Road Infrastructure Improvement Project and the Emergency Flood Rehabilitation Project. Capacity building support has also incorporated support for staff in the PDRD's within the various project areas.

176. At present the DRR has a total staff of 38, and the offices are staffed as follows:

Office	Number of staff
General Affairs	9
Planning and statistics	8
Maintenance Management	6
Monitoring and Evaluation	5
Research and development	10

The staff share responsibility for the work in the various office sections shown below the office titles in Figure 8.2. The structure of DRR is suitable for capacity building programs as planned under this project.

177. While previous interventions have trained staff in technical and administrative roles and in project implementation procedures, it has been noted that after projects are completed there is a tendency for staff to leave for career advancement reasons. Thus sustainability of the organization remains in question and further capacity building is required. In the case of this project, paved roads are being introduced to MRD's portfolio of assets to administer and capacity building is essential.

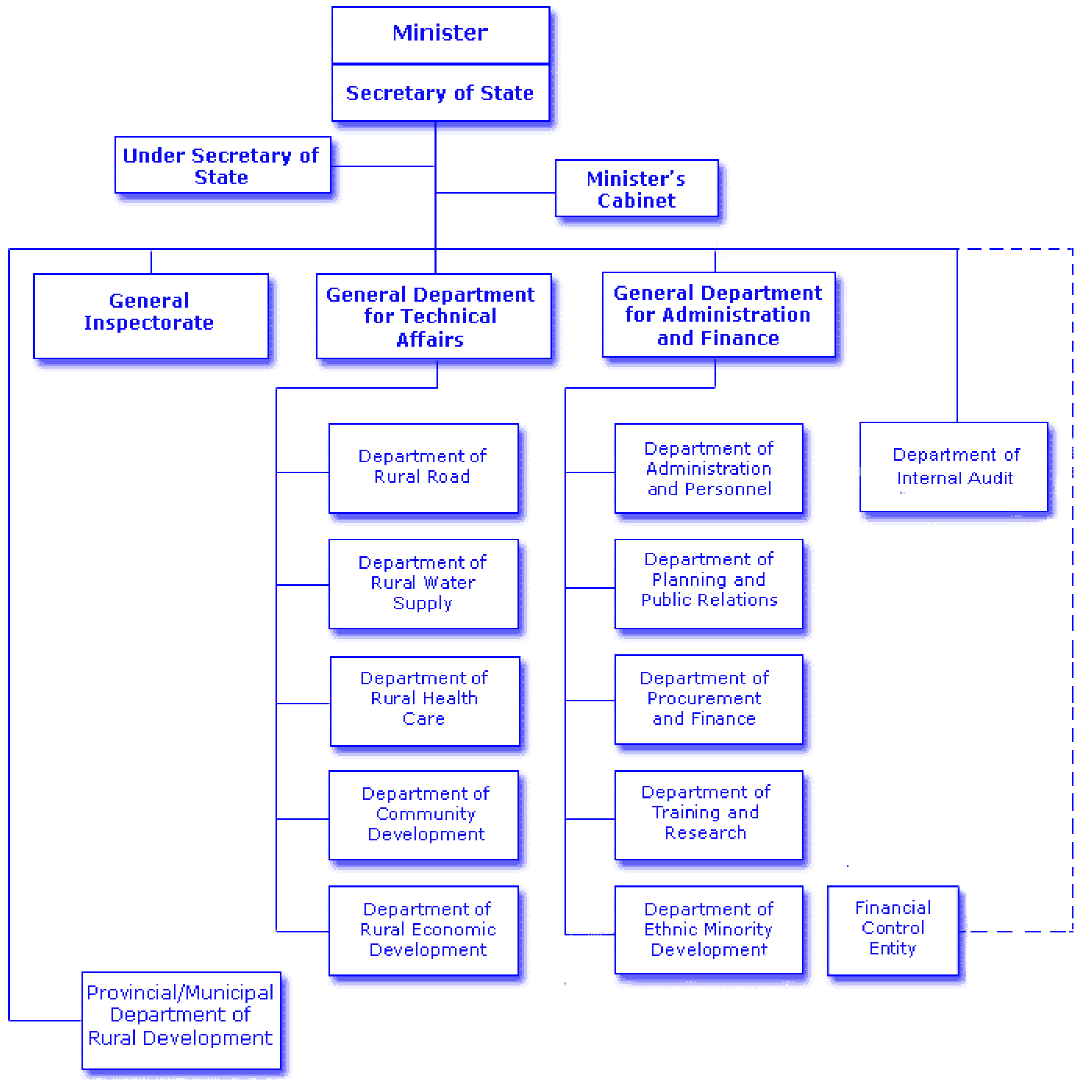


Figure 8.1 Organizational structure of MRD

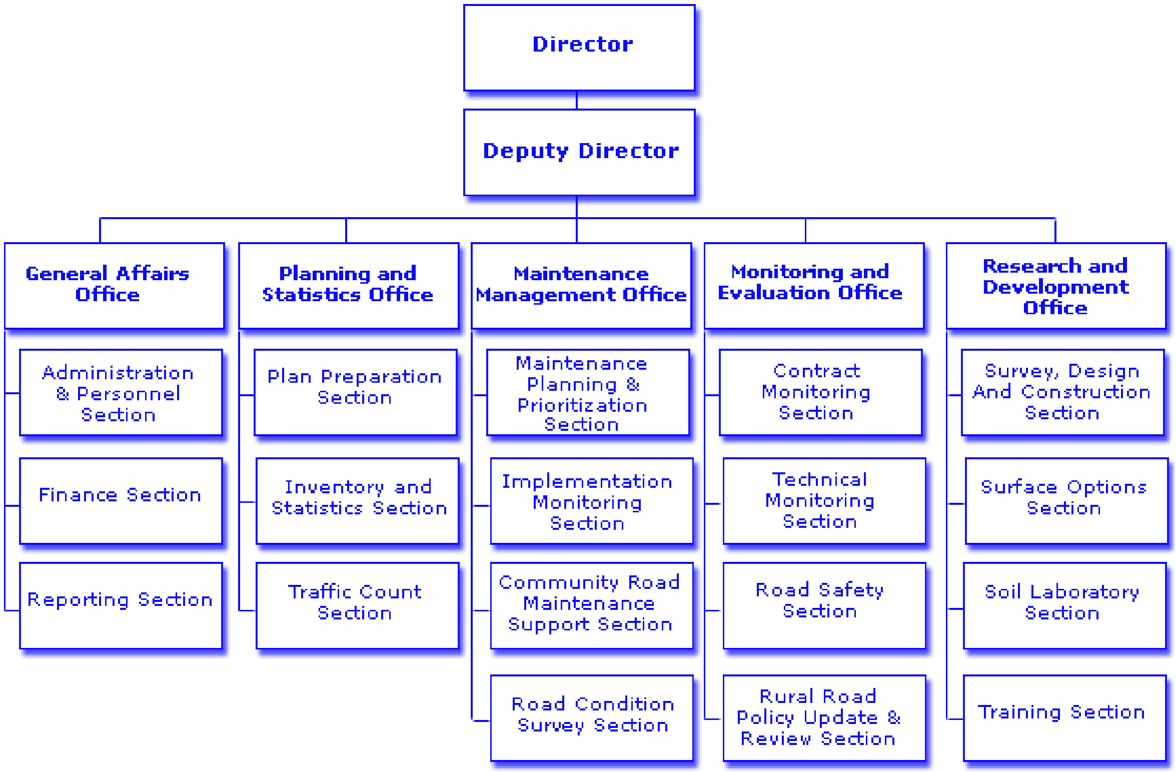


Figure 8.2 Structure of the Department of Rural Roads at MRD

8.1 RURAL ROAD POLICY AND STRATEGY

178. A draft road policy and strategy has been prepared by MRD. The following paragraphs have been extracted from that document.

179. The MRD policy for rural roads is to provide all year access to all; that is access to basic needs, economic and social facilities, services and opportunities. The goal is to develop and manage sustainable road transport infrastructure, modes and services.

More specifically the goals are:

a) Rural access will be efficiently developed and managed to ensure optimal economic returns on investment; connectivity to higher order infrastructure; benefits to society and the use of local resources

b) Rural access will be sustainable in economic environmental and social terms

c) Land and water rural infrastructure will be complementary to improve rural access for women and men

d) Rural transport modes and services will be equitable, affordable, dependable and safe.

180. To achieve this policy a strategy has been developed for rural roads. The seven most important issues addressed in the strategy are summarised below in

order of priority, together with a summary of the proposed actions for addressing the issue (shown in italics).

1. Adoption of the draft Policy for Rural Roads by the RGC as official government policy.

   MRD will submit the draft rural roads policy to the Council of Ministers for its consideration and subsequent approval.

2. Development of a comprehensive road Inventory supported by spatial data: *Since a road inventory is one of the fundamental requirements for any sensible road planning system, MRD will start immediately the development of a complete rural infrastructure inventory, including roads, building on experience recently gained from an ADB assisted project.*

3. Developing an appropriate planning system including an appropriate method for prioritising and targeting road investments to reduce rural poverty and to promote the social and economic development of rural Cambodia:

   MRD will encourage capital investment in poorer provinces to maximise the investment impacts on the rural poor. A priority list of provinces has been developed to guide future capital investment. A road prioritisation methodology that takes into consideration the economic and social benefits of rural roads investment will be developed and made operational at different levels. Further, a simplified system for maintenance prioritisation will be developed.

4. Clear and comprehensive guidelines to address technical and other issues that are related to rural road development and maintenance:

   MRD will develop guidance on a number of issues linked to the technical, social and environmental aspects of rural road improvements including appropriate road surfacing, the use of appropriate technology for roadworks, rural roads and rural water transport complementarity, and rural road standards.

5. Development of a comprehensive maintenance system that supports asset preservation:

   MRD will implement a simple basic maintenance management system on a priority basis, trialling the system in a number of provinces and then moving progressively towards a more sophisticated system.

6. Provision of appropriate resources for development and maintenance:

   More emphasis will be placed on maintaining and adding asset value to the rural road network. MRD will seek increased maintenance funding from the government, and increased donor support to supplement the RGC's efforts.

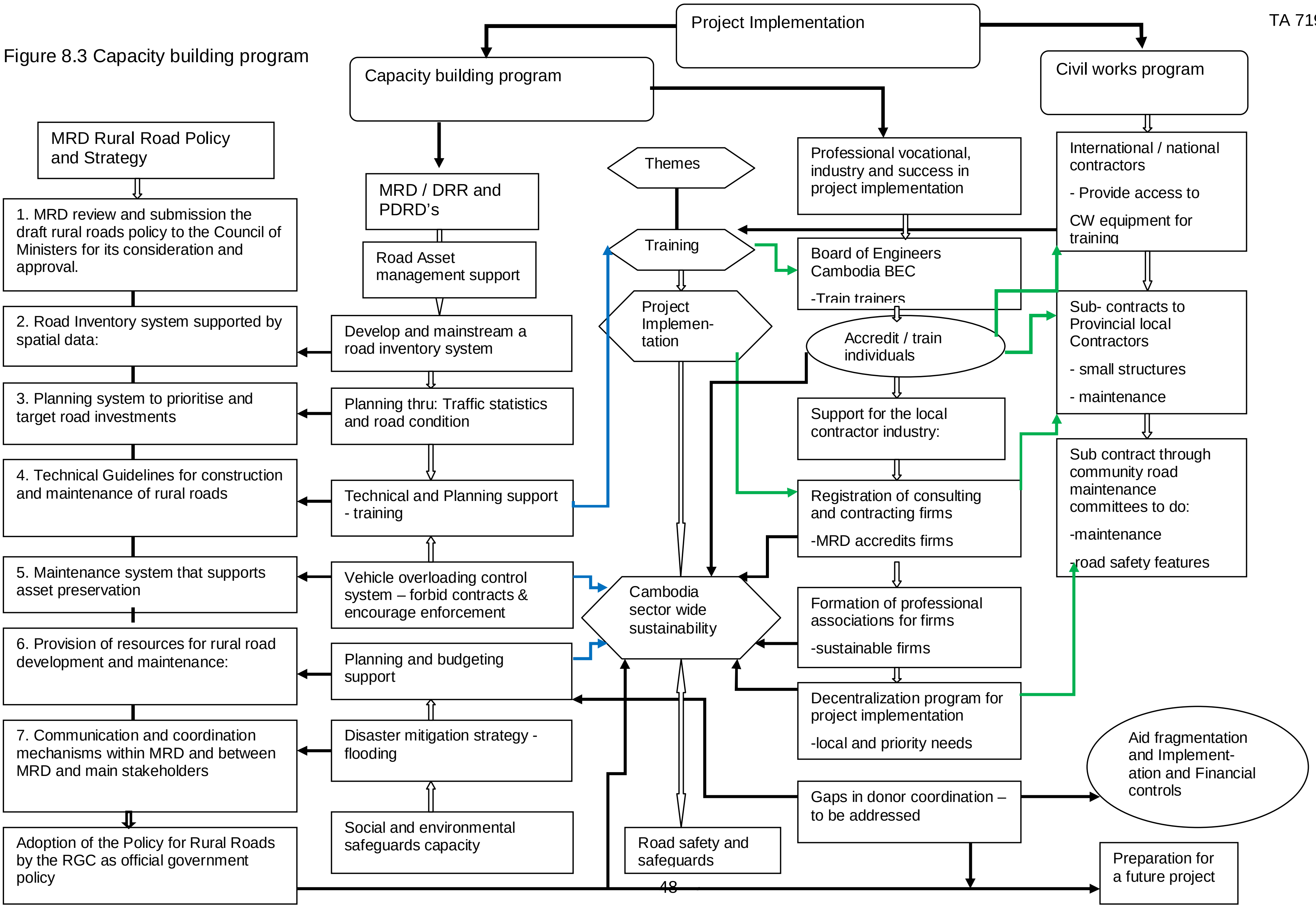
7. Setting up appropriate communication and coordination mechanisms within MRD and between MRD and main stakeholders:

181. At the time of writing, the 2008 draft rural road strategy had yet to be translated into Khmer, and none of the PDRD directors contacted as part of the study had been given access to it. However this project can be used to effectively kick start the policy directions described in the Rural Road Strategy, including training of PDRD engineers, increased support to the provincial contractors and support to the

Commune Councils (CC) with an emphasis on using both equipment and labour based road maintenance methods.

182. Item 1 of the Policy and strategy document given above indicates that MRD should submit the draft document to the Council of Ministers for consideration and approval. It is vitally important that the Rural Road Policy is finalized and adopted by MRD and rolled out to the staff and the public. As such it is appropriate that this objective forms a covenant under the proposed loan to be achieved towards the end of the loan period given the high level government path that must be taken to process draft and respond to comments and clarifications. The capacity building components proposed in this report support the strategy given in the draft. It is also proposed that the capacity building components support achievement of the Policy and Strategy itself. The capacity building components of this project are illustrated in Figure 8.3. The links between components show how the program supports the policy, the MRD and DRR, the contracting industry and the implementation of the project, and overall the sustainability of the sector. To aid clarity, not all links are shown, but it is envisaged that the reader will be able to obtain an overview of the complementary nature of the capacity building program.

Figure 8.3 Capacity building program



8.2 ROAD ASSET MANAGEMENT SUPPORT

8.2.1 ROAD INVENTORY SYSTEM

183. The existing approach taken for scheduling and managing the maintenance of gravel roads in the provinces was found to vary from reliance on paper-based record systems to the use of GIS and the ROMAPS asset management software. A component of the capacity building program, to building the capacity of MRD and the PDRDs, is therefore to introduce a road inventory system in the project provinces for eventual use on a national basis. MRD have indicated that licensed software such as ROMAPS used in some provinces has been difficult to sustain and expand to other provinces because of the high cost of the licenses. A simpler system, probably using spreadsheets, suitably designed for interactive use by MRD and the PDRD's is preferred. Training courses in its use will be provided. Additional GPS units will be made available under this project. The system should include a risk management capability for recording sections of road that are subject to flooding (see Section 8.4.4). It is proposed that a brief review of recent work carried out under the Provincial Roads Improvement Project (PRIP) at MRD is undertaken and a suitable system is developed and mainstreamed under this project.

184. It is also proposed that a road numbering system is introduced that is consistent with the numbering system operated by MPWT. The MRD were party to the introduction of the latest system (June 2009) and the roads to be upgraded under this project have been numbered according to the system introduced in June 2009.

8.2.2 TRAFFIC STATISTICS

185. The structure of the DRR at MRD (see Figure 8.2) indicates a capability in many of the critical components of rural road infrastructure management. However, in practice, support is needed to ensure that essential data about the rural road network is collected and evaluated to inform decision makers of the priority links within the network. One function that is not being undertaken, and that is critical for decision making, is the collection and evaluation of traffic statistics. This requires information on traffic types, volumes and loadings on the network. At present, routine classified traffic counting is not being carried out.

186. It is important that the collection and reporting of traffic statistics conforms to national standards so it is a resource for the needs of other ministries. MRD staff require operational support and training in traffic counting and reporting systems. The system so established should also be developed to inform the Ministry about axle loading levels on the network and how to integrate their system with that operated by MPWT, being the Locational Referencing and Condition System (LRCS) which provides information on the national network and the newly established full scale weigh stations established on major national roads. Portable, axle weighing equipment will be provided under the project; further information is given in Section 8.2.4.

187. Information is also required on the condition of road links on the network. Support will also be given to introduce a relatively simple means of recording road condition to supplement information on traffic.

8.2.3 MRD AND PDRD TECHNICAL AND PLANNING CAPACITY

188. All PDRDs contacted during this study reported that until now all road construction and maintenance activities undertaken by PDRDs have been restricted

to the provision of earth or gravel surfaced roads. The proposed project will form an introduction to paved road techniques for which the provincial engineers will require training to be able to manage and supervise civil works and maintenance contracts in the future. (Consultants and contractors are being used for this project.) The most significant and consistent requirement for capacity building of PDRDs is training courses in the design, construction and maintenance of paved roads. Topics such as bituminous materials, bituminous surface treatments, unbound materials and stabilized materials and appropriate site supervision and testing will be taught and practical training will be given. Formal lectures will be given in Phnom Penh, followed by site-based practical training courses, in the provinces and on the project roads. The courses will be highly practical, and targeted at mid-level engineers and technicians rather than senior management. Access to civil works equipment during the training is essential and this will be provided by obtaining access to the equipment of the civil works contractors for agreed periods see paragraph 202 and paragraph 252. The courses will be accredited and count as professional development from the Board of Engineers Cambodia, with certificates issued on completion that will contribute to professional training achievements (see Section 8.2.6. A tentative curriculum is shown below:-

- Introduction to asphalt materials
- Bitumen rheology
- Aggregate properties
- Design of bituminous surfaces
- Specification of asphalt materials
- Methods of construction
- Procurement of contractors and contract management
- Site supervision and quality control
- Site testing
- Laboratory testing
- Maintenance techniques

189. Project planning and management courses are equally important and required. A series of courses on these subjects will be provided under this project.

8.2.4 VEHICLE OVERLOADING CONTROL FOR RURAL ROADS

190. All PDRDs contacted during this study considered vehicle overloading to be a problem for rural roads, and reported that load control posts and barriers were generally ineffective and subject to vandalism. In Kampong Speu this has led local communities to introduce barriers at which road maintenance tolls are collected from heavy trucks. Rather than restricting overloaded trucks on roads potentially subjected to regular heavy quarry traffic, another approach taken in Kampong Speu and Siem Reap provinces is to allow the quarry operators to maintain the existing gravel roads. They are apparently willing to do so to reduce their vehicle journey times and vehicle maintenance. However, this arrangement is unlikely to continue once roads are sealed. Effective enforcement of load controls with weigh-scales at or close to the quarries for example has become necessary. Effective control of other (agricultural

for example) overloaded trucks is most likely to be achieved through a publicity campaign intended to raise awareness and by applying social pressure on truck operators to curb excessive overloading. Quarry owners, for example, must be caused to comply with vehicle loading legislation. Indeed, it would be normal practice for efficient quarries to establish and maintain their own weighing systems for control of their own businesses. Encouraging that approach may make it easier to exert some control. However, it is expected that high level assistance from Government Officials will be required to curb overloading in the project area, and this must be supported by the Community Councils. It will also be necessary to use enforcement to ensure axle loading is controlled.

191. Seven permanent weigh stations have been installed on national roads and powers of enforcement of legal load limits are established. This project will provide portable weigh bridges for use by the PDRD's in the project area and training in their use and in the engineering concepts of vehicle overloading. These weighbridges will be used to identify the main offenders. Offenders may be caused to travel to the permanent stations for law enforcement purposes. Vehicles (motor cycles) are to be supplied to the local authorities and the police for the road safety component (see Section 8.3) and the authorities must also use these to enforce axle load control.

192. It is also proposed that the project does not enter into supply contracts with operators of quarries who obviously disregard the law and overload their trucks. When contracts are entered into, they must contain clauses so that overloaded supply trucks may be refused at their origin, ideally, or at the work site.

193. It is also proposed that MRD as an entity agrees not to enter into any contracts for goods or works with any supplier who disregards the law on overloading vehicles. Furthermore, it is recommended that compliance with this approach should be a condition of registration for eligibility for civil works. Registration of firms and entities is discussed in Section 8.2.7.

8.2.5 PLANNING AND BUDGET SUPPORT

194. The ADB SAPE[2] of 2009 reports that while attempts have been made over time to ensure the availability of funds for road maintenance the provision of sufficient funding remains a major challenge to the sustainability of Cambodia's road network. One of the initiatives was to encourage the establishment of a road maintenance fund in the year 2000. However the fund remained part of the general budget and the concept of a road fund with an assured stable inflow of funds has so far not been implemented. The chronic lack of funds was addressed by the RGC adopting a levy system on fuel of $0.02 per litre of diesel and $0.04 per litre of gasoline. The RGC has also agreed to raise the road maintenance budget by 5.5% per year. The proceeds go to the general budget. An interministerial committee consisting of representatives from MEF, MPWT, and the private sector was created in 2005 to determine the annual maintenance allocations. As a result, road maintenance funding has increased from about $2-$3 million in year 2002/03 to about $26 million in 2007, about $33 million in 2008, and about $32 million in 2009. As reported above, the MRD does not have representation on the interministerial committee and it is understood that funding for the MRD's road assets is not included in the above figures. The budget for MRD for both routine and periodic maintenance was about $5.8million in 2009 and the planned budget for 2010 is $6.5million. While a year-on-year increase can be noted and it can be expected that rural roads are less costly to

[2] Sector Assistance Evaluation Program: SAP CAM2009-34. Transport Sector in Cambodia: Focusing on Results; September 2009.

maintain than national roads on a per kilometer basis, MRD's assets are approximately 28,000kms whereas MPWT's assets are about 11,500km. From the above it is clear that MRD also suffers from a chronic shortage of annual funding to maintain and develop its assets. The budget for 2010 is targeted at providing routine maintenance for 524kms of rural roads and providing periodic maintenance of 617kms for rural roads, a small component of their network. At the same time only one-sixth (4,600kms) of the rural road network is judged to be in a good to fair condition. Further information on the rehabilitation of the rural road network taking a life cycle approach is given in Chapter 12.

195. It has been recommended in this report that the policy and strategy for rural roads must be formalized and, on the basis of this, the MRD should obtain further representation at high levels within the government to further portray the current situation and attract additional funding. At the same time it should urgently seek further external investment funding. Providing an inventory and rational system for prioritizing investments as well as providing more durable assets through technology changes (towards paved roads) and providing training for its staff, and for the road engineering professionals and practitioners, its local consultants and contractors are all vital to be able to implement change for the development of the country and achieve a reduction in poverty and access to services.

8.2.6 PROFESSIONAL ASSOCIATIONS

196. The Board of Engineers Cambodia (BEC) has been derived recently from The Engineering Institution of Cambodia (EIC) and was established by Royal Degree on 07 April, 2009. The BEC is now the sole National Engineering Institution in Cambodia. Its vision is to provide a professional association of registered engineers and to develop their professional qualifications to an internationally accepted standard and, therefore, enhance their contribution to national development and alleviation of poverty.

197. The mission of the BEC is the:

- improvement of the engineering profession for the honor and dignity of engineers;
- preservation and glorification of national identity;
- strengthening of technical capacity of all engineering fields and the expansion the engineering human resources;
- maintain high quality, efficiency, safety, stability, and responsibility in engineering profession;
- strengthen and expand cooperation and relationship among engineers at national and international level;
- set up an acceptable standard to recognize and grant title of Professional Engineers at a national level and screen engineers to apply for an international level;
- contribute to professional training for development of human resources in order to satisfy social demands;
- define and maintain high standards for the registration of professional engineers.

198. Registration of Engineers with the BEC may be granted upon the award of a degree, and newly academically qualified engineers may progress to professional

status after 5-years of relevant experience. By review of the BEC, existing and experienced engineers may be granted national professional status, and then by further review, to meet the requirements of the ASEAN professional association, they may be granted international status. Registration is open to individuals only, it is not available for business or other entities. The annual registration fee is $20.

