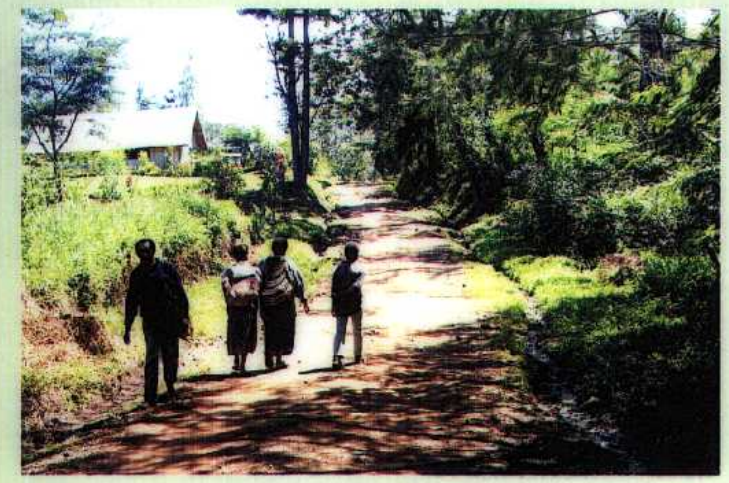
16-A13



ASIAN DEVELOPMENT BANK

and

GOVERNMENT OF PAPUA NEW GUINEA

Department of Transport, Works and Civil Aviation

TA No. 3037 - PNG

ROAD UPGRADING & MAINTENANCE PROJECT

ROAD FEASIBILITY STUDIES

Volume 2

FINAL REPORT

June 1999

egis consulting Australia

16. A13

TABLE OF CONTENTS

APPENDICES

LIST OF TABLES

LIST OF FIGURES

ACRONYMS AND ABBREVIATIONS

AADT	Annual Average Daily Traffic
ADB	Asian Development Bank
ADT	Average Daily Traffic
AusAID	Australian Agency for International Development
B/C	Benefit Cost Ratio
BBL	Barrels
BPNG	Bank of Papua New Guinea
BRUP	Bridge Replacement and Upgrading Programme
CBR	Californian Bearing Ratio
CFCs	Cash Flow Certificates
Ch	Chainage from Start of Project
CIC	Coffee Industry Corporation
CIDP	Construction Industry Development Program
CIF	Carriage, Insurance and Freight
CIU	Construction Industry Unit
CoCaS	Cares of Competency and Satisfaction
COP	Code of Practice
Coronus	Crushed Coral
CRCS	Constructors Registration and Classification System
DCI	Department of Commerce and Industry
DEC	Department of Environment and Conservation
DL	Department of Lands
DOF	Department of Finance
DOT	Department of Transport
DOTW	Department of Transport and Works (former)
DOTWCA	Department of Transport, Works and Civil Aviation (former)
DOW	Department of Works
DPM	Department of Personnel Management
DVM	Division of Vehicle Management
EHP	Eastern Highlands Province
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate of Return
EMP	Environmental Management Plan
EPU	Economic Planning Unit
ESA	Equivalent Standard Axles
EU	European Union
FAD	First Assistant Director
FAS	First Assistant Secretary
FAT	Field Assistance Team
FINRA	Finnish Road Association
FOB	Free on Board
GDP	Gross Domestic Product
GNP	Gross National Product
GOPNG	Government of Papua New Guinea
GVW	Gross Vehicle Weight
Ha	Hectare
HDM III	Highway Design and Maintenance Standards Model III
HHA	Highland Highway Authority

HHPO	Highland Highway Project Office
HHRA/B	Highlands Highway Rehabilitation Authority/Board
HRD	Human Resource Development
ICB	International Competitive Bidding
IEE	Initial Environmental Examination
IMF	International Monetary Fund
IRI	International Roughness Index
IRR	Internal Rate of Return
ISA	Initial Social Assessment
JICA	Japan International Co-operation Agency
K	PNG Kina
Km	Kilometre or Kilometres
Km	Kilometres
kph	Kilometres Per Hour
Kph	Kilometres per Hour
L	Litres
LCB	Local Competitive Bidding
LGE	Local Government Engineering
LGES	Local Government Engineering Services
LLG	Local Level Government (Urban and District)
LTB	Land Transport Board
m	Metres
MEB	Mechanical Engineering Branch
MP	Member of Parliament
MTDS	Medium Term Development Strategy
MVIT	Motor Vehicle Insurance Trust
NCD	National Capital District
NCIU	
NEC	National Executive Committee
NGO	Non-Government Organisation
NOL	New Organic Law
NPV	Net Present Value
NRB (A)	National Roads Board (Authority)
NRC	National Rebuild Centre
NRF	National Roads Fund
NRRP	National Road Resealing Project
NRSC	
OCA	Office of Civil Aviation
OECF	Overseas Economic Co-operation Fund
OoT	Office of Transport
OoW	Office of Works
OPUS	The short name for Works Consultancy (N.Z.)
PA	Provincial Administrator
PCE	Provincial Civil Engineer
PCR	Project Completion Report
PG	Provincial Government
PIP	Planned Investment Programme
PIU	Project Implementation Unit
PMO	Project Management Office
PMV	Public Motor Vehicle

PNG	Papua New Guinea
PNGCA	Papua New Guinea Construction Association
POoW	Provincial Office of Works
PPAR	Project Performance Audit Report
PPTA	Project Preparation Technical Assistance
PRIP	Provincial Road Investment program
PTB	Plant and Transport Branch
PTBTA	Plant and Transport Board Trust Account
PWD	Provincial Works Division of Provincial Government
PWM	Provincial Works Manager
RAMS	Road Asset Management System
RIRMS	Road Inventory and Road Maintenance System
RMT	Road Management Team
RPNGC	Royal Papua New Guinea Constabulary
RUMP	Road Upgrading and Maintenance Project
SAL	Standard Axle Load
SAL(Finance)	Sub Appropriation Ledger
SAT	Services and Administration Team
SDCT	Small Domestic Contractors Training Project
Sealed Road	Road with bitumen surface (surface dressing), roadbase and sub-base
SHP	Southern Highland Province
SIA	Social Impact Assessment
SOW	Scope of Works
STF	Special Task Force
TA	Technical Assistance
The Consultant	Egis Consulting Australia
TRRL	Transport and Road Research Laboratory
UNDP	United Nations Development Programme
VAT	Value Added Tax
VIP	Very Important Person
VOC	Vehicle Operating Cost
VWIM	Vehicle Weigh In Motion monitoring station
WB	World Bank
WHP	Western Highlands Province
WID	Women in Development
WPGTA	Provincial Government Works
WRCTA	Works Recurrent Costs Trust Account
WSOSTA	Works Supply and Outside Services Trust Account

CHAPTER 1. INTRODUCTION

1.1 BACKGROUND TO THE TECHNICAL ASSISTANCE

On 21 December 1998, the Asian Development Bank ("the Bank") appointed Egis Consulting Australia Pty Limited ("the Consultant") to prepare TA No. 3037-PNG: Road Upgrading and Maintenance Project in Papua New Guinea. The National Government's Department of Transport, Works and Civil Aviation (DOTWCA) is the Executing Agency in PNG. DOTWCA's Office of Works (OoW) is the Implementing Agency, which has provided the project office and support services in Port Moresby for the Consultant's Project Team.

The broad objective of this PPTA is to enhance the capacity of future investment in the PNG road sector to build a sustainable and efficient road system. In particular, an integrated investment program for rehabilitating, upgrading and maintaining both National and Provincial roads is proposed for the four provinces of Morobe, and Eastern, Western and Southern Highlands (Figure 1.1). In addition, the Consultant has examined institutional and policy issues in the road sector, with a particular focus on developing sustainable maintenance operations.

An overriding consideration in the Consultant's approach to the assignment has been the key time deadlines established by the Bank for completion of the work. The work program consisted of four phases as follows:

- **Inception Phase (January 1999)**

  The Project Team commenced work in PNG in early January 1999, and the Inception Report was reviewed at the tripartite meeting in Port Moresby on 3-4 February 1999. A key feature of the Consultant's approach to the work (particularly in view of the limited time period for the PPTA) has been to make maximum use of prior relevant studies and related information (such as road and bridge inventory data, traffic counts, etc).

- **Field Surveys (February to mid March 1999)**

  The Project Team completed an extensive program of field surveys in the four Study provinces on target road sections and bridges, and worked closely with both National and Provincial Government Works agencies in each province.

- **Preparation of Draft Report (mid March to mid April 1999)**

  In Volumes 1 – 4, the draft findings and conclusions of the Project Team were presented for detailed review and discussion with the Bank, PNG Government agencies, and concerned donors.

- **Preparation of Final Report (mid April to June 1999)**

  The final work module focussed on finetuning the proposed investment program, preparing Volume 5 – Sub Project Profiles on 26 road sections proposed for upgrading and sealing, and responding to specific issues and requirements raised by the Bank, the PNG Government agencies, and concerned donors.

1.2 OBJECTIVES OF THE FEASIBILITY STUDIES

The objectives of the Feasibility Studies are:

1. To analyse a range of improvement works for the highest priority roads in Morobe, Eastern, Western and Southern Highlands Provinces for technical, financial, economic and implementation aspects.

2. To prepare an integrated investment program for road upgrading, rehabilitation and maintenance of high priority roads in the four Provinces.

1.3 THE CONTEXT OF THE FEASIBILITY STUDIES

Funding for the maintenance of both National and Provincial roads has declined dramatically over the past decade to where the actual funding provided in 1995 – 1998 is estimated at 15 to 20% of the amount necessary to keep the network in routinely maintainable condition.

Despite the lack of funding for maintenance, the road network has increased with the addition of new roads and the upgrading of and sealing of roads, increasing the funding required for maintenance.

With the lack of funding, combined with the difficult environmental conditions for road maintenance in PNG, the road network has deteriorated substantially. In 1995 it was estimated that providing the required amount for routine maintenance would save over K100 million in VOC alone.

The reduction of maintenance work over a long duration has also led to a reduction in skills available within the OoW to administer maintenance works. In addition, maintenance under day labour historically used by OoW is being replaced with maintenance under contract and plant hire. OoW officers have not been trained to manage maintenance by this approach, reducing its effectiveness.

The irregular provision of funds for maintenance has reduced planning for maintenance to an ad hoc approach based on applying scarce available funds to individual road sections with the highest priority, based on network requirements or political pressures. Therefore the current maintenance strategy is to keep the roads open by spreading the funding as broadly as possible under a regime of crisis management. As a result, the overall condition of the road network is deteriorating and a large proportion of scarce funds must be consumed in emergency repairs.

1.4 THE STUDY APPROACH

The Feasibility Studies began with collection of all relevant data and reports in relation to the National and Provincial road networks in the four Provinces. The key sources of data included:

- Maresman maintenance data on National roads providing data on the road characteristics of all National roads.

- Fourth Road Improvement (Sector) Project, Provincial Roads and Bridges Investment Programme, Provincial Reports for Morobe, and Eastern, Western and Southern Highlands, Kampsax International A/S providing the results of feasibility studies of upgrading Provincial roads.

- Bridge Replacement and Upgrading Program underway and funded by AusAid providing maintenance costs for bridges investigated under the Program.

- Gravel Pit Inventory providing data on gravel sources.

- OoW and Provincial Government offices.

The roads selected for investigation comprised all of the National roads and important Provincial roads in each of the four Provinces. Each road was inspected by the Consultant to assess the existing condition of the road and to collect data not available from other sources.

The HDM III model was selected to analyse the economic viability of various improvement options for each section of road. The improvement options considered the extent of works and the costs for rehabilitation, upgrading and maintenance appropriate to each section of road.

Traffic forecasts over the 20 year analysis period were determined by projecting available traffic counts and traffic counts conducted during the study for Provincial roads by traffic growth rates calculated for each road.

Vehicle operating costs were determined to allow the benefits from improved roads to be included in the economic analysis. The economic analysis determined the optimum rehabilitation and maintenance strategy for each road section and viable road upgrading projects.

A range of five year investment programs for road rehabilitation, upgrading and maintenance was compiled based on achieving different standards of road improvement in the road network in each Province.

1.5 STRUCTURE OF THE REPORT

Volume 1 covers the five aspects of institutional arrangements and reforms, sector policies, organisational capability, financial management and private sector participation. The pattern of treatment of these aspects is to:

- establish the current situation and trends;
- identify main issues;
- explore options and recent experience; and
- propose recommendations for improvement.

The findings and recommendations are taken forward in the final chapter as the context for implementing the proposed ADB-funded program of road upgrading and maintenance.

This **Volume 2** covers a feasibility study to determine a program of viable rehabilitation, upgrading and maintenance road projects from the National roads and important Provincial roads in the four Provinces. The key elements comprise collecting data on the existing roads, analysing appropriate improvement proposals for each section of road, selecting an investment program of road improvement projects and determining its implementation arrangements.

Volume 3 presents the findings of an Initial Environmental Examination (IEE) of the project. It is concluded that the overall project should have minor environmental impacts. Road rehabilitation and maintenance works do not require a further IEE. Road upgrading subprojects are judged to have some adverse environmental impacts requiring an IEE.

Volume 4 presents a social analysis and an Initial Social Assessment (ISA) of the project. The project would have net positive benefits to rural people, including women and children, however land acquisition and compensation processes will need to be managed carefully to avoid costly time delays in project implementation.

Volume 5 presents Sub Project Profiles for 26 sections of road warranting upgrading and sealing. Each profile contains an economic assessment and an IEE with recommendations for the preparation of an EMP and monitoring requirements.

The Tasks as derived from the Terms of Reference, and organised for the Inception Report of 5 February 1999, are set out here as a guide to the overall coverage of the PPTA.

TASKS AND SUBTASKS: PART A – ROAD SECTOR REVIEW

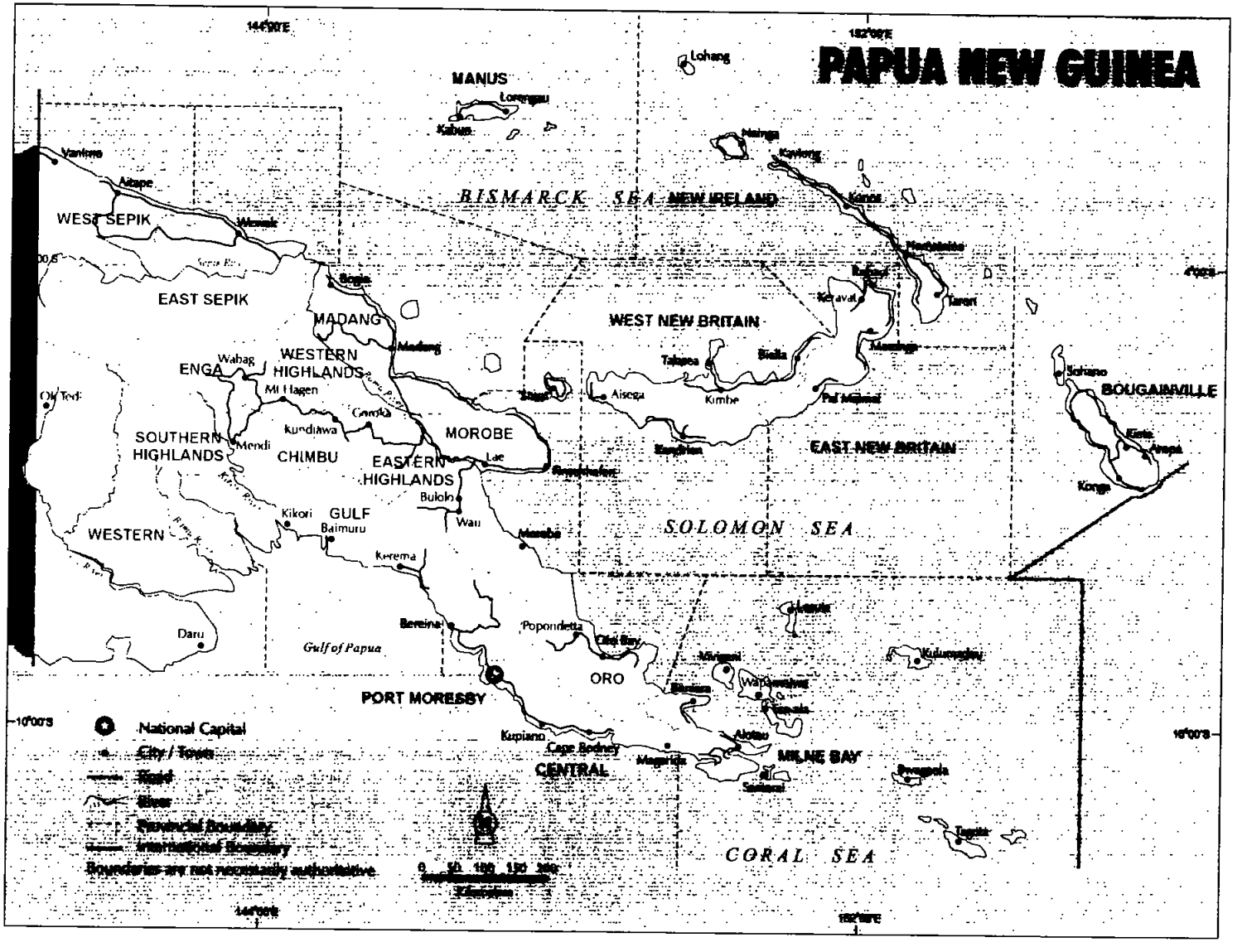
Task 1	**Institutional Review**
	• Review Sector Agencies
	• Examine Plant Pool and Equipment and Investigate Improvement Options
	• Develop Implementation of Reforms
Task 2	**Road Sector Policy Review**
	• Review Road Policies of DOTWCA and OoW Province Units
	• Determine Organisation to Consolidate Government and Provinces Initiatives
	• Review Road Sector Policy Framework
	• Identify Alternative Road Policies to Improve Performance
Task 3	**Organisational Capability Review**
	• Identify Capacity Building Needs
	• Review Major Projects and Propose Improvements to Enable Effective Road Sector Funding
Task 4	**Financial Management Review**
	• Review co-ordination in accounting and budgeting systems
	• Propose program of improvements
Task 5	**Private Sector Participation Issues**
	• Review contract management practices
	• Determine training program for contract management
	• Determine private sector capacity and interest
	• Determine improvements for contracting
Task 6	**Program Implementation Issues**
	• Identify feasible implementation arrangements
	• Develop performance indicators

TASKS AND SUBTASKS: PART B – FEASIBILITY STUDY

Task 7	**Data Assembly and Analysis**
	• Collect and review available data
	• Initial Scoping Survey
Task 8	**Formulation of Investment Program Options**
	• Upgrading and maintenance options
	• Selection of target road sections
Task 9	**Assess the Past and Future Economic Developments**
	• Examine past economic development in area
	• Examine future economic development in area
	• Carry out forecast of economic activity
Task 10	**Traffic Analysis**
	• Collect existing data on traffic movements
	• Collect additional traffic data
Task 11	**Prepare Traffic Forecasts**
Task 12	**Assess Improvement Requirements**
	• Determine alternative road improvement levels
	• Prepare preliminary design
Task 13	**Prepare Cost Estimates**
Task 14	**Update Vehicle Operating Costs**
	• Review existing VOC data
	• Update VOC data
Task 15	**Estimate Economic Benefits**
	• Prepare data for HDM III analysis
	• Examine types of economic benefit
Task 16	**Determine Economic Internal Rates of Return**
Task 17	**Carry out Sensitivity Tests**
Task 18	**Identify Preferred Investment Program**
Task 19	**Prepare Initial Environmental Examination**
Task 20	**Prepare Initial Social Assessment**
Task 21	**Prepare Project Implementation Schedule**
	• Examine ongoing work
	• Review Cofinancing Arrangements
	• Prepare Terms of Reference
	• Recommend Benefit Monitoring & Evaluation System

LOCALITY MAP

ADB TA No. 3037: PNG ROAD UPGRADING AND MAINTENANCE PROJECT



N

Date : 29 April 1999

File Name : XP/Z060/XPZ06004.CDR

egis consulting Australia

Figure 1.1

CHAPTER 2. DESCRIPTION OF PROJECT

2.1 INTRODUCTION

Individual roads in the Highlands region in PNG have generally evolved from a walking track used by local villagers or Kiaps (patrol officers). The tracks over time were improved by dozer construction to allow passage of vehicle principally in dry weather, with limited engineering for the selection of pavement material or thickness or design of the alignment. Over time the important roads were further improved to a good gravel standard with pavement materials from nearby quarries. With increasing traffic, major roads linking Provinces are upgraded to a high standard with an improved alignment and a sealed pavement. Few roads have been designed to locate the best engineered road alignment, because of the difficulty in obtaining land for new roads or realignment of existing roads.

Over the past two decades many National roads have been upgraded and sealed after a detailed feasibility study of individual roads or sections showed that upgrading was economically viable under the parameters defined in the study. Post audit studies[1] have reported that few of the road upgrading projects implemented have returned the economic benefits determined in their feasibility study. Several of the Study roads had been selected for upgrading following favourable economic returns in their feasibility studies, but were not upgraded due to lack of funding by GOPNG, such as the Ogelbeng – Dona road in WHP.

In the late 1980's Provincial roads in many Provinces were investigated[2] and analysed by a standard incremental cost benefit analysis to determine which roads were viable for upgrading and sealing, and regravelling. Few of the road shown to be viable for upgrading were improved, and these roads have been specifically included in the Study roads.

The approach for the Study allows examination and analysis of all important roads in a Province to determine on a network basis which roads should have priority in rehabilitation, upgrading or maintenance. With this information, various programs of improvement works can be developed depending on the funds available for the works. The analysis considers different maintenance regimes for each road to determine its optimum maintenance works.

2.2 ROAD SELECTION

The study has investigated the improvement of all National roads and important Provincial roads in each Province. Minor National roads such as town roads and short Institutional roads have not been included in the Study as they are not readily identifiable and do not constitute interurban roads. The Provincial roads included in the Study were discussed and agreed with officers of the Provincial Government in each Province. A summary of the roads selected is listed in Table 2.1, while a detailed listing is provided in Table 2.2. The location of the study roads in shown on the location plans in Figures 2.1, 2.2, 2.3 and 2.4.

[1] Asian Development Bank. Fourth Road Improvement (Sector Project) in Papua New Guinea. PPAR, December 1998.
[2] Kampsax International A/S. Fourth Road Improvement (Sector Project). Provincial Roads and Bridges Investment Programme. Provincial Reports for Morobe, Eastern Highlands, Western Highlands, Southern Highlands. Department of Transport, 1990

TABLE 2.1: SUMMARY OF STUDY ROADS

PROVINCE	GRAVEL ROADS (Km)	SEALED ROADS (Km)	TOTAL (Km)	RATIO OF ROADS SEALED
Morobe	436.2	278.4	714.6	39.0%
Eastern Highlands	277.4	200.7	478.1	42.0%
Western Highlands	312.9	204.6	517.5	39.5%
Southern Highlands	745.3	32.6	777.9	4.2%
Total	1,771.8	714.3	2,486.1	28.7%

The road lengths for each road section were determined from a number of sources including the Consultant's site inspections, the Maresman reports, studies, design reports and mapping provided in the Gravel Inventory. The lengths for each section in each source vary, in some cases considerably. Accurate lengths for all National Roads and some Provincial roads will be determined by the RAMS project using satellite global positioning systems equipment.

2.3 EXISTING ROAD CHARACTERISTCS

2.3.1 Introduction

All Study roads were inspected unless access was not possible due to either lack of safe timber bridge decks or the very poor condition of a road. Generally the Consultant inspected the roads by vehicle with frequent stopping to assess particular features or to measure parameters such as pavement or shoulder width. The road characteristics were collected on project data sheets designed to collect all data required for the HDM modelling.

Key features in each Study road were photographed to assist the review of the roads. A description of each section of the roads was prepared to define the road condition, parameters, recent maintenance history and key issues identified during the field inspections. The descriptions are provided in Appendix C (Road Survey).

Roads were classified as follows for the existing condition of the road:

Good: Sealed roads substantially free of defects and requiring only routine maintenance. Gravel roads needing only routine grading and spot repairs.

Fair: Sealed roads having significant defects and requiring resurfacing or strengthening. Gravel roads needing reshaping or resurfacing (regraveling) and spot repair of drainage.

Poor: Sealed roads with extreme defects and requiring immediate rehabilitation or reconstruction. Gravel roads needing reconstruction and major drainage works.

TABLE 2.2: DETAILS OF STUDY ROADS

Road Number	Road Name	Location	Section	Start Chainage	End Chainage	Gravel Length Km	Sealed Length Km	Length Km	Pavement Type	Condition
MOROBE PROVINCE										
NR07	Highlands Highway	Lae Wharf - Yalu Bridge	MN01	0.0	20.8		20.8	20.8	Sealed	Fair
NR07	Highlands Highway	Yalu Bridge - Erap Bridge	MN02	20.8	45.9		25.1	25.1	Sealed	Fair
NR07	Highlands Highway	Erap Bridge - Clearwater Bridge	MN03	45.9	76.3		30.4	30.4	Sealed	Fair
NR07	Highlands Highway	Clearwater Bridge - Maniang	MN04	76.3	120.4		44.1	44.1	Sealed	Fair
NR07	Highlands Highway	Maniang - Waterise Junction	MN05	120.4	156.7		36.3	36.3	Sealed	Fair
NR07	Highlands Highway	Waterise Junction - Yung Creek	MN06	156.7	164.4		7.7	7.7	Sealed	Fair
NR08	Ramu Highway	Waterise Junction - Gusap	MN07	0.0	32.0		32.0	32.0	Sealed	Good
NR04	Wau Road	Highlands Highway - Umsis	MN08	0.0	20.0		20.0	20.0	Sealed	Fair
NR04	Wau Road	Umsis - Zenag River	MN09	20.0	70.4		50.4	50.4	Sealed	Good
NR04	Wau Road	Zenag River - Baiune	MN10	70.4	90.4	15.5	4.5	20.0	Gravel/Sealed	Upgrading
NR04	Wau Road	Baiune - Wau	MN11	90.4	129.3	36.8	2.1	38.9	Gravel/Sealed	Poor
NM4201	Aseki Road	Bulolo - Pararua	MN12	0.0	32.8	32.8		32.8	Gravel	Fair
NM4201	Aseki Road	Pararua - Aseki	MN13	32.8	84.0	51.2		51.2	Gravel	Poor
ND4201	Bukawa Road	Malahang - Busu	MN14	0.0	8.0	3.0	5.0	8.0	Gravel/Sealed	Fair
ND4201	Bukawa Road	Busu - Buso	MN15	8.0	36.7	28.7		28.7	Gravel	Poor
	Provincial Road	Aseki - Menyamya	MP16			32.5		32.5	Gravel	Poor
	Provincial Road	Finschhafen - Heldsbach	MP17			21.0		21.0	Gravel	Good
	Provincial Road	Heldsbach - Pondui	MP18			58.6		58.6	Gravel	Poor
	Provincial Road	Buso - Buhem	MP19			28.5		28.5	Gravel	Poor
	Provincial Road	Erap - Boana	MP20			31.0		31.0	Gravel	Poor
	Provincial Road	Wasu - Kabum	MP21			34.6		34.6	Gravel	Fair
	Provincial Road	Leron - Wantoat	MP22			62.0		62.0	Gravel	Poor
	TOTAL LENGTH					436.2	276.4	714.6		

TABLE 2.2: DETAILS OF STUDY ROADS

Road Number	Road Name	Location	Section	Start Chainage	End Chainage	Gravel Length Km	Sealed Length Km	Length Km	Pavement Type	Condition
EASTERN HIGHLANDS PROVINCE										
NR07	Highlands Highway	Yung Creek - Kassam Pass	EN01	164.4	168.4		4.0	4.0	Sealed	Good
NR07	Highlands Highway	Kassam Pass	EN02	168.4	174.1		5.7	5.7	Sealed	Good
NR07	Highlands Highway	Kassam - Kainantu	EN03	174.1	207.7		33.6	33.6	Sealed	Good/fair
NR07	Highlands Highway	Kainantu - Henganofi	EN04	207.7	246.2		38.5	38.5	Sealed	Good/fair
NR07	Highlands Highway	Henganofi - Goroka	EN05	246.2	290.4		44.2	44.2	Sealed	Fair
NR07	Highlands Highway	Goroka - Daulo	EN06	290.4	317.1		26.7	26.7	Sealed	Good
NR07	Highlands Highway	Daulo Pass - Simbu Border	EN07	317.1	343.5		26.4	26.4	Sealed	Fair
ND4101	Aiyura Access Road	Kainantu - Aiyura NHS	EN08	0.0	6.6		6.6	6.6	Sealed	Poor
ND4102	Dunantina-Dumpu Road	Dunantina - Dumpu	EN09	0.0	47.7	47.7		47.7	Gravel	Poor
NI4102	Institutional Road	EHP Police & CIS	EN10	0.0	6.7	6.7		6.7	Gravel	Fair
	Provincial Road	Korofegu - Oleguti	EP11				15.0	15.0	Sealed	Good
	Provincial Road	Oleguti - Okapa	EP12			44.0		44.0	Gravel	Poor
	Provincial Road	Raipinga - Okapa	EP13			49.0		49.0	Gravel	Poor
	Provincial Road	Oleguti - Lufa	EP14			15.0		15.0	Gravel	Poor
	Provincial Road	Aiyura - Obura	EP15			32.0		32.0	Gravel	Poor
	Provincial Road	Goroka - Lahame	EP16			13.0		13.0	Gravel	Fair
	Provincial Road	Lahame - Magabo	EP17			21.0		21.0	Gravel	Poor
	Provincial Road	Goroka - Unggai	EP18			29.0		29.0	Gravel	Fair
	Provincial Road	Asaro - Lapego - Kifamu	EP19			20.0		20.0	Gravel	Poor
	TOTAL LENGTH					277.4	200.7	478.1		

TABLE 2.2: DETAILS OF STUDY ROADS

Road Number	Road Name	Location	Section	Start Chainage	End Chainage	Gravel Length Km	Sealed Length Km	Length Km	Pavement Type	Condition
WESTERN HIGHLANDS PROVINCE										
NR07	Highlands Highway	Garniger - Minj	WN01	398.9	416.4		17.5	17.5	Sealed	Fair
NR07	Highlands Highway	Minj - Kudjip	WN02	416.4	428.4		12.0	12.0	Sealed	Fair
NR07	Highlands Highway	Kudjip - Tuman R	WN03	428.4	444.6		16.2	16.2	Sealed	Fair
NR07	Highlands Highway	Tuman R - Hgn Town Bdy	WN04	444.6	470.1		25.5	25.5	Sealed	Fair
NR07	Highlands Highway	Mount Hagen Town Area	WN05	470.1	472.6		2.5	2.5	Sealed	Poor
NR07	Highlands Highway	Hgn Town Bdy - Togoba	WN06	472.6	483.5		10.9	10.9	Sealed	Fair
NR07	Highlands Highway	Togoba - SHP Border	WN07	483.5	511.6		28.1	28.1	Sealed	Good
NR06	Enga Highway	Togoba - Paigona	WN08	0.0	13.0		13.0	13.0	Sealed	Good
NR06	Enga Highway	Paigona - Enga Border	WN09	13.0	29.9		16.9	16.9	Sealed	Good
NM3901	Baiyer Road	Mt. Hagen - Kumdi School	WN10	0.0	21.0		21.0	21.0	Sealed	Good
NM3901	Baiyer Road	Kumdi School - Baiyer R	WN11	21.0	49.3	28.3		28.3	Gravel	Fair
NM3901	Baiyer Road	Baiyer R - Ruti Ranch	WN12	0.0	28.9	28.9		28.9	Gravel	Poor
NM3902	Kagamuga Airport	Airport Access Road	WN13	0.0	1.5		1.5	1.5	Sealed	Fair
NM3903	Ogelbeng-Dona Road	Ogelbeng - Ambra	WN14	0.0	9.2	9.2		9.2	Gravel	Good
NM3903	Ogelbeng-Dona Road	Ambra - Kotna	WN15	9.2	28.7	15.5	4.0	19.5	Gravel	Fair
NM3903	Ogelbeng-Dona Road	Kotna - Banz	WN16	28.7	61.7	33.0		33.0	Gravel	Fair
NM3903	Ogelbeng-Dona Road	Banz - Donna	WN17	61.7	80.7	13.2	6.0	19.2	Gravel/Sealed	Fair
NI3901	Institutional Road	Tea	WN18	0.0	4.0	4.0		4.0	Gravel	Good
NI3901	Institutional Road	CIS	WN19	0.0	11.3	11.3		11.3	Gravel	Good
	Provincial Road	Tomba - Tambul	WP20			16.0		16.0	Gravel	Fair
	Provincial Road	Balk - Bukapina	WP21			15.3		15.3	Gravel	Poor
	Provincial Road	Bukapina - Koge	WP22			6.4		6.4	Gravel	Good
	Provincial Road	Bukapina - Nengil	WP23			16.4		16.4	Gravel	Poor
	Provincial Road	Bukapina - Kadua No 1	WP24				10.0	10.0	Sealed	Good
	Provincial Road	Baiyer River - Lumusa	WP25			13.0		13.0	Gravel	Poor
	Provincial Road	Kagamuga - Kelua No 1	WP26			8.7	3.5	12.2	Gravel/Sealed	Poor
	Provincial Road	Korn Farm - Ambra	WP27				8.0	8.0	Sealed	Good
	Provincial Road	Kum - Wurup	WP28			8.8		8.8	Gravel	Fair
	Provincial Road	Wurup - Korn Farm	WP29			6.3		6.3	Gravel	Good
	Provincial Road	Kotna - Tigi - Baiyer River	WP30			24.0		24.0	Gravel	Poor
	Provincial Road	Kindeng - Kondopina	WP31			10.3	1.0	11.3	Gravel	Good
	Provincial Road	Kudjip - Banz	WP32				7.0	7.0	Gravel	Good
	Provincial Road	Banz - Karap	WP33			36.5		36.5	Gravel	Fair
	Provincial Road	Highlands Hwy - Donna - Nondugal	WP34			7.8		7.8	Gravel	Fair
	TOTAL LENGTH					312.9	204.6	517.5		

TABLE 2.2: DETAILS OF STUDY ROADS

Road Number	Road Name	Location	Section	Start Chainage	End Chainage	Gravel Length Km	Sealed Length Km	Length Km	Pavement Type	Condition
SOUTHERN HIGHLANDS PROVINCE										
NR07	Highlands Highway	WHP Bdr - Kisenepoi	SN01	513.0	533.5		20.5	20.5	Sealed	Good
NR07	Highlands Highway	Kisenepoi - Kumbame	SN02	533.5	557.3	23.8		23.8	Gravel	Fair
NR07	Highlands Highway	Kumbame - Ankura Bridge	SN03	557.2	567.3	10.1		10.1	Gravel	Fair
NR07	Highlands Highway	Ankura Bridge - Mendi	SN04	567.3	600.4	18.0	11.1	29.1	Gravel/Sealed	Upgrading
NM3701	Koroba Road	Mendi - Kar Mission	SN05	0.0	35.0	35.0		35.0	Gravel	Fair
NM3701	Koroba Road	Kar Mission - Fakandah	SN06	35.0	72.0	37.0		37.0	Gravel	Fair
NM3701	Koroba Road	Fakandah - Ambua Lodge	SN07	72.0	126.2	54.2		54.2	Gravel	Fair
NM3701	Koroba Road	Ambua Lodge - Tari	SN08	126.2	148.6	22.4		22.4	Gravel	Fair
NM3701	Koroba Road	Tari - Koroba	SN09	148.6	187.1	38.5		38.5	Gravel	Fair
NM3701	Koroba Road	Koroba- Fugwa T/O	SN10	187.1	194.9	7.8		7.8	Gravel	Fair
NM3702	Kutubu Road	Poroma T/O - Moro	SN11	0.0	112.0	112.0		112.0	Gravel	Fair
NM3703	Erave Road	Kisenepoi - Ialibu	SN12	0.0	15.6	15.6		15.6	Gravel	Good
NM3703	Erave Road	Ialibu - Kagua	SN13	15.6	47.4	31.8		31.8	Gravel	Fair
NM3703	Erave Road	Kagua - Erave	SN14	47.4	87.0	39.6		39.6	Gravel	Fair
ND3701	Oksapmin Road	Fugwa T/O - Tagobi	SN15	0.0	15.0	15.0		15.0	Gravel	Poor
ND3701	Oksapmin Road	Tagobi - Kopiago	SN16	15.0	68.5	53.5		53.5	Gravel	Poor
NR05	Wabag - Mendi Road	Soba - Peane	SN17	109.1	114.1	5.0		5.0	Gravel	Poor
NR05	Wabag - Mendi Road	Peane - Mendi	SN18	115.1	141.1	25.0	1.0	26.0	Gravel/Sealed	Fair
NM3704	Sumia - Pinj Road	Peane T/O - Sumia	SN19	0.0	27.0	27.0		27.0	Gravel	Poor
NM3705	Kagua Road	Sumia - Kagua	SN20	0.0	41.0	41.0		41.0	Gravel	Poor
ND3704	Tambul Road	Koine - Tambul	SN21	0.0	46.0	46.0		46.0	Gravel	Fair
ND3705	Pangia Road	Ialibu - Pangia	SN22	0.0	23.0	23.0		23.0	Gravel	Fair
	Provincial Road	Ialibu - Kumbene	SP23			12.7		12.7	Gravel	Good
	Provincial Road	Nipa - Munihu	SP24			20.0		20.0	Gravel	Poor
	Provincial Road	Hiwanda - Nogoli	SP25			23.0		23.0	Gravel	Poor
	Provincial Road	Soba - Winza	SP26			8.3		8.3	Gravel	Poor
	TOTAL LENGTH					745.3	32.6	777.9		

The existing condition of the each study road provided in Appendix C is based on this rating as determined by the Word Bank[3]. The road condition rating is also listed in Table 2.2 to provide an overview of the condition of the roads in each province. A summary of the condition of the study roads based on the ratings is provided in Table 2.3.

TABLE 2.3: SUMMARY OF CONDITION OF STUDY ROADS

PROVINCE	GOOD	FAIR	POOR
Morobe	17%	36%	46%
Eastern Highlands	11%	40%	49%
Western Highlands	29%	49%	22%
Southern Highlands	10%	65%	25%
Four Provinces	16%	49%	35%

In the following sections the typical characteristics are presented to provide an appreciation of the condition of the road network. Major issues related to the condition of the road network are also presented to assist the understanding of the existing condition of the road network.

2.3.2 Sealed Roads

(a) Geometry

Sealed roads have generally have been designed to engineering standards as part of the upgrading process, and therefore they have geometry that suits the road environment. Pavement widths vary but are typically in excess of 5.5 m increasing to 7m for the Highlands Highway, while shoulder widths are generally a minimum of 0.5 m. The roads are located in all terrain types from flat terrain to mountainous with corresponding curvature. The altitude varies from a few metres at Lae to over 2,000 m in SHP.

Recently several National and Provincial roads in WHP have been upgraded by the Provincial Government, without modifying the alignment or the increasing the formation width to comply with engineering standards, due to the extreme difficulties with land compensation in purchasing land for the road. In one example the pavement was 5.5 m wide without shoulders in hilly terrain with deep side drains, and was considered unsatisfactory by the Consultant.

(b) Surface

The surfaces of the sealed roads are generally good but with localised sections requiring maintenance to prevent complete deterioration of the seal. Without the required maintenance, water ingress into the pavement advances the deterioration of the seal. Many of the roads need resealing as the age of the seal exceeds 10 years. The subgrade CBRs typically range in values between 2 and 5.

(c) Condition

Generally the roads have an IRI in the range of 4-6 for reasonably smooth to medium rough surfaces. The poor sections of seal are in relatively short sections and have a moderate impact on the average roughness of a road length. Surface distress including cracking, ravelling, potholing and edge breaks

[3] Road Deterioration in Developing Countries, Causes and Remedies, World Bank Policy Study, 1988.

generally affect limited areas of the roads. The local defects are typically associated with poor drainage and inadequate shoulder maintenance.

Gravel Roads

(a) Geometry

Gravel roads vary in width from a minimum of 3 m up to 6.5 m for well maintained sections. Many of the roads have been designed to a Rural class design standard with alignments that closely follow the terrain to minimise earthworks when the road was constructed. The roads are located in all terrain types with associated curvature and rise/fall.

(b) Condition

The condition of gravel roads is generally fair as most roads are in need of resheeting and spot regravelling. However many roads in hilly to mountainous terrain such as the Aseki road in Morobe Province are in poor condition due the lack of maintenance leading to vegetation encroaching the pavement, and significant damage to the pavement by vehicles and uncontrolled runoff. Patch gravelling is commonly used in emergency maintenance to reinstate the pavement in areas where the subgrade is exposed in the roadway, due to localised erosion of the pavement.

(c) Surface

Gravel pavements generally do not comply with engineering standards due to the placement of non-conforming regravelling materials over the years. While the pavement may have been constructed initially with materials complying with engineering standards, the ensuing maintenance, particularly with the increasingly limited funds over the past five years, generally allowed non-conforming materials to be placed on the pavement. The Consultant observed use of unscreened and uncrushed quarry run materials on all gravel roads in the Southern Highlands Province, and uncrushed river gravels on many gravel roads in Morobe and Eastern Highlands Provinces.

Use of non-conforming materials reduces the life of the gravel pavement as fines in a coarse matrix are eroded more quickly leading to high roughness, or water may be held in a pavement with excess fines leading to excessive rutting in wet weather. Overall the pavement quickly develops a coarse lean surface with high roughness. The very high roughness of many gravel roads in the SHP is a result of a lack of regravelling or use of coarse gravels which do not conform to standards. In SHP quarry run materials have been used due to lack of available processing facilities, which also allows the limited funds to regravel or patch gravel a longer road length due to the lower cost compared to use of processed materials.

Accordingly most gravel roads have high roughness in the range of IRI 12-15 for medium rough to rough roads. Screening and grading of gravel materials is recommended for all Study roads when resheeting works are implemented, unless the source materials without processing comply with the standards.

2.3.3 Bridges

Two types of bridges are common in PNG: Bailey bridges and concrete deck steel beam composite bridges. Most bridges are in fair condition but require maintenance. Timber decks on Bailey bridges in PNG have a low life expectancy from the environment and also suffer vandalism by local villagers. Many older bridges, particularly on the Highlands Highway are single lane providing a dangerous feature especially overnight. The load rating of many bridges is not known requiring particular investigations when heavy loads are required to cross the bridges as often occurs for the mining, oil

and gas developments in SHP and WHP. Details of bridges where available are provided in Appendix C5.

2.3.4 Major Issues

(a) Lack of Maintenance

The lack of funding for maintenance works in recent years is increasing the rate of degradation of the road network so that a substantial backlog of maintenance projects exists. Funds that are made available for maintenance often are diverted to other activities on the path of commitment to the PoOW, providing even less funds for the actual road maintenance.

In addition maintenance funds are not available on a planned or consistent distribution discouraging planning of maintenance works which can lead to inefficient use of the funds available.

Maintenance of roads is lacking in all areas leading to lack of vegetation control, poor drainage systems, higher rate of gravel loss, higher rate of damage to sealed pavements by lack of repairs to potholes, reduction of usage and safety of bridges due to poor or missing deck timbers. The cause and effect of the lack of maintenance in the short and long term is shown on Figure 2.5. The combined effect of the lack of maintenance is a dramatic increase of surface roughness of the pavement and a loss of functionality of the road network.

A substantial increase in maintenance funding is required. In 1999 the allocation of K70 million for National roads has increased to well over four times the amount provided for maintenance in 1998 which should reduce this increasing network degradation. However, in previous years the amount provided has often be considerably less than the allocation.

(b) Quality of Materials

Gravel materials for maintenance works are generally placed without testing or reference to the Gravel Pit Inventory to confirm their suitability. These materials are typically not screened or crushed due to lack of suitable plant or equipment or in an attempt to reduce the cost of materials. Accordingly the materials do not comply with engineering standards which leads to poor pavement properties.

Substandard seal patching materials were in use for maintenance from a supplier but no action was underway to prevent its use.

Materials used for maintenance works must be selected and tested to ensure compliance with engineering standards.

(c) Quality of Workmanship

With the reduction of maintenance funds over recent year, a change in Government policy on road maintenance and the subsequent decline in the POoW plant and personnel there is an increasing emphasis on providing maintenance by contract plant hire or by contract packages. Without consistent and reliable funding for maintenance works, contractors will not gear up for this work in terms of plant and trained personnel, thereby reducing the quality and increasing the cost of maintenance by this approach.

Contractors selected for maintenance works must be screened for capability and experience to ensure they have the skills required to complete the works in a contract package. Contractors must also have the capability to work with specification, tender and contract administration procedures.

(d) Quality of Supervision

The loss of personnel experienced in maintenance from the POoW is reducing their capacity to implement maintenance works. In addition POoW have historically provided maintenance by day labour and are now administering contracts for maintenance without experience or training, reducing the quality of the maintenance and increasing the cost of the services provided. The uneven supply of maintenance funding can require intensive periods of maintenance activity with insufficient personnel to supervise the works.

A training program to update and improve skills by POoW employees is essential to enable efficient implementation of maintenance services.

(d) Land Compensation

Compensation for land affected by road widening or realigning, clearing of landslides, and quarry activities is becoming an increasingly significant issue with local landholders. Often existing agreements for access to quarries are not being recognised by the current generation of landholders reducing the availability of gravel sources. Modifications to road alignments or formation widths during road upgrading works is discouraged due the difficulty in obtaining agreement for compensation with landholders. Emergency works to restore local failures such as erosion of bridge abutments and repairs to culverts are hampered by landholders seeking compensation.

All roadworks require clear policies, strategies and procedures for dealing with compensation claims, and sufficient lead times to minimise the prospect of delays to improvement works.

2.4 DESIGN STANDARDS

2.4.1 Road Design Standards

The geometric design standards adopted for the project are contained in the DOW 'Road Design Manual' April 1985 edition. The road cross-section details and design speed are dependent on the total average daily traffic for the road section, counted in both directions. The traffic categories of Light, Medium and Heavy are defined by traffic volumes in Table 2.4. Traffic volumes are those projected to occur at the end of the design life, taken in this project to be 20 years after completion of construction.

A further factor in the determination of design standards is the terrain type. Terrain type is defined on the basis of lateral natural ground slope angles as shown in Table 2.5.

Cross-section details provided in the DOW Road Design Manual based on the traffic category and terrain type and are shown in Table 2.6. Longitudinal geometric standards relating to the design speed are shown on Table 2.7.

TABLE 2.4: TRAFFIC CATEGORY BY VOLUME

Traffic Category	Traffic Volume (Vehicles per day)
Light	Less than 100
Medium	100 – 400
Heavy	More than 400

Source: DOW Road Design Manual

TABLE 2.5: TERRAIN TYPE BY LATERAL SLOPE

Terrain Type	Natural Ground Cross Slope
Flat Rolling	Less than 10 deg (17.5%)
Hilly	10 to 30 deg (17.5 % to 58%)
Mountainous	more than 30 deg (58%)

Source: DOW Road Design Manual

TABLE 2.6: ROAD WIDTHS AND DESIGN SPEED BY TERRAIN TYPE

Traffic Category	Volume Range (vpd)	Terrain Type	Design Speed (kph)	Width of Pavement (m)	Width of Formation (m)
Heavy	Over 400	Flat & rolling	80	6.5	8.5
		Hilly	50	6.5	8.0
		Maintainous	30	6.0	7.5
Medium	100 - 400	Flat & rolling	70	6.5	7.5
		Hilly	50	6.0	7.0
		Maintainous	25	5.5	6.5
Light	Under 100	Flat & rolling	60	Not applicable	6.5
		Hilly	40	Not applicable	6.0
		Maintainous	25	Not applicable	5.5

Source: DOW Road Design Manual

TABLE 2.7: GEOMETRIC STANDARDS

Design Speed kph	Sight Distance (m)				Horizontal Radius (e=0.10)		Gradients			
	Gravel		Seal				Gravel Max		Absolute Max	
	Stopping	Overtaking	Stopping	Overtaking	Gravel	Seal	%	Length	%	Length
	-	-	170	800	-	340	5	-	7	750
80	135	480	115	480	250	210	6	-	8	1000
70	105	350	90	350	185	155	6	-	8	700
60	80	300	70	300	130	115	7	1100	9	400
50	60	200	55	200	85	75	8	600	10	300
40	45	160	40	160	55	45	10	500	10	250
30	30	90	30	90	27	25	10	500	12	250
25	25	75	-	-	-	-	12	300	14	150

Source: DOW Road Design Manual

2.4.2 Bridge Design Standards

The current policy for the design of bridges as provided by OoW is as follows:

Load Capacity:	All National road bridges due for replacement are designed in accordance with AustRoads 1992. For Provincial Roads NAASRA T44 live load rating is adopted but lower standards can be negotiated.
Width:	The minimum width between the face of the kerbs is 3.3 m for a single lane and 6.0 m for a dual lane carriageway. However 4.2 m extra wide bridges are often adopted for safety on single lane bridges. The minimum width above the handrails is the deck width plus 2.45 m.
Number of Lanes:	Bridges of not more than 30 m total length on a sealed highway have the number of lanes provided by the sealed highway.
Bridges on Unsealed Highways:	Designed for a single lane
Vertical Clearance:	A minimum vertical clearance of 5.0 m is provided above the deck surface level.
Materials:	Permanent forms of bridge construction are investigated for all new bridges, although steel truss bridges can be adopted.

2.4.3 Review Of Design Standards

The commentary on design standards given in Volume 1 Chapter 3 generally endorses the basic geometric standards provided in the Design Manual. However the 6.5 m wide formation adopted in the Manual for roads with medium traffic in mountainous terrain is considered too narrow. As the shoulders can become eroded from minor slips.

The details in the Design Manual in prescribing cross sections and sight distances, and its vertical and horizontal design principles are built on sound highway and traffic engineering practice and are appropriate for the purposes of the Study. Any review of the standards must be in the context of a wider study of the road transport sector in PNG. As Volume 1 illustrates, 1999 is not an appropriate time to be considering such an issue.

2.4.4 Current Practice In Road Upgrading

A number of roads in the four Provinces are being or have been recently upgraded to one of the following categories presented in Table 2.8. Each category may have a different standard of road geometry, engineering design and supervision.

The strategies adopted for the first two categories of roads are supported and will be adopted in the Study. However the strategy for the third category is not supported as the roads are not designed or supervised to comply with engineering standards, and the reduced pavement life and increased maintenance is not expected to provide significant life cycle cost reductions. In addition, a higher rate of serious accidents is likely as a result of not complying with design standards compared to upgraded roads subject to engineering design and supervision.

TABLE 2.8: CURRENT PRACTICE IN ROAD UPGRADING

ROAD	CURRENT PRACTICE
Roads that link Provinces and major roads within Provinces	Roads are designed to high standards with vertical and horizontal realignment to improve the sight distance. Pavements are designed to suit the expected traffic load and constructed in accordance with strict specifications. Bridges for roads in this category are upgraded to a permanent bridge, typically a concrete deck on steel beams, where the load capacity of the existing bridge or the waterway area is inadequate. Detailed engineering investigations and designs are prepared and the works specified in ICB or LCB contract documentation, depending on the contract size and if a donor agency is funding the works. Examples: Ramu Highway (Morobe), Highlands Highway (SHP), Enga Highway (Enga) and Wau Road (Mumeng – Bulolo in Morobe)
Roads that link District Centres	Roads are designed to standards with a minimum of vertical and horizontal realignment to improve the sight distance at critical locations. Existing bridges for roads in this category are generally maintained, except where the load capacity of the existing bridge or the waterway area is well below the design standard. Detailed engineering investigations and designs will be prepared and the works specified in LCB contract documentation. These roads could also be constructed by force account. Examples: Korefugo – Oliguti Road (EHP) and Malahang Road (Morobe)
Roads that link villages	Roads are upgraded with no change to the existing vertical and horizontal alignment. The new pavement may be based on nominal additional base or subbase layers. The existing bridges for roads remain unchanged. Detailed engineering investigations, designs and contract documentation are not prepared. These roads would be constructed by minor contracts or force account with minimal supervision. This approach provides a low cost sealed road with minimum standards of design and construction which may not comply with engineering standards. Examples: Kadua – Bukapena road (WHP), Mt Hagen - Kumdi School (WHP)

2.4.5 Design Standards Adopted For Investment Program

When considering upgrading existing gravel roads to a sealed surface in this Study, four functional classifications have been used based on the existing terminology applied to the PNG network and the classification system used in the Road Design Manual. The four classes are:

Category A: Major highways linking Provinces and serving Nationally significant regions; design traffic flow likely to exceed 1,000 vpd;

Category B Main roads linking Provinces and provincial centres; design traffic flow likely to exceed 500 vpd;

Category C Secondary roads linking districts and villages; design traffic flow between 250 and 500 vpd;

Category D Connector roads within districts; design traffic flow between 100 and 250. Minor access roads and paths connecting settlements to the road network have not been considered in this study.

In considering design standards for upgrade schemes for gravel roads two factors have been balanced, the safety aspects of non-uniform design geometry of the existing road formation and the cost of imposing formal geometric standards. The preliminary analysis using HDM III and road and traffic parameters from this Study has led to a conclusion that considerable benefit will result from low cost road upgrades. However, use of geometric standards below those in the Road Design Manual can result in safety hazards, as travel speeds will increase on the sealed surface.

The design traffic volume cut off between Road Categories Band C has been increased from the value of 400 vpd between the medium and heavy traffic category in the Design Manual to 500 vpd to more appropriately fit with the functional definition.

For the purpose of estimating costs to upgrade candidate road sections a general set of project standards has been adopted, based on the Design Manual but with some compromise in the width of seal. In applying costs to these road upgrade standards two sub-categories have been used for B and C to account for additional earthworks in hilly and mountainous terrain. These project standards are provided in Table 2.9.

TABLE 2.9: DESIGN STANDARDS ADOPTED FOR ROAD UPGRADING

Road Class and Function	Traffic Flow AADT		Sealed Upgrading of Gravel Roads - All Terrains		Management Issues
	Present	Design			
Category A Major highways linking Provinces and serving Nationally significant regions	>500	>1000	Pavement width Shoulder width Formation width Design Speed Surface Type	7.0 m 1.0 m 9.0 m 50-100 kph Seal	1) Capacity to maintain traffic flow on steep sections, at junctions and in urban areas; 2) Pavement strength under heavy axle loads
Category B Main roads linking Provinces and Provincial Centres	250 – 500	500 – 1000	Pavement width Shoulder width Formation width Design Speed Surface Type	6.0 m 0.75m 7.5 m 40-80 kph Seal	Adequate width and surface condition to maintain efficient travel speed
Category C Secondary Roads linking Districts and villages	150 – 250	250 – 500	Pavement width Shoulder width Formation width Design Speed Surface Type	5.5 m 0.75m 7.0 m 40-70 kph Seal or Gravel	Adequate surface condition to maintain travel speed within acceptable vehicle operating costs.
Category D Connector Roads within Districts linking villages to the road network	<150	100 – 250	Pavement width Formation width Design Speed Surface Type	6.0 m 7.0 m 40-70 kph Gravel	All weather accessibility with acceptable roughness.

In applying these standards the road function has been selected considering both an appraisal of the role each section plays in the network and the present and forecast future traffic. The traffic flow categories are to broadly indicate the flow appropriate to each road class and should not be read precisely. A road in any class may have a traffic flow outside the nominated range on Table 2.9. In the economic evaluation an upgrade option has been tested for Category D roads using the same construction costs as for Category C.