199. The BEC intends that, rather than relying solely on membership fees for income, they will derive their revenue by providing services such as training, publications and insurance or legal services for their membership, in a similar fashion to that of professional associations in developed countries This revenue is to be used to develop new services which help to attract and retain members.

200. The BEC is currently (2009) preparing documentation and promotional materials to launch a membership drive in 2010. In a meeting with senior members of the BEC council it was pointed out that:

- The Council were seeking further knowledge about examples of successful engineering professional bodies internationally to be able to develop a suitable model for Cambodia.
- Cambodian engineers are taught at formal education establishments in Khmer or sometimes in the French language, but none of the courses are taught in English whereas nowadays there is a common requirement for the use of English in the workplace. The Council noted that engineers strive to develop their English skills by taking private courses. (This point emphasizes the need for training of national trainers in many circumstances, partly because of language.)

201. It is the view of the consultants that the BEC should be supported by the project to assist in bringing the BEC together with professionals of other international engineering societies of internationally renowned status to promote dialogue and understanding through visits by the Board members to those renowned organizations with the objective of developing a suitable model for Cambodia that is sustainable in the long-term.

202. It is also the view of the project that technical training courses in road engineering be planned jointly with BEC and should be supported by the project with the objective of developing the technical capacity and promoting the quality of engineers towards the award of national or international status. The project should assist by identifying a core body of Cambodian engineering professionals and educators who will link with international training experts funded by the project to share knowledge and receive training in road engineering at the formal level. To achieve the core group of national trainers, the project will associate closely with the Institute of Technology, Cambodia (ITC) which is one of the most eminent academic institutions in the country. The role of the international experts would be to train national trainers such that they in-turn may impart a high level of effective professional training to engineers registered with BEC.

203. While the BEC will register engineers of all disciplines it is intended that the project will support training in road engineering and its associated disciplines. Training courses would be in areas such as bituminous materials, CAD software, road geometric design hydrology and asset management. The training will be carried out in association with the training planned for MRD and PDRD engineers and other professionals and for contractors as described in Section 8.2.3 and Section 8.2.10 of this report.

204. It is vitally important that the trainees receive hands-on practical training on-site with civil engineering equipment. To achieve this, the civil works packages will be contracted in such a manner, with relevant clauses, such that access to equipment and time for its use is assured for training purposes.

205. The Cambodia National Community of Transport Practitioners (CNCTP) declares it is a partnership of organisations and individuals that share a concern for good management and use of rural road network assets in Cambodia and whose interests are best served and developed through a common platform that has government recognition. Its mission is to facilitate and promote the successful application of improved policies, planning frameworks, financing mechanisms, technologies and best practices. CNCTP has the support of MRD in its endeavors and the secretariat office of CNCTP is located at MRD. It is active in the professional engineering community It is recommended that CNCTP should be involved with the training and development programs.

8.2.7 REGISTRATION OF CONSULTING AND CONTRACTING FIRMS

206. As mentioned above, the BEC does not permit the registration of firms, only that of individuals. The development of a register for firms is essential for the RGC to ensure competency of its contractors, whether as consultants or as civil works contractors. A register must be developed and maintained that indicates such competency by experience of work types previously carried out, equipment owned and also importantly the competency of its professional staff. Competency of staff should be judged on their status with the BEC. Through previous interventions contractors from the local level and higher have been trained and have exhibited competency and have complemented the work carried out by firms with a provincial or national status. It is recommended that the development of a register is supported under this project.

8.2.8 FORMATION OF PROFESSIONAL ASSOCIATIONS FOR FIRMS

207. While informal groups of contractors exist in the provinces, they should now be registered as mentioned above and encouraged to form a professional association to promote, develop and sustain their capacity for undertaking civil engineering works at various levels. The associations should support the BEC's mission by encouraging membership of their staff and encouraging the vision of best practice by formally engaging in dialogue and knowledge exchange with the BEC to strengthen the link between the profession and the industry.

208. The formation of a professional association of firms should be supported by the project. This will be carried out by the training experts provided under the road asset management capacity building program. The expert(s) will promote dialogue with seniors of registered firms and entities and formulate the concepts and articles of association for a professional body to be formed.

8.2.9 SUPPORT FOR THE LOCAL CONTRACTOR INDUSTRY

209. Six small to mid-size provincial contractors were interviewed during the course of this study. Most claimed to have access to adequate equipment for carrying out bitumen work, but reported that the most significant barrier to entry for smaller contractors into the paved road building sector was the requirement for a bank guarantee of 10% of bid price after successful award. This becomes a significant barrier when SBST and DBST projects are let in large packages, as has historically occurred for national road projects administered by the Ministry of Public

Works and Transport. A possible approach to effectively lower this barrier would be to form a construction guarantee fund offering preferential rates and credit for smaller provincial contractors. This is expected to have a significant effect in enhancing local road building capacity especially when combined with a national policy of dividing future SBST and DBST projects into smaller contract packages. While these views are recognized by the consultants, the positive approach under this first project involving paved roads is to offer the smaller scale private contractors opportunities through sub-contracts with the main contractors. This provides further experience under a less arduous financial regime, and the registration of firms with MRD and the registration of individuals with BEC will provide substance for eligibility for financing for future projects. This is discussed further in the paragraphs below.

210. Local and provincial level contracting firm and entities have received practical training and have carried out works under previous ADB loans, as mentioned above. They are also carrying out works under contract from the MRD, through the PDRDs, for contracts wholly funded by RGC. These works include the construction of cross drainage and other small structures and the supply of materials for example. They are reported to have been effective in conducting these works[3] . This support for the smaller scale contractors will continue through sub-contracts for similar works from the major firms contracted under this project.

211. However the contract packages should be specified such that sub-contracts must be issued to cascade the experience into Cambodia at national and provincial levels. It is also intended that contracts cascade to Community Council level through the local road maintenance committees to build experience for routine maintenance and other functions for the future; the provision and maintenance of road safety features are an example of works that are best carried out (and then maintained) by the local communities.

8.2.10 CONTRACTOR TRAINING

212. Although national and provincial contractors claim access to equipment to construct sealed roads, their experience with MRD contracts has been limited to the construction and maintenance of only gravel surfaced roads and small structures. Furthermore, with only 2,400kms of bitumen sealed national roads experience with the construction and maintenance of paved roads is likely to be very limited.

213. The construction of the project roads requires both equipment and experience, and practical training is required to gain the latter quickly. Practical training is essential and can only be carried out using relatively expensive equipment such as bitumen distributors and aggregate chipping spreaders. The civil works contracts are to be targeted at international contractor firms, which in Cambodia permits bids from national contractors. To provide training in a comprehensive and measurable manner, resources will be required. The training should be carried out concert with the development of a contractors' association, or in advance of that through the register of engineering firms, as mentioned above, which provides a form of accreditation to those firms whose staff have received training.

214. It should be noted that the use of DBST will require a resealing with an SBST after about eight years in service. This provides a target to focus training of

[3] ADB Loan 1385-CAM. Project Completion Report of the Rural Infrastructure Improvement Project. PCR CAM20899. Project Completion Report on the Emergency Flood Rehabilitation Project. IDA Credit Number 3472-KH, World Bank. ADB Loan 1824. Emergency Flood Rehabilitation Project. ADB Loan 1862-CAM. Project Completion Report: NRDP: Northwestern Rural Development Project.

provincial contractors so that they may bid for future civil works contracts. The project considers that non-contracted contractors, that is not directly associated with the project by civil works contract, should also receive practical training. These firms may be identified through the register.

8.2.11 DECENTRALISATION PROGRAM FOR PROJECT IMPLEMENTATION

215. The Decentralizaton and Deconcentration (D&D) process is advancing in Cambodia. Commune Councils of elected officials who in turn elect officials at district and provincial level has been achieved, with the latest elections being held in May 2009. Thus, delegation and decision making power is being transferred to localities at sub-national levels. A primary role of the councilors is to design development plans for their commune. Development plans include infrastructure development such as local roads, sanitation and schools. Central Government has established the Commune and Sangkat Fund (CSF) to support approved development plans. In April 2008 the organic law on Administration and Management was adopted which empowers sub-national entitles and supports the funding intentions of development partners including international donors. The project roads pass through 23 districts and 71 different communes. A list of these is given in Table 8.1.

Table 8.1 List of Communes traversed by the project roads

No	Province	Road number	Name of Road	Name of Districts	Name of Communes	Lengths, km
1	Kampong Cham	370	Cheung Long - Oraing Ov	Thbaung Khmum	Soung, Moung Riev, Chikor,	29.39
				Oraing Ov	Damrel, Chork, Toul Sophi, and Korng Chey	
		371	Peus Pir - Kdol Leu (Trea)	Krouch Chhma	Peus Pir, Svay Kleang, Krouch Chhmar, and Trea	20.84
		373C	Memot (NR7) - Kabas	Memot	Memot, and Memong	18.47
2	Kampong Thom	2620	NR64 - Prasat Sambo(Chamres village)	Kampong Svay	Chey	28.75
				Prasat Sambour	Sambour, and Chhuk	
		2KT2	Chamres Village - Sandan Town(East River)	Sandan	Mean Chey, Ngan, Sandan, and Mean Rith	37.43
3	Kampong Chhnang	1KCH2	Phsar Pong Ror - Ra Krang Skear	Rolea Bier	Pongror, and Banteay Preal	25.27
				Teuk Phos	Kraing Skea	
		151C	Phsar Trach - Tbeng Khpos	Sameakki Mean Chey	Svay, and Thbeng Khpos	11.10
		151C	Wat Tbeng Khpos - Spean Our Tatep	Sameakki Mean Chey	Thbeng Khpos, and Svay Chuk	7.60
		151C	Spean Our Tatep - Phnom Prah Theat	Sameakki Mean Chey	Peam	16.33
		1KCH3	Spean Pour - Ra Meannor	Sameakki Mean Chey	Sedthei, and Thbeng Khpos	12.51
4	Pursat	154D	Boeng Khnar - Metoeuk	Bakan	Beung Khna, and Me Teuk	11.11
		152E	NR5(Beung Kantout) - Kampong Po	Krakor	Beung Kantout, and Kampong P	8.80
		155D	Boeng Khnar - Talou	Bakan	Beung Khna, Rumlech, and Talo	20.00
		155C	NR5 (Trpaing Chorng) - Bord Rumdoul Village (Phtah Roung commune)	Phnom Kravanh	Phteah Rung	22.37
				Bakan	Trapaing Chong	
		1PS2	Talou(connect from 12) to Samroang village, Samroang commune	Bakan	Talou	18.25
				Phnom Kravanh	Phteah Rung, and Samraong	
5	Battambang	1BB1	NR5 (Prey Svay) - Sdok Praveuk, Preytralach commune	Moung Reussey	Prey Svay	
				Rokhakiri	Prey Tralach, Reussey Kraing	24.93
		1BB2	NR5(Railway) - Prek Chik - Chong Por village	Mong Reussey	Moung Reussey, Robas Mongkol, Prek Chik	
				Rokhakiri	Prey Tralach	23.20
		1BB3 &1BB4	NR5(Chrey) - Talas - Karkos	Moung Reussey	Kakaoh, Taloah, Chrey, and Kea	23.91
6	Kampong Speu	1KS3	Phsar Trapang Kraleung - Phsar Pang Kassey	Phnom Srouch	Kiri Vaon, and Prey Khmeng	45.44
				Basedth	Svay Chacheb, Toul Sala, Svay Rumpea, Pheari Meanchey, and Toul Ampil	
		1KS4	Samki Reaksmey - Kraing Thom - DakPor	Phnom Srouch	Ou, Prey Rumdoul, Taing Samraong, Tumpor Meas, Kraing Deivay and Tang Sya	23.91
7	Siem Reap	266E	Pouk - Angkor Chum	Pouk	Pouk, Lvea, Reul, Trei Nhoar	29.61
				Angkor Chum	Nokor Pheas, Ta Saom	
		266D & 2SR2	Leang Dai - Svay Sor	Angkor Thom	Leang Dai, Peak Sneng, Chop Ta Trav	46.18
				Angkor Chum	Kouk Daung	
				Varin	Svay Sor	
Total	**Total**					**505.40**

216. As highlighted in the rural road strategy, the CCs currently have little technical or managerial skills however they currently assist the PDRD's by planning and coordinating routine maintenance of gravel roads. The proposed project will extend and strengthen the role and experience of the CCs and positively impact the income of local residents by first offering training and then opportunities to work on road construction and maintenance activities under the cascading civil works contracts approach. The emphasis will be on recognizing that some local residents may be engaged on other vital activities at particular times of the year, such as farming, and so are only available intermittently, while others may be available for permanent work and, and others may see the opportunity to establish equipped, small business entitles that can receive civil work contracts.

8.3 ROAD SAFETY AND SAFEGUARDS PROGRAM

8.3.1 ROAD SAFETY

217. Unfortunately, Cambodia endures an extremely high accident rate that is three times that of other countries in the ASEAN region, and in Cambodia, accidents, casualties and fatalities have all increased faster than the growth in road traffic and the population[4]. From 2003 to 2008, the number of crashes increased by 135% and the number of fatalities almost doubled. At the same time, the population increased by 6% and the number of registered vehicles increased by 123%. In 2008, 25,796 traffic casualties were reported from 10,015 crashes. Among these casualties, 1,638 were fatalities. The fatality rates in 2008 were 12.2 per 100,000 inhabitants and 15.1 per 10,000 registered vehicles. The fatality rate per 100,000 inhabitants has increased since 2005. The fatality rate per 10,000 registered vehicles is four times its 1998 level and double the Government's target of 7 per 10,000 registered vehicles for 2010. Data from 2009 indicates that, currently, the annual rate is 21.5 fatalities per 10,000 registered vehicles.

218. The road accident database, the Road Traffic Accident and Victim Information System (RTAVIS) has been developed in Cambodia since 2004 by the Ministries of Health, Interior, and Public Works and Transport, together with Handicap International. Information on accidents is collected from the traffic police, hospitals and other public health facilities, and private clinics. The data cover all roads, but accidents on urban, national and provincial roads dominate, and many minor accidents not involving injuries are clearly not included. The data show that 40 percent of casualties are injured in urban areas and 50 percent on national/provincial roads, with overall 80 percent occurring on paved roads. Only a small part of the data relates to rural roads.

219. Most road accidents (92%) have been caused by road users violating traffic rules, notably through speeding and drunk driving. The second most frequent cause of accidents is at " accident blackspots," or locations and sections of roads prone to accidents because the infrastructure was either not designed to appropriate safety standards or is poorly maintained, or both. Poor roadworthiness of vehicles forms the third most important cause of road accidents. Seventy-seven per cent of accidents occurred on straight sections of road, others occurred at road intersections, with vehicles turning left (crossing the other lane). Sixty-one per cent of fatal crashes occurred in rural areas.

220. Sixty-seven percent of the casualties were aged between 0 and 14 years, and 30% were injured on minor roads and tracks. They were injured between the

[4] Source ADB Sector Assistance Program Evaluation September 2009, based on Cambodia Road Traffic Accident and Victim Information System (RTAVIS).

hours of 11:00 am and 12:00 noon and between 4:00pm and 6:00pm, clearly associated with school hours. Forty two per cent were motor cycle users, and 47% were pedestrian.

221. The initiatives to improve road safety in Cambodia are well developed and expressed in the 15-point National Road Safety Action Plan (NRSAP). The plan receives support from both public and private sector entities.

222. The rural communities are aware that paving the roads is likely to lead to an increase in traffic speeds, and have expressed their concern. The project includes a component to address the Road Safety problem through the provision of a road safety expert who will, in concert with existing programs in Cambodia, support the NRSAP and deliver practical solutions including public awareness of the road law, road user competence and education and vulnerability awareness. The road safety component will include the provision of direct training and training of trainers to be based in the communities. Information documents and pamphlets will be provided for distribution in the communities. The road safety expert will be an international with supporting expertise at national level and the support of a psychologist will also be required in the design of appropriate materials for children at home, in the schools, young adults and other members of the communities. Some material must be specifically targeted at motor cycle users who are perceived as a very high risk group, and a considerable proportion of the traffic is motor cycles. The social safeguards study has highlighted in particular the concern of mothers of young and older children, and they should be involved in the accident prevention measures and training. The program must attain the support of the mothers and train them and others in how to teach and maintain and reinforce RS awareness and involve them to cause long-term change in patterns of behavior. The local authorities especially the police should also receive training and guidance to enforce the law as necessary. A Road Safety Officer will be appointed at Commune Council level.

223. Importantly, the road safety component will also address the role of the civil engineering community in reducing the accident rates with clear guidance on adherence to good, safe, road design, construction and maintenance practice. Road safety has been addressed in the civil works packages by providing traffic signs, structure painting, and road marking on the approach to hazards.

224. This project will seek to provide safe road improvements to paved standard and ameliorate the risks of increasing the incidence of road traffic accidents by the taking the following capacity building measures.

- MRD will take a prominent role on the NRSC to encourage the take-up of initiatives within and through the Ministry
- DRR and PDRD engineers will participate in road safety engineering courses such as those undertaken in 2009 to ensure the fundamentals and best practice envelope the road design used in this project. The impetus is to recognize that the project roads are not being widened, but are being paved, and it is therefore essential to identify potential accident blackspots on all project roads at the time of detailed design.
- The DDIS (see section 10.2) will, in the engineering designs, ensure that traffic signage and traffic calming measures are incorporated in the works for narrow and other sections of road that impose a greater risk.
- The road safety expert will review which provinces have received road safety education under the NRSAP within local schools and elsewhere in the

community, and ensure that these, and other social centres receive further training or initial training as the case may be.

- The road safety expert will devise suitable training packages, and training for representatives in the local communities of whom the majority are expected to be women within the local community, to take up the cause for education and discipline for young roadside persons and young road users and implement them.
- The road safety expert will devise programs and educate local community councils of the risk and cause them to work with or appoint a local road safety officer to sustain the program and protect the community. In this it is essential that educational or enforcement measures are conducted directly to the age group of 20 to 29 year old males who are at most risk of being injured or killed in road accidents. The program must also educate the age groups between 0 to 20 years, in stages with different requirements, to complete the process.
- Either community officials or the local police will be equipped for enforcement by providing motor cycles under the project so they may engage with offenders at the time and deal with the offence appropriately. The local police will also be equipped with GPS units so they can adequately record locational information and report this information to the higher authorities for inclusion in the national statistics and therefore identify emerging accident black spots. These motorcycles will also be available for overloading control as well as for other road traffic law infringements, as mentioned in Section 8.2.4 of this report.

8.3.2 MRD SOCIAL SAFEGUARDS AND ENVIRONMENTAL PROTECTION CAPACITY

225. As MRD is seeking to finance improvements to its rural road assets from the providers of Overseas Development Assistance (ODA), it is aware that most of these providers have in place social and environmental safeguards, with which they are legally obliged to comply. These are safeguards that have been developed over the past 20 years as a result of extensive discussions between providers of ODA and recipients. ADB policies and procedures are those accepted by member countries of which Cambodia is also a member and by joining with the ADB it has implicitly agreed to accept these policies and procedures. It is necessary for MRD to have an in-house capacity to be able to assess social and environmental risks arising from its intended development programs, and it is therefore proposed that a Social and Environmental Unit (SEU) is established at MRD under the capacity building program of this project. The case for this and the requirement is discussed further in the following paragraphs.

226. The social safeguards and environment component of this TA study has emphasized the broad role of MRD in the development of Cambodia for example one of the other main functions is being the provision of safe water supplies for rural communities. The structure of MRD is given in Figure 8.1 above. This broad role serves to emphasis the importance of having an SEU capacity to provide a focal point for both development partner programs and for MRD’s own road (and other infrastructure) development programs. The SEU should cooperate with the MoE and other Ministries on aspects of infrastructure development for the protection of communities and the environment.

8.3.3 SOCIAL SAFEGUARDS CAPACITY

227. There are four social safeguard issues for which MRD needs to acquire an in-depth understanding. These are (i) resettlement; (ii) ethnic minorities; (iii) HIV/AIDS and other STIs; and, (iv) human trafficking prevention. The requirement is to be able to assess the potential impact of these issues and determine the mitigation measures that may be necessary.

8.3.4 ENVIRONMENTAL SAFEGUARDS

228. MRD also needs to have an understanding of both ADB requirements and RGC requirements for assessing the environmental impact of rural road improvements. While MRD assets are unlikely, in most instances, to require a full EIA they do routinely require a IEE. MRD also needs to have the capacity to prepare, implement, monitor and evaluate an Environmental Management Plan (EMP). This will also enable MRD to be aware of, contribute to and ensure due diligence is being applied in studies that may be undertaken by consultants.

229. During the training carried out under this study, MRD staff demonstrated competence in identifying road safety issues and the continuing importance of rural roads for non-motorized transport users (NMT), being among the poorest and most vulnerable of rural road users. MRD's role as a rural development Ministry rather than only a provider of rural roads further emphasizes the need for MRD to have a Social and Environmental Unit (SEU) at MRD.

230. While office space should be provided by MRD the SEU requires practical and operating resources and training to be provided both locally, regionally and internationally. Thus, study tours are proposed to develop the in-depth knowledge required to be able to function as an effective SEU for MRD. The SEU would then provide training in social and environmental safeguards and pro-poor approaches to rural transport issues to each of the PDRD's. The provision of this capacity building support is included under this project.

8.4 CLIMATE CHANGE ADAPTION

231. In the context of the ADB Sustainable Transport Initiative and commitment towards addressing climate change in its Strategy 2020, ADB has been developing a number of pilot projects to develop knowledge and replicable models in DMCs on how to climate proof transport projects and programs. This project in Cambodia represents one of those case studies and the only one in Southeast Asia. The aim has been to incorporate concerns about climate change impacts into project design in order to reduce the damages caused to planned and existing transport infrastructure and affected areas. Overall methodology and lessons learned are being incorporated into the development of guidelines which can be replicated elsewhere.

232. The levels of intervention to climate proof transport projects include: i) engineering or structural adjustments, such as adjusting drainage; ii) non-engineering or ecosystem based approaches, such as improved natural flood management; iii) policy and institutional capacity building to improve early warning systems, planning and alignment choices. A combination of these types of activities are ideal as part of a comprehensive adaptation strategy.

233. This Project specifically aims to rehabilitate and pave 505.4 km of rural roads of 5-6 m in width to improve rural connectivity to paved national and provincial

road network. The total loan amount is $67 million, out of which ADB finances $35 million, with co-financing from KEXIM for civil works in the amount of $19.35 million, and a $6 million grant from Nordic Development Fund (NDF) for the climate change adaptation component of the Project.

234. The Project has 4 major components; (i) civil works component; (ii) road asset management component, dealing with asset management capabilities of the Ministry of Rural Development (MRD); (iii) road safety and safeguards component; and (iv) climate change adaptation component, which deals with climate change and emergency management activities. The following describes the framework for the adaptation strategy.

8.4.1 CLIMATE CHANGE IMPACTS ON CAMBODIAN RURAL ROADS

235. A rapid climate change adaptation assessment was undertaken during the fact finding Mission including a field visit to the project area. Existing climate change projections supported by field observations highlight two major concerns related to current and future climate changes. Specifically, there appears to be an overall increase in average total annual rainfall and, this increase is poorly distributed over seasons, resulting in increased floods during the rainy season as well as increased drought incidence during the dry season. Increased flooding and soil moisture content is already of primary concern to protecting the investment in question and will be addressed as a priority in the adaptation strategy.

236. The proposed adaptation strategy therefore includes a combination of cost-effective engineering and non engineering adaptation approaches to manage the changes observed and predicted in the project area. The engineering changes have been mainstreamed in the detailed project design itself in view of mainstreaming adaptation into core development planning activities. These include elevation of the road in areas where major flooding is becoming increasingly common and changing the selection of sub-grade materials to withstand higher moisture contents. However, other adaptation activities which are outside the scope of the existing transport project can be more difficult to finance and manage within the existing scope and it is on these activities that the NDF co-financing will be focused.

8.4.2 CLIMATE CHANGE ADAPTATION COMPONENT ACTIVITIES

237. The adaptation component activities are focused on reducing the severity of climate change impacts on the infrastructure and to improve planning to prevent and respond to climate changes. These activities include, but not limited to: (i) vulnerability mapping for rural roads due to climate change to improve planning for climate changes; (ii) introducing ecosystem-based adaptation strategies focusing on environmental/green planning for project roads to improve flood and drought management (i.e. increasing ground cover and infiltration of floods and water retention during droughts, which has the added co-benefits of improving rural livelihoods by improving the soil structure for agriculture); (iii) piloting the use of climate monitoring systems to improve road maintenance and management program, since certain maintenance works can only take place during the dry season but as seasons are shifting it becomes more difficult to plan; (iv) developing pilot program for early warning system and a pilot program for emergency management planning for rural roads; and (v) planning water capture and storage systems to manage the increase intensity of floods and drought periods, in concert with the above mentioned ecosystem measures, for the project provinces.

238. ADB retains a climate change modeler and an adaptation economist through financing from the ADB Climate Change Fund (CCF) to provide advice and undertake initial activities, particularly with respect to vulnerability and adaptation mapping as described above. The work of these experts will be expanded on through this NDF grant. The experts will provide inputs to the grant consultants during the inception stages of the component.

8.4.3 DISASTER MITIGATION STRATEGY

239. The principal disaster risks in Cambodia are from flood and drought. Although drought is a severe problem for the population it is much less so for the rural road infrastructure, whereas flooding may cause severe damage and repairs are costly. At the same time, manageable degrees of flooding are expected in many regions of Cambodia and are essential to provide the water source for rice growing and many other agricultural activities. Clearly, disaster emanates when flooding is excessive and cannot be controlled and prevent access. In recent years excessive flooding has become more frequent and this has led to the occurrence of disaster situations, with loss of life and the destruction of homes and crops (TA 4574-CAM). Government, civil society and international development partners are actively engaged in disaster prevention, preparedness and mitigation measures. The National Committee for Disaster Management (NCDM) is the body that provides coordination of relief efforts and the supply of emergency aid. The project is located in the areas that flood and it is appropriate to contribute to the international effort to prevent or mitigate the threat. The PDRD's can provide a valuable contribution to the overall effort.

8.4.4 FLOODING RISKS

240. All PDRDs contacted noted that the Ministry of Water Resources and Meteorology played a central role by reporting weather and water levels. PDRD's indicated little awareness of evacuation plans or flood control works within PDRDs. The activities of PDRDs are currently limited to raising embankments for roads subjected to flooding when funds permit. Also, the equipment held by the PDRD's is generally very limited, suitable only for some routine maintenance. This is appropriate because the majority of civil work is carried out by contract and managed by the PDRD's. Other works are carried out by the military, who play a major role in upgrading the rural road network. Thus, there are resources available within the provinces and a first step towards mitigating flooding risks would be to compile a register of firms, equipment and other resources in the province so they may be engaged at short notice, once alerted by the authorities. Providing access in times of flood is of paramount importance to disaster mitigation strategies. Clearly prevention is better than a cure, so a next step is to gather and disseminate information about flooding risk locations and plan mitigation before the event. This project will support the PDRD's in developing a register of resources, and an inventory of road sections that are at various levels of flooding risk, so that the requirements can be included in budget planning. This parameter would form part of the road inventory system as discussed in Section 8.2.1 for emergency management planning.

8.5 GAPS IN DONOR COORDINATION

241. In 2007 the aid program from its development partners amounted to $888million from over 30 development partners. For 80% of these partners the disbursement was less than $1million per year. Aid fragmentation of this nature causes excessive weight and overlap of effort which detracts from the effective administration for the implementation of projects and the disbursement of funds. The

processes involved are in danger of overwhelming the RGC. The issues, problems and actions are clearly set out in the Aid Effectiveness Report of 2008 (AER) prepared by the Council for the Development of Cambodia (CDC). The Paris accord of 2005 and the Accra action plan of 2007 address this problem with the Harmonization and Alignment and Results H-A-R Action Plan. Coordination of aid is managed through the Annual Development Partners forum, as well as through more frequently held working group meetings. The development partners and the RGC signed the declaration on enhancing aid effectiveness in 2006. The plan calls for delegation of funds from multiple donors through a lead donor.

242. The donor community is addressing this issue, for example the EU has presented its concepts in a position paper on its Division of Labour approach for harmonizing the efforts of development partners in the Education, Health and D&D sectors where the EU had more than three development partners. Active partners have been limited to three and new initiatives and contributions from other partners into the sector can be provided through the lead partner. They may remain as silent partners they they may also engage with budget support initiatives. The EU also called for RGC to encourage its other development partners to engage in a similar rationalization process.

243. The ADB leads development partner contributions in the transport sector and actively seeks joint or parallel financing for its transport projects. It is also strongly supportive of setting in place standard operating procedures and guidelines (as mentioned further below). In taking this approach the ADB supports the RGC's wish for increasing aid effectiveness and reducing fragmentation.

244. The RGC also wishes to attract more of the available funding through a Program Based Approach (PBA) which is under consideration by the development partners. It also urges its development partners to adopt a common approach to project design and implementation through its Standard Operating Procedures (SOP), Financial Management Manual (FMM) and Financial Management Handbook (FMH), and Procurement of Goods and Works Procedures. These documents were prepared with assistance from the WB and the ADB.

245. The purpose of the SOP manual is to improve the efficiency and effectiveness of the management and administration of the RGC's externally assisted projects and programs, and it is intended that the manual should be applicable to projects developed with other external donors. The manual was passed into law in 2005. It clearly sets out the processes from developing a project concept though its implementation to its closure. The manual is declared to be in-line with the harmonization and alignment declaration that was jointly declared with RGC's eleven major external donor organizations in 2004. While being a manual of best practice limitations are recognized in the processes of development planning, program and project identification, and it does not cover the activities of decentralized projects.

246. The SOP manual is complemented by the Financial Management Manual for the investment of externally assisted projects by the WB or the ADB, which was also prepared in 2005. The FMM records that it should be used for projects with other external donors, if they so agree. In 2006, a Handbook on the Financial Management Activities for the Financial Management of Decentralized and Deconcentrated projects (FMH) was prepared to supplement the FMM in the development and implementation of decentralized and deconcentrated investment projects.

247. As mentioned above, the SOP, FMM and FMH are further supported by the Manual on the Procurement of Goods and Works. Procurement, in particular, to meet

the requirements of the other manuals and to ensure procurement is carried out at a standard that meets the current ADB documented requirements. It provides a transparent and systematic process for the effective implementation of the project. Training will be provided to MRD and PDRD's in the fundamentals and practical use of the system and procurement specialists will be provided from within the DDIS team. Audit procedures must be included in the training and "dummy and pilot audits" must be carried out at least internally on a routine and unannounced basis during project implementation, and tested by professional auditors as the implementation evolves. Independent professional auditors will also be required, as is usual.

248. In addition, ADB is planning interventions into related sectors of Government to enhance public sector approach to governance in financial matters[5].

[5] ADB Proposed Loan Public Finance Management for Rural Development Program

9 PROJECT COST ESTIMATES

9.1 FINANCIAL UNIT RATES

249. Indications of the expected financial unit rates are given in Table 9.1. These have been obtained in part from TA 4691 which was carried out with MPWT in 2008. Some items have been adjusted. The primary works under this project are items numbered 1 to 5, and possibly 6. If item 6 is used, then item 5 is not required. Based on these costs and some additions for drainage and structure clearance and repair, the expected cost for the civil works will be $57,000 to $103,000 per kilometre. Costs have increased for some roads where special works are required such as raising the road to prevent flooding and providing erosion protection. However these are not necessarily the roads with the highest costs per kilometer as other factors apply.

Table 9.1 Financial unit rates.

Item.	Description	Unit	Rate US$
1	Subgrade	cu.m	5.0
2	Unbound sub-base course	cu.m	9.0
3	Stabilized sub-base course	cu.m	16.5
4	Aggregate base course	cu.m	23.0
5	Stabilized base course[1]	cu.m	25.0
5	Single Bituminous Surface Treatment (SBST)	sq.m	2.6
6	Double Bituminous Surface Treatment (DBST)	sq.m	4.2
7	Bridges(PSC deck)	sq.m	623
8	Pipe culverts	l.m	876
9	Box culverts	each	53,400
10	Covered concrete ditches (market areas)	l.m	43
10	Mine/Unexploded ordinance - normal	Ha	1,764
11	Mine/unexploded ordnance - intense	Ha	3,859

Note (1) using local raw material (usually laterite)

Source: TA4691-CAM Consultants report 2009; amended as necessary

9.2 CIVIL WORKS COSTS AND PACKAGES

250. A summary of the cost of civil works for the individual roads is given in Table 9.2. The costs are the base cost without physical and price contingencies.

Table 9.2 Cost of civil works (US$)

Province	Road number	Length km	Cost US$	Per km US$	Civil W. Package	Amount US$
Kampong Cham and Kampong Thom	370	29.3	2,272,017	77,517	A	11,394,721
	371	20.8	2,229,110	106,963		
	373C	18.5	1,465,458	79,343		
	2620/2KT2	66.2	5,428,137	81,971		
Kampong Chhnang and Kampong Speu	1KCH2	25.3	1,843,762	72,963	B	10,573,734
	151C	35.0	2,682,571	76,579		
	1KCH3	12.5	1,121,058	89,649		
	1KS3	45.4	3,524,785	77,570		
	1KS4	23.9	1,401,558	58,618		
Pursat and Battambang	154D	11.1	872,701	78,551	C	12,276,176
	152E	8.8	808,873	91,917		
	155D	20.0	2,115,469	105,773		
	155C	22.4	1,539,235	68,808		
	1PS2	18.3	1,099,448	60,244		
	1BB1	24.9	2,150,679	86,269		
	1BB2	23.2	1,953,174	84,189		
	1BB3 & 1BB4	23.9	1,736,598	72,631		
Siem Reap	266E	29.6	1,789,364	60,431	D	5,106,683
	266D & 2SR2	46.2	3,317,318	71,835		
Total		505.4	39,351,314			

9.2.1 CIVIL WORKS PACKAGES

251. Although the roads of seven provinces are to be upgraded, it is not the intention to locate one civil works package for each province. The case against that approach is that it creates too many packages (contracts) each of a smaller value which would be more difficult to manage and administer. The advantage of grouping packages is to attract larger firms with greater capacity and equipment, such as large efficient stabilization machines for example. It also creates other efficiencies such as fewer laboratory and office facilities. The packages are geographically grouped as much as possible. The grouping is shown on the map in Figure 9.1. Coordinating offices will be required at the PDRD in each province (the PIUs).

252. The civil works contractors will be required to make their equipment available for practical training programs for the MRD and for those carried out through the BEC, as described above in Section 8.2.6 .

253. It should be possible to arrange this on a day-works basis, and the work done could be considered for payment and part of works completed provided it meets the usual standards set in place under the civil works contracts, although the rates may be different to ensure there is no double counting of work done for payment.

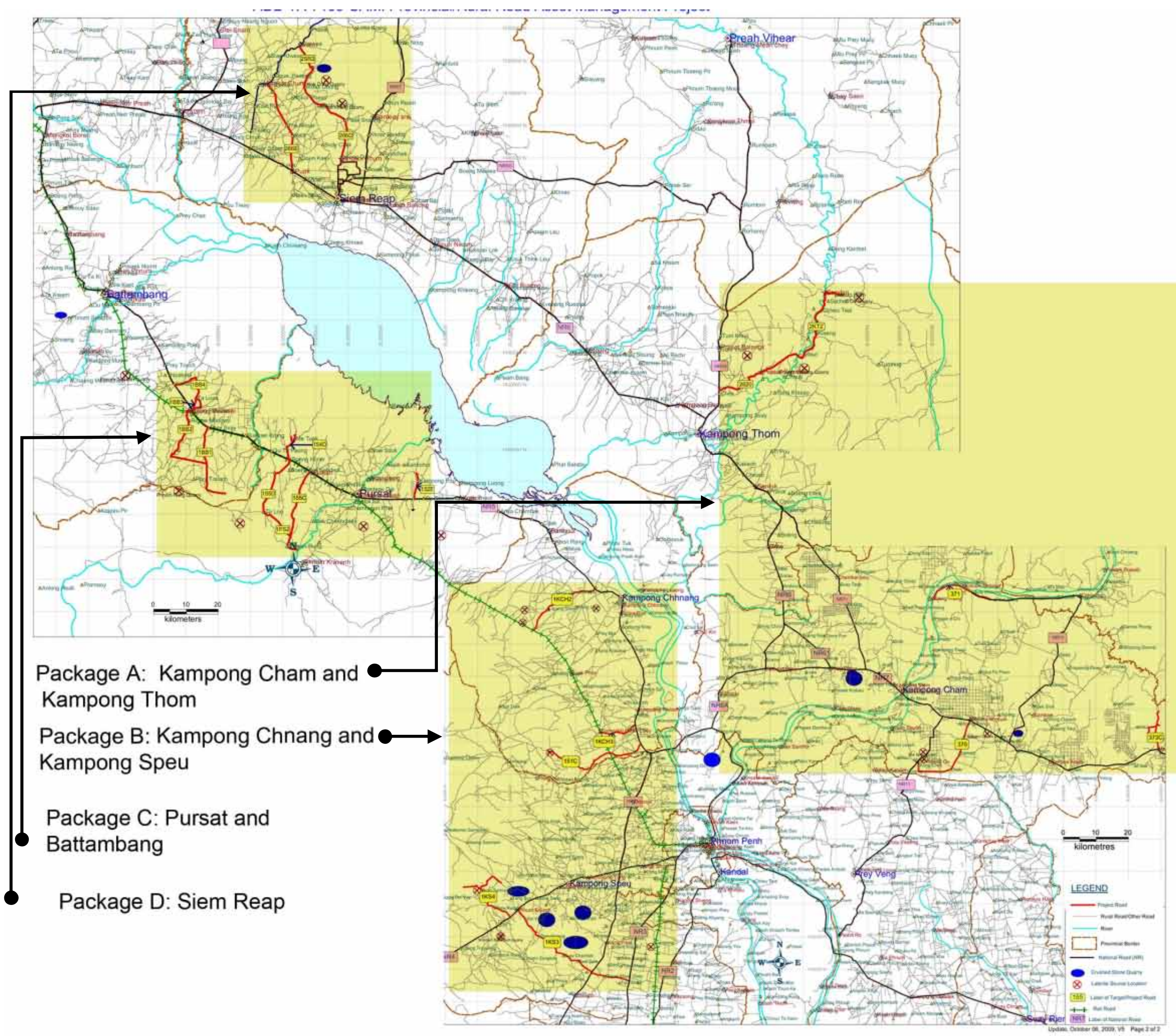


Figure 9.1 Geographic locations of the civil works contract packages

9.3 CAPACITY BUILDING COMPONENTS

254. The concepts for the capacity building component were presented and discussed in Chapter 8. The project contains some capacity building components such as HIV/AID's and Human Trafficking Prevention and Road Safety programs which are considered absolutely essential for the civil works to be undertaken and for the program of sealing roads to be sustainable in the future. The road safety program is discussed in Chapter 8. The HIV/AID's and human trafficking prevention program is mentioned below. In this chapter the primary content for each program taken forward are presented in Table 9.3 below. A schematic plan is shown in Figure 8.3.

Table 9.3 Primary content of project components

Project component	Primary content
Road asset management support	Preparation of an inventory of road assets
	Provide GPS units as necessary
	Implement the road numbering system
	Establish traffic statistics
	Obtain road condition data
MRD and PDRDs technical and planning capacity	Develop and run formal training courses on design construction and maintenance of paved roads, and planning
	Run practical training courses on project roads using contractors equipment
Vehicle overloading control for rural roads	Provide portable weighbridges
	Provide training in their use
	Cooperate with MPWT on overloading control
	Encourage businesses to cooperate with program. e.g. quarry operators
	Prepare contact clauses to prevent supply/ use of overloaded vehicles for project roads
	Prepare documentations to prevent use of overloaded vehicles for all MRD projects and implement
	Provide enforcement by police support with motor cycles – and see road safety
Planning and budget support	Using approved MRD policy, attract additional funding for development and maintenance of rural roads
	Obtain representation on inter-ministerial committee for additional maintenance funding
Professional Associations (BEC)	Arrange for BEC to undertake study tours to regional ASEAN and international renowned institutes to develop model for Cambodia
	Identify and train national trainers in paved roads/new technology to support BEC long term. ITC will be a primary institutional source for national trainers
	Practical training on project roads. Link with MRD,DRR and PDRD training
	Provide support and links with CNCTP
Registration of consulting and contracting	Development of a comprehensive

firms	register at MRD on competency of firms, equipment held and qualifications of their staff refer to BEC accreditation
Formation of professional associations	Assist with the development of articles etc to formalize associations for contractors and consultants
	Encourage dialogue with BEC to achieve links between profession and industry
Support for local contractor industry and contractor training	Cause sub-contracts to be issued for civil works on the project roads based on competency: contracts to Provincial, local and Community council levels Provide training
	Provide access to training whether or not contracted, through registration and BEC
Decentralization for project implementation	Ensure sub-contracts are prepared for the 23 districts and 71 different communes through which the project roads pass.
Road safety program	Provide international expert with access to a psychologist to design programs. Support with national experts
	Cooperate with NRSAP. And the 15-point action plan. Heighten role of MRD on Road Safety initiatives
	Train at local community level especially local women. Appoint /support road safety officer at community level
	Train engineers in safe road design
	Apply safe road design during detailed design for the project roads
	Let contracts to CC's for road safety measures – project ancillary works (see sub-contracts
	Provide motor cycles for enforcement
	Support RTAVIS for accident data collection and reporting for rural roads
MRD Social and environmental unit	Establish unit and links to cooperate with MoE, for example
	Undertake study tours: regional and elsewhere
	SEU staff to inform/ train other offices of MRD/DRR and PDRDs
	Project to fund SEU operations for 24 months
Disaster mitigation strategy	Identify and add road links vulnerable to flooding to road inventory
	Prepare register of equipment and resources in province for rapid deployment as needed
	PDRD's to work with communities to plan safe havens.
Gaps in donor coordination	Support the development of links for co financing and for other funding initiatives especially in consideration of the preparation of a future project role
	Review use and train implementation

	staff in the use of SOP, FMM and FMH manuals, and in Procurement manuals. Apply ADB guidelines and update MRD manuals as necessary.
	Implementation and procurement activities ensure compliance through training and audits

9.3.1 HIV/AIDS AND HUMAN TRAFFICKING PREVENTION PROGRAM

Estimates have been made to ensure activities for HIV/AIDs and human trafficking prevention program are supported. Further details of the risks are given in the social safeguards sections of this report (see paragraph 385).

9.3.2 MINES AND UXO AWARENESS

255. The potential risk to the project workers and to the local communities has been mentioned in this report. The project provides for the DDIS to appoint an expert to assess the risks. The expert will also advise the local communities of the increase in risk caused by civil works activities, and hold meetings and deliver awareness documents/pamphlets to the local communities, as appropriate in areas of risk. The funding for demining/UXO removal is listed under the civil works activities.

9.3.3 PREPARATION FOR A FUTURE PROJECT

256. Having embarked on a rational program of sealing roads as appropriate instead of constructing and maintaining all MRD assets as gravel surfaced roads, it is vitally important to expand the program to other roads and other provinces. This report indicates the failings of gravel surfaced roads where frequent regravelling is required and where traffic levels are sufficient to ensure that benefits for Cambodia are achieved. Given the high benefits from the investments, the economic analysis suggests that bitumen sealing of certain roads is even overdue. The capacity building components of this project will provide the training, awareness and experience for MRD and the industry in Cambodia to assist in the launch of new projects.

257. In addition, maintenance of the sealed roads that have been up-graded under this project (with an SBST) will become critical soon after this project has been completed. Because of the risk that government funding will not be sufficiently available for the resealing, the technical requirements and the funding required for the resealing must be identified and quantified so that it may be included in the future project.

258. As with this project, technical preparation is required to take the next project forward for funding. Technical assistance of a similar form will be required from international consultants in association with local consultants and local engineering survey firms. For the future project, greater support will be available from the capacity building on road inventory and traffic counting from within MRD and the PDRD’s. This project provides the funding to attain a sustainable approach to the program for the foreseeable future.

9.4 PROJECT COST ESTIMATE

259. A summary of the project costs is given in Table 9.4.

Table 9.4 Summary of project costs, US$ millions

Item		Description	Amount
A	**Base Cost**		
	1	Civil works: Road Rehabilitation	39.35
	2	Consulting Services for Design and Supervision	5.26
	3	Road Asset Management Program	2.00
	4	Road Safety and Safeguards Program	0.95
	5	Climate Change Adaption Program	6.00
	6	Project Management	1.95
		Total Base Cost	**55.51**
B	**Contingencies**		**10.52**
	1	Physical Contingencies	*4.95*
	2	Price Contingencies	*5.57*
C	**Financing Charges During Construction**		0.97
		Total	**67.00**

9.5 BASE COSTS

260. The base costs include taxes and duties of $6.68 million which are to be met by the RGC. The base costs uses prices estimated at the third quarter of 2009.

9.6 PHYSICAL AND PRICE CONTINGENCIES

261. The physical contingencies have been estimated at 10%. The price contingencies have been calculated by escalating the local and foreign components of the costs according to the projected inflation rates for Cambodia over the period of implementation of the project. Inflation rates for Cambodia are provided by ADB. The increase in local prices has been estimated at 5% and the increase in foreign costs has been estimated from the provided by the Manufacturers Unit Value Index (MUV). (The MUV index is calculated as a weighted unit value index of exports of manufactures by industrial countries. (WB))

9.7 INTEREST DURING CONSTRUCTION

262. Interest during construction (IDC) has been calculated at 1% of the cumulative amount drawn down from the loan during the implementation period.

9.8 CONSULTING SERVICES AND PROJECT MANAGEMENT

263. The cost of the DDIS consulting services has been estimated at so that it includes the requirements for detailed design, supervision and implementation of the project. These roles include the establishment of the social and environmental unit and the preparation of a future project and essential support for the capacity building components that will be undertaken by other consultants. The cost of project management has been estimated to include support for all project components. It provides support for the project management unit based at MRD in Phnom Penh and the project implementation units based in the project provinces.

9.9 DETAILED COST ESTIMATE BY CATEGORY

264. The detailed estimate of project costs by expenditure category is given in Table 9.5.

Table 9.5 Detailed Cost Estimate by Expenditure Category

		US$ millions			% Foreign	% Base
		Foreign	Local	Total	Exchange	Costs
A	**Investment costs**					
	1 Improvement of 19 roads	17.53	16.89	34.42	50.9	62.0
	- CW Package A Improve 4 roads, 135km	*5.24*	*4.56*	*9.80*	*53.5*	*17.7*
	- CW Package B Improve 5 roads 142 km	*4.65*	*4.60*	*9.25*	*50.3*	*16.7*
	- CW Package C Improve 8 roads, 153km	*5.38*	*5.37*	*10.75*	*50.0*	*19.4*
	- CW Package D Improve 2 roads, 76km	*2.21*	*2.26*	*4.46*	*49.4*	*8.0*
	- UXO assessment for 19 roads	*0.05*	*0.11*	*0.16*	*29.0*	*0.3*
	2 Consulting Services for Design and Supervision	2.63	1.64	4.27	61.6	7.7
	- Consulting Services for 19 roads and SEU	*2.33*	*1.44*	*3.77*	*61.2*	*6.8*
	- Preparation of a Future Project	*0.32*	*0.18*	*0.50*	*64.0*	*0.9*
	3 Road Asset Management Program	0.94	0.79	1.73	51.8	3.1
	4 Road Safety and Safeguards Program	0.36	0.48	0.84	42.5	1.5
	- Road Safety Program	*0.30*	*0.33*	*0.63*	*47.0*	*1.1*
	- HIV/AIDS & Human Trafficking Prevention Program	*0.06*	*0.15*	*0.21*	*29.0*	*0.4*
	5 Climate Change Adaption Program	3.84	2.16	6.00	64.0	10.8
	6 Taxes and duties	-	6.31	6.31	-	11.4
	Subtotal (A)	**25.30**	**28.26**	**53.56**	**47.2**	**96.5**
B	**Incremental Administration Cost**	**0.19**	**1.76**	**1.95**	**9.7**	**3.5**
	1 Project Management: improvement of 19 roads	0.19	1.39	1.58	12.0	2.8
	2 Taxes and duties	-	0.37	0.37	-	0.7
	Subtotal (B)	**0.19**	**1.76**	**1.95**	**9.7**	**3.5**
	Total Base Costs	**25.49**	**30.02**	**55.51**	**45.9**	**100.0**
C	**Contingencies**					
	1 Physical	2.17	2.79	4.95	43.7	8.9
	2 Price	0.38	5.19	5.57	6.8	10.0
	Subtotal (C)	**2.54**	**7.98**	**10.52**	**24.2**	**19.0**
D	**Financial Charges During Implementation**					
	1 Interest during construction	0.97	-	0.97	100.0	1.7
	Subtotal (D)	**0.97**	**-**	**0.97**	**100.0**	**1.7**
	Total (A+B+C+D)	**29.00**	**38.00**	**67.00**	**43.3**	**120.7**

10 PROJECT IMPLEMENTATION

10.1 EXECUTING AGENCY

265. The Executing Agency (EA) will be the MRD. A Project Management Unit (PMU) will be set-up and maintained at MRD for the duration of the project, and a Project Implementation Unit (PIU) will be set up and maintained at each PDRD. The PMU will be headed by a Director of MRD and a team will be established to meet the requirements of the project. Office space is available at MRD and at each PDRD. The costs of the PMU and the PIUs will be met by the project as mentioned earlier. Vehicles and other office facilities and equipment will be suitable for the project and the vehicles located at MRD should be large 4-wheel drive station wagon type (as opposed to large pick-up vehicle types) so they are suitable for the travel with visitors from ADB, for example. Large pick-up type vehicles may be more suitable for the PIU's.