2.5 ROAD IMPROVEMENT PROJECT UNDERWAY

A number of upgrading and rehabilitation projects are underway in the Study Provinces as listed in Table 2.10. In addition bridges on both National and Provincial roads are being maintained and upgraded under the bridge replacement and upgrading project (BRUP) funded by AusAID. BRUP has been a five year program and will end late in 1999.

2.6 MAJOR TRANSPORT INVESTMENT PROPOSALS

2.6.1 Southern Highlands To Gulf Road Link

The National Government is developing a National Road which will link the Southern Highlands and the Gulf Province via the existing road network from Kagua to Erave and then from Samberigi toward the Kikori District in the Gulf Province. The road will be implemented through a 100% state owned company "Trans-Highland Road Company". The PNG Banking Corporation, acting as the lead bank, will be responsible for securing the loan fund from its resources, and other banks and institutions. The project has the following three phases:

Phase 1 – Erave to Kikori Road

The roadworks estimated to cost K200 million are:

- Stage 1 – the first 10 km of the road from the Oil Pipeline Access Road towards Samberigi will be funded by K5.0 million of tax credits accrued to Chevron Niugini Pty Ltd, with that company taking responsibility for undertaking or contracting the design and construction under the supervision of OoW;
- Stage 2 – about 37 km of the middle section of the road to be constructed under the supervision of the OoW by a negotiated contract to implement this stage when design is completed by OoW under the supervision of the contractor;
- Stage 3 and 4 – the design and construction of the remaining sections of the road from Samberigi to Erave to Kikori will be constructed when the designs are completed by OoW under the supervision of the contractor.

Phase 2 – Kikori (Km 137) to Towei Road

The 43 km section will be constructed at a cost of K60 to K70 million by the contractor once the designs are completed by OoW and managed by the contractor.

Phase 3 – Towei to Kerema Road

The 272 km road commences 15 km north of Towei in difficult terrain. The works are estimated to cost about K250 to K275 million to be constructed once the designs are completed by OoW under the management of the contractor.

2.6.2 Mendi – Lake Kopiago Road Sealing Project

The Southern Highlands Provincial Government is preparing to upgrade, reconstruct and seal the highway linking Mendi Town to Lake Kopiago via, Nipa, Margarima, Tari and Koroba. The total road length is about 238 km. Prequalification of contractors interested in undertaking the upgrading, reconstruction and sealing of the project on a Design, Construct and Finance basis was advertised in March 1999.

The Contractor prequalification documents are to be submitted in accordance with the FIDIC Standard Prequalification Form of Contractors to the Southern Highlands Provincial Government.

2.6.3 Upgrading Of Tari Airport

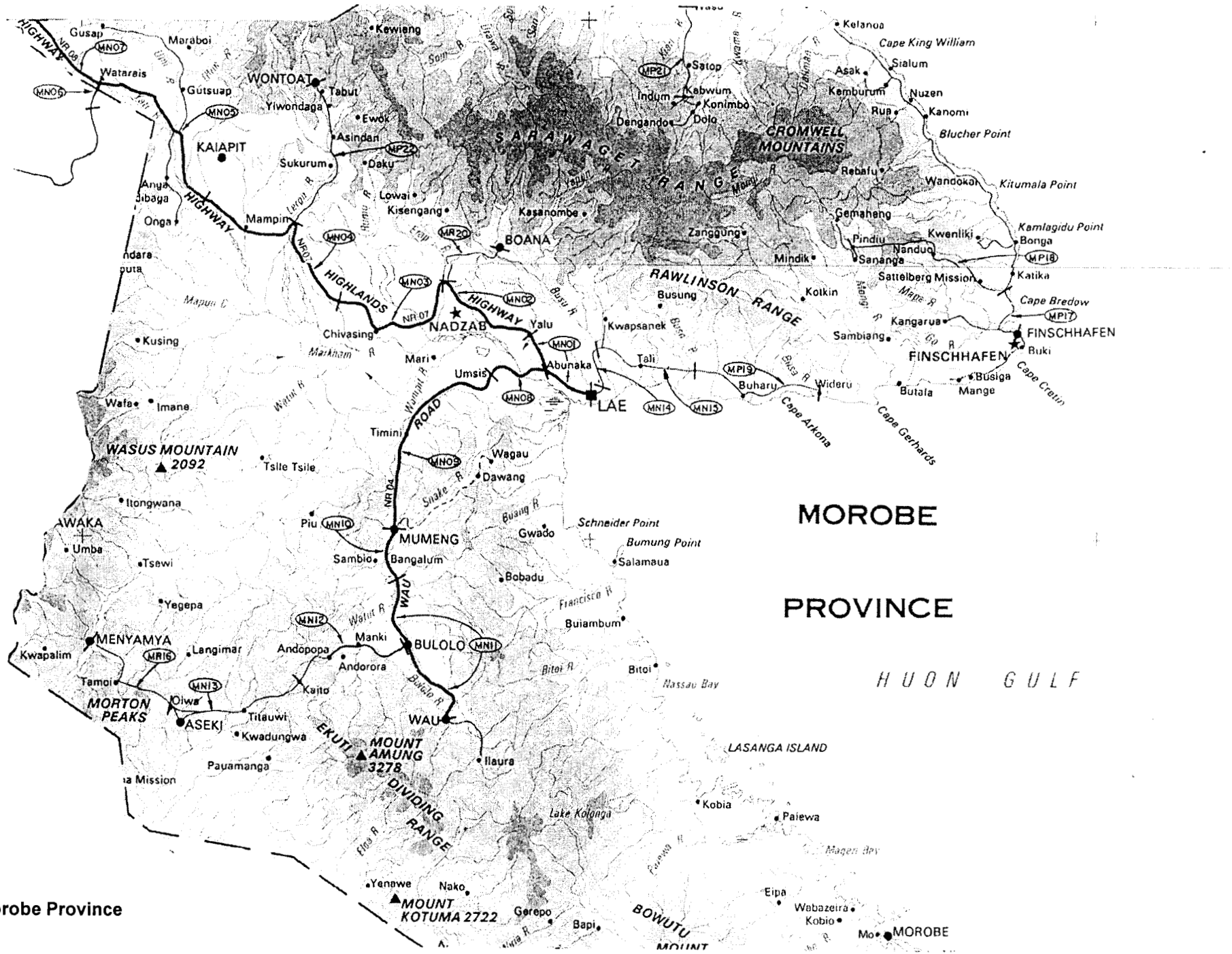
The Southern Highlands Provincial Government is proposing to upgrade the Tari Airport to an international standard at an estimated cost of K46 million.

2.6.4 Construction Of Lai River To Hiri Rural Access Road

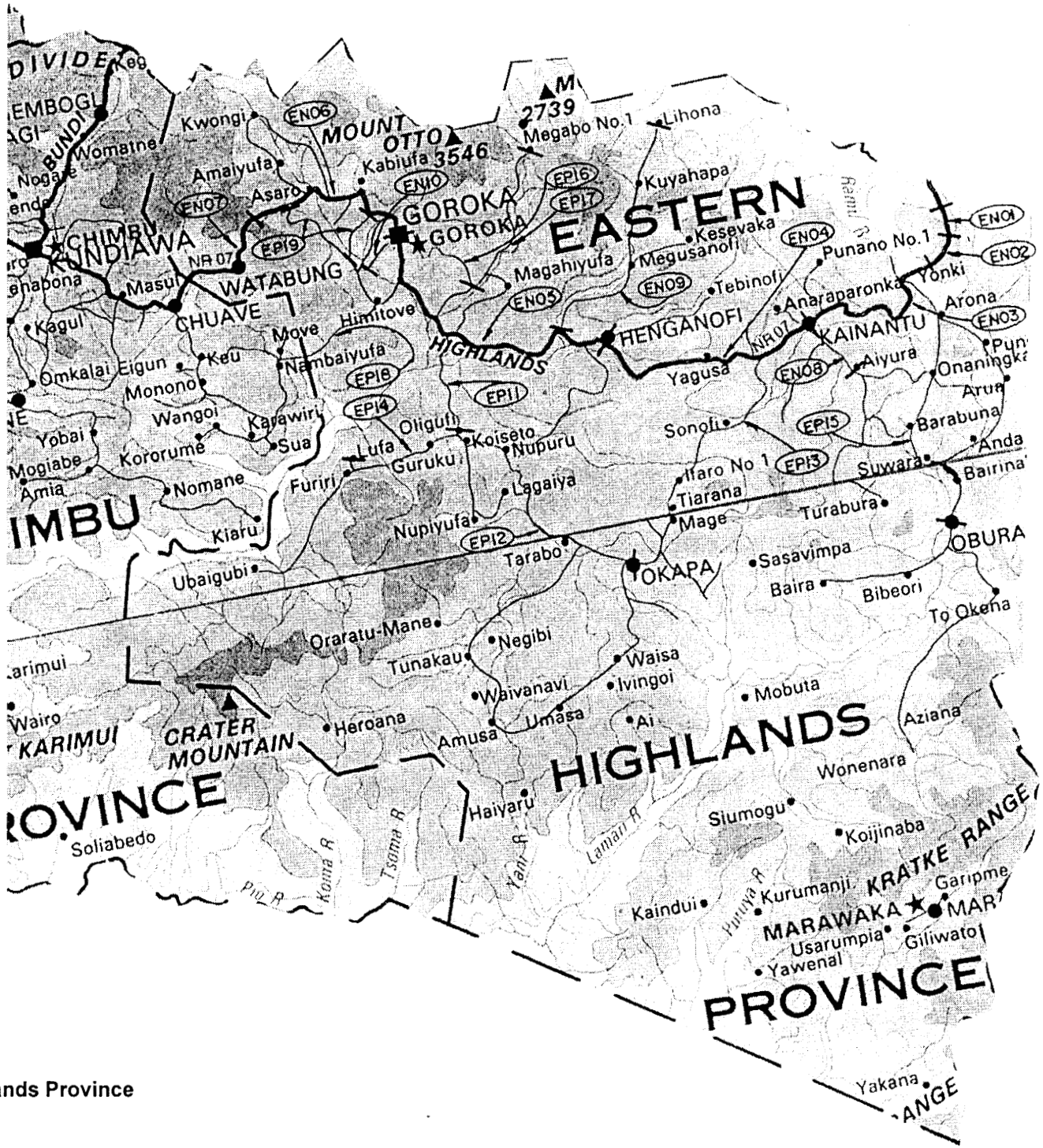
The Southern Highlands Provincial Government is preparing to construct the proposed 30.7 km section between Lai River and Hiri to rural class access road standard. Contractors interested in undertaking the works under a design and construct basis were invited to submit an expression of interest for pre-qualification in April 1999 to the Southern Highlands Provincial Government.

TABLE 2.10: ROAD UPGRADING AND REHABILITATION UNDER CONSTRUCTION

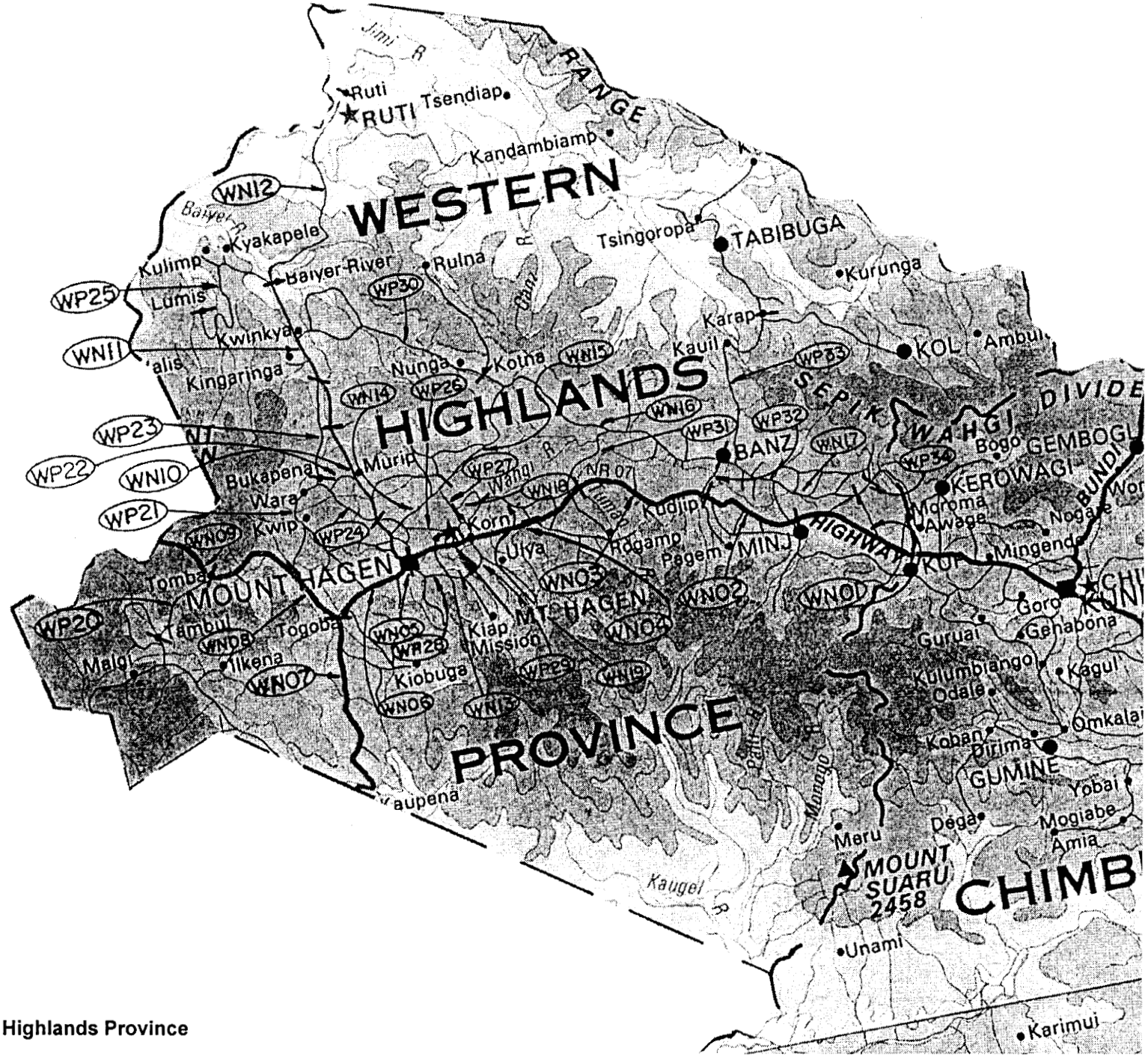
PROVINCE	PROJECT NAME	DONOR	CONTRACT PRICE (K1 MILLION)	CONSTRUCTION	CONSTRUCTION PERIOD	DESCRIPTION OF WORKS
Morobe	Specific Maintenance of Highlands Highway. Lae – Clearwater (Km 3.2 – 75.3)	ADB	2.76	Co-econ	Jun 98 – Apr 99	Raising the level of finished road surface by construction of embankments, a raise pavement level. Constructing new culverts, replacement or extension of existing culverts. Excavating trenches where pavement has failed up to a depth not exceeding 600 mm, lining the excavation with geotextile material, filling with sub base material and compacting crushed stone base course in the trenches above sub base to a compacted thickness of 150 mm priming and sealing it. Excavating to top of sub base or sub grade level or to a depth not exceeding 600 mm in other failed areas of the pavement, reconstructing sub base and/or base course. Laying a crushed stone base course with a compacted thickness of 150 mm over the prepared road surface. Applying prime coat to the surface of the completed surface. Applying the first coat bituminous seal with 19 mm nominal size cover aggregate over the primed surface. Applying second coat bituminous seal with 13 mm cover.
Morobe	Specific Maintenance of Highlands Highway Clearwater to Yung Creek. (Km 75.3 – 164.4)	ADB	3.6	Coecon	Mar – Aug 99	As above.
Morobe	Upgrading road from Wau Road from Mumeng to Bulolo	OECF				
SHP	Upgrading of Highlands Highway from Mendi to Kispenopoi	AusAid		Global Engineering		
EHP	Upgrading Oleguti – Okapa Road	ADB		Plant hire		Upgrading and sealing of a 10 km section.



Study Roads - Morobe Province
Figure 2.1



Study Roads - Eastern Highlands Province
Figure 2.2



Study Roads - Western Highlands Province
Figure 2.3

Study Roads
Southern Highlands Province
Figure 2.4

Figure 2.5: Impact from Lack of Maintenance on Roads

Physical Impacts	Pavements	Lack of Maintenance	Effects Short Term	Effects Long Term
Rain and Runoff	Gravel and Sealed Pavements	- Infrequent Cleaning of Drains - Improper Grass Cutting - Inadequate cleaning of drains	- Blocked Table Drains - Culverts Blocked - Water Retained on Bench - Lateral Blockages on Bench - Matting of Vegetation and Debris	- Raised Water Table - Land Slumps and Slides - Bogging - Gulleying - Sub base Lost and Washout
Wind	Gravel Pavement	- Infrequent Grading - Unsuitable Gravel - Infrequent Regravelling - Inadequate Response to Potholes - *Inadequate Response to Rutting*	- Higher Roughness - Gravel Lost Faster	- Pavement Failure - Poor Riding Quality of Pavement
Wheel Impacts	Sealed Pavement	- Inadequate response to Potholes - Inadequate response to Cracking	- Higher Pavement Roughness - *Higher damage to seal*	- Pavement Failure - *Poor Riding Quality of Pavement*

CHAPTER 3. NATIONAL AND REGIONAL ECONOMIC ANALYSIS

3.1 NATIONAL ECONOMY

3.1.1 PNG Economic Overview

PNG has a dual economy; exports of mineral and oil wealth sustain a handful of urban centres at a relatively high standard. These centres such as Port Moresby and Lae exist as enclaves on the edges of traditional farming cultures, which have living standards comparable to the poorest countries of Asia. Because of its nominally high GNP per capita of between US$ 940 (1997)[4] and $1,150 (1996)[5] the country is placed in the lower middle income group in World Bank classification terms.[6] Exploitation of its natural resources has created an enclave modern sector with considerable wealth and amenities. The majority of the population however rely on subsistence agriculture with an annual per-capita income[7] for the rural agricultural sector in the order of US$300 to 350. This compares with an average urban income in the order of US$3,500.[8].

AusAID estimated per capita GDP growth to have been 1.8% per year in the 1986-96 period. However, outside the minerals sector, real GDP/capita grew much more slowly, averaging about 0.4%/yr.[9] The distribution of income is more unequal than that of neighbouring Asian countries with the richest 10% accounting for 36% of total consumption and the poorest 50% accounting for only 19%. As detailed in Volume 4 – Initial Social Assessment, PNG also ranks low in other indicators of social development.

Formal employment outside the mineral sector has been stagnant throughout the 1990's. About 60,000 jobs of the formally employed 220,000 were in the public sector, but this is in decline with Government lay-offs and down-sizing. Lack of formal employment opportunities and continued high levels of migration to urban areas are major causes of PNG's chronic law and order problem and under-utilization of education skills.

As detailed in Volume 4, and recent studies,[10] average annual cash incomes per capita from village agriculture range as low as K7 (Ialibu) in the Southern Highlands which has a provincial average of K15, to K112 in the Western Highlands and K132 in the Eastern Highlands. In Morobe, the range is also dramatic in the districts along the study corridors. With a provincial average cash income/capita of only K36, the range among districts along the study corridors is between K12 (Finschhafen and Siassi Districts) to K6 (Mumeng) to K156 (Kaiapit). Variations can be attributed to extent of participation in the market economy and export crop production.

Agriculture provides income, employment and livelihood for more than 85% of PNG's population. During the period 1980 to 1990, this sector accounted for 27% of the country's GDP, 35% of the export revenues, and 40% of the formal sector employment. Nearly 80% of the monetized work force of about 1.1 million persons in 1990 was dependent on the cash crop sector. While the mineral resource sector with its booms (and slumps) has accounted in recent years for an increasing share of

[4] As calculated by the World Bank on an estimated GNP of $ 4.2 billion and an estimated population of 4.5 million, World Bank Country Brief, 10/1/98.
[5] ADB Annual Report, 1997
[6] Table 1, Classification of Economies by Income and Region, Global Economic Prospects and The Developing Countries, The World Bank, 1999. In classifying countries by 1997 GNP/capita, (ie., lower middle income group of $786 - $3125) the World Bank Atlas method notes that low and middle income countries although referred to as "developing" economies are at widely varying stages of development.
[7] Defined as Agricultural Sector Income/Rural population, actual cash income accruing to rural families is much lower; see Table 1 in Socio-Economic Assessment, Volume 4.
[8] Papua New Guinea: Accelerating Agricultural Growth, An Action Plan, World Bank, February 1997
[9] The Economy of Papua New Guinea, January, 1988, Australian Agency for International Development
[10] Field survey data and analysis by Dr. Bryant Allen , Australian National University, 1999

GDP, it has generated only about 1% of formal employment in the economy. With the prospect that mineral and oil resources could taper off in the next century, the agricultural sector will become more significant as a source of employment and export revenues.

However, given the sluggish performance of the agriculture sector in the past two decades, its impoverishment has exacerbated unemployment and led to the increasing disparities between urban and rural income levels and standards of living. Experience among PNG's Southeast Asian neighbours indicates that increases in smallholder productivity can be potentially the most cost-effective and powerful engine of sustainable and broad-based growth. A major constraint however remains accessibility, both to markets and to supporting social services. Poor rural infrastructure and road linkages combined with topographic constraints aggravate the problems of small and spatially fragmented markets for agricultural produce. Where accessibility and market opportunities are made available however, the response of the smallholder can be dramatic. The economic context and circumstances as well as the conditions for these responses in the transport sector are discussed further below as well as in Volume 4 – Initial Social Assessment.

Since 1989, investor confidence has been subdued compared with the previous, more ebullient decade. Although a few major mineral developments such as the Porgera and Lihir gold mines and the Kutubu oil fields have been made, the number of business start-ups and expansions with accompanying employment generation has remained stagnant to declining.[11] Mineral exploration activities have declined since 1988.

3.2 RECENT ECONOMIC GROWTH AND PERFORMANCE

From 1985 to 1998, the PNG Gross Domestic Product averaged in constant terms, an annual rate of growth of 4%. The trend however has been erratic, particularly in recent years, with negative growth of 2.3% in 1995, a positive 5% in 1996, and in 1997, a further contraction of 8.1%.[12] The agricultural sector grew at an average 3%/yr from 1985 to 1990, but since 1993, has sustained only a 1% annual growth. Mining grew rapidly in the early 1980's, then dropped sharply with the closure of the Bougainville mine in 1989, and then expanded again, peaking in 1995. The pattern of economic growth is illustrated in Appendix D, Chart D.1, and Tables D.1 – D.3.

The agriculture, forestry, and fisheries sector has fallen in share since the period 1985 - 1990, from 40% or more of GDP, to 32% in 1998. Mining has fluctuated in share of GDP from highs of 19 and 20% in 1986 to 1988 to lows of 10% and 8% in 1996 and 1997. Petroleum is a recent addition, appearing in 1992 in the National Accounts with an 8% share of GDP, 21% in 1993, and then settling at 13% and 14% shares by 1997 and 1998.

In 1997, mining and petroleum output fell, and the El Nino related drought affected crop production severely. The drought severely affected the country, particularly the Central, Western, and Highlands Provinces during the second half of 1997 and into 1998. By January 1998, it was estimated that in the order of 1.2 million people - almost a quarter of the population, were in need of food assistance. According to World Bank[13] estimates, Southern, Western, and Eastern Highlands had severely affected populations. These were classed in emergency food supply categories 4 (little or no food supply with many people at risk) and category 5 (small children and elderly either at severe risk or dying). Those so classed amounted to 47%, 61%, and 62% of populations within those respective provinces. In Chimbu Province, 100% of the population was considered to be in these two at-risk categories.

[11] Commentary on investor confidence reported in March, 1999 issue of PNG Business, "Economic Outlook " by Dr. Agogo Mawuli, National Research Institute.
[12] ADB Annual Report, 1997
[13] Papua New Guinea El Nino Drought Response Project

Almost all of PNG's commercial crops sustained losses with production of coffee, cocoa, and copra oil all down. Lack of water also forced shut-down of the Ok Tedi mine and reduced production at Porgera.

In 1997, inflation was reportedly held to 4%; for 1998, this was estimated by the Bank of Papua New Guinea (BPNG) at 13.6%, although estimates quoted from the IMF January 1999 report estimated the 1998 rate at 21.8%.[14] For 1999, BPNG expects a rate of 8%. This may be optimistic given continued depreciation of the Kina and a projected budget deficit of K80 million, 0.9% of nominal GNP.[15] As reported in the Australian Financial Review on March 29, 1999, the sell-off of the Kina in 1st Quarter 1999 has been accompanied by a collapse in reserves to less than one-month's coverage of imports. Cash flows to the Government would remain tight until proceeds from coffee, palm oil, cocoa and copra begin to flow in the second quarter of 1999.

GDP growth is estimated at 2.5% for 1998 and forecast for 1999 is 2.9%. Excluding the mining and petroleum sector, GDP growth is estimated at only 1%. As reported by the IMF in their January 1999 report, foreign direct investment fell from K470 million in 1997 to K145 million in 1998. The IMF also warned that mortgaging of future mineral tax revenues to secure external commercial borrowing would increase the vulnerability of the economy to external shocks and internal weaknesses.

Registration of businesses with the Investment Promotion Authority while enjoying a temporary recovery in 1996 and 1997, have again fallen in 1998 and 1999, approaching again the nadir of 1995. In that year liberalization and deregulation led to a subsequent positive business response, but since then the optimism of investors has dissipated. This is reflected in outward capital movements, deteriorating foreign exchange reserves, and more difficulty in obtaining commercial and concessional loans.

For the last quarters of 1998, the NCD accounted for the greatest number of Investment Promotion Authority (IPA) approvals, 55 out of 89. Morobe, was next in the country with 12, and the Western Highlands was next with five approvals. The other Highlands Provinces had three approvals each. However, these investment intentions were in the majority for the wholesaler/retailer sector and dependent heavily on imported goods trading. In contrast, the manufacturing, agriculture, construction, and hotel/restaurant sectors all showed declines in applications, reflecting both the high input costs due to a weakening Kina and poor market prospects.

3.3 EXPORTS

Mineral products have accounted for more than half the country's export earnings over the past two decades. In 1991, mineral export earnings were 71% of total export value. This share has since slipped slightly to more than half, 53% in 1997. Gold has been traditionally the major earner, but in 1996, oil earnings became the top export commodity in US$ terms.

Agriculture as a share of export earnings has fallen from 32% of the total in 1985 to 21% by 1997. Coffee is the major source of export earnings in this sector, contributing 9% of total export value. Log exports grew rapidly from the 1980's, until peaking in 1994. Since then volumes have declined, with a severe drop in 1998 because of reduced demand from Japan and other Asian markets.

Agricultural and timber commodity exports were substantially down in both quantity and earnings in 1998 compared with the previous year. According to data released by the Economic Planning Unit (EPU) of the Department of Treasury in March 1999, exports of logs for the first three quarters of 1998 fell by 64% from volumes in the comparable 1997 period. The PNG Forest Association reported that

[14] As quoted in INA Forum with Mike Manning, Post Courier, March 19, 1999
[15] Announcement of 1999 monetary policy by Bank Governor Morea Vele, March 28, 1999 as reported in *The National.*

collapse of the Asian log market led to a decline in log exports from 3 million m^3 in 1997 to 1.6 million m^3 in 1998. Log prices declined from US$ 78/m^3 at year end 1997 to $64/$m^3$ in September, 1998.[16]

Similarly, EPU reported declines (first 3 quarters of 1998 vs. 1997) for all agricultural exports. Coffee exports dropped 26% to 36,000 tonnes, cocoa fell by 21% from 27,100 tonnes, and palm oil fell 28% from 239,000 tonnes in the comparable 9 months of 1997. Exports of copra, coffee, and cocoa were running at their lowest levels since 1995. Coffee, as mentioned previously, has recovered in 1998 with coffee year exports reaching a record 72,000 tonnes and export earnings of over K410 million.[17]

Other indicators on the state of the economy include new vehicle sales and fuel consumption. With the downturn in the economy, truck sales have fallen. During the mid-1990's, about 800 heavier (greater than 6 tonne) units were reported sold annually by dealers. In 1998, this had fallen to 340 units, and for 1999, only 300 heavier units are expected to be sold.

As another indicator of commercial activity, in 1997/98, discussions with major importers indicated that growth in retail fuel sales was in the order of 6%; in 1998/99, fuel sales are reported to be stagnant or declining outside Port Moresby. In 1995, the UNDP Infrastructure Study estimated petrol consumption at 76 million litres. According to 1997 Customs import statistics, 340 million litres of fuel were imported, of which 60 million were petrol and 280 million were diesel.[18] Of this, it is estimated by fuel importers and distributors that retail sales of diesel fuel for the road sector make up about 60% of total consumption. The remaining 40% is consumed off-road in the industrial sector.

Sales of new vehicles and retail petrol sales in the Highlands Provinces generally follow the pattern of coffee production which has a large impact on household income and demand. In 1998, retail fuel sales were down by 15%. Only in the Port Moresby area has there been any growth in motor fuel demand.

3.4 NATIONAL AND STUDY AREA POPULATION

Based on the 1990 census and demographic projections prepared by the UNDP 1998, the National Statistical Office has released estimates of the 1997 population by province. With an average annual growth rate of 2.4%, the total country population has increased from the 1990 estimate of 3.8 million to a 1997 estimate of 4.4 million. As detailed in Volume 4 – Initial Social Assessment, the extent of under-counting in the last 1990 census is not known, nor can the projected annual growth rates be given with certainty either.

Using the same data base, NSO reports the Highlands region and Morobe Province to have an estimated population of 1.6 million and 438,000 respectively. The study area, in particular the Highlands has a relatively high density, 26 persons/km^2 compared with the national average of 10 persons/km^2. Among the Highlands Provinces, Chimbu, Western and Eastern Highlands Provinces have the highest concentrations outside the NCD with densities of 47, 31, and 28 persons/km^2 respectively. Morobe Province is lower with a density of 13 persons/km^2.

3.5 STUDY AREA REGIONAL ECONOMIES

The last year for which the NSO has data available by province for domestic factor incomes is 1989. At that time the NCD was dominant with a 25% share of national income, a share which has probably increased since. Morobe with its large port centre of Lae was next highest in income with a 10% share of national income. The Highlands Region as a whole made up a 17% share in 1989 with the

[16] As reported in The National, March 15, 1999
[17] As reported in The National, April 8, 1999.
[18] Customs Reports as furnished by National Office of Statistics; data submitted by private importers to Government may be incomplete or inconsistent.

Western Highlands dominant in the region with a 7% share of national income. The Eastern Highlands were next with a 5% share of national income, and Enga (2%), Chimbu (2%) and the Southern Highlands (3%) trailed behind. Since that time, oil and gas developments in the Southern Highlands Province would have boosted that Province's share, as would the development of the Porgera Mine in Enga Province. Chimbu has probably stayed the same or slipped in relative share of income.

A more recent measure would be the Kina/person transfers required to equalize per capita income across the country. In a 1995 study prepared by the World Bank[19], hypothetical equalizing transfers were ranked in order of relative poverty and estimated as follows for the provinces within the zone of influence for the Highlands Highway:

Province	Income Gap (1993 K/person)
Southern Highlands	225
Chimbu	200
Enga	150
Eastern Highlands	140
Western Highlands	135
Morobe	130

For the country as a whole, smallholders produce virtually all of the domestically produced food and 80% of the coffee. This carries true for the Highlands Region and Morobe as well. Traditional subsistence production systems which continue to grow indigenous root crops and vegetables, have successfully incorporated new crops since the 1700's, 1800's, and this century. These include yam and taro, corn, peanuts, pumpkin, "Irish" potatoes, cocoa, coffee as well as a wide variety of vegetable and tree fruit crops. Poultry and pigs have also been integrated into farming systems, and to a lesser extent, sheep, goats, and cattle. Evolution of smallholder farming systems has demonstrated both resilience and rational behaviour in spite of low incomes, poor to non-existent social and health support systems, difficult terrain and infrastructure constraints, and complex socio-cultural environments.[20]

Crop production patterns and estimated cash incomes by district within the study area are detailed more thoroughly in Volume 4 – Initial Social Assessment but as a general picture, income in Western Highlands can be attributed to coffee (65%) and food crops (7%). In the Eastern Highlands, Coffee accounted for 52% of income and food crops 32%.[21] The remainder is drawn from a variety of sources including sale of firewood, poultry and livestock, formal and casual labour.

More recently in the Highlands Region, volume of retail and wholesale sales and activity in construction has shown a declining pattern in 1998 compared with 1997 with the completion of construction of the Gobe Oil project and several bridge and road projects in the region.

[19] Volume II, Figure 1.5, WB Report No. 14414-PNG, Papua New Guinea, Delivering Public Services, August, 1995

[20] The World Bank Agricultural Operations Division (CD III, EAPR) quotes estimates of price elasticity of supply for PNG smallholders ranging between 0.18 (with a two year lag) to 0.27 (with a one year lag) for coffee. (PNG: Accelerating Agricultural Growth, An Action Plan, February, 1997)

[21] Figure 3.1, op.cit.

In Morobe Province, timber, copra and some manufacturing and government activities including higher educational institutions at Lae form the economic base. There is also some tourism, with prospects for future resort investment. The logging sector, discussed further below, has been down since 1997 given the lower level of exports with reduced demand in the Asian markets.

3.5.1 Mineral Sector

With a resumption of the Porgera Mine operations following the drought-induced shutdown in 1997, gold exports increased from Enga Province. Crude oil export volumes also increased over 1997 with the commencement of full production at Gobe Main and South East Gobe oil projects in Southern Highlands Province. This off-set lower production and declining reserves at the Kutubu oil project.

3.5.2 Agricultural Sector

Productivity in smallholder root crop production remains high in most areas. However, with the pressure of population increases and the consequent increasing crop intensification coupled with stagnating yields, there is increasing stress on arable lands. Average area for cassava, sweet potato, yam and taro increased since the 1960's by averages of 75%, 32%, 45% and 52% respectively. Yield increases ranged between 1% for taro and 10% for sweet potato. [22] Fallow periods are shortening from an average of 15-25 years to 2-5 years in some areas. Forest lands are being encroached on in many parts of the Highlands.

PNG is self-sufficient in poultry, eggs and pork meat, but attempts to increase domestic beef herds have not been particularly successful. According to the World Bank 1997 Agricultural Action Plan document, the beef cattle herd has fallen by 50% in the last ten years, with 25% decline in largeholder herds and 60% declines in smallholder herds. Domestic supply of beef has stagnated at about 2,000 tonnes/year (70% from smallholders), but the number of goats and sheep has tripled since the mid-1980's. Coffee, tea, tree fruit, and vegetables are the major production and export commodities from the Highlands Region. These crops are discussed in more detail below.

In Morobe Province, some 3,500 to 4,000 tonnes of maize is grown in the Markham valley, mostly as livestock feed. This valley also supports a few larger poultry and cattle growing operations together with smallholder outgrowers.

Morobe in the past supported a significant logging and timber business. However, valley forests were largely cut-over in the last twenty years, and only around Bulolo is there any sustained forest activity at present. This consists of a plywood mill supported by the 1,200 Ha pine plantation in the area. Product from the mill is transported to Lae for domestic markets primarily with a small amount for export. The plywood mill in Bulolo has a design capacity of 36 – 40,000 m^3 per year and operates at about 75% capacity. The sawmill in Bulolo and the veneer mill in Lae, which formerly operated in the 1980's are now closed for lack of supply. Within a 30 to 50 km radius of Lae, a few logs are harvested, but volumes are now quite minor. South from Lae, coastal forests are producing logs and operations could be expected to move further inland in the future.

The Highlands Provinces mainly rely on sawn timber brought up from Lae by truck. Some minor logging and sawmilling occurs in the Eastern and Western Highland Provinces, but most of the remaining timber is on steep slopes or difficult to access.

As elaborated in more detail in the Volume 4 – Initial Social Assessment, a major constraint to extensifying and intensifying smallholder vegetable and cash crop production is the available time and

[22] Endnotes, p. 33, World Bank report: (PNG: Accelerating Agricultural Growth, An Action Plan, February, 1997)

skills of rural women.[23] On average women provide from half to three-quarters of agricultural labour as well as rear livestock and poultry. In addition they handle marketing of surplus vegetables, fruits, fish, and meat. They currently provide 40 to 50% of the workdays on coffee and cocoa and 25 to 30% on copra and rubber. The number of coffee gardens owned by men is highly correlated with the number of women in the household. Given this important role of women in agriculture, delivery of credit facilities and agricultural extension support services must be geared to ensure their full support and coverage.

Coffee

The coffee industry is PNG's largest non-mineral export and provides sustainable employment and income for almost half the population. In the Highlands region, this proportion is even higher, being the largest cash crop.

Exports in 1997/98 (October/September coffee year) amounted to 1.2 million bags or 72,000 tonnes. This earned over K410 million for PNG. Actual PNG production was 77,000 tonnes, which represented a 19% increase on 1996/97 - this despite the 1997 El Nino - induced drought. World prices were up in 1997, which induced much more picking as a result. The prospects for the 1999 crop are not quite as good, according to Coffee Industry Corporation (CIC) staff, partly because of producer response to the lower world market prices. The green bean exports in 1997/98 were largely Y1 grade (67%). A-grade exports were off because of the drought. Roast and ground exports are fairly minor, only 55 tonnes in the last coffee year, 44% less than in 1996/97.

The large majority of coffee production occurs in the Highlands region. Morobe Province accounts for less than 1% of production. The major production comes from Western Highlands Province. According to processor reports, this province accounts for 44% of the national production, but this includes some coffee brought over from Enga Province. For Western Province, about 20% comes from large acreages, respectively from plantations (12%) and 20 Ha blocks (8%); the majority 80% share comes from small holders. Eastern Highlands is next and accounts for about 31% of national production. About 12% of Eastern Highland's production originates from plantations. In Chimbu province, all production comes from small holders.

It is estimated by CIC that two-thirds of Highlands cash incomes come from coffee. On average small holders cultivate 1.5 gardens of 0.1 Ha each, and produce 400 kg of green beans per Ha. Based on a farm-gate income of K1/kg, average income to coffee small holders is in the order of K200 to 300/yr. [24] In the longer run, with extension services and more intensive husbandry, production per Ha could increase significantly. Noting that yields can vary between 100 Kg and 1,500 Kg/Ha, life-cycle yields on trees can be increased by careful pruning on a five year cycle and plot management. Short-term yields are reduced in the first season or two after pruning, but subsequently, increased yields more than compensate. In the interim, opening up of coffee tree cover allows inter-cropping and complementary crop benefits.

Tea

Tea production is a minor item compared to coffee. While the last published figures were from 1993, the tonnage then amounted to 6,500 tonnes, about 10% of the coffee export tonnage that year. Tea estates around Mt Hagen do however supply a large number of picking jobs to migrant workers from the Southern Highlands Province.

[23] Discussions with CIC Chief Economist, 3/99; also reference UNDP PNG:WID Sector Review, Andrew Nakikus, et al., 1991
[24] Studies for PNG Coffee Industry Corporation, Gerard Stapleton, Chief Economist.

3.5.3 Transport Operations And Implications For Traffic Growth And Generation

Existing traffic patterns and future estimates of growth are discussed in more detail in Chapter 4. As a background to this discussion of traffic growth, it is useful however to examine present commodity and passenger flows within the study area as a context for present and future traffic. From interviews with shippers and transport operators in the study area, it is apparent that transport activity is suppressed and traffic levels down from previous levels because of three major factors. These include:

- Down-turn in economic activity with maturation of resource development and construction projects, as well as the decrease in mineral exploration activities;
- Deteriorating road conditions making transport more expensive and difficult; and
- Public safety and law and order concerns which discourage commercial and private transport and constrain any tourism development.

The role of Lae as the major port handling exports of coffee and tea from the region has been described earlier in this chapter. Lae also serves as the major point of entry for consumer and manufactured products to Morobe and inland to the Highlands region. Major movements up from Lae are fuel, general cargo and trade goods, fertiliser for coffee plantations, frozen foods, building materials, and hardware. Major freight movement down to Lae includes empty bottles, vegetables, personal effects, and tea and coffee in season.

The tariff for fuel from Lae to Goroka is K45/tonne (21Tonnes/load). For a 20 foot container, the rate is K650/box with an average load of 13 tonne. Reefer containers travel at the same rate. Generally trucks leave Lae at 6am and arrive in Goroka at 1 or 2pm. Onward to Mt Hagen, trucks leave Goroka at 3am and arrive around 10 to 11am, allowing a return the same day. The major back-haul from Goroka is coffee. Cost to Lae from Goroka is K2.50/bag for a 60kg bag. Generally they carry 25 to 26 tonne/load. At 17 bags/tonne, cost per tonne K42.5 or per load, K1060/load. Rates from Lae to Mt Hagen are K1339/container (not including tax). The road conditions to Mt Hagen are more dangerous, and a premium is added to the rate.

Operations over the Daulo Pass, Mt Hagen – Goroka are difficult with the extensive stretches of disintegrated pavement with numerous rough and bouldered patches. On March 30 this year, a trailer bounced loose from the fifth wheel pin and was almost lost. The driver was able to move the tractor around to the back of the trailer and block the container doors from pillage. Police patrols were luckily in the area because of elections and a rescue truck was dispatched from Mt Hagen in time to do repairs. A month previously, a container was completely looted under similar break-down circumstances.

Mt Hagen serves as a service and distribution centre for the Western and Southern Highlands and Enga Provinces. For example, Transwest Transport Company brings about 4 trucks/day from Lae to Mt Hagen, averaging 25 tonne/load with general goods. Almost all commodities are brought up in containers for security. Lumber, plywood, and timber products presently are hauled up from Lae and Bulolo, Morobe, to the Highlands.

Examples of major consumer goods distributors from Mt Hagen includes SP Holdings. SP do their own distribution only within the township and rely on commercial carriers for other more distant points. Beyond Mt Hagen, Wahgi Valley Transport serves Lae to Mendi; East-West Transport serves Lae - Mendi, Tari and Wabag with about 2 to 3 trips month to each town on average. The SP Holdings Mt Hagen warehouse also distributes back to Chimbu (about 3 loads/month).

During the low period before coffee harvest, SP brings up 5 to 6 loads of soft drinks/month to Mt Hagen. During the high season when coffee money is abundant, this increases to 7 or 8 trips/

month. Beer is handled by Wahgi Valley Transport and distributed through Wamp Nga Ltd. with about 4 trips/month in low season.

Major problems reported by shippers are the high breakage and damage rates on the Highlands Highway because of the rough spots. From Lae to Goroka, SP Holdings reported damage of only 2 to 3% of loads, but beyond through Chimbu to Mt Hagen, where the highway is disintegrating, damage is in the order of 10% of every load of canned or bottled drinks. About 2 to 3 times/year, a truck is lost by running off the road or theft. Maximum loads are 30 to 35 tonnes per shipment. For the Mendi and Tari runs, 4 x 4 and 4 x 6 drive trucks designed for off-highway operation are becoming a requirement because road conditions are too difficult for conventional vehicles. Sometimes police escort is also required.

Transport operators distributing out from Mt Hagen include Transwest, East-West, and Pagini Transport. These companies haul on main routes including Wabag (now improved with AusAID). Up to Wabag, fuel, general cargo, consumer goods are hauled with coffee as a back-haul. A number of Highlands owner-operator trucks serve the Mt Hagen - Porgera run. Presently 10 to 15 trucks/week. supply the Porgera Mine. During the construction phase, this same number travelled every day.

Although runs were more frequent in past years, major distribution routes out of Mt Hagen include Mendi, Kutubu, and Tari. Transwest has now stopped going to Tari because road conditions and the local law- and -order situation has made operations difficult and uneconomical. Instances abound in the last 6 months of trucks being hi-jacked on difficult, slow sections of the road, or where villagers dig-up the road to extort tolls. In some cases, cargoes have been completely stripped - including driver's clothing and shoes.

Similarly, East -West Transport which still serves the Mendi - Tari route reported operational problems. Operators agree that this is one of the worst routes because of road conditions, bridges and hostile villagers, and this affects getting supplies to Hides gas fields and Tari. East-West are still running with 9 trucks, 3 trips/week, but Wahgi Valley Transport now hauls for their customers to Margarima and Ambuna, about 4 times/week to each town. In the last 6 months, transporters have had extensive losses in ransacking by locals. Tolls are demanded at several villages along the way.

East-West Transport also make about 7 to 8 trips up from Lae per week with general goods, dry and freezer foods. They also haul fuel up from Lae to Goroka. During coffee season, East/West makes 24 trips/week back down with 2 containers/load @ 25 tonnes/box. The run to Lae is a 24 hr operation with trailer drop, driver change, and quick turn-around during this peak season.

Pagini Transport and Wahgi Valley Transport still operate into the Southern Highlands, but frequency has dropped to half the number of runs/week which are desired by merchants and contractors in the Tari and Hides gasfield area. Cargo going up for BP Exploration includes equipment, pipe, and drilling chemicals. From the gas plant and refinery at Tari, diesel and naphtha come back to Mt Hagen. Naphtha is used for drying tea at the plantations in the area.

Besides coffee hauled back to Goroka from Mt Hagen for processing, and thence to Lae, other agricultural products include potatoes and fresh vegetables. Potato volumes are estimated at about 4 containers/month at 10 to 12 tonne/container. Cost is K70/tonne; for vegetables loaded light, the cost is K400/trip, Mt Hagen to Lae. About 3 to 4 reefer containers/mo. of vegetables are shipped by a broker down to Lae and thence on to Port Moresby. Although a year-round business, this is a difficult undertaking with much spoilage and damage in transit. Timely delivery is critical and only one businessman is reported to be surviving so far. Potential appears attractive for this market if roads and distribution systems were improved.

The local market in Mt Hagen displays a large variety of fresh, high quality vegetables and fruit grown in the region. Products raised in the area include a wide variety of vegetables (potatoes, bell peppers, lettuce, cabbage, broccoli, carrots, onions), tropical (oranges, bananas, guava, and passion fruit) and

temperate (strawberries and melons), as well as chili peppers, garlic and ginger. At present, only small volumes are either air-freighted to Port Moresby on a space-available basis or trucked to Lae for onward shipment. Enlarging the markets for produce depends upon availability and consistency of suitable transport, including refrigerated and vented containers for surface shipment.

As mentioned previously, Mt Hagen and Goroka depend largely on sawn lumber trucked from Lae. One Western Highlands sawmill had tried shipping sawn timber out from Mt Hagen to Lae, but shipments were rejected because the mill could not produce specification lumber. Timber supplies in the region are limited, and the small mills in the area produce only for local demands.

Besides acting as a service and distribution point for the Porgera Mine in Enga Province, other economic activities in the Highlands region include the Kotubu oil field, and the refinery for the Hides gas field near Koroba in the Southern Highlands Province. As mentioned above, the small refinery there produces diesel for Porgera plus a small quantity diesel, naphtha, and kerosene for Mt Hagen. When the planned export gas pipeline project is finalized, pipe and other project cargo will have to be moved into the Southern Highlands. During the construction period, most of this freight would have to come over the Highlands Highway.

CHAPTER 4. TRAFFIC

4.1 INTRODUCTION

4.1.1 Sources Of Information

Information on traffic was obtained from three sets of sources. The first was interpretation from the national and regional economic analysis (Volume 2 Chapter 3 and Volume 4 – Initial Social Assessment), the second was from a run of the Carts PNG national traffic model by R J Nairn and Partners Pty Ltd especially for this project, and the third source was from traffic count data on roads in the four Provinces under investigation.

4.1.2 Traffic Variability

The first two sources of information have shown that there is an historical perspective and an expectation of steady increases in population and production for the whole of the Highlands and for the Nation. However, the detailed traffic count data indicates a very high variability in traffic flows, both on specific roads and between roads which might be expected to show comparable or consistent patterns of flows.

Reasons for this variability are considered later but it is important to note the variability as a real parameter of traffic flow in the Provinces studied. Traffic flow is used to appreciate the function of each road and is a specific input to the economic evaluation of maintenance and upgrade scenarios for each road section selected for study. The variable nature of the traffic flow data and the factors which promote the variability, including widely different road conditions and trafficability over time, have been recognised when drawing conclusions from the transport analysis. Therefore a simplistic interpretation of traffic data can lead to a grossly understated or overstated economic viability for upgrading a candidate road.

4.1.3 Travel Purpose And Road Function

A road functional classification has been set up by the DOTWCA and is described in Chapter 2. The classification system requires elaboration, particularly at the lower end where traffic flows are small, and the use of design standards needs greater explanation and some refinement. These matters are addressed in Chapter 2 where the objectives of the analysis to support this maintenance and upgrade program are described.

Traffic flow is one of the primary determinants of investment in roads. However travel purpose and the role of a section of road in assisting that purpose and travel must also be understood. Though the economic evaluation attempts to quantify purpose, it is also represented through road function which recognises societal values and the worth of a road of a particular standard.

The four categories of road examined in this study and described in Chapter 2 are:

- Highway – the most important roads linking Provinces and serving significant National regions; design traffic flow likely to exceed 1000 vpd.
- Main Roads – major roads linking Provinces.
- Secondary Roads 1 – linking districts and carrying traffic in excess of 150 vehicles per day.

- Secondary Roads 2 – access within districts linking villages and carrying less than 150 vehicles per day.

Access roads, a fifth class, provide access from the above network to villages and settlements, but were not included in the Study.

The proposed physical provision for these roads given as design standards in Chapter 2 are consistent with the functional requirement of the private, public service and commercial sectors for the business that each sector wants and expects to be able to conduct. In Chapter 2 the actual condition of the road network is described. On many sections of the network, the road is in such poorly maintained condition and has been so for such a long period, that the expected activities of each community sector cannot be fulfilled because travel is too costly and too slow. People are not able to do the things they want or need to do when they require travel. Traffic flow on the network becomes more erratic, more variable, and demand for travel is suppressed; there is a desire to carry out activities which require travel but that desire is not fulfilled because its value is reduced by the long time and high cost of the travel.

When these sections of poorly maintained road are improved by upgrading to a sealed road or by adequate and regular maintenance, travel expectations become more predictable and more travel is made. The suppressed demand is released by reduced time and cost spent in travel and by a greater certainty. The impact of this effect on the traffic analysis for the Study is the occurrence of generated traffic which is seen as traffic growth rates higher than other indicators of economic and population growth. In the economic evaluation in Chapter 6, generated traffic is treated as a supplement to the base growth which is derived from the population and economic analysis described in Section 4.2.

4.2 ENVIRONMENTAL MANAGEMENT IN PRACTICE

4.2.1 General

Chapter 3 presents the structure and functioning of the economy of PNG and the study region. Volume 4 presents an Initial Social Assessment of the road upgrading and maintenance proposals made in Volume 2. The key points from these sections are outlined in the sections below.

4.2.2 Summary Of Macro-Economic Impacts On Traffic

Outside the main urban areas of Port Moresby and Lae the national economy is highly dependent on agriculture, oil and mineral production, and the per-capita income in these rural areas is low by world standards. Average cash incomes in the Highlands region generally are very low and income growth has been erratic; in the agriculture sector it has been less than 1% since 1993.

PNG gross domestic product has grown from K1,842 million in 1985 to K3,097 million in 1998, all at 1983 prices. Growth has been extremely cyclical with annual variations ranging from negative 8% to positive 18%. The overall annual growth from 1985 to 1990 was 1%, and from 1990 to 1998 was 6%. The major activities carried out in the area under study are agriculture, forestry, petroleum and mining and these have grown at between 2% and 5% per annum over the last eight years, but at less than 1% since 1993. In 1997 mining and petroleum production fell and the drought reduced crop production.

Transport operations and their implications for traffic growth are also discussed in detail in Chapter 3 which examines present commodity and passenger flows within the study area as a context for present and future traffic. From interviews with shippers and transport operators in the study area, it is apparent that transport activity is suppressed and traffic levels are down from levels in previous years because of three major factors:

- Down-turn in economic activity with maturation of presently committed resource development and construction projects;
- Deteriorating road conditions making transport more expensive and difficult;
- Public safety and law and order concerns which are discouraging commercial and private transport and constraining development of tourism.

Smallholder productivity is low, and highly variable with seasonal conditions and local wants, which is reflected in the highly variable traffic flows observed in the four Provinces. Experience in other comparable countries indicates that increases in smallholder productivity can be potentially the most cost-effective and powerful engine of sustainable and broad-based economic growth. However poor rural infrastructure including road linkages aggravate the problems of smallholders when their markets are small and spatially segregated. Where accessibility and market opportunities are made available the response of the smallholder can be dramatic.

At the regional level road transport difficulties are also apparent and are described in Chapter 3 and Volume 4. The aftermath of the severe drought of 1997/98 had a massive effect on commercial and subsistence agriculture in areas which had not experienced significant drought impacts. Likewise massive inundation on the Sepik coast from the tidal wave in 1998 has severely affected the regional economy, and though not directly impacting the Highlands, there have been some consequential affects. The following paragraphs summarise transport in the regional situation.

Lae is the major port handling exports of coffee and tea from the Highlands region. Lae also serves as the major point of entry for consumer and manufactured products to Morobe and inland to the Highlands Region. Operations over the Daulo Pass and through Chimbu Province from Goroka to Mt Hagen are difficult with the extensive stretches of very rough, disintegrated pavement. Mt Hagen serves as a service and distribution centre for the Western and Southern Highlands, and Enga Provinces. Timber products, fuel and general merchandise are hauled from Lae and Bulolo in Morobe to the Highlands. The local market in Mt Hagen displays a large variety of fresh, high quality vegetables and fruit which could be sent out to Lae for onward shipment to Port Moresby or Australia.

Major problems reported by shippers are the high breakage and damage rates on the Highlands Highway because of the rough sections. Sometimes a police escort is also required. One operator has stopped going to Tari because road conditions and the local law-and-order situation have made operations difficult and uneconomical.

These factors have been considered when interpreting traffic and travel data, and setting the traffic flows used in the economic analysis.

4.2.3 Summary Of The Impacts Of Social Issues On Traffic

National population at the 1990 census was 3.76 million and for the four Provinces was 1.08 million with between 370,000 and 470,000 in each Province. The estimated National population made in 1997 was 4.38 million and the study area population was 1.33 million. The annual growth rates leading to these figures varied as follows; Morobe 2.0%, Eastern Highlands 0.8%, Western Highlands 2.4%, Southern Highlands 3.0%. In Morobe Province 73% of the population live in rural areas and between 91% and 97% live in rural areas in the three Highlands provinces.

Rural incomes in the four Provinces are between K15 and K330 per person per year with the wages employment rate very low at between 2.5% and 7.5%. Levels of literacy and health in the four Provinces are very poor and worse than National standards. By international standards the income levels, health and educational status of the bulk of the rural population of the four Provinces is so poor that they would be considered to be living in poverty.

Overall the stage of development of the target population, those who would directly benefit from the road improvement projects being considered, may be assessed as low.

From the community consultation carried out and reported in Volume 4 the following observations and conclusions which impact on traffic flow have been drawn:

1. Roads were very important and any improvement was greatly appreciated for the benefits that accrued.

    a) Quantifying the anticipated benefits was difficult.

    b) Increased road safety risks (especially for pedestrians) that might arise once a poor quality road had been improved was not seen as an issue.

    c) One exception was from a community which had a recently sealed road through their village; increased injury and death to pedestrians, and vehicle collisions from speeding were now a major problem.

    d) Where previously gravelled roads have been sealed communities report improvements to health and personal lifestyle as a consequence of the reduction in dust from the road.

    e) Some people were keen to use an improved road for improved access to schools and health facilities in nearby towns.