10.2 DETAILED DESIGN AND SUPERVISION CONSULTANT

266. The whole of the project will be implemented by one international consulting firm in association with a local consulting firm. The Detailed Design, Implementation and Supervision Consultant (DDIS) will be responsible for all aspects of the project including detailed design, civil works and other contract preparation and bidding and award, supervision of the civil works, and for all the capacity building components. Where specialists are to be engaged from outside the DDIS firm, the DDIS will provide a coordinating role. The DDIS will report to the Director of the Project Management Unit (PMU). The main offices of the consultant will be at MRD and field offices will be established at the location of the civil works contractors' office and maintained by the civil works contractor.

10.3 IMPLEMENTATION PLAN

267. It is estimated that the implementation period for the project will be four years as shown in Figure 10.1. The Implementation plan anticipates that advanced action will be undertaken to engage the consultants during the loan processing period. This greatly advances the progress towards the commencement of civil works contracts and therefore the overall implementation of the project. The schedule under consideration for the Loan is:

- Fact finding: end of January 2010
- Appraisal: mid to end of March 2010
- Loan Effective: August 2010

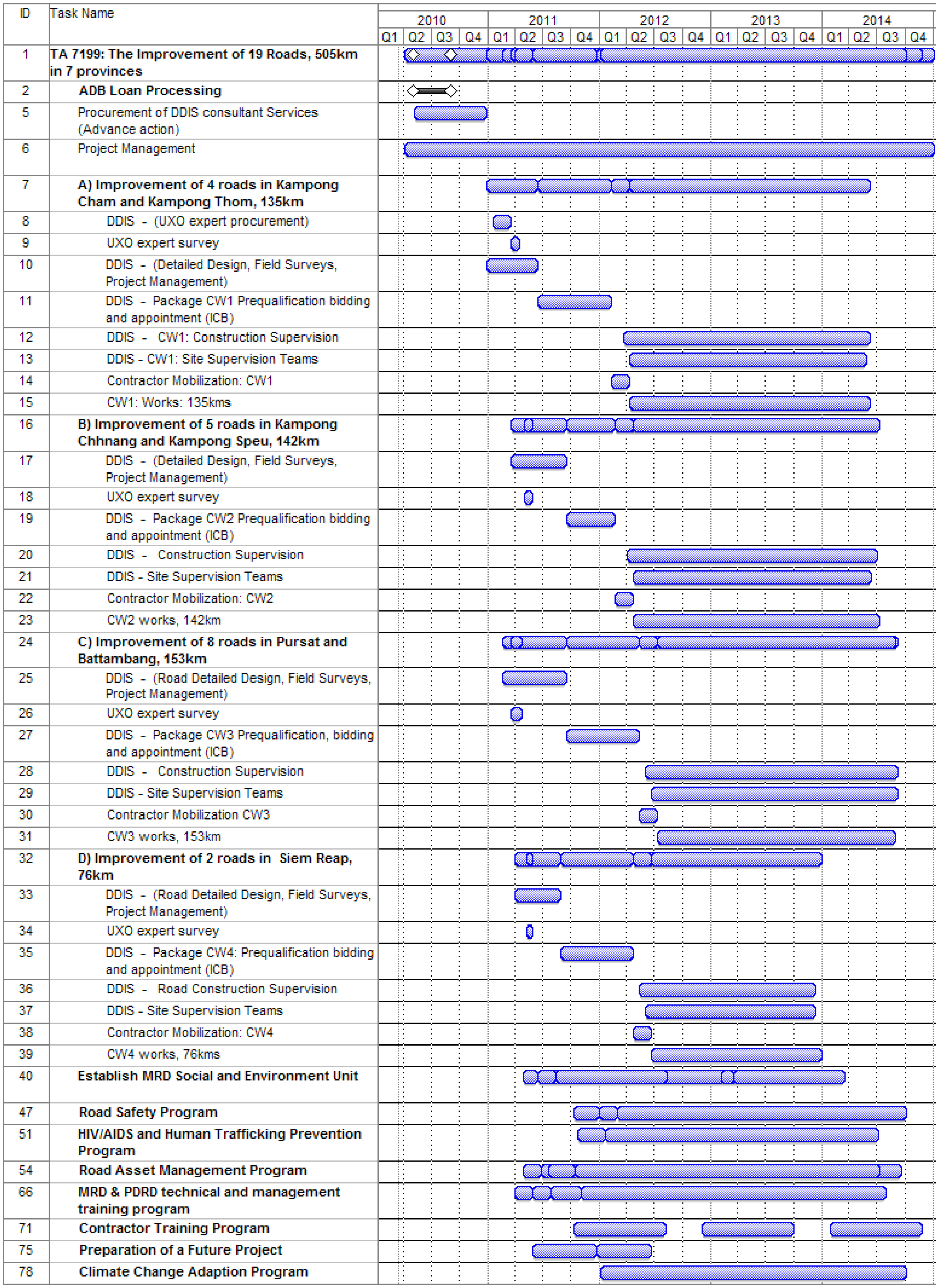


Figure 10.1 Summary project implementation plan

11 ECONOMIC EVALUATION

11.1 GENERAL

268. The final stage in the selection and evaluation process has been a conventional road project economic appraisal. The approach used for this follows standard evaluation methodology for road improvement schemes. That is, the situation forecast to occur with improvements to the roads, referred to as the "with project case", has been compared with the situation expected if the roads are maintained at their present standard, the "base case". It takes into account factors which can be quantified, such as the road construction and maintenance costs, forecast volumes of traffic, and the potential level of benefit per vehicle. These items are considered over an evaluation period, with costs and benefits discounted and expressed in present value terms. It provides measures of the overall returns obtainable from the project, which can be compared to returns from expenditure on other types of road works and other types of investment, so that capital resources can be distributed throughout the economy as efficiently as possible.

269. In total 21 road sections were identified for evaluation purposes, and each of these has been appraised individually, with specific characteristics and conditions for each used as inputs to the evaluation. In some cases where traffic levels vary along the road, or the road consists of distinct sections, the road was divided into subsections for evaluation purposes. In addition the viability of the project as a whole was assessed and sensitivity tests were applied to the results for the overall project.

11.2 EVALUATION CRITERIA

270. Annual cost and benefit streams have been considered over a 24 year period from 2009 and discounted to 2009 values using a discount rate of 12 per cent. Road improvements were assumed to be completed in 2012, giving a benefit period of 20 years. No benefits have been included for any savings which may occur before the opening year as a result of some sections of the networks being completed before the end of the overall construction period. Similarly, no costs to road users caused by disruptions to traffic during the construction period have been included.

271. Two indicators of economic viability have been calculated from the annual cost and benefit streams:

- The Net Present Value (NPV) is a measure of economic viability based on the concept of discounting, that is expressing all future costs in terms of their present value. The NPV is the difference between the present value of costs and the present value of benefits. If the NPV is greater than zero the project is considered to be viable. If there are alternative projects the overall return on each indicated by the NPV can be used to determine the optimum choice. If the discount rate used is correct the project with the highest NPV is the optimum. A feature of the NPV calculation is that it takes into account the different levels of capital costs with alternative projects of a different scale. For example, a higher NPV indicates that the greater investment required for a larger project is justified because the additional benefit from the larger scheme must be producing at least the required rate of return on the additional cost.

- The Internal Rate of Return (IRR) is the discount rate at which the present value of benefits equals the present value of improvement costs. If it exceeds the required rate of return then the project is considered viable. This provides a measure of the return on an investment which illustrates the general scale of the rate of return more readily than the NPV criterion. Normally the NPV and IRR will give the same indications of viability and priority ranking between projects.

11.3 PRICES

272. Costs and benefits have been calculated from unit prices expressed in economic terms, rather than financial or actual market prices. Economic prices are intended to reflect the resource cost, or the real value of an item to the country. The economic prices were based on border prices for traded goods and services, with domestic market prices net of tax or subsidy used for non-traded items. The unit prices used for costing purposes and for assessing benefits have been based on prices in mid-2009. As is usual with internationally funded projects in Cambodia, the evaluation has been conducted using the United States dollar (US$) as the unit of currency. The prices for most inputs used in the evaluation are quoted in US dollars, and so prices can be used directly. Where prices quoted in Cambodian riel (KHR) were used they were converted to US$ assuming an exchange rate of 4150 KHR to 1 US$.

273. The economic evaluation has been conducted on the conventional basis of constant prices, that is without taking the impact of inflation on prices into effect. An exception was made in the case of fuel, where the long-term economic price was considered. Fuel prices have been volatile in recent years, reflecting major changes in the price of crude oil, and the current price may not represent an appropriate price to use as the price in real terms over the evaluation period. The future pressure of demand and the limit on supply are expected to increase the oil price above current levels. A long-term average crude oil price of US$100 per barrel in current price terms has been assumed. This is consistent with border prices of about US$0.68 per litre for diesel fuel and US$0.65 per litre for petrol. Given the uncertainty about future oil prices, these fuel prices are only indicative. However, it should be noted that although fuel is an important component of VOCs, it does not dominant the total, even with the relatively high fuel prices assumed. Passenger time values are likely to increase in real terms, that is faster than the general price level, if economic growth rates above population growth are sustained. An allowance was made for an increase in the real value of time savings.

274. There is considerable under-employment in Cambodia among unskilled labour. The degree of under-employment probably varies between provinces, but a full analysis is beyond the scope of this Study. A shadow price of 0.75 of the market rate has been used for unskilled labour.

11.4 EVALUATION MODELS

275. It was specified in the Terms of Reference for this study that the economic analysis of upgrading the roads should be based on the Highway Development and Management Tool HDM-4. This model was developed by the International Study of Highway Development and Management (ISOHDM), funded by the World Bank, Asian Development Bank, and other sponsors. The objective was to produce a standard model to be used throughout the world to prepare road investment programs and to analyse road network strategies. The latest version available for general use is version 2.05, and this has been used in this Study.

276. The HDM-4 model simulates road condition for each road section, year-by-year, using three sets of sub-models:

- Road Deterioration - which predicts pavement deterioration and surface roughness.
- Works Effects - which simulate the effects of road works on pavement condition and determines the corresponding costs.
- Road User Effects - which determine costs of vehicle operation and travel time.

277. These sub-models are used to analyse the costs and benefits of alternative road improvement and maintenance strategies. The size of the investment is determined by the costs of construction upgrading. The economic returns are mainly in the form of savings in road user costs due to the provision of a better road facility. These construction and road user costs plus road maintenance costs constitute what is commonly referred to as the total (road) transport cost, or the whole life cycle cost. The objective is to minimise these total transport costs by determining the best engineering and economic alternatives for individual road sections.

278. Calibration of HDM-4 is required to reflect local conditions. The model has been used in a number of road studies in Cambodia, and information from these has been incorporated in the analysis for the present study. The most comprehensive calibration of the model and listing of input values seems to have been carried out for the Location Referencing and Condition Survey (LRCS)[6] undertaken as part of the Road Rehabilitation Project carried out for the Ministry of Public Works and Transport. Most of the input data were taken from LRCS, with updating of prices to 2009 levels. Reference was also made to other studies involving the use of HDM-4, in particular the Provincial and Rural Infrastructure Project (PRIP)[7] and the Transport Infrastructure Development and Maintenance Project[8].

279. Further calibration of HDM-4 was found to be required to reflect conditions on the project roads. For example, it was found that predicted vehicle speeds were too high for the roads and adjustments to the speed parameters were required. Some specific problems arose from the very high proportion of motorcycles in the total traffic flow on all roads. For example, on narrow pavements the calculation of edge break damage is based on the number of vehicles that are estimated to use the shoulder when meeting oncoming vehicles. Motorcycles are treated as other vehicles in this calculation, causing major overestimation of edge break unless the relationship in the model is adjusted when motorcycle traffic is a high proportion of the vehicle flow. Similarly, the progression of the development of potholes is based on the total number of axles in the traffic flow, with motorcycles regarded as two axle vehicles, and is overestimated without adjustment. Simple calibration to make adjustments to compensate for these effects is possible in the model. The impact of motorcycles on the predicted speeds of all vehicles, especially on narrow pavements, resulting from the congestion analysis incorporated in the model also needed to be revised. This was done by adjusting the default Passenger Car Space Equivalent (PCSE) value for a motorcycle of 0.5 to a value of 0.2, which is considered more

[6] Road Rehabilitation Project – Location Referencing and Condition Survey – WB Credit no 3181-KH - HDM-4 Configuration Report, November 2004, MWH New Zealand Ltd.
[7] Provincial and Rural Infrastructure Project PRIP (KH-PO71207) – Main Technical Report, July 2003, International Labour Organisation.
[8] TA No 4681-CAM – Transport Infrastructure Development and Maintenance Project, September 2008, Asian Development Bank.

appropriate for predicting speeds on rural roads. The sensitivity of motorcycle speed to pavement width was also reduced by adjusting the speed calibration factors.

11.5 BENEFITS

280. It has been possible to quantify two types of benefits with sufficient accuracy for inclusion in the analysis; road user savings and the residual value of the works. The derivation of these is described in the following sections. Road user savings, that is vehicle operating cost savings and passenger time savings are the most important. The road user savings include those to generated traffic, that is the additional traffic that operates as a result of cost savings. (Generated traffic is discussed earlier in the chapter related to traffic.) As is conventional, savings to generated traffic are valued at half the level of those to normal traffic in the HDM-4 model. Road maintenance costs will also be lower, and therefore will constitute a benefit of the project in the evaluation. These are discussed in the following section covering costs.

11.5.1 VEHICLE OPERATING COST SAVINGS

281. Vehicle operating costs (VOC) savings have been estimated using HDM-4. VOCs are a basic item in road project evaluations and the main source of benefits. Using a computer model such as HDM-4 they can be calculated in detail. The HDM-4 model predicts the consumption of resources for each component of vehicle operating cost per kilometer, such as the number of litres of fuel consumed and amount of tyre wear, for each category of vehicles. The model takes into account a wide range of factors, including the surface condition and geometry of each road section, and the characteristics of representative vehicles. When multiplied by the appropriate unit prices, such as $ per litre of fuel and $ per tyre, this consumption is converted to a cost per kilometre. The total of costs for all components is the VOC.

282. There are a many different vehicle types in use in Cambodia. The range of types is particularly wide among the vehicles operating on rural roads where, in addition to conventional motorised vehicles, there are large numbers of non-motorised vehicles and unconventional motorised vehicles. Fortunately, HDM-4 enables a wider range of vehicle types to be specified than earlier road evaluation models, and has the flexibility to enable additional vehicle types to be defined and added to the evaluation. A maximum of 19 different types can be included in a project evaluation. This enables the unconventional vehicle types, which have very different operating characteristics and costs, to be incorporated in the evaluation.

283. In this study this facility of HDM-4 has been used and a wide range of vehicle types has been included. On some of the roads the traffic levels are low, and dominated by motorcycles. Analysis of such roads would not normally warrant the level of detail suggested by the range of vehicle types used. Often several of the defined vehicle types were not found to be operating on individual roads, or were found in insignificant numbers. However, it is both more accurate and easier to use a wide range of types, rather than to develop a small number of compromise vehicle types and allocate vehicles identified in traffic surveys to these types. All of the vehicle types identified in the traffic surveys have been adopted for use in the evaluation. These are:

Non-motorised

- Bicycle - All two and three-wheeled non-motorised vehicles, including cyclos and those used for carrying freight.

- Animal Cart - All animal-drawn vehicles (ox-carts, buffalo-carts, horse and cart). All three of these types occur in Cambodia but it was considered acceptable to combine them as one type as the benefits are not critical to the evaluation result. The type of wheel on these vehicles can be important; traditional narrow wheel rims can cause significant damage to paved roads. However, the great majority of animal-drawn vehicles in use in Cambodia now have wheels fitted with pneumatic tyres, which have no impact on pavements, and this type was specified in the definition of the vehicle type.

Motorised

- Motorcycle - Motorcycles, scooters and any other 2-wheeled motorised vehicles, but not those with trailers. They are the dominant motorised vehicle type in the traffic flow on all the roads in this study. Most have engine capacities of 90-125cc. Japanese makes such as Honda, Yamaha and Suzuki predominate, but some lower-priced Chinese brands are also operated. Some of the Japanese brands are assembled in Cambodia from imported components. Motorcycles are generally used for private transport, but many are also used to provide a taxi service for passengers, or to carry small amounts of freight.

- Motorcycle with Trailer - Motorcycles with a trailer (remoque), or any 3-wheeled motorised vehicle, used for freight or passenger transport. These are generally referred to as 3-Wheelers in this study, but most are remoques and have four wheels.

- Car - This type includes sedan cars and station wagons (but not 4-wheel drive vehicles) with a maximum of 7 seats. They are used for private passenger transport, with many also operated by businesses and government with paid driver included as vehicle crew. Very few operate as taxis on rural roads. A wide range of types is operated in Cambodia but the majority are sedan cars with 4-cylinder engines of up to 2000 cc.

- 4-wheel Drive Vehicles - Four-wheel drive (FWD) vehicles, such as Toyota Landcruiser or Mitsubishi Pajero, with a maximum of 7 seats are often used in Cambodia for private transport or business use as an alternative to sedan cars. These types are available with a range of specifications. Typically they have 3000 cc diesel engines. They are expensive vehicles, with the prices of most models about twice that of sedan cars of the same make, and operating costs are also significantly higher than those of cars. As with cars many have a paid driver. A significant proportion in the Phnom Penh area are very high value, luxury vehicles, but these are rare on rural roads.

- Pick-up - Vehicles such as the Toyota Hi-lux designed for use as light freight vehicles, but are also used for private transport as an alternative to sedan cars, or for public transport. They are also known as utilities. Most have diesel engines of 2500 cc and a capacity of about 1.2 tons. Very small trucks are also included in this category, being distinguished from the Light Truck category in having only single wheels on the rear axle.

- Minibus - The minibus type is typically an 8-16 seat vehicle, such as the Mercedes MB 140D (now replaced by the Sprinter), sometimes referred to as a microbus or van. They are used for public transport on most of the project roads, often loaded above the design seating capacity, and sometimes also used for freight transport.

- Bus - All buses with more than 16 passenger seats. They are distinguished from the Minibus type by having dual-wheels on the rear axle and an engine capacity of not less than 2800 cc. Normally buses would be divided into small and large bus categories, but virtually no buses operate on rural roads in Cambodia, and a single type, based on a small bus with less than 30 seats, has been used to represent all buses.

- Small Koyun/Etan - Small two-wheeled tractors made into a road vehicle by attaching a single-axle trailer, or small, slow moving, locally-made trucks. They have a capacity of about one ton. They are also used for short distance passenger transport.

- Large Koyun/Etan - Locally-made medium sized 2-axle trucks that typically have engines designed for water pumps or boats. Often they are made in small workshops from second-hand parts from other vehicles, and therefore vary in size and capacity, but most carry a load of about two tons. These are much slower than conventional vehicles and are normally only used for short distance freight movements.

- Light Truck - These are trucks with a gross vehicle weight (GVW) usually in the range 3-7 tonnes with a payload of up to 4 tonnes. They have two axles and dual-wheels on the rear axle.

- Medium Truck - These are larger trucks than the light truck, but also have two axles and dual-wheels on the rear axle. They usually have a GVW between 12 and 16 tonnes and have a carrying capacity up to 10 tonnes.

- Heavy Truck - All 3, 4 or 5-axle rigid trucks, articulated trucks and truck-trailers. The numbers operating on rural roads are so low that a single heavy truck category has been used to represent all types. This is based on the most common type, a 3-axle truck, with a tandem rear axle and twin tyres on the rear wheels. The recommended GVW of such vehicles is typically 20 to 28 tons with a 10 to15 tons load capacity, but they are often heavily overloaded.

284. Pedestrian movements can be incorporated in HDM-4 and are a common form of short-distance transport on some roads. Freight, especially agricultural produce or inputs, is often carried short distances by pedestrians, sometimes using handcarts. The cost of such transport is measured in terms of the value of personal time. Benefits to pedestrians are not normally included in the evaluation of rural roads in Cambodia. Although road improvement can produce a benefit by allowing higher walking speeds, it is not clear that this is always achieved. A more difficult issue is the level of pedestrian traffic. It is clear that many journeys are very short and it is almost impossible to determine appropriate average pedestrian traffic levels for road sections of the length being considered in this study.

285. The key characteristics of the vehicles are based on the specified default values in the HDM-4 model, with some adjustment for Cambodian conditions. The more important characteristics are shown in Table 11.1. HDM-4 requires a number of input values relating to vehicle age and annual utilisation that are used to calculate the capital cost component of VOCs, that is depreciation and interest. Vehicle age, expressed as average life, is also used in the calculation of vehicle maintenance costs. These inputs are difficult to determine. Estimates have been made from the information used in other studies in Cambodia. Vehicle registration and import statistics have been considered, although these are not detailed enough to give more

than a general impression of the age structure of the vehicle fleet. Many vehicles used in Cambodia are imported second-hand, although this is becoming less common for cars. This means that the defined service life in Cambodia is much less than the total service life, and that the average age of vehicles in Cambodia is greater than in most other countries. This has implications for the calculation of vehicle maintenance costs, which are assumed in HDM-4 to be much higher for older vehicles. With all vehicle types there is a general pattern of new vehicles being used intensively for a few years and then used less intensively as they become older, and the older vehicles generally used only for short hauls. Therefore the average service life used as input to the model is less than the estimated average age of all vehicles, to reflect that the majority of annual vehicle-km are operated by the newer vehicles in the fleet. For practical reasons the vehicle prices used in the analysis are based on those of new vehicles, and vehicle age and utilization values were based on an assumption that only new vehicles enter the fleet. Using default values in the model HDM-4 seems to estimate a very high capital cost component in VOCs. This has been overcome by increasing the working hours, as the capital cost model is inversely linear to this value.

Table 11.1: Vehicle Characteristics

Vehicle Type	ESA[1]	Service Life (years)	Annual Utilisation		No. of Passengers	Economic Price (US$)
			Hours	km		
Bicycle	0	10	150	2,500	1	40
Animal Cart	0	6	1,300	4,000		300
Motorcycle	0	8	600	8,000	1.2	700
3-wheeler	0	8	600	8,000	1.2	850
Car	0	12	750	15,000	3	22,000
Jeep/4WD	0.01	10	750	15,000	2.5	66,500
Pick-up	0.05	10	1,250	25,000	1	20,000
Minibus	0.04	10	3,800	75,000	9	23,500
Bus	0.7	10	1,750	35,000	20	57,000
Small Koyun	0.05	10	400	6,000		1,500
Large Koyun	0.2	10	400	6,000		3,000
Light Truck	0.2	10	1,600	30,000		31,000
Medium Truck	0.8	12	2,000	40,000		42,000
Heavy Truck	3.5	12	2,400	45,000		110,000

[1] Equivalent Standard Axles

286. The level of VOCs is determined by many factors but the two main determinants are surface roughness and speed. Speed is partially determined by roughness, and so a simple indication of VOCs can be given in terms of roughness alone. In Table 11.2 VOCs are shown for the vehicle types used in the study for a range of roughness levels. They are for a typical road section in flat terrain. An IRI of 3 represents the expected level of a new DBST surface in this project, the other IRI levels shown cover the range of typical roughness levels of the existing surfaces of most of the project roads. The VOCs are lower than those used in some other recent studies in Cambodia, mainly as a result of the adjustments made to the calculation of vehicle capital costs, or standing costs, in the analysis.

Table 11.2: Vehicle Operating Costs ($/km)

Vehicle Type	IRI 3	IRI 6	IRI 12
Bicycle	0.03	0.04	0.05
Animal Cart	0.11	0.13	0.16
Motorcycle	0.03	0.03	0.04
3-wheeler	0.04	0.05	0.05
Car	0.22	0.26	0.31
Jeep/4WD	0.32	0.42	0.56
Pick-up	0.29	0.34	0.47
Minibus	0.15	0.20	0.32
Bus	0.32	0.46	0.57
Small Koyun	0.05	0.06	0.08
Large Koyun	0.21	0.36	0.45
Light Truck	0.22	0.29	0.36
Medium Truck	0.29	0.38	0.51
Heavy Truck	1.04	1.32	1.53

11.5.2 TIME SAVINGS

287. Travel time savings are obtained when road improvements lead to an increase in vehicle speeds, thus reducing the journey times of passengers. A value of time per hour for each vehicle type is applied as a unit cost to journey times to produce passenger time costs. A time cost per vehicle can be included in HDM-4 to value time savings, and the costs per km are calculated directly from the speeds predicted in the VOC submodel. These savings are in addition to the time value of the vehicle itself and crew costs for commercially operated vehicles. HDM-4 allows values for work and non-work time per hour per person to be specified separately, which are combined with an average passenger load per vehicle and an estimate of the percentage of passenger trips that are work related, to produce a passenger time cost per vehicle hour.

288. Passenger time savings are not always included in road appraisals in developing countries, but it is generally considered appropriate to include them. Savings in time when journeys are related to work clearly have a value; if less time is spent traveling more time in the working day can be used for productive purposes, resulting in an increase in the economic output of the country. The value of working time spent traveling is generally considered to be closely related to the wage rates of passengers. This is the standard approach used in valuing such time in transport studies, and is based on the assumption that, unless there is major distortion in the labour market, wage rates will reflect the economic value of work performed.

289. Non-working time savings do not increase national production but, as there is evidence that people are prepared to pay for such savings, they must be considered as increasing the welfare of passengers. In principle there is no reason why a monetary value should not be attached to the time spent on trips for social, educational and other non-work purposes, but the value of non-working time is more difficult to quantify than working time. There is a wide variation in the values people

give to travel time savings outside working hours, but most values are in the range 25-50 percent of earnings. Marginal values of time may vary for the same individual, depending on the amount of time saved on each occasion and the activities for which the time saved is used.

290. The practice for valuing travel time recommended by the World Bank is that non-working time should be valued and included in the analysis of road projects. The recommended practice for valuing travel time is that, where specific information is not available from surveys, working time travel should be valued at the wage rate times 1.33, to allow for non-wage costs to the employer, and non-working time travel should be valued at 0.3 times the household income in the case of adults and 0.15 times household income in the case of children. These guidelines are difficult to apply in rural areas of countries such as Cambodia where many people are not in formal wage employment and there is only limited information available on household expenditures. Because of the difficulties in valuing time if detailed information on wage rates, household incomes and trip purpose is not available, a simple and pragmatic approach has been suggested in a report[9] by the United Kingdom Department for International Development (DFID). This is to base time values on a common per capita Gross Domestic Product (GDP) value for all travelers. The advantage of the approach is that it is economic, and the per capita hourly value can be applied to all travelers; economically active and inactive, producers and dependants. The approach can be justified on grounds of equity since all travelers are treated equally and there is no bias toward the upper income groups.

291. Using a value of time based on GDP per head is considered appropriate and has been adopted for the present study. However, there are a number of issues that need to be taken into account, and the simple approach, using a common GDP value for all passengers, is not considered to be suitable. It is probable that those traveling will have incomes higher than the average, especially those traveling during working time. Coupled with these points is the question that, if non-working time is to be valued, should the leisure time of higher income groups, for example those living in the main urban centers or those traveling in cars, be valued more highly than that of other road users, or of the population as a whole. A further issue is that, although the economic evaluation of projects is normally undertaken with costs at constant base year levels, passenger time values are sometimes increased over time. This is to reflect that economic growth faster than population growth will result in an increase in real income per head over time. It is considered a real increase because incomes, and therefore time values, tend to rise more quickly than the prices used to value other inputs in an evaluation. Most evaluation models, including HDM-4 cannot incorporate an escalating unit value of time, but it is possible to include an allowance for future increases in the time value used. Also a clear distinction between working and non-working time is not considered appropriate in countries such as Cambodia, especially in rural areas. Surveys often try to distinguish between those traveling for work purposes, those traveling to or from work, and those traveling for social or other reasons that are not work related. However, in the case of those engaged in agriculture, and others who are self-employed, their time spent traveling for any purpose may be preventing them from performing their normal work activities.

292. In this study roads over a wide area are being considered, but it is not possible to derive separate time values for each province and national average time values are needed. Accordingly the level of GDP from national statistics, expressed per head of the working population, is used as the basic indication of the value of

[9] "Appraisal of Investments in Improved Rural Access – Economist Guide", Department for International Development, London U.K., August 2001.

working time. The latest GDP information for Cambodia by the International Monetary Fund[10] (IMF) is that the estimated annual per capita GDP in 2009 at current prices is US$853. Assuming that 45 percent of the population are economically active and on average work 2000 hours per year, the average hourly income in 2009 is US$0.95. This is much higher than typical rural wage incomes, and a value of US$ 0.5 per hour has been used for the working time of motorcycle users and other passengers, except those in cars and 4-wheel drive vehicles. Typically passengers in these two vehicle types have incomes well above the average, usually being in the highest 20 percent income group. Without information on household income levels for road users being available an assumption was made that these passengers have an average working time value of US$2 per hour, that is approximately twice the national average. These rates include an allowance for a real increase in incomes over the evaluation period. The overall proportions of working and non-working time are uncertain. Previous studies have suggested 25 percent of light vehicle passenger and 20 percent of motorcycle users are traveling in working time. No attempt was made to verify these figures in this study. As stated above, it is considered that, with such a large proportion of the population engaged in agriculture, travel time will result in a greater loss of work time than indicated by the declared purpose of the journey. For this reason a general assumption was made that 30 percent of travel time should be valued as working time, but for car and 4-wheel drive vehicle passengers 50 percent was used. Non-working time was valued at U$0.3 per hour for car and 4-wheel drive passengers and US$0.15 for all other passenger time.

293. Reducing cargo delay costs can also be considered as a potential source of benefit. Freight in transit is capital and a reduction in travel times can therefore be translated into savings in inventory costs. Thus the saving in time can be valued by the price of capital, that is the rate of interest. In addition reduced travel time can produce benefits in the form of reduced spoilage of perishable goods, or reduced disruption to production resulting from delays in the supply of materials or components. However the savings are normally small and are not normally included in rural road studies of this type. Accordingly freight time costs have not been included.

11.5.3 RESIDUAL VALUES

294. A residual value for the project at the end of the evaluation period is often included in road project evaluations, although the impact on the result is small when a 20-year evaluation period is used, because of the impact of discounting when costs and benefits are expressed as present values. A residual value is a difficult concept to apply accurately in the evaluation of a road project. If it is included in an evaluation it is usually calculated simply as a percentage of the construction cost, and this is the default method used with HDM-4. Often this will not represent the true value of the project remaining at the end of the evaluation period. A more accurate valuation would be based on the estimated future net benefits to be obtained beyond the evaluation period, which are not related to the original construction cost. In cases where the road project is expected to be further upgraded to a higher standard at the end of the evaluation period, the residual value can be considered to be the reduction in the cost of upgrading the road to the higher standard, compared with constructing it at the higher standard without the original project having been built.

295. In this study a nominal value of 25% of the construction costs has been included as a residual value of all subprojects on the basis that much of the cost is in

[10] World Economic Outlook Database, International Monetary Fund, April 2009

the base course rather than the surfacing, and a significant part of this material could be recovered.

11.5.4 OTHER POTENTIAL BENEFITS

296. Cambodia has the worst road accident fatality rate in the ASEAN Region when related to vehicles using the road network (currently the annual rate is 21.5 fatalities per 10,000 registered vehicles), although this may be partly a reflection that vehicle registration data are incomplete. Accident savings are often included in the evaluation of road improvements, especially where the road is widened and the alignment improved. They are less commonly applied when considering the upgrading of rural roads. Reducing dust levels will improve visibility and help prevent some accidents, but it is possible that there will be an overall increase in accident costs, given the higher speeds that will be possible on improved surfaces and the higher traffic levels as a result of traffic generation. Data from international sources on the impact of sealing gravel roads on accident rates are not consistent, and there is not enough information specific to Cambodia to predict the change in accident rates and severity of accidents following improvement. A road accident data base has been developed in Cambodia since 2004 by the Ministries of Health, Interior, and Public Works and Transport, together with Handicap International. This Cambodia Road Traffic Accident and Victim Information System (RTAVIS) collects accident information from the traffic police, hospitals and other public health facilities, and private clinics. The data cover all roads, but accidents on urban, national and provincial roads dominate, and many minor accidents not involving injuries are clearly not included. The data show that 40 percent of casualties are injured in urban areas and 50 percent on national/provincial roads, with overall 80 percent occurring on paved roads. Only a small part of the data relates to rural roads, and there is no information relating to relative accident rates on gravel and sealed roads. Accordingly it has not been possible to quantify potential benefits with sufficient accuracy for inclusion in the evaluations.

297. Producer surplus benefits can occur when the reduction in transport costs associated with road improvements is large enough to induce an increase in the output in the area of influence of the road. Generally these benefits are considered in terms of agricultural production, and are often referred to as agricultural development benefits, although they can also occur in the industrial sector or any other area of economic activity. Normally such benefits only arise when a project removes a significant transport constraint, thereby allowing motorised transport access to an area for the first time, rather than improving a road already in use. The project roads are all open to traffic and it is not likely that transport cost reductions and improvements in access would be sufficiently large to stimulate identifiable changes in agricultural production. Therefore producer surplus benefits have not been considered in the evaluation.

298. The maintenance assumed to be applied in the base case would be sufficient to ensure that the projects roads were generally all weather roads in the base case. But in at least two cases the roads are subject to flooding at times, and on a number there are basic timber, or otherwise inadequate, bridges. The project works will include raising embankment height in flood-prone areas and replacing inadequate bridges. These will improve the reliability of the roads, ensuring that there are no significant disruptions to traffic or limitations on vehicle types that can operate, which may occur in the base case. The benefits of this improved viability are difficult to quantify and no attempt has been made to do so.

299. The reduction in traffic related dust that will occur with sealing of the roads will have an economic benefit, as dust affects agricultural production and in settled areas it represents a loss of amenity value. As a minimum this is annoyance at the increased requirement for cleaning. There are also potential effects of inhaling dust on human health. Methods of quantifying the impact of road dust are being considered in a current research project by the World Bank and DFID. Previous work carried out mainly in New Zealand suggested that it was only if high value horticultural crops were being grown adjacent to an unsealed road that the benefits of dust reduction were significant. Potential benefits from the reduction in dust have not been included in the evaluation.

300. Without inclusion of these other sources of benefit the evaluation is considered to be conservative in terms of potential overall benefit levels.

11.6 PROJECT COSTS

11.6.1 IMPROVEMENT COSTS

301. The road improvements costs are the costs of the civil works proposed for each road section to upgrade it to a DBST standard. Specific cost estimates have been produced for each road project based on the inventories derived from the engineering field surveys. The cost estimates include the DBST pavement and the base course, plus allowances for repairs to minor structures and the sub-base. In the case of roads in the provinces of Kampong Cham, Kampong Speu, Battambang and Siem Reap it is assumed that a granular base course will be used, with a cement-stabilised base in the remaining provinces. This would be done to provide the lowest cost option according to the location of material sources and haulage costs. Also incorporated in the costs are; an allowance for facilities and contractors' overheads, 10% for physical contingencies and miscellaneous cost items not specifically included in the unit rates, 8% for consultancy services (detailed design and supervision), and 4.5% for project management.

302. An initial evaluation using general costs tested the relative viability of three pavement widths; 3.5m, 4.5m and 5.5m. This showed that the 3.5m pavement width, that is providing a single-lane running surface, consistently showed the lowest rate of return, the traffic levels being sufficiently high that the additional benefits from a wider pavement were greater than the additional cost. Time savings were often negative on the 3.5m pavement option because of the congestion effects on vehicle speeds. For the final estimates only a two-lane design standard was used for each road, with combined carriageway and paved shoulder widths of 5.5m to 7m according to the available road width.

303. The current bridges are adequate in most cases, with many newly constructed. Where bridges are inadequate the cost of replacing them has been included in the project cost. Similarly flood and river bank erosion protection works have been included in the costs where considered necessary. These works add significantly to the overall cost per km in some cases.

304. No land acquisition or resettlement costs are expected. Only minor environmental mitigation measures are expected to be required, and an allowance for any costs is included in the contingencies.

305. It is assumed that civil works will be implemented during 2011 and 2012. In some cases the road improvements might not be implemented until later, depending on the size of the contract packages. However, it was decided that it was preferable

at the evaluation stage to consider all subprojects assuming the same timing, so that they could be compared directly to determine relative rankings in the economic evaluation. The small proportion of project related costs that will be incurred before 2011 has been allocated to 2011 costs. The cost estimates are based on 2009 costs and do not include any allowance for price escalation over the design and construction period. The costs in economic terms were estimated at 80 percent of the financial costs excluding price contingency, to allow for taxes included in the financial costs and shadow pricing of unskilled labour.

306. It has been assumed that to preserve the integrity of the surface an SBST reseal will be required after eight years, or earlier if cracking affecting more than 40% of the pavement area is predicted. The cost of this has been included in the maintenance costs of the project.

307. The pavement design has been made according to the strength of the materials and the predicted cumulative equivalent standard axle load (ESA) on each road to provide a design life of 15 years. In order to extend the evaluation period to include benefits over 20 years a structural overlay has been assumed to be applied in 2028, or earlier if the roughness reaches a level of IRI 16. This is considered to be a capital cost item in HDM-4. As a result of the impact of discounting on present values it has little effect on the evaluation result.

308. The overall economic costs used for the evaluation range from US$55,000 to US$100,000 per km. The costs used for each of each road is shown in Table 11.3 in financial and economic terms.

Table 11.3: Road Improvement Costs (US$ per km)

Road No. and Name		Financial	Economic
370	Tbong Khmum - Ou Reang Ov	78,594	62,875
371	Peus Pir - Kdol Leu (Trea)	119,800	95,840
373C	Memot (NR7) – Kabas	93,361	74,689
2620 & 2KT2	NR62- Prasat Sambour – Sandan	87,903	70,322
1KCH2	Phsar Pong Ror - Ra Krang Skear	85,259	68,207
151C.1	Phsar Trach - Tbeng Khpos	90,914	72,731
151C.2	Wat Tbeng Khpos - Spean Our Tatep	90,914	72,731
151C.3	Spean Our Tatep - Phnom Prah Theat	90,914	72,731
1KCH3	Spean Pour - Ra Meanor	108,541	86,833
154D	Boeng Khnar - Metoeuk	93,980	75,184
152E	NR5 (Beung Kantout) - Kampong Po	100,610	80,488
155D	Boeng Khnar -Taluo	125,926	100,741
155C	NR5 (Trpaing Chorng) - Bord Rumdoul (Phtah Roung)	82,427	65,942
1PS2	Talou - Samraong Village	72,327	57,862
1BB1	NR5 (Prey Svay) - Sdok Praveuk	108,589	86,871
1BB2	NR5 (Railway) - Prek Chik - Chong Por	98,640	78,912
1BB3 & 1BB4	NR5 (Chrey) - Talas - Karkos	98,976	79,181
1KS3	Phsar Traepang Kraleung - Phsar Pang Kassey	96,709	77,367
1KS4	Samki Reaksmey - Dak Por	69,018	55,214
266E	Puok- Angkor Chum	71,502	57,202
266D & 2SR2	Leang Dai - Svay Sor	85,186	68,149

11.6.2 ROAD MAINTENANCE COSTS

309. The cost of road maintenance is usually not a major factor in the evaluation of roads, but can be important in the case of upgrading unsealed, low traffic roads of the type under study. (The traffic is generally low in terms of motorised vehicles with four or more wheels - high levels of motorcycle traffic occur on most of the roads but these are less significant in terms of overall costs and benefits.) The cost of maintaining a sealed road with low traffic is normally low compared with the cost of maintaining an unsealed road to a good standard. This maintenance cost reduction is considered as a benefit in the evaluation.

310. The actual maintenance that would be carried out the roads in the "base" and "project" cases in practice is difficult to determine. The roads are currently unsealed, usually with a laterite surface. Despite the low traffic levels gravel loss rates are high, about 40mm per year, so that a typical gravel surface normally only lasts for about three years. The roads are not maintained in an ideal way for gravel roads, in particular they do not receive the frequent grading required to minimize roughness. Roads generally receive ad hoc repair works each year, plus periodic maintenance involving regravelling every few years. Grading is rarely carried out at other times. In the evaluation it has been assumed that regravelling occurs when gravel thickness has reduced to 25mm, but with a minimum period of three years between regravelling, and that grading is carried out annually. Often actual maintenance in the base case would be less than this, but this would result in the road surface condition deteriorating rapidly, producing very high levels of benefit from the improvement to sealed standard. Thus an effective, but not ideal, maintenance schedule has been assumed in the base case. This is to show that the proposed improvements are not economically viable largely as a result of inadequate maintenance of the existing surface. (A lower maintenance standard would cost less, but result in higher VOC and time costs that increase project benefits.)

311. The maintenance operations applied each are determined within HDM-4 according to road condition and assumed intervention standards or specified time intervals. In the case of the improved roads maintenance items such as crack sealing and pothole patching were assumed to be carried out as required according to the predicted surface condition. An SBST reseal was specified to be carried out if 40 percent of the carriageway was predicted to become cracked, or after eight years irrespective of predicted surface condition. The unit costs of the maintenance operations are shown in Table 11.4.

Table 11.4: Road Maintenance Cost Rates

Work Item	Unit	Cost (US$)
Unsealed Road		
Grading	km	100.0
Regravelling	m^3	7.0
Sealed Road		
Crack Sealing	m^2	1.0
Patching	m^2	4.2
Edge Repair	m^2	6.4
SBST Reseal	m^2	2.5
All Surfaces		
Annual Routine	km	350

312. These have been applied in the model to produce estimates of annual maintenance costs. Purely routine maintenance procedures, such as drain clearance, grass cutting and traffic sign repair, would be similar in both the “base” and “with project” cases. As such it does not affect the evaluation result and a nominal estimate of annual costs per km of road has been applied.

11.7 ECONOMIC ANALYSIS

11.7.1 RESULTS OF THE COST BENEFIT ANALYSIS

313. The results of the evaluation for each road are summarised in Table 11.5 in terms of the EIRR and the NPV expressed in 2009 values discounted at 12%. All the sections evaluated are viable, but with a wide range in the rates of return. The lowest EIRR is 12.5% and the highest is 67.3%, with the majority in the range 15% to 30%. The rates of return are correlated with traffic levels. All of those with an EIRR above 30% have a traffic level of more than 250 vehicles plus more than 1,000 motorcycles per day. Those with EIRRs below 15% are those with low traffic and higher than average construction costs as a result of bridge or embankment works. Benefits have not been determined for these additional works, although they would occur, and so the roads are less marginal that appears from the HDM-4 output.

Table 11.5: Summary of Evaluation Results by Road Section

Road No. and Name		NPV (US$ mill)	EIRR (%)
370	Tbong Khmum - Ou Reang Ov	18.279	67.3
371	Peus Pir - Kdol Leu (Trea)	2.336	23.5
373C	Memot (NR7) - Kabas	2.509	27.2
2620 & 2KT2	NR62- Prasat Sambour – Sandan	10.335	31.1
1KCH2	Phsar Pong Ror - Ra Krang Skear	1.955	23.4
151C.1	Phsar Trach-Tbeng Khpos	3.548	42.3
151C.2	Wat Tbeng Khpos - Spean Our Tatep	0.482	21.8
151C.3	Spean Our Tatep - Phnom Prah Theat	1.441	22.4
1KCH3	Spean Pour - Ra Meanor	0.363	16.5
154D	Boeng Khnar - Metoeuk	0.106	13.8
152E	NR5 (Beung Kantout) - Kampong Po	0.266	17.4
155D	Boeng Khnar - Taluo	2.692	25.1
155C	NR5 (Trpaing Chorng) - Bord Rumdoul (Phtah Roung)	0.046	12.5
1PS2	Talou - Samraong Village	0.817	21.7
1BB1	NR5 (Prey Svay) - Sdok Praveuk	5.933	26.4
1BB2	NR5 (Railway) - Prek Chik - Chong Por	0.905	18.9
1BB3 & 1BB4	NR5 (Chrey) - Talas - Karkos	2.025	22.9
1KS3	Phsar Traepang Kraleung - Phsar Pang Kassey	2.392	20.3
1KS4	Samki Reaksmey - Dak Por	0.698	18.9
266E	Puok- Angkor Chum	7.222	41.7
266D & 2SR2	Leang Dai - Svay Sor	16.479	46.3

314. When all road sections are combined and evaluated as a single project the EIRR is 31.6% and the NPV US$80.8 million. The annual cash flows of the total project are shown in Table11.6.

Table11.6: Total Project Annual Cash Flows (US$ million)

Year	Costs		Benefits					Total
	Capital Works	Recurrent Works	Normal Traffic		Non-Motorised Traffic Savings	Generated Traffic		
			VOC Savings	Time Savings		VOC Savings	Time Savings	
2011	10.158	0.000	0.000	0.000	0.000	0.000	0.000	-10.158
2012	24.120	-0.050	-6.530	-0.890	-0.055	0.000	0.000	-31.546
2013	0.000	-0.050	6.606	1.513	0.068	0.499	0.102	8.836
2014	-1.512	-0.050	9.633	2.034	0.084	0.746	0.151	14.210
2015	-0.328	-0.050	6.190	1.664	0.059	0.463	0.105	8.858
2016	-0.240	-0.050	9.491	2.206	0.073	0.740	0.157	12.956
2017	-1.512	-0.050	12.942	2.859	0.087	1.022	0.217	18.689
2018	-0.032	-0.050	8.170	2.260	0.061	0.626	0.148	11.346
2019	-0.536	-0.050	13.798	3.226	0.083	1.090	0.239	19.022
2020	-1.512	-0.050	18.907	4.195	0.103	1.505	0.328	26.601
2021	6.777	-0.050	10.580	3.030	0.062	0.824	0.203	7.972
2022	-0.536	-0.050	17.692	4.313	0.086	1.407	0.321	24.404
2023	-1.512	-0.050	26.794	6.227	0.121	2.152	0.496	37.351
2024	-0.032	-0.050	13.922	4.147	0.065	1.098	0.286	19.599
2025	-0.536	-0.050	22.773	5.877	0.088	1.822	0.441	31.585
2026	-1.512	-0.050	33.619	8.312	0.123	2.702	0.656	46.975
2027	18.489	-0.050	18.403	5.691	0.067	1.458	0.399	7.578
2028	-0.536	-0.050	38.654	9.476	0.120	3.111	0.740	52.685
2029	-1.512	-0.050	45.711	11.482	0.134	3.686	0.907	63.481
2030	-0.032	-0.050	28.409	8.341	0.078	2.276	0.606	39.792
2031	-0.536	-0.050	55.795	14.465	0.139	4.502	1.141	76.628
2032	-9.625	-0.050	65.982	17.528	0.155	5.334	1.399	100.072

315. Table11.6 is based directly on the HDM-4 output. The Capital Works costs include periodic maintenance costs. The negative amounts shown in most years are the savings in regravelling costs that would be required on different sections of road in the base case. Recurrent Works costs are routine maintenance costs and the negative amounts shown represent the net savings, which are the road grading costs that have been assumed in the base case.

316. The generally poor average surface condition expected on the roads in the base case means that high levels of benefits are obtained when traffic levels are significant. The high levels of motorcycle traffic are sufficient to produce major benefits. The largest source of benefits is VOC savings to normal traffic, which are about four times the level of passenger time savings. Time savings are relatively low because of the low value of time and the modest increase in speeds in most cases, because of the road alignments and friction from roadside activity and non-motorised traffic. Benefits to non-motorised traffic are low as these are mostly time related, and benefits to generated traffic are also low because of the modest amount of traffic generation assumed.

11.7.2 SENSITIVISY TESTS

317. The impact of adjusting some of the key input values has been tested to show the sensitivity of the overall Project EIRR to the changes. The EIRR was analyzed with respect to changes in the benefit and cost streams. Because of the high level of viability of the Project the parameters were varied over a wider range than is usual in sensitivity tests. The tests applied were:

- Construction costs increased by 20%,
- Vehicle operating costs (VOC) reduced by 20%,
- Construction costs increased by 20% and VOC reduced by 20%,
- Base year traffic reduced by 20%,
- Traffic growth rates reduced by 20%,
- Value of time benefits excluded,
- Generated traffic excluded

318. The results are shown in Table 11.7. The EIRR remains above 25% in all tests, indicating a high level of robustness.

319. The switching values (SV) and sensitivity indicators (SI) have also been calculated for changes in construction costs, the level of VOC savings, and removing passenger time savings. They cannot be calculated for the other sensitivity tests variables.

320. A switching value identifies the percentage change in a variable for the NPV to become zero, that is the EIRR to be 12%. The switching value is calculated as:

$$SV = 100 * (NPVb / (NPVb - NPV1)) * ((Vb - V1) / Vb)$$

Where: Vb is the value of the variable in the base case

NPVb is the value of the NPV in the base case

V1 is the value of the variable in the sensitivity test

NPV1 is the value of the NPV with the sensitivity test.

321. A sensitivity indicator compares the percentage change in a variable with the percentage change in the NPV. It is in effect the elasticity of the EIRR against the input variable. For example an SI of 1 shows that with a 1% change in the value of the input the EIRR will also change by 1%.

322. The sensitivity indicator is calculated as:

SI = ((NPVb - NPV1) ÷ (Vb - V1)) ÷ NPVb Vb

Where the variables are defined as above.

323. The results for the switching value and sensitivity indicator are shown in Table 11.7.

Table 11.7: Sensitivity Analysis Results

Scenario	EIRR	NPV	Switching Value	Sensitivity Indicator
Base Case	31.6	80.092		
Costs +20%	28.4	75.032	-316.6	-0.3
VOC –20%	28.6	63.386	95.9	1.0
Costs +20% & VOC –20%	25.6	58.326		
Base Traffic –20%	26.4	51.728	56.5	1.8
Traffic Growth –20%	27.7	52.884	58.9	1.7
No Time Benefits	27.6	58.526	371.4	0.3
No Generated Traffic	30.0	72.441	1046.8	0.1

324. The results for the switching value and sensitivity indicator are also shown in Table 11.7. They show that the results are most sensitivity to traffic data, either base year traffic or traffic growth, but that either of these would have to decrease by almost 60 percent for the Project not to be viable.