2. Road design standards throughout the country are constrained by funding.

    a) Pavement and shoulder widths are the minimum for vehicle use and no provision is made for pedestrians who are forced to walk on or immediately adjacent to the traffic lane.

    b) Pedestrians become more at risk when roads are sealed.

    c) Safety issues have resulted from road improvements, even though these may not be perceived by communities living on poor quality roads.

3. Most rural communities do not have a well developed concept of how they might translate an improved road into economic and social benefits. Road upgrading projects should include a business advisory service component:

    a) to assist villagers in providing their labour and plant for road construction work; and

    b) to support micro-business development following their improved access to wider markets after the road is upgraded.

4.2.4 Implications For Traffic Flows And Traffic Growth

The analysis of national economics, demographics and social conditions reported in Chapter 3 and Volume 4 – Initial Social Assessment gives a basis for interpreting historical traffic count data and future traffic forecasts. Interpreting the history of economic growth over the last two decades has been affected by concerns from the National Statistics Office who consider that both the 1980 and the 1990 Census under-enumerated population with a particular bias against enumeration of women.

However, two broad conclusions from the census data are that the current growth rate for the country as a whole is 2.4% and the population growth rate in the 1980's appears to be lowest in EHP (less than 1% over the decade) and highest in WHP (about 3%). The analysis of economic growth shows great volatility over time, regions and commodities and can be summarised as ranging between 8%

and minus 18% with an average of 4% per annum growth over the 15 years between 1983 and 1998. The economy of the four Provinces is dominated by the agricultural sector which has been more stable than the whole economy. It had an annual growth ranging from 9% to minus 5%, with growth over the last five years of 1% per year but with a long term average below the whole economy, of 2% over the last 15 year period.

Some observations are drawn from these figures. With the agricultural sector growing at less than the population but maintaining reasonable stability, with a predominantly subsistence agriculture in rural areas, with land available for enhanced cropping and with the Nation importing basic food, there is opportunity and a high expectation that rural areas will turn to increased primary production given even small shifts in the restraining factors. Road access is one of these factors and one consequence of reliably maintained roads and further improvements from upgrading some roads would be increased agricultural production in areas where the other required factors and initiatives allow. There is reason to expect that road use and traffic will then grow at a rate comparable with growth in the agricultural sector. This provides a lower bound estimate for growth in road traffic over the present decade of between I% and 2% per year, reflecting the adverse conditions affecting rural activity in the areas under study.

Traffic counts also show considerable volatility over this period and they reflect two aspects of the economy. At the national and regional level traffic flows respond directly to changes in the economy; the populace appear to use vehicles only where there is a perceived economic purpose; and the low stage of development of rural communities in the four Provinces (described in Volume 4) leads to motor vehicle use at the village community level which is sporadic and which responds to domestic demands which do not follow set patterns. These responses lead to vehicle trip generation and consequential traffic flows which have wide temporal variations in a district and on a road section.

These factors have been considered when interpreting traffic count data and determining forecasts of traffic growth.

4.3 TRAVEL MODELING

4.3.1 The National Transport Model

Early in 1998, under an AusAID funded Advisory Support Facility for the Department of Transport, the consultant transportation firm of R J Nairn and Partners Pty Ltd was engaged to develop a traffic model, the Carts traffic forecasting model, to be used in transport planning for the whole of PNG. The transport model has the capability to forecast, country-wide and in all transport corridors and can develop nationwide 20-year traffic forecasts for all transport modes.

Further enhancement work has been done on the model to include:

- Provision of Provincial and additional National statistics;
- Mapping of model outputs by Province or group of Provinces; and
- Correlation to social welfare issues;

The road inventory and traffic data was obtained largely from the Kamsax Beca Gure "Provincial Roads and Bridges Investment Program" project, which is embedded in Mapinfo in the DOTWCA, from Maresman and from the numerous reports available on particular roads. Additional classified traffic data was obtained from the DOT traffic data cell.

4.3.2 Carts Analysis

Some notes about the forecasts of Population growth for several Provinces had been prepared in 1998 by the Department of Planning and Implementation as demographic studies. Data in East New Britain (post-Tuvurvur volcanic eruption) was obtained from the Province during the Kokopo Planning Study. In other Provinces the estimates were prepared from trends but balanced against the National population totals prepared by the Department of Planning and Implementation. In all cases these estimates had to be distributed to zones in each Province and this was done on the basis of recent inter-census growth in each zone. No adjustment has been made for the 1998 drought or flood disasters. The implied annual compound population growth rates for the four Provinces are summarised in Table 4.1.

TABLE 4.1: ESTIMATED AND FORECAST ANNUAL COMPOUND POPULATION GROWTH RATES BY PROVINCE

Province	1990/95	1995/00	2000/05	2005/10	2010/15	2015/20
Southern Highlands	3.6%	3.2%	2.3%	1.8%	1.8%	1.2%
Western Highlands	2.4%	2.0%	1.7%	1.5%	1.3%	1.1%
Eastern Highlands	0.8%	0.6%	0.8%	1.0%	1.1%	1.1%
Morobe	2.7%	2.7%	2.4%	2.2%	1.9%	1.9%

Source: R.J.Nairn & Partners

These population growths are higher for several provinces than those obtained directly for this study (Chapter 3). However this difference is offset by the model behaviour using all necessary economic inputs. In general, as a rough rule, it has been established that the annual traffic growth rates in PNG have been about 1.5% higher than the population growth. The model found that traffic growth was lower than this and so is not likely to be over-estimated.

The growth of employment will be faster than this if the shift toward urbanisation and cash economy continues, based on analysis of the previous inter-census data to establish the rate of urbanisation, both in Port Moresby and to the Provincial capitals. Trip attractions are based on employment. Trucks and freight traffic are derived from several sources as follows:

- Inter-Provincial City freight movements which were calibrated against the available classified traffic counts.

- Zone agricultural production for a variety of crops for which data and forecasts were obtained from the Department of Agriculture, The Forestry Commission and other sources.

Trip generation rates vary with vehicle ownership. Data was obtained from OoT on registrations and imports as well as from Household Interview Travel Surveys in Port Moresby, Lae, Madang and Rabaul.

The network incorporates all known roads and tracks, not just classified National or Provincial roads, whether they are paved or not. Some are coded as walk tracks in order to provide the connectivity. Data on road condition was updated following the field surveys carried out in February 1999. The model lengths of each class of road are given in Table 4.2.

TABLE 4.2: MODEL KILOMETRES OF EACH ROAD CLASS BY PROVINCE

Province	Arterial	Rural Road	Feeder Road	Walking Path	Total
Southern Highlands	245	39	1832	317	2433
Western Highlands	212	81	998	39	1329
Eastern Highlands	293	39	1383	393	2108
Morobe	331	180	879	1804	3194

Source: Carts model

4.3.3 Base Year Calibration And Model Results

Traffic data from recent counts (1996 to 1999 as detailed in Appendix E) were supplied as inputs to the model and several base year runs conducted to calibrate the model for the detailed networks in the four Provinces. Note that in the feasibility analysis described in Chapter 6 only traffic growth rates over time were taken from the model, with base year flows derived from field traffic count data as described in the following section.

Forecast future traffic growth from the model and estimated traffic flows for each road section investigated are given in Appendix E. Some of the growth rates have been adjusted down as shown in the tables, on the basis of historical count data and population growth forecasts.

4.4 TRAFFIC COUNT INFORMATION

4.4.1 Historical Sources

Historical traffic count data was obtained from the primary OoT source and from a series of incidental sources which provided in-fill data on road sections or for time periods. The primary source was OoT classified vehicle counts which were conducted between March and July 1996. The counting period varied from several days to 17 days, but was generally a seven day count. Counts were taken for 12 hours and have been factored by OoT to 24 hour ADT values typically using a 1.29 factor.

The incidental sources of traffic data were:

- Traffic counts on selected Provincial Roads specifically commissioned for this work by the study team, February, March and April 1999.
- 1997 Maresman records from Maintenance Management Branch of OoW.
- Province reports for the four Provinces from the ADB Provincial Roads Assistance Programs for 1987 and 1990.
- Individual investigation reports for upgrading of specific sections of road within the area of interest of this study.

The traffic count data is tabled in Appendix E.

4.4.2 Vehicle Classification Data

Traffic counts recorded at most stations on the network include counts of each vehicle class. These are generally available in the format in accordance with the OoT's "Transport Data System – 1, Traffic

Surveys" with eleven classes. However the economic analysis within HDM III utilises the following seven classes, amalgamated from these eleven:

A – Car, taxi, station wagon

B – Pickup, small commercial

C – Bus, medium commercial

D – Light truck (2 axles)

E – Medium truck (3 axles)

F – Heavy truck (4 axles)

G – Articulated truck (3 to 6 axles)

There was wide variation in the counts collated of the proportion of the total traffic in each of these vehicle classes. They have been analysed and grouped to incorporate the economic, industrial and road network differences between the Provinces and between road function categories. Traffic data from recent counts (1996 to 1999) were supplied as inputs to the model and several base year runs carried out to calibrate the model for the detailed networks in the four Provinces.

The following groupings have been adopted and the proportions of vehicle classes are shown in Table 4.3:

Group A Major National Highways – Morobe, EHP and WHP.

Group B Major National Highways – SHP.

Group C Other Main Sealed roads – all Provinces.

Group D Main unsealed roads; Morobe – EHP and WHP.

Group E Main unsealed roads – SHP.

Group F Minor Provincial roads – all Provinces.

Group G Institutional roads – all Provinces.

TABLE 4.3: VEHICLE PROPORTIONS BY ROAD TYPE

Road Group	Road Type	Provinces	Car	Pick-Up	Bus	Light Truck	Medium Truck	Heavy Truck	Art. Truck
A	Major National Highways	Morobe, EHP, WHP	18.0%	48.0%	25.0%	3.0%	1.0%	1.0%	4.0%
B	Major National Highways	SHP	35.0%	24.0%	15.0%	10.0%	4.0%	4.0%	8.0%
C	Other Main Sealed Roads	ALL	30.0%	35.0%	18.0%	10.0%	3.0%	2.0%	2.0%
D	Main Unsealed Roads	Morobe, EHP, WHP	10.0%	45.0%	15.0%	23.0%	3.0%	2.0%	2.0%
E	Main Unsealed Roads	SHP	18.0%	27.0%	15.0%	30.0%	3.0%	3.0%	4.0%
F	Minor Provincial Roads	ALL	12.0%	35.0%	15.0%	30.0%	6.0%	1.0%	1.0%
G	Institutional Roads	ALL	25.0%	35.0%	15.0%	15.0%	6.0%	3.0%	1.0%

The principal factors affecting the proportion of vehicles of each class are:

- Southern Highlands Province is more remote from centres of administration, distribution and from markets. Transport costs are therefore higher than for other provinces and there is a higher proportion of larger commercial vehicles.

- The roads in Southern Highlands Province in general have a much worse condition than those in the other provinces. There are fewer buses on major roads, and it appears that the total amount of travel (the number and length of trips made by each family unit) is lower because of remoteness and road condition.

The vehicle classes were grouped into car and pickup, bus and light truck, and medium trucks to articulated trucks as shown in Table 4.4. This grouping demonstrates a more consistent fleet make up on the road categories.

TABLE 4.4: VEHICLE CLASSES – GROUPED

Road Group	Road Type	Provinces	Grouped Proportions		
			Cars + Pick-Up	Bus + Light Truck	Medium Articulated Truck
A	Major National Highways	Morobe, EHP, WHP	66.0%	28.0%	6.0%
B	Major National Highways	SHP	59.0%	25.0%	16.0%
C	Other Main Sealed Roads	ALL	65.0%	28.0%	7.0%
D	Main Unsealed Roads	Morobe, EHP, WHP	55.0%	38.0%	7.0%
E	Main Unsealed Roads	SHP	45.0%	45.0%	10.0%
F	Minor Provincial Roads	ALL	47.0%	45.0%	8.0%
G	Institutional Roads	ALL	60.0%	30.0%	10.0%

4.4.3 Traffic Counts Variability

The traffic count data collated for the Study has exhibited a high degree of variability; between sites which would be expected to have comparable flows; at stations over time periods when a stable growth variation might be expected; and in the proportions of different vehicle classes at comparable sites. This variability results from three sources:

- Errors in enumeration and transcription;
- Statistical variability associated with reasonably homogeneous populations; and
- Overlying major changes in travel behaviour of the communities in the four Provinces over time.

The first two sources of error are statistical in nature and are expected and allowed for in traffic engineering practice. They are reduced by a greater emphasis on travel data collection and analysis within the relevant departments.

The third source of variability is true variability in travel behaviour as discussed in Section 4.2 and is a reflection on the change which the communities are undergoing from their presently undeveloped state as services (schools, health clinics and administration) and infrastructure (water supply, electricity, communications and roads) is extended into these Provinces and as commerce and economic activity evolve.

The variability in traffic flows affects the forecasting of future traffic on which economic evaluation is based and for which road construction standards are applied. Growth rates based on a low reading of historical trends will result in under-investment in the road network, whilst a high reading of trends could result in over-investment. However, in conditions of budget constraints, as applies in PNG, and if a strict economic feasibility analysis is adopted, as was done in this study, this real traffic variability will have little effect on selection of recommended road upgrade sub projects.

4.5 TRAVEL BY PEOPLE

4.5.1 Passenger Carrying Vehicles

A considerable proportion of traffic carries passengers. Enumerators who conducted the field counts for this study noted the significance of passenger transport in the traffic stream. In this discussion passengers are those who are using the vehicle for transport but who are not otherwise involved with business use of the vehicle. Some of the "cars" and "pick up" vehicle class carried passengers and many of the light trucks were also acting as passenger transport, particularly on unsealed roads where rough road conditions did not favour conventional buses because they incur damage too readily.

Without data on trip lengths or purposes it is not possible to quantity the amount of passenger travel, but it is possible to estimate the number of people travelling by vehicle on the road system, as discussed further in Section 6.1.4.

Another issue deriving from the traffic data is the treatment of time. Measurement of value of travel time in developing countries is always complex and includes a high degree of uncertainty. Wages do not properly reflect the economic costs of labor (high unemployment and under-employment); there is no satisfactory framework for measurement of the value of non-working travel time especially in rural areas; absence of an empirical base and studies on issues such as willingness to pay for time and social value of leisure; no distinction is made between value of travel time using noncommercial vehicle types (car and pick-up) and value of travel time using commercial vehicles (PMV and Bus).

The economic analysis in Chapter 6 does not quantify passenger and pedestrian travel.

4.5.2 Pedestrian Facilities

The significance of roads for personal transport is highlighted in the previous section and supports social requirements of road infrastructure presented in Volume 4. People travelling as passengers become pedestrians before and after they access a vehicle. Facilities are required as part of the road infrastructure for pedestrians, both those accessing vehicles and those using the road corridors. The basic provisions required for road travellers and pedestrians are:

- Paths along the road for pedestrians at locations of high activity such as villages.
- Pedestrian access to paths linking into abutting land.
- Stopping points for vehicles to pick up and set down passengers.

4.6 TRAFFIC DATA SETS FROM HDM III ANALYSIS

The traffic information was collated and is set out as input to the HDM III model in Appendix E. The input data provides 1999 AADT subdivided for each vehicle category and growth rates for traffic from 2000 to 2010 and from 2011 to 2020 for each section of road.

Base year (1999) traffic was taken from the count data presented in Section 4.3.4 and Appendix E. Counts were not available for every section of road investigated, and counts on comparable roads and the Carts model flow for 1999 were used to infill missing data. The variability in traffic counts was checked with the model which provided a set of internally consistent traffic flows on every road section.

Traffic growth was reported by the Carts model (Section 4.2) for each road section for the two periods, 1999 to 2009 and 2010 to 2020. These growth rates were examined for internal consistency and where the model was showing some extreme values, mostly on very low trafficked roads, adjustments were made manually. The modelled traffic flows and adopted period growth rates are given in Appendix E.

CHAPTER 5. ROAD IMPROVEMENT PROPOSALS AND COSTS

5.1 INTRODUCTION

The Consultant inspected the study roads in the four Provinces and determined options for improvements. The improvements comprised upgrading, rehabilitation and maintenance. A range of strategies for improvement works was developed to define the extent of the works tested in the economic modelling.

The costs for road upgrading and rehabilitation works were determined from reviewing design and contract documentation for similar projects. The costs for maintenance works were determined in consultation with the OoW and from maintenance projects, and defined in the particular format for the HDM analysis. All costs are based on February 1999 prices.

5.2 ROAD IMPROVEMENT STRATEGIES

5.2.1 Introduction

Road improvements comprising of upgrading, rehabilitation and maintenance are presented in Table 5.1. Rehabilitation restores the road to its original standard or better while upgrading provides a sealed surface to a gravel pavement. Maintenance is the regular activity to minimise the degradation of the road. The objective of the improvement strategies is minimise the total cost over the life cycle for a road when considering its existing condition.

5.2.2 Road Upgrading

Road upgrading provides for sealing existing gravel roads and generally involves reconstruction of the pavement and improvement of drains, culverts, bridges and road furniture. The upgrading also provides the opportunity to improve the safety of the road by changing the alignment to improve sight distance, changing the geometry to comply with approved engineering standards, and installing safety features such as guardrail. Therefore the upgrading of a road provides a significant step in the evolution of the roadway and requires a significant capital investment compared to the high recurring maintenance cost for a gravel road. Feasibility studies are often conducted for major roads to determine if the proposed upgrading is economically viable.

TABLE 5.1: ROAD IMPROVEMENT DEFINITIONS

IMPROVEMENT	EXISTING PAVEMENT	DESCRIPTION OF IMPROVEMENT WORKS
REHABILITATION	Sealed	Selective repair, strengthening of pavement with drainage improvements to restore structural strength and resealing to restore ride quality
	Gravel	Selective repair, strengthening of pavement with drainage improvements to restore structural strength and resheeting to restore ride quality
UPGRADING	Unsealed	Road improvement related to width, alignment, curvature, or gradient of road, and sealing of unsealed road to improve traffic speed, safety or capacity
MAINTENANCE	Sealed	Routine - local repair of roadway and pavement, grading of shoulders, regular maintenance of road drainage, side slopes, verges, furniture; vegetation removal and maintain safety devices. Resurfacing - reseal to preserve structural integrity and ride quality of pavement and forms part of periodic maintenance
	Gravel	Routine - grading of surfaces and shoulders, regular maintenance of road drainage, side slopes, verges, furniture; vegetation removal and maintain safety devices. Resurfacing - regravel to preserve structural integrity and ride quality of pavement and forms part of periodic maintenance.

5.2.3 Road Rehabilitation

(a) Gravel Roads

Rehabilitation of gravel pavements involves resheeting works and improvements to the drainage system to restore the road to a sound gravel pavement with effective drainage. Material conforming with engineered specifications is adopted to reduce the pavement roughness, which otherwise increases quickly when unscreened material is used.

A significant cost associated with rehabilitation of gravel pavements is the haulage from the quarry to the site of the works.

(b) Sealed Pavements

Rehabilitation of sealed pavements involves pavement reconstruction which restores the road its earlier condition and allows the road to be maintained under a planned maintenance regime. In this option the road is assumed to only require rehabilitation of the pavement as the drainage is effective and does not require substantial improvement.

In the maintenance option, the unit cost rates provided in HDM will allow calculation of the cost of the pavement rehabilitation works based on the degrees of distress determined in the fieldwork.

In a rehabilitation project, specific works are identified from engineering studies, and the works are specified in a contract under LCB or completed under day labour. A specific example is the pavement rehabilitation for all of the Highlands Highway in Morobe Province funded by the ADB under LCB with construction under two contracts by Coecon.

5.2.4 Road Maintenance

Alternative maintenance strategies were developed from various combinations of maintenance operations and standards. A maintenance operation is defined as a specific activity such as resealing or grading. A maintenance standard is a defined amount of an operation, such as resealing every 6 years, or patching of 75% of all potholes. Maintenance strategies comprise practicable combinations of maintenance standards such as routine maintenance and grading every 180 days.

(a) Maintenance Operations

Maintenance operations were selected from available operations in the HDM Model operations and comprise:

Gravel Roads	**Sealed Roads**
Routine Maintenance	Routine Maintenance
Spot Regravelling	Patching
Gravel Resurfacing	Resealing
	Reconstruction

The detailed list of maintenance operations is shown in Tables 5.2 and 5.3. The tables include measurement of unit costs, cost types and the model controls that enable structuring of the maintenance standards.

(b) Maintenance Strategies

The approach to the formulation of the alternative maintenance strategies used in the HDM model prepared for the Study considered the nature of the analysis and the HDM program limitations. A complex set of eight models was developed to analyse parameters such as the 101 road links and 108 sections, two pavement types, a variety of pavement conditions and 101 traffic sets.

In order to model such a heterogeneous network the Consultant adopted maintenance strategies that assume the following levels of maintenance:

- ❑ Minimum maintenance
- ❑ Regular maintenance
- ❑ Improved maintenance
- ❑ Rehabilitation and upgrading

Minimum maintenance was defined to reflect a maintenance regime under low funding conditions. In economic evaluation terms this strategy represents the 'base case'.

Regular maintenance assumes an adequate routine maintenance regime including limited pavement repairs. Improved maintenance includes both adequate routine and periodic maintenance with more intervention levels.

The rehabilitation and upgrading strategy includes major capital works such as pavement reconstruction or upgrade from gravel to sealed roads.

Each maintenance strategy was composed from a combination of the maintenance standards separately for the sealed and gravel roads. The summary of the maintenance standards is shown in Table 5.4.

TABLE 5.2: LIST OF MAINTENANCE OPERATIONS USED IN THE HDM-III MODEL – GRAVEL ROADS

Operation	Description	Unit Cost	Cost type	Model Contol		
				Scheduled	Condition Responsive	Other
Grading	Shaping the gravel surface layer.	K per km graded	Recurrent	• Time interval between gradings (days)	• Traffic interval between gradings (vehicles) • Minimum applicable time interval (days) • Maximum applicable time interval (days)	
Spot Regraveling	Repair of areas of severe depressions (gravel loss, rutting, potholes)	K per m^3	Recurrent	• Gravel volume (m3/km/year)	• Percent annual material loss replaced (%) • Maximum applicable gravel volume (m3/km/year)	
Resurfacing	Gravel resurfacing in fixed intervals or in response to reduced gravel thickness of gravel surface.	K per m^3	Capital	• Resurfacing interval (years)	• Minimum allowable thickness (mm) • Minimum applicable resurfacing interval (years) • Maximum applicable resurfacing interval (years)	- increase in gravel thickness (mm) - last applicable year - initial roughness (IRI) - material properties (passing sieves, plasticity index)
Routine Maintenance	Includes drainage maintenance, vegetation control, shoulder maintenance, etc.	K per km per year	Recurrent	N/A	N/A	

TABLE 5.3: LIST OF MAINTENANCE OPERATIONS USED IN THE HDM-III MODEL – SEALED ROADS

Operation	Description	Unit Cost	Cost type	Model Contol		
				Scheduled	Condition Responsive	Other
Patching	Includes surface patching and repair of small areas with surface distresses, and filling the potholes	K per m^2	Recurrent	Area to patch (m^2/km/year)	• Pothole area to be patched (%) • Maximum applicable area (m^2/km/year)	- last applicable year - Max. applicable roughness (IRI)
Resealing	Resurfacing operation that repairs surface distresses. It implies preparatory patching.	K per m^2	Capital	Resealing interval (years)	• Maximum allowable total damaged area (%) • Min. applicable resealing interval (years) • Max. applicable resealing interval (years)	- resealing type - resealing strength - resealing thickness - last applicable year - Max. applicable roughness
Reconstruction	It applies in the model to all works that require re-specification of the surfacing and base types. and pavement thickness and strength parameters. The costs include cost of scarification, stripping, base repair, recompaction and resurfacing.	K per m^2	Capital	Reconstruction interval (years)	• Maximum allowable roughness (IRI)	- Min. reconstruction interval (years) - Max. reconstruction interval (years) - New structural number - New layer thickness - Last applicable year - initial roughness (IRI)
Routine Maintenance	Includes drainage maintenance, vegetation control, shoulder maintenance, etc.	K per km per year	Recurrent	N/A	N/A	

TABLE 5.4: MAINTENANCE STRATEGIES

Strategy	DESCRIPTION	MAINTENANCE STANDARDS
Minimum Maintenance	Current maintenance regime assuming low funding, i.e. partially covers routine (non-pavement) maintenance and emergency works.	Sealed: Routine maintenance Patching (<100%) Gravel: Routine maintenance Spot regraveling (<100%)
Regular Maintenance	Higher maintenance level that assumes adequate routine maintenance and pavement repairs. Roughness and the extent of repair increases until rehabilitation is required.	Sealed: Routine maintenance Full patching, limited texture improvement Gravel: Routine maintenance Grading at regular intervals Spot regraveling
Improved Maintenance	Adequate maintenance standard that includes both regular maintenance and periodic maintenance. Roughness increases but at a slower rate than for regular maintenance.	Sealed: Routine maintenance Full patching Resealing at regular intervals Gravel: Routine maintenance Grading at regular intervals Spot regraveling Resheeting at regular intervals
Rehabilitation and Upgrading	Sufficient funding situation that allows undertaking major capital works to reconstruct the pavement or upgrade it to sealed surface when required along with improved maintenance standard. Rehabilitation is carried out at an economically optimal time when the costs of routine and periodic maintenance and vehicle operating costs become so high that rehabilitation is warranted.	Sealed: Reconstruction when required Routine maintenance Full patching Resealing at regular intervals Gravel: Upgrade to sealed when justified Sealed: Routine maintenance Full patching Resealing at regular intervals

(a) Maintenance Strategies – Gravel Roads

(i) Minimum maintenance includes the following operations and standards

- routine maintenance;
- grading after 50,000 vehicle passes; and
- spot regravelling with replacement of 50% of lost material, limited to 15 m^3 per kilometre per year.

(ii) Regular maintenance includes the following operations and standards

- routine maintenance;
- grading after 25,000 vehicle passes; and
- spot regravelling, replacing 50% of material lost.

(iii) Improved maintenance for gravel roads includes:

- routine maintenance;
- grading after 25,000 vehicle passes;
- spot regravelling, replacing 30% of material lost; and
- gravel resurfacing where gravel thickness is less than 50 mm.

(iv) Upgrade strategy includes:

- routine maintenance of the gravel road to the 'regular maintenance' strategy prior to upgrading.
- upgrade to sealed road.
- maintenance of sealed road (routine maintenance + full patching + resealing).

(b) Maintenance Strategies – Sealed Roads

(i) Minimum maintenance for sealed roads includes:

- routine maintenance; and
- patching of 50% of area affected by potholes.

(ii) Regular maintenance for sealed roads includes:

- routine maintenance;
- full patching; and
- resealing when 75% of the surface is affected by damage and distress.

(iii) Improved maintenance for sealed roads includes:

- routine maintenance;
- full patching; and
- resealing when 25% of the surface is affected by damage and distress.

(iv) Rehabilitation strategy includes the following operations and standards:

- routine maintenance;
- full patching;
- reconstruction when roughness IRI reaches 5.5 mm/km; and
- resealing at regular intervals.

In defining the above strategies the following assumptions were adopted:

- Grading includes a combination of the patrol and team grading operations. It is priced as a weighted average assuming that the team grading follows two patrol grading operations.
- Regravelling assumes use of the same gravel type as that of the original surfacing. The thickness of regravelling is 150mm.
- Upgrade to sealed road assumes use of an adopted design standard appropriate for road categories A, B or C as discussed in Chapter 2.
- Maintenance of new sealed roads includes routine maintenance, full patching and resealing when total damaged area of surface exceeds 25%. This maintenance starts one year after completion of construction. In the meantime, it is assumed the contractor is responsible for maintenance within the warranty period.
- Resealing was taken to consist of the application of a single coat up to 19mm thick with a strength coefficient of 0.25. The resealing operation is condition responsive, triggered by maximum allowed area that is affected by cracking, potholling and ravelling.
- Patching is considered as both a separate operation and a part of resealing operation, i.e. 'preparatory patching'.

The reconstruction operation consists of removing existing seal, scarifying and recycling existing base course, strengthening and compacting the base course and applying a two coat bituminous surface treatment with thickness of 25 mm. This operation is condition responsive, triggered in the HDM model by maximum allowed roughness level.

5.2.5 Selection Of Road Improvement Proposals

As described in Section 2.4.5 a system of functional classification has been developed based on network connectivity and traffic flows, and on the present road classification used by DOTWCA and the Provincial Administrations. A detailed picture of the road network was developed from the field survey, examination of reports from previous studies, discussions with DOTWCA other government officers and professionals in the Provinces and in Port Moresby and from a study of the traffic count data. This was translated into a hierarchy classification for each of the road sections being examined. Design standards for these functional classification groups are based on those in the Road Design Manual and are given in Section 2.4.5.

The road management principles adopted in setting up the improvement proposals to be examined in detail were:

(a) All roads will be maintained into the long term; three standards of maintenance – "maintenance regimes" – will be evaluated and the most cost effective will be recommended for funding; these are termed minimum, regular and improved maintenance.

(b) If a road already has a sealed pavement then it will be maintained to its present formation width for the period of analysis; if its condition were to deteriorate sufficiently then the pavement surface will be rehabilitated by pavement reconstruction to a sealed surface.

(c) If a road now has a gravel pavement it will be examined to see what will be the economic feasibility of upgrading it to a sealed pavement to the design standard appropriate to its functional classification; the timing of upgrading will be assumed to be within the five years from 2000; prior to upgrading the road will be maintained to a regular regime and following upgrading to an improved regime.

(d) The standards propose that gravel roads in Categories A, B and C should be examined for the economic feasibility of upgrading to a sealed pavement. As the method of analysis using HDM III was available, roads of Category C were also tested for upgrading to a sealed pavement though economic feasibility was unlikely.

The road system examined in this study is scheduled in detail in Chapter 2 and is described as follows, using the functional classification adopted.

Category A – Highways

- Highlands Highway – Lae, Watarais, Goroka, Mt Hagen, Kisenpoi, Mendi.
- Ramu Highway – Waterais to Madang border.
- Enga Highway – Togoba to Enga border.
- Kagamuga Airport access road, Mt Hagen.

Category B – Main Roads

- Wau Road – Highlands Highway to Wau.
- Bukawa Road – Malahang to Buso.
- Aiyura Road – Kainantu to Aiyura.
- Goroka – Police and CIS access road.
- Korofegu-Oleguti – Okapa Road.
- Baiyer Road – Mt Hagen to Kumdi School.
- Ogelbeng, Ambra, Kotna, Banz, Dona, Highlands Highway road.
- Mendi – Tari Road.
- Erave Road – Highlands Highway to Ialibu.

Category C, Secondary Roads and Category D, Connector Roads are the remaining roads and are scheduled in Table 2.2.

5.3 ROAD UPGRADING COSTS

5.3.1 Introduction

Road upgrading provides for improvement and sealing of gravel roads which changes the nature of the road significantly. Three categories of upgrading projects have been determined based on design and construction standard, traffic volumes and importance of the road in the road network.

The quantities for the upgrading works determined in each road category are based on bills of quantities and design reports for similar projects under construction or subject to preliminary or detailed design. The documentation was reviewed and compared to determine the estimated quantities per kilometre for each road category.

Unit rates and percent items were determined from construction projects underway for projects in a similar category. While the unit rates vary for projects in different terrain and provinces, the rates selected reflect current prices for similar works. The costs for upgrading and maintaining bridgeworks were estimated separately for typical road sections in each category and included in the upgrading costs for each improvement proposal. All costs are based on February 1999 prices.

5.3.2 Category A Roads

Category A roads comprise major inter Provincial roads. For these projects, the upgrading resembles reconstruction of the road to provide a high standard road. These roads generally have traffic volumes in excess of 500 vpd, with many sections of the Highlands Highway having volumes in excess of 1,000 vpd.

Construction of roads underway in this category include:

- Ramu Highway in Madang Province funded by the EU with construction under ICB by a chinese contractor.
- Mumeng – Bulolo section of the Wau Road funded by the OECF with construction under ICB by a foreign contractor.
- Mendi – Kisenpoi section of the Highlands Highway funded by AusAID with construction under LCB by Global Construction.
- Wabag – Wapenamanda section of the Enga Highway to funded by AusAID with construction about to commence under LCB.

The documentation from these projects provided details of quantities for road upgrading works in this category and current construction rates.

5.3.3 Category B Roads

Category B roads comprise major roads that link highly populated districts within a Province such as the Korefugo – Oliguti road in EHP, Koroba road in SHP and the Ogelbeng – Donna road in WHP. The traffic volumes in this category are in the range 250 – 500 vpd.

Roads designed or constructed in this category include:

- Korefugo – Oliguti road, a provincial road in EHP constructed under LCB with funding by the ADB.
- Ogelbeng – Dona Road, with detailed design prepared by Kinhill Kramer in 1994.
- Kagua Road, with detail design prepared by Frame Harvey West & Maso in 1992.

A Category B1 road was developed to allow for significant excavation of high batters where the road bench for existing roads in mountainous terrain is very narrow. An example is the Wau road from Bulolo to Wau in Morobe Province.

5.3.4 Category C Roads

Category C roads comprise roads that link villages or less populated districts within a Province such as the Okapa road in EHP, Kagua road in WHP. The traffic volumes in this category are in the range 150 – 250 vpd.

Roads designed or constructed in this category include:

- Okapa road, a provincial road in EHP, with upgrading underway by day labour under ADB funding.

A Category C1 road was developed to allow for significant excavation of high batters where the road bench for existing roads in mountainous terrain is very narrow. An example is the Aseki road and the Aseki - Menyamya road in Morobe Province.

5.3.5 Cost Estimates

The major parameters used to determine the quantities for works are provided in Table 5.5 and the rates for major cost items and percent items adopted in for each road category are listed in Table 5.6.

Table 5.5 Scope of Construction Works for Road Upgrading

GROUP	DESCRIPTION	UNIT	CATEGORY A	CATEGORY B	CATEGORY C
3	CLEARING AND GRUBBING				
	Clear corridor either side of existing road to width	m	2	1.6	1.6
4	EARTHWORKS				
	Vertical and horizontal realignment		Minimum to improve safety	nominal	nominal
5	PAVEMENT MATERIAL				
	Construct road formation with:				
	Pavement width	m	7	6	5.5
	Shoulders	m	1	0.75	0.75
	Base thickness	mm	200	150	150
	Subbase thickness	mm	200	200	180
6	BITUMINOUS SURFACING				
	Prime, binder, and one coat 19mm aggregate of width	m	9	7.5	5.5
	Second coat 13mm aggregate	m	7	-	-
7	DRAINAGE				
	Replace existing culverts and placing new culverts, and extending culverts		Major works	Minor works	Minor works
	Lined drains	m	200	100	100
8	ROAD FURNITURE AND MARKINGS				
	Install guardrails at bridges		yes	yes	yes
	Install linemarking		3 lines	1 line	1 line
9	BRIDGE WORKS				
	Replace or refurbish existing bridges		Replacement & maintenance	Maintenance	Maintenance

TABLE 5.6: COSTS FOR MAJOR CONSTRUCTION ITEMS

Major Item	Rate		
	Category A	Category B	Category C
Construction preliminaries	25%	15%	15%
Contingencies	15%	15%	15%
Day labour	5%	5%	5%
Detailed design and supervision	5%	5%	5%
Supervision	8%	8%	8%
Clearing	K1,600/Ha	K1,600/Ha	K1,600/Ha
Cut to fill	K11/m^3	K11/m^3	K11/m^3
Base material	K60/m^3	K60/m^3	K60/m^3
Subbase material	K50/m^3	K50/m^3	K50/m^3
Prime, bind and one coat bitumen	K8/m^2	K8/m^2	K8/m^2
Second coat bitumen	K5/m^2	K5/m^2	K5/m^2

The financial cost estimates for upgrading works for each road category are provided in Table 5.7, and the economic costs are presented in Appendix D.

The total financials cost for implementing the road works for each category of upgrading works on a cost per kilometer basis are:

Category	Cost (K million/km)
A	0.93
B	0.44
B1	0.54
C	0.36
C1	0.44

The upgrading cost costs for particular gravel roads in each Province is presented in Table 5.8.

5.4 ROAD REHABILITATION COSTS

Road rehabilitation is treated as a maintenance strategy so that the HDM III model determines the timing and extent of rehabilitation works based on characteristics of the road input into the model. For gravel roads the rehabilitation works are treated as gravel resurfacing through maintenance. For sealed roads the maintenance strategy will consider pavement reconstruction to improve pavement properties such as strength and riding quality.

TABLE 5.7 COST ESTIMATES FOR ROAD UPGRADING (Kina/kilometre)

GROUP	DESCRIPTION	UNIT	RATE	CATEGORY A 7 0m Seal		CATEGORY B 6 0m Seal		CATEGORY B1 6 0m Seal		CATEGORY C 5.5m Seal		CATEGORY C1 5.5m Seal	
				Quantity	Amount	Quantity	Amount	Quantity	Amount	Quantity	Amount	Quantity	Amount
1 & 2	GENERAL ITEMS AND PRELIMINARIES												
	Percentage of Groups 3 - 9			25%	137,025	15%	41,979	15%	51,879	15%	34 245	15%	42,660
3	CLEARING AND GRUBBING												
	Clear corridor	Ha	1600	2 0	3,200	1 6	2,560	1 6	2,560	1 6	2,560	1 6	2,560
4	EARTHWORKS												
	Cut to fill	m3	11.00	13,000	143,000	2,000	22,000	8,000	88,000	900	9,900	6,000	66 000
5	PAVEMENT MATERIAL												
	Scarify, trim and compact existing pavement	m2	0.90	11,000	9,900	10,000	9,000	10,000	9,000	7,600	6,840	7,600	6,840
	Supply, spread, trim, and compact base material	m3	60.00	1,900	114,000	1,180	70,800	1,180	70,800	1,100	66,000	1,100	66,000
	Supply, spread trim, and compact subbase material	m3	50 00	2,100	105,000	1,750	87,500	1,750	87,500	1 480	74,000	1,480	74,000
6	BITUMINOUS SURFACING												
	Supply, place prime, binder, and one coat 19mm aggregate	m2	8.00	9,000	72,000	7,500	60,000	7,500	60,000	5 500	44,000	5,500	44,000
	Supply, place second coat 13mm aggregate	m2	5.00	7,000	35,000	-	-	-	-	-	-	-	-
7	DRAINAGE												
	Lump sum for replacing existing culverts and placing new culverts, and extending existing culverts	Item			20,000		8,000		8,000		7,000		7,000
	Install lined drains	m	100	200	20,000	100	10,000	100	10,000	100	10,000	100	10,000
8	ROAD FURNITURE AND MARKINGS												
	Install guardrails at bridges and linemarking	Item			6,000		4,000		4,000		4,000		4 000
9	BRIDGE WORKS												
	Replace or refurbish existing bridges	Item			20,000		6,000		6,000		4 000		4 000
	TOTAL GROUP 1 - 9				685,125		321,839		397,739		262,545		327 060
	Add contingency - % of Groups 1 - 9			15%	102,769	15%	48,276	15%	59,661	15%	39,382	15%	49 059
	Add dayworks - % of Groups 1 - 9			5%	34,256	5%	16,092	5%	19,887	5%	13 127	5%	16,353
	TOTAL - CONSTRUCTION				822,150		386,207		477,287		315 054		392 472
	Detailed Design - % of construction cost			5%	41,108	5%	19,310	5%	23,864	5%	15,753	5%	19,624
	Supervision - % of construction cost			8%	65,772	8%	30,897	8%	38,183	8%	25,204	8%	31 398
	PROJECT TOTAL (Kina / kilometre)				929,030		436,414		539,334		356,011		443,493
	rounded				930,000		440,000		540 000		360,000		440,000

Table 5.8 Candidate Upgrading Roads with Financial and Economic Costs (Kina million)

Road Number	Road Name	Location	Section	Pavement Type	Gravel Length Km	Sealed Length Km	Total Length Km	Upgrading Category	Financial Cost	Economic Cost
MOROBE PROVINCE										
NR04	Wau Road	Baiune - Wau [2]	MN11	Gravel/Sealed	19.8	19 1	38.9	B1	10.69	9 20
NM4201	Aseki Road	Bulolo - Pararua	MN12	Gravel	32.8		32.8	C1	14.43	12.41
NM4201	Aseki Road	Pararua - Aseki	MN13	Gravel	51.2		51 2	C1	22.53	19.37
ND4201	Bukawa Road	Malahang - Busu	MN14	Gravel/Sealed	3 0	5.0	8 0	B	1.32	1.14
ND4201	Bukawa Road	Busu - Buso	MN15	Gravel	28 7		28 7	C	10.33	8 89
EASTERN HIGHLANDS PROVINCE										
ND4102	Duantina-Dumpu Road	Dunantina - Dumpu	EN09	Gravel	47.7		47.7	C1	20.99	18.05
NI4102	Institutional Road	CIS	EN10	Gravel	6 7		6.7	B	2.95	2.54
	Provincial Road	Oleguti - Okapa [3]	EP12	Gravel	28.0	16 0	44 0	C	10.08	8.67
	Provincial Road	Raipinga - Okapa	EP13	Gravel	49.0		49.0	C	17.64	15.17
	Provincial Road	Oleguti - Lufa	EP14	Gravel	15.0		15 0	C	5.40	4.64
	Provincial Road	Aiyura - Obura	EP15	Gravel	32.0		32.0	C1	14.08	12.11
	Provincial Road	Goroka - Lahame	EP16	Gravel	13 0		13.0	C	4.68	4 02
	Provincial Road	Lahame - Magabo	EP17	Gravel	21.0		21.0	C	7.56	6 50
	Provincial Road	Goroka - Unggai	EP18	Gravel	29.0		29 0	C	10.44	8.98
	Provincial Road	Asaro - Lapego - Kifamu	EP19	Gravel	20.0		20.0	C	7.20	6.19
WESTERN HIGHLANDS PROVINCE										
NM3901	Baiyer Road	Kumdi School - Baiyer R	WN11	Gravel	28 3		28 3	C	10.19	8.76
NM3903	Ogelbeng-Dona Road	Ogelbeng - Ambra	WN14	Gravel	9.2		9.2	B	4.05	3.48
NM3903	Ogelbeng-Dona Road	Ambra - Kotna	WN15	Gravel	15 5	4.0	19.5	B	6.82	5 87
NM3903	Ogelbeng-Dona Road	Kotna - Banz	WN16	Gravel	33.0		33 0	B	14 52	12.49
NM3903	Ogelbeng-Dona Road	Banz - Dona	WN17	Gravel/Sealed	13 2	6.0	19.2	B	5.81	4 99
NI3901	Institutional Road	Tea	WN18	Gravel	4.0		4.0	C	1.44	1 24
NI3901	Institutional Road	CIS	WN19	Gravel	11 3		11 3	C	4.07	3 50
	Provincial Road	Tomba - Tambul	WP20	Gravel	16.0		16 0	C	5.76	4.95
	Provincial Road	Kagamuga - Kelua #1	WP26	Gravel/Sealed	8.7	3.5	12 2	C	3.13	2 69
	Provincial Road	Wurup - Korn Farm	WP28	Gravel	6 3		6.3	C	2.27	1.95
	Provincial Road	Kindeng - Kondopina	WP31	Gravel	10.3	1.0	11 3	B	4 53	3.90
	Provincial Road	Banz - Karap	WP33	Gravel	36.5		36 5	C	13.14	11.30
	Provincial Road	High. Hwy - Donna - Nondugal	WP34	Gravel	7 8		7.8	C	2.81	2.41
SOUTHERN HIGHLANDS PROVINCE										
NR07	Highlands Highway	Kisenapoi - Kumbame	SN02	Gravel	23.8	0.0	23 8	A	22.13	19.04
NR07	Highlands Highway	Kumbame - Ankura Bridge	SN03	Gravel	10.1	0 0	10 1	A	9.39	8.08
NM3701	Koroba Road	Mendi - Kar Mission	SN05	Gravel	35.0	0.0	35 0	B	15.40	13.24
NM3701	Koroba Road	Kar Mission - Fakandah	SN06	Gravel	37.0	0.0	37.0	B	16.28	14.00
NM3701	Koroba Road	Fakandah - Ambua Lodge	SN07	Gravel	54.2	0.0	54.2	B	23.85	20.51
NM3701	Koroba Road	Ambua Lodge - Tari	SN08	Gravel	22.4	0 0	22.4	B	9.86	8.48
NM3701	Koroba Road	Tari - Koroba	SN09	Gravel	38.5	0 0	38.5	C	13.86	11.92
NM3701	Koroba Road	Koroba- Fugwa T/O	SN10	Gravel	7 8	0 0	7.8	C	2.81	2.41
NM3703	Erave Road	Kisenpoi - Ialibu	SN12	Gravel	15.6	0 0	15 6	B	6.86	5 90
NM3703	Erave Road	Ialibu - Kagua	SN13	Gravel	31.8	0 0	31.8	C	11 45	9 85
NR05	Wabag - Mendi Road	Peane - Mendi	SN18	Gravel/Sealed	25 0	1 0	26.0	C	9 00	7.74
ND3704	Tambul Road	Koine - Tambul	SN21	Gravel	64.0	0 0	64.0	C	23.04	19 81
ND3705	Pangia Road	Ialibu - Pangia	SN22	Gravel	23.0	0 0	23 0	C	8 28	7 12
	Provincial Road	Ialibu - Kumbene	SP23	Gravel	12 7	0 0	12 7	C	4 57	3.93

5.5 ROAD MAINTENANCE COSTS

5.5.1 Introduction

The HDM III model requires that unit maintenance costs be developed for a range of maintenance activities that are to be considered for implementation in a maintenance or rehabilitation program. The activities are divided into the categories of routine and periodic maintenance for each of the project roads.

The maintenance activities are defined by specific work tasks performed by a crew of personnel using specific equipment and material. A formal definition of a particular maintenance activity is important to define the work included in each activity.

The activities are divided into gravel road maintenance and sealed road maintenance.

5.5.2 Gravel Road Maintenance

Maintenance operations for gravel roads are divided into two groups:

Recurrent maintenance:

- routine – miscellaneous
- grading
- spot regravelling – patching

Periodic maintenance:

- gravel resurfacing.

Routine Maintenance

Routine maintenance activities are those activities that are not pavement or traffic related and have to be performed on a routine recurring basis. The HDM III model considers routine maintenance to be one activity.

Routine maintenance normally covers the following items:

Vegetation control

Ditch clearing

Culvert and bridge cleaning

Culvert and bridge repair

Shoulder maintenance

Erosion control

General road maintenance

The unit cost for routine maintenance is measured in Kina per kilometre per year.

Grading

Grading is shaping of the gravel surface layer in order to control roughness and corrugations. To reflect the practice in the provinces, in this study grading assumes a combination of the 'patrol' grading (grader only) and 'team' grading (grader, roller and water truck). The HDM-III model assumes that the grading is performed in regular time intervals, or alternatively after a fixed number of vehicle passes. The unit cost for grading operation is measured in Kina per kilometre graded.

Spot Regravelling

Spot regravelling, also called patching, is applied to severe depressions, potholes, ruts and erosion gullies. This operation is assumed to be done every year. Its extent is defined in the model as a replacement of specified percentage of material lost each year. The unit cost for spot regravelling is measured in Kina per cubic metre.

Regravelling

Regravelling or gravel resurfacing is applicable where the surface gravel material is worn away by traffic and/or eroded by rain. Regravelling operation is required to replace lost surfacing material and increase the thickness of the gravel layer. The HDM-III model considers this operation as a periodic maintenance and may be performed in fixed intervals or in response to reduced gravel thickness. Unit cost for regravelling is measured in Kina per cubic metre.

5.5.3 Sealed Road Maintenance

Maintenance operations for sealed roads are selected to mach the characteristics of pavements in the study area (surface treatments type of pavement). The operations are divided into the following two groups and four categories.

Recurrent maintenance:

- routine maintenance – miscellaneous
- patching

Periodic maintenance:

- resealing
- pavement reconstruction

Routine Maintenance

Routine maintenance is carried out annually and includes attention to shoulders, ditches, culverts, slopes and road furniture. It is required irrespective of the traffic volume. The HDM does not model the effects of alternative levels of routine maintenance to the pavement condition. A lump sum cost per kilometre per year is used as a basis for costing routine maintenance.

Patching

Patching operation is applied to repair small areas with surface distresses (cracking and potholes). The patching may be applied by itself or in conjunction with other maintenance operations (i.e. resealing). The various intervention levels are specified in the HDM model (fixed area to be patched per year, or percentage of the area with potholes, or percentage of severely damaged area). The unit cost of patching is measured by Kina per square metre.

Resealing

Resealing assumes applications of a single surface treatment to seal cracks and improve surface texture. Patching precedes this operation. Resealing is triggered in the model when cracking area exceeds a certain percentage (e.g. 50%). The unit cost of resealing is measured by Kina per square meter.

Pavement Reconstruction

Pavement reconstruction is a complete rehabilitation of the pavement. It applies in the model to all works that require re-specification of the surfacing and base types, and pavement thickness, and strength parameters. This activity normally includes scarification, striping, base repair, re-compaction and resurfacing. Reconstruction is performed when roughness exceeds a maximum allowable level. The unit cost of resealing is measured by Kina per square meter.

5.5.4 Resource Unit Costs

The unit costs for the major types of maintenance work are calculated from the resource costs of labour, equipment and materials, and are based on February 1999 prices. The costs presented in this section are in financial terms. These financial costs will be converted into economic costs for use in the HDM III model. An explanation on the conversion of financial costs to economic costs is provided in Chapter 6.

Labour

The labour rates in PNG Kina/day were determined from an analysis of various road maintenance contracts, feasibility studies by other consultants, and from the OoW. The rates that were used in the Study are shown in Table 5.9.

TABLE 5.9: LABOUR RATES (KINA/DAY)

ITEM	FINANCIAL LABOUR RATE
Construction Foreman	20.00
Driver	18.00
Operator	18.00
Skilled Labour	15.00
Unskilled Labour	12.00

Source: OoW: Minute dated 14 January 1999

Equipment

Equipment costs are also stated in PNG Kina/day. The rates for the equipment used in this study are based on data obtained from the OoW and presented in Table 5.10. The costs used will be converted into economic costs by deducting any taxation such as import duties and sales tax to allow use in the HDM III Model and the economic evaluations. This data is presented in Table 5.10.

TABLE 5.10: EQUIPMENT OPERATING COSTS (KINA/DAY)

ITEM	FINANCIAL COST
Bulldozer	300.00
Motor Grader	300.00
Pneumatic Roller 6tn	224.00
Pneumatic Roller 10tn	320.00
Steel Roller	245.00
Bitumen Distributor	80.00
Rotary Broom	40.00
Dump Truck	65.00
Compressor	40.00
Chip Spreader	65.00
Service Vehicle	200.00

Source: OoW: Hire Rates 1998/99

Materials

The prevailing prices for construction materials were obtained from recent bid documentation for major projects. Material unit costs are stated in Kina per unit of measure. The financial prices are shown in Table 5.11.

TABLE 5.11: MATERIAL PRICES (KINA)

ITEM	UNIT	FINANCIAL
Crushed Stone 15-25mm	m^3	55.00
Crushed Stone 5-25mm	m^3	52.00
Bitumen	tonne	903.00

Source: OoW: Recent bid prices

5.5.5 Unit Costs

For each major cost item, the daily output for a team of men and equipment was estimated with the consumption of materials for the output. The mix of labour, equipment, and materials for each of the maintenance activities in this Study has been based upon the current maintenance practices of the OoW. The quantities of each item of labour, equipment, and materials were multiplied by the unit prices in financial terms to obtain the appropriate direct production cost. These financial costs are then converted into economic costs, in the same way in which the capital costs are converted, by applying conversion factors for unskilled labour as discussed in Chapter 6. For input into the HDM III model rates are required per km, and per square/cubic metre depending on the type of maintenance cost.

Table 5.12 shows a summary of the maintenance costs in both financial and economic terms. The economic costs are input into the HDM III model.

TABLE 5.12: SUMMARY OF FINANCIAL AND ECONOMIC COSTS FOR ROAD MAINTENANCE

	OPERATION	UNIT	FINANCIAL COST (K)	ECONOMIC COST (K)
Gravel Roads	Grading	km of road graded	500.00	440.79
	Spot Regravelling	m^3	42.00	34.93
	Gravel Resurfacing	m^3	55.00	47.54
	Routine Maintenance (includes "non-pavement" items: vegetation control, drainage clearing, road furniture, etc.) (Note 2)	km per year	1,753.00	1,314.75
Sealed Roads	Patching	m^2	20.00	16.48
	Resealing (excludes preparatory patching of potholes)	m^2	10.00	9.17
	Reconstruction	m^2	45.00	36.98
	Routine Maintenance (includes "non-pavement" items: vegetation control, drainage clearing, road furniture, etc.) (Note 3)	km per year	2,092.00	1,569.00

Note

1. Rate for grading is a weighted average for team and patrol grading.
2. Routine maintenance for gravel roads comprise:
   - Routine Maintenance: Roads K1,184, Bridges K250
   - Emergency Maintenance: Roads K221, Bridges K98
3. Routine Maintenance for sealed roads comprise:
   - Routine Maintenance: Roads K1,476, Bridges K250
   - Emergency Maintenance: Roads K268, Bridges K98

5.6 BRIDGE IMPLEMENTATION WORKS

5.6.1 Maintenance

The cost estimates for bridge maintenance was derived from a study by Works Consultancy[25] in 1996 and adjusted to February 1999 prices using the consumer price index. The adopted rate per kilometre for routine and emerging maintenance are provided in Table 5.13 and were incorporated in the summary of financial and economic costs for road maintenance presented in Table 5.12.

[25] Bridge Inventory and Bridge Management Study, Works Consultancy Services, Draft Final Report, Volume 1, September 1996

TABLE 5.13: COST ESTIMATES FOR BRIDGE MAINTENANCE

Maintenance Type	Network	No. Bridges	Annual Budget K million (Feb 1999)	Total Road Length (m)	Amount pe Bridge (K)	Avg Bridge Per Km	Amount per Km (K)	Adopted per Km (K)
Routine	National	1200	3 32	8,900	2,767	0 13	373	
	Provincial	600	1 53	10,600	2,554	0.06	145	
	Total	1,800	4 85	19,500	2,696	0.09	249	250
Emergency	National	1,200	1 28	8,900	1,064	0.13	144	
	Provincial	600	0 64	10,600	1,064	0.06	60	
	Total	1,800	1.92	19,500	1,064	0.09	98	100

Note: Annual budget adjusted for Feb 1999 prices by consumer price index
Source: Works Consultancy Services, Bridge Inventory and Bridge Management Study Draft Final Report, Volume 1, September 1996

5.6.2 Upgrading

The cost of bridge works as part of a road upgrading project was determined from a review of the extent of bridge works within overall construction projects. The amounts adopted are provided below and represent the lower bound of costs estimated for upgrading projects:

Category A	K20,000/km
Category B	K6,000/km
Category C	K4,000km

Replacement of significant bridges, particularly permanent bridges with concrete deck composite steel been construction, may significantly increase the above cost estimates for a particular road project.

CHAPTER 6. ECONOMIC ANALYSIS

6.1 ROAD USER COSTS

The Vehicle Operating Cost (VOC) sub-model contained in the HDM-III model was used to calculate the effects of the physical characteristics and road conditions on vehicle operating speeds, resource consumption, and maintenance requirements. These relationships in turn determine the operating costs for representative types of vehicles in the study area of Morobe and the Highlands Provinces. The physical state of the travelled surface and its effect upon operating cost was the focus of this study.