12 REHABILITATION OF RURAL ROADS

12.1 BACKGROUND

325. The total length of the classified road network in Cambodia is approximately 39,500 km. The roads are divided into four broad categories: national, provincial, tertiary and sub-tertiary roads, with the sub-tertiary roads further divided into three sub-categories. The tertiary and sub-tertiary roads are referred to collectively as rural roads. The Ministry of Public Works and Transport (MPWT) is responsible for the national and provincial roads, the Ministry of Rural Development (MRD) is responsible for the tertiary and sub-tertiary roads. Table 12.1 indicates the basis of the road classification and division of responsibilities.

Table 12.1: Cambodia Road Classification and Division of Responsibilities

Category	Definition	Responsibility
National Roads	Roads that connect the capital to the main international border crossings and/or provincial capitals.	MPWT
Provincial Roads	Roads that connect: • District centres to provincial centres or to primary roads • A provincial centre to another adjacent provincial centre • Industrial, commercial, tourist and other centres that have large transport needs	MPWT
Tertiary Roads (T roads)	District to district roads	MRD
Sub-tertiary Roads: • Sub-tertiary Road Type 1 (ST1 roads) • Sub-tertiary Road Type 2 (ST2 roads) • Sub-tertiary Road Type 3 (ST3 roads)	 • District to commune • Commune to commune • Commune to village or village to village	MRD

326. Although the classification is clear there does appear to be uncertainty in practice, with some roads designated as provincial roads, but under the responsibility of the MRD. Possibly for this reason, and the lack of a comprehensive inventory of rural roads, the length of the rural road network is uncertain. The length of the national and provincial roads is normally given as 11,500 km and that of rural roads as about 28,000 km. There are estimates that the length of all rural roads is about 44,000 km, but official figures are significantly less than this. An MRD inventory carried out in 2003 gave a length of 27,800 km, but data collected in 2005 as part of the preparation of a strategic plan for rural roads showed the network to be only

approximately 24,000 km[11]. The results of this data collection are summarised in Table 12.2. All rural roads were recorded as being unsealed, with approximately 40 percent having a laterite surface and the remainder an earth surface. In the case of tertiary roads, the highest level of rural roads, approximately 70 percent had a laterite surface.

Table 12.2: Rural Road Length by Type, Surfacing and Condition - 2003

Road Type	Length (km)	Road Surface (km)		Condition (km)	
		Laterite	Earth	Good to Fair	Poor to Bad
Tertiary	1,972	1,373	599	729	1,243
ST1	2,651	1,682	968	659	1,992
ST2	3,949	2,460	1,489	689	3,260
ST3	15,456	3,937	11,520	1,859	13,597
Total	24,028	9,452	14,576	3,936	20,092

Source: Department of Rural Roads (DRR) of MRD

327. The most recent estimate of the rural road network, made in 2008 by MRD, was that the total length was approximately 28,000 km, with lengths of different road surface types as follows:

Laterite	10,734 km
Surface Treated	96 km
Concrete	1 km
Other	5,110 km
Earth	approx. 12,000 km

The category "Other" includes crushed stone and other gravel material and is applied to any case where the surface material is not natural earth, but presumably such roads were classified as Earth Roads in the 2003 inventory. It is clear that the great majority of the rural road network of Cambodia has an unsealed surface, and this will remain the case for many years. Rural roads comprise at least 70 percent of the total Cambodian road network of 39,500 km, and the management of these unsealed roads presents a major challenge for the MRD.

328. A major effort to upgrade or rehabilitate the Cambodia road network began in the mid 1990s, involving national and provincial roads and rural roads. The World Bank reported in 2003[12] that approximately 11,000 km of 27,800 km of rural roads had been constructed or rehabilitated, although it is not always clear what type of works are involved in rehabilitation of rural roads in Cambodia. It does not involve sealing, apart from a few isolated cases where surface treatment was applied. In some cases it is simple, low-cost work, using locally available material and labour, such as that carried out under the World Food Program schemes. In the majority of cases it involves the provision of a laterite surface, when all previous surface material has usually been lost. Usually it also involves raising of embankments, the repair or replacement of structures where necessary, the provision of road signs, localized safety improvements and, in some cases, tree planting. For this reason such work is sometimes referred to as improvement rather than rehabilitation.

[11] Royal Government of Cambodia - Ministry of Rural Development - Strategic Plan for Rural Roads, September 2006.

[12] Provincial and Rural Infrastructure Project (PRIP), Project Appraisal Document, Report No: 25594-KH, pp3-4, The World Bank, Washington DC, USA, August 2003.

329. Virtually all of the rehabilitation has been carried out in donor-funded projects. Between 1998 and the present time there have been 12 major foreign aided projects or programmes for rural roads improvement or rehabilitation, with a total value of approximately US$160 million. The largest were two ADB projects; the Northwestern Rural Development Project (NRDP) and the Rural Infrastructure Improvement Project (RIIP), with other major projects funded by the World Bank (Provincial and Rural Infrastructure Project - PRIP) and the German development agency KfW (Tertiary Rural Infrastructure Programmes - TRIP I to IV). The project descriptions for these refer to rehabilitation and maintenance works, but in MRD documentation these works are described as improvement and maintenance. Usually these projects concentrated on a number of provinces and typically carried out between 250 km and 600 km of rehabilitation works. The average cost of rehabilitation or improvement to laterite standard in these projects has been approximately $17,000 per km, compared with a cost of regravelling alone of $6,000 - $8,500 per km.

330. Several years ago there was already concern that these newly rehabilitated roads were deteriorating prematurely, thereby putting the sustainability of these road assets in jeopardy. This was thought to be due to lack of maintenance, which was attributable both to ineffective road management and to insufficient allocation of reliable and adequate funds. Lack of maintenance still appears to be a major problem. The MRD budget allocations for 2010 are for only 524 km of routine and 617 km of periodic maintenance, although some more maintenance will be carried out as part of donor-funded projects.

331. More recently technical difficulties in maintaining laterite roads in Cambodia have been identified as serious problems (these are discussed in the following section). A number of the donor assisted projects have included both routine and periodic maintenance works in addition to rehabilitation. As a result MRD has had experience of about ten tools and systems for undertaking road maintenance in the last 15 years. The system that was probably the most comprehensive was under RIIP, when MRD disseminated ROMAPS[13] in eight provinces, and now RIP (the successor to TRIP) is extending ROMAPS to seven provinces. However MRD consider it to be too expensive and complicated to operate, and alternative systems are now being considered.

332. MRD has formulated a Policy for Rural Roads which adopted labour-based appropriate technology (LBAT) as its preferred technical strategy. LBAT implies optimal use of local resources such as labour, materials and skills. The evidence is that LBAT is slightly more expensive than machine-based techniques. MRD also has a policy to assign management and implementation responsibilities for rural roads to the provincial level, that is by the Provincial Departments of Rural Development (PDRD). In addition MRD is committed to developing an efficient private sector and is contracting out all construction work to private contractors that have received training in LBAT.

333. The South-East Asia Community Access Programme (SEACAP) funded principally by the United Kingdom international development agency DfID, has carried out research for low cost surfacing of low volume rural roads in Cambodia, Laos and Vietnam over a period of several years. Much of the material in following sections has been taken from SEACAP reports.

[1313] Road Maintenance Planning, Budgeting and Programming System – proprietary software developed by Roughton International of the UK.

12.2 PROBLEMS IN MAINTAINING LATERITE ROADS

12.2.1 COSTS

334. Natural gravel or laterite surfacing has been generally used as a “low-cost” solution to rural access problems in many developing countries. It provides an intermediate surface between basic engineered earth and higher cost, usually bituminous paving. Gravel is appropriate where certain conditions are met. These conditions are

- Suitable material is available and can be laid to surfacing specifications.
- Gravel haul distances are short (< about 10 km).
- Road gradients are less than about 6%.
- Rainfall is low or moderate (< about 700 mm/annum).
- Traffic is relatively low (< about 200 motorised vpd).
- Finance resources and management capacity are available for routine maintenance (including grading/reshaping) and periodic regravelling.
- Dry season dust generation is not severe.

335. For gravel to be the lowest cost option normally all of these conditions must be met, but only some of them can usually be achieved in Cambodia. A general problem is that rainfall is above 700 mm/annum in all areas of Cambodia. A major problem is that supplies of naturally occurring lateritic and other suitable gravels are usually limited, and the good quality deposits that are still left unused are often located far from the roads requiring regravelling. Material is lost from the surface of the road due to the action of traffic and rainfall; gravel loss increasing approximately proportionate to both. Most of Cambodia experiences rainfall that is high in both volume and intensity, which leads to severe erosion of gravel roads and often also impassable conditions. In the dry season the binding effect of the fines is reduced due to moisture loss and they are ‘sucked’ out by traffic in the form of dust, leading to surface ravelling.

336. Annual rates of gravel surfacing loss are 40mm to 50mm, which means that regravelling is required after three years. Losses are higher if poor gravel is used, or if it is not properly constructed. (The gravel loss will also be higher on steep gradients, and gradients are often steep on low volume roads in rolling and mountainous terrain to minimise earthworks and overall construction costs.) Gravel surfaces also disintegrate if they are subjected to flooding.

337. Maintenance of gravel is expensive, especially for periodic regravelling, which is typically required at 3-year intervals. Routine maintenance of a gravel road is typically US$500/km/year in Cambodia, but the need to replace the surface losses by periodic maintenance re-gravelling can cost a further US$2,000/km/year. These levels of funding are difficult for governments or communities to provide. There is an inevitable increase in gravel haulage distances, and therefore in costs, over time as deposits are depleted out. Because of these problems gravel roads are not maintained systematically in Cambodia and many revert to earth road standard.

12.2.2 ENVIRONMENTAL AND HEALTH ISSUES

338. There are also environmental and health issues involved with gravel roads, most of which impose economic costs on the communities along the roads, although these are difficult to quantify. Much of the gravel loss is associated with rainfall but

there is also substantial loss during the dry season, caused by dust generated by traffic, and to a lesser extent wind erosion. One vehicle travelling one kilometre every day will typically generate between 0.2 and 0.6 tonnes of fines over during one year. Thus, in a single dry season, vehicles and wind can remove of the order of 25 tonnes of dust per kilometre of unsealed road.

339. Dust spreads over villages and fields and has many detrimental impacts leading to costs that cannot be fully quantified, for example food stores and water resources can be polluted . Health risks associated with mineral airborne dust are well known. Particles finer than 10 microns and can result in bronchitis, emphysema, silicosis and pneumoconiosis. There is also evidence of increased lung and skin cancer associated with high airborne dust concentrations. Dust enters machinery and electrical equipment, usually leading to substantially reduced life and/or greater servicing frequency and maintenance costs. During rainy periods runoff of fines into streams can have a serious impact on water quality. Runoff siltation causes a high maintenance requirement in the drainage system. Roads also become slippery leading to increased safety hazards. Gravel pit excavations can eventually fill with water and become sources of disease. They are dangerous for children and livestock and can become dumping sites for garbage, building rubble and scrap.

340. These effects can be summarized as:

- Safety hazards (fatalities on dry gravel roads are disproportionate to the number of vehicles using them).
- Health hazards.
- Discomfort and nuisance.
- Air pollution.
- Water pollution.
- Reductions in agricultural yields and livestock health.

341. Perhaps the biggest environmental issue associated with gravel roads is that of sustainability of a non-renewable resource. Suitable gravel is becoming a scarce commodity and its continued large-scale use will eventually lead to there being no such material for any form of road construction.

12.3 WHOLE LIFE CYCLE COSTING

342. Experience in Cambodia has shown that many unpaved roads deteriorated faster than expected. This has caused the Government additional expenditure, and lost benefits, sometimes resulting in the re-investment of their limited funds in reconstructing the same road section. In many cases gravel is a low capital but a high maintenance cost option, and it is now widely believed that gravel is often expensive when the whole life-cycle costs of different surfacing/paving options are evaluated. Providing longer lasting paving options would require higher initial investment cost if compared to the cost of providing a gravel surfacing. However if whole life cycle costs are to be considered, providing more durable surfacing with less maintenance requirements would show higher economic returns.

343. There are two basic approaches to the assessment of whole life costs for rural roads. These can be characterized as:

- Whole Life Asset Costs (WLACs).

- Whole Life Transport Costs.

344. WLAC assessment is a process of assessing all costs associated with a road investment that the road agency must bear over the assessment period selected (for example, 12 years from construction). The aim is to minimize the sum of these values to obtain the minimum overall expenditure on the asset, yet achieving a defined acceptable level of service of the asset. There are three principal cost components; the initial investment or construction cost, the future costs of maintaining (or rehabilitating) the asset, and the residual value at the end of the design life. Any rehabilitation costs will need to be included (for example, if maintenance is deficient and the road will need to be reconstructed during or at the end of the assessment period). Usually an assessment of the residual value of the asset at the end of the assessment period is included to incorporate the possible different consequences of construction and maintenance strategies for the pavement and surface options investigated. A WLAC assessment is based on a comparison of costs incurred over a period of a number of years. From an economic viewpoint, an important decision therefore is the reduction in value that is given to future costs. A discount rate is usually used to reflect the present value of future costs, as in a conventional economic appraisal. The WLAC for the road authority is simply the different between discounted costs over the analysis period and discounted residual value of road asset at the end of the analysis period.

345. A Whole Life Transport Cost assessment adds road user costs (vehicle operating costs and time costs), and possibly other socio-economic and environmental impacts to the WLAC. This gives the total transport cost over time and, when different options are compared, is in effect an economic evaluation of a proposed pavement option. The use of WLAC comparisons for the selection of alternative low volume rural roads (LVRR) technologies is a practical, simple and transparent tool for LVRR managers to make better decisions. Adopting the general use of WLAC analysis can be considered an important first step in understanding the impacts of various road management decisions. Next a more comprehensive analysis in terms of the Whole Life Transport Cost, that is including road user costs and other economic implications of the decision making, should be considered. Road evaluation tools such as HDM-4 can then be introduced to provide this more comprehensive analysis.

346. For WLAC purposes it is necessary to have accurate construction or rehabilitation costs. Therefore they should be compiled on a regional basis, and broken down for each surface and paving option. In view of the high variability of energy/transport and materials costs the data should also be compiled by year, so that adjustments for cost changes can be made. Refinements can also be incorporated for such factors as size of contract and remoteness from main administrative centres, as these aspects can influence the overall cost of works.

347. Similarly maintenance costs must be predicted accurately, which is best if based on empirical knowledge developed in the environment in which the road is located. Once the deterioration characteristics are known, accurate costing of the required maintenance regime can be determined. Some surface types are more demanding of maintenance and more sensitive to the timing of its provision than others. Therefore, before coming to a final decision on the selection of a pavement or surface type using WLAC it is advisable to assess the future maintenance requirements of the options being considered and to decide whether or not there is a likelihood of this level of maintenance being resourced (financially and physically), and being arranged in a timely manner. This should include provision for urgent,

unplanned, maintenance works that may also be required, as a result of particularly severe weather conditions, floods, unexpected deterioration, landslips or exceptional damage caused by over-weight vehicles. Thus a pragmatic assessment of the costs of the maintenance operations and the expected maintenance resources and capacity are needed to achieve a realistic WLAC assessment.

348. Although the analysis is "Whole Life" many road investments will have an economic value beyond the analysis period. In these cases realistic estimation of residual value of the asset is essential for the evaluation of WLAC. Certain technologies, such dressed stone paving, will have much higher residual values than wasting technologies such as gravel. Residual values can be high enough to have an important influence on the results of the analysis.

12.4 ALTERNATIVE PAVEMENT AND SURFACES

12.4.1 OPTIONS TESTED IN THE REGION

349. There exist a number of proven alternatives to laterite surfacing for rural roads, involving both sealed and unsealed surfaces, many have which have been tested in trials in Cambodia or the region in recent years. The surface types used in these trials are shown in Table 12.3.

Table 12.3: Summary of Regional Pavement and Surfacing Trials

Type of Surface/Roadbase	Cambodia			Vietnam SEACAP 1		Laos
	SEACAP 8	ILO	NRDP	RRST-I	RRST-II	SEACAP 17
SEALS:						
DBST					2006	
DBST (Emulsion)	2004		O		2006	
SBST + Slurry Seal (Emulsion)				2005		
Slurry Seal (Emulsion)	2004			2005	2006	
Otta Seal		O				2008
UNSEALED SURFACES:						
Gravel Wearing Course	2004			2005	2006	2008
Water Bound Macadam				2005	2006	
Hand Packed Stone						2008
Lime Stabilised Gravel			O			
Engineered Natural Surface						2008
SEALED BASES & SUB-BASES:						
Water Bound Macadam	2004			2005	2006	2008
Dry Bound Macadam				2005	2006	
Emulsion Stabilised Sand				2006		
Cement Stabilised Sand				2005		
Lime Stabilised Gravel			O			
Lime Stabilised Clay				2005		
Lime & Cement Stabilised Gravel			O			
Armoured Gravel				2005	2006	
Graded Crushed Stone		O				
Sand				2005		
Sand-Aggregate Mix	2004					
Gravel	2004	O		2005	2006	
BLOCK SURFACES						
Stone Setts	2004			2005		
Cobble Stone					2006	2008
Fired Clay Brick				2005	2006	
Concrete Brick				2005	2006	2008
CONCRETE						
Steel Reinforced				2005	2006	
Bamboo Reinforced	2004			2005	2006	2008
Non-Reinforced	2004				2006	
Cast in Situ Blocks (Hysen Cells)						2008

Source: SEACAP 19 Development of Local Resource Based Standards – Technical Paper 5 - Economic Evaluation for Low Volume Rural Road Upgrading

350. In Table 12.3 the column headed SEACAP 8 refers to trials carried out near Puok in Siem Reap Province by the SEACAP project, which is described in the following section. The years shown indicate the year in which performance monitoring began (it has been intermittent in the case of the SEACAP 8 trials at Puok), with O indicating that there has been no monitoring.

351. Most of these trials were carried out by SEACAP. In Vietnam SEACAP carried out trails on 140 km of rural roads in association with the Ministry of Transport and the World Bank. Also SEACAP completed construction of a number of trial sections in 2007 in Bokeo province of Lao PDR. In addition to the SEACAP trials there were two other road surface trials in Cambodia. The ILO undertook trial construction of OTTA sealed natural gravel (laterite) road bases as part of an overall labour-based maintenance project. The trials were constructed during February to May 2007 in Otaka Commune in Battambang Province. Six trial sections of between

100m to 150m in length were constructed. In addition demonstration trials of laterite stabilised by lime and by lime with cement were undertaken as part of the ADB-funded Northwestern Rural Development Project (NRDP). These trials took place during March-April 2007 with technical assistance by NZAID on sections of provincial road in Banteay Meanchay Province. Not all these trials have involved performance monitoring and hence they have limited usefulness as input to the development of WLAC assessment.

12.4.2 ROAD PAVEMENT PERFORMANCE

352. Road pavements are complex structures that can deteriorate in many different ways. 100% reliability is not mandatory and designing for high levels of reliability increases costs considerably. Designing for no failures is prohibitively expensive. For low volume rural roads in particular high levels of reliability are not economically justified. Thus the 'safety factor' for the design of rural roads is relatively low, and there are more ways in which they can deteriorate. In particular, the impact of environmental factors is greater.

353. The design of road pavements can be considered separately in terms of the surfacing and the structure. The surfacing is primarily designed to keep the pavement dry and waterproof whereas the main structure underneath the surfacing is designed to spread the loads from traffic to protect the subgrade from deformation and failure. As a result, the selection of surfacings and basic structure are often independent of one another and a large number of combinations are possible.

354. Some structures will naturally last longer than others, and some will be better suited to particular conditions. In principle, the least- cost option that is available in a particular location should be selected, but this should be based on whole life costs so that the durability of a particular option and maintenance costs are taken properly into account. As a result, the best available solution will vary with the environmental conditions.

12.5 SEACAP PROJECT

355. The South-East Asia Community Access Programme (SEACAP) funded principally by DfID, has carried out research for low cost surfacing of low volume rural roads in Cambodia, Laos and Vietnam over a period of several years. The programme ended in 2009. It was realised that laterite roads are becoming more and more expensive and that the scarcity of good quality of laterite will lead to the need to haul ever longer distances, which will increase the haulage cost and therefore increase not only construction costs, but also maintenance funding requirements.

356. SEACAP advocates two simple premises for achieving sustainable community access:

- Maximizing the use of local resource-based technologies.
- Minimizing full life cycle costing.

357. The two main SEACAP projects relevant to this study were SEACAP 8, Cambodia Low Cost Surfacing Phase 2, and SEACAP 19, Development of Local Resource Based Standards. In SEACAP 8 ten different trial sections were constructed at Puok Market in Siem Reap Province seeking suitable alternative solutions to replace laterite surfaced roads.

358. The construction of Pouk the Low Cost Surfacing Trials was completed in September 2002 under the ILO Upstream Project utilising DfID funding provided under the Engineering Knowledge and Research programme. The objective was to trial rural road surfacing alternatives that were likely to be more sustainable than unsealed natural gravel. An initial monitoring of the surfacing trials undertaken in April-May 2003 indicated that all trial road sections were in good condition. However, by July-August of 2003 the trial sections were being subjected to loading by a significant numbers of sand haulage trucks. It was apparent that these trucks hauling wet sand were heavily overloaded and used the road on a regular daily basis. The result was that two sections of the trials became severely damaged and some other sections also showed signs of distress, requiring that they were repaired. The damage was primarily structural.

359. Analysis of the different surfaces based on the results of the Puok trials are summarized in the following series of tables. Table 12.4 shows the base year traffic level, which was increased using annual growth rates of 3-4 percent for the analysis.

Table 12.4: Daily Traffic on Puok Test Sections

Vehicle Type	ADT
Bicycle	2,291
Animal Cart	22
Motorcycle	1,312
Total Non-motorized vehicles and 2-wheel	**3,625**
Motorcycle Trailer	38
Car	10
Pickup Private	5
Pickup Commercial	15
Minibus	7
Light Truck	15
Medium Truck	13
Heavy Truck	3
Total Motorized vehicles	**106**

Source: SEACAP 8 Cambodia Low Cost Surfacing Phase 2

360. The WLAC analysis was carried out for a 10-year period and the results using discounted present values are summarized in Table 12.5. Laterite is not the lowest cost, but is lower than many options. (When the analysis is made with undiscounted costs the laterite surface is the highest cost option by a wide margin.) It should be noted that this analysis was based on the SEACAP 1 Model, which does not take into account road user costs. Therefore the benefits of a smoother road surface are not included.

Table 12.5: Asset Whole Life Cycle Costs (discounted)

Analysed Design Options	Initial Investment	Discounted Maintenance	Salvage Value in 10th Year C = % * A	Whole Life Cycle Cost

	Cost (US$/km) A	Cost over 10 years (US$/km) B	Percent of Initial Investment	Discounted Value in US$/km	US$/km D=A+B-C
Gravel/Laterite surfaced road	$16,344	$27,132	50%	$2,849	$40,626
70 mm Armouring with SBST	$35,381	$7,639	40%	$4,935	$38,086
70mm Armouring with DBST	$41,185	$2,817	40%	$5,744	$38,257
200mm of Sand-aggregate Roadbase with SBST	$47,252	$6,736	50%	$8,238	$45,750
200mm of Sand-aggregate Roadbase with DBST	$53,055	$1,160	50%	$9,250	$44,966
200mm of WBM Roadbase with SBST	$47,953	$6,736	50%	$8,360	$46,329
200mm of WBM Roadbase with DBST	$53,757	$1,160	50%	$9,372	$45,545
200m of Dressed-stone with SBST	$52,124	$6,736	50%	$9,087	$49,772
200m of Dressed-stone with DBST	$68,546	$1,160	50%	$11,950	$57,755
100mm of Hand-packed Stone with SBST	$42,825	$7,639	50%	$7,466	$42,998
100mm of Hand-packed Stone with DBST	$48,628	$2,817	50%	$8,478	$42,967
150mm of Hand-packed Stone with SBST	$38,884	$6,736	50%	$6,779	$38,840
150mm of Hand-packed Stone with DBST	$55,305	$1,160	50%	$9,642	$46,823
200mm of Hand-packed Stone with SBST	$48,904	$6,736	50%	$8,526	$47,114
200mm of Hand-packed Stone with DBST	$65,326	$1,160	50%	$11,389	$55,097
200 mm Un-reinforced Concrete Pavement	$72,297	$925	70%	$17,646	$55,576

Notes: Asset Whole Life Cycle Cost does not include the management and supervision cost. Discount rate used = 10%.

Source: SEACAP 8 Cambodia Low Cost Surfacing Phase 2

361. A more complete analysis using road user costs derived from HDM-4 was applied to four of the options. These four options are shown in Table 12.6.

Table 12.6: Design Condition and Improvement Options

Upgrading Scenarios	Expected Maintenance and Overloading risk	Proposed Design for cost benefit analysis
Scenario 1	No overloading risk with reliable maintenance system	Design Option 1A - 70mm armouring with SBST
Scenario 2	No overloading risk with unreliable maintenance system	Design Option 1B - 70mm amouring with DBST
Scenario 3	Risk of overloading with unreliable maintenance system	Design Option 6B - 150mm of hand-packed stone with DBST
Scenario 4	Risk of extreme overloading with unreliable maintenance system	Design Option 8 - 200mm un-reinforced concrete pavement

Source: SEACAP 8 Cambodia Low Cost Surfacing Phase 2

362. The results the Whole Life Transport Cost for these four options are shown in Table 12.7, in the form of the EIRR obtained when each option is compared with a base case of a laterite road. The EIRR was calculated for the actual traffic level on the test sections as shown in Table 12.4 above, and two lower traffic levels. It can be seen that with the actual traffic level all the options have EIRRs well over 12%, indicating that the whole life transport costs are significantly lower than those with a laterite road, but when the traffic level is halved the additional investment cost compared with a laterite road cannot be justified.

Table 12.7: Internal Rate of Return for Different Traffic Levels

Expected Maintenance and Overloading Risk	Improvement Options	Financial Cost of Construction (US$/km)	IRR (%)		
			Pouk Traffic	75% of Pouk Traffic	50% of Pouk Traffic
Scenario 1	Paved Option 1-A (Machine based)	35,381	35.6	23.2	11.2
	Paved Option 1-A (LBAT)	38,447	32.5	20.9	9.7
Scenario 2	Paved Option 1-B (Machine based)	41,185	31.7	21.1	10.9
	Paved Option 1-B (LBAT)	44,538	29.1	19.1	9.5
Scenario 3	Paved Option 6-B Machine based)	55,305	23.1	14.9	7.2
	Paved Option 6-B (LBAT)	58,121	21.8	13.9	6.5
Scenario 4	Paved Option 8 (Machine based)	72,297	18.4	12.2	6.6
	Paved Option 8 (LBAT)	74,126	18.9	12.6	6.8

Source: SEACAP 8 Cambodia Low Cost Surfacing Phase 2

12.6 PRESENT SITUATION

363. A number pavement trials have been undertaken in the last few years, but only one trial programme so far in Cambodia has involved performance monitoring, and hence there has been limited input to determining appropriate pavement upgrade options specifically for Cambodia. Also this monitoring was only carried out for a few years.

364. Even though the long term monitoring of these alternative pavements has not yet been completed, the initial research results have already had significant and positive impact on other road development projects which have adopted these paving options. The experience and knowledge gained on alternative surfaces has helped MRD substantially to move away from reliance on gravel/laterite surfacing, which is problematic and unsustainable for many situations in Cambodia. MRD is currently reviewing the results of SEACAP with the intention of producing guidelines on surfacing alternatives in 2010. These guidelines will facilitate informed decisions on low-cost surfacing/paving options..

365. As part of SEACAP 19 draft design standards for rural roads have been proposed[14] and were used in TA-7199. Table 12.8 shows the recommended combinations for surfacing and the structure. These potentially fall into just four

[14] South East Asia Community Access Programme, Development of Local Resource Based Standards, SEACAP 19, Rural Road Standards and Specifications: Classification, Geometric Standards and Pavement Options, Final Project Report, May 2009

thickness designs for each traffic level although the more expensive options will not be suitable for the lowest categories of road. The basic gravel wearing course is not recommended for the highest traffic levels.

Table 12.8: Structural Options

Layer	Structure 1	Structure 2	Structure 3	Structure 4
Surface	Gravel	DBST or Otta	Pen Mac	Concrete
Road base		WBM, DBM, GCS, Stabilised	WBM, DBM, GCS, Stabilised	-
Sub-base		Gravel	Gravel	Gravel
Selected Fill[1] where required		CBR > 10%	CBR > 10%	CBR > 10%

Notes[1] If suitable material is not available a stabilisation option is required and sub-base thicknesses can be reduced.

366. Based on the findings of other studies, a whole life costs approach was adopted for TA 7199, whereby the base case of gravel surfacing was compared to that of providing a paved surfacing and evaluated over a 20-year cycle. The analysis confirms the trends and opinions given in earlier work; that is it is economically beneficial to pave gravel roads where traffic levels are sufficiently high to derive these benefits.

367. Although, several pavement options (for paved roads) are offered in previous work, those adopted for this project conform to the use of those given in the draft MRD standards, being a stabilised or aggregate base with a bituminous surface treatment. While previous work indicates that lower standard materials may be used for low traffic situations the performance of these has not been proven. In the MRD draft standards savings in pavement costs have been primarily derived by using thinner pavements composed of standard quality materials. This ensures good performance under the prevailing traffic loading of the project roads. The pavement type selected uses locally available materials in the project areas.

368. The life cycle analysis undertaken shows the importance of including total transport costs in the calculations. To date little work has been carried out at this level; the detailed analysis in SEACAP uses only WLAC, that is using only construction and maintenance costs, and residual values. More work needs to be carried out taking into account the impact of road user costs associated with different levels of traffic to determine the optimal pavement and surfacing options.

13 SOCIAL SAFEGUARDS

13.1 POVERTY AND SOCIAL ASSESSMENT

This Executive Summary has been extracted from the Poverty and Social Analysis prepared for the above TA. The opinions expressed in this Executive Summary and the analysis thereof is that of the TA Consultant and does not necessarily represent the views of either the Ministry of Rural Development or the Asian Development Bank.

369. This Project has the potential to benefit an estimated 560,000 rural people living in the Project zone (defined not simply as living along the roads to be permanently paved but in close enough proximity to use these roads) of whom 296,018 are females or 52.8% of the Project beneficiaries and 18,309 ethnic Cham people or 3.2% of the beneficiaries based on both the General Population Census of Cambodia 2008 which has just become available in August 2009 and the most recent population data held at the commune level. If the annual growth rate of 1.54% were to be calculated another 9,184 persons could be added to that total but annual growth rates vary from a low of 0.43% in Kampong Cham, Cambodia's largest province, to a high of 2.56% in Battambang.

370. The PSA is based on the findings of an extensive socio-economic survey covering 840 interviewees in locations selected at random in the Project zone covering 58 communes in 19 districts of the 7 Project provinces. It is also based on the qualitative insights gleaned from a series of key informant interviews numbering 100 and 19 focus group discussions with 210 participants. Interviewees were selected on the basis of stratified sampling to ensure that women, the poor, ethnic minorities, physically impaired and aged were interviewed. Similar criteria were utilized for the focus group discussions although for key informants the emphasis was on identifying informants with good local knowledge pertaining to rural transport issues. These activities commenced on the 15th of July and concluded on the 1st of October. The eight member team consisted of youngish university graduates with knowledge of agricultural and rural development issues (including rural business) and also included several female members. Training was provided by the TA Consultant who also provided quality assurance in the field. The database generated from this survey will be made available to the MRD to be utilized for baseline monitoring and it is assumed MRD will share this database with providers of ODA.

371. Additionally secondary data has been utilized including official databases on rural Cambodian socio-economic development, studies supported by providers of ODA, local research institutes and a range of local and international NGOs. Analytical insights from empirical studies elsewhere in transitional societies have also been utilized. As the PSA implies this is not a descriptive undertaking but an analytical undertaking grounded in the empirical realities of each of the 19 Project roads.

372. At the outset it can be unequivocally stated that most local stakeholders support a project of this nature because they believe (a) it will have a significant impact on poverty reduction; (b) it will enable a greater meeting of community needs; (c) offer opportunities for the poor to be involved in construction and maintenance activities; (d) improve access to health, education, markets, credit and other government services; and, (e) provide greater localized opportunities for non-farm based income generation. Stakeholders also highlighted the significant reduction in dust, especially during the dry season and also a reduction in road noise.

373. However, these same stakeholders also identified some negative impacts, notably (a) greater likelihood of traffic accidents posing dangers to the young and very old and those visually and otherwise physically impaired; (b) possible increase in lack of local security due to ease of access from outside the local community; (c) competition from outside the local community reducing profit margins or even forcing existing small traders out of business; and, (d) threats to common property resources (e.g. fisheries, wildlife and forestry). Some key informants went as far to attribute climate change in their locality, especially highly unpredictable weather patterns (extended dry season and un-seasonally heavy rainfall and floods difficult to manage) with (d). Interestingly few identified known social risks associated with HIV/AIDS and human trafficking or if they did they considered them to be minor by comparison with the putative benefits of the Project.

374. This does not mean that these social risks are ignored and the TA Consultants are in the process of preparing adequate safeguards for both HIV/AIDS and human trafficking prevention in recognition of the fact that such social risks exist despite claims to the contrary by many local stakeholders. However, it is very necessary to recognize genuine concerns local stakeholders express in relation to road safety issues and a road safety awareness program that MRD can assist rural schools develop is one of the key recommendations flowing from stakeholder consultations at the local level. Of course this does not negate responsibility for improved road signage, traffic calming measures or more adequate enforcement of traffic regulations but it incorporates the aspirations of local stakeholders who are not simply motorized users of local rural roads but of equal importance non-motorized road users (pedestrians, cyclists and animal powered transportation). In relation to climate change issues these are complicated although the manifestations are not and people are being forced to cope with probably more substantive climate change than in their living memory.

375. The argument articulated in this PSA is that MRD needs to recognize the continuing importance of NMT on the rural roads of Cambodia. This way MRD also adopts a pro-poor approach to rural roads without compromising a pro-growth approach. This Project is not simply about the construction of permanent pavements along 19 rural roads identified in the 7 provinces but of equal importance what road-map does MRD need to develop to ensure sustainable approaches to the provision of rural transport infrastructure.

376. Non-rural based stakeholders in this Project, including agricultural extension workers (argued that the best form of extension is on-farm because female farmers can also be targeted), land-titling officials (argued that at present it is logistically impossible for them to provide transparent assistance in the cases of conflict over land), and providers of micro-finance (argued that most of their lending officers and local agents are disinclined to travel along poor rural roads to offer a range of financial products) also argued permanently paved roads would improve their ability to access local rural communities. Whether these claims materialize needs to be part of the impact assessment of this Project on local communities but evidence from the Project study strongly suggests that improved access to local communities facilitates an improvement in household livelihoods: access to improved agricultural technologies and inputs, secure access to agricultural land, and improved access to micro-finance are three critical approaches in the reduction of rural poverty.

377. The incidence of poverty (defined for international comparative purposes as US$1.20 per day, per capita and adjusted using World Bank Purchasing Power Parity estimates) ranges from a low of 30.5% in the Kampong Cham to a high of 65.0% in Kampong Thom. In relation to food poverty (defined as experiencing food

shortages within the past 12 months) the lowest incidence of food poverty is in Kampong Cham at 12.0% and highest in Kampong Speu at 53.1%. These estimates are in excess of the current estimates for rural poverty in Cambodia but reflect the following indicators – monthly per capita household income and expenditure levels (methodological decision taken to take expenditure as a more important indicator than income because of lesser distortion); sources of income; and, ownership/access to and area of productive agricultural land, livestock and fish ponds, productive non-land assets and household assets – and can be used by MRD to assess the extent to which this Project reduces poverty in the Project zone.

378. Additional poverty-related indicators that can be used from this survey include: selected educational indicators, expenditure on education in the past 12 months, illnesses suffered in the past 12 months, expenditure on healthcare in the past 12 months, housing construction/materials, and access to potable water and sanitation. Such indicators are also available from existing databases but they are not specific to the Project zone but rather to provinces and while generally useful do not assist MRD to utilize these proxy indicators to further quantify the impact of the Project on poverty reduction. It also needs to be noted that where possible these indicators have been gender disaggregated and in the context of the one ethnic minority group in the Project zone also disaggregated by ethnicity.

379. The PSA argues that this Project represents an opportunity for MRD to further develop its pro-poor policy framework. MRD appears to have quite a good understanding of such policy frameworks based on its earlier work with the ILKO and WFP but such a policy framework is also part of the RGC Rectangular Strategy 2006-10, which even when updated in 2010 will still be retained as one of the four pillars in its pro-poor but also pro-growth approach to development. However, it does need to be clearly stated that permanently paving rural roads is really only a partially pro-poor approach to development. There are other transport-related issues for the very poor including local village pathways, safe stream crossings, and access to areas typically at some distance from the actual village but from which livelihoods are also derived.

380. The survey predictably found that throughout the Project zone rural roads are used on a highly regular basis for school attendance but other uses such as market access (ranges from 100% in Kampong Cham and Battambang to a low of 30.5% in Kampong Thom), farm access (100% in Kampong Cham. Kampong Chhnang and Battambang to a low of 31.5% in Pursat), and non-farm work related (high of 15% in Siem Reap and not at all in Kampong Thom). The most commonly used transport mode is divided between NMT forms (pedestrian, draft animal) and motorcycle powered trailer and 4-wheelded motorized vehicles are used less frequently (18.5% in Battambang to a low of only 1% in Kampong Thom. This does not mean that local rural stakeholders never travel by motorized vehicular means but the emphasis is on common usage. Average intra-village travel costs vary from KHM 500 – 1,000, intra-commune KMR 1,000 – 2,500; inter-commune KHM 1,500 – 3,500; intra-district 3,000 – 4,500; and, inter-district 10,000 – 18,500. Key informants pointed out that with more competition, cheap vehicle imports (but one has to question the real roadworthiness of some of these vehicles) and even better rural roads transport costs have decreased across the board by up to 45% over the past decade.

381. Specifically in relation to the social characteristics of transport use there are a number of key issues arising from the use of the right-of-way. Social issues raised by NMT users include the local ROW being used to (a) dry newly harvested crops or fish catches; (b) graze livestock during the height of the wet season when water

levels are often very high (also needs to be noted that this sometimes include people physically displaced by seasonal flooding); (c) as places to sleep during the hot season when it is too hot to sleep inside the house; (d) as meeting places during the evenings or during or after local religious festivals and other cultural ceremonies; (e) as venues for extended weddings and funerals when there is insufficient space to accommodate invited guests in the household compound; and, (f) as sites to conduct small-scale business activities including bicycle repair and motorized vehicle puncture repair.

382. In a similar manner it is also important to understand the gendered nature of transport use in the Project zone. While women were generally as supportive of this Project as men during FGDs it was clear that women are more village-focused than men (although ironically over the past decade it has been young rural women rather than young rural men that have been able to find waged employment in significant numbers in Cambodia's garment assembly industry) because they argued that MRD should invest more heavily in water supply and sanitation projects, which they acknowledged it has been doing for over the past decade but prevention of water-borne diseases such as diarrhea and dysentery are of equal importance to local roads being permanently paved. Moreover, when analyzing the transport patterns of women and men at the village level, women in the Project zone are more likely to make multiple, short trips on a daily basis then men thereby exposing themselves to greater danger from faster moving traffic than men.

383. The PSA stresses that it is important for MRD to understand the different perceptions of MT and NMT users. It is sometimes understandable why transport ministries have little or no understanding of such perceptions, but MRD cannot afford to adopt a similar approach and this came through loud-and-clear during the TA survey. For instance in relation to linking transport issues and greater gender equity MRD does have some experience in this area from its RWSS programs therefore analytically it does not require a significant shift in the institutional culture of the MRD in relation to GAD and transport development issues. However, MRD could benefit rural female transport users by also utilizing female staff members in the area of rural transport issues.

384. As part of the TA the TA Consultant was required to also focus on social risks because the ADB is required to ensure that social safeguards are integrated with actual project design. To date this Project does not involve any land acquisition or loss of other physical assets – the involuntary resettlement process in ADB policies – but should MRD agree with PDRD proposals in the Project zone to connect roads where it is necessary to widen or raise the alignment than there will be resettlement-based issues. For ADB financed projects (same applies to WB and some other ODA providers) that MRD needs to address. The standard approach to date has been to state that people agree to give up a portion of their road frontage to ensure the alignment can be widened and in most instances this is probably correct but due processes (inventory of loss and detailed measurement survey) will still be required.

385. Whether the Project increases the risk of exposure to HIV/AIDS and Human Trafficking is somewhat problematic but it does need to be recognized that if these social risks exist – and on Project roads in Kampong Cham, Siem Reap, Battambang, and Pursat they do to some extent based on the TA survey (in relation to human trafficking this also involved consultations with Vietnamese border officials and NGOs concerned with the trafficking of young Cambodians to Vietnam) – which requires measures to minimize or mitigate these social risks. The Environmental Management Plan to be incorporated into the environmental safeguards (as per the

Initial Environment Examination) will address the social risk posed by HIV/AIDS (contractor's requirement to provide HIV/AIDS awareness and prevention measures such as the supply of condoms as per usual transport infrastructure projects although employing local labor where possible is also another preventive measure). In relation to human trafficking MRD cannot directly address this issue but in late September 2009 the RGC has promulgated its new anti-trafficking measures and this is an issue that requires coordination with labor officials within Cambodia and counterparts in neighboring Thailand and Vietnam.

386. The Project provides the opportunity for improved social planning outcomes in practical terms by adding social value via (a) enhanced stakeholder analysis (outcome is for MRD to work closely with PDRDs and potential investors to identify rural roads that can be leverage for economic growth purposes); (b) consultation and participation strategies (listening to and learning from local communities what their actual priorities are and then working where practical with these same local communities); (c) gender plan (concrete and specific measures to benefit females such as Project related employment but also a requirement for the RRP prepared by the ADB); (d) community outreach (very important in the context of both road safety and human trafficking but for which MRD can contract responsive NGOs); and (e) social framework (very important for assessing the impact of this Project and subsequent projects on poverty reduction).

387. For social monitoring and evaluation purposes the PSA has identified a range of impact (e.g. rural incomes among women, the poor, the aged, and the disabled) and outcome indicators (e.g. increase in the number of visits by extension workers, credit providers, and health and education providers) and output indicators (e.g. number of poor and vulnerable workers, including especially women, hired for construction and maintenance). However, it is also being considered whether environmental indicators related to climate change should also be included because of their poverty and social implications because the underlying thrust of the PSA is premised on this Project also contributing to sustainable livelihood improvements of all households in the Project zone.

388. By Project completion MRD should be in a position to assess a range of outcomes, including the ability of stakeholders to influence Project processes during civil works construction and identification of lessons learned for future projects. But it is necessary for the Project to provide support to both the MRD and PDRDs to develop this capacity and a financing plan is in the process of being prepared to ensure this is possible. The PSA argues a Social and Environmental Unit (SEU) should be established in the MRD and the TA Consultant has spent some time working with two nominated staffers from the MRD, including in the field and it should be possible to build upon their existing strengths which *inter alia* include willingness to learn-on-the-job. The PSA has been structured around the underlying argument that the Project represents a very good opportunity for MRD to use this Project as an exemplar for subsequent projects, building of course on its existing strengths.

13.2 ENVIRONMENTAL EXAMINATION

13.2.1 INTRODUCTION

389. This section of the report presents a summary of the environmental examinations that have been carried out. Although it may repeat earlier sections of this report, a description of the project is included here for easy reference.

390. The project proposes the upgrading 19 existing rural roads from gravel standard to a paved road standard. The provision of a durable paved road with a structural design life of, say, 15 years will greatly reduce road maintenance costs and road user costs. Although it will be more costly to construct the upgrade, the whole life costs of the road will be lower. During the design life the road will require resealing to maintain the integrity and waterproofing function of the bituminous seal. At the end of the design life an engineered structural overlay will be required. A typical structural overlay could be an additional road base layer or a structural surfacing. As the Project will only upgrade roads within their existing widths, no land or other physical assets need to be acquired and hence no resettlement issues.

391. The project roads are located in seven provinces of Cambodia. Five of these are in the Tonle Sap region, namely Kampong Chhnang, Pursat, Battambang, Siem Reap, Kampong Thom and the remaining two are Kampong Speu and Kampong Cham located to the south east and north-east of Phnom Penh, respectively. The roads serve primarily agricultural based rural communities.

392. The total length of the proposed project roads is 518km approximately. The individual roads vary in length from 9km to 66kms. The total length of roads is shared fairly equally between the provinces. They comprise a mix of well established and frequently trafficked road links and a number of links that are currently being or have been recently improved to gravel road standard. Some of these roads may carry less traffic than others at present. However, they form important links to new or established centers and are often links that MRD has invested in recently. On some project roads, upgrading works are ongoing, but these are expected to be complete before the implementation of the proposed project. Collectively the project roads will provide better access to essential services, reduce remoteness and increase economic opportunities. All the project roads link to a national or provincial road and provide access to the road network at large. With the exception of one link the national road links are paved. For the exception it is understood that paving is proposed.

393. While many of the roads carry predominantly motor cycle traffic and light 4 wheeled vehicles, a few are trafficked by heavy vehicles at least for part of their length. It is also important to recognize the usage of these roads by non-motorized traffic, especially children and poorer people who are either pedestrians or use bicycles or where animal-powered transport is also in use.

394. The existing condition of the project roads is very variable, ranging from those that have been re-graveled and otherwise maintained to a good standard as recently as 2008 to roads that have not been maintained recently and are in a deteriorated condition with a very high road roughness values, and very little remaining wearing course gravel. Generally on the project roads that have been recently maintained or improved, have a gravel wearing course that is at present about 250mm thick.

395. The Project is classified as environmental category B and an initial environmental examination (IEE) was conducted as part of project preparation in accordance with ADB Environment Policy (2002) and Environmental Assessment Guidelines (2003)

13.2.2 DESCRIPTION OF THE ENVIRONMENT

13.2.2.1 PHYSICAL RESOURCES

396. Cambodia lies in the southwestern part of the East Asia peninsula and has a land area of 181,035 km2. International borders are shared with Thailand to the west, the Lao People's Democratic Republic to the north, and the Socialist Republic of Vietnam on the east and southeast. The country is bounded on the southwest by the Gulf of Thailand and has a coastline of 440 km.

397. Cambodia's climate is dominated by the monsoon which causes distinct wet and dry seasons. The southwest monsoon typically brings the rainy season from May to October. The northeast monsoon brings drier and cooler air from early November to March, then hotter air prevails in April and early May. The southern part of the country typically has a two-month dry season whereas the northern areas have a four-month dry season although weather patterns have been changing and what is typical is now increasingly problematic. It needs to be stated that while no reliable data on the impact of climate change on agriculture, forestry and fisheries based livelihoods are available for the Project zones anecdotal evidence is strongly suggestive that such changes are underway.

398. The annual mean rainfall is 1,400 mm in the central lowland regions and can reach 5,000 mm in coastal areas. However, there are really no reliable rainfall databases for the Project zones and rainfall can vary from a low of less than 1,000 mm to a high of 2,000 mm. The important issue is when this rain falls rather than simply assessing annual mean rainfall. The relative humidity is high throughout the year, usually exceeding 90%, and even in the dry season rarely falls below 50%.

399. Temperatures are fairly uniform throughout the country, with only small variations from the average annual temperature of around 28°C. January is the coldest month where temperatures as low as 12°C have been recorded and April is the warmest where temperatures as high as 42°C have been recorded. Most of Cambodia’s regions have an average wind velocity of less than 3 m/s. Maximum wind speeds can reach in excess of 20 m/s during the wet season. During the dry season the maximum wind velocities are lower and are commonly in the range of 6 - 8 m/s.

400. Topographically Cambodia is divided into three distinct regions: the central plains, the flat coastal areas, and the mountain ranges with high plateaus. The central plains form 75% of the country and consist of the alluvial plains of the Mekong River and the Tonle Sap basin. These are Cambodia's two dominant topographical features and this is where over 90% of the population resides.

401. The Project roads are located within or in close proximity to three of Cambodia’s agro-ecological zones, which are based on a study of available data, including soil maps, topographic maps and land use maps. In all three zones lowland rice cropping is the main activity but other crops grown include soybean, cassava, and cashew. Fruit and vegetables crop are also cultivated although primarily for domestic consumption. Large and small livestock are raised and some households during the early dry season once the rice harvest is completed travel to flood recessed areas of the Tonle Sap to cultivate flood recessed rice and fish. To corroborate this existing database the TA Consultant has driven along each of the 19 Project roads to ensure that databases match at least approximately what can be visually recognized on the ground.

402. Zone 1 is classified as the Upland Mixed Cropping Zone and encompasses Road No. 373C in Kampong Cham (the 19.6 km. road from National Road No. 7 in Memot to Kabbas), Road No. 2620 and 2KT2 in Kampong Thom (the 66 km. road from Prasat Sambour to Sandan, including as a result of road substitution the eastern side of the Stung Sen River), and Road No. 1KS4 in Kampong Speu (the 25 km. road from Kiri Reaksmei to Dak Por).

403. All other roads are located within or in close proximity to Zone 2, which is classified as the Lowland Rain-fed Rice Land Zone, which includes the transition zone of the Tonle Sap Biosphere Reserve but it also includes roads above Highways 5 and 6 that circumnavigate the Tonle Sap, there being three zones, (i) lower terrace (below the highways); (ii) middle terrace and market (along the highways); and, (iii) upper terrace (above the highways).