The economic cost of road use to the economy, measured in terms of discounted user costs per vehicle-kilometre over the analysis period, forms the basis of estimating benefits or user savings with different maintenance strategies. Economic costs for fuel, vehicles, spare parts, and tyres have been derived from the financial costs or end-customer prices by removing Customs import duties, excise taxes, Drought Relief Fund surcharges, and provincial sales taxes. The tax structure on vehicles, spare parts, and tyres is shown in Appendix D Table D.11; Economic cost inputs and vehicle parameters which were used as inputs to the VOC sub-model are shown in Appendix D Table D.13.

6.1.1 Vehicle Operating Costs

For input to the VOC sub-model, financial costs for major vehicle types were obtained from interviews with major vehicle dealers and transport operators in Port Moresby, Goroka and Mt Hagen. Data was gathered for eight major vehicle types which represent the spectrum of makes and models in current common use in PNG and particularly the Highlands Highway corridor. Prices for tyres, maintenance parts and labour, and commercial vehicle crew costs were also obtained from dealers and operators.

Vehicle types and their corresponding tyre sizes have been based on the following standard models:

- Passenger car, medium size with 1.5 to 2L motor (typically Toyota Corona/Tercel, Nissan, Mazda).
- Utility/pick-up, one-tonne GVW with diesel engine (typically Toyota Hilux, Nissan 2500, Mitsubishi L200). Because the utility fleet is made up of both single and double cab vehicles with the latter taxed at a higher rate (55% import duty compared to 11% for commercial vehicles) an average cost weighted by import composition was used for the financial and economic costs).
- Bus, the vehicle type used for the VOC model is a 5.3 tonne GVW with diesel engine; costs were derived from the average PMV based on traffic composition, a weighted average of 15 passenger mini-buses, (typically Toyota Hiace or Nissan Urvan) and 25 passenger medium buses, (typically Toyota Coasters and Mitsubishi Rosa).
- Light trucks, diesel with less than 4 tonne unladen weight or max 5.3 tonne GVW (typically a Toyota Dyna 250 or Mitsubishi Canter).
- Medium Truck, diesel with 13 tonne GVW (typically a GD Hino and Mitsubishi Fuso).
- Heavy Truck, diesel with 20 tonne GVW (typically a Hino FS and Nissan Cabstar).
- Articulated tractor trailer combination, diesel tractor with three axles pulling a trailer with a double axle with a 37 tonne GVW (typical prime-mover is a Hino SS, Kenworth, Western Star, and Mack).

Financial costs for passenger cars include a 75% import duty, 1.5% surcharge for the Drought Relief Fund, and provincial sales tax. Except as mentioned above for double cab pick-ups, which incur an import duty of 55%, all other commercial vehicles, tyres, and spare parts incur an import duty of 11% plus Drought Relief Surcharge and provincial sales tax. Diesel fuel incurs an import excise tax of 6 toea/L, while petrol has an excise of 30 toea/L. In addition, provincial sales taxes are imposed on dealer cost.

6.1.2 Vehicle Utilization

Annual hours and kilometres driven have been estimated based on discussions with the motor industry and transport operators. Utilization varies widely depending upon the region, owner and type of operation. For example, private cars circulate mainly in urban area and may only achieve 10,000 km/yr. On the other hand, hire cars and taxis are used more intensively and in the Study area make up more of the on-the-road traffic. Hence 20,000 km was applied for this vehicle type. Economic lives of vehicles also vary widely, depending upon the type of roads and the pattern of maintenance. Service life estimates varied between 4 and 8 years, with 6 years taken as a representative life.

Utility vehicles used by tradesmen and contractors receive more intensive use and annual kilometres were estimated at 35,000. Service life estimates again varied widely, between 3 and 10 years, but 6 years was taken as representative. Buses in the PMV trade are also used intensively with reports ranging from 40,000 km to 100,000 km/yr. For the purposes of this analysis, 55,000 km and a service life of 5 years was used. This is higher than the estimate made in 1995 for the Department of Transport[26] of between 30,000 and 40,000 km/yr, but PMV operators on the Highlands Highway between Goroka and Lae are reporting utilization in excess of 60,000 km/yr.

It is noted that within the Highlands Provinces, the PMV fleet is being run down with operators not setting aside enough revenues to carry out regular maintenance or repairs. Banks are also becoming reluctant to finance purchase of new units until the local economy does improve. It can be expected that in the medium term, a shrinking fleet will be worked to the limit as many of the older vehicles fall out of service and are cannibalized for parts.

Light and medium trucks have been estimated to have service lives of 5 years on average and annual utilization of 45,000 and 50,000 km respectively. This is comparable to estimates made in the 1995 DoT study.

Heavy trucks and articulated vehicles have been estimated to have service lives on an average of 5 to 7 years and annual utilization of 75,000 km and 90,000 km respectively. Again, lives and annual use vary widely among operators. Some tractors serving the resource industry or running on the Mt Hagen - Lae run achieve from 100,000 to 150,000 km/yr. Some of these prime movers are retained for only 3 years, while other fleet operators are running Kenworth and Mack tractors which are 12 to 15 years old. Commercial freight hauliers generally keep their units longer, but extensive motor and power train rebuilds are carried out every 5 to 7 years and vehicles substantially renewed. On the other hand, other fleet operators around Lae and Port Moresby may use their heavy trucks and tractors less than 40,000 km/yr.

6.1.3 Labour Costs

In the 1995 DOT study, there was considerable discussion of rates for maintenance labour and whether to use actual mechanic wage rates or commercial charge-out rates. That study ended using

[26] Vehicle Operating Cost Review, prepared for PNG Department of Transport, Beca International Consultants Ltd., March, 1995.

a financial cost of K17/hr and an economic cost of K8.5/hr. Commercial garage charge-out rates have not changed significantly since then, reported by Port Moresby car agencies in 1999 interviews at K25/hr. Commercial vehicle owners in the study area tend however to do their maintenance in-house and pay their mechanics as skilled labour, earning K5/hr. Since overhead mark-up is applied to commercial vehicle costs in any case, the straight wage rate of K5/hr has been taken as the economic cost for maintenance labour/hr.

Driver wages and crew costs have been based on hourly wages reported by transport operators in Port Moresby, Goroka, and Mt Hagen. For PMV's and light trucks, these were reported to be in the K1.5 to K3/hr with a mid-range of K2/hr which has been used for this analysis. For medium, heavy and articulated trucks, driver wage rates of K3.5, 4 and 4.5/hr have been taken as representative.

6.1.4 Passenger Time Values

For the purposes of the initial runs of the HDM model, no value was assigned for passenger time savings. For subsequent runs and sensitivity tests, weighted passenger time values based on vehicle type, occupancy, and distribution of trips by income group were entered in the HDM. Wage rates of K4, 2, and 0.5/hr have been applied for skilled, semi-skilled, and unskilled labour groups. Occupancies by vehicle type were based on field survey and traffic count data. The passenger time value calculation by vehicle type is shown in Appendix D Table D12.

6.1.5 Generated Traffic Benefits

The lowering of vehicle operating costs following an upgrading will result in more trips being taken, particularly by PMV's, trade, and service vehicles. These benefits to generated traffic arise as a result of increased economic and trip activity catalyzed as a function of reduced transport cost. Following the conventional treatment of consumer surplus thus generated, these benefits are calculated as half the VOC savings times the estimated volume of generated traffic.

The volume of generated or induced traffic is a function of the elasticity of trip response to reductions in VOC. Three different scenarios have been developed to estimate elasticities and their use in calculation of generated traffic volumes and their benefits. These reflect firstly the relative isolation and difficulty in access for communities which will be affected by road improvement. Secondly, the population in the corridor and catchment area is taken into account. The greater the population which will be affected by the road improvement, the higher the elasticity of trip response. The third factor is the present state of agricultural development along the corridor and within the area served by the road. For example, mature areas with existing plantations and little or no remaining land for agricultural extensification will have much less potential to respond with large increases in marketed crops than will "pioneer" areas with available fertile land.

As discussed further below in the section dealing with exogenous benefits, many other factors besides accessibility will affect the response of agricultural producers in growing and marketing more cash crops. While observations of ADT, PMV trip frequency, and vehicle ownership correlate closely with road conditions in the Highlands, evidence from post-investment evaluation studies does not indicate that Highland gardeners respond by growing more produce solely as a result of road improvement.[27] Therefore, generated and induced traffic benefits have been used to approximate benefits which

[27] Post–Investment Evaluation Study, Government of Papua New Guinea Department of Transport, Unisearch (PNG) PTY, University of Papua New Guinea in Association with Beca Gure (PNG) & Hughes Economic Planning, September, 1991. In one of the case studies, that of the Enga Highway, surveys indicated that welfare did increase in terms of consumption and savings with road improvement. Frequency of vehicle use increased because of easier access to vehicles, goods and services. Out of households surveyed regarding perceived benefits, 8 percent cited the benefits of increased production and 48 percent of respondents cited easier access to friends, relatives, and shopping in Mt Hagen.

would accrue to the economy from improvement – over and above those in VOC savings to normal growth traffic. These elasticities of induced trip response and their corresponding percentage increases in generated travel are shown in Table 6.1.

TABLE 6.1: ELASTICITY OF INDUCED TRIP RESPONSE

Induced Travel Potential	Elasticity: % increase in Trips to % chg. In VOC	Generated Traffic as a % of Normal Traffic	Staging of Response: Years After Improvement
Low	-0.3	23%	1
Medium	-0.6	48%	2
High	-0.9	79%	3

6.1.6 Accident Costs

Road safety is of concern and accident costs and occurrence rates are relatively high in PNG. The 1990 Department of Transport Yearbook showed 347 fatalities and 3,175 injuries occurred in 5,046 accidents. An estimated 50,000 vehicles were registered that year. This would imply that accidents occurred at a rate of over 100 per 1,000 vehicles on the road, and there were 63 injuries and 7 fatalities for every 1,000 registrations.

According to the Motor Vehicle Insurance Trust (MVIT), in 1999 there are an estimated 84,000 vehicles on PNG roads, of which perhaps a quarter are unregistered. This vehicle fleet is producing now in the order of 850 insurance claims per year, making an incidence rate of about 10 accidents per thousand vehicles on the road. The MVIT has carried out some analysis of traffic accidents in PNG. According to their studies, about 50% of accidents are apparently attributed to no human error. However, they do cite 18% of accidents as caused by carelessness, and another 13% caused by driving too fast. Unsafe turns, driving too close, and driver inexperience account respectively for about 4% each of accident causes. Utility vehicles and PMV 's account for a major share, respectively about 30% and 36% of injury claims[28]. In a typical year, some 400 accidents can be attributed to drunk-driving, majority of which happen with company and private cars. There are also a large number of pedestrian injuries, of which about 175 children are hit per year.

Although about 55% of the vehicle fleet are domiciled in the Highlands provinces, this region accounts for some 65% of the accidents in PNG. The majority of these accidents occur in or near the urban areas of Goroka, Mt Hagen, and Mendi, and MVIT estimates that 90% of accidents in the region take place on the Highlands Highway. While no "black spot" analysis has been undertaken, failure of vehicles to yield on the numerous one-lane bridges is cited as one common cause on this highway.

Particular concerns of the MVIT are non-roadworthy PMV's and overloaded trucks. The MVIT also has safety concerns about the use of long, heavily loaded "B" trains, which are being introduced on the Highlands Highway. While also discussed in Volume 4 – Initial Social Assessment, measures to improve safety and reduce the social and economic costs of road accidents will entail driver education,

[28] [28] Recently an accident on the Kisenpoi -lalibu road killed two persons and paralyzed one. In this particular case, compensation /fatality amounted to about K76,000 value and was paid out in the following form:
10 large pigs @ K1000 ea
20 medium pigs @ K500/600 ea
20 smaller pigs @ K200
+cash of K50,000

more stringent licensing, and enforcement of traffic rules by police. More police checks and road blocks to test for drunk drivers should also be implemented - particularly during coffee harvest.

In general, as road surfaces are improved, speeds increase and without adequate driver education or police enforcement, severity and frequency of accidents increase in tandem. To aggravate the safety problem, there is no provision for pedestrian traffic or protected crosswalks, even in settlements or near schools on most roads within the study area. Hence, without substantial investment in wider shoulders for pedestrians and sidewalks or footpaths through settlement areas as well as PMV pull-off areas, pedestrian-vehicle conflicts will increase with foot traffic coming out second-best. Hence no accident reduction benefits have been considered for Study projects.

6.2 ECONOMIC ANALYSIS METHODOLOGY

6.2.1 General

The HDM III model has been used to predict discounted total transport costs or net present values according to alternative strategies of routine and periodic maintenance and upgrading for each link being considered. The total transport costs include vehicle operating cost savings (VOC's) and agency costs associated with the life cycle of each alternative strategy. These alternatives are evaluated against the base case alternative, that of minimal maintenance for each link studied. The alternative which yields the highest net present value per associated increment of agency cost stream is the optimal strategy given the level of traffic and existing road condition.

The predicted economic benefits are then transferred in to the Expenditure Budgeting Model (EBM) to analyze and select the set of alternatives which maximizes the total net present value for the entire network subject to budget constraints. The incremental benefit cost ratio is used to choose among strategies for individual segments. This approach measures the increase in net present value associated with proceeding to a higher strategy of maintenance compared with the additional expenditure.

6.2.2 Economic Shadow Pricing

Following discussions with officials at the Internal Revenue Commission and Economic Planning Unit as well as a review of World Bank and ADB recent studies, the following approach and values for determining economic costs have been applied. It is noted that in a 1998 World Bank Staff Appraisal Report, (WB No. 16551-PNG) a standard economic factor of 0.8 was applied across the board for determining the economic costs of rehabilitation and maintenance activities. For the purposes of this Study, the analysis takes into account current tax rates and employment patterns in the Study area.

Motor Vehicles, Equipment And Fuel

For these traded items with established border prices, the approach has been to determine economic costs as equal to financial costs (cif and in-country transport/distribution cost) less import duties, excises, and sales taxes prevailing in the first quarter of 1999. This includes construction equipment and bitumen. For domestically produced items such as cement and gravel, sales taxes and royalties as applicable have been netted out. These are summarized below in Table 6.2. Economic factors reflecting motor vehicles and fuel are discussed in Section 6.1.1.

TABLE 6.2: ECONOMIC FACTORS FOR EQUIPMENT AND MATERIALS

ITEM	ECONOMIC FACTOR
Equipment	
Special purpose constr. Equip. (scrapers, grades, crushers etc.)	0.91
Conventional road transp. Equip. (dump trucks, tankers, etc.)	0.86
Materials	
Cement	0.97
Bitumen	0.86
Gravel (pit-run)	0.95
Aggregate haulage	0.80
Labour	
Supervision (Engineers)	1.00
Skilled Labour (equipment operators, mechanics)	1.00
Semi-skilled (drivers, etc.)	0.85
Unskilled (hand labour)	0.5

For the determining the economic cost of labour, this component of maintenance and rehabilitation costs has been broken down into supervisory, skilled, semi-skilled and unskilled labour. For the first two levels, the market price or going wage with benefits is taken as the economic cost since these skills are in relatively short supply within the study area of the Highlands.

For the third and fourth levels, semi- and unskilled, economic factors of 0.85 and 0.5 have been taken respectively as shown in Table 6.2. After discussions with officials in Economic Policy Unit (Treasury and Corporate Services) and the National Planning and Implementation Department, these values appear to represent the best current estimate of the economic cost of labour given employment levels in the Highlands and the opportunity cost of alternative rural/agricultural employment. In this regard it is noted that the 1995 DOT study[29] valued unskilled labour at zero cost, using as arguments the high unemployment rate and the lack of alternative employment. However and as discussed more thoroughly in Volume 4 dealing with social analysis, cash incomes to people are important - even in the subsistence rural sector. Cash income is required for school fees, kerosene for lighting, and tinned food. Villagers go to considerable effort to market small quantities of vegetables, firewood, and coffee, hence there is a real opportunity cost for unskilled labour.

6.2.3 Distribution Of Benefits

Poverty reduction is one of the objectives of ADB lending policy. Where possible project implementation should be designed to increase participation of lower income groups. An analysis has been carried out for a Category B upgrading project comparing the costs and distribution of benefits using conventional contract approach and a contract designed with more labour intensive

[29] Preparation of Inventory of Roads and 5 Year Road Maintenance and Rehabilitation Programme, (Draft Final) Main Report, BECA International Consultants Ltd., 1995. In Chapter 7 of that report, in the discussion of economic pricing of labour, the analysis assumed that the shadow unskilled wage rate was zero since there would be no production foregone by a family member working on a road maintenance project.

components. By using additional labour intensive works it is possible to double the low-skilled labour input with an additional 580 man-months on a typical upgrading contract. This would increase financial costs in the order of 7% and economic costs by about 4%. This would have the effect, however of increasing the poverty impact ratio from 0.27 to 0.33.

Additional labour intensive operations which could be added to the scope of works include the following:

Pedestrian footpaths

Bus stands, laybys, and scenic area pull-offs

Increased use of ashlar box gabion retaining walls for slip protection

Selective tree and shrub planting for erosion control

Increased use and length of lined roadside drains

The addition of pedestrian footpaths and laybys would also help reduce pedestrian-vehicle conflicts and contribute to accident reduction. Erosion control measures are needed in any case to protect road assets, and labour intensive means may in some cases off-set more machine-intensive solutions for erosion control and drainage protection.

The poverty-reducing impact of road improvement projects has been estimated by tracing the expected distribution of economic benefits to different groups. Beneficiaries include the road agency (Department of Works), project employees (labour), Government, and road users. The last group includes freight and passenger transport operators, shippers and passengers, and those people induced to generate additional trips because of reductions in trip cost. Agency benefits are the reductions in maintenance costs brought about by sealing of the roadway. Benefits to employees consist of the difference between the financial cost and the economic opportunity cost of labour. Government benefits are the amount of tax collections as measured by the difference between the financial and economic costs of upgrading.

In the example shown in Table 6.3, the costs and benefits for an average kilometre are shown in net present value terms. Benefits in terms of maintenance cost savings, VOC savings, passenger time savings and generated traffic have been distributed among the beneficiaries as described above. Differences between net economic benefits and costs and net financial benefits and costs are distributed by group. The poverty impact ratio for a conventionally structured improvement contract has been calculated to be 0.27; which is the ratio of benefits to the lowest income group to the total economic benefits of the project. Increasing the labour intensive component of the project raises financial costs by K14,500/km, in economic terms, K7,250/km. The poverty impact ratio increases to 0.33, because of the accruing of the additional economic benefit to this low-skill sector.

TABLE 6.3: DISTRIBUTION OF BENEFITS AND POVERTY IMPACT RATION PER KILOMETRE OF ROAD UPGRADING

		NPV thousand K/km				Distribution of Project Effects					
		Financial NPV	Conv. factor	Economic NPV	Difference: Fin'l- Econ	Road Agency	Government/ Economy	Labour	Road Users		Producers
									Pass.	Frt.	
Benefits											
	Maintenance cost svgs	266.3	0.86	229.0	37.3	229	37.3				
	VOC svgs	294.0	1.14	258.8	35.2		35.2		70.10	188.71	
	Pass. time svgs	28.3	1.20	23.5	4.8		4.8		6.37	17.15	
	Gen. traffic	3.0	1.14	2.7	0.4				0.72	1.95	2.67
Total benefits		325.3		285.0	40.3	229.0	77.2		77.19	207.81	2.67
Costs											
	Labour	21.0	0.95	20.0	1.1			1.1			
	Plant	89.9	0.88	79.2	10.8		10.8				
	Materials	42.8	0.85	36.4	6.4		6.4				
	Overheads	47.9	0.80	38.4	9.6		9.6				
Total Costs		201.7	0.86	173.5	27.9		26.8	1.1			
Net benefits		123.6		111.5							
Beneficiaries						229.0	104.0	1.1	77.19	207.81	2.67
Proportion of poor		5.00%					15%	5%			
Benefits to Poor		16.27		14.25			15.61	0.05			
Poverty Impact Ratio		0.27									
With Labour-intensive Contract Additions											
	Incremental unskilled labour	14.5	0.5	7.25	7.3			7.25			
Total Costs with incr. Labour added		35.5		27.24	8.3			8.30			
Benefits to Poor		16.27		14.25			15.61	7.30			
Poverty Impact Ratio		0.33									

6.3 THE HDM-III INPUTS

The HDM-III model was used to make comparative cost estimates and economic analysis of different policy options ranging from minimum (basic) maintenance to road upgrade for selected links on the road network in the four provinces.

Data collection methodology was based upon the data requirements of the HDM-III model. The following section describes the elements of data sets and main steps undertaken to obtain and assemble all required inputs. As the HDM model inputs are presented in different sections and appendices of the Study, the following section will refer to them only.

6.3.1 Existing Link Characteristics

The data set for existing link characteristics has a purpose to describe characteristics and condition of road sections at the beginning of the analysis period. The majority of information was collected during the inspection carried out by the Consultant at an early stage of the project. A specially designed input sheet was used during the inspection.

Data Type	Items	Source	Comment
Link Identification	Road name, classification, sections.	Maresman database, maps, inspection	
Geometry	Length, pavement width, shoulder width, rise plus fall, curvature.	Inspection	
Environment	Altitude, monthly rainfall	Maresman database, maps	
Surface (sealed)	Type, thickness	Inspection, interview	
Surface (gravel)	Material, max. particle size, passing sieves by mass, plasticity index	Inspection, reports	Reports on pavement materials laboratory tests and Gravel Pit Inventory used.
Base/subgrade	Material type, CBR	Inspection, reports, interview	Reports on pavement materials laboratory tests and Gravel Pit Inventory used.
Condition (sealed)	Roughness, cracking, potholing, ravelling, rut depth, SD of rut depth	Inspection	Estimated using the inspection guidelines
Condition (gravel)	Roughness, gravel thickness	Inspection	Roughness estimated using the inspection guidelines
History	Surfacing and construction age; gravel age	Maresman database, interview	

6.3.2 Construction Options and Costs

The data set for construction options and costs is used to specify optional projects for upgrading gravel road sections, including costs of construction and characteristics of the road after improvement. The post-project link description is similar in form to the existing link characteristics.

Data Type	Items	Source	Comment
Link Identification	Road name, sections.	Existing link characteristics	
Geometry	Length, pavement width, shoulder width, rise plus fall, curvature.	Design standards, existing link characteristics	Pavement and shoulder widths defined for road categories A, B and C (see section 2.3.6)
Environment	Altitude, monthly rainfall	Existing link characteristics	
Surface	Type, thickness	Pavement design guidelines	
Base/subgrade	Material type, CBR	Pavement design guidelines	CBR increased as existing gravel considered as improved subgrade for new road.
Condition	Roughness, cracking, potholing, ravelling, rut depth, SD of rut depth	This study.	Estimated.
Construction costs	Financial, economic costs	This study, recent tender documents	Unit rates defined for five road categories (see section 5.2).

6.3.3 Road Maintenance Standards And Unit Costs

The data set for road maintenance standards and unit costs was used to specify alternative maintenance standards to be applied to different types of road surface and associated road maintenance costs. A maintenance standard is defined as a set of operations with definitive intervals or other criteria to determine when to carry them out.

Data Type	Items	Source	Comment
Sealed road maintenance standards	Routine maintenance, patching, resealing, pavement reconstruction	OoW, interviews, previous HDM analyses	Intervention levels, criteria and timing adjusted to match maintenance needs for each section on the network (see section 5.4)
Gravel road maintenance standards	Routine maintenance, spot regravelling, gravel resheeting	OoW, interviews, previous HDM analyses	
Maintenance Unit Rates	Financial, economic costs	Current rates used in OoW, interviews, questioners	Refer to section 5.4

6.3.4 Vehicle Fleet Characteristics And Unit Costs

The data set vehicle fleet characteristics and unit costs was used to describe the physical and utilisation characteristics and related unit costs of different types of vehicles. The Consultant conducted a number of interviews with transport operators from the study area and wider, in order to obtain reliable information on vehicle characteristics, operating costs and utilisation. Details on this data are shown in Appendix D and in Section 6.1.1.

Data Type	Items	Source	Comment
General vehicle characteristics	Engine power, number of axles, number of tires, gross vehicle weight, braking power, aerodynamic drag coefficient, etc.	Interviews, questionnaires	Eight vehicle types selected to represent traffic composition on the network: Car (sedan) Pick-up (single/dbl cabin) PMV (15 seats) Bus (25 seats) Light Truck (4 t) Medium Truck (10 t) Heavy Truck (20 t) Articulated Truck (38 t)
Unit costs	Cost of new vehicle, cost of tires, fuel costs, crew costs, maintenance labor costs, overhead costs, interest, etc.	Interviews, questionnaires, recent transport studies	Economic costs calculated as an input to the HDM analysis.
Utilization	Annual km driven, annual hours driven, vehicle life, hourly utilisation ratio, depreciation method, etc.	Interviews, questionnaires, recent transport studies	

6.3.5 Traffic Volumes And Growth Characteristics

The data set for traffic volumes and growth characteristics provides time profiles of the flows of different types of vehicles. The part of the inputs is provided from existing records on regular traffic counts on National roads. As there were no available traffic information on Provincial roads, the Consultant carried out 7-day traffic counting on these roads. The traffic data required for the HDM analysis are presented in detail in Chapter 4.

Data Type	Items	Source	Comment
Normal traffic	Current ADT values for all vehicle groups	Records on regular traffic counts, the Consultants traffic counts	Assigned for each link on the network.
Growth rate	Annual growth rate in different growth periods.	Traffic forecast carried out by R.J. Nairn and Partners	CARTS model used as a forecasting tool.
Generated traffic	Increment in ADT	Estimate	On upgraded links only.

6.3.6 Link-Alternatives, Report Requests, Comparison Of Alternatives And Run Controls

The data sets for link-alternatives, reports requests, comparison of alternatives and run controls were created to link the above mentioned model inputs into a manageable simulation tool. A variety of inputs were provided in order to specify a profile of the simulation and to produce comprehensive reports.

Data Type	Items	Source	Comment
Link Alternatives Specification	Traffic, maintenance and construction codes, timing		Four link alternatives assigned for each link on the network, i.e. over 400 link alternatives.
Group Alternatives	Link-alternatives to be compared		
Report Requests	Annual traffic report, annual road condition report, annual road user costs, comparison of alternatives, summary of comparison of alternatives by discount rate, etc		Number of reports reached the limits of 500 reports per model, i.e. 4,000 per network.
Run Control	General model inputs, analysis period, error control, interface with budgeting model, roughness conversion, currency		IRI specified as an input/output roughness unit. PNG Kina specified as input/reporting currency.

6.4 EVALUATION OF ALTERNATIVES AND SELECTION FRAMEWORK

6.4.1 General

In using the HDM III model to evaluate the benefits and costs associated with alternative strategies of maintenance and upgrading, four maintenance strategies were tested on each study link. These strategies and their maintenance standards are described in detail in Section 2.7.4. The strategies and their identifier code are:

- Minimum maintenance – ALT0
- Regular maintenance – ALT1
- Improved maintenance – ALT2
- Rehabilitation and upgrading – ALT3.

6.4.2 Road Sections And Alternatives

The build-up of economic costs associated with each maintenance and improvement strategy has been detailed in Chapter 5. Optimal maintenance strategies were determined for each study link on the basis of highest net present value (NPV) of net benefits of user savings taken over the 20 year horizon using a 12% discount rate. Following this step, results of the HDM analysis were taken into the EBM in order to establish a budget framework for optimizing the net present value of maintenance and improvement strategies across the network. The EBM was then run without budget constraint.

Budget constraints can be imposed to evaluate the impact of reduced funds on the set of optimal maintenance strategies, but following consultation with ADB and GOPNG, no constraints were imposed.

The EBM output selected the best maintenance and improvement strategy for each link on the basis of NPV. Analysis also produced a measure of the incremental NPV of net benefits as a fraction of agency costs, defined for the purposes of this analysis as the B/C ratio in the provincial summary Table 6.4. This is a measure of the steepness of the slope of the efficiency curve as increasingly costly agency strategies are tested against the additional benefits or user savings produced. The next step of the analysis grouped the optimal sets of improvement and maintenance strategies for study links by province according to the most optimal regime. These regimes included upgrading, rehabilitation and resealing of sealed roads, and gravel resheeting programs for non-sealed roads. Five-year slices of routine maintenance costs are also shown in these provincial program summaries. These are also shown in Tables 6.4.

6.4.3 Summary Of Results

The unconstrained budget for candidate road sections amounts in financial cost terms is K277 million (in the order of US$140 million at current exchange rates) for the first five years. This takes into account upgrading and maintenance on almost 2,500 km of sealed and gravel roads in the four provinces studied. This five-year total however is only the first tranche of maintenance expenditure which must extend over the entire life cycle of the road sections. Optimal upgrading and maintenance regimes assume consistent maintenance policies being applied over the 20 year horizon considered for the analysis. Additional funding will be required for reconstruction and periodic maintenance beyond the first five - year slice shown. A summary of the program by province is provided in Table 6.5.

Table 6.4 Optimal Road Improvement Strategies (Financial Costs Kmillion)

Road Number	Road Name	Location	Section	Pavement Type	Gravel Length K	Sealed Length Km	Total Length Km	Strategy	Maintenance Alternative	Upgrade Cost	Grading	Spot Gravelling	Resheetin	Routine Gravel	Patching	Resealing	Rehabilitation	Routine Sealed	NPV (mil K)	Upgrade IRR (%)
MOROBE PROVINCE																				
NR07	Highlands Highway	Lae - Wharf - Yalu Bridge	MN01	Sealed		20.8	20.8	Resealing	ALT2		-	-	-	-	0.148	1.483	-	0 220	10 137	
NR07	Highlands Highway	Yalu Bridge - Erap Bridge	MN02	Sealed		25.1	25 1	Resealing	ALT2		-	-	-	-	0.078	1.722	-	0.257	8.379	
NR07	Highlands Highway	Erap Bridge - Clearwater Bridge	MN03	Sealed		30.4	30.4	Resealing	ALT3		-	-	-	-	0 026	2.156	-	0.322	2.612	
NR07	Highlands Highway	Clearwater Bridge - Maniang	MN04	Sealed		44.1	44.1	Resealing	ALT2		-	-	-	-	0 038	3.101	-	0 464	2.279	
NR07	Highlands Highway	Maniang - Watense Junction	MN05	Sealed		36.3	36 3	Resealing	ALT2		-	-	-	-	0.082	2.527	-	0.379	1.468	
NR07	Highlands Highway	Watense Junction - Yung Creek	MN06	Sealed		7.7	7 7	Resealing	ALT2		-	-	-	-	0.054	0 539	-	0 082	0.898	
NR08	Ramu Highway	Watense Junction - Gusap	MN07	Sealed		32 0	32.0	Maintenance	ALT0		-	-	-	-	-	-	-	0.335	-	
NR04	Wau Road	Highlands Highway - Umsis	MN08	Sealed		20 0	20 0	Rehabilitation	ALT3		-	-	-	-	-	-	1 800	0 209	3.034	
NR04	Wau Road	Umsis - Zenag River	MN09	Sealed		50.4	50 4	Resealing	ALT1		-	-	-	-	-	3.414	-	0.596	0 640	
NR04	Wau Road	Zenag River - Baiune [2]	MN10	Sealed		20.0	20 0	Maintenance	ALT0		-	-	-	-	-	-	-	0 209	-	
NR04	Wau Road	Baiune - Wau [2]	MN11	Gravel/Sealed	19 8	19 1	38.9	Upgrade	ALT3	10 690	0 027	0.012	-	0.035	-	-	-	0.324	5 137	20 9
NM4201	Aseki Road	Bulolo - Pararua	MN12	Gravel	32.8		32 8	Upgrade	ALT3	14.430	0.031	0.021	-	0.058	-	-	-	0.205	4.132	17.8
NM4201	*Aseki Road*	*Pararua - Aseki*	MN13	Gravel	51.2		51.2	Resheeting	ALT2		0.309	0.364	1.690	0.449	-	-	-	-	3.922	
ND4201	Bukawa Road	Maiahang - Busu	MN14	Gravel/Sealed	3.0	5 0	8.0	Upgrade	ALT3	1.320	0.004	0.002	-	0.005	-	-	-	0 071	0.590	19.3
ND4201	Bukawa Road	Busu - Buso	MN15	Gravel	28.7		28.7	Upgrade	ALT3	10.330	0.022	0.018	-	0 051	-	-	-	0 180	1 897	15 6
	Provincial Road	Aseki - Menyamya	MP16	Gravel	32 5		32.5	Maintenance	ALT1		0 087	0.390	-	0.286	-	-	-	-	0.523	
	Provincial Road	Finnschhafen - Heidsbach	MP17	Gravel	21 0		21.0	Maintenance	ALT1		0.127	0.191	-	0.184	-	-	-	-	0.633	
	Provincial Road	Heidsbach - Pondui	MP18	Gravel	58 6		58 6	Maintenance	ALT1		0.342	0.611	-	0.514	-	-	-	-	1.782	
	Provincial Road	Buso - Buhem	MP19	Gravel	28.5		28.5	Maintenance	ALT1		0.058	0.194	-	0.251	-	-	-	-	0.153	
	Provincial Road	Erap - Boana	MP20	Gravel	31.0		31 0	Resheeting	ALT2		0.126	0 199	1.023	0.272	-	-	-	-	1.334	
	Provincial Road	Wasu - Kabum	MP21	Gravel	34.6		34 6	Resheeting	ALT2		0.217	0.153	0 999	0.303	-	-	-	-	2.723	
	Provincial Road	Leron - Wantoat	MP22	Gravel	62 0		62 0	Maintenance	ALT1		0.129	0.626	-	0.543	-	-	-	-	0 868	
	TOTAL				403 7	310 9	714.6			36 770	1.456	2 781	3.712	2.950	0 424	14.922	1.800	3 853		
	TOTAL COST																	68.668		

Table 6.4 Optimal Road Improvement Strategies (Financial Costs Kmillion)

Road Number	Road Name	Location	Section	Pavement Type	Gravel Length K	Sealed Length Km	Total Length Km	Strategy	Maintenanc Alternative	Upgrade Cost	Grading	Spot Gravelling	Resheetin	Routine Gravel	Patching	Resealing	Rehabilitation	Routine Sealed	NPV (mil K)	Upgrade IRR (%)
EASTERN HIGHLANDS PROVINCE																				
NR07	Highlands Highway	Yung Creek - Kassam Pass	EN01	Sealed		4 0	4 0	Maintenance	ALT0		-	-	-	-	-	-	-	0.042	-	
NR07	Highlands Highway	Kassam Pass	EN02	Sealed		5.7	5.7	Maintenance	ALT0		-	-	-	-	-	-	-	0.061	-	
NR07	Highlands Highway	Kassam - Kainantu	EN03	Sealed		33 6	33 6	Maintenance	ALT0		-	-	-	-	0.034	-	-	0 351	-	
NR07	Highlands Highway	Kainantu - Henganofi	EN04	Sealed		38.5	38.5	Maintenance	ALT0		-	-	-	-	0.008	-	-	0 404	-	
NR07	Highlands Highway	Henganofi - Goroka	EN05	Sealed		44 2	44.2	Resealing	ALT3		-	-	-	-	0.034	3.094	-	0 462	3.874	
NR07	Highlands Highway	Goroka - Daulo	EN06	Sealed		26 7	26.7	Resealing	ALT3		-	-	-	-	0 018	1.869	-	0.280	15 200	
NR07	Highlands Highway	Daulo Pass - Simbu Border	EN07	Sealed		26 4	26 4	Rehabilitatio	ALT3		-	-	-	-	0 004	-	0.630	0.276	-	
ND4101	Aiyura Access Road	Kainantu - Aiyura NHS	EN08	Sealed		6.6	6.6	Rehabilitatio	ALT3		-	-	-	-	-	-	2 228	0.069	1.094	
ND4102	Duantina-Dumpu Road	Dunantina - Dumpu	EN09	Gravel	47.7		47.7	Resheeting	ALT2		0.375	0 417	1 771	0.419	-	-	-	-	3.562	
NI4102	Institutional Road	CIS	EN10	Gravel	6 7		6.7	Upgrade	ALT3	2.950	0 008	0.004	-	0.012	-	-	-	0 042	1.123	18.3
	Provincial Road	Korofegu - Oleguti	EP11	Sealed		15.0	15.0	Resealing	ALT2		-	-	-	-	0.030	0.750	-	0 157	0 248	
	Provincial Road	Oleguti - Okapa [3]	EP12	Gravel	28.0	16 0	44.0	Resheeting	ALT2		0 262	0.245	1.155	0 245	-	-	-	0 167	2 862	
	Provincial Road	Raipinga - Okapa	EP13	Gravel	49.0		49.0	Resheeting	ALT2		0 223	0.298	1 609	0.342	-	-	-	0.105	1 807	
	Provincial Road	Oleguti - Lufa	EP14	Gravel	15 0		15 0	Maintenance	ALT1		0 076	0 179	-	0.131	-	-	-	-	0.528	
	Provincial Road	Aiyura - Obura	EP15	Gravel	32 0		32.0	Resheeting	ALT2		0.248	0 198	1 452	0.280	-	-	-	-	3.055	
	Provincial Road	Goroka - Lahame	EP16	Gravel	13 0		13 0	Upgrade	ALT3	4.680	0.012	0.008	-	0 023	-	-	-	0.082	2.564	22 9
	Provincial Road	Lahame - Magabo	EP17	Gravel	21.0		21.0	Maintenance	ALT1		0.080	0.220	-	0.184	-	-	-	-	0.399	
	Provincial Road	Goroka - Unggai	EP18	Gravel	29.0		29 0	Maintenance	ALT1		0.110	0.303	-	0 254	-	-	-	-	0.691	
	Provincial Road	Asaro - Lapego - Kifamu	EP19	Gravel	20.0		20 0	Upgrade	ALT3	7.200	0.015	0.013	-	0.035	-	-	-	0.126	1 397	15.8
	TOTAL LENGTH				261.4	216.7	478.1			14.830	1.408	1.885	5 987	1.927	0 128	5 713	2 858	2 623		
	Total Cost																	37 358		

Table 6.4 Optimal Road Improvement Strategies (Financial Costs Kmillion)

Road Number	Road Name	Location	Section	Pavement Type	Gravel Length Km	Sealed Length Km	Total Length Km	Strategy	Maintenance Alternative	Upgrade Cost	Grading	Spot Gravelling	esheetin	Routine Gravel	Patching	Resealin	Rehabilitation	Routine Sealed	NPV (mil K)	Upgrade IRR (%)
WESTERN HIGHLANDS PROVINCE																				
NR07	Highlands Highway	Gamiger - Minj	WN01	Sealed		17.5	17 5	Resealing	ALT3		-	-	-	-	0.104	1 225	-	0.184	1.583	
NR07	Highlands Highway	Minj - Kudjip	WN02	Sealed		12 0	12.0	Resealing	ALT3		-	-	-	-	0.010	0.840	-	0 126	1.827	
NR07	Highlands Highway	Kudjip - Tuman R	WN03	Sealed		16.2	16.2	Resealing	ALT3		-	-	-	-	0.118	1.134	-	0.169	14.140	
NR07	Highlands Highway	Tuman R - Hgn Town Bdy	WN04	Sealed		25 5	25 5	Resealing	ALT3		-	-	-	-	0.162	1.785	-	0 268	36 883	
NR07	Highlands Highway	Mount Hagen Town Area	WN05	Sealed		2.5	2.5	Rehabilitation	ALT3		-	-	-	-	-	-	0.788	0.027	9.155	
NR07	Highlands Highway	Hgn Town Bdy - Togoba	WN06	Sealed		10.9	10.9	Resealing	ALT3		-	-	-	-	0 050	0 763	-	0.115	4.434	
NR07	Highlands Highway	Togoba - SHP Border	WN07	Sealed		28 1	28.1	Maintenance	ALT0		-	-	-	-	-	-	-	0.295	-	
NR06	Enga Highway	Togoba - Paigona	WN08	Sealed		13.0	13.0	Maintenance	ALT1		-	-	-	-	-	-	-	0 136	0 059	
NR06	Enga Highway	Paigona - Enga Border	WN09	Sealed		16.9	16 9	Maintenance	ALT0		-	-	-	-	-	-	-	0.178	-	
NM3901	Baiyer Road	Mt Hagen - Kumdi School	WN10	Sealed		21 0	21 0	Maintenance	ALT1		-	-	-	-	-	-	-	0.220	0.202	
NM3901	Baiyer Road	Kumdi School - Baiyer R	WN11	Gravel	28 3		28.3	Upgrade	ALT3	10.190	0.027	0 018	-	0.049	-	-	-	0.178	6.221	23 4
NM3901	Baiyer Road	Baiyer R - Ruti Ranch	WN12	Gravel	28 9		28.9	Maintenance	ALT1		0.117	0.311	-	0.254	-	-	-	-	0 837	
NM3902	Kagamuga Airport	Airport Access Road	WN13	Sealed		1 5	1 5	Resealing	ALT3		-	-	-	-	0.004	0.090	-	0.017	0 952	
NM3903	Ogelbeng-Dona Road	Ogelbeng - Ambra	WN14	Gravel	9.2		9 2	Resheeting	ALT2		0 097	0.048	0.342	0 081	-	-	-	-	0.996	
NM3903	Ogelbeng-Dona Road	Ambra - Kotna	WN15	Gravel	15.5	4 0	19.5	Upgrade	ALT3	6.820	0.029	0.010	-	0.028	-	-	-	0.140	7.424	29.4
NM3903	Ogelbeng-Dona Road	Kotna - Banz	WN16	Gravel	33 0		33.0	Upgrade	ALT3	14.520	0.062	0 021	-	0 058	-	-	-	0.207	15.906	29.6
NM3903	Ogelbeng-Dona Road	Banz - Dona	WN17	Gravel/Seale	13 2	6 0	19 2	Resh /Reseal	ALT2		0.098	0.076	0.528	0.140	0.018	0 300	-	0 063	0 734	
NI3901	Institutional Road	Tea	WN18	Gravel	4 0		4.0	Maintenance	ALT1		0.009	0.037	-	0.035	-	-	-	-	0.049	
NI3901	Institutional Road	CIS	WN19	Gravel	11.3		11 3	Upgrade	ALT3	4 070	0 013	0.007	-	0.019	-	-	-	0 071	1 185	17.0
	Provincial Road	Tomba - Tambul	WP20	Gravel	16.0		16.0	Resheeting	ALT2		0 192	0.215	1 345	0.272	-	-	-	-	1.706	
	Provincial Road	Balk - Bukapina	WP21	Gravel	15.3		15 3	Maintenance	ALT1		0.031	0.168	-	0.135	-	-	-	-	0.190	
	Provincial Road	Bukapina - Koge	WP22	Gravel	6.4		6 4	Maintenance	ALT1		0.013	0 047	-	0.056	-	-	-	-	0 077	
	Provincial Road	Bukapina - Nengli	WP23	Gravel	16.4		16 4	Resheeting	ALT2		0.100	0.074	0 541	0.144	-	-	-	-	1.265	
	Provincial Road	Bukapina - Kadua #1	WP24	Sealed		10 0	10.0	Maintenance	ALT0		-	-	-	-	-	-	-	0.105	-	
	Provincial Road	Baiyer River - Lumusa	WP25	Gravel	13 0		13.0	Maintenance	ALT1		0 028	0.159	-	0.114	-	-	-	-	0 179	
	Provincial Road	Kagamuga - Kalua #1	WP26	Gravel/Seale	8.7	3 5	12 2	Upgrade	ALT3	3 130	0 012	0.006	-	0.016	-	-	-	0 092	2.372	24.0
	Provincial Road	Kom Farm - Ambra	WP27	Sealed		8.0	8.0	Maintenance	ALT0		-	-	-	-	-	-	-	0.084	-	
	Provincial Road	Kum - Wurup	WP28	Gravel	8 8		8.8	Upgrade	ALT3	3.170	0.009	0 006	-	0 016	-	-	-	0.054	1.474	19.8
	Provincial Road	Wurup - Kom Farm	WP29	Gravel	6.3		6 3	Maintenance	ALT1		0.051	0 052	-	0 056	-	-	-	-	0.258	
	Provincial Road	Kotna - Tigi - Baiyer River	WP30	Gravel	24 0		24.0	Resheeting	ALT2		0.051	0.111	0.792	0.210	-	-	-	-	0 384	
	Provincial Road	Kindeng - Kondopina	WP31	Gravel	10 3	1 0	11.3	Upgrade	ALT3	4 530	0 022	0.007	-	0 019	-	-	-	0.071	3 721	24.6
	Provincial Road	Kudjip - Banz	WP32	Sealed		7.0	7 0	Resealing	ALT3		-	-	-	-	-	0 420	-	0 073	1.541	
	Provincial Road	Banz - Karap	WP33	Gravel	36 5		36.5	Maintenance	ALT1		0.143	0.481	-	0 321	-	-	-	-	1.118	
	Provincial Road	Highlands Hwy - Donna - Nondu	WP34	Gravel	7 8		7.8	Resheeting	ALT2		0 040	0 038	0.227	0.044	-	-	-	-	0.551	
	TOTAL LENGTH				312 9	204 6	517 5			46 430	1 137	1.891	3.774	2.067	0.466	6.557	0 788	2 872		

	Total Cost	65 982

Table 6.4 Optimal Road Improvement Strategies (Financial Costs Kmillion)

Road Number	Road Name	Location	Section	Pavement Type	Gravel Length Km	Sealed Length Km	Total Length Km	Strategy	Maintenance Alternative	Upgrade Cost	Grading	Spot Gravelling	esheetin	Routine Gravel	Patching	Resealin	Rehabilitation	Routine Sealed	NPV (mil K)	Upgrade IRR (%)
SOUTHERN HIGHLANDS PROVINCE																				
NR07	Highlands Highway	WHP Bdr - Kisenapoi	SN01	Sealed	0.0	20.5	20.5	Rehabilitation	ALT3		-	-	-	-	-	-	0.473	0.215	0.586	
NR07	Highlands Highway	Kisenapoi - Kumbame	SN02	Gravel	23.8	0.0	23.8	Resheeting	ALT2		0.293	0.279	1.473	0.209	-	-	-	-	5.381	
NR07	Highlands Highway	Kumbame - Ankura Bridge	SN03	Gravel	10.1	0.0	10.1	Maintenance	ALT0		0.107	0.069	-	0.089	-	-	-	-	-	
NR07	Highlands Highway	Ankura Bridge - Mendi [1]	SN04	Sealed		29.1	29.1	Maintenance	ALT0		-	-	-	-	-	-	-	0.305	-	
NM3701	Koroba Road	Mendi - Kar Mission	SN05	Gravel	35.0	0.0	35.0	Maintenance	ALT1		0.222	0.694	-	0.307	-	-	-	-	3.009	
NM3701	Koroba Road	Kar Mission - Fakandah	SN06	Gravel	37.0	0.0	37.0	Resheeting	ALT2		0.157	0.365	1.832	0.324	-	-	-	-	1.958	
NM3701	Koroba Road	Fakandah - Ambua Lodge	SN07	Gravel	54.2	0.0	54.2	Maintenance	ALT1		0.230	0.873	-	0.475	-	-	-	-	3.951	
NM3701	Koroba Road	Ambua Lodge - Tan	SN08	Gravel	22.4	0.0	22.4	Upgrade	ALT3	9.856	0.028	0.014	-	0.039	-	-	-	0.140	10.743	28.1
NM3701	Koroba Road	Tan - Koroba	SN09	Gravel	38.5	0.0	38.5	Upgrade	ALT3	13.860	0.030	0.024	-	0.068	-	-	-	0.243	10.550	23.9
NM3701	Koroba Road	Koroba- Fugwa T/O	SN10	Gravel	7.8	0.0	7.8	Resheeting	ALT2		0.032	0.035	0.257	0.068	-	-	-	-	0.395	
NM3702	Kutubu Road	Poroma T/O - Moro	SN11	Gravel	112.0	0.0	112.0	Maintenance	ALT1		0.461	1.583	-	0.982	-	-	-	-	3.224	
NM3703	Erave Road	Kisenpoi - Ialibu	SN12	Gravel	15.6	0.0	15.6	Upgrade	ALT2	5.860	0.145	0.150	-	0.137	-	-	-	-	0.787	14.0
NM3703	Erave Road	Ialibu - Kagua	SN13	Gravel	31.8	0.0	31.8	Upgrade	ALT3	11.450	0.019	0.020	-	0.058	-	-	-	0.199	1.699	14.7
NM3703	Erave Road	Kagua - Erave	SN14	Gravel	39.6	0.0	39.6	Maintenance	ALT1		0.160	0.517	-	0.347	-	-	-	-	1.211	
ND3701	Oksapmin Road	Fugwa T/O - Tagobi	SN15	Gravel	15.0	0.0	15.0	Maintenance	ALT1		0.033	0.170	-	0.131	-	-	-	-	0.201	
ND3701	Oksapmin Road	Tagobi - Kopiago	SN16	Gravel	53.5	0.0	53.5	Resheeting	ALT2		0.116	0.182	1.324	0.470	-	-	-	-	0.864	
NR05	Wabag - Mendi Road	Soba - Peane	SN17	Gravel	5.0	0.0	5.0	Resheeting	ALT2		0.015	0.026	0.185	0.044	-	-	-	-	0.162	
NR05	Wabag - Mendi Road	Peane - Mendi	SN18	Gravel/Sealed	25.0	1.0	26.0	Upgrade	ALT3	9.000	0.021	0.016	-	0.044	-	-	-	0.157	7.672	27.1
NM3704	Sumia - Pirly Road	Peane T/O - Sumia	SN19	Gravel	27.0	0.0	27.0	Maintenance	ALT1		0.046	0.286	-	0.237	-	-	-	-	0.413	
NM3705	Kagua Road	Sumia - Kagua	SN20	Gravel	41.0	0.0	41.0	Maintenance	ALT1		0.089	0.449	-	0.359	-	-	-	-	0.602	
ND3704	Tambul Road	Koine - Tambul	SN21	Gravel	64.0	0.0	64.0	Upgrade	ALT3	23.040	0.049	0.040	-	0.112	-	-	-	0.402	16.074	24.6
ND3705	Pangia Road	Ialibu - Pangia	SN22	Gravel	23.0	0.0	23.0	Upgrade	ALT3	8.280	0.018	0.014	-	0.040	-	-	-	0.144	1.951	15.8
	Provincial Road	Ialibu - Kumbene	SP23	Gravel	12.7	0.0	12.7	Resheeting	ALT1		0.080	0.120	-	0.112	-	-	-	-	0.854	
	Provincial Road	Nipa - Murihu	SP24	Gravel	20.0	0.0	20.0	Resheeting	ALT2		0.064	0.109	0.485	0.175	-	-	-	-	1.010	
	Provincial Road	Hiwanda - Nogoli	SP25	Gravel	23.0	0.0	23.0	Resheeting	ALT2		0.096	0.104	0.759	0.202	-	-	-	-	1.247	
	Provincial Road	Soba - Wiraa	SP26	Gravel	8.3	0.0	8.3	Maintenance	ALT1		0.014	0.063	-	0.074	-	-	-	-	0.062	
	TOTAL LENGTH				745.3	50.6	795.9			82.348	2.540	6.303	8.305	5.101	-	-	0.473	1.805		
	Total Cost																	104.873		

Table 6.5 Summary of Costs for Improvement Program (K million)

Province	Upgrading	Rehabilitation	Resealing	Gravel Resheeting	Five Year Maintenance	Five Year Total
Morobe	36.8	1.8	14.9	3.7	11.5	68.7
Eastern Highlands	14.8	2.9	5.7	6.0	8.0	37.4
Western Highlands	46.4	0.8	6.6	3.8	8.4	66.0
Southern Highlands	82.4	0.5	0.0	6.3	15.8	104.9
TOTAL	180.4	5.9	27.2	19.8	43.6	276.9

Notes

1. Five year maintenance for sealed roads comprises patching and routine maintenance
2. Five year maintenance for gravel roads comprises grading, spot regravelling and routine maintenance

CHAPTER 7. INVESTMENT PROGRAM AND IMPLEMENTATION ARRANGEMENTS

7.1 INTRODUCTION

The institutional policy and implementation arrangements presented in Volume 1 cover funding options, employment impacts; program and project management, land access, community and environmental procedures; construction and contracting procedures; financial management procedures; and program monitoring. These arrangements are recommended to implement the investment program and particular aspects are discussed in this Chapter.

7.2 INVESTMENT PROGRAM

The optimal improvement strategy determined for each section of road investigated was provided in Section 6.4 and these works are proposed to form the investment program. Further analysis of candidate roads for upgrading was prepared in Volume 5 and those results may differ from the results presented in Section 6.4, due to changes to input data following more detailed analysis for that economic modelling.

The three criteria available for selection of the improvement options are:

- Maintaining a sustainable road condition - tolerable roughness;
- Economic worth of investment - considering road agency costs for maintenance and upgrading works, and road user costs comprising vehicle operation and crew labour costs; and
- Financial affordability - the affect of a constrained budget and a loan facility. As a financial constraint was not provided by DOTWCA this criteria was not considered.

A base level schedule of maintenance was applied to all roads, comprising a Do-Minimum case which would result in progressive deterioration of road surface conditions and continuously increasing vehicle operating costs. The Do-Minimum option is not sustainable for the long term. Three maintenance regimes were then specified and the effects of these on agency costs, vehicle user costs and road condition were examined over a twenty year period. All three maintenance regimes were sustainable in the long term in that they produced stable or improved road conditions and comprise:

Alternative 1: Moderate maintenance providing tolerable and long-term stable road conditions with regravelling and resealing at extended intervention periods.

Alternative 2: Increased levels of maintenance providing improved road conditions; regravelling and resealing at more frequent intervention periods.

Alternative 3: On gravel roads moderate maintenance followed by upgrading to a sealed road and then improved levels of maintenance and reseal; on sealed roads a moderate level of maintenance, reseal at intervention levels as for regime 2 and with rehabilitation when economically justified.

The economic evaluation showed which maintenance regime had the highest worth (or rate or return) for each road section. The financial affordability assessment allowed selection of those gravel road sections which when upgraded to a sealed surface provided highest returns within budget constraints and sensitivity analysis, and the social and environmental assessment showed which sections of road would provide significant community benefit if upgraded.

The potential investment program proposed comprises all project listed by province in Table 7.1. The actual order and timing for implementing the improvement works will be determined by the PIU in discussion with DOTWCA, Provincial Government and the Steering Committee.

The program allows for a year of planning and consolidation, followed by a five year period of upgrading and rehabilitation works covering Years 2000 – 2005. Maintenance is a continuous and ongoing process. All roads in the program will require ongoing maintenance beyond the six years of this program. The costs for maintenance beyond Year 2005 is not present in Table 7.1, but have been included in the analysis over a 20 year period.

7.3 PROGRAM MANAGEMENT AND ADMINISTRATION

A Project Implementation Unit is recommended to implement the upgrading and maintenance works located in the four provinces investigated which are to be funded under the terms of the ADB loan. The PIU will be responsible to the DOTWCA and will have management responsibility for:

1. Defining the scope of the road improvement works comprising maintenance, upgrading and rehabilitation.
2. Conducting community liaison and issuing public information.
3. Facilitating land and compensation issues.
4. Incorporating requirements for women's participation and interests.
5. Planning road safety.
6. Preparing designs and specifications of the rehabilitation and upgrading works.
7. Pre-qualifying contractors.
8. Tendering.
9. Administering contracts.
10. Supervising and testing of the construction works.
11. Environmental management and monitoring.
12. Quality control and assurance procedures.
13. Monitoring and reporting on the program.
14. Executing emergency maintenance using the basic fleet of MEB-DVM and the re-vitalised FATs-POoWs, for both national assets and PG assets on request of PGs.

The PIU will be guided by a Steering Committee with representatives of a number of National and Provincial Government agenies and of the private sector. The Steering Committee will approve an Annual Plan and Quarterly Reports, and advise on the necessary independent accounting and auditing procedures.