404. As there are no Project roads in sub-zone (ii) the IEE will focus on sub-zones (i) and (ii). In sub-zone (i) there are three Project roads, Roads 1BB3 and 1BB4 in Battambang (the 15 km. road from Chrey to Taloas Kakoah) and Roads 154D and 152E in Pursat (the 12 km. Project road from Boeng Khnar to Me Touk and the 9 km. Project road from Kantout to Kampong Po). The other remaining roads in Battambang, Siem Reap, Pursat and Kampong Chhnang are located in sub-zone (ii). However, even though Project roads 370 and 371 and in Kampong Cham are not contiguous with the Tonle Sap they are nevertheless within Zone 2 as they are also lowland rain-fed rice growing areas although agriculture is considerably more diverse along these roads.

13.2.2.2 ECOLOGICAL RESOURCES

405. Forests make up a major part of the country's natural resources. Hill evergreen, tropical rain and dry land evergreen forests are found in the humid coastal ranges, humid northeastern uplands, and the very humid to sub-humid low altitude areas. Freshwater inundated forests are found in the Tonle Sap Lake and in areas of the Mekong River. Mangrove forests are found along the coasts of Kaput and Kohl Kong provinces. In 1960 Cambodia's forests covered 73% of the total land area of the country. By 1998 the forest cover had decreased to 58% and at least until the mid-2000s it was estimated that Cambodia was losing forest cover at the rate of 2% per annum. The reduction has been attributed mainly to commercial logging, illegal logging (both large and small scale), large scale agricultural concessions, fuel wood collection, non-traditional shifting cultivation and the settlement of new villages. Secondary measures include forest fires and infrastructure development. Nevertheless, Cambodia still has substantial forest cover in comparison with other GMS countries with the exception of the Lao PDR.

406. Forests are divided into concession forests and protected forests. In the Project zone there are some protected forest areas and indigenous tree species (e.g. the Diptherocarpus species) are protected by Cambodia’s Forestry Law of 1995. Concession forests may be harvested for sale but there are no longer such concessions in the Project zone. Community forests are managed by local residents who must abide by a management plan that is supervised by the Forestry Department. The community has access to the forest and may remove forest products and cut trees for their own use but they are prohibited from selling the trees. Timber harvesting for sale is only allowed from forest concessions. There are also non-timber forest products (NTFPs) that poorer households rely on such as bamboo, resins, wild fruits and vegetables, honey bees and other insects, and larger wildlife, although the collection of some NTFPs for commercial purposes are circumscribed by Cambodian laws.

407. Each year, a combination of subsistence, middle-scale and large-scale commercial fishing harvests produce 300,000 to 430,000 tons of freshwater fish. This production ranks fourth in the world and is worth approximately US$300 million. However, there have been incremental declines in fish catches and it is now estimated that less than 250,000 tons of fish is being caught, consisting of approximately 105,000 tons of household fisheries, 75,000 tons of rice field fisheries and 68,000 tons of middle and large-scale fisheries (marine fisheries production account for an additional estimated 55,000 tons). Fish is the most important source of animal protein in the diet of all Cambodians, constituting upwards of 75% of total animal protein input. Fish are also an important source of calcium and Vitamin A, especially for the rural poor. On average the countrywide consumption rate is 65.5 kg/capita/year. Most of the Project roads are in relatively close proximity to major fish resources including of course rice field fisheries.

408. Cambodia has 27 different soil types but the main ones in the Project zone are either soils developed on the old alluvial terraces of the colluvial-alluvial plains. Four types – Prey Khmer, Prateah Lang, Bakan and Tuol Samroung – are where most of the agricultural production occurs although just one, the Toul Samroung, which occupies just 10% of the rice area is really suited to high yielding rice production. Soils developed on the active flood plains – Kabal Po and Krakor – are also highly suited for rice production and occupy approximately 30% of soils where rice production takes place in the Project zone. Such soils respond well to improved ditch and drainage irrigation and judicious application of fertilizers if there is also a timely available of suitable seed varieties, which unfortunately is not always so in Cambodia. However, yields have increased incrementally over the past two decades with wet season yields averaging 2.40 tons per hectare and dry season yields (only 15% of rice produced) averaging 3.96 tons per hectare. These are below regional averages but the labor intensive SRI system is currently recording average yields of 3.56 tons per hectare in the wet season. Last year Cambodia produced a surplus of 3 million tons although there are still food security problems for rice deficit households.

409. Cambodia's natural mineral resources include gem stones such as sapphires, ruby and zircon; coal, offshore gas and oil; basalt, granite, limestone, dolomite, quartzite; and phosphate deposits. There are no major mineral resources in the vicinity of the project roads, although in close proximity to Project roads in kampong Cham and Kampong Chhnang there are white clay and clay for cement non-metallic deposits.

410. Cambodia has a rich biodiversity. The forests, wetlands and other habitats support many species of flora and fauna, including 212 species of mammals, 536 species of birds, 240 reptile species, 850 freshwater and 436 marine fish species and more than 2,300 plants (800 of these plants are used in for the local manufacture of traditional Khmer medicine).

411. Cambodia is a signatory to the Ramsar Convention on International Wetlands (four Project roads – 1BB3 and 1BB4 in Battambang and 154D and 152E in Pursat - are located in very close proximity to wetlands also in close proximity to the UNESCO designated Tonle Sap Biosphere Reserve) and the Convention on International Trade of Endangered Species – CITES – and there are a range of endangered species such as the Siamese Crocodile and a variety of monkeys (e.g. silvered leaf monkey) and birds (e.g. white-shouldered Ibis) in the Project zone. However, with a greater focus by the Government of Cambodia in halting illegal logging and cancellation of some forest concessions hitherto endangered species such as the yellow-choked gibbon and black-shanked douc langur are increasing in numbers.

412. The National Environmental Action Plan 1998 specifies four types of protected areas. These are National Park, Wildlife Sanctuary, Protected Landscape and Multiple-use Management Area. National Parks in close proximity to Project roads include the Phnom Kulen National Park in Siem Reap and Kirirom National Park in Kampong Speu. There is one wildlife sanctuary, the Boeng Per Wildlife Sanctuary in Kampong Thom. There is also the famous Angkor Protected Landscape in Siem Reap but another famous archaeological site is Prasat Sambour in Kampong Thom that predates Angkor historically and is considered culturally very important by all Cambodians. It is not currently designated as a Protected Landscape but the Protected Area Law promulgated in January 2008 contains adequate provisions to ensure that Prasat Sambour would enjoy a similar level of protection to the Angkor Protected Landscape.

413. The Law on Forestry Management prohibits the hunting of wildlife. As well as maintaining checkpoints and providing rangers the Ministry of Environment (MOE) has an active community education program to create environmental awareness especially within the rural communities. At least one Project road in Kampong Thom – Road No. 2KT2 - is in close proximity to the Boeng Per Wildlife Sanctuary.

414. The Tonle Sap is the largest freshwater lake in the GMS Sub-Region with an area of 2,500-3,000 square kilometers in the dry season and 10,000 – 15,000 square kilometers in the wet season with water depths ranging from 1 meter in the dry season to 10 meters in the wet season and home to nearly one-third of Cambodia's population. In 1997 it was nominated as a Biosphere Reserve under the Man and the Biosphere Reserve Program of United Nations Education and Scientific Cooperation Organization (UNESCO). None of the Project roads are located in the core areas or the buffer zone but rather in the transition zone where agricultural cropping and livestock are the main livelihood activities. However, improved road access might negatively impact upon buffer zone biodiversity values (flooded forests, fish and wildlife) and increase in squatter communes along these roads.

13.2.2.3 SOCIAL AND ECONOMIC DEVELOPMENT

415. Most people in the Project zone are ethnic Khmer and largely Buddhist although there are a few Christian households largely as a result of some NGOs with programs in rural areas. Literacy and numeracy rates for males over 18 ranges from a high of 78.2% in Kampong Cham (68.2% for females) to a low of 69.5% in Kampong Thom (59% for females), according to the Social and Environmental Impact Study undertaken as part of activities associated with this TA.. Completion of primary schooling ranges from a high of 73.5% in Battambang (68.5% for females) to a low of 60% in Kampong Thom (58.2% for females). Males who have completed higher and further education range from a high of 1.6% in Kampong Cham (1.1% for females) to a low of 0.8% in Kampong Speu (0.9% for females) according to recent surveys. Somewhat higher literacy and numeracy rates are reported for the ethnic Cham, the only significant ethnic minority group living along several of the Project roads in Kampong Cham and Pursat. These ethnic Cham are Muslim but consider and are considered to be Cambodians and are very well integrated with the majority ethnic Khmer population.

416. Housing construction materials range from the use of NTFPs typically belonging to the poorest and most vulnerable households to houses constructed using permanent building materials such as wood, concrete, steel and iron that belong to better off households. Very few households have access to sanitary toilets and access to water within 150 meters of the house ranges from a high of 91.2% in Kampong Chhnang to a low of 71% in Battambang and there are serious seasonal

water shortages in four of the Project zones (Siem Reap, Kampong Speu, Pursat and Battambang). Most of the major diseases are waterborne such as diarrhea although other diseases include malaria, tuberculosis and upper respiratory infections. HIV/AIDS rates appear to be quite low but there is a reluctance to report on people living with AIDS. There are local health centers in each of the communes but service provision is problematic and many people prefer to use private clinics than such centers. Use of these centers by women giving birth is very low.

417. Most people derive their livelihoods from some type of agriculture, most notably the cultivation of wet season rice (although poorer households rely on common property resources in forestry and fishing to a greater extent than better off households) but over the past decade a significant number of younger people, especially females from the Project zone have secured employment in the garment-assembly industry although as Cambodia faces strong competition from other lower cost producers of garments there may no longer be the same number of off-farm waged employment opportunities available. For households able to derive a portion of their incomes from off-farm or non-farm based income generation opportunities (e.g. owning or managing small grocery shops, tailoring and dress-making, wood-working, vehicle repair, provision of beauty services, managing cultural and religious festivities and producing handicrafts) there are generally greater opportunities to increase incomes and reduce exposure to seasonal vulnerabilities such as food shortages. This has reduced their reliance on natural resources.

418. Food poverty rates vary from a low of 12.5% in Kampong Cham to a high of 53.4% in Kampong Speu but three provinces (Kampong Speu, Siem Reap and Kampong Thom) have poverty rates well in excess of the national poverty rate of 36.1% in 2008. Major causes range from land shortages in Kampong Cham, Siem Reap and Battambang to lack of non-farm income generation activities in Kampong Thom, poor transport links in Kampong Speu and Pursat and lack of access to credit in Kampong Chhnang but in actuality there are multiple causes, including especially high expenditures on healthcare, right throughout the Project zones. The most vulnerable households are those with less than 0.5 hectares of productive agricultural land ranging from 39.5% of all households surveyed living along the Project roads in Kampong Cham (although fertile land used for vegetable cultivation is a mitigating factor) to 14.8% in Kampong Thom (but here low rice yields during the wet season and lack of dry season cropping opportunities are major causative factors). These households are often female-headed households but not exclusively so because there are also physically impaired people with a high dependency ratio that are also very vulnerable.

13.2.2.4 SCREENING OF POTENTIAL ENVIRONMENTAL IMPACTS AND MITIGATION MEASURES

(a) Encroachment on Historical/Cultural Areas

419. The Project involves the permanent sealing of existing alignments and on none of the Project roads will any of the alignments be widened therefore there will be no encroachment on historical or cultural areas but in the case of the Project road no 2620 from Prasat Sambour to Sandan in Kampong Thom as the road to be paved passes directly through the actual archaeological complex it will be necessary to ensure that the permanently paved road does not encroach upon the actual complex. It will be necessary to consult with the Ministry of Culture and Fine Arts, which has overall responsibility for this site to ensure that pavement sealing does not encroach upon this actual complex. This is an activity that must not be left to the pavement contractor to determine.

(b) Encroachment on Precious Ecology

420. The Tonle Sap Biosphere Reserve was created partly to (a) prevent over-fishing; (b) minimize destructive fishing practices; (c) reduce the exploitation of flooded forests; and, (d) put a halt to the conversion of flooded forest land into agricultural cropping land. While none of the Project roads are directly in the core or buffer zone roads in Battambang and Pursat that are on the periphery of the buffer zone and the transition zone (where land has already been converted into agricultural cropping land) may result in some encroachment if left unchecked. Currently the MOE is working closely with provincial authorities to ensure this does not happen but it is also necessary to work closely with Commune Council officials because they consist of elected officials from the villages who understand the specific situation of individual villages more effectively than provincial officials.

421. In Kampong Thom the road no 2KT2 to be permanently paved traverses the eastern edge of the Boeng Per Wildlife Sanctuary. With an increase in traffic to the Prasat Sambour archaeological complex it is reasonable to assume that at least some of the tourist traffic will proceed further to Sandan because the road will be permanently paved. However, Wildlife Protection Officers from the Provincial Department of Environment in Kampong Thom currently patrol this area and reports suggest they have largely succeeded in preventing outsiders from hunting wildlife in either the Sanctuary and wildlife products from the Sanctuary being sold on local markets. The situation in relation to Kirirom National Park is less clear but there will be more visitors with the road being improved and this is a strategy endorsed by the Provincial Government of Kampong Speu and the Ministry of Tourism but in terms of wildlife the Kirirom National Park does not contain the same diverse species of wildlife as the Boeng Per Wildlife Sanctuary.

(c) Cultural Resources

422. The cultural heritage site that can be accessed by the Project road no 266D from Leang Dai to Svay Sa in Siem Reap will be permanently sealed at an intersecting point some 3 kilometers from the Bayon Gate at Angkor Wat. However, access to Angkor Wat by motorized vehicles is restricted to passenger service vehicles and light utility trucks. Trucks carrying heavy or hazardous loads (e.g. crushed stone from nearby quarries) are not permitted under any circumstances to drive through Angkor Wat. This is rigorously enforced by both Angkor management authorities and the police and will continue to be enforced.

423. In relation to the road no 2620 from Prasat Sambour to Sandan in Kampong Thom it is necessary for heavy trucks to traverse the road that goes through the archaeological complex at Prasat Sambour as there is no alternative route to Sandan by road. MRD in conjunction with the Ministry of Culture and Fine Arts will need to decide upon a realistic approach to ensure that heavy trucks do not damage this archaeological complex (e.g. requirement that is rigorously enforced that trucks carrying hazardous loads need to have these loads firmly secured including covered if carrying materials generating dust).

(d) Noise and Dust

424. Noise and dust from unpaved roads is a major nuisance for roadside residents, especially those in built-up areas. The Project will have positive impacts on the quality of life of roadside residents as it will result in a significant reduction in dust and to a smaller extent noise.

425. During construction, mitigation measures for noise and dust will be necessary. In order to reduce impacts by noise; (i) construction activities will be

avoided at night close to residential areas and during events such as Friday Prayers attended by Muslim Cham or when ethnic Khmer are attending temple festivals or holding weddings in close proximity to the roadside; and (ii) vehicles and paving equipment will be equipped with effective mufflers. In order to minimize dust; (i) construction sites will be watered several times a day depending on the condition; (ii) road paving will be commenced first in built-up areas so as to minimize the numbers of the inhabitants that would be affected by dust; and, (iii) trucks carrying crushed stone and other construction materials will be required to cover loads to ensure the dust nuisance is minimized.. It is unlikely that there will be any blasting but if there is it will be controlled to minimize disturbances. Where possible existing commercial quarries will be used although it needs to be noted there are no existing crushed stone quarries in Pursat and therefore it is more than likely that an existing quarry in Battambang will need to supply crushed stone for the roads to be permanently paved in Pursat.

(e) Construction Materials

426. Gravel and crushed stone will be hauled by trucks from more distant gravel and rock deposits but full use should be made of existing stone quarries in close proximity to specific Project roads.

427. Fuel and oil, and bitumen storage areas will be located well away from any watercourses. Storage areas will be bunded and provided with interceptor traps so that accidental spills do not contaminate the environment. All waste oil will be stored and disposed of to acceptable oil industry standards. Washing down water will be directed to this system and held in separation areas for treatment. Wherever possible, refueling will be carried out at a fuel storage area and not permitted within or adjacent to watercourses.

(f) Cleanup of the Construction Site

428. When construction is completed, the contractors will clean up the construction sites by removing all equipment and buildings (unless requested by local Commune Council officials, which has been suggested during some of the consultations undertaken as part of the IEE) and carrying out site remediation work (such work needs to ensure that sites are at least restored to pre-construction levels)..

(g) Health and Safety

429. The main risks during the construction stage may arise from; (i) inadequate sanitation facilities in work camps; (ii) lack of preparation for accidents and injuries; (iii) introduction of sexually transmitted or other diseases by non-local workers, and; (iv) outbreaks of malaria, dengue fever, diarrhea, dysentery and A (H1N1) in the labor force. In order to minimize these risks; (i) HIV/AIDS awareness and prevention program to be financed from the Project; (ii) the contractor will be required to prepare a worker health and safety plan which will include provision of sanitation facilities, equipment and medical care; (iii) workers will receive health and safety training; and (iv) workers will undergo pre-employment health screening but the screening program cannot be used in accordance with ILO guidelines to discriminate against workers living with HIV/AIDS. .

13.2.3 INSTITUTIONAL REQUIREMENTS AND ENVIRONMENTAL MONITORING PROGRAM

430. The project complies with procedures set out by MOE on environmental review processes. Based on the IEE the MRD Consultants and MRD will develop a

detailed environmental management plan (EMP) during detailed design as required by the ADB and MOE. The detailed EMP will be implemented by the contractors under supervision of the construction supervision consultants (CSC) and MRD.

431. During the detailed design stage, close consultations will be undertaken with relevant line ministries such as MOE, Ministry of Water Resources and Meteorology, Ministry of Agriculture Forestry and Fisheries, and the Ministry of Culture and Fine Arts. However, because this Project is focused on roads in rural areas it will also be necessary to consult with both district authorities and local commune councils.

432. The CSC will submit results to the MRD, and will be incorporated in the quarterly project progress reports submitted to ADB.

13.2.4 FINDINGS AND RECOMMENDATIONS

433. The environmental screening process for the project indicates that overall environmental impacts are acceptable because mitigation measures have been identified that are necessary yet sufficient to satisfy all environmental requirements in accordance with ADB requirements and Cambodian regulations. However, the IEE does not address issues associated with climate change that may be impacted upon by increased agricultural activity in the Project zone as a result of improved transport connectivity. This is an environmental issue that cannot be ignored but at present there is totally inadequate baseline data that would assist in the monitoring and evaluation of climate change.

13.2.5 CONCLUSION

434. The potential environmental impacts, which appear to be greatest on the two roads in Kampong Thom – 2620 and 2KT2 - have been identified and mitigation measures provided. Implementation of the proposed mitigation measures and the monitoring program will reduce impacts to acceptable levels. Consequently, the IEE is regarded as sufficient and an EIA is not necessary.

14 DISCUSSION AND CONCLUSIONS

435. The project is viable with respect to the engineering required. The roads have a strong foundation and many also have gravel wearing courses. The existing pavement layers can be reused (recycled) with stabilization as necessary, making significant savings in the use of new pavement materials. Where necessary new pavement materials should be added to meet the pavement design requirements they can be either locally sourced gravels that are then stabilized or graded crushed aggregates from nearby sources. Stabilization of existing materials or of locally sourced additional materials is preferred because stabilized materials impart a better structure for the needs of this project. They are hardened, and resist erosion and resist weakening under severely wet conditions. They can also be repaired using local materials and a stabilizer (cement, or lime) which can be sourced readily. It is essential that the pavement design table given in Chapter 5 is adhered to and that construction standards are met. Paved roads are totally intolerant of the deficiencies in quality that plague the existing practice of using locally sourced gravel wearing course materials which are so often below standard. The surfacing is relatively expensive (compared with a gravel wearing course) but will perform very well if the underlying pavement meets the quality required.

436. The traffic on the selected roads although a mix of light and non-motorized traffic and heavier 4-wheeled vehicles, and not solely 4-wheeled with many heavy vehicles, in many cases, has reached a level where gravel wearing courses are unsuitable. They are not durable under the prevailing traffic and they are not durable under the climatic conditions of Cambodia, requiring periodic maintenance (replacing the gravel) at a frequency that is unsustainable. Dust is also a hazard that must be addressed. This is proven by the benefits, EIRR's, that ensue from the road improvement measures proposed.

437. The environmental impacts are limited to those that will occur during the construction period. Long lasting negative impacts are so extremely unlikely, as to be non-existent. The negative impacts that will occur during the construction period are those that are usual as construction is implemented and will be managed by an environmental management plan.

438. Social impacts from the improvement of the roads are on the whole seen as beneficial. The main concerns are those of increased traffic and especially increased traffic speeds. These risks are being managed by implementing good safe engineering standards during detailed design, including use of signage traffic calming and road marking, not seen before on rural roads. They are also being managed by road safety awareness training of roadside communities and road users, and importantly through enforcement by the authorities.

439. Implementation can be achieved over a project period of 4 years. The plan ensures that at least two dry seasons are available to the contractors to undertake those works which are susceptible to wet weather. Large contract packages have been chosen over a multitude of smaller packages. This is deliberate to attract international (or large scale national) contractors to ensure their equipment includes stabilization machines. These are preferred to obtain the quality and speed of construction required. Fewer, larger packages are also seen to be more readily implementable. The capture of too many large (or small) packages by one contractor is to be resisted, because, invariably, it leads to delays in implementation as contractual time based agreements are not met, and economic losses ensue.

440. At the same time it is essential to involve smaller contractors, (the local small contracting strength of Cambodia is weak) and this is being achieved in a formal way through the essential requirement to sub-contract works that are appropriate. Cascading contracts through to local Community Councils and their Road Maintenance Committees. This provides work and experience that is so essential, and the smaller firms and entities will have to meet the demands, including quality of works of the main contractors, who will themselves be measured by international standards. Registration of firms and entities is essential to qualify those who are already competent to carry out the works and also to identify those who would benefit from training and experience.

441. Capacity building programs with very strong training components are required to ensure the success of the project and engender a sustainable program of up-grading roads to a sealed standard when it is economically beneficial to do so. Training of both the MRD and its Departments is essential because this is the first time that they will engage in the construction of paved roads. The training is linked to the training of contractors, again to impart a quality of knowledge that is essential as MRD moves to a sustainable road network. The training given is being formalized through support to BEC to ensure sustainability of knowledge and experience. Access to equipment for practical training is being provided through the civil works contracts. BEC will accredit individuals.

442. Asset management support is required. At present MRD and its Departments are not sufficiently and comprehensively aware of the priority links within the network. That is not to say that they do not know locally the important links within their remit, but knowledge is held in the provinces and it is not clear how this is being used to identify, and then attract funding for developing the network and attracting development partners to assist in solving the deficiencies that exist. An inventory system will be prepared under this project that will also identify links that are at risk from flooding as part of disaster preparedness. Knowledge of traffic on the network links is also essential being the main cause of road deterioration, and in explaining the benefits that can be achieved from investments. The collection and reporting of traffic statistics to a national standard and the condition of network links will be supported by the project. The links within the network will also be identified by a unique numbering system consistent with that being used by MPWT.

443. Overloading of vehicles and its damage to the road network and the economic consequences of failure to achieve the benefits from investments because of this, have been endured for too long. Measures such as physical barriers to prevent access have not worked, they are simply removed. Road tolls stations have been tried but have also been seen to be ineffective and in any case they cannot demand tolls that are commensurate with the cost of damage caused by economic loss. Some further education and encouragement at the source of offenders, such as some quarry operators is important, as bringing the weight of high Government Officials to bear to cause change, but, in-line with the law, it is now time for enforcement. Measures recommended in this project are to prohibit contracts with suppliers who break the law on overloading vehicles and to enforce the law through the authorities. Portable weigh-bridges and vehicles, motor cycles, are being provided to apprehend offenders. The latter is being carried out in concert with the road safety program.

444. Social safeguard measures are essential and are included to protect people and the environment in the project area. These include awareness programs on HIV/AIDs and Human Trafficking Prevention, environmental management plans, and road safety.

445. Inclusion of the preparation for the preparation of a future project faces the fact that Cambodia will benefit not only from the loan investments themselves, but also from the identification, in association with its development partners, and preparation of information on which roads should be improved and how these maybe assembled into project(s) should be formalized to attract investment. There are many opportunities for further interventions both within the provinces of this project but also in other provinces. This approach is in-line with Cambodia continuing to drive its development with the support of its development partners.

446. A good quality and timely reseal is vital for the long term performance of the project roads. The preparation for a future project should identify and quantify the technical and funding requirements for the resealing of the project roads within its scope of works for road improvements.

447. Previous interventions, and hard, dedicated work within MRD, have done much to bring the MRD to the present stage. It is necessary to further formalize the work required within the network and the contributions to be made by all the stakeholders for the benefit of Cambodia, and the skills they require to achieve it. The provision of paved rural roads is an essential part of Cambodia's strategy for poverty reduction through better access to economic opportunities and services. The program should be expanded to other roads and provinces in Cambodia.