The Office of Works in each Province have knowledge, experience and expertise with road maintenance by day labour and will manage the contracts for maintenance works, effect emergency maintenance works, conduct investigations and road condition surveys, and provide advice to the PIU on rehabilitation and upgrading projects.

Table 7.1 Road Improvement Program (Financial Costs Kmillion)

Road Number	Road Name	Location	Section	Pavement Type	Gravel Length K	Sealed Length Km	Total Length Km	Strategy	Upgrade Cost	Grading	Spot Gravelling	Resheetin	Routine Gravel	Patching	Resealing	Rehabilitation	Routine Sealed	NPV (mil K)	Upgrade IRR (%)
MOROBE PROVINCE																			
NR04	Wau Road	Baiune - Wau [2]	MN11	Gravel/Sealed	19.8	19 1	38.9	Upgrade	10.690	0.027	0 012	-	0.035	-	-	-	0.324	5.137	20 9
NM4201	Aseki Road	Bulolo - Pararua	MN12	Gravel	32.8		32.8	Upgrade	14.430	0.031	0.021	-	0.058	-	-	-	0.205	4 132	17.8
ND4201	Bukawa Road	Busu - Buso	MN15	Gravel	28 7		28.7	Upgrade	10.330	0.022	0.018	-	0.051	-	-	-	0.180	1.897	15 6
ND4201	Bukawa Road	Malahang - Busu	MN14	Gravel/Sealed	3.0	5 0	8 0	Upgrade	1.320	0.004	0 002	-	0.005	-	-	-	0.071	0.590	19.3
NM4201	Aseki Road	Pararua - Aseki	MN13	Gravel	51 2		51 2	Resheeting		0.309	0.364	1 690	0.449	-	-	-	-	3.922	
	Provincial Road	Wasu - Kabum	MP21	Gravel	34.6		34.6	Resheeting		0.217	0.153	0 999	0.303	-	-	-	-	2.723	
	Provincial Road	Erap - Boana	MP20	Gravel	31 0		31 0	Resheeting		0.126	0.199	1 023	0.272	-	-	-	-	1 334	
NR07	Highlands Highway	Erap Bridge - Clearwater Bridge	MN03	Sealed		30 4	30 4	Resealing		-	-	-	-	0.148	1.463	-	0.220	10.137	
NR07	Highlands Highway	Lae - Wharf - Yalu Bridge	MN01	Sealed		20 8	20 8	Resealing		-	-	-	-	0.076	1.722	-	0.257	8.379	
NR07	Highlands Highway	Yalu Bridge - Erap Bridge	MN02	Sealed		25.1	25 1	Resealing		-	-	-	-	0.026	2.156	-	0 322	2 612	
NR07	Highlands Highway	Clearwater Bridge - Maniang	MN04	Sealed		44.1	44 1	Resealing		-	-	-	-	0.038	3.101	-	0 464	2.279	
NR07	Highlands Highway	Maniang - Watense Junction	MN05	Sealed		36 3	36 3	Resealing		-	-	-	-	0.082	2.527	-	0.379	1 488	
NR07	Highlands Highway	Watense Junction - Yung Creek	MN06	Sealed		7 7	7 7	Resealing		-	-	-	-	0.054	0.539	-	0.082	0 898	
NR04	Wau Road	Umsis - Zenag River	MN09	Sealed		50 4	50 4	Resealing		-	-	-	-	-	3.414	-	0.596	0.640	
NR04	Wau Road	Highlands Highway - Umsis	MN08	Sealed		20 0	20.0	Rehabilitation		-	-	-	-	-	-	1 800	0 209	3.034	
	Provincial Road	Heldsbach - Pondui	MP18	Gravel	58.6		58.6	Maintenance		0.342	0 611	-	0.514	-	-	-	-	1 782	
	Provincial Road	Leron - Wantoat	MP22	Gravel	62.0		62.0	Maintenance		0.129	0 626	-	0.543	-	-	-	-	0.868	
	Provincial Road	Finnschhafen - Heldsbach	MP17	Gravel	21 0		21 0	Maintenance		0.127	0.191	-	0.184	-	-	-	-	0 633	
	Provincial Road	Aseki - Menyamya	MP16	Gravel	32 5		32 5	Maintenance		0 067	0.390	-	0.286	-	-	-	-	0.523	
	Provincial Road	Buso - Buhem	MP19	Gravel	28.5		28.5	Maintenance		0.058	0.194	-	0.251	-	-	-	-	0 153	
NR08	Ramu Highway	Watense Junction - Gusap	MN07	Sealed		32 0	32 0	Maintenance		-	-	-	-	-	-	-	0.335	-	
NR04	Wau Road	Zenag River - Baiune [2]	MN10	Sealed		20.0	20 0	Maintenance		-	-	-	-	-	-	-	0.209	-	
	TOTAL				403 7	310.9	714 6		36 770	1.456	2 781	3 712	2.950	0 424	14.922	1.800	3 853		

	TOTAL COST	68.668

Table 7.1 Road Improvement Program (Financial Costs Kmillion)

Road Number	Road Name	Location	Section	Pavement Type	Gravel Length K	Sealed Length Km	Total Length Km	Strategy	Upgrade Cost	Grading	Spot Gravelling	Resheeting	Routine Gravel	Patching	Resealing	Rehabilitation	Routine Sealed	NPV (mil K)	Upgrade IRR (%)
EASTERN HIGHLANDS PROVINCE																			
NI4102	Institutional Road	CIS	EN10	Gravel	6 7		6 7	Upgrade	2.950	-	-	-	-	0.018	1.869	-	0.280	15.200	
	Provincial Road	Goroka - Lahama	EP16	Gravel	13 0		13 0	Upgrade	4 680	-	-	-	-	0.034	3.094	-	0 462	3 874	
	Provincial Road	Asaro - Lapego - Kifamu	EP19	Gravel	20.0		20.0	Upgrade	7.200	0 375	0 417	1.771	0.419	-	-	-	-	3 562	
ND4102	Duantina-Dumpu Road	Dunantina - Dumpu	EN09	Gravel	47.7		47.7	Resheeting		0.248	0.198	1.452	0.280	-	-	-	-	3 055	
	Provincial Road	Oleguti - Okapa [3]	EP12	Gravel	28.0	16 0	44.0	Resheeting		0.262	0.245	1.155	0.245	-	-	-	0.167	2.862	
	Provincial Road	Raipinga - Okapa	EP13	Gravel	49.0		49 0	Resheeting		0.012	0.008	-	0.023	-	-	-	0.082	2 564	22.9
	Provincial Road	Aiyura - Obura	EP15	Gravel	32.0		32.0	Resheeting		0.223	0 298	1.609	0.342	-	-	-	0 105	1.807	
NR07	Highlands Highway	Henganofi - Goroka	EN05	Sealed		44.2	44.2	Resealing		0.015	0.013	-	0 035	-	-	-	0 126	1.397	15.6
NR07	Highlands Highway	Goroka - Daulo	EN06	Sealed		26.7	26.7	Resealing		0.008	0 004	-	0.012	-	-	-	0.042	1 123	18.3
	Provincial Road	Korofegu - Oleguti	EP11	Sealed		15.0	15.0	Resealing		-	-	-	-	-	-	2.228	0.069	1 094	
NR07	Highlands Highway	Daulo Pass - Simbu Border	EN07	Sealed		26.4	26.4	Rehabilitation		0.110	0 303	-	0.254	-	-	-	-	0.691	
ND4101	Aiyura Access Road	Kainantu - Aiyura NHS	EN08	Sealed		6.6	6.6	Rehabilitation		0.076	0.179	-	0.131	-	-	-	-	0 528	
NR07	Highlands Highway	Yung Creek - Kassam Pass	EN01	Sealed		4 0	4 0	Maintenance		0.080	0 220	-	0.184	-	-	-	-	0 399	
NR07	Highlands Highway	Kassam Pass	EN02	Sealed		5.7	5.7	Maintenance		-	-	-	-	0 030	0 750	-	0.157	0 248	
NR07	Highlands Highway	Kassam - Kainantu	EN03	Sealed		33.6	33.6	Maintenance		-	-	-	-	-	-	-	0.042	-	
NR07	Highlands Highway	Kainantu - Henganofi	EN04	Sealed		38.5	38.5	Maintenance		-	-	-	-	-	-	-	0 061	-	
	Provincial Road	Oleguti - Lufa	EP14	Gravel	15 0		15 0	Maintenance		-	-	-	-	0 034	-	-	0 351	-	
	Provincial Road	Lahame - Magabo	EP17	Gravel	21 0		21.0	Maintenance		-	-	-	-	0.008	-	-	0.404	-	
	Provincial Road	Goroka - Unggai	EP18	Gravel	29 0		29.0	Maintenance		-	-	-	-	0 004	-	0.630	0 276	-	
	TOTAL LENGTH				261 4	216 7	478.1		14 830	1.408	1 885	5 987	1 927	0.128	5 713	2 858	2.623		
	Total Cost																	37 358	

Table 7.1 Road Improvement Program (Financial Costs Kmillion)

Road Number	Road Name	Location	Section	Pavement Type	Gravel Length Km	Sealed Length Km	Total Length Km	Strategy	Upgrade Cost	Grading	Spot Gravelling	esheetin	Routine Gravel	Patching	Resealing	habilitati	Routine Sealed	NPV (mil K)	Upgrade IRR (%)
WESTERN HIGHLANDS PROVINCE																			
NM3901	Baiyer Road	Kumdi School - Baiyer R	WN11	Gravel	28.3		28.3	Upgrade	10.190	-	-	-	-	0.162	1 785	-	0.268	36 883	
NM3903	Ogelbeng-Dona Road	Ambra - Kotna	WN15	Gravel	15.5	4.0	19.5	Upgrade	-	0 062	0.021	-	0 058	-	-	-	0.207	15 906	29 6
NM3903	Ogelbeng-Dona Road	Kotna - Banz	WN16	Gravel	33 0		33.0	Upgrade	-	-	-	-	-	0.118	1.134	-	0.169	14.140	
NI3901	Institutional Road	CIS	WN19	Gravel	11.3		11.3	Upgrade	4.070	-	-	-	-	-	-	0 788	0.027	9.155	
	Provincial Road	Kagamuga - Kelua #1	WP26	Gravel/Seale	8 7	3.5	12 2	Upgrade	3.130	0.029	0.010	-	0.028	-	-	-	0.140	7 424	29.4
	Provincial Road	Kum - Wurup	WP28	Gravel	8.8		8.8	Upgrade	3.170	0.027	0 018	-	0 049	-	-	-	0 178	6.221	23.4
	Provincial Road	Kindeng - Kondopina	WP31	Gravel	10.3	1.0	11.3	Upgrade	4 530	-	-	-	-	0.050	0.763	-	0.115	4.434	
NM3903	Ogelbeng-Dona Road	Ogelbeng - Ambra	WN14	Gravel	9.2		9.2	Resheeting		0 022	0.007	-	0.019	-	-	-	0.071	3.721	24.6
	Provincial Road	Tomba - Tambul	WP20	Gravel	16.0		16 0	Resheeting		0 012	0.006	-	0 016	-	-	-	0.092	2 372	24.0
	Provincial Road	Bukapina - Nengil	WP23	Gravel	16 4		16 4	Resheeting		-	-	-	-	0 010	0.840	-	0 126	1.827	
	Provincial Road	Kotna - Tigi - Baiyer River	WP30	Gravel	24 0		24.0	Resheeting		0.192	0 215	1.345	0.272	-	-	-	-	1 706	
	Provincial Road	Highlands Hwy - Donna - Nondug	WP34	Gravel	7.8		7.8	Resheeting		-	-	-	-	0 104	1.225	-	0.184	1 583	
NM3903	Ogelbeng-Dona Road	Banz - Dona	WN17	Gravel/Seale	13 2	6 0	19 2	Resh./Reseal		-	-	-	-	-	0.420	-	0 073	1 541	
NR07	Highlands Highway	Garnuger - Minj	WN01	Sealed		17 5	17.5	Resealing		0 009	0 006	-	0.016	-	-	-	0.054	1 474	19.8
NR07	Highlands Highway	Minj - Kudjip	WN02	Sealed		12 0	12.0	Resealing		0.100	0.074	0.541	0.144	-	-	-	-	1 265	
NR07	Highlands Highway	Kudjip - Tuman R	WN03	Sealed		16.2	16.2	Resealing		0.013	0.007	-	0.019	-	-	-	0.071	1 185	17.0
NR07	Highlands Highway	Tuman R - Hgh Town Bdy	WN04	Sealed		25.5	25.5	Resealing		0 143	0.481	-	0.321	-	-	-	-	1.118	
NR07	Highlands Highway	Hgh Town Bdy - Togoba	WN06	Sealed		10 9	10.9	Resealing		0.097	0 048	0 342	0 081	-	-	-	-	0.996	
NM3902	Kagamuga Airport	Airport Access Road	WN13	Sealed		1 5	1.5	Resealing		-	-	-	-	0.004	0.090	-	0.017	0.952	
	Provincial Road	Kudjip - Banz	WP32	Sealed		7 0	7.0	Resealing		0.117	0.311	-	0 254	-	-	-	-	0.837	
NR07	Highlands Highway	Mount Hagen Town Area	WN05	Sealed		2.5	2 5	Rehabilitation		0 098	0.076	0.528	0.140	0.018	0.300	-	0 063	0 734	
NR07	Highlands Highway	Togoba - SHP Border	WN07	Sealed		28.1	28.1	Maintenance		0.040	0 038	0.227	0.044	-	-	-	-	0.551	
NR06	Enga Highway	Togoba - Paigona	WN08	Sealed		13 0	13.0	Maintenance		0.051	0.111	0 792	0.210	-	-	-	-	0.384	
NR06	Enga Highway	Paigona - Enga Border	WN09	Sealed		16 9	16.9	Maintenance		0.051	0.052	-	0.056	-	-	-	-	0.258	
NM3901	Baiyer Road	Mt.Hagen - Kumdi School	WN10	Sealed		21 0	21.0	Maintenance		-	-	-	-	-	-	-	0 220	0.202	
NM3901	Baiyer Road	Baiyer R - Ruti Ranch	WN12	Gravel	28 9		28.9	Maintenance		0.031	0.168	-	0 135	-	-	-	-	0 190	
NI3901	Institutional Road	Tea	WN18	Gravel	4 0		4 0	Maintenance		0 028	0.159	-	0.114	-	-	-	-	0 179	
	Provincial Road	Baik - Bukapina	WP21	Gravel	15 3		15.3	Maintenance		0.013	0.047	-	0 056	-	-	-	-	0.077	
	Provincial Road	Bukapina - Koge	WP22	Gravel	6.4		6.4	Maintenance		-	-	-	-	-	-	-	0 136	0.059	
	Provincial Road	Bukapina - Kadua #1	WP24	Sealed		10.0	10 0	Maintenance		0 009	0.037	-	0.035	-	-	-	-	0 049	
	Provincial Road	Baiyer River - Lumusa	WP25	Gravel	13 0		13.0	Maintenance		-	-	-	-	-	-	-	0 295	-	
	Provincial Road	Korn Farm - Ambra	WP27	Sealed		8.0	8 0	Maintenance		-	-	-	-	-	-	-	0.178	-	
	Provincial Road	Wurup - Korn Farm	WP29	Gravel	6 3		6.3	Maintenance		-	-	-	-	-	-	-	0.105	-	
	Provincial Road	Banz - Karap	WP33	Gravel	36 5		36.5	Maintenance		-	-	-	-	-	-	-	0 084	-	
	TOTAL LENGTH				312.9	204.6	517.5		25.090	1.137	1 891	3 774	2.067	0 466	6.557	0 788	2 872		

-	Total Cost	44.642

Table 7.1 Road Improvement Program (Financial Costs Kmillion)

Road Number	Road Name	Location	Section	Pavement Type	Gravel Length Km	Sealed Length Km	Total Length Km	Strategy	Upgrade Cost	Grading	Spot Gravelling	esheetin	Routine Gravel	Patching	Resealin	Rehabilitation	Routine Sealed	NPV (mil K)	Upgrade IRR (%)
SOUTHERN HIGHLANDS PROVINCE																			
NM3701	Koroba Road	Ambua Lodge - Tan	SN08	Gravel	22 4	0.0	22.4	Upgrade	9.856	0.049	0.040	-	0.112	-	-	-	0.402	16.074	24.6
NM3701	Koroba Road	Tari - Koroba	SN09	Gravel	38.5	0.0	38.5	Upgrade	13.860	0.026	0.014	-	0 039	-	-	-	0 140	10 743	28.1
NM3703	Erave Road	Kisenpoi - Ialibu	SN12	Gravel	15.6	0.0	15 6	Upgrade	6.860	0 030	0.024	-	0.068	-	-	-	0.243	10.550	23.9
NM3703	Erave Road	Ialibu - Kagua	SN13	Gravel	31 8	0.0	31.8	Upgrade	11.450	0 021	0.016	-	0.044	-	-	-	0.157	7.672	27.1
NR05	Wabag - Mendi Road	Peane - Mendi	SN18	Gravel/Sealed	25.0	1 0	26 0	Upgrade	9 000	0.293	0 279	1 473	0 209	-	-	-	-	5.361	
ND3704	Tambul Road	Koine - Tambul	SN21	Gravel	64 0	0 0	64.0	Upgrade	23.040	0 230	0.973	-	0.475	-	-	-	-	3 951	
ND3705	Pangia Road	Ialibu - Pangia	SN22	Gravel	23.0	0 0	23.0	Upgrade	8.280	0.461	1 583	-	0.982	-	-	-	-	3.224	
NR07	Highlands Highway	Kisenapoi - Kumbame	SN02	Gravel	23 8	0 0	23.8	Resheeting		0.222	0.694	-	0.307	-	-	-	-	3.009	
NM3701	Koroba Road	Kar Mission - Fakandah	SN06	Gravel	37.0	0.0	37.0	Resheeting		0.157	0 365	1 832	0.324	-	-	-	-	1.958	
NM3701	Koroba Road	Koroba- Fugwa T/O	SN10	Gravel	7.8	0 0	7.8	Resheeting		0.018	0.014	-	0.040	-	-	-	0.144	1.951	15 8
ND3701	Oksapmin Road	Tagobi - Kopiago	SN16	Gravel	53.5	0 0	53 5	Resheeting		0 019	0.020	-	0.056	-	-	-	0.199	1.699	14.7
NR05	Wabag - Mendi Road	Soba - Peane	SN17	Gravel	5 0	0 0	5.0	Resheeting		0 096	0.104	0.759	0.202	-	-	-	-	1.247	
	Provincial Road	Ialibu - Kumbene	SP23	Gravel	12.7	0.0	12 7	Resheeting		0.160	0 517	-	0.347	-	-	-	-	1.211	
	Provincial Road	Nipa - Munihu	SP24	Gravel	20 0	0.0	20.0	Resheeting		0 084	0 109	0.495	0.175	-	-	-	-	1.010	
	Provincial Road	Hiwanda - Nogoli	SP25	Gravel	23.0	0 0	23.0	Resheeting		0.118	0.182	1 324	0.470	-	-	-	-	0.854	
NR07	Highlands Highway	WHP Bdr - Kisenapoi	SN01	Sealed	0 0	20 5	20 5	Rehabilitation		0.145	0 150	-	0.137	-	-	-	-	0.767	14.0
NR07	Highlands Highway	Kumbame - Ankura Bridge	SN03	Gravel	10.1	0.0	10.1	Maintenance		0 080	0.120	-	0.112	-	-	-	-	0.654	
NR07	Highlands Highway	Ankura Bridge - Mendi [1]	SN04	Sealed		29.1	29.1	Maintenance		0.089	0.449	-	0.359	-	-	-	-	0.602	
NM3701	Koroba Road	Mendi - Kar Mission	SN05	Gravel	35.0	0 0	35.0	Maintenance		-	-	-	-	-	-	0.473	0.215	0.586	
NM3701	Koroba Road	Fakamdah - Ambua Lodge	SN07	Gravel	54 2	0.0	54.2	Maintenance		0.046	0 286	-	0.237	-	-	-	-	0.413	
NM3702	Kutubu Road	Poroma T/O - Moro	SN11	Gravel	112.0	0 0	112.0	Maintenance		0.032	0.035	0.257	0.068	-	-	-	-	0 395	
NM3703	Erave Road	Kagua - Erave	SN14	Gravel	39.6	0.0	39.6	Maintenance		0 033	0.170	-	0.131	-	-	-	-	0.201	
ND3701	Oksapmin Road	Fugwa T/O - Tagobi	SN15	Gravel	15 0	0.0	15.0	Maintenance		0.015	0.026	0.165	0.044	-	-	-	-	0 162	
NM3704	Sumia - Pirri Road	Peane T/O - Sumia	SN19	Gravel	27.0	0.0	27.0	Maintenance		0 014	0.063	-	0.074	-	-	-	-	0.082	
NM3705	Kagua Road	Sumia - Kagua	SN20	Gravel	41.0	0.0	41.0	Maintenance		0 107	0 069	-	0.089	-	-	-	-	-	
	Provincial Road	Soba - Winza	SP26	Gravel	8.3	0 0	8 3	Maintenance		-	-	-	-	-	-	-	0.305	-	
	TOTAL LENGTH				745 3	50.6	795.9		82 346	2 540	6.303	6.305	5 101	-	-	0.473	1.805		
	Total Cost																104 873		

The organisation chart for the PIU is provided in Figure 7.1, while the functions of the PIU are listed in Figure 7.2. The personnel proposed for the PIU are listed in Figure 7.3. The roles of the Steering Committee, DOW Executive Team and Road Maintenance Team are defined in Chapter 7, in Volume 1.

FIGURE 7.1: RUMP PROGRAM IMPLEMENTATION UNIT ORGANISATION

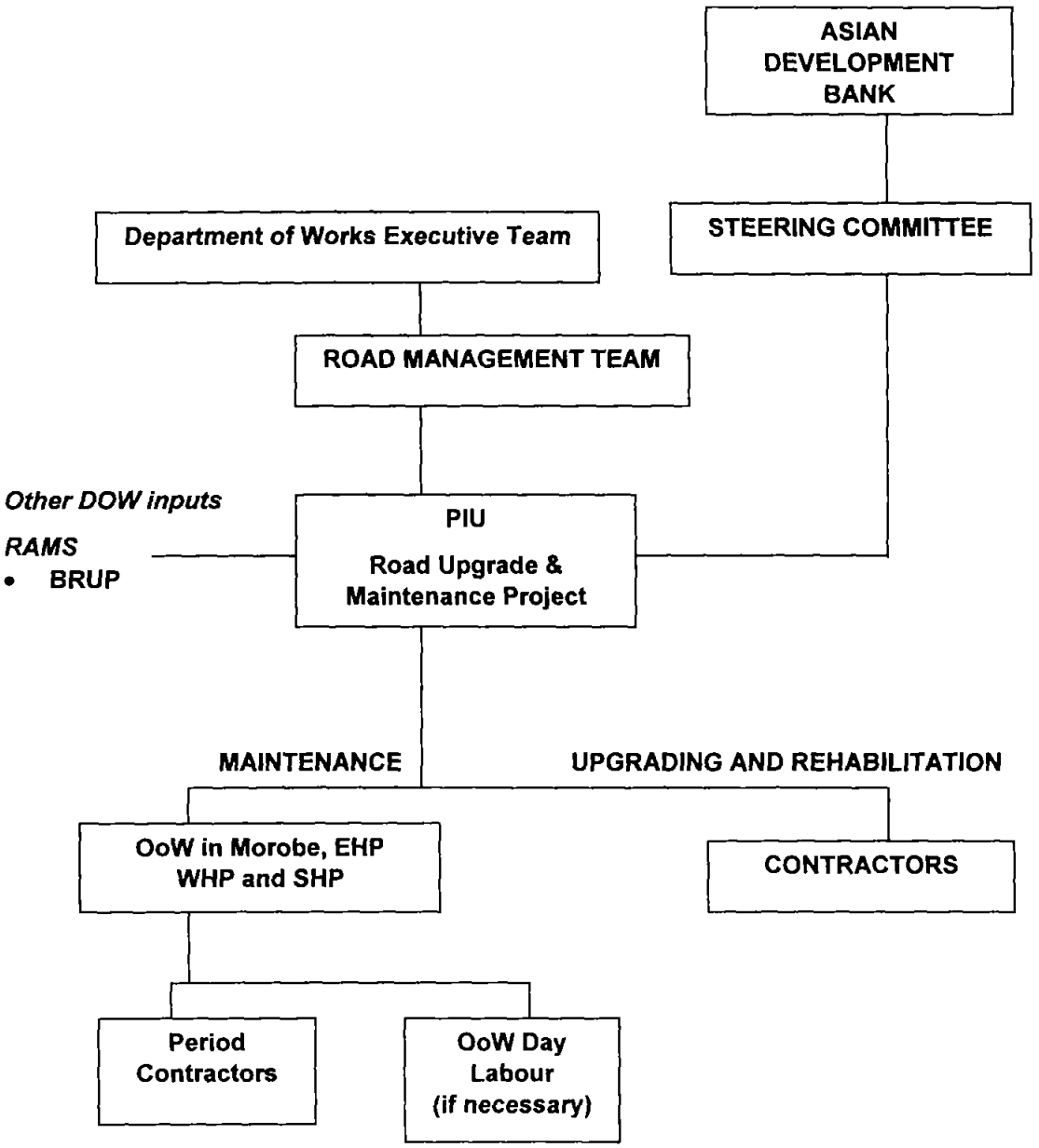


FIGURE 7.2: PIU FUNCTIONS

Establishment	Establish PIU within DOTWCA
	Appoint Steering Committee from Government and Provincial agencies and the private sector
	Engage a Contractor to provide specialist staff with expertise in period maintenance, quality control, construction contracts, training and institutional strengthening.
Planning	Prepare programs of improvement works and manage budgets
	Establish and manage Quality System
	Implement tender and contract procedures
	Establish program monitoring and reporting procedures
	Provide training in maintenance management and institutional strengthening
Program and Budgeting	Prepare Five Year Plan for the network, using RAMS systems
	Develop annual PIU Plan from Five Year Plan
	Budget appropriation
	Program revised by PIU to accord with appropriation
	Program and Budget approved by Steering Committee
	Funds authorised to DOTWCA from GOPNG and loan sources
Informing	PIU implements program; reports to Steering Committee quarterly
	PIU report notifies SC and ADB of new mobilisations, and tenders
Audit	External Audits carried out on program implementation and operations
	PIU reports back to SC and ADB on results of Audits.

FIGURE 7.3: PIU PERSONNEL AND FUNCTIONS

FUNCTION	PERSONNEL
PIU Management	Project Director
• Planning	Deputy Project Director
• Budgeting	Administrative Assistant
• Report and respond to Steering Committee	
• Quality Systems	
Lands and Community	Land and Community Liaison Manager
• Land Title Negotiations	Lands and Community Affairs Officer #1
• Community liaison	Lands and Community Affairs Officer #2
Asset Management	Asset Manager
• RAMS liaison and reporting	Road Maintenance Engineer
• Road condition monitoring	Bridge Maintenance Engineer
• Maintenance planning	Materials Technician
Upgrading and Rehabilitation Projects	Project Manager – Upgrading and Rehabilitation Works
• Conduct Studies	Traffic Engineer/Transport Economist
• Conduct Traffic Engineering	Design Engineer
• Plan Upgrading Works	Contracts Manager
• Manage Design Contracts	Contracts Clerk
• Prepare Contract Documents	CAD Draftsman #1
• Prepare Contract Documents	CAD Draftsman #2
• Conduct Tender and Contract Process	
• Manage Contracts	
• Conduct Technical Audits	
Financial Control	Financial Controller
• Programming	Quality and Quantity Surveyor
• Cost Control	Cost Clerk
• Reporting	
• Manage Audits	

7.4 PROJECT OPERATIONS

Private sector contractors are proposed to construct the major of the road upgrading, rehabilitation and maintenance projects. The projects will be used to develop skills and capacity within the private sector road construction industry in PNG and to develop skills within DOTWCA and OoW. Some maintenance works will be completed by the POoW with day labour where no suitable contractor is available. For emergency works, PIU will utilise the resources of the MEB basic fleet and the FAT-POoWs.

For administrative and business efficiency, a limited number of maintenance Period Contracts will be awarded in each province in accordance with local market conditions and fragmentation. The scope of works includes all of the routine maintenance, periodic maintenance and upgrade works in their area of responsibility. Each contract will run for a specified period, and may be re-tendered or extended, depending on performance and market conditions. Contracts for rehabilitation and upgrading works will be awarded on a project basis.

The mode of procurement will vary, depending on the PIU perception of the sub project needs and available contractor capacity. Pre-qualification of contractors will be conducted with transparency with the assistance of a representative of the PNG Contractors' Association. Contractors will be given sufficient time to prepare for the tendering process to allow them to form alliances and joint ventures to bring the necessary skills, equipment and experience together. International tenderers may be included if the skills and capacity are not available in PNG. It is essential that all contractors selected for the projects have a proven track record in PNG and a formal establishment in PNG.

A Demonstration Contract is proposed in each province to be awarded by tender under limited letters of invitation. The invitees will be drawn from a prequalified list prepared by PIU, PG and PNG Contractors Association, based on a particular criteria presented in Section 7.2.2 of Volume 1.

A program of consultation with and information to the construction industry should commence at least six months before the pre-qualification procedures commence, and be led by the OoW 'focal point' for industry liaison and extension.

The prime contractor will be expected to engage smaller local contractors for parts of the work and in this way will help develop a range of construction experience and capability in the provinces. Successful international contractors will have an additional task of providing in-project training.

The PIU will commission engineering consultants to prepare detailed designs and tender documentation for the road upgrading sub projects. A number of terms of reference (TOR) for detailed design of upgrading projects used by the DOTWCA have been reviewed and the preferred TOR has been provided in Appendix G.

CHAPTER 8. BENEFIT MONITORING AND EVALUATION

8.1 GENERAL

The purpose of the benefit monitoring system is to set up indicators and methodology for gauging the impact on transport demand, trip generation, and transport services from the improvement and upgrading of candidate roads. Monitoring consists of measuring "before and after" impacts on transport. The process is one of selecting indicators, collecting data related to each indicator, and analyzing the results. This monitoring of benefits and socio-economic impacts is a component of the project performance indicator system described in Section 7.3, Volume 1.

The focus of benefit monitoring is on the direct and indirect impacts of road improvements on transport of persons and goods within the study corridors, and their adjacent or tributary zones of influence. Impact indicators and measures are discussed below.

The baseline surveys must be prepared within the framework of project implementation and the current PNG social and "law-and-order" context. It is envisaged that the Project Implementation Unit or execution supervisory office would commission and give direction to these "before and after" studies. The studies should be conducted at the same time and as part of the community liaison task which is detailed in the Volume 4 – Initial Social Assessment. Details for identification of impacts and base-line measures are provided in Table 8.1.

The "before-improvement" surveys should be carried out when works are tendered and award of contract is certain. Expectations of target communities should not be raised until works are certain to proceed. These surveys are directed at measuring quantum changes brought about by significant improvements in accessibility. Consultation with local community leaders and councillors and law enforcement authorities is necessary to increase compliance and ensure safety of interviewers. Survey work depends on the co-operation and support from local community leaders and village councillors. This must be gained during the initial field reconnaissance phase when survey locations and households are being picked for sampling. A public information campaign/announcement should precede the survey.

Pre-project assessments and surveys should be conducted before construction begins, ideally during the community awareness phase described in Volume 4 – Initial Social Assessment. The "after-improvement" phase should be undertaken from one to two years after completion of construction to assess the response of corridor settlements to the road improvement.

8.2 ROAD CONDITIONS AND PHYSICAL CHARACTERISTICS

Indicators for this component include:

- Roadway width;
- Surface type and visual signs of surface deterioration and stress;
- Roughness and quality of service; and
- Seasonal limitations on use.

Quantitative measures for this category include width of travelled road and shoulders, and factors affecting side friction and traffic conflicts. Before and after roughness measurement using a bump integrator or similar type of equipment to give International Roughness Index (IRI) should also be undertaken. If in their existing unimproved condition, roadways are so pot-holed and disintegrated as to make IRI measurements meaningless, visual assessments with photographed examples would have to suffice.

TABLE 8.1: IDENTIFICATION OF IMPACTS AND BASE-LINE MEASURES

Indicator	Object/Target	Instrument of Measure		Diabnostics
Road Condition	Width			
	Surface	Field investigations/ rideability		
	Seasonality	User interviews & days closure/limited use		
	Roughness	IRI measurement/ observation		
	Side friction	Observation		Encroaching structures in right of way Pedestrian traffic
Traffic	Volume	ADT		
		12hr & 24hr count Sample by day of		Composition of traffic stream
Utilization	Transport Industry & Travelling Public User Profile	O/D survey Vehicle Passenger Terminal Interviews	Driver Trip purpose avg. speed trip length trip frequency/season itineraries Household transport expenditure patterns Occupation	Commodities carried Avg. payload & Est. value of goods Back-haul
User costs	Vehicle operating cost	Transport Industy Inverviews	Fuel consumption repair costs tyre life cost/km trip time	Vehicle utilization fleet composition
Safety	Fares & rates Travel time Design & enforcement	Frequency & No severity of accidents:	No. of accidnts/injuries/1000 motor	1000 motor vehicles fatalities/1000 motor vehicle
		Casual factors location Anaylsis		Black-spot & number of accidents/location
Impact on other Modes	Diversion from Air	Interviews with air charters and carriers	Flights/week or season, occupancy no. of passengers	Freight volumes by commodity & seasonality
				Cost/pass-km & tonne-km

These studies should be supplemented by field observations and an inventory of surface condition, roadway characteristics, and rideability. Quality of service, utilization, and seasonal limitations would be assessed by traffic counts and interviews with users with surveys as discussed below.

8.3 UTILIZATION

Indicators for this component include:

- Traffic volume and composition by hour and day of week;
- User profiles:
  - Goods transport; and
  - People transport.
- Travel speeds, time and cost between major settlements; and
- Accident rates, with incident locations plotted on maps, and data collection showing contributing causes, property damage, and severity of injuries.

Classification counts should be to determine traffic flow and composition. At the same time during daytime hours, origin/destination surveys should also be carried out on large as possible sample of vehicles. PMV passenger surveys, most conveniently carried out at PMV pick-up/waiting points and public markets should also be prepared. Information to be collected would include trip purpose and itinerary by vehicle and user type, commodity, estimated payload and capacity of vehicle. Additional information to be gained from road-side and passenger terminal/lay-by interviews would include travel time and average speed within the study corridor, costs/fares, annual/seasonal travel habits, and estimated trip frequency by regular route users. Monthly household expenditures on transport should also be included in the passenger survey.

OoT and police statistics should be consulted to gain available data on road accidents. Indicators would include probable cause, and seriousness of injuries, as well as occurrence of fatalities, and estimated damage costs per incident to the extent to which records are available.

8.4 IMPACTS ON ROAD TRANSPORT INDUSTRY AND TRIP BEHAVIOUR

Measures of impacts upon commercial and private transport include the following:

- Goods hauliers;
- Public passenger transport services; and
- Private/personal trips.

In addition to the roadside interviews carried out in the O/D surveys, further interviews should be carried out with passenger and freight transport operators.

Information to be obtained would include fleet and vehicle operating characteristics and performance, ownership and operating costs, company history and future plans. The interview format would include both set questions (i.e., number of vehicles by type and age, utilization, costs of vehicles, tyres, spare parts, and maintenance labour), and open-ended questions to explore operating problems and industry perceptions of present and future road conditions and their effect on costs, market penetration, and business opportunities.

8.5 IMPACT ON AIR TRANSPORT

Road improvements could in certain corridors be expected to have an impact on air transport services with an expected diversion of goods and passenger traffic to road. Trip and market patterns may also change depending upon back-haul opportunities and point of end-sale of goods. In some cases, increased air trips to Port Moresby or Lae may be an out-growth of greater marketing of produce to and through Lae and south. Indicators include present ridership and flight scheduling of air service to centres within Study area zones of influence.

8.6 MEASUREMENT OF ASSOCIATED AND INDUCED SOCIO-SECONOMIC IMPACTS

It is valuable to compare before and after conditions along the corridor in terms of settlement patterns, land use, commercial development, and agricultural activity. The social and other exogenous effects of road improvement have not often been studied as part of internationally-funded project implementation and post project evaluation. The Swedish International Development Agency (SIDA) is one exception among donor agencies for including assessments of these less easily quantifiable aspects in their project evaluations. The only comparable effort carried out in PNG was the 1991 Post-Investment Evaluation Study carried out for the Department of Transport on four road improvement projects.[30] These studies were carried out from one to four years after road improvement was completed and showed a marked increase in material standards, mobility, and easier access to public services such as health, agricultural extension services, and education. It was however difficult to quantify the impact of road improvement in isolation where other developments had occurred such as provision of power, water, and telecommunications, or improved agricultural infrastructure. A major difficulty cited in the study was the lack of any consistent and comparable "ex-ante" data for comparison.

Information for pre-investment and post-investment studies should include the types of business activity and proximity to road access, estimates of corridor population and employment, and indicators of economic activity in terms of value, quantity and type of agricultural and non-agricultural production. Also of interest are the number of small trade stalls presently located on road shoulders and within 20 m of the centre-line of the road.

In general, road improvement projects should help to improve accessibility to markets, social services, and other activities for communities. Assuring year-round accessibility should assist in social and economic integration and development. To monitor the positive and negative impacts on livelihood and quality of life, assessments should be designed to detect changes in the following:

- Household incomes;
- Cash crop and commodity production and sale;
- Prices of commodities imported into the region; and
- Farm gate and market prices for agricultural commodities.

Surveys should also include whole family quality of life and development indicators including:

- Changes in school attendance and drop-out rates by sex and cohort;
- Changes in health patterns from improved access to aid posts, clinics, and hospitals:

[30] Post-Investment Evaluation Study, Department of Transport, GoPNG, Unisearch (PNG) PTY, University of PNG in association with Beca Gure (PNG) PTY & Hughes Economic Planning, September, 1991. Projects examined included the Magi Highway, Enga Highway, Ramu Highway, and the Simbai Highway.

- morbidity; and
- mortality rates and causes.

Measures should also cover Women In Development (WID) issues and include:

- Participation rates and workload on and off-farm;
- Access to health services and health indicators;
- Education levels and literacy; and
- Marketing of produce and income patterns.

General community accessibility and transport cost indicators should include such measures as:

- Vehicle ownership and utilization;
- Trip-making behavior (monthly trips/capita to larger centres);
- Passability by season and interruptions to service (extent and severity);
- Transport costs:
  - PMV fares by route;
  - Commercial rates for goods transport; and
  - Seasonal variations in transport prices.

Appendix A

List of Contacts

LIST OF CONTACTS

Organisation	Name	Position/Title
National Capital District		
DOTWCA	Henry Veratau	Secretary
OOW	Roy Mumu	Deputy Director
	Joel Luma	Deputy Director Operations
	Alphones Niggins	Project Director - ADB
	Bernard Alois	Project Director (IBRD)
	K. (Wicky) Wickramarthe	A/Director, Maintenance
	Eduardo Sangrador	Principal Engineer, Road Maintenance
	Rupa Kalamo	Assistant Director (ROADS)
	Jan Juslem	Road Asset Management
	Robert Nanayakkara	ADB Technical Advisor
	Wesley Waiwai	F/Assistant Director, ITB
	Vaghi Gairowagga	Assistant Director Architecture
	Mosely Pukut	Project Director (AusAid)
	Graham Curnow	Team Leader, AusAID Regravelling and Sealing Project
	Bala Muhunthan	Bridge Maintenance Engineer, BRUP
	Mogia Miamil	OIC, Land Acquisition Unit
	Russell Bourke	SMEC project
	Francis Natera	Project Engineer, Bereina-Malalaua road project
	Andrew Ralpha Buna	Manager Engineering, MEB
	Naeses Womara	Assistant Coordinator
	Gerard Songi	Assistant Director, Finance & Budgets
	Dr Chuku	Assistant Director, HRD
OOT	Henry Parakei	Deputy Secretary - DOTW
	Lister Heni	Director
	John Siola	Director - Road Safety Council
	Rei Miria	FAS Policy & Planning
	Hyabian Bannah	FAS, Land Transport Division
	Warol Ulea	Executive Officer, Freight Transport, Land Transport Division
	Philip Habon	
	Eunice Talao	
Department of Finance and Planning	Marianna J. Ellingson	First Assistant Secretary
Department of Environment & Conservation	Dr Wari Iamo	Secretary
	Gunther Joku	Director, Environment
	John Douglas	Technical Advisor
National Statistical Office	Joseph Aka	Principal Statistician
Department of Lands	John Kondika	Senior Lands Officer, Highlands

Organisation	Name	Position/Title
Office of Rural Development	Raul Santa Cruz	Program Manager
	Paul Sai	Director
		Director
Department of Treasury and Corporate Affairs	Vali Tanaperry	Price Control Office
	Jeffery Kop	Price Control Office
	Anthony Yauieb	Principal Economist, General Economic Policy, Economic Planning Unit
Internal Revenue Commission	John Sam	Tariff Research Officer
	Rob Rudy	Economist
	Richard Filmer	Advisor
National Planning Office	Homolpi Warom	Acting FAS
	Leka Pitol	Programmes Officer, ADB
	Elizabeth Aviasa	Principal Budgets Officer
	Illivitalo Saneto	Infrastructure Planner
PNG Forest Authority	David Pannett	Advisor, Auditing Department
	Kanawi Pouru	Director of Policy
Office of Rural Development	Paul Sai	
National Research Institute	Dr Colin Filer	Head of Social and Environmental Studies
	Dr Agogo Mawuli	Head of Economic Studies
Australian High Commission	Paul O'Neil	First Secretary - AusAID
	Violeta Kuenne	Second Secretary - AusAID
Japan International Cooperation	Masahiro Kobayashi	Resident Representative
	Kei Jinnai	Assistant Resident Representative
World Bank Liaison Office	Ms. Kearau Kila	Adminstrative Assistant
	Richard Schoerner	Engineer
Arman Larman Surveys	Jeff Sanderson	
Ela Motors	Chris Batten	Technical Service Manger
	John Bland	Sales & Marketing Manager
	Geoff Dunlop	Field Sales Manager
	Norm Keay	Business Development Manager
Shell PNG Ltd	Tim Lai	Retail Marketing Manager
	Lee Pokarop	Assistant Marketing Manager
Port Moresby Transport	Gapi Karo	Customer Service Manager
	Frank Schmidt	Work Shop Supervisor

Organisation	Name	Position/Title
MOROBE		
OOW	Giawa Tiaga	F/Assistant Director
	Brian Alois	Project Engineer
	Michael Siomale	Finance & Admin Officer
	John Wakma	Provincial Works Manager
	Herman Smidt	Regional Merb Eng, MEB
	Lito Galura	OIC, MEB
	Brian Mogu	
	Andelito Galura	Provincial Plant Manager
Provincial Government	Ainea Sengero	Provincial Administrator
	K. Lucas	A/Provincial Works Manager
	T. Danggun	Provincial Disaster Coordinator
	E. Kurua	Road Supervisor
	J. Wari	Road Supervisor
	L. Obe	Airstrips & Works Supervisor
	Tera Gauba	Provincial Coordinator
	Kokoda Willie	Provincial Planner
	Murewec Zurenuoc	Provincial Information & Monitoring Unit
EASTERN HIGHLANDS		
OOW	Dick Karim	Provincial Works Manager
	Joe Kalip	Works Foreman
	Kevin Oya	OIC Kainantu
Provincial Government	Henol Omenefa	Provincial Administrator
Department of Lands	McLaren Ririka	Provincial Manager, Lands Office
	Reid Koyomiafa	Valuer, Valuer General's Office
	Lynch Oridua	Adviser, Technical Services
	Israel Zuwi'e	Civil Engineer
Coffee Industry Corporation	Gerard Stapleton	Senior Economist
	B. Umetrifo	Economist
Small Rural Project Management	R. Kimiramba	Manager
	Ifuka Kofiaba	FAO
	Lynch Oridua	Adviser, Technical Services
Small holder Cofferr Growers Association	Yanga Karre	Chairman, Watabung, EHCGA
Rodao Pty Ltd	David Monks	Director-Construction
	Roger Tipton	Director - Electronics
Transwest Transport	Goro L. Nime	Depot Manager
Collins & Leahy Pty Ltd	Daniel Leahy	Founding Chairman

Organisation	Name	Position/Title
WESTERN HIGHLANDS		
OOW	Kemp Nori	First Assistant Director
	Henry Pagla	Provincial Works Manager
	Dan Muturam	Provincial Engineer
Provincial Government	Dr Thomas Webster	Provincial Administrator
Department of Lands	Joel Pomgopia	Senior Lands Officer
Provincial Administration	Georgina Dui	Assistant District Administrator, District Services
	Kari Makinta	Land Mediator, District Services
	Marcus Pup	Land Mediator, District Services
	Damien Lucas	District Officer, Lands, Hagen Central District
Gomis Women's Association	Nancy Rus	President
	Paka Kot	Vice President
Bank of South Pacific	David Burrows	Regional Manager
Wellcos Resources & Constructions Co Ltd	Sikens Oki	Acting General Manager
Niugini Engineering	John Las	Project Engineer
	Thomas Daki	Project Engineer
SP Holdings Ltd	Charles Daniel	Assistant Regional Operations Manager
Global Construction	Hyung-Sub Joo	Administration Manager
	Mathew Male	Company Secretary
	Sandy Hill	General Manager
East West Transport	Pascal Taru	Terminal Manager
Pagani Transport, Kutubu Transport & Naptha JV	Andrew Rice	Australian Local I/C
Transwest	Peter Laurie	Depot Manager
Mobil Oil	Rod Griffiths	General Manager, Highlands
	Bill Wartoro	Territory Manager
Pogera JV	David Yok	Senior Environmental Officer
SOUTHERN HIGHLANDS		
OOW	Major Steven Noble	Provincial Works Manager
	Sgt John Taylor	Provincial Plant Manager
	Captain Phil Miles	Provincial Civil Engineer

Organisation	Name	Position/Title
	Captain Ian Picket	Provincial Building Engineer
	Dave Allen	Senior Road Supervisor
	Sgt Andy Keats	
	Arnold Fox	Senior Building Supervisor
SMEC/QCPP	Peter Biggs	Team Leader
Global Construction	Sandy Hill	General Manager
AUSTRALIA		
AusAid, Canberra	Dr Marjorie Sullivan	Adviser Environment
	Jan Gammage	PNG Desk Officer
Australian National University, Canberra	Dr Bryant Allen	Senior Fellow, Research School of Pacific and Asian Studies

Appendix B

Bibliography

BIBLIOGRAPHY

A LENDING AND AID AGENCIES

Asian Development Bank

Guidelines for the Economic Analysis of Projects, Asian Development Bank, February 1997.

Asian Development Outlook 1997 and 1998, Asian Development Bank.

Technical Assistance to Papua New Guinea for Preparation of the Road Upgrading and Maintenance Project, TAR: PNG 32124, Asian Development Bank, July 1998.

Technical Assistance to Papua New Guinea for Road Sector Cost Recovery Improvement (Draft), Asian Development Bank, October 1998.

Fourth Road Improvement (Sector) Project in Papua New Guinea, Asian Development Bank, December 1998.

Asian Development Bank, PPA: PNG 19029, Project Performance Audit Report on the Fourth Road Improvement (Sector) Project (Loan Nos. 690 – PNG and 691 – PNG [SF]) in Papua New Guinea, December 1998.

Asian Development Bank, Fourth Road Improvement (Sector) Project, Provincial Roads and Bridges Investment Programme, Phase II Provincial Roads Improvement Manual.

Asian Development Bank, Fourth Road Improvement (Sector) Project, Provincial Roads and Bridges Investment Programme; Final Report.

Contract for Consultants Services between Asian Development Bank and Egis Consulting Australia Pty Ltd, Australia, TA No. 3037-PNG, Road Upgrading and Maintenance Project, December 1998.

Minutes of Contract Negotiations on TA No. 3037-PNG, Road Upgrading and Maintenance Project, 14-17 December 1998.

Road Asset Management System (RAMS), Inception Report, Asian Development Bank TA No. 3004-PNG, November 1998.

Asian Development Bank; Road Upgrading and Maintenance Project – TA No. 3037 – PNG, Inception Report Draft. February 1999.

Key Indicators of Developing Asian and Pacific Countries, Economics and Development Resource Center, Asian Development Bank.

Guidelines for Social Analysis of Development Projects, Asian Development Bank, June 1991.

Guidelines for Incorporation of Social Dimensions in Bank Operations, Asian Development Bank, October 1993.

Handbook for Incorporation of Social Dimensions in Projects, Asian Development Bank, May 1994.

Handbook on Resettlement, A Guide to Good Practice, Asian Development Bank.

The Bank's Policy on Indigenous Peoples, Asian Development Bank, April 1998.

Environmental Assessment Requirements of the Asian Development Bank, Asian Development Bank, Environmental Division, Office of Environment and Social Development, March 1998

Environmental Guidelines for Selected Infrastructure Projects, Office of the Environment, Asian Development Bank, 1993.

Economic Evaluation of Environmental Impacts, A Workbook, Asian Development Bank, Environment Division, Office of Environment and Social Development, March 1996.

Economic Evaluation of Environmental Impacts, A Workbook, Executive Summary Asian Development Bank, Environment Division, Office of Environment and Social Development, March 1996.

Handbook on Policies, Practices and Procedures Relating to Procurement Under Asian Development Bank Loans, Asian Development Bank, Central Projects Services Office, February 1983 (revised February 1990).

Guidelines for Procurement under Asian Development Bank Loans, Asian Development Bank, January 1994.

Guide on Prequalification of Civil Works Contractors, Asian Development Bank.

Guide on Bid Evaluation, Asian Development Bank, June 1998.

Loan Disbursement Handbook, Asian Development Bank, 1996.

Cost Accounting System, TA No. 2255-PNG, Asian Development Bank, August 1997.

Papua New Guinea – Road Maintenance and Rehabilitation Project (Project Implementation Plan (PIP)) Oct 97 – 2000

Asia Development Bank(Draft TARPNG) Technical Assistance to Papua New Guinea for Road Sector Cost Recovery Improvements, October 1998.

Mainstreaming Participatory Development Processes.

Sample Bidding Documents, Design-Build and Turnkey Contracts, Asian Development Bank, December 1996.

Sample Bidding Documents, Procurement of Civil Works, Small Contracts, Asian Development Bank, February 1996.

Sample Bidding Documents, Procurement of Civil Works, Second Edition, Asian Development Bank, December 1993.

Sample Bidding Documents, Supply, Delivery and Installation of Goods, Asian Development Bank, September 1998.

Asia Development Bank; Road Maintenance Project Loan No.1153 – PNG Contract Tender Board Document for Specific Maintenance of Highlands Highway 1997.

World Bank

Terms of Reference for the Rehabilitation of the Highlands Highway, Papua New Guinea, The World Bank, February 1998.

Drafting Instructions for the Highlands Highway Authority, The World Bank, March 1998.

Road Transport Research, Road Monitoring For Maintenance Management, Volume 1, Manual for Developing Countries, Paris, 1990.

A World Bank Policy Study, Road Deterioration in Developing Countries. Causes and Remedies.

Papua New Guinea, Road Maintenance and Rehabilitation Project, The World Bank.

World Development Indicators, The World Bank, 1998.

The Highway Design and Maintenance Standards Model, Volume 2 – Users Manual for the HDM-III Model, T. Watanatada, C.G. Harral, W.D.O. Paterson, A.M. Dhareshwar, A. Bhandari, and K. Tsunokawa, World Bank, 1989.

Report No. P7213-PNG, Memorandum and Recommendation of the President of the International Bank for Reconstruction and Development to the Executive Directors on a Proposed Loan in an Amount Equivalent to US$ 5.0 Million to the Independent State of Papua New Guinea for an El Nino Drought Response Project; February 24, 1998

Papua New Guinea. Accelerating Agricultural Growth: an Action Plan. Agriculture Operations Division, CD III, East Asia and Pacific Region, The World Bank, February 1997.

Papua New Guinea Recent Economic Development & Medium Term Prospects, Earp, 1995.

Papua New Guinea Delivering Public Services Main Report, August 1995, Report No. 14419. PNG.

Road Deterioration in Developing Countries. Causes & Remidies, World Bank Policy Study, Clell Hurral, osif Faizit 1988.

Australian Agency for International Development (AusAID)

Discussion Paper on Road Maintenance and Road Maintenance Funding – PNG Aid donors Workshop on Road Maintenance (30 November 1995).

Australian Agency for International Development. Papua New Guinea Programme Profiles 1998. Canberra 1998.

The PNG Bridge Replacement and Upgrading Project, Programming of Bridge Maintenance Work Training Workshop – Hand book; Funded by AusAID Under the Australia-Papua New Guinea Development Cooperation Program, Job No: 1512/29; April 1998.

AusAID, Australia – Papua New Guinea Development Cooperation Project; Mendi to Kisenepoi, Project Implementation Document; Draft, Australian Agency for International Development; December 1995.

B Papua New Guinea Government Agencies

Government of Papua New Guinea

The Highlands Highway Rehabilitation Authority, Draft Instructions, May 16 1998.

Independent State of Papua New Guinea, Confidential Policy Submission Proposal to establish a Papua New Guinea Roads Authority, John Orea, MP, Minister for Public Service, May 1994.

Volume 2, Part 3, 1999 Estimates of Development Expenditure for the National Departments, Statutory Authorities and Provincial Governments, For the year ending 31st December 1999, Presented by the Hon. Iairo Lasaro, MP, Deputy Prime Minister and Minister for Treasury & Planning on the occasion of the 1999 Budget.

Volume 2, Part 1, 1998 Estimates of Revenue & Recurrent Expenditure the National Government, For the year ending 31st December 1998, Presented by the Hon. Iairo Lasaro, MP, Deputy Prime Minister and Minister for Treasury & Corporate Affairs on the occasion of the 1998 Budget. First Legislative Council.

Independent State of Papua New Guinea. Draft Organic Law on Provincial Governments and Local-Level Governments.

DOTWCA

Road Design Manual, Department of Works, Papua New Guinea, June 1994.

Papua New Guinea, Road Maintenance and Rehabilitation Project, Project Implementation Plan (PIP), Department of Transport and Works, April 1997.

Papua New Guinea, Updated Strategy, Department of Transport and Works, October 1997.

Department of Works Road Design Manual.

Department of Works (Government Agency for Public Works), Corporate Plan 1994 – 2003.

Papua New Guinea Department of Works and Supply, Road Maintenance Study, Volume II, Operations Report, Part A – Text, May 1985.

Specifications for Road Maintenance, Department of Transport and Works, November 1996.

Papua New Guinea Shipping, Transport & Aviation Handbook. Published in Conjunction with PNG Harbours Board.

Papua New Guinea Department of Works, Road Maintenance Field Manual, Section One, Road Maintenance Management and Glossary of Terms.

Papua New Guinea Department of Works, Road Maintenance Field Manual, Section Two, Safety at Roadworks.

Papua New Guinea, Department of Works, Road Maintenance Field Manual, Section Six, Bridge and Culverts.

MARESMAN, Road Maintenance Resource Management Program, January 1990.

Bridge Inventory and Bridge Management Study, Draft Final Report, Volume 1 and 2, Works Consultancy Services, September 1996.

Corporate Strategic Plan 1998-2001 (Draft), Department of Transport and Works.

Bundi Access Road Economic Evaluation, Policy and Planning Division: Infrastructure Branch, Department of Transport, April 1990.

Bridge Design Standards Papua New Guinea, Department of Works and Supply, November 1983.

White Paper on Transport Infrastructure Development Plan (Sea and Road), Part II, Department of Transport, November 1990.

Transport Improvement Project, Papua New Guinea, Road Materials Resources Study and Gravel Pit Inventory; Western Highlands Province, Volume III; Addendum Proformas, September 1992

Transport Improvement Project, Papua New Guinea, Road Materials Resources Study and Gravel Pit Inventory; Western Highlands Province, Volume II; Summary Proformas and Schematic Pit Sketches, September, 1992

Transport Improvement Project, Papua New Guinea, Road Materials Resources Study and Gravel Pit Inventory; Western Highlands Province, Volume I; Main Report, September, 1992

Department of Transport & Works, Feasibility Study for Bogia – Del River road, Final Report, May 1996.

Department of Works – Blueprint on Capital Works 1994 – 2003.

Department of Transport and Works Corporate Strategic Plan (Draft) 1998 –2001.

Department of Transport, Works & Civil Aviation Office of Transport, Mission Statement, Objectives, Functions, Responsibilities, January 1999.

Office of Transport, Proposed Structure January 1999.

Department of Transport and Civil Aviation, Office of Transport, Mission Statement, Objectives, Functions and Responsibilities, January 1998.

Department of Transport, White Paper on Transport Infrastructure Development Plan. (Sea and Road) Part II, November 1990.

Department of Works (Government agency for public works) Corporate Plan 1994 – 2003.

Department of Works and Supply, Roads and Bridges Section; Preliminary Report, Bulolo – Menyamya Road Morobe Province.

Papua New Guinea Department of Works and Supply road Maintenance Study Volume II, Operations Report Part A – Text.

Papua New Guinea Department of Transport and Works, Bridge Inventory and Bridge Management Study, Draft Final Report, Volume 1.

Department of Transport Planning and Research Division. Bridge Rehabilitation and Replacement Program. Re-check on Economic Feasibility June 1993.

Government of Papua New Guinea Department of Transport policy Planning Division Vehicle Operating Costs manual & Tables [Renders Economics August 1979]

Department of Transport & Works Papua New Guinea, The Australia-Papua New Guinea Bridge Replacement and Upgrading Project (Brup), Monthly Report No. 18 – May 1998. Funded By AusAID Under the Australia – Papua New Guinea Development Co-operation Program. Job No: 1512/29. June 1998.

The PNG Bridge Replacement and Upgrading Project, Programming of Bridge Maintenance Work Training Workshop – Handbook, Funded By AusAID Under the Australia – Papua New Guinea Development Co-operation Program. Job No: 1512/29. April 1998.

Road Maintenance Field Manuals, Department of Works.

Department of Works, Memorandum 002/96. Road Maintenance Budget and Categories, 1996.

Department of Transport and Works, Parliamentary Brief for the Minister for Transport and Works; Hon. Peter Yama, MP, March 1997.

Department of Works HQ September 1994, Major Contracts Section; Supervision of Contract TC 120-39-807, Togoba Ialibu Road; Consultancy Agreement No 3441 – 26 October 1990, Financed under IBRD Loan No 2742-PNG; Amendment No 1.

Appendix 4 Cost Estimates [Kagua to Pangia].

Tender CSTB – 0139 PTB 3/99, Department of Works; Registered Price Agreement. ***Date of Publication = Unknown***.

Independent State of Papua New Guinea, Department of Transport, Works, and Civil Aviation; Asian Development Bank, Funded Transport Infrastructure Development Project Loan NO. 1153-PNG; Contract NO. SCH 159001-20000-33, Regravelling of Magi Highway from Matairuka to Ormond River in Central Province; Conformed Contract, February 1999.

Papua New Guinea Department of Works; Togoba – Ialibu Turn Off Road in Western Highlands/Southern Highlands Provinces, Contract NO 120-39-807; Volume 2, Conformed Contract. ***Date of Publication = Unknown***.

Department of Environment and Conservation and Department of Transport and Works

Papua New Guinea. Environmental Guidelines for Roads and Bridges, January 1997.

Department of Commerce & Industry

Final Report Assistance to Domestic Civil Engineering Contracting Industry [Prepared for Department of Commerce and Industry].

The CIU Construction Training Programmes; An Evaluation of their Economic Impact to the Development of the Construction Industry and the Country [Prepared by Construction Industry Unit Department of Commerce and Industry May 28, 1997].

Department of Trade and Industry Construction Industry Unit. Brief on the Activities of the Construction Industry Unit, August, 1998.

The Department of Commerce & Industry Construction Industry Unit. Small Contractors Training. Construction Entrepreneurship Bidding Procedures Contract Administration & Documentation and Construction Plant Management. [This training manual was developed by the Construction Industry Unit for training of small domestic builders and contractors in Madang, Madang Province] November 1998.

Department of Trade and Industry/Construction Industry Unit Small Domestic Contractor Training Project, August 1998.

Department of Commerce and Industry; Construction Training Programme; An Evaluation of their Economic Impact to the Development of the Construction Industry and the Country; Prepared by Construction Industry Unit, May 1997.

Department of Commerce and Industry; Technical Assistance to Domestic Civil Engineering Contracting Industry, World Bank Loan ToR and Agreement, November 1992

National Planning Office

Independent State of Papua New Guinea Medium Term Development Strategy 1997 – 2002, A Bridge into the 21st Century.

Volume 3, Public Investment Programme, 1998 – 2002, Presented by Sir Mekere Morauta, Kt., MP, the Minister for National Planning and Implementation on the occasion of the 1998 Budget.

Economic Planning unit Treausres & Corporate Affairs monthly Economic Monitor (Various Issues up to Jan 1999.

Bank of Papua New Guinea, Quarterly Economic Bulletin, September 1998.

Abstract of Statistics, September Quarter, 1996, Import Statistics, Lae and Port Moresby, 1997.

Morobe Provincial Government

Morobe Provincial Government [Volume1] 1999 Annual Implementation of the Provincial Five Year [1998 ~ 2002] development Plan. Presented by Honourable Bart Philemon MP. Chairman for Policy & Planning. On the Occasion of the Handing Down of the 1999 Budget Estimates on Revenue & Expenditure for the year ending 31st December, 1999. On the Tuesday 22nd Day of December 1998.

Morobe Provincial Administration, Division of Works, Inventory of Provincial and Local Level Government Roads, May 1998.

Morobe Provincial Administration, List of Approved Contractors 1998. Provincial Supply and Tenders Board.

Morobe Provincial Government, Division of Works, Road Bridge Maintenance and Construction, Tender Document 028, 1999.

Morobe Provincial Government, Annual Implementation Plan, 1999.

National Statistics Office

1990 Census, Morobe, Eastern Highlands, Western Highlands and Southern Highlands Provinces.

Report on the 1990 National Population and Housing Census in Morobe Province, 1994.

Report on the 1990 National Population and Housing Census in Eastern Highlands Province, 1994.

Report on the 1990 National Population and Housing Census in Western Highlands Province, 1994.

Report on the 1990 National Population and Housing Census in Southern Highlands Province, 1994.

PNG Coffee Industry Corporation Ltd

Papua New Guinea Coffee Industry Corporation Ltd, Industry Affairs Division; Coffee Discussion Paper No. 22, 1997 Exporter Costs Study; Gerard Stapleton Senior Economist, December 1998.

Industry Affairs Division; Coffee Discussion Paper #. 19, Plantation Cost of Production Survey 1995; Gerard Stapleton, January 1997.

Papua New Guinea Coffee Industry Corporation Ltd, Industry Affairs Division; Coffee Report No. 43, July 1998; Gerard Stapleton, Baluwe Umetrifo, Mick Wheeler.

Papua Coffee, Exporter's Directory.

C REPORTS BY CONSULTANCY COMPANIES AND AGENCIES

Beca International

Inception Report, Preparation of Inventory of Roads and 5 Year Road Maintenance and Rehabilitation Programme, Prepared for Department of Transport by Beca International Consultants Ltd, September 1994.

Preparation of Inventory of Roads and 5 Year Road Maintenance and Rehabilitation Programme, Draft Final Report and Appendixes. Beca International Consultants Ltd in association with Wilbur Smith Associates, and Beca Gure Pty. Ltd, November 1995.

A Review of Pavement Management System Options for Papua New Guinea, Beca International Consultants Ltd., February 1995.

Papua New Guinea Infrastructure Sector Study Phase II Report, Beca International Consultants Ltd., November 1995.

Feasibility Study of New Britain Highway (Rabaul-Kimbe-Gloucester). Draft Final Report. Prepared for Department of Transport and Works by Beca International Consultants Ltd, August 1997.

Feasibility Study of New Britain Highway (Rabaul-Kimbe-Gloucester). Supplementary Information to the Draft Final Report. Prepared for Department of Transport and Works by Beca International Consultants Ltd, August 1997.

Beca Gure

Feasibility Study of New Britain Highway (Rabaul-Kimbe-Gloucester) Draft Final Report Volume III Appendices. Prepared for Department of Works by Beca Gure [PNG] Pty Ltd.

Beca Worley International

The Independent State of Papua New Guinea, Department of Works; Lae to Wau Road – Morobe Province, Contract No. T.C. 20-30-481; Umisis to Timini and Timini To Mumeng, Final Report. Beca Worley International Ltd.

Cardno and Davis Australia

Hagen – Baiyer – Ruti Road Feasibility Study, Cardno and Davies Australia Pty. Ltd., June 1989.

The PNG National Roads Regravelling and Sealing Project. Environmental Impact Assessment Guidelines for Roads and Bridges, Cardno and Davies Pty Ltd, Job No. 151/25, AusAID, February 1996.

Independent State of Papua New Guinea, Department of Works; Final Report – Vol 4, Field Manual; Transport Improvement Project, Papua New Guinea; Loan IBRD 2742, Research on Coronous Materials and their use in Road Construction; Cardno & Davies PNG Pty Ltd Consulting Engineers & Planners, Job No. 6001/14 December 1993.

Crowns Agent

Road Maintenance Study, Part A – Text, Crown Agents, May 1985.

Egis Consulting Australia

Department of Transport and Works. Feasibility Study for Bogia-Del Rive Road, Final Report.

Department of Transport and Works. Feasibility Study for Bogia-Del River Road appendices.

Department of Transport and Works. Feasibility Study for Del River Road, Executive Summary.

Enginuity. An Egis Consulting Australia Update, A new image – a new culture, Egis Consulting Australia, Issue 5 January, 1999.

Hughes Economic Planning

IBRD Roads Improvement Project, Southern Highlands Highway, Mendi to Ialibu Junction. Hughes Economic Planning in association with Wilbur and Partners, July 1990.

Maunsell Consultants

River Training Works, Review of Threats to Bridges (Various), Maunsell Consultants PNG in association with Ian Drummond and Associates Pty Ltd, November 1989.

Ove Arup & Partners Pacific

Oksapmin to Kopiago Penetration Road. Final Report to Department of Transport, 1988.

Okapa Road, Eastern Highland Province; Final Design Report, Prepared for Department of Works; Prepared by Ove Arup & Partners Pacific Consulting Engineers, November 1993.

Roadao Communications

DAW 100 – Bending Plate, Automatic Vehicle weight and Classification System, System Description.

R.J. Nairn & Partners

Department of Transport. Papua New Guinea. Port Moresby Traffic Forecast and Investigations Study. Final Report, R.J. Nairn and Partners Pty Ltd, December 1996].

Department of Transport Papua New Guinea Final Report Urban Transport Study of Lae, Madang and Rabaul. R. J. Nairn and Partners Pty Ltd, supported by Colquhoun Transportation Planning and Cardno and Davies (PNG) Pty. Ltd, November 1992.

Department of Works Papua New Guinea, Draft Report on the Economic Evaluation of improvements to the Southern Highlands Highway Togoba – Ialibu Turnoff Section. R.J.Nairn & Partners Pty. Ltd in association with Cardno & Davis (PNG) Pty Ltd, October 1993.

Strategic Options for Transport – Gulf-Southern Highlands Highway, September 1991; R.J.Nairn & R.J.Skermer.

Unisearch PNG Pty Ltd

Government of Papua New Guinea, Department of Transport; Post-Investment Evaluation Study, Magi Highway (Tubusereia – Vailala) Enga Highway (Togoba – Tomba) Ramu Highway (Waterais – Pompuquato) Simbai Highway (Simbai – Aiome); Exexcutive Summary, Volume I Final Report, Volume II Annexes, Unisearch PNG Pty Ltd in association with Beca Gure (PNG) Pty Ltd and Hughes Economic Planning, September, 1991.

Government of Papua New Guinea, Department of Transport; Post-Investment Evaluation Study, Magi Highway (Tubusereia – Vailala) Enga Highway (Togoba – Tomba) Ramu Highway (Waterais – Pompuquato) Simbai Highway (Simbai – Aiome, Volume I Final Report, Unisearch PNG Pty Ltd in association with Beca Gure (PNG) Pty Ltd and Hughes Economic Planning, September, 1991.

Government of Papua New Guinea, Department of Transport; Post-Investment Evaluation Study, Magi Highway (Tubusereia – Vailala) Enga Highway (Togoba – Tomba) Ramu Highway (Waterais – Pompuquato) Simbai Highway (Simbai – Aiome, Volume II Annexes, Unisearch PNG Pty Ltd in association with Beca Gure (PNG) Pty Ltd and Hughes Economic Planning, September, 1991.

Willing and Partners

Mumeng to Wau Road Feasibility Study Main Final Report. Prepared for Department of Transport by Willing and Partners Consulting Engineers Pty Ltd, December 1988.

Mumeng to Wau Road Feasibility Study, Executive Summary. Prepared for Department of Transport by Willing and Partners Consulting Engineers Pty Ltd, December 1988.

Toanumbu to Lumi Road feasibility Study, Final Report, Main Report. Prepared for Department of Transport by Willing and Partners Consulting Engineers Pty Ltd, January 1993.

Works Consultancy Services Ltd and Opus New Zealand

Papua New Guinea Department of Transport and Works, Bridge Inventory Bridge Maintenance Study, Draft Bridge Manual, September 1996 (Works Consultancy Services Ltd).

Papua New Guinea Department of Transport and Works, Bridge Inventory and Bridge Maintenance Study, Draft Final Report Volume 1, September 1996 (Works Consultancy Services Ltd).

Papua New Guinea Department of Transport and Works, Bridge Inventory and Bridge Maintenance Study Final Report Volume 2, November 1996 Works Consultancy Services Ltd).

Papua New Guinea department of Transport and Works Updated Strategy October 1997, Incorporating Infrastructure Sector Study and Provincial Review. (Optus New Zealand).

Papua New Guinea Infrastructure Sector Study Phase II Report, Executive Summary. (Optus New Zealand).

Papua New Guinea Infrastructure Sector Study, Provincial Review Report, 1997, Draft. (Optus New Zealand).

Frame Harvey West & Maso

Hiritano Highway Reconstruction, Brown River to Veimauri; Contract No. TC120-33-804, Project Completion Report, January 1994.

Magi Highway Reconstruction, Vailala to Rigo Road; Contract No. TC120-33-532, Project Completion Report; May 1994.

Downer

Tender for Ramu Highway Upgrading, Pompaqua to Bridge to Gogol River Bridge; DOW Tender Reference DPC 9/95 – EDF Tender NO, 4056. ***Date of Publication – Unknown***.

Kinhill Kramer

Department of Works, Ogelbeng to Dona Road; Western Highlands Province and Kundiawa to Gumine Road Simbu Province, Final Design Report; March 1994, Kinhill Kramer.

Design and Cost Estimates for Bulolo and Wau Town Roads Upgrading and Sealing, Prepared by: Gonelau Construction Pty Ltd; September 1998.

Ernst & Young Consultants Pte Ltd

Final Report, Department of Transport and Works – Papua New Guinea; Cost Accounting System (TA No. 2255-PNG) August 1997. Ernst & Young Consultants Pte Ltd.

Cost Accounting System, Chapter 1 Introduction; Department of Transport and Works, User Reference Manual. ***Publication Date = Unknown***.

Scott & Furphy Pty. Ltd

Government of Papua New Guinea Department of Transport; Hiritano Highway, Veimauri River – Tapini Junction Road Study; Final Report June 1991, Scott & Furphy Pty Ltd.

Government of Papua New Guinea Department of Transport; Hiritano Highway, Veimauri River – Tapini Junction Road Study; Executive Summary June 1991, Scott & Furphy Pty. Ltd.

C Reports/Publications By Overseas Government Agencies

Austroads

Road Maintenance Practice, Austroads 1991.

A guide to the Visual Assessment of Pavement Condition, Austroads 1987.

NSW Department of Main Roads

Notes from Gangers – Road Construction Course. Training Section, Department of Main Roads New South Wales.

UK Transport & Road Research Laboratory

A Guide to Surface Dressing in Tropical and Sub-Tropical Countries, Overseas Unit, Transport and Road Research Laboratory, Overseas Road Note 31, 1982.

National Road Safety Council

No.16 of 1977. National Road Safety Council Act 1997. Certified on: 25 November 1997.

FIDIC

Federation Internationale De-Cousels, Conditions of Contract for Works of Civil Engineering Construction Part 1 General Conditions with Forms of Tender and Agreement, Fourth Edition, 1987.

Gibb Australia

Papua New Guinea Department of Works, ADB Third Road Improvement Project Morobe Province – Upgrading of Highlands Highway from Lae to Munum; Contract No: TC 20-42-322, Project Completion Report; July 1987.

Papua New Guinea Department of Works, ADB Third Road Improvement Project Northern Province – Upgrading of Northern Highway from Buna Road to Beamu Creek Bridge; Contract No: TC 20-36-414, ***Date of Publication = Unknown***.

Papua New Guinea Department of Works, ADB Fourth Road Improvement Project East Sepik Province – Upgrading & Sealing of N9 Coastal Highway Wariman to Hawain River; Contract No: TC 120-45-812, Project Completion Report; August 1992.

Rendels Economics

Government of Papua New Guinea, Department of Transport; Policy Planning Division, Vehicle Operating Costs Manual & Tables, Rendels Economics; August 1979.

Nippon Koei Co. Ltd

Independent State of Papua New Guinea, Department of Transport and Works; National Road Improvement Project, Investigation Phase Report for Bridge Crossings; Bulolo to Wau, May 1997; Nippon Koei Co., Ltd in association with T.I Kias Pty Ltd.

Hill International, Inc.

Contract Manual for Conditions of Contract; Part A: Major Civil Works, Architectural/Intermediate Civil Works; Part B: Minor Works, Prepared for Papua New Guinea Department of Works by Hill International, Inc. ***Date of Publication = Unknown***.

D Authored Publications And Papers

J. Burton

The principles of compensation in the mining industry. In Toft, S. (ed) *Compensation for resource development in Papua New Guinea.* Law Reform Commission of Papua New Guinea Monograph No. 8, pp. 116-136, 1997

Jose E. Cabanting

Planning & Scheduling by CPM, Critical Path Method.

Construction Estimating for Profit.

Management for the Small Construction Firm.

United Nations Office for Project Services. Project Terminal Report, May 1993 to December 1997.

N.O. Jorgensen

Traffic safety. In B. Thagesen (ed) *Highway traffic engineering in developing countries.* E&FN Spoon, London, pages 102-115, 1995.

Graeme Read

Discussion Paper on Road Maintenance and Road Maintenance Funding, PNG Aid Donors Workshop on Road Maintenance, 30 November, 1995.

PNG National Transport Infrastructure Plan, Draft 30 October, 1998.

S. Toft

Compensation for resource development in Papua New Guinea. Law Reform Commission of Papua New Guinea Monograph No. 8, 1997 (edited by J. Toft)

Patrons or clients? Aspects of multinational capital – landowner relations in Papua New Guinea. In Toft, S. (ed) *Compensation for resource development in Papua New Guinea.* Law Reform Commission of Papua New Guinea Monograph No. 8, pp. 10-22, 1997.

Munare Uyassi

The Eastern Highlands, Papua New Guinea; 1990.

Mark Turner

Institutional Strengthening Issues in Papua New Guinea, Desk Study; Prepared for AusAID by Mark Turner, September 1997.

Appendix C

Road Survey

C.1 Morobe Province

MOROBE PROVINCE

HIGHLANDS HIGHWAY

Highlands Highway is a major transport route in the Highlands and Morobe Province. It serves to inter-provincial transport, linking Lae with the major centres in the Highlands and Madang via Ramu Highway. It also has an important role for economic development of the region as it is used for a voluminous transport of people and goods. The typical cross-section of the road is 7 m wide sealed carriageway with 1.0-1.5 m gravel shoulders and wide table drains. The road typically traverses flat terrain.

The pavement consists of a crushed rock base and two seal coats. The original seal is 16 to 17 years old and a new seal placed 6 years ago. The subgrade quality is generally good. Many sections of the road are constructed in fill. The road is designed to a highway standard.

The routine maintenance by OoW comprises shoulder grading, edge breaks repair, vegetation control, and emergency pothole repair. The funding allows for only one shoulder grading and grass cutting during the year.

Specific maintenance by contract carried out by Coecon Limited and funded by the Asian Development Bank. The scope of the works includes repair major pavement failures and resealing of selected segments in two separate contracts: Lae Wharf km0.0 to Clearwater km75.3, and Clearwater to Yung Creek km164.4. The specific maintenance works are progressing slowly according to the OoW.

MN01: Lae Wharf – Yalu Bridge

The 20.9 km road starts at Lae Warf and continues through the Lae urban area for about 4 km. The road width varies through the urban area and some short segments include dual carriageway. The remainder of the road runs westward through flat rural terrain.

The section was constructed in 1986 and resealed in 1993 due to surface ravelling. The riding roughness is relatively good. However, signs of surface distresses are present such as potholes, cracking, rutting and ravelling. The distress is probably due to high traffic volumes, heavy vehicle loads, and inadequate drainage. The pavement level is not raised above the natural ground level in the flat terrain causing the drainage problem. The pavement level should be raised to prevent pavement damage due to water ingress in the pavement. Overall the pavement is in fair condition.

MN02: Yalu Bridge – Erap Bridge

The 25.1 km road was constructed in 1983 and resealed ten years later. The pavement and gravel shoulders are generally in good condition. The drainage system appears to be working well. Surface distresses include occasional potholes and slight rutting.

There are a number of unsuccessful patches on this section which OoW advise is due to poor quality of cold premix supplied by a local company.

MN03: Erap Bridge – Clearwater Bridge

The 30.4 km road is good condition and the best section compared to the other sections of the Highway in the Province. The road was constructed at same time as the other section in 1983/93. The surface distresses include some shoving/rutting.

There is a significant agricultural production in vicinity of the road including corn fields, pigs, chicken and cattle farms. Heavy vehicles are in use for transport of these crops.

MN04: Clearwater Bridge – Maniang

The 44.1 km road was constructed in 1982 and resealed in 1993 and is in fair condition. The pavement is relatively smooth in this section of the Highway but with visible pavement rutting/shoving as well as cracking. These distresses are probably due to combination of factors including traffic loading, poor base compaction, and inadequate mix used for reseal. There are signs of maintenance activities underway such as marks for heavy patching on the pavement.

MN05: Maniang – Waterise Junction

The 36.3 km road is generally in good condition, but there are occasional local pavement failures comprising groups of potholes. The shoulders have been maintained well.

There are two sites with massive erosion of the road formation along a 1 km section of the road about 5 km from the start of the road. In recent years the path of the Maniang river complete hydrology on surrounding area has been changed and the road is exposed to a new arm of the Maniang River. Some remedial works are planned comprising large stone fill, reshaping of the road formation. However OoW seeks for a comprehensive solution and separate funding for remedial works. These works should include diversion of the Maniang River to its original path upstream in the mountains. OoW in Lae is preparing a report on this issue.

MN06: Waterise – Yung Creek

The 7.7 km road follows undulating terrain up to the Eastern Highlands Province border. The pavement is in fair condition. The maintenance on the road is inadequate as there are frequent areas with large and deep potholes. The shoulders are overgrown with high and dense grass and the drainage system requires maintenance.

Construction of new bridge over Yung Creek is underway to replace the bridge severely damaged by villagers.

MN07: RAMU HIGHWAY

The Ramu Highway connects Madang with the Highlands Highway providing an efficient transport route that serves the economy and overall development of the connecting Provinces. The 32.0 km section of the highway runs from Waterise Junction to Gusap on the border of the Province. Flat terrain and transversal waterways are characteristics of the road environment. The typical cross section includes fill, 7 m wide sealed carriageway, 1.0 m shoulders and wide table drains.

The pavement consists of a crushed rock base over sound subgrade and two seal coats. The road was constructed in 1985 and resealed in 1996. The condition of the pavement is good with no visible surface distresses.

The low level of funding allows only one grass cutting annually which is insufficient to control the vegetation on the shoulders and drains.

The bridges on the section are the most vulnerable locations. Bridge over Gusap River was blocked with the river sediment in 1997, immediately removed to the new location, approximately 300 m upstream, and connected via detour with the highway. The river deposits still continuously threaten to block the bridge. The OoW engaged a local contractor to monitor site and to gradually reshape the riverbanks in vicinity of the bridge. A similar problem occurred with nearby Bora Bridge which was raised on its original location.

WAU ROAD

Wau Road is an important link between Lae and the southern part of Morobe Province. The road commences at the Highlands Highway at Abunaka and ends at Wau. The road was built in the 1930's to provide access to a significant gold mining region around Bulolo and Wau. The road also serves a major agricultural region, particularly coffee production in Menyamya.

MN08: Highlands Highway - Umsis

The 20.0 km sealed road comprises three distinct sections reflecting the different construction and maintenance conditions.

- Highlands Highway – Markam River

  The 4.4 km section was resealed in 1995 with 25 mm chips and is in good condition. The terrain is flat and rolling through wooded country. The base is formed with uncrushed river gravel blended with fine material graded from roadsides and cuttings. The road is 6.5 m wide with 1.0 m shoulders.

- Markam River – Km 12

  The 7.6 km section has a 5 m wide sealed pavement in fair condition. The road traverses rolling terrain along the Markam River. A 1.5 km section near the Markam River has a high water table and the pavement is showing signs of high distress and has edge breaks. Tall grass grows adjacent to the pavement and in the shoulders significantly reducing sight distance. The surfacing is about 17 years old and has 19mm chip. The section requires rehabilitation.

- Km 12 – Umsis

  The road has a 6.0 m wide pavement and 0.5 m wide shoulders and traverses rolling terrain. Tall vegetation in the shoulder severely restricts sight distance.

  The road was surfaced about 10 years ago and it not showing any signs of distress. With the exception of the 1500 metre portion which shows evidence of high distress the basic requirement is attention to the routine maintenance to remove grass and clean table drains, blocked culverts and to repair potholes. The distressed length will need to be reworked to prepare the base course to a standard suitable to receive resealing with surface treatment.

MN09: Umsis Road - Zenag River

The 50.4 km road was upgraded and sealed in 1991-92 under a major works contract 'Umsis to Mumeng'. The road was designed and constructed to DOW engineering standards and has a 6 m wide pavement with 0.5 m shoulders. The OECF funded the works which were constructed by a Chinese contractor and supervised by Beca International.

The road is in good condition, but urgently requires routine maintenance to control vegetation and to clear drains and culverts.

MN10: Zenag River - Baiune

The first 4.5 km has a 4m wide sealed pavement with high distress. The remainder of the road is effectively a 6 m wide unsealed pavement and is under reconstruction. The 15.5 km section is being ugpraded to a sealed road under OECF funding as part of the Mumeng – Bulolo road improvement. The Chinese contractor is being supervised by Nippon Koei.

The Mumeng River Bridge was recently overtopped during heavy flooding of the Mumeng River. A massive amount of river gravel and debris was transported with the floods and has significantly reduced the available waterway area beneath the bridge. A dozer and hydraulic excavator were seen clearing the waterway channel immediately downstream of the bridge during the Consultant's inspection.

MN11: Baiune to Wau

The 38.9 km road from Baiune to Wau has two distinct sections:

- Baiune – Bulolo

  The 20.1 km section is being ugpraded to a sealed road under OECD funding as part of the Mumeng – Bulolo road improvement. The road was designed and constructed to DOW engineering standards and has a 6 m wide pavement with 0.5 m shoulders.

- Bulolo - Wau

  South of Bulolo an unsealed road runs through rolling terrain to the old mining town of Wau. The road varies in width from 4 – 6 m and in poor condition due to lack of maintenance. Tall vegetation abuts the pavement reducing sight distance.

  A 0.5 km section requires realignment and river protection works to protect the road bench from erosion by the Bulolo River. The road was graded in 1998 and was resheeted over 10 years ago. Emergency maintenance has been applied to keep the road.

ASEKI ROAD

The Aseki road connects the towns of Bulolo and Aseki, and joins with the road to Menyamya. It has two road sections.

MN12: Bulolo to Pararora

The 32.8 km gravel road is 4.5 m wide and traverses hilly terrain. The road is in fair condition. The Department of Forestry maintains the road from the outskirts of Bulolo Town to Km16 as the road passes through timber plantations managed by the Department. The road is an important access road for the plantations and has many logging trucks carting logs for processing in Bulolo.

The surface material is river gravel with fines collected from roadside borrow or patrol grading operations. Patrol grading was last completed in the middle of 1998. The road requires spot regravelling as the gravel thickness is low and the quality is poor with oversize fragments exposed in many sections of the road. On steep sections the fines from the gravel have eroded by scouring from run off. Landslips occur regularly in the steeper terrain and require emergency maintenance to prevent further deterioration of the road. Vegetation control and drainage maintenance is also poor.

MN13: Pararura to Aseki

The 51.2 km road has a rough 4 m wide earth/gravel pavement. The road is in very poor condition. The road traverses hilly to mountainous terrain and in many parts the weak subgrade is exposed providing boggy sections when wet. A very boggy section of road prevented the Consultant from reaching Aseki. Landslides are common and require constant maintenance to keep the road open.

4WD vehicles use the road to take supplies to Aseki and Menyamya and to transport coffee and other agricultural products to Bulolo and Lae. Often in wet weather the road is not passable to 4WD vehicles due the boggy sections of road. The drainage is very poor with water collecting on the pavement or scouring it on grades.

In 1998 some spot regravelling was completed under emergency maintenance in conjunction with clearance of side cut slips. Materials used for the pavement are quarry run products without grading which provides a very rough pavement after erosion of fines.

BUKAWA ROAD

The Bukawa road connects a number of coastal villages north of Lae to the town roads in Lae and is defined in two sections.

MN14: Balahang – Busu

The 8 km road from Balahang to Busu is being upgraded and sealed under ADB funding. Work commenced in 1994 but stopped within a year, and recently recommenced. A 5 km section should be completed in March 1999. Further funds are being sought from the ADB to upgrade and seal the remaining 3 km in this section. The road is in flat terrain and has a 6.5 m wide pavement.

MN15: Busu - Buso

The 28.7 km road from Busu river to Buso river has a pavement width of about 4 m in flat terrain. The gravel road is in poor condition with many low sections, poor drainage, frequent potholes and high roughness. Four major river crossings have significant deposition of river gravels which allow crossing the river in dry weather only.

The road was planned for upgrading to a sealed pavement. Detailed design and specifications were completed in 1995, but no upgrading works have commenced. The design provides for a 6.0 m wide sealed pavement for the first 1.3 km, and then a 4.5 m wide pavement for the remaining section. Three bridges and two fords would be replaced, but the four major river crossings were to remain as fords or informal crossings in their current condition.

PROVINCIAL ROADS

The Morobe Provincial Government maintains the Provincial road network and provides funding at three monthly intervals each year. All Provincial roads are gravel and their condition is dependent on the amount and type of maintenance conducted and the period since the last maintenance works.

Maintenance works are conducted by local contractors active in the vicinity of each road under a plant hire period contract, and supervised by a works coordinator living near the road section. The plant available for a road section is dependent on the particular plant operated by a contractor, and generally there is a very limited choice of contractors for maintenance of remote roads, such as in the districts of Finschaffen and Menyamya.

MP16: Aseki – Menyamya Road

The road was not inspected by the Consultant as a section of the Bulolo - Aseki road was not passable about 18 km east of Aseki, preventing access to the road section. The Morobe Provincial Government provided the following details on the road.

The condition of the road is poor due to limited funds for maintenance, with all funds directed to emergency repairs. Drainage is very poor and landslides and rockfalls reduce the road width in places and also deposit soil on the roadway. The road is only suitable for 4WD vehicles in dry weather. The 32.5 km road was constructed in part by the DOW, and then completed by Nawae Construction between 1976 and 1978. The road is important for transport of coffee and market products to Lae, and the principal traffic is light to medium vehicles.

The road has very steep grades in mountainous terrain and a pavement width of about 4m. The road alignment and section was not constructed to engineering design standards. The road is maintained by contractors engaged by the Provincial Government with a current annual allocation of K80,000. The maintenance provides for a D3 bulldozer to clear landslides and excess vegetation once per year. A grader is not available locally for maintenance.

MP17: Finschaffen – Sialum

The road follows the coast north of Finschaffen for about 21 km to a junction at Heldsbach and then continues to Sialum. The 94 km road was built in the early 1970's. The road is used to transport garden produce, coffee, copra and cocoa from the high country in Pindui and Kabwum and along the road to Finschaffen. Commodity products are then shipped to Lae.

The road is in flat and undulating terrain and is in good condition due to a reasonable level of maintenance. The road has a number of causeways which prevent the road from all weather use. The coronus gravel pavement has a width of 5-6 m and is well formed to promote drainage.

The annual funding for maintenance is K100,000 which allows patrol grading at three monthly intervals and selective resurfacing where required and subject to availability of funds. Filling of potholes is conducted on a continuous basis. Additional drainage works including installation of more culverts would improve the road but limited funds prevent these works. A local contractor, Disome, provides

plant on a plant hire basis with reasonably skilled operators but requiring significant supervision. The plant comprises a grader, D3 and D6 dozers, dump trucks and backhoe. A roller and water truck are not available and the contractor does not have funds to permit their purchase. These items would improve the placement of gravel during resheeting works.

MP18: Heldsbach – Pondiu

The Heldsbach – Pindiu road connects the highlands district around Pindiu to Finschhafen. The 58.6 km road was constructed in two stages initially from Heldsbach to Sattelberg Mission, and then the remaining section to Pindiu was constructed in 1984 using a dozer. The road allows transport of coffee and garden produce to Finschhafen, which otherwise would be transported by aeroplane from Pindiu.

The road has steep grades in mountainous terrain, particularly the last 30 km. The coronus gravel pavement has a width of about 4 m. The first 40 km was last graded in August 1998 and is a medium rough road in fair condition for all weather use. Grading of the road is required at three monthly intervals to provide a good running surface and to maintain side drains according to the local Provincial works coordinator.

The remaining section was last graded in February 1997, and is in poor condition with a lack of defined side drainage and a number of landslides narrowing the pavement, and depositing soil over the pavement. Quarry run river gravels are placed on the steep grades to improve friction, and the subgrade is often exposed in the running surface. The road does not permit all weather use.

The annual funding for maintenance is K200,000 but often additional funds are requested to attend to urgent works. Further maintenance funds are required to improve drainage to reduce pavement damage and gravel loss. Gravel sources of coronus are limited and investigations are required to locate new coronus sources to reduce cartage of good quality coronus material over 30 km.

Upgrading of the last 16 km is required to improve drainage, reduce slopes of batters to reduce the prospect of landslides, widen the formation to permit construction of drainage measures and placement of a pavement. A one lane Bailey bridge about 4 km from Pindiu on the Mone River was damaged by floodwaters and has moved off the bearings on one abutment. Blasting of bedrock in the riverbed upstream of the bridge has been proposed to redirect flows during floods away from the abutment. Remedial works are required to ensure the bridge does not fail and therefore prevent road access to Pindiu.

MP19: Buso – Buhem

The 28.5 km road was not inspected by the Consultant as the Buso River was not passable by 4WD.

MP20: Erap – Boana

The 31 km road extends from the Highlands Highway at Erap to Boana. For first 4 km the road is constructed from uncrushed river gravel to the foot of the hills. This road section is in poor condition. Thereafter the road is in poor condition in the hilly to mountainous terrain. Many landslips occur along the road. The road is paved with materials cut by dozer from road side cuttings. The road is difficult and dangerous to use in wet conditions. The drainage is in poor condition and significant scouring occurs in steep sections of side cut.

Coffee and vegetable growing are the main market crops. The DOW constructed the road in about 1984 using dozers, front-end loaders and two-tonne trucks. The condition of the road is so rough in sections that grading of the grading is necessary to allow transport of heavy earth moving equipment by low loader.

In 1996 a flood washed out the Upper Busu River bridge, located near Boana. The PNG army blew up a dam upstream of the bridge and the resulting torrent undermined the bridge abutment inducing the bridge failure. The EU is investigating replacement of the bridge.

Over the past few years about K90,000 has been allocated for ,maintenance with about 60% of the funds used for clearing slips in hillside cuts. Therefore the annual emergency maintenance cost is about K3,000 per km.

Rehabilitation works should comprise regravelling, drainage works including replacement culverting to improve the road from a dozed track.

MP21: Wasu - Kabwum

The 34.6 km road connects the highlands around Kabwum with the coastal town of Wasu located on the northern side of the Province. The road was constructed by Finshhafen Kabwum Construction in the late 1970's and allows transport of coffee and market produce to Wasu, and store goods to Kabwum and the surrounding district. Light 4WD vehicles mainly use the road.

The road follows rises up the coast initially in hilly terrain and then into mountainous terrain where there are many steep grades and tight bends. The coronus gravel pavement is about 3 m wide and is reasonable well formed to promote drainage away from the pavement.

The road is in fair condition due to the ongoing maintenance of the coronus pavement. The annual budget of K50,000 permits patrol grading at three monthly intervals with a D4 dozer and local patching.

MP22: Leron – Wantoat

The 62 km road is an unsealed gravel track about 3 m wide in poor condition. The road traverses hilly to mountainous terrain with a large number of difficult sections, even in the dry weather.

The DOW constructed the road in 1983-84 using uncrushed river gravel for the first few kilometres to the foot of the hills. From there the track was dozed using locally available borrow from side cuts. Most of the road is on side-cut and wherever grades are steep and material is weak. Bogging occurs where drainage is poor and scouring causes washout of fines, exposing the course gravel subbase on steep slopes.

PMV's usually travel in tandem so they can pull each other out when one gets bogged. The road serves an agricultural hinterland. The estimated travel time from the Highway to Wontoat by PMV is about 6–7 hours and the return trip down takes about 5 hours.

A small concrete causeway at about 0.5 km from the start of the road needs repair as the gabions supporting the causeway are partly washed out. A 20 m long concrete causeway has failed at about 3.5 km from the start of the road.

In 1998, K200,000 was allocated for maintenance. About 60% of the funds was spent on emergency maintenance with slip clearance by dozer. A grader maintained the first 38 km section of the road.

Routine maintenance, extensive regravelling and improvement to side drains, culverts and bridges is required to improve the road.

C.2 Eastern Highlands Province

EASTERN HIGHLANDS PROVINCE

HIGHLANDS HIGHWAY (NR07)

The Highlands Highway is the major transport route in the Eastern Highlands Province. It links major population centres including Goroka and Kainatu with neighbouring provinces. The highway starts and ends in mountainous terrain that have very steep grades and sharp curves. A major part of the highway, between Kainantu and Goroka, is in rolling and hilly terrain.

The pavement is 7 m wide and consists of a crushed rock base and seal coat. The original pavement was constructed between 1979 and 1984. Some sections were reconstructed and others were resealed in 1993. The subgrade quality is good.

The current maintenance is inadequate and highly dependent on available funding. It appears that DoW can conduct routine maintenance with sufficient funding, but not specific maintenance that requires a higher degree of technical competence especially in diagnostic of the pavement failures and preparation of adequate remedial works.

Local contractors like Tiong Seng (reconstruction), Skyline Development Corporation (linemarking), Global (pavement repairs) and Morobe Road Company (cold premix supply) support the maintenance works on the Highway.

ENO1: Yong Creek – Kassam Pass

The 4 km section traverses mountainous terrain with steep grades and sharp curves. The road was reconstructed in 1993 including improvements of the drainage system and is in good condition. Concrete lined drains are in very good condition. The pavement is in good condition and is relatively smooth, but the surface texture is inadequate due to pavement bleeding.

EN02: Kassam Pass

The 5.7 km section was reconstructed in 1998 and has a similar alignment as the previous section. Overall, the quality of construction appears good, and the road is in good condition.

The pavement is smooth, but the seal does not have an appropriate texture due to excessive bitumen in the mix. To improve the friction, OoW applied a thin chips film which, under the traffic, penetrates into the seal. Guideposts on this section are effective, especially for safe driving overnight and in hard weather conditions (rain, mist). The drainage system appears well designed and solidly constructed.

EN03: Kassam Pass – Kainatu

The 33.6 km section runs through hilly terrain with less severe alignment elements compared to the previous sections. The pavement was resealed 14 years ago. However, there are signs of various maintenance activities like heavy labour patching and resealing on a number of smaller road segments. The road is in good-fair condition.

The roughness varies along the section, but overall the road is relatively smooth. There are visible local pavement defects including groups of potholes, rutting and cracking, especially in the last 10 km of the section. Some areas have been prepared for resealing. The vegetation control is not consistent along the section.

Line marking on the first third of the section is new while the rest is practically invisible. Guardrails are in relatively good condition.

EN04: Kainatu - Henganofi

The 38.5 km section was constructed in 1983 and resealed in 1993. The condition and maintenance needs vary along the section. The pavement is reasonably smooth and the road is in good-fair condition. Maintenance of potholes and vegetation control on the section is generally good.

Obvious drainage problems have caused several massive pavement defects typically at the culvert locations. There is also a site with large erosion of the road formation where DoW has carried out remedial works.

EN05: Henganofi

The 44.2 km section was constructed in 1984 and resealed in 1993.

The local pavement distresses include cracking and potholing and are more frequent than adjoin road section. Areas with large pavement defect are characteristic for this section. The deformation of the pavement, broken seal and groups of large potholes have developed generally due to inefficient drainage. An OoW EHP engineer advised land slippage and poor base compaction caused the problem. The road is in fair condition.

Vegetation control on this section is poor and presents a safety issue. Shoulders of the pavement are overgrown with high, dense grass allowing very little space for pedestrians As a result then pedestrians walk on the carriageway.

EN06: Goroka – Daulo Pass

The 26.7 km section runs through the Goroka urban area and westwards through rolling terrain. The section was constructed in 1984 and resealed in 1993. The road is in good condition including the pavement, shoulders and drainage system. In some areas close to the markets and PMV stops, there are edge brakes on the pavement seal due to loss of shoulder gravel.

EN07: Daulo Pass – Simbu Border

The 26.4 km section was reconstructed in 1993, but large areas of the road have rapidly deteriorated and are in urgent need of attention. About 10% of the area has severe pavement defects, including massive deformations, loss of seal and large cracking areas. The defects are caused by ineffective drainage, allowing ponding of water on the surface and ingression of water in the pavement. The road is in fair condition.

EN08: Aiyura Access Road (ND4101)

The 6.6 km road commences at the bridge on the southern end of Kainantu and ends at Aiyura town. The 5.5 m pavement has many edge breaks and the surface treatment is now damaged beyond repair or in places totally removed. Some pothole patching was underway during the inspection. The sub-grade is fair and the road base is generally sound but requires re-working before re-sealing. Uncrushed river gravel was used for the base when the road was constructed in the colonial period.

The road traverses rolling terrain and has had little or no road maintenance since 1990. The road is in poor condition.

EN09: Dunatina – Dumpu Road (ND4102)

The 47.7 km gravel road has strategic importance for the Province if potential link between the Highlands Highway to the Ramu Region and Madang (through the northern part of the provinces is developed). The alignment and the pavement condition varies along the road. The pavement consists of river gravel and selected local gravel. Since 1993 there has been no regular maintenance of the road, only sporadic emergency maintenance like bridge works. Overall, the road is in poor condition.

The Consultant inspected about 60% of the road. The first 5 to 6 km through undulating terrains, is in satisfactory condition. The 5 m wide pavements, has sufficient gravel thickness and only requires grading to provide better riding quality.

For the next 5 km, the road runs through hilly terrain with sharp alignment elements. The 4 m wide pavement in some areas have no gravel material over riverbed gravel. This section requires spot regraveling and grading to improve the road to acceptable level.

The remainder of the road inspected, traverses mountainous terrain. The road has a narrow section with steep grades and sharp curves especially at waterway crossings. The pavement condition is poor. At some locations there is complete loss of pavement material and the road is hardly passable even for 4WD vehicles. This section of the road requires realignment of selected segments, pavement restoration at critical sections and regraveling.

EN010: Institutional CIS Road (NI4102)

The 6.7 km road starts in the Goroka's central urban area and runs through a populated area to the CIS buildings. Goroka Town Authority have maintained the road since 1995. The gravel pavement is 6 m wide for the first 5 km and 4.5 m wide afterwards. It is relatively rough road due to the lack of maintenance but has enough gravel for grading. The first 5 km can be considered for sealing where there is no need for realignment or widening. The road is in fair condition.

PROVINCIAL ROADS

EP11: Kerofegu - Oliguti

The 15 km road was sealed in 1996 under an ADB loan and is in good condition. The pavement is 5.5 m wide with 0.5 m shoulders and is sealed with 25 mm chips. The road traverses rolling terrain and is an important coffee growing area. Pavement material consists of river gravel. There have been some slips on cuts, induced by lack of cutoff drains and unstable material. Some spot sealing is necessary where the surface of the road has been removed by slips or run off and there are sporadic edge breaks. A concrete bridge over the Tua River was constructed as part of the road upgrading. No routine maintenance has been provided since construction. During the Consultant's inspection box gabion protection work were being constructed on the downstream side of a culvert where a slip has occurred. The road needs routine maintenance, and spot resealing for about 300 m.

EP12: Oliguti To Okapa

The 44 km road has two sections:

From Oliguti there is about 300 m of sealed pavement which was constructed in 1996 with 25 mm chip. From here a 10 km section is being upgraded. A new base course was being placed with blended river gravel during the Consultant's inspection. The river gravel was from a large borrow pit 5 km from Oliguti. The principal items of equipment observed on this site were grader, vibrating roller (Bomag), 2 dump trucks, water tank (fixed on to flat top truck) and hydraulic excavator at the borrow pit. The river gravel was partially crushed under the Bomag Roller (no level pegs were observed). The surface treatment is a single coat seal to a width of 4.5 m. The terrain is hilly and laterised clay is common in road cuttings.

Past the construction work the road becomes a rough earthen track. On steep grading is particularly boggy, around. The road condition is very poor and badly maintained, reducing travel speed to about 5 km/hr.

EP13: Okapa To Raipinga

The 49 km road is an earth track about 4 – 6 m wide through hilly to mountainous terrain. Soils are frequently red lateritic clays.

Most of the bridge decks are in very poor condition. Market day at Okapa is Wednesday and peak day for traffic. PMV's travelled the road to Okapa with difficulty even in dry condition. The road is in very poor condition for about the last 25 km before Okapa.

In 1998, about K200,000 was provided for maintenance to resheet a 12 km section about 22 km from the Highlands Highway. The work involved the improvement of the road formation by grader, dozer and the application of river gravel with limited compaction at a unit cost of about K9,000 per kilometre.

At Okapa there is a Council Plant Yard with two graders, a dozer and a hydraulic excavator. The Council provides some emergency maintenance when funds are available.

EP14: Oliguti - Lufa

The 15 km road has a 4m wide unsealed pavement and traverses hilly terrain condition with heavy scouring and needs routine maintenance and spot regraveling. About K50,000 has been allocated for maintenance in 1999. The road is in poor condition.

EP15: Aiyura – Obura

The 32 km gravel road has a pavement width of 7 m at the start of the junction and gradually reduces to a 3 m wide track. The pavement comprises river gravel at the start of the road. The road is in poor condition. Routine maintenance is well overdue, and spot re-sheeting is required using improved river gravel blended with selected borrow from roadside. Coffee is the main cash crop and the road links local district missions south to Obura. The Consultant was advised that the road has deteriorated badly south of Nori Kori.

EP16: Goroka - Lahame

The 13 km road was constructed in colonial times and runs through a hilly agricultural region with coffee as the main cash crop. The gravel road is in fair condition. Its formation width varies from 4 – 6 m and is formed from natural material in roadside cuttings and locally improved with uncrushed river gravel. In 1998, K100,000 was allocated to grade and clear drains along the road.

The maintenance comprises excavation of roadside drains using a grader and spot re-sheeting. Vegetation control is required. Traffic is mainly light pick-up trucks and PMV's taking villagers to and from Goroka. March to July is the coffee harvesting seasons and generates the main traffic flows.

EP17: Lahame - Magabo

The 21 km road is in poor condition and suitable for only 4WD vehicles in dry weather. The terrain is hilly through as important coffee growing region. The road has not been maintained since about 1984 when the road was handed over to the Provincial Government by the DoW. The road is dangerous due to mud on steep inclines. Gravel surfacing in places has been largely removed by traffic and scouring. The pavement is 4 m wide and comprises uncrushed river gravel blended with local borrow from roadside material of poor quality. Overall the road is in poor condition.

EP18: Goroka - Unggai

The 29 km road starts at a road junction about 5 km from the Highlands Highway in Goroka at the junction with the Bihute Corrective Institute Road and just past the Asaro Bridge, heads south to Yabiufa, and then leads west. From Yabiufa the route follows footpaths past Mt Unggai and reaches the Chimbu boarder at a village about 2 km east of Nami post in Chimbu Province.

The road was inspected to 1 km past the Yabiufa Health Centre. The road varies in width from 3 – 5 m until the Health Centre and from there it continues as a 3 – 4 m wide unsealed track to the border with Chimbu. The road is in fair condition. The road serves a subsistence agriculture and coffee cash crop region within 3 – 4 hours by PMV journey to the Goroka centre and coffee mills.

The original pavement was made with uncrushed river gravel and local borrow and placed by dozer along old footpaths.

In 1998, a K100,000 allocation allowed maintenance of spot re-sheeting with river gravel (75 mm thick) to poor sections and some hand cleaning of drains. Lateritic clay is a common material observed in cuttings.

Ep19: Asaro – Lapega – Kifamu

The 20 km road links prime coffee plantations to the Highlands Highway and is only a few kilometres from the Goroka coffee mills. Rothmans have a tobacco plantation and factory near Lapegu and they run semi-trailers in their operations on the Lapegu – Kifamu section. The road was built in colonial times and with a narrow 4 m single coat seal. There has been little or no maintenance for a long time until late 1998 when K100,000 was provided for maintenance. A compensation claim for K2,000 was paid out by the Provincial Government in regard to blockage of drains culverts which reduced drainage and hence coffee production. Recently another compensation claim over the condition of a 17 m span bridge at Lapegu was rejected.

Negotiations are in progress with Rothmans for a joint-operation in 1999 to upgrade the road. K50,000 has been allocated for 1999 to the Province and it is hoped Rothmans will also contribute in a joint operation. Last year's work including spot-regravelling in difficult areas with the depth of river gravel varying according to the state of the poor sections. The main plant employed under PTB3 was grader, front end loader, and ten off 6 cubic metre tipper trucks.

In some places only a 25 mm gravel topping was placed, elsewhere 125 mm or more. Some 10 km was spot re-gravelled. Trucks were the main method of compaction. This work is regarded as emergency maintenance to keep the road open. The quality of gravel and compaction are poor in order to stretch the limited funds and keep the road open.

The section from Lapego to Kifamo was sealed by the National Government about 10 – 12 years ago due to the lack of maintenance by the Provincial government. The seal has deteriorated and eroded away. The formation width is 5.5m. Overall the road is in poor condition.

C.3 Western Highlands Province

WESTERN HIGHLANDS PROVINCE

HIGHLANDS HIGHWAY (NR07)

The Highlands Highway is a major transport route in Western Highlands Province. It links major population centres including Mt Hagen and connects them with the neighbouring provinces. A major part of the highway is in level terrain.

The 7 m pavement consists of a river gravel base and seal coat. The age and condition of the seal vary from section to section. The sub-grade quality is generally good. The current maintenance standard is inadequate as a result of available funding.

A number of local contractors participate in road maintenance activities in the province. They are Global (bitumen sealing, construction), Shornecliff (construction), Highway Engineering (bridge maintenance, supervision), Niugini Engineering Services (drainage and bridge construction), Komun Gravel Supplies (material supply and rehabilitation).

WN01: Garinger – Minj

The 17.5 km section was constructed in 1980 and the last resealing was completed 14 years ago. The pavement shows signs of fatigue with distresses including cracking, rutting, regravelling and occasional potholes. On some segments there are extensive edge breaks due to lack of gravel on shoulders. The pavement is due for resealing and is in fair condition.

There are signs of various maintenance activities like pothole repairs, heavy patching and resealing on short segments. The vegetation control and drainage maintenance is satisfactory, but there is no link marking on the pavement.

WN02: Minj – Kudjip

The 12 km section was reconstructed in 1987 and is in good condition. The drainage system was well designed and constructed.

The seal show signs of bleeding. There are a few potholes in vicinity of the bridge abutments. Excluding a single deformation due to soil settlement, there are no evidences of pavement deterioration. Vegetation control is poor to fair while linemarking is visible only at the bridge approaches.

WN03: Kudjip – Tuman River

The 16.2 km section was constructed in 1983. The seal is 12 years old and with visible distresses including cracking, rutting, bleeding and potholes. There are signs of maintenance activities such as frequent heavy patching areas and repaired potholes. The section is due for resealing and is in fair condition.

Vegetation control is unsatisfactory. High grass on the shoulders, pedestrians on the carriageway, and massive edge breaks are major safety concerns on this section. There is no linemarking on the pavement.

WN04: Tuman River – Mt. Hagen Town Boundary

The 25.5 km section runs through flat terrain ending at a busy industrial area east of Mt Hagen. The section was constructed in 1979 and resealed 10 years later. In 1997, the shoulders of a 3 km long segment were widened and sealed.

The seal shows signs of aging and occasional potholes, bleeding, cracking and edge breaks are typical for this section. There is an evidence of extensive pothole patching, especially at the position of outer wheel paths.

Linemarking is poor along the section. The pavement is in fair condition and requires resealing.

WN05: Mt. Hagen Town Area

The 2.5 km section passes through Mt. Hagen urban area. The cross section includes a concrete footpath on one side of the road. The pavement is rough and deteriorated under heavy traffic. The seal is 10 years old with all signs of aging, including cracks, potholes and bleeding. The pavement is in poor condition and requires rehabilitation.

WN06: Mt. Hagen Town Area – Togoba

The seal on the 10.9 km section is over 15 years old. Apart from the typical distresses for an aged pavement (cracking, bleeding, patching), extensive edge breaks affect safety on the road. Vegetation control on the section is good. The section is due for resealing and is in fair condition.

WN07: Togoba – SHP Border

The 28.1 km section was reconstructed in 1995 is in good condition. Road furniture that includes RPM's is also in good condition. Vegetation control on the section is satisfactory and the drainage system is well maintained.

However, there are several massive landslides that require remedial works. Two contractors, Global Construction and Komun Gravel Supplies are constructing the remedial works. The scope of these works includes construction of gabion retaining walls, replacement of the base, subsoil drainage and resealing.

ENGA HIGHWAY (NR06)

WN08: Togoba – Paigona – 13km

WN09: Paigona – Enga Border – 16.9km

This section of Enga Highway through the Western Highlands Province was reconstructed in 1990 by Barclay Brothers. The road runs through rolling terrain between the Highlands Highway and the Enga Border. The road is well designed, in good condition and well maintained.

The pavement comprises of a crushed rock base and a two coat seal. There are no signs of pavement distresses and the surface texture is good overall.

The drainage system appears well designed and is in good condition. The deep lined drains and culvert inlets are clean. Linemarking is present on about 50% of the road centre line. The guardrails are in fair condition.

The routine maintenance of the road appears effective. Grass cutting in 1998 included two cycles. Routine maintenance must continue in order to preserve the asset.

BAIYER ROAD (NM3901)

WN10: Mt. Hagen – Kumdi School

The 21 km road has two distinct sections.

- A sealed section of 1.5 km in poor condition from the outskirts of Mt. Hagen has deteriorated badly and urgently needs reworking and sealing.

- Beyond 1.5 km, the Provincial Government sealed the remaining section to Kumdi. The work was completed without DOTWCA authority by a contractor and the Provincial Government is trying to recoup their costs from DOTWCA. The sealing was completed in October 1998, and is a single coat with 19mm chips. There are doubts about the quality of the work, as the base may not have been adequately prepared, or incorrect spray rates used. The seal is already showing signs of distress with potholes and patching maintenance already being completed by OoW. The terrain is flat and rolling.

Overall, the road is in good condition.

WN11: Kumdi School – Baiyer River

The 28.3 km gravel road traverses rolling to hilly terrain. The road was re-sheeted with gravel hauled from a quarry near Mt Hagen, requiring an average haul distance of 35 km. The road is in fair condition.

The road width reduces from 6 m to 4 m as a rough gravel track about 1 km before the Baiyer bridge. Team grading four times each year is required to keep the road in good condition.

WN12: Baiyer River – Ruti

The 28.9 km length gravel road is in very poor condition. In 1998 the road was closed because of a 400 m long landslip. The road is a 4 m track through hilly to mountainous terrain only passable at times with 4WD vehicles. About K60,000 was spent in 1998 on Emergency Maintenance to clear slips. No routine maintenance has been conducted for several years. The bridges are in dangerous condition, with many deck timbers missing or rotten.

WN13: Airport Access Road (Institutional)

The 1.5 km links the Kagamuga Airport and Highlands Highway and was constructed in 1989. The pavement consists of river gravel base and the original bitumen seal.

The seal shows signs of aging including cracking, bleeding and potholes. There is no gravel on the shoulders promoting extensive edge breaks. Resealing of the pavement and regravelling of the shoulders is required as soon as possible. The road is in fair condition.

OGELBENG – DONA ROAD

Many important tea and coffee plantations are located to the north of the Wahgi River. The Ogelbeng to Dona road is located near the edge of the Waghi flood plain and foothills. The roads consist of four sections.

WN14: Ogelbeng – Ambra

The 9.2 km road (known as the Banz North Road) is formed mostly of uncrushed river gravel from a pit near Mt Hagen. The road width varies from about 4 to 5m and lateritic clay is prominent in cuttings. The terrain is rolling from Ogelbeng to Ambra. An OoW supervisor advised that maintenance was limited to grass cutting and a single spot regravelling operation in 1998. The road is in good condition.

The gravel size taken from the main pit is free of oversize material and this also contributes to the stability of the pavement, which was not built to an 'engineered' specification. The first two Bailey bridges from the Ogelbeng Junction with Baiyer Road were rehabilitated in 1999.

WN15: Ambra – Kotna

The 19.5 km road comprises two sections:

- A 4 km section was sealed by the Provincial Government in 1998. The seal width is about 6 m with 1 m shoulders. The terrain is flat and rolling.

- A 15.5 km section with a 4.5 m gravel pavement and 0.5 m shoulders of loose gravel. The terrain is hilly. Uncrushed river gravel is won from the Moka River pit which means that haul distances up to 15 Km are necessary for regravelling operations. The maintenance in 1998 comprised of spot patching with gravel in June – July and patrol grading in November – December and no vegetation control.

WN16: Kotna Junction – Banz

The 33 km road comprises two sections:

- A 28 km gravel road which is maintained by regravelling from the Moka River pit. The pavement varies from 3 to 4 m. Road drainage is effective because the gravel base has been built up over the years to an effective depth above natural surface. The gravel source is low on oversize and suitable for regravelling even without screening. Compaction of regravelling works is by truck haul and road traffic. The maintenance in 1998 comprised gravel patching and filling potholes and little vegetation control. An OoW road supervisor advised that K125/km was paid for vegetation control, clearing out drains and culverts in 1998.

- A 5 km sealed section, which was upgraded in 1998, was sealed by the Provincial Government. An OoW road supervisor advised that a 100 mm river gravel was applied, rolled, machine broomed, primed and a single coat – 6m seal applied including linemarkings.

WN17: Banz – Dona

The 19.2 km road comprises:

- A 6 km sealed section of old seal shows medium to high distress, including potholes and edge breaks. The road has an average width of 5m and traverses flat and rolling terrain. About 10% of the pavement needs the base reworked and sealed. The balance of the section may be resealed with improvement to edges shoulders and drainage.

- A 13.2 km gravel section with a 3.6m gravel running surface. The river gravel pavement has accumulated over the years of maintenance to produce an elevated pavement. Patrol grading and patching was last carried out in early 1999. Last year patrol grading was carried out only once. A 5 km section was gravelled last year by the Ministry of Defence who have a facility adjoining the road. Patrol grading three times per year is considered ideal by an OoW supervisor, but in 1998 the road was graded only once Vegetation control is poor. Overall, the road is in fair condition.

WN18: Institutional Road Tea (NI3901)

The Consultant inspected only 4 km of the road section. The other sections (total 23.4 km) are perimeter roads with Kuk Tea Research and are not included in the study. The gravel pavement is 4 to 5m wide and is in good condition. The gravel thickness is up to 100 mm and is suitable for grading. Limited areas need spot regravelling. Widening and minor horizontal realignment should be considered for upgrading of the road.

WN19: Institutional CIS Road (NI3902)

The 11.3 km road starts at Korn Farm – Ambra Road Junction to Baisu CIS and ends at Avi Market. The Maresman data includes perimeter roads of 11.7 km inside the CIS Station, which were not inspected by the Consultant or included in the study.

The 5 m wide gravel pavement is in good condition. The gravel surface is about 200 mm thick and has occasional depressions requiring spot regravelling. The remainder of the road requires regular grading in order to retain good riding quality. The road has a good alignment and a formation which would facilitate future sealing if required.

PROVINCIAL ROADS

WP20: Tomba – Tambul

The 16 km gravel road runs south west from a junction with the Enga Highway. The pavement width is 5.5 – 6.0 m. The road traverses hilly terrain.

The road was upgraded in early 1998 by a contractor but work was stopped due to a disagreement over compensation. A pit near the Enga Highway has supplied improved sub-grad for a substantial length and there is a large base course stockpile next to the Highway. Local gravel for surfacing was observed near to the Tambul village where there is a Health Centre.

A new Bailey bridge was under construction during the inspection. One abutment was partially concreted, the far abutment had frame work erected for the abutment. A fast flowing stream/river has washed out previous bridge over the Kaugal River. Extensive gabion protection is to be provided.

WP21: Balk – Bukapena

The 15.3 km road has an earth and gravel pavement with no defined drainage. The 4.5 m pavement is formed with river gravel. The road traverses hilly terrain. The road is in poor condition as no effective maintenance has been provided by the Provincial Government over the past five years, including no vegetation control.

The four Bailey bridges require deck replacement and new guardrails. Several local communities are assisting with maintenance as self-help projects.

WP22: Bukapena – Koge

The 6.4 km road leads into a large Tea Plantation, which has maintained the road and applied gravel. The terrain is flat and rolling. The road is 3.2 m wide and is in good condition. A large borrow pit was seen at about 3 km from the Baiyer Road Junction. The Provincial Government has not contributed to maintenance since 1995.

WP23: Bukapena – Nengil

The 16.4 km gravel track is in very poor condition with no maintenance over at least the past four years by the Provincial Government. The road urgently needs routine maintenance and spot regravelling. The terrain is rolling to hilly.

WP24: Bukapena – Kadua # 1

The 10.0 km road was upgraded to a sealed standard in 1998 by the Provincial Government. The nominal seal width is 5.2m with generally no shoulders and steep side drains. The terrain is hilly. Sealing chips are 19 mm and there are loose gravel shoulders 0.5m wide in some sections. The sight distances are frequently inadequate. Overall, the road design provides a dangerous road due to poor sight distance and a narrow pavement. The upgrading was completed by Global Construction for about K1 million.

WP25: Baiyer River – Lumusa

The 13 km gravel road runs through rolling terrain from the junction with the Baiyer Road. No maintenance has been carried out by the Provincial Government since 1995. The road is rough to very rough especially in the steeper sections and is in poor condition. Coffee and vegetables are grown in the hinterland.

WP26: Kagamuga – Kelua # 1

The road comprises two sections:

- A 3.5 km section was upgraded and sealed in 1995. The road is 5 m wide with 0.5 m wide shoulders. The road alignment is satisfactory, except for two tight bends. The pavement consists of river gravel base and bitumen seal, which is in good condition with no distresses. Apart from the routine maintenance, no specific maintenance is required on this section.

- A 8.7 km section is a part of a bypass link between Highlands Highway and Baiyer Road. It passes through highly populated area and serves for transport of people and agricultural products. The gravel road is 5 m wide with a narrow road formation. The pavement consists of a thin river gravel base (70 – 100 mm) and was last regravelled in 1995. Since then there was no regular maintenance of the road. The riding quality is poor due to large potholes and insufficient pavement thickness. Regravelling and grading would be required as an immediate remedial treatment. The alignment of the road is satisfactory, but widening will be required if the road is upgraded.

WP27: Korn Farm – Ambra

The 8 km sealed road traverses rolling terrain. The road was upgraded in 1994 to provide a 6 m wide seal with 0.5 m shoulders. Routine maintenance has been neglected, especially vegetation control and grading of shoulders. Overall, the road is in good condition.

WP28: Kum - Wurup

The 8.8 km gravel road is 5m wide and traverses rolling terrain. The gravel thickness is about 100 mm, and the gravel surface is medium rough. In general the drainage is adequate, and principal need is for spot regravelling and grading. The road is in fair condition.

WP29: Wurup – Korn Farm

The 6.3 km gravel road has a 5 m wide pavement. The gravel thickness is about 200 mm and is two to three years old. The road surface is reasonably smooth and is formed with local river gravel. The road is in good condition.

WP30: Kotna – Tigi – Baiyer River

The 24 km road is between 3 – 5 m wide. The inspection was stopped at about 6 km due to lack of deck timbers on a Bailey bridge. The terrain is flat and rolling for most of the road length.

No maintenance has been provided since 1995. Originally the roadway was constructed with the river gravel compacted by dump truck. The road is in poor condition with a rough surface.

WP31: Kindeng – Kondopina

The 11.3 km road comprises two sections and traverses flat terrain:

- A 1.0 km sealed section from Kindeng on the Highlands Highway towards Kondopina. Kindeng has a tea factory. The road is 6.5 to 7.0 m wide and the pavement is smooth and has 25 mm chips. There is little evidence of distress in the seal.

- A 10.3 km gravel section built of river gravel and roadside material. The road is about 4.5 m wide and has loose gravel at edges. Routine maintenance, spot regravelling and improved drainage is required. River protection is required to the Waghi River (right side) for a length of about 50m using box gabions and reno mattresses.

WP32: Kudjip – Banz

The 7 km road was sealed in 1998 and is 6 m wide with 1 m gravel shoulders. The seal was placed with 25 m chips. The road has no signs of distress and is in good condition. About 4 km from the Highlands Highway Junction there is a large bridge over the Waghi River, which is in good condition. The span is about 50 m.

WP33: Banz – Karap

The 36.5 km road extends from Banz on the Ogelbeng to Dona road northwards to Karap. The pavement is 4 – 6 m wide and the surface is uncrushed river gravel with loose gravel in shoulders. The road traverses hilly to mountainous terrain.

The road was regravelled in 1996. The gravel thickness varies in depth. It is satisfactory for the first 6 km, thereafter the gravel thickness is much less on the steeper ground. Scouring is causing washout of fines leaving the rough oversize material. There were a few small earth slips with laterite clay prominent in roadside cuttings. At 6 km from the Banz Junction the grade steepens and the road surface condition deteriorates. The road is in fair condition.

WP34: Highlands Highway - Dona – Nondugat

The 7.8 km earth and gravel road has a running width of between 4 – 5 m with 1 m shoulders. The road traverses hilly terrain. The road continues past Nondugal to Kewamugl and Kerowagi where there is a sub-district headquarters.

Little effective maintenance has been provided by the Provincial Government. The pavement is lean and needs regravelling over a substantial portion to improve the running surface. Little or no work done in recent years on vegetation clearance. A 15 panel Bailey bridge was refurbished under BRUP.

C.4 Southern Highlands Province

SOUTHERN HIGHLANDS PROVINCE

NATIONAL ROADS

The Province has three concentrations of road networks: around Tari in the west of the Province, north west of Mendi towards the Enga and Western Highlands Provinces, and around Ialibu and Kagua in the southeast of the Province. The National road network links all District centres in the Province to Mendi, the Provincial centre.

The Highlands Highway and the Koroba Road together provide a 282 km spine that transverses the northwest – southeast axis of the Province. Only about 32 km of the 782 km National road network (4.1%) in the Province is sealed, and comprise several sections of the Highlands Highway between Mendi and the border with Western Highlands Province. Sealing of the remaining section between Kisenapoi – Mendi is being upgraded and sealed under an AusAID grant. The sealed roads in the Province were upgraded about five years ago and are in good condition

The unsealed roads have received minimal maintenance over the past five years, and almost all roads are in need of resheeting to provide a smooth running surface and restoring the drainage system. The gravel base has eroded providing a rough running surface of limestone subbase, which with erosion on steep grades and poor drainage areas leads to bogholes in the subgrade.

As a result of the limited amounts of funding for maintenance and the uncertainty over timing of the funding, all maintenance works are based on the keeping roads open in order of urgency. Therefore maintenance has little planning and a substantial backlog of rehabilitation works will be required before a planned regime of maintenance works can be implemented.

With the decreasing funds in recent years, the OoW in Mendi allocate funds to maintain the roads in the following priority when funds become available:

1. Highlands Highway and Koroba road, Mendi - Tari
2. Erave road
3. Oksapmin road
4. Kutubu Access road
5. Remaining National roads

HIGHLANDS HIGHWAY

The Highlands Highway sections lies between Mendi and the Kaugel River on the Western Highlands border. The road was constructed to a gravel pavement in the late 1970's. About 31.6 km of the road is sealed out of the total length of 87.5 km (36%). From Mendi, a 11 km section was recently upgraded to a sealed pavement and a upgrading of further 20 km section is underway with funding by AusAid. The highway is the principal route for road transport into the Province.

SN01: WHP Border – Kisenapoi

The 20.5 km road was upgraded to a higher standard and sealed between 1994–1996. The road has a good alignment in the hilly terrain and has several very steep sections. Subsidence in the vicinity of Kaugel Gorge causes recurrent failure of the pavement.

The sealed pavement is 7m wide and has 0.5m wide sealed shoulders. The pavement is in good condition, with local deficiencies such as seal breaks, potholes groups and edge breaks. The road has a 1.1 km section of extremely rough gravel road, which has not been upgraded due to an ongoing land dispute. Land issues also disrupt maintenance operations on this section. An example is a dangerous washout on the Mt Hagen approach to Ori Bridge that cannot be repaired due to dispute with local landowners. The approach restricts access to the bridge to a single lane which will fail over time without rectification works.

Vegetation control and drainage maintenance are poor. Grass cutting and drain clearing was completed twice per year, but since 1998 no work has been completed. Road furniture comprising of linemarking and guardrails is in relatively good condition, but signage us usually stolen within days of installation.

The road needs urgent repair of damaged sections including the gravel section, on about 8% of the road length. Better roadside maintenance is also required, especially for drainage maintenance. Locally constructed access roads often fill in the drain to provide entry, aggravating the drainage problems.

SN02: Kisenapoi – Kumbame

The 23.8 km road has an unsealed pavement which varies in width between 6 and 7 m. The road has a good alignment through the rolling terrain, and is in fair condition. The gravel surface material is uncrushed river gravel placed in 1998 and has a thickness of between 100 and 200 mm.

The riding quality is satisfactory although there are potholed areas on some locations. The maintenance regime includes vegetation control, drainage maintenance, spot regravelling and resheeting. Repair of pavement depressions and potholed areas has not been fully implemented as part of the maintenance works.

Maintenance by OoW includes grading, and spot regravelling and resheeting in limited areas. Spot regravelling is not regular and there is minimal roadside maintenance. Sealing of the road will require widening of the pavement, but there is no need to improve the existing alignment.

SN03: Kumbame – Ankura Bridge

The 10.1 km unsealed road has a gravel surface of limestone for about 90% of the road and river gravel for the remainder, and is in fair condition. Both of these materials are direct quarry run materials without crushing or grading. River gravel provides a relatively good riding quality compared to the coarse limestone aggregate which forms a rough surface. The average gravel thickness is about 150 mm and it was placed about 1 - 3 years. The pavement width is 6 m.

Little roadside maintenance has been completed in the past 5 years and the shape of the road is inadequate, especially the table drains. Vegetation is control is minimal but it does not affect the road. The road is relatively heavily populated with many gardens.

Maintenance of the existing gravel road should focus on provision of a smoother surface, using graded crushed limestone, and better shaping of the road formation. Upgrading of the road to a sealed pavement would include widening of the pavement, but with no realignment.

SN04: Ankura Bridge – Mendi

The 29.1 km road form Ankura bridge to Mendi comprises of two distinct sections:

- 18 km unsealed section from Ankura Bridge through hilly terrain. The road width varies from 6 – 7 m. Global Construction is upgrading and sealing the road under AusAid funding. About 30% of the section was already widened and prepared for upgrade at the time of the inspection. The remaining section was recently graded by patrol grading. The remaining section was recently graded by patrol grading. The gravel pavement consists of 300 mm thick crushed limestone, mostly well graded. Omai quarry is used for subbase and base materials and the Lumbi Quarry is the main source of good quality sealing and fine crushed rock material for the road works. Global Construction are maintaining this road as part of their construction contract. The road is in good condition.

- 11.1 km new sealed section from to the Tari turnoff through hilly terrain. Global Construction upgraded and sealed the road in 1998 under AusAid funding. The road is in very good condition.

Five bridges replaced with concrete deck steel beam bridges have been constructed under AusAID funding in the past 1-2 years.

KOROBA ROAD

The Koroba road links the district centres of Koroba, Tari and Nipa to the Provincial centre of Mendi. The DOW built the 194.9 km road in the early 1970's. The gravel road transverses a high altitude environment through sections of mountainous terrain with rainfall over 3000mm. The pavement varies from 5-6m.

The road between Mendi and Tari has deteriorated to a poor condition over the past five years due to lack of maintenance. The condition of the road has increased the travel time from 1.5 hours when the road was well maintained to over 8 hours at present, aggravated by a number of major boggy sections. The deteriorated road condition has prompted village groups along the road to charge a toll to assist vehicles through the boggy sections. Security along the road is poor and vehicles travel in convoy to provide greater security. Oil Search transport fuel from their facility at Nigola to Mendi and Mt Hagen by a convoy of 6WD 30t tanker trucks. Cargo trucks supply goods to Tari and Nigoli, and are likely to be overloaded. The road was designed to a Rural Medium standard which allows for 12t trucks.

The Provincial Government is promoting the upgrading and sealing of the entire length of the Koroba road under a design, construct and finance contract. In March 1999 the Provincial Government called for expressions of interest from contractors to implement the project.

SN05: Mendi – Kar Mission

The 35 km road from the Tari turnoff at Mendi to Kar Mission traverses hilly terrain. The road is in fair condition due to minimal maintenance over the past five years. Drainage is poor and over 10 sites of landslides are active each year. The pavement has a high roughness due to loss of fines by rainfall and poor drainage, particularly on steep sections. Vegetation has not been controlled in the past four years but is not affecting the road. Vertical grades are over 20% near Megi Hill.

Recent maintenance includes patch gravelling and grading from Mendi to Margarima in 1999 by a local contractor. The road requires resheeting with a crushed gravel to reduce the pavement

roughness and drainage improved. The four Bailey bridges require maintenance and deck replacement, and the Lai River bridge is programmed for replacement under the BRUP.

SN06: Kar Mission – Fakarandah

The 37 km road is in fair condition due to lack of maintenance. The pavement surface is course sub-base material for over 50% of the road, and subgrade is exposed in many locations. The area around Tindom Hill has grades over 30% along a 2 km section, and is sealed to reduce maintenance requirements and provide traction. In the past 5 years there has been no regular maintenance, only emergency maintenance for patch gravelling.

SN07: Fakarandah – Ambua Lodge

The 54.2 km road is in fair condition due to lack of maintenance. Emergency works for patch gravelling and grading were completed in 1998. The pavement surface is sub-base material and the sub-grade is exposed in many locations. Cordroad was used on about 10% of the road to stabilise the weak subgrade, particularly along the Ambua Gap. Cordroad comprises of 50-100mm diameter timbers placed across the road under the pavement, and is exposed where the pavement has been eroded. About five landslide sites are active each year. No routine maintenance works have been constructed over the past three years, except for emergency work. Gravel is carted from the Hiwanda quarry near Tari involving average return haul distances of about 60km, which significantly increased the cost of resheeting works. The existing Bailey bridges should be maintained and the decks replaced.

SN08: Ambua Lodge – Tari

The 22.4 km road is in fair condition due to lack of maintenance. The road has a high roughness due to the sub-base running surface. The road lies in rolling terrain. In the past three years there has been no regular maintenance, only emergency maintenance for patch gravelling. The road requires resheeting and drainage works. Gravel is carted from the Hiwanda quarry near Tari or the Tango quarry towards Margarima. The existing Bailey bridges should be maintained and the decks replaced.

SN09: Tari – Koroba

The 38.5 km road is in very fair condition with no resheeting works completed since 1993. The sub-base running surface is very rough and the pavement has reduced in width from 6 m to 4m due to encroachment by vegetation. The road lies in rolling terrain. The road has good access to the Hiwanda quarry along the road. No funds were available for this road maintenance in 1998 and1999. The road requires resheeting and drainage works, as many culverts are blocked.

SN10: Koroba – Fugwa Turnoff

The 7.8 km road is in fair condition due to lack of maintenance. The pavement has a medium roughness and requires resheeting. The Provincial Government has provided funding for OoW Mendi to complete minor pothole repairs, drainage clearance and vegetation control in mid 1999.

SN11: KUTUBU ACCESS ROAD

The 112 km road commences at Poroma turnoff and ends at Moro which is the base camp for the Chevron operations in the Province. Chevron extract oil at Iagifu and Hedinia in the southwest of the Province and transport the oil in their pipeline south to Kikori in Gulf Province. The majority of the oil is exported and the royalties and taxes are an important revenue source for the National and the Provincial Government. The road connects Moro with Mendi and allows for road transportation of goods to support the operations by Chevron. Drilling operations involve transport of drilling rigs with around 100 trucks per rig travelling from Lae to Mendi, but are hold due to the low oil price at present.

Tax credits are used by Chevron to develop facilities such as medical centres, police stations and schools in remote communities in need of such services. The funds spent, when approved by the National Government, are deducted from the tax payments due by Chevron on a dollar for dollar basis. Projects must be for new works and generally exclude maintenance works.

The road is in fair condition, and requires resheeting to restore a smooth gravel running surface, particularly the section in hilly terrain between Km30 - 60. The road was designed and constructed by Chevron in 1991-93 to a rural heavy standard. The road is located in sections of flat and rolling terrain and hilly terrain, and the alignment fits well with the terrain.

The last significant maintenance was completed in 1996 when K300,000 was allocated to routine maintenance including patrol and team grading, patch regravelling, and vegetation control. Since 1996, the Government has not funded any maintenance works. However the last 25 km near Moro has been maintained by a contractor working for Chevron at the contractor's expense during the term of their contract. The contractor was concerned for the damage to their plant from the high roughness of the road. The eight bridges on the road require regular maintenance and deck replacement.

Chevron recently gained approval from the National Government to use their tax credits to fund a K1.4 million rehabilitation of the road, given the Government is not able to finance maintenance of the road.

ERAVE ROAD

The unsealed Erave road connects the district centres of Ialibu, Kagua and Pangia with the Highlands Highway at Kisenpoi to allow road transport to Mendi and Mt Hagen. The proposed Gulf – Southern Highlands Highway would connect Kikori in Gulf Province with Erave in Southern Highlands. Construction of the new road would increase traffic volume and loading on the Erave road, as many imported goods to the Province would in future be transported via Kikori and the Erave road rather than the Highlands Highway. The Erave road has three sections through hilly terrain.

Design of the upgrading and sealing of 53km of the road Kagua - Ialibu – Pangia was prepared by Frame Harvey West and Maso, and a design report issued in October 1995. The design used the existing pavement as subgrade for the new pavement with widening where required, and no change to the alignment to minimise land compensation issues. A single seal coat was recommended for the typical section with a second coat applied on steep grades and tight curves. Five bridges were recommended for replacement with Compact 100 Bailey bridges. Five other Bailey bridges were recommended for maintenance and installation of steel decking.

SN12: Kisenpoi – Ialibu

The 15.6 km road was in good condition due emergency maintenance works completed in December 1998. Prior to these works the road was in extremely poor condition due to the lack of maintenance over the past four years, requiring a travel time of 1-2 hours by only 4WD vehicles. The DOW constructed the road in the 1960's to a Rural Medium standard.

The emergency works comprised of team grading and resheeting of the 6 m pavement with scoria and limestone from nearby borrow pits. However the scoria is unlikely to comply with the DOTWCA specifications for use as a base material, so that the improved pavement will degrade earlier than material that complies with specifications, particularly if road shape and drainage are not maintained by regular grading. The drainage was restored and vegetation cleared. The works were completed by Makati Constructions with direct funding from the National Government and managed by the Provincial Government. The OoW Mendi were not involved in defining the maintenance works, the selection of the contractor, supervision of the works, despite the work was conducted on a National road.

The two Bailey bridges were recently maintained under the BRUP.

SN13: Ialibu – Kagua

The 31.8 km road is in fair condition with large potholes, poor drainage and a lack of vegetation control. Landslides and washouts are common in the hilly terrain. The road has a 6 m wide limestone pavement and was constructed by the OoW in the 1960's to the Rural Medium standard. The road has many sharp corners and requires realignment when upgraded to a sealed standard.

The bridges comprise of five Bailey bridges and one single lane concrete bridge. All of the Bailey bridges were recently maintained under the BRUP.

Improvement works to the value of K670,000 are underway by a local contractor which was appointed directly under funding provided by the National Government. The funds were part of a larger funding package to be directed to the OoW to maintain the Erave road where required. The OoW Mendi were not involved in defining the maintenance works, the selection of the contractor, supervision of the works, despite the work was conducted on a National road.

SN14: Kagua - Erave

The 39.6 km road has a 6 m wide limestone gravel pavement in fair condition, except for about the last 4 km which is a narrow earth road in poor condition for use by 4WD vehicles in dry weather only. The road typically has potholes, culvert blockages and poor drainage. The DOW constructed the road in the 1960's to the Rural Medium standard.

Vegetation control works have recently been completed and were not funded or managed through the OoW. In 1998 emergency maintenance works were completed to clear slips and culvert blockages using local village labour.

The two Bailey bridges require maintenance and replacement of decking.

OKSAPMIN ROAD

The gravel road commences at the end of the Koroba road at the Fugwa turnoff and continues for 68.5 km to Kopiago. The road has two sections through rolling terrain:

SN15: Fugwa Turnoff – Tagobi

The 15 km road is in poor condition as the road has had no maintenance since its construction in 1992/3. The road was 6m wide when constructed but has been reduced to 4–5 m due to lack of vegetation control. The five Compact 100 Bailey bridges are in good condition.

Maintenance works are underway by OoW Mendi by pothole patching, vegetation clearing and drainage improvement. The Provincial Government is funding the works.

SN16: Tagobi - Kopiago

The 53.5 km road is a Kiap track only and was built by hand without mechanical equipment. The lack of maintenance for over at least the past five years has left the road in a poor condition. Timber bridges are used over waterways. The road passes through swampy and hilly terrain. Landcruiser utilities and 4WD PMV trucks use the road to transport produce to markets. A 2 km section from Tagobi is being upgraded by the OoW Mendi for the Provincial Government.

WABAG - MENDI ROAD

The 31 km road comprises of two sections: Soba – Peane and Peane – Mendi as part of the National road network. The road provides a 4WD road connection to Enga Province and part of an alternative route to Nipa and Margarima on the Koroba road. The road is an important link for transport of local crops to markets.

SN17: Soba – Peane

The 5 km unsealed road is in poor condition due to lack of maintenance. The 4 - 5m wide pavement is uncrushed quarry run material from Wapon limestone quarry which provides a rough surface. The road was built in 1989 by the DOW to a Rural Light standard and followed a Kiap track through the hilly terrain. No routine maintenance has been provided in the past 3 years, and only emergency repairs have been provide to keep the road open. The road requires resheeting with graded gravel, drainage improvement and vegetation control.

SN18: Peane – Mendi

The 26 km road has a 6 m wide pavement through hilly terrain. The gravel road is very rough and constructed from quarry run material from the Poramanda quarry and has a 1 km section of seal which is in very poor condition. Overall the road is in fair condition. The DOW constructed the road in 1984 to a Rural Medium standard when the Kiap track was reconstructed.

No maintenance works have been conducted in the past two years. The road requires resheeting with graded gravel. An extremely steep section near Mt Wiru has grades over 20% and needs realignment when the road is improved.

Design of the upgrading and sealing of the 60.7 km road from Peane to Mendi and Koin to the Western Highlands border was prepared by Frame Harvey West and Mason, and a design report issued in October 1995. The design used the existing pavement as subgrade for the new pavement with widening where required, and no change to the alignment due to land compensation issues. A single seal coat was recommended for the typical section with a second coat applied on steep grades and tight curves. Ten bridges were recommended for replacement. The remaining three bridges were recommended for maintenance, and installation of steel decking on the Bailey bridges, and a new concrete deck on the steel girder bridge at Nemerep Bridge.

SN19: Sumi – Pinj Road

The 27 km unsealed road from Peane turnoff to Sumia has a section missing which prevents travel along the full road length. The missing section requires many new bridges as the existing timber bridges are deteriorating and unsafe for travel. The DOW constructed the northern section in 1988 and the southern section in 1992.

The 2 – 4 m wide gravel road is in very poor condition due to the total lack of maintenance over the past five years. The road has potholes, landslides, poor drainage, and vegetation overgrowing the road. The road would need significant rehabilitation works and replacement of many bridges to provide an effective road link in the network. Alternatively the existing road could provide maintained without overcoming the missing section.

SN20: Kagua Road

The unsealed 41 km road connects Sumia to Kagua and provides a more direct route to Mendi than via Kisenpoi on the Highlands Highway. However a significant bridge is required to span the Ankurra River about 6 km from Sumia, and it prevents vehicles from travelling from the Kagua to Mendi. AusAid have indicated support to fund construction of the bridge.

The 4 m pavement is in poor condition due to lack of maintenance and has a very rough surface of quarry run material requiring resheeting to restore a gravel pavement. The alignment is poor with narrow sections and sharp bends. The road was constructed by the DOW through hilly terrain in 1984/5 to rural light standard and is used by light vehicles. A footbridge over the Ankurra River allows only pedestrian access over the river.

No maintenance has been provided in the past three years. This year funds have been allocated for emergency repairs at the Waghi slip to construct a 30 m by 20 m gabion wall. Five bridges along the road require maintenance and deck replacement.

SN21: TAMBUL ROAD

The 46 km road commences at Koine on the Wabag – Mendi road and ends at Tambul in Western Highlands Province. The road provides an alternative route to Western Highlands Province. The first 15 km of the road serves a heavily populated area with numerous villages.

The road was constructed manually in the 1960's through hilly terrain to provide the initial access to the Province from the Western Highlands Province. The road allows transport of cash crops to markets by 4WD vehicles.

The 5 m unsealed pavement is generally in fair condition due to potholes, loss of pavement material, poor drainage and lack of vegetation control. The pavement is constructed from uncrushed unscreened river gravel and subsequent layers of quarry run limestone from Poromanda quarry on boggy sections. The pavement surface is very rough due to the lack of a gravel running surface.

No regular maintenance has been provided for the road over the past five years. Emergency maintenance works were completed in 1998 and provided for patch gravelling of 13 km, team grading, resheeting of 2.5 km, vegetation control and drainage works in the worst sections of the road.

The road needs resheeting with crushed material to reduce the surface roughness and drainage improvement. OoW Mendi advise that four Bailey bridges require maintenance and redecking, and two other Bailey bridges require replacement due to damage from overloaded or wayward vehicles.

A detail design to upgrade and seal the road has been prepared as presented in the Peane to Mendi section of the Wabag – Mendi road.

SN22: Pangia Road

The 23 km road connects the district centre of Pangia with Ialibu. The gravel road was constructed in 1978 by the DOW, and allows transport of cash crops and coffee to markets. The road is in hilly terrain for the first half of the road, and then in flat and rolling terrain heading towards Pangia.

The road is in fair condition due to the lack of maintenance, particularly for drainage and surfacing works. The limestone pavement has a 5 m wide formation and has a high roughness as the gravel running surface has been eroded, leaving the coarser sub-base material. There is minimal vegetation control, many culverts are blocked and the side drains require reshaping. Three sections of the road are prone to landslides. A number of major boggy sections restrict access in wet weather and the road subgrade is visible. The last major maintenance work was completed in 1993 when the road was resheeted.

The four Bailey bridges along the road require maintenance and deck replacement due to missing timbers. The poor timber deck on the bridge over the Andawe River, about 7.4 km from Ialibu limited the inspection of the road by the Consultant.

Road maintenance works comprising patrol grading and drain clearing and reforming were underway during the inspection. A contractor for the K100,000 works was appointed directly by a Member of Parliament. The funding was provided by the National Government. The OoW Mendi was not involved in definition of the scope of works, the selection of the contractor, or supervision of the contractor even though the road is classified as a National road.

PROVINCIAL ROADS

The Southern Highlands Provincial Government maintains a large network of Provincial roads. All roads are gravel, except for a few sealed town roads. The Provincial Government appoints and supervises local contractors to complete maintenance works . In recent years they have also managed a number of maintenance works for the National Government at the direction of senior personnel in the OoW in Port Moresby which has excluded the provincial office of the OoW. Four roads were selected for investigation:

SP23: Ialibu – Kumbene

The 12.7 km road is in good condition following recent resheeting works with limestone along about 50% of the road in late 1998. The remainder of the road is satisfactory, but some gabion protection works are required to prevent ongoing erosion to the road approach to a bridge about 1.5 km from Ialibu. The terrain is flat and rolling and through a flood plain. The road provides a much shorter travel route for vehicles between Ialibu and Mendi. The three bridges are in fair condition.

SP24: Nipa – Munihu

The 20 km road is a rough 2-3 m track that traverses hilly terrain. The DOW constructed the road by dozer about 10 years ago with limestone ripped from the Wapul quarry. The road is in poor condition with no maintenance in the past five years. A Bailey bridge over the Lai River requires maintenance

and deck replacement and four timber bridges should be replaced with bridges or culverts. The road requires resheeting and drainage works.

SP25: Hiwanda – Nogoli

The 23 km road is in poor condition overgrown with vegetation, poor drainage and in need of resheeting. The formation has reduced from 6 m to 4 m due to the encroachment of vegetation and lack of maintenance. The DOW constructed the road in the early 1980's. The BP Hides gas operations are located near Nogoli and their supply and fuel trucks use the road constantly. The road is also used to transport vegetables, coffee and timber to markets.

In 1997 BP Hides funded maintenance works to resheet, remove vegetation and drainage works. No maintenance works has been conducted since those works. Refurbishment of the road is required. Good material sources are located at each end of the road. There are many villages and gardens along the road, which could lead to claims for compensation.

SP26: Soba – Winza

The 8.3 km road is an extension of the Wabag – Medni road towards the Enga border. The road is 3-4 m wide and has a high roughness. The road is in poor condition and resheeting to improve the pavement. The DOW constructed the road in 1996 by dozer and placed quarry run from Wapun quarry. No maintenance has been provided since construction of the road. The two Bailey bridges require maintenance and redecking.

C.5 Bridges

Road Number	Road Name	Road Section	Bridge ID	Bridge Name	Chainage	Bridge Type	Span	Bays	Span Configuration	Load	Review by BRUPS	Works Completed	Maint Cost	Replacement Works	Replacement Cost
MOROBE PROVINCE															
NR07	Highlands Highway	Lae Wharf	001\00	9 Mile Creek (Bewapi Bridge)	10.5	Steel Conc Comp.	1 0		18.5	T33	Yes	No	0		
		Yalu Bridge	002\00	Yalu Creek	20.9	Steel Conc. Comp.	2.0		36,36	T33	Yes	No	0		
		Erap Bridge	003\00	Erap River	45.5	Steel Uni. Beam	3.0		25,26.75,25	T44	Yes	No	0		
			004\00	Maralume Creel	54.6	Steel Uni. Beam	2.0		14.5,14.4	T44	Yes	No	0		
			005\00	Ramu River	63.2	Steel Uni. Beam	1.0		30.3	T33	Yes	No	0		
		Clearwater Bridge	006\00	Clearwater Creek	76 3	Steel Conc. Comp.	2.0		14.5,14.5	T44	Yes	No	0		
			007\00	Leron River	98.7	Steel Conc. Comp.	3.0		51.2,51.2,51.2	T33	Yes	No	0		
			008\00	Garambampon River	111.1	Steel Conc. Comp.	3.0		20.5,20.5,20.5	T44	Yes	No	0		
			009\00	Nuraburan Creek	114.4	Steel Conc. Comp.	1.0		21.1	T44	Yes	No	0		
			010\00	Little Maniang Creek	118.4	Steel Conc. Comp.	1.0		21.0	T44	Yes	No	0		
		Maniang Bridge	011\00	Manaing River	120.6	Steel Conc. Comp.	3.0		20.4,20.4,20.4	T44	Yes	No	0		
			012\00	Garia Creek	130.9	Steel Conc. Comp.	1.0		21.0	T44	Yes	No	0		
			013\00	Yafatz Creek	134.9	Steel Conc. Comp.	1.0		21.0	T44	Yes	Yes	50,500	Maintenance only	
			014\00	Umi River	138.8	c100Bailey/t' truss	2.0	17bays	50,50	T33	Yes	Yes	36,500	Maintenance only	
			015\00	Bintia Creek	148.6	Steel Conc. Comp.	1.0		14.5,14.5	T44	No	No	0		
			016\00	Ohman Creek	150.5	Steel Conc. Comp.	1 0		20.0	T44	No	No	0		
			017\00	Utwin Creek	154.7	Steel Conc. Comp.	1.0		21.0	T44	No	No	0		
			018\00	Bitjia Creek (Beboi Bridge)	155.1	Steel Conc Comp.	2.0		24.8,24.8	T44	Yes	Yes	10,300	Maintenance only	
		Waterise Junction	019\00	Waterais Creek	158.3	Steel Conc. Comp.	1.0		21.0	T44	No	No	0		
		Yung Creek													
NR08	Ramu Highway	Waterise Junction	001\00	Nipun	6.9	Steel Conc. Comp.	1.0	-	25.0	NKNOW	No	No	0		
		Gusap River	002\00	Gusap	16.5	S/Truss Con.deck	1 0	0.0	27.0	NKNOW	No	No	0		
													0		
NR04	Wau - Road	Highlands Highway	001\00	Pumpkin No1	1.6	S/truss Conc. Deck	1.0	12.0m	12.0	NKNOW	No	No	0		
			002\00	Pumpkin No2	1.7	S/truss Conc. Deck	1.0	15.1	15.1	NKNOW	No	No	0		
			003\00	Pumpkin No3	2.0	S/truss Conc. Deck	1.0	10.3	10.3	NKNOW	No	No	0		
			004\00	Markham River	4.0	Steel Conc. Comp.	15.0	37x(15)	37,37,37,37,37	NKNOW	Yes	Yes	22,900	Maintenance only	
		Umisis Creek	005\00	Umsis Creek	20.1	Steel Conc. Comp.	2.0		9 1,9 1	NKNOW	No	No	0		
			006\00	Gabensis Creek	24.0	Steel Conc. Comp.	1.0		35.9	NKNOW	No	No	0		
			007\00	Guragos River No1	28.6	Steel Conc. Comp	0.0		0.0	NKNOW	No	No	0		
			008\00	Guragos River No2	37.7	Steel Conc. Comp.	1 0		20.3	NKNOW	No	No	0		
			009\00	Perenim River	43.2	Steel Conc. Comp.	1.0		36.8	NKNOW	No	No	0		
			010\00	Tuoima River (Timina Bridge)	47 0	DSR Std Bailey	1 0	8.0	27.5	NKNOW	Yes	Yes	73,600	Maintenance only	
			011\00	Gurakor River	53.5	No. Con.Box Culv	1.0		9.6	NKNOW	No	No	0		
			012\00	Patep Creek	61 0	Steel Conc. Comp.	1 0		19.8	NKNOW	No	No	0		
			013\00	Perakles Creek	66.3	Steel Conc. Comp	1.0		30.5	NKNOW	No	No	0		
		Zenag River	014\00	Wahuk River (Zenag Bridge)	70.3	Steel Conc. Comp.	1.0		32.0	NKNOW	Yes	Yes	22,500	Maintenance only	
			015\00	Mumeng River	72.0		2.0		24.1,24.1	NKNOW	No	No	0		
			016\00	Clearwater Creek	74.8	Steel Conc. Comp.	1.0		19.6	NKNOW	No	No	0		
			017\00	Snake River (Bangalum Bridg	81.2	Steel Conc. Comp.	1.0		29.0	NKNOW	No	No	0		
			018\00	Scour Creek	85.7	Steel Conc. Comp.	1.0		21.0	NKNOW	No	No	0		
		Baiune River	019\00	Baiune River	90.4	Steel Conc Comp.	1.0		21.2	NKNOW	No	No	0		
			020\00	Cedar River	96.7	Steel Conc. Comp.	1 0		34.0	NKNOW	No	No	0		
			021\00	Pine Tops	115.2	Steel Conc. Comp.	1 0		27.1	NKNOW	No	No	0		
			022\00	Regina Creek	122.4	Steel Mult Culvert.	1.0		0.0	NKNOW	No	No	0		
			023\00	Kaili (Bulolo River)	125.0	Steel Conc. Comp.	1.0		33.9	NKNOW	No	No	0		
		Wau	024\00	Karanga Creek	126.0	Steel Conc Comp.	1.0		18.5	NKNOW	No	No	0		

Road Number	Road Name	Road Section	Bridge ID	Bridge Name	Chainage	Bridge Type	Span	Bays	Span Configuration	Load	Review by BRUPS	Works Completed	Maint Cost	Replacement Works	Replacement Cost
ND4201	Bukawa Road														
		Busu - Buso		Bumpi River	1.4	Bridge type not known until replace with culverts								Replace with culvert	
				Bualo River	4	Bridge type not known until replace with culverts								Replace with culvert	
				Tikeling River	12.4	Bridge type not known until replace with culverts								Replace with culvert	
NM4201	Bulolo- Aseki Road	Bulolo	001\00	Watut	16.3	Steel/u truss/t'deck	45.0	unknown	45.0	unknown	No	No	0		
			002\00	Napini	22.3	T/deck on s/truss	0.0	unknown	0.0	unknown	No	No	0		
			003\00	Agagonda	29 8	T/deck on s/truss	0.0	unknown	0.0	unknown	No	No	0		
			004\00	Bini Greek	35.5	T/deck on s/truss	0.0	unknown	0.0	unknown	No	No	0		
			005\00	Giawai	38 7	T'deck on s/beams	0.0	unknown	0.0	unknown	No	No	0		
			006\00	Angaya	64.1	SS Std Bailey	18.3	unknown	18.3	unknown	No	No	0		
			007\00	Amayonga	66.8	T'deck on s/beams	0.0	unknown	0.0	unknown	No	No	0		
			008\00	Kapau	67.5	SS Std Bailey	12.2	unknown	12.2	unknown	No	No	0		
		Aseki	009\00	Pingdu	67.9	T'deck on s/beams	0.0	unknown	0.0	unknown	No	No	0		
Provincial	Aseki - Menyamya														
Provincial	Finnschhafen - Heldsbach														
Provincial	Heldsbach - Pondui														
Provincial	Buso - Buhem														
Provincial	Erap - Boana														
Provincial	Wasu - Kabum														
Provincial	Leron - Wantoat														

Road Number	Road Name	Road Section	Bridge ID	Bridge Name	Chainage	Bridge Type	Span	Bays	Span Configuration	Load	Review by BRUPS	Works Completed	Maint Cost	Replacement Works	Replacement Cost
EASTERN HIGHLANDS PROVINCE															
NR07	Highlands Highway		020\00	Sing Sing	162.0	Steel Uni.Beam	2.0		20 6,20.6	T44	No	No	0		
			021\00	Yung Creek	164.4	Steel multiplate cul	1.0				No. Replace with Multiplate		0		
			022\00	Undono Creek	175.7	Steel Uni.Beam	1.0		24.1	H20-	No	No	0		
			023\00	Tapiruna Creek	177 2	Steel Uni.Beam	1.0		21.8	H20-	No	No	0		
			024\00	Ramu River	183.6	Conc. Steel Beam	6.0		28.0	T33	No	No	0		
			025\00	Arona Creek	184.7	Steel multiplate cul	1.0		20.5X6		No	No	0		
			026\00	Darasimpi Creek	194 8	Steel Uni.Beam	1.0		18.0	H20-	No	No	0		
			027\00	Namupinpa Creek	201.6	Steel Uni.Beam	1.0		28.0	UNK	No	No	0		
			028\00	Benapa Creek	207.7	Conc. Steel Beam	2.0		18.6	UNK	No	No	0		
			029\00	Iyunopa River	211.0	Conc. Steel Beam	1.0		12.4,24.7	T44	No	No	0		
			030\00	Orompaka Creek	216.3	Conc. Steel Beam	1.0		35.8	UNK	No	No	0		
			031\00	Nonompinka Creek	216..60	Conc. Steel Beam	1.0		15.5	H20-	No	No	0		
			032\00	Honerangka Creek	218.5	Conc. Steel Beam	1.0		18.6	H20-	No	No	0		
			033\00	Ofiga Creek (Roteka)	218.9	Conc. Steel Beam	1.0		24.5	H20-	Yes	No	14,800		
			034\00	Umbaka Creek	219.7	Conc. Steel Beam	1.0		11.3	H20-	No	No	0		
			035\00	Kingkio Creek	229.6	Conc. Steel Beam	1.0		15.4	H20-	Yes	No	9,800		
			036\00	Avari Creek	232.1	Conc. Steel Beam	1.0		18.4	H20-	No	No	0		
			037\00	Kafetina River	234 8	Conc. Steel Beam	1.0		18.1,17.8	T44	Yes	No	7,900		
			038\00	Kamanotina River	243.4	Conc. Steel Beam	1.0		23.5	UNK	No	No	0		
			039\00	Kurongka Creek	243 6	Conc. Steel Beam	1.0		18.4	UNK	No	No	0		
			040\00	Berefi Creek	244.8	Conc. Steel Beam	1.0		24.5	UNK	Yes	No	9,100		
			041\00	Dirtywater Creek (Detwara)	251.8	Conc. Steel Beam	1.0		49.6	UNK	No	No	0		
			042\00	Siguya Creek	259.8	Conc. Steel Beam	1.0		18.4	H20-	No	No	0		
			043\00	Yasifo Creek	265.0	Conc. Steel Beam	1.0		18.5	H20-	Yes	No	8,000		
			044\00	Parirosay Creek	265.9	Conc. Steel Beam	1.0		24.5	UNK	No	No	0		
			045\00	Bena Bena River (Bena)	273.6	Conc. Steel Beam	4.0		24.5X4	H20-	No	No	0		
			046\00	Sunufamu Creek (Sunufamu)	278.3	Conc. Steel Beam	1 0		12.3	UNK	No	No	0		
			047\00	Hatigu Creek	280.7	Conc Steel Beam	2.0		13.4,12 5	T44	No	No	0		
			048\00	Zokozoi Creek	294.4	Conc. Steel Beam	1.0		30.7	T44	Yes	No	9,600		
			049\00	Kitamu Creek (Kefamo)	297.4	Steel Uni.Beam	2.0		15,16.2	T44	Yes	No	12,300		
			050\00	Maniyata River (Ifiufa)	306.3	Conc. Steel Beam	3.0		20.4,20.4	T44	No	No	0		
			051\00	Geteya Creek	309.8	Conc. Steel Beam	1.0		23.0	T44	No	No	0		
			052\00	Asaro River	310.2	Steel Uni.Beam	3.0		35.7	T44	No	No	0		
			053\00	Feonoku Creek	330.9	Conc. Steel Beam	1.0		18.5	UNK	No	No	0		
			054\00	Nurape Creek	338.6	Steel Uni.Beam	1.0		46.8	UNK	No	No	0		
			055\00	Main River	340.9	Conc Steel Beam	3.0		45.7,9.9,6.2	UNK	No	No	0		
ND4101	Aiyura Access Road														
ND4102	Duantina - Bumpa Road														
NI4102	EHP Police & CIS														

Road Number	Road Name	Road Section	Bridge ID	Bridge Name	Chainage	Bridge Type	Span	Bays	Span Configuration	Load	Review by BRUPS	Works Completed	Maint Cost	Replacement Works	Replacement Cost
Provincial	Korofegu - Oleguti														
Provincial	Oleguti - Okapa														
Provincial	Raipinga - Okapa														
Provincial	Oleguti - Lufa														
Provincial	Aiyura - Obura														
Provincial	Goroka - Lahame														
Provincial	Lahame - Magabo														
Provincial	Goroka - Unggai														
Provincial	Asaro - Lapego - Kifamu														

Road Number	Road Name	Road Section	Bridge ID	Bridge Name	Chainage	Bridge Type	Span	Bays	Span Configuration	Load	Review by BRUPS	Works Completed	Maint Cost	Replacement Works	Replacement Cost
WESTERN HIGHLANDS PROVINCE															
NR07	Highlands Highway		60\00	Memintz River	403.9	Steel UB Con. Dec	1.0		27.7	H20-	Yes	Yes	45,700	No replacement.	0
			061\00	Aal River	413.4	Steel UB Con. Dec	2.0		33.4,33.4	H20-	Yes	Yes	56,600	"	0
			062\00	Wahgi River	414.3	Steel UB Con. Dec	3 0		27.1.54.78,27.1	H20-	Yes	Yes	27,000	"	0
			063\00	Bilu River	421.9	Steel UB Con. Dec	1.0		18.5	unknown	Yes	Yes	49,900	No replacement	0
			064\00	Darmena Creek	422.8	Steel UB Con. Dec	1.0		18.5	unknown	Yes	Yes	35,900	"	0
			065\00	Mildip Creek	424.0	Steel UB Con. Dec	1.0		18.7	unknown	Yes	Yes	67,000	"	0
			066\00	Umilga Creek	424.3	Steel UB Con. Dec	1.0		17.2	unknown	Yes	Yes	34,700	"	0
			067/00	Kurumul Creek	427.1	Steel UB Con. Dec	1.0		18.5	unknown	Yes	Yes	45400	"	0
			068\00	Wagamil Creek	431.6	Steel UB Con. Dec	1.0		23.2	unknown	Yes	Yes	32,300	"	0
			069\00	Koman River	446.5	Steel UB Con. Dec	3.0		24.67.24.46,24 7	unknown	Yes	Yes	23,700	No replacement.	0
			070\00	Pin River	454.5	Steel UB Con. Dec	1.0		18.0	unknown	Yes	Yes	42,600	"	0
			071\00	Tuman River	461.1	Steel UB Con. Dec	3.0		24.75,25.5,24.3	unknown	Yes	Yes	34,000	"	0
			072\00	Whagi River	436.1	Steel UB Con. Dec	1.0		28.2	unknown	Yes	Yes	45,000	"	0
			073\00	Wanta Creek	482.1	Steel UB Con. Dec	1.0		18.6	H20-	Yes	Yes	27,000	"	0
			074\00	Turuk River	484.9	Steel UB Con. Dec	1.0		18.3	unknown	Yes	Yes	78,000	"	0
			075\00	Nebilya River	495.6	Std Bailey T/Deck	1.0		55.0	H15-	Yes	Yes	67,200	"	0
			076\00	Moli Creek	502.3	Steel UB Con. Dec	1.0		25.0	T44	Yes	Yes	66,500	No replacement.	0
NR06	Enga Highway			Kumia Creek	8.8	Std Bailey	New Bailey Bridge under BRUP Programme.				Yes	Yes	0	New Bridge	160,000
				Matona River	9.2	Std Bailey	unknown	unknown	unknown	unknown	No	No	0		
NM3901	Baier Road														
NM3902	Kagamuga Road														
NM3903	Ogelbeng - Dona Road														
SOUTHERN HIGHLANDS PROVINCE															
ND3703															
ND3704															

Road Number	Road Name	Road Section	Bridge ID	Bridge Name	Chainage	Bridge Type	Span	Bays	Span Configuration	Load	Review by BRUPS	Works Completed	Maint Cost	Replacement Works	Replacement Cost
ND3705															
NM3704															
NM3705															
NM3701	Koroba Road		001\00	Kolongia Creek	0.4	DS Std Bailey	1.0	7.0	21.3	unknown	Yes	Yes	32,000		
	(Oksapmin Road)		002\00	Mendi River Brdg	0.6	DS Std Bailey	2.0	9.0	13.71,13.71	unknown	Yes	Yes	17,000		
			003\00	Pini River Bridge	17.6		3.0		18.28(3)	unknown	Yes	Yes	43,000		
			004\00	Lai River Bridge	24.5	Std Bailey S/Deck	5.0		28.95,28.95	unknown	Yes	Yes	23,600		
			005\00	Kaso Creek Bridge	49.2	Std Bailey T/Deck	1.0		15.2	unknown	No	No	0		
			006\00	Youl Creek Bridge	52.1	Std Bailey T/Deck	1.0		18.3	unknown	No	No	0		
			007\00	Mara Creek Bridge	55.5	Std Bailey T/Deck	1.0		4.5	unknown	Yes	Yes	12,600		
			008\00	Waga River Bridge	80.5	Std Bailey T/Deck	2.0		18.29,18.29	unknown	No	No	0		
			009\00	Magarima River	92.5	Std Bailey T/Deck	5.0		18.48(5)	unknown	No	No	0		
			010\00	Magarima River No.2	98.5	Std Bailey T/Deck	2.0		12.9,12.9	unknown	No	No	0		
			011\00	Dris Creek Bridge (Lai)	106.0		2.0		7.55,7.55	unknown	Yes	Yes	22,700		
			012\00	Benaria River Brdg	113.2		1.0		11.0	unknown	No	No	0		
			013\00	Huria River Brideg	119.7	Std Bailey T/Deck	2.0		12.9,12.9	unknown	Yes	Yes	44,400		
			014\00	Tigibi Creek Bridge	130.0	Std Bailey T/Deck	1.0		12.9	unknown	Yes	Yes	27,700		
			015\00	Huria River Bridge	131.5	Std Bailey T/Deck	1.0		18.3	unknown	Yes	Yes	12,900		
			016\00	Torna River Bridge	134.2	Std Bailey T/Deck	1.0		18.3	unknown	No	No	0		
			017\00	Dauti Creek Bridge	139.6	Std Bailey T/Deck	2.0		9.85,9.85	unknown	Yes	Yes	14,800		
			018\00	Arua River Bridge	139.9	Std Bailey T/Deck	2.0		6.3,6.3	unknown	No	No	0		
			019\00	Pari Creek Bridge	143.2	Std Bailey	2		15.24,15.24	unknown	No	No	0		
		Tari - Koroba	020\00	Dagia River Bridge	144.0	Std Bailey	1		12.2	unknown	No	No	0		
			021\00	Waleta River Brdg	153.8	Std Bailey	2		18.3	unknown	No	No	0		
			022\00	Tagar River Bridge	166.1	STd Bailey	1		18.3	unknown	No	No	0		
			023\00	Nagia River Bridge	176.2	Std Bailey T/Deck	1		9.85,9.85	unknown	Yes	Yes	21,200		
NR05			001\00	Magani River	113.2	Std Bailey T/Deck		1.0	36.6	unknown	No	No	0		
NR07	Highlands Highway		077\00	Kaugel River	513.0	Steel Thru' Truss	1		54.5	H15	No	No	0		
			078\00	Gargi River	524.1	2 lane concrete	1		24.4	H20	No	No	0		
			079\00	Iaro River	545.3	2 lane concrete	3		10.98,15.3,11.0	UNK	No	No	0		
			080\00	Ankura River	565.6	Steel plate Girder	4		6.2,11.9,38.1,11.	H20-	No	No	0		
			081\00	Baino River	570.0	New conc bridge by BRUPS									
			082\00	Pino River	570.4	New conc bridge by BRUPS									
			083\00	Andei River	579.9	New conc bridge by BRUPS								Replacement Costs for these five(5) bridges cannot be gathered	
			084\00	Arkim River	581.5	New conc bridge by BRUPS									
			085\00	Anga River	585.0	New conc bridge by BRUPS									
			086\00	Korogi River	594.0	DS Standard		1	21.3	UNK					
	Erave Road	Kisenpoi - Ialibu	001\00	Ige River	6.6	SS Standard		1	4.0	UNK	yes	yes	7,300	Required only maint.	
			002\00	Yali River	13.4	DS Standard		1	8.0	UNK	yes		9700	Required only maint.	
	Erave Road	Ialibu - Kagua	003\00	Linenger River	2.8	DSR Standard		1	12.0	UNK	yes	yes	12,700	Reqiured only maint.	
			004\00	Kuni River	10.4	DS Standard		1	6.0	UNK	yes	yes	6,400	Reqiured only maint.	
			005\00	Yalo River	17.0	1 lane concrete		single span		UNK		N			

Road Number	Road Name	Road Section	Bridge ID	Bridge Name	Chainage	Bridge Type	Span	Bays	Span Configuration	Load	Review by BRUPS	Works Completed	Maint Cost	Replacement Works	Replacement Cost
			006\00	Puti	17.3	SS Standard	1	5.0		UNK	yes	yes	9,800	Reqiured only maint.	
			007\00	Alipina	17 6	SS Standard	1	4.0		UNK	yes	yes	6,800	Reqiured only maint	
			008\00	Kagua River	31.0	DS Standard	1	8 0		UNK	yes	yes	7,400	No replacement. Only maint'ce	
		Kagua - Erave	009\00	Sugu River	10 8	UNK	UNK	UNK		UNK	yes	no	0		
			010\00	Erave River	30.5	UNK	UNK	UNK		UNK	yes	no	0		
		Ialibu - Pangia		Andawe River	7.4	DS Standard	UNK	UNK		UNK	No	no	0		
				Ombere	10.9	DS Standard	UNK	UNK		UNK	No	no	0		
				Yoropini River	11.6	DS Standard	UNK	UNK		UNK	No	no	0		
				Wwi River	20.2	SS Standard	UNK	UNK		UNK	No	no	0		
		Kagua - Somia		Nemoro	3.7	SS Standard	UNK	UNK		UNK	No	no	0		
				Uru River	5.4	SS Super	UNK	UNK		UNK	No	no	0		
				Uru River 2	8.5	Super	UNK	UNK		UNK	No	no	0		
				Uru River 3	10.6	Super	UNK	UNK		UNK	No	no	0		
				Kagua River	17.7	Super Bailey	UNK	UNK		UNK	No	no	0		
				Marita River	19.9	Compact st deck	UNK	UNK		UNK	No		0		
				Uba	20.5	Super	UNK	UNK		UNK	No	no	0		
				Rarpuit	23.0	Standard	UNK	UNK		UNK	No	no	0		
	Provincial Road														

Appendix D

Economics

Table D 1
PNG: GROSS DOMESTIC PRODUCT BY ECONOMIC ACTIVITY (1985 - 1998)
(Constant 1983 prices in millions of Kina)

Economic Activity	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	Av. % chg/yr 85-98	85-90	90-98	93 -98
Agriculture, forestry & fisheries	700	711	749	775	786	803	782	830	908	950	970	1029	992	944	2%	3%	2%	1%
Mining & quarrying	275	365	354	364	226	277	393	427	407	411	417	301	227	410	3%	0%	5%	0%
Petroleum								187	589	558	475	505	350	414				-7%
Manufacturing	242	220	222	231	250	193	224	242	246	246	261	300	297	294	2%	-4%	5%	4%
Electricity,gas &water	34	34	36	37	37	37	39	40	39	42	43	45	44	45	2%	2%	2%	3%
Construction	88	90	85	105	119	109	145	133	116	140	105	178	167	192	6%	4%	7%	11%
Trade, transport & finance	410	423	447	447	459	416	479	486	509	556	558	606	625	611	3%	0%	5%	4%
Community & social svcs	378	378	379	379	395	385	382	402	424	468	451	437	459	459	2%	0%	2%	2%
Subtotal	**1749**	**1843**	**1893**	**1959**	**1877**	**1835**	**2062**	**2345**	**2814**	**2903**	**2829**	**2964**	**2702**	**2910**	4%	1%	6%	1%
Import Duties	93	103	117	122	152	131	131	133	118	143	148	163	173	187	6%	7%	5%	10%
Gross Domestic Product	**1842**	**1946**	**2010**	**2081**	**2029**	**1966**	**2193**	**2478**	**2932**	**3046**	**2977**	**3127**	**2875**	**3097**	4%	1%	6%	1%
Annual % chg.		5.6%	3.3%	3.5%	-2.5%	-3.1%	11.5%	13.0%	18.3%	3.9%	-2.3%	5.0%	-8.1%	7.7%				

Source: PNG National Statistical Office and World Bank

Table D.2
PNG: GROSS DOMESTIC PRODUCT BY ECONOMIC ACTIVITY (1985 - 1998
(Per cent share based on Constant 1983 prices)

Economic Activity	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Agriculture, forestry & fisheries	40%	39%	40%	40%	42%	44%	38%	35%	32%	33%	34%	35%	37%	32%
Mining & quarrying	16%	20%	19%	19%	12%	15%	19%	18%	14%	14%	15%	10%	8%	14%
Petroleum	0%	0%	0%	0%	0%	0%	0%	8%	21%	19%	17%	17%	13%	14%
Manufacturing	14%	12%	12%	12%	13%	11%	11%	10%	9%	8%	9%	10%	11%	10%
Electricity,gas &water	2%	2%	2%	2%	2%	2%	2%	2%	1%	1%	2%	2%	2%	2%
Construction	5%	5%	4%	5%	6%	6%	7%	6%	4%	5%	4%	6%	6%	7%
Trade, transport & finance	23%	23%	24%	23%	24%	23%	23%	21%	18%	19%	20%	20%	23%	21%
Community & social svcs	22%	21%	20%	19%	21%	21%	19%	17%	15%	16%	16%	15%	17%	16%
Subtotal	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Import Duties	5%	6%	6%	6%	8%	7%	6%	6%	4%	5%	5%	5%	6%	6%
Gross Domestic Product	105%	106%	106%	106%	108%	107%	106%	106%	104%	105%	105%	105%	106%	106%

Source: PNG National Statistical Office and World Bank

Table D.3
PNG: Major Exports By Type of Product, 1985 - 1997
(US$ million at current prices, fob)

	1985		1988	1991		1994	1995	1996	1997		Avg. % chg./yr 85-97	91-97	94-97
	$mill	% sh.		$mill	% sh.				$mill	% sh.			
Total	**1038**	**100%**	**1530**	**1469**	**100%**	**3176**	**2880**	**2837**	**2408**	**100%**	**7%**	**9%**	**-9%**
Mineral	**549**	**53%**	**994**	**1046**	**71%**	**1826**	**1826**	**1684**	**1287**	**53%**	**7%**	**4%**	**-11%**
copper	209	20%	516	337	23%	437	566	290	182	8%	-1%	-10%	-25%
gold	335	32%	467	694	47%	688	630	581	503	21%	3%	-5%	-10%
silver	5	0%	11	15	1%	10	10	8	6	0%	1%	-15%	-18%
oil						691	620	806	596				-5%
Non-mineral	**410**	**39%**	**415**	**318**	**22%**	**848**	**704**	**785**	**811**	**34%**	**6%**	**17%**	**-1%**
Agricultural	**331**	**32%**	**294**	**213**	**14%**	**346**	**353**	**416**	**501**	**21%**	**4%**	**15%**	**13%**
coffee	118	11%	131	83	6%	195	161	143	227	9%	6%	18%	5%
cocoa	62	6%	53	35	2%	30	36	50	48	2%	-2%	6%	17%
palm oil	62	6%	38	55	4%	77	107	137	145	6%	7%	18%	23%
copra oil	24	2%	20	13	1%	21	23	38	36	1%	3%	18%	19%
copra	33	3%	22	5	0%	14	20	37	33	1%	0%	37%	33%
tea	12	1%	7	6	0%	4	4	10	7	0%	-4%	3%	21%
rubber	4	0%	5	2	0%	3	3	3	5	0%	2%	16%	18%
other (a)	16	2%	18	14	1%	2	n/a	n/a	n/a				
Forest products	**67**	**6%**	**112**	**94**	**6%**	**487**	**338**	**361**	**303**	**13%**	**13%**	**22%**	**-15%**
logs	58	6%	104	85	6%	477	328	349	286	12%	14%	22%	-16%
other (b)	9	1%	8	9	1%	10	10	12	17	1%	5%	11%	19%
Marine products (incl. prawns & fish)	**12**	**1%**	**9**	**11**	**1%**	**15**	**13**	**8**	**7**	**0%**	**-4%**	**-7%**	**-22%**

Source: PNG National Statistical Office and World Bank

Table D.4
PNG: Major Exports By Type of Product, 1995 - 1997
(Kina million at current prices, fob)

	1995	1996	1997
Mineral			
copper	755	387	260
gold	840	774	719
silver	13	10	8
oil	827	1074	852
Non-mineral			
Agricultural			
coffee	215	190	324
cocoa	48	66	69
palm oil	142	182	207
copra oil	30	51	51
copra	27	49	47
tea	5	13	10
rubber	4	4	7
Forest products			
logs	437	465	409
other (b)	13	16	24
Marine products (incl. prawns & fish)	17	10	10

Source: PNG National Statistical Office

Table D.5
PNG: Volume of Major Exports by type of Prouct : 1985 - 1997
(thousand tonnes except where indicated)

	1985	1988	1991	1992	1993	1994	1995	1996	1997	Avg. % chg./yr 85-97	92-97
Copper	169	222	192	188	192	207	216	128	78	-6%	-16%
Gold	32	35	58	67	59	56	55	47	44	3%	-8%
Oil (mil bbl)				15	46	44	37	39	28		14%
Coffee	41	45	47	53	60	65	55	62	59	3%	2%
Cocoa	31	37	36	38	37	26	31	41	37	1%	-1%
Copra	104	77	44	38	44	50	64	99	90	-1%	19%
copra oil	42	36	33	35	44	32	n/a	n/a	n/a		
Palm oil	124	103	200	186	243	231	187	267	275	7%	8%
Tea	7	6	5	2	3	3	n/a	n/a	n/a		
Rubber	5	5	3	2	2	3	n/a	n/a	n/a		
Fish products	14	1	2	2	n/a	n/a	n/a	n/a	n/a		
Logs (000m3)	1141	1348	1062	1601	2375	2944	2513	2607	2376	6%	8%

Table D.6

PNG: Domestic Factor Income by Region & Selected Provinces, 1985 - 1989

(million kina, current prices)

	1985		1987		1989	
	(mill. K)	(% ofPNG)	(mill. K)	(% ofPNG)	(mill. K)	(% ofPNG)
Total PNG	**2018**	**100%**	**2328**	**100%**	**2384**	**100%**
Southern Region	**652**	**32%**	**778**	**33%**	**890**	**37%**
of which						
NCD	410	20%	467	20%	585	25%
Highlands Region	**345**	**17%**	**362**	**16%**	**417**	**17%**
Southern	49	2%	56	2%	64	3%
Enga	38	2%	46	2%	47	2%
Western	119	6%	127	5%	156	7%
Chimbu	29	1%	35	2%	41	2%
Eastern	110	5%	98	4%	109	5%
Northern Region	**366**	**18%**	**400**	**17%**	**462**	**19%**
of which						
Morobe	198	10%	207	9%	250	10%

Source: PNG National Statistical Office

Table D.7

PNG: National and Regional Population

For Morobe and Highlands Provinces, 1990 and Est. 1997

('000 persons)

	1990	1997	avg. % chg/yr	Area (000 km2)	Density (pop./km2)
Total PNG	3762.0	4432.2	2.4%	462.8	9.6
Morobe	380.1	438.4	2.1%	29	15.1
Highlands Region	**1373.6**	**1596.1**	**2.2%**	**62.4**	**25.6**
Southern Highlands	317.4	389.5	3.0%	23.8	16.4
Enga	235.6	301.9	3.6%	12.8	23.6
Chimbu	336.2	397.9	2.4%	8.5	46.8
Western Highlands	183.8	187.9	0.3%	6.1	30.8
Eastern Highlands	300.6	318.9	0.8%	11.2	28.5

Source: National Statistical Office

Table D.8

Coffee Production by Province, 1988/89 - 1997/98

('000 bags @60kg., coffee year October/September)

Coffee yr. ending:	W. Highlands	E. Highlands	Chimbu	Morobe	E. Sepik	Enga	S. Highlands	Other Provinces	Total PNG	Highlands Total	Highlands % of total
1989	442	337	110	70	38	29	34	34	1094	952	87%
1990	403	308	100	63	35	27	31	33	1000	869	87%
1991	328	248	80	50	17	19	24	21	787	699	89%
1992	384	258	75	51	21	16	19	17	841	752	89%
1993	510	372	71	43	40	13	4	6	1059	970	92%
1994	494	408	62	54	56	14	7	5	1100	985	90%
1995	457	321	74	43	50	29	16	3.4	993	897	90%
1996	500	387	102	31	39	37	24	15	1135	1050	93%
1997	475	314	91	75	68	30	22	0	1075	932	87%
1998	569	396	132	89	43	34	15	3	1281	1146	89%
Avg. % chg/yr											
1989 -1998	3%	2%	2%	3%	1%	2%	-9%	-24%	2%	2%	
1994 -1998	4%	-1%	21%	13%	-6%	25%	21%	-12%	4%	4%	

Source: Coffee Industry Corporation Ltd.

Table D.9
Coffee Prices and Production, 1994 -1998

		Coffee Year ending:						
		1993	**1994**	**1995**	**1996**	**1997**	**1998**	**Avg. %chg/yr 93 -'98**
World Prices US$/lb		0.668	0.534	0.616	1.345	1.384	1.021	9%
Avg. FOB prices (green bean)	(kina/ tonne)	1436	3296	3726	2918	5406	5697	32%
	($/ tonne)	1463	2797	2811	2204	3769	2564	12%
Exch. rate: $/K		1.02	0.85	0.75	0.76	0.70	0.45	
PNG Production (000 bags)		1026	1100	989	1085	1076	1316	5%
Largeholder		298	330	257	260	204	263	-2%
Small holder		728	770	732	825	872	1053	8%

Note: Total production statistics differ from provincial totals because of reporting methods to CIC
Source: Coffee Industry Corporation Ltd.

Table D.10 Economic and Financial Ccost for Road Upgrading Works

GROUP	DESCRIPTION	DIRECT COST BREAKDOWN (%)				ECONOMIC FACTORS				CATEGORY A 7.0m Seal		CATEGORY B 6.0m Seal		CATEGORY C 5.5m Seal	
		Labour	Machinery	Materials	Overheads	Labour	Machinery	Materials	Overheads	*Financial*	*Economic*	Financial	Economic	Financial	Economic
1 & 2	GENERAL ITEMS AND PRELIMINARIES	16.0	21.0	41.0	22.0	0.95	0.88	0.8	0.8	137,025	115,211	41,979	35,296	42,660	35,869
3	CLEARING AND GRUBBING	20.0	53.0	5.0	22.0	0.95	0.88	0.8	0.8	3,200	2,792	2,560	2,233	2,560	2,233
4	EARTHWORKS	15.0	55.0	8.0	22.0	0.95	0.88	0.8	0.8	143,000	123,910	22,000	19,063	66,000	57,189
5	PAVEMENT MATERIAL	9.0	59.0	9.0	23.0	0.95	0.88	0.87	0.8	228,900	198,456	167,300	145,049	146,840	127,310
6	BITUMINOUS SURFACING	10.0	11.0	51.0	28.0	0.95	0.88	0.86	0.8	107,000	91,421	60,000	51,264	44,000	37,594
7	DRAINAGE	11.0	32.0	34.0	23.0	0.95	0.88	0.85	0.8	40,000	34,364	18,000	15,464	17,000	14,605
8	ROAD FURNITURE AND MARKINGS	16.0	19.0	43.0	22.0	0.95	0.88	0.85	0.8	6,000	5,164	4,000	3,443	4,000	3,443
9	BRIDGE WORKS	11.0	26.0	40.0	23.0	0.95	0.88	0.85	0.8	20,000	17,146	6,000	5,144	4,000	3,429
	CONTINGENCY	25.0	22.0	30.0	23.0	0.95	0.88	0.85	0.8	102,769	89,419	48,276	42,005	49,059	42,686
	DAYWORKS	25.0	33.0	20.0	22.0	0.95	0.88	0.85	0.8	34,256	29,937	16,092	14,063	16,353	14,291
	TOTAL - CONSTRUCTION									822,150	707,819	386,207	333,023	392,472	338,649
	Detailed Design and Supervision	50	10	10	30	0.95	0.88	0.8	0.8	106,880	85,910	50,207	40,356	51,021	41,011
	PROJECT TOTAL (Kina / kilometre)									929,030	793,728	436,414	373,380	443,493	379,660
	rounded									929,000	794,000	436,000	373,000	443,000	380,000
	Economic/Financial Factor - Overall										85.4%		85.6%		85.6%

Table D.11 Vehicle Tax Structure: 1st Quarter 1999

Vehicle Type	Pass. Car Medium (1.5 - 2L)	Utility/pickup (single cab)	Utility/pickup (double cab)	Mini Bus (15 pass)	Med. bus (25 pass.)	Light Truck <4T	Med Truck < 10T	Hvy Truck > 10T	Artic. Truck (tractor & trailer)	Spare parts	Tyres
Taxes & vehicle Registration fees											
Import Duty (as of 1st Q, 1999; see note below)	75%	11%	55%	11%	11%	11%	11%	11%	11%	11%	11%
Other taxes on purchase											
Surcharge on landed value (drought relief fund)	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%
Prov. sales tx (a)	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%
Economic cost factor (=fin. cost *[1/(1+sum of taxes & excise)]	0.55	0.86	0.62	0.86	0.86	0.86	0.86	0.86	0.86		
Other fees & licenses								*	**		
Vehicle registration fees (Kina/veh)	103	103		150	180	150	200	275	650		
Public Motor Vehicle License				32.25	36.75						
Roadworthiness Inspection	8	8	8	15	15	10	10	10	15		
VAT planned for implementation July 1, '99 with 10% rate											
Import Duty	0	0	0	0	0	0	0	0	0	0	0
Excise tax	60%	10%	60%	10%	10%	10%	10%	10%	10%	0	0
VAT (levied on CIF value + excise)	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%

(* Based on a 12.6T GVW truck; K 200 basic charge for 10 tonne+ K 25 / additional Tonne)
(** Based on a 27.7T GVW truck/trailer combination; K 200 basic charge for 10 tonne + K 25 / additional Tonne)

Notes:
a) import duty on used cars 100%; reported to be suspended after July 1, '99
b) Excise on motor cycles, commercial vans & trucks (tariff code Sect. 87.04) to be 10%;
Hearses, fire engines & prison vans exempt from exise
Import duties on vehicles and spare parts reportedly to be removed with introduction of VAT
c) Provincial sales taxes range from 4% (NCD) to 2% (E. Highlands); to be replaced with VAT

Sources: Internal Revenue Commission;
Customs Tariffs from PNG Import and Export Tariff, 1997 Edition, Commissioner of Customs,
Registration and license fees: Land Transport Board, Department of Transport, Motor Traffic Act, Ch. No. 243 (1983) Schedule 10 as amended 1989

Table D.12 PASSENGER TIME VALUE CALCULATION

1. Average number of passengers per vehicle

Vehicle Type	Average number of passengers
CAR	2.5
PICK UP	3.0
BUS[1]	15.2
LIGHT TRUCK[1]	7.6

[1)] Adopted ratio PMV(15 seater):BUS(25seater)=60%:40%, utilisation 0.8
[2)] Half of passengers in the BUS category

2. Business Trips

Vehicle Type	Percentage of business trips by vehicle type
CAR	70%
PICK UP	50%
BUS	50%
LIGHT TRUCK	20%

3. Time Value

Vehicle Type	Labour Group	Wage rate Kina/hour	Shadow Factor	Distribution of trips per labour group	Percentage of businesss trips for vehicle type	Rate (Kina/h)
CAR	Skilled	4.00	1.00	60%	70%	1.680
	Semi Skilled	2.00	0.85	30%	70%	0.357
	Unskilled	0.50	0.50	10%	70%	0.018
					Total Car	**2.055**
PICK UP	Skilled	4.00	1.00	10%	50%	0.200
	Semi Skilled	2.00	0.85	40%	50%	0.340
	Unskilled	0.50	0.50	50%	50%	0.063
					Total Pick up	**0.603**
BUS	Skilled	4.00	1.00	35%	50%	0.700
	Semi Skilled	2.00	0.85	55%	50%	0.468
	Unskilled	0.50	0.50	10%	50%	0.013
					Total BUS	**1.180**
LIGHT TRUCK	Skilled	4.00	1.00	10%	20%	0.080
	Semi Skilled	2.00	0.85	20%	20%	0.068
	Unskilled	0.50	0.50	70%	20%	0.035
					Total Light Truck	**0.183**

Chart D.1

PNG: GDP 1985 - 1998

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Gross Domestic Product	1842	1946	2010	2081	2029	1966	2193	2478	2932	3046	2977	3127	2875	3097
Agriculture, forestry & fisheries	700	711	749	775	786	803	782	830	908	950	970	1029	992	944
Mining & quarrying	275	365	354	364	226	277	393	427	407	411	417	301	227	410
Petroleum								187	589	558	475	505	350	414
Manufacturing	242	220	222	231	250	193	224	242	246	246	261	300	297	294

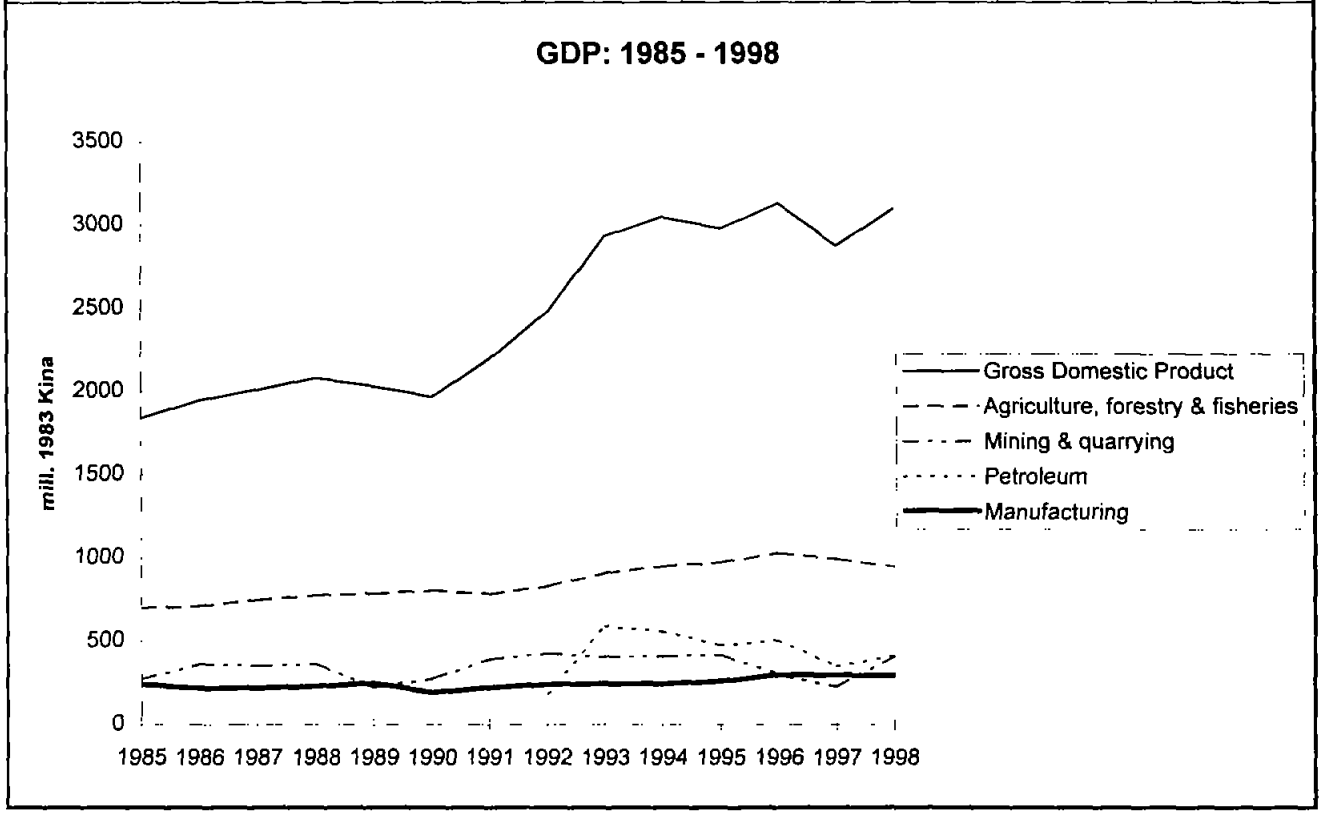


Chart D.2

Coffee Prices and Production

	1993	1994	1995	1996	1997	1998
World Prices US$/lb	0.67	0.53	0.62	1.34	1.38	1.02
Avg. FOB prices ('000 kina/tonne, green bean)	1.44	3.30	3.73	2.92	5.41	5.70
PNG Production (mill. bags)	1.03	1.10	0.99	1.09	1.08	1.32
Largeholder	0.30	0.33	0.26	0.26	0.20	0.26
Small holder	0.73	0.77	0.73	0.83	0.87	1.05

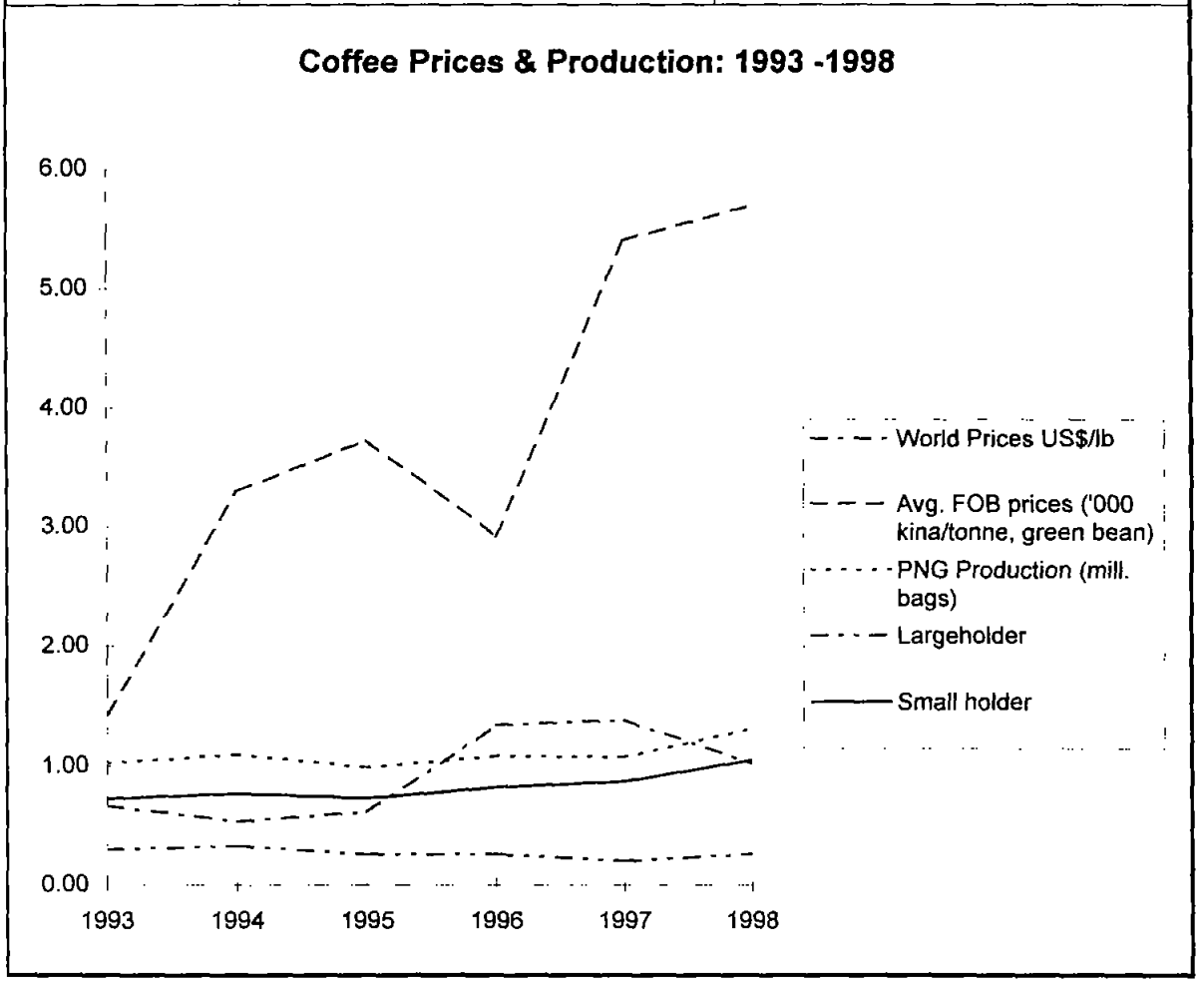


TABLE D.13 VEHICLE OPERATING COSTS

1 / / SHP-1 Province SERIES D : PAGE 1

VEHICLE FLEET CHARACTERISTICS AND UNIT COSTS

COSTS IN PNG Kina

		CAR	UTIL	BUS	LTRUCK	MTRUCK	HTRUCK	ATRUCK
0ECONOMIC COSTS								
NEW VEHICLE	(COST/VEHICLE)	27500.00	31000.00	40000.00	39000.00	71000.00	138500.00	247000.00
TIRES	(COST/TIRE)	80.00	125.00	125.00	90.00	190.00	450.00	450.00
MAINT LABOR	(COST/LABOR-H)	5.00	5.00	5.00	5.00	5.00	5.00	5.00
CREW TIME	(COST/CREW-H)	.00	.00	2.00	2.00	3.50	4.00	4.50
PASSENGER DELAY	(COST/PASS-H)	2.06	.60	1.18	.18	.00	.00	.00
CARGO DELAY	(COST/VEH-H)	.00	.00	.00	.00	.00	.00	.00
ANNUAL OVERHEAD COSTS	(%)	.00	.00	10.00	25.00	25.00	25.00	25.00
ANNUAL INTEREST RATE	(%)	25.00	25.00	25.00	25.00	25.00	25.00	25.00

FUEL & LUBRICANTS (COST/LITER) PETROL = .63 DIESEL FUEL = .60 ENGINE OIL = 2.10

TABLE D.13 VEHICLE OPERATING COSTS

VEHICLE FLEET CHARACTERISTICS AND UNIT COSTS

	CAR	UTIL	BUS	LTRUCK	MTRUCK	HTRUCK	ATRUCK
VEHICLE DESCRIPTIONS							
VEHICLE TYPE	2	4	5	7	8	9	10
FUEL TYPE	PETROL	PETROL	DIESEL	DIESEL	DIESEL	DIESEL	DIESEL
GROSS VEH WGHT (TONS)	1.00	1.30	5.30	5.30	13.00	20.00	37.00
EQUIVALENT AXLES(EXP=4.0)	.00	.00	.03	.03	1.25	2.28	4.63
EQUIVALENT AXLES(EXP=2.0)	.01	.02	.26	.26	1.54	2.55	4.72
AVERAGE VEHICLE AXLES	2.00	2.00	2.00	2.00	2.00	3.00	5.00
AXLE TYPE:							
AXLE NO 1	1	1	1	1	1	1	1
AXLE NO 2	1	1	2	2	2	3	3
AXLE NO 3						3	3
AXLE NO 4							2
AXLE NO 5							2
PAYLOAD(TONS)	.00	.30	1.80	3.20	6.50	13.00	24.70
AERODYNAMIC DRAG COEFFICIENT	.50	.46	.65	.70	.85	.85	.63
PROJECTED FRONTAL AREA	2.08	2.72	6.30	3.25	5.20	5.20	5.75
DRIVING POWER(METRIC HP)	70.00	40.00	100.00	60.00	100.00	100.00	210.00
BRAKING POWER(METRIC HP)	21.00	30.00	160.00	100.00	250.00	250.00	500.00
FRATIO0(PAVED)	.268	.221	.233	.253	.292	.292	.170
FRATIO0(UNPAVED)	.124	.117	.095	.099	.087	.087	.040
FRATIO1(PAVED)	.000000	.000000	.000000	.012800	.009400	.009400	.002300
FRATIO1(UNPAVED)	.000000	.000000	.000000	.000000	.000000	.000000	.000000
PSYCH SPEED(KM/H, PAVED)	98.30	94.90	93.40	81.60	88.80	88.80	84.10
PSYCH SPEED(KM/H, UNPAVED)	82.20	76.30	69.40	71.90	72.10	72.10	49.60
CALIBRATED ENGINE SPEED(RPM)	3000.00	3300.00	2300.00	2600.00	1800.00	1800.00	1700.00
MAX AV RECT VELOCITY(MM/S)	259.7	239.7	212.8	194.0	177.7	177.7	130.9
WIDTH PARAMETER FOR SPEED	.7400	.7400	.7800	.7300	.7300	.7300	.7300
WEIBULL SHAPE PARAMETER	.2740	.3060	.2730	.3040	.3100	.3100	.2440
ENERGY EFFICIENCY FACTOR	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
FUEL ADJUSTMENT FACTOR	1.1600	1.1600	1.1500	1.1500	1.1500	1.1500	1.1500
RECAP COST RATIO(%)	15.0	15.0	15.0	15.0	15.0	15.0	15.0
TIRE RUBBER VOLUME(CU DM)	.00	.00	6.85	4.30	7.60	7.30	8.39
BASE NUMBER OF RETREADS	.00	.00	3.39	1.93	3.39	3.39	4.57
CONSTANT TREAD WEAR TERM	.00	.00	.16	.16	.16	.16	.16
WEAR COEFFICIENT	.00	.00	1.28	1.28	1.28	1.28	1.28
CONSTANT SPARE PARTS TERM	45.00	3.00	2.00	3.00	5.00	15.00	25.00
ROUGH COEFF SPARE PARTS TERM	13.70	13.70	3.56	251.79	251.79	35.31	15.65
ROUGH. LIMIT, SPARE PARTS EQU	9.23	9.23	14.62	.00	.00	.00	.00
CONSTANT LABOR HOURS TERM	77.14	77.14	293.44	242.03	242.03	301.46	652.51
EXPONENTIAL LABOR HOURS TERM	.55	.55	.52	.52	.52	.52	.52
ROUGH COEFF LABOR HOURS TERM	.00	.00	.01	.00	.00	.00	.00

TABLE D.13 VEHICLE OPERATING COSTS

VEHICLE FLEET CHARACTERISTICS AND UNIT COSTS

	CAR	UTIL	BUS	LTRUCK	MTRUCK	HTRUCK	ATRUCK
0VEHICLE UTILIZATION							
NO. OF PASSENGERS/VEHICLE	2.5	3.0	15.2	7.6	.0	.0	.0
ANNUAL HOURS DRIVEN	0.	1500.	2600.	2200.	2400.	2400.	3120.
ANNUAL KILOMETERS DRIVEN	20000.	35000.	55000.	45000.	50000.	75000.	90000.
VEHICLE SERVICE LIFE (YEARS)	6.	5.	4.	5.	5.	5.	7.
VEHICLE DEPRECIATION CODE	2	2	2	2	2	2	2
VEHICLE UTILIZATION CODE	1	3	3	3	3	3	3
HOURLY UTILIZATION RATIO	.00	.60	.75	.85	.85	.85	.85
NUMBER OF TIRES/VEHICLE	4	4	6	6	6	10	18
MAXIMUM PASSABILITY FACTOR	1.50	1.50	1.50	1.50	1.50	1.50	1.50

1. VEHICLE TYPE CODES

1=SMALL CAR	2=MEDIUM CAR	3=LARGE CAR
4=UTILITY	5=BUS	6=LIGHT GAS TRUCK
7=LIGHT DIESEL TRUCK	8=MEDIUM TRUCK	9=HEAVY TRUCK
10=ARTICULATED TRUCK		

2. VEHICLE DEPRECIATION CODES

1=DEWEILLE'S VARYING VEHICLE LIFE	2=CONSTANT VEHICLE LIFE

3. VEHICLE UTILIZATION CODES

1=CONSTANT ANNUAL KILOMETERAGE	2=CONSTANT ANNUAL HOURLY USE	3=ADJUSTED USE

4. VEHICLE AXLE TYPES

1=SINGLE-WHEEL, SINGLE AXLE	2=DUAL-WHEEL, SINGLE AXLE	3=DUAL-WHEEL, TANDEM AXLE
4=DUAL-WHEEL, TRIPLE AXLE		

Appendix E

Traffic

ROAD CHARACTERISTICS AND TRAFFIC GROWTH

Road Number	Section Number	Road Characteristics						CARTS Model Growth Estimates		Adopted Traffic Growth			
		Road Name	Location	Pavement Type	Section Length Km	Road Total Length Km	Road Functional Category	% Growth from 1999	% Growth from 2010	% Growth from 1999	% Growth from 2010	Adopted 1999 AADT	Road Section Number
MOROBE PROVINCE (Sheet 1 of 2)													
NR07	MN01	Highlands Highway	Lae - Wharf - Yalu Bridge	Sealed	20.8	164.4	A	3.78	3.50	3.8%	3.5%	3500	MN01
NR07	MN02	Highlands Highway	Yalu Bridge - Erap Bridge	Sealed	25.1		A	3.85	3.37	3.9%	3.4%	2200	MN02
NR07	MN03	Highlands Highway	Erap Bridge - Clearwater Bridge	Sealed	30.4		A	3.75	3.19	3.8%	3.2%	1100	MN03
NR07	MN04	Highlands Highway	Clearwater Bridge - Maniang	Sealed	44.1		A	3.81	3.40	3.8%	3.4%	1000	MN04
NR07	MN05	Highlands Highway	Maniang - Waterise Junction	Sealed	36.3		A	3.72	3.20	3.7%	3.2%	1000	MN05
NR07	MN06	Highlands Highway	Waterise Junction - Yung Creek	Sealed	7.7		A	3.53	3.20	3.5%	3.2%	1000	MN06
NR08	MN07	Ramu Highway	Watense Junction - Gusap	Sealed Sealed	32.0	32.0	A	2.90	2.67	2.9%	2.7%	680	MN07
NR04	MN08	Wau Road	Highlands Highway - Umsis	Sealed	20.0	129.3	B	4.17	3.87	4.2%	3.9%	620	MN08
NR04	MN09	Wau Road	Umsis - Zenag River	Sealed	50.4		B	4.06	3.73	4.1%	3.7%	400	MN09
NR04	MN10	Wau Road	Zenag River - Baiune	Gravel/Seale	20.0		B	4.16	3.71	4.2%	3.7%	360	MN10
NR04	MN11	Wau Road	Baiune - Wau	Gravel/Seale	38.9		B	4.21	3.97	4.2%	4.0%	350	MN11
NM4201	MN12	Aseki Road	Bulolo - Pararua	Gravel	32.8	84 0	C	1.91	2.76	1.9%	2.8%	250	MN12
NM4201	MN13	Aseki Road	Pararua - Aseki	Gravel	51 2		C	2.98	3.29	3.0%	3 3%	150	MN13
ND4201	MN14	Bukawa Road	Malahang - Busu	Gravel/Seale	8.0	36.7	B	2 94	3.82	2.9%	3.8%	350	MN14
ND4201	MN15	Bukawa Road	Busu - Buso	Gravel	28.7		C	3.07	2 83	3.1%	2.8%	200	MN15
	MP16	Provincial Roads	Aseki - Menyamya	Gravel	32.5	268.2	D	2.86	3.67	2.9%	3.7%	50	MP16
	MP17	Provincial Roads	Finschhafen - Heldsbach	Gravel	21 0		D	2.89	2.72	2.9%	2.7%	150	MP17
	MP18	Provincial Roads	Heldsbach - Pondui	Gravel	58.6		D	1.67	3.42	1 7%	3.4%	150	MP18
	MP19	Provincial Roads	Buso - Buhem	Gravel	28 5		D	2.00	3.00	2.0%	3.0%	50	MP19
	MP20	Provincial Roads	Erap - Boana	Gravel	31.0		D	3.46	2,13	3.5%	2.1%	100	MP20
	MP21	Provincial Roads	Wasu - Kabum	Gravel	34 6		D	4.00	3.00	4.0%	3.0%	150	MP21
	MP22	Provincial Roads	Leron - Wantoat	Gravel	62.0		D	3.18	1.91	3.2%	1.9%	50	MP22
			Total Length		714.6	714 6							

HDM TRAFFIC DATA AND TRAFFIC SOURCE DATA

Section Number	Road Name	Vehicle Category by Road Group	HDM TRAFFIC DATA - 1999 Vehicle Numbers (vehs per day)							Present Traffic	Forecast Traffic w/o gen'd traffic		Traffic Count Source Data - Various sources, Year of coun						MARESMAN DATA
			Car	Pick-Up	Bus	Light Truck	Med. Truck	Hvy Truck	Artic Truck	Adopted 1999 AADT	Estimated 2010 AADT	Estimated 2020 AADT	ADT	Year of Count	ADT	Year of Count	ADT	Year of Count	Traffic Category one way vpd
MOROBE PROVINCE (Sheet 2 of 2)																			
MN01	Highlands Highway	A	630	1680	875	105	35	35	140	3500	5275	7441	3013	99	3411	96	2694	90	>1530
MN02	Highlands Highway	A	396	1056	550	66	22	22	88	2200	3351	4682	2177	97	1008	96	639	88	760-1530
MN03	Highlands Highway	A	198	473	275	33	11	22	88	1100	1658	2272			935	96	360	79	760-1530
MN04	Highlands Highway	A	180	430	250	30	10	20	80	1000	1507	2106	637	96	629	96			760-1530
MN05	Highlands Highway	A	180	430	250	30	10	20	80	1000	1491	2043	[1074]	Carts	641	96			760-1530
MN06	Highlands Highway	A	180	430	250	30	10	20	80	1000	1460	2001	[680]	Carts	481	96			760-1530
MN07	Ramu Highway	A	122	326	170	20	7	7	27	680	931	1216	1040	97	394	96	924	91	190-250
MN08	Wau Road	C	186	217	112	62	19	12	12	620	975	1429			561	96	555		190-250
MN09	Wau Road	C	120	140	72	40	12	8	8	400	622	895	286	98					90-190
MN10	Wau Road	C	108	126	65	36	11	7	7	360	566	814	328	96	337	96	164	84	90-190
MN11	Wau Road	D	35	158	53	81	11	7	7	350	550	815	514	96	280	96	418	85	90-190
MN12	Aseki Road	D	25	113	38	58	8	5	5	250	309	407	[260]	Carts	675	96	153	87	20-45
MN13	Aseki Road	D	15	68	23	35	5	3	3	150	209	289	112	99	[150]	Carts	156	87	20-45
MN14	Bukawa Road	D	35	158	53	81	11	7	7	350	481	698	288	99	474	87			190-250
MN15	Bukawa Road	D	20	90	30	46	6	4	4	200	281	371	[260]	Carts	270	87			45-90
MP16	Provincial Roads	F	6	18	8	15	3	1	1	50	70	100	101	99	[44]	Carts	83	87	
MP17	Provincial Roads	F	18	53	23	45	9	2	2	150	207	270	160	99	148	99			
MP18	Provincial Roads	F	18	53	23	45	9	2	2	150	182	254	148	99	[125]	Carts			
MP19	Provincial Roads	F	6	18	8	15	3	1	1	50	63	85	[9]	Carts					
MP20	Provincial Roads	F	12	35	15	30	6	1	1	100	147	182	72	99	115	96	71	87	
MP21	Provincial Roads	F	18	53	23	45	9	2	2	150	232	312	224	99					
MP22	Provincial Roads	F	6	18	8	15	3	1	1	50	72	87	52	99	32	96	22	87	

ROAD CHARACTERISTICS AND TRAFFIC GROWTH

Road Number	Section Number	Road Characteristics						CARTS Model Growth Estimates		Adopted Traffic Growth			
		Road Name	Location	Pavement Type	Section Length Km	Road Total Length Km	Road Functional Category	% Growth from 1999	% Growth from 2010	% Growth from 1999	% Growth from 2010	Adopted 1999 AADT	Road Section Number
EASTERN HIGHLANDS PROVINCE (Sheet 1 of 2)													
NR07	EN01	Highlands Highway	Yung Creek - Kassam Pass	Sealed	4.0	179 1	A	3.38	3.00	3.4%	3.0%	1000	EN01
NR07	EN02	Highlands Highway	Kassam Pass	Sealed	5.7		A	3.38	3.00	3.4%	3.0%	1000	EN02
NR07	EN03	Highlands Highway	Kassam - Kainantu	Sealed	33.6		A	3.08	3.14	3.1%	3 1%	1000	EN03
NR07	EN04	Highlands Highway	Kainantu - Henganofi	Sealed	38.5		A	2.86	3.03	2.9%	3.0%	1500	EN04
NR07	EN05	Highlands Highway	Henganofi - Goroka	Sealed	44.2		A	2 66	2 88	2.7%	2 9%	1500	EN05
NR07	EN06	Highlands Highway	Goroka - Daulo	Sealed	26.7		A	2.27	2.39	2.3%	2 4%	2500	EN06
NR07	EN07	Highlands Highway	Daulo Pass - Simbu Border	Sealed	26.4		A	2 05	2.26	2.1%	2.3%	1000	EN07
ND4101	EN08	Aiyura Access Road	Kainantu - Aiyura NHS	Sealed	6.6	54 3	B	2.44	2.66	2.4%	2.7%	700	EN08
ND4102	EN09	Dunantina-Dumpu Ro	Dunantina - Dumpu	Gravel	47.7		C	2.52	2.87	2.5%	2.9%	200	EN09
NI4102	EN10	Institutional Road	EHP Police & CIS	Gravel	6 7	6 7	B	2.00	2.00	2.0%	2.0%	300	EN10
						238.0							
	EP11	Provincial Road	Korofegu - Oleguti	Sealed	15.0		B	1.06	1.39	1.1%	1.4%	500	EP11
	EP12		Oleguti - Okapa	Gravel	44.0		C (B)	1.00	1.27	1.0%	1 3%	250	EP12
	EP13		Raipinga - Okapa	Gravel	49.0		C	1.00	1.26	1.0%	1 3%	150	EP13
	EP14		Oleguti - Lufa	Gravel	15.0		C	1.00	1.57	1 0%	1.6%	100	EP14
	EP15		Aiyura - Obura	Gravel	32.0		C	2.00	2.00	2.0%	2.0%	200	EP15
	EP16		Goroka - Lahame	Gravel	13.0		C	2.21	2.78	2.2%	2.8%	250	EP16
	EP17		Lahame - Magabo	Gravel	21 0		C	1.26	2 00	1.3%	2.0%	100	EP17
	EP18		Goroka - Unggai	Gravel	29.0		C	2.00	2.00	2.0%	2.0%	100	EP18
	EP19		Asaro - Lapego - Kifamu	Gravel	20.0		C	3.12	2.86	3.1%	2.9%	200	EP19
			Total Length		478.1	478.1							

HDM TRAFFIC DATA AND TRAFFIC SOURCE DATA

Section Number	Road Name	Vehicle Category by Road Group	HDM TRAFFIC DATA - 1999 Vehicle Numbers (vehs per day)							Present Traffic	Forecast Traffic w/o gen'd traffic		Traffic Count Source Data - Various sources, Year of coun						MARESMAN DATA
			Car	Pick-Up	Bus	Light Truck	Med. Truck	Hvy Truck	Artic Truck	Adopted 1999 AADT	Estimated 2010 AADT	Estimated 2020 AADT	ADT	Year of Count	ADT	Year of Count	ADT	Year of Count	Traffic Category one way vpd
EASTERN HIGHLANDS PROVINCE (Sheet 2 of 2)																			
EN01	Highlands Highway	A	160	430	250	30	10	20	80	1000	1445	1941	[1247]	Carts					760-1530
EN02	Highlands Highway	A	180	430	250	30	10	20	80	1000	1445	1941	[1247]	Carts					760-1530
EN03	Highlands Highway	A	180	480	250	30	10	10	40	1000	1399	1899	1113	96	831	86	424	75	760-1530
EN04	Highlands Highway	A	270	720	375	45	15	15	60	1500	2054	2761	860	98					760-1530
EN05	Highlands Highway	A	270	720	375	45	15	15	60	1500	2011	2676	3716	96	739	91	533	90	760-1530
EN06	Highlands Highway	A	450	1200	625	75	25	25	100	2500	3210	4070	3548	96			593	86	760-1530
EN07	Highlands Highway	A	180	480	250	30	10	10	40	1000	1257	1578			543	96			760-1530
EN08	Aiyura Access Road	C	210	245	126	70	21	14	14	700	909	1186	575	90					45-90
EN09	Dunantina-Dumpu Ro	D	20	90	30	46	6	4	4	200	262	349	[200]	Carts					45-90
EN10	Institutional Road	G	75	105	45	45	18	9	3	300	373	455	[500]	Est'd					45-90
EP11	Provincial Road	C	150	175	90	50	15	10	10	500	564	648	261	99	552	96	376	90	
EP12		D	25	113	38	58	8	5	5	250	279	317	206	99	227	90			
EP13		D	15	68	23	35	5	3	3	150	167	190	127	99	274	90			
EP14		F	12	35	15	30	6	1	1	100	112	131	79	99					
EP15		D	20	90	30	46	6	4	4	200	249	303	180	99	155	90			
EP16		F	30	88	38	75	15	3	3	250	318	419	[300]	Carts					
EP17		F	12	35	15	30	6	1	1	100	115	141	148	99					
EP18		F	12	35	15	30	6	1	1	100	124	152	83	99					
EP19		F	24	70	30	60	12	2	2	200	280	372	122	99	197	90			

ROAD CHARACTERISTICS AND TRAFFIC GROWTH

Road Number	Section Number	Road Characteristics						CARTS Model Growth Estimates		Adopted Traffic Growth			
		Road Name	Location	Pavement Type	Section Length Km	Road Total Length Km	Road Functional Category	% Growth from 1999	% Growth from 2010	% Growth from 1999	% Growth from 2010	Adopted 1999 AADT	Road Section Number
WESTERN HIGHLANDS PROVINCE (Sheet 1 of 2)													
NR07	WN01	Highlands Highway	Garniger - Minj	Sealed	17.5	112.7	A	2.50	2.57	2.5%	2.6%	1350	WN01
NR07	WN02	Highlands Highway	Minj - Kudjip	Sealed	12.0		A	3.06	2.43	3.1%	2.4%	1750	WN02
NR07	WN03	Highlands Highway	Kudjip - Tuman R	Sealed	16.2		A	3.06	2.86	3.1%	2.9%	3000	WN03
NR07	WN04	Highlands Highway	Tuman R - Mt. Hagen Town B'dary	Sealed	25.5		A	3.63	3.25	3.6%	3.3%	4000	WN04
NR07	WN05	Highlands Highway	Mount Hagen Town Area	Sealed	2.5		A	2.83	2.81	2.8%	2.8%	8000	WN05
NR07	WN06	Highlands Highway	Mt Hagen Town B'dary - Togoba	Sealed	10.9		A	3.97	3.41	4.0%	3.4%	2000	WN06
NR07	WN07	Highlands Highway	Togoba - SHP Border	Sealed	28.1		A	3.48	3.25	3.5%	3.3%	1000	WN07
NR06	WN08	Enga Highway	Togoba - Paigona	Sealed	13.0	29.9	A	4.21	3.63	4.2%	3.6%	1000	WN08
NR06	WN09	Enga Highway	Paigona - Enga Border	Sealed	16.9		A	4.46	3.30	4.5%	3.3%	700	WN09
NM3901	WN10	Baiyer Road	Mount Hagen - Kumdi School	Sealed	21.0	78.2	B	2.32	2.34	2.3%	2.3%	700	WN10
NM3901	WN11	Baiyer Road	Kumdi School - Baiyer R	Gravel	28.3		C	3.49	2.75	3.5%	2.8%	250	WN11
NM3901	WN12	Baiyer Road	Baiyer R - Ruti Ranch	Gravel	28.9		D	3.45	2.64	3.5%	2.6%	100	WN12
NM3902	WN13	Kagamuga Airport	Airport Access Road	Sealed	1.5	1.5	A	3.50	2.50	3.5%	2.5%	2000	WN13
NM3903	WN14	Ogelbeng-Dona Road	Ogelbeng - Ambra	Gravel	9.2	80.9	B	1.82	2.04	1.8%	2.0%	275	WN14
NM3903	WN15	Ogelbeng-Dona Road	Ambra - Kotna	Gravel	19.5		B	2.86	3.06	2.9%	3.1%	500	WN15
NM3903	WN16	Ogelbeng-Dona Road	Kotna - Banz	Gravel	33.0		B	3.06	2.54	3.1%	2.5%	500	WN16
NM3903	WN17	Ogelbeng-Dona Road	Banz - Dona	Gravel/Seale	19.2		B	3.39	3.62	3.4%	3.6%	150	WN17
NI3901	WN18	Institutional Road	Tea	Gravel	4.0	15.3	C	3.13	2.77	3.1%	2.8%	50	WN18
NI3901	WN19	Institutional Road	CIS	Gravel	11.3		C	3.00	2.50	3.0%	2.5%	300	WN19
	WP20	Provincial Road	Tomba - Tambul	Gravel	16.0	199.0	C	3.73	2.95	3.7%	3.0%	150	WP20
	WP21	Provincial Road	Balk - Bukapina	Gravel	15.3		D	2.05	3.87	2.1%	3.9%	150	WP21
	WP22	Provincial Road	Bukapina - Koge	Gravel	6.4		D	2.40	1.65	2.4%	1.7%	100	WP22
	WP23	Provincial Road	Bukapina - Nengil	Gravel	16.4		D	4.99	2.86	3.0%	2.9%	150	WP23
	WP24	Provincial Road	Bukapina - Kadua #1	Sealed	10.0		C	2.99	2.67	3.0%	2.7%	250	WP24
	WP25	Provincial Road	Baiyer River - Lumusa	Gravel	13.0		D	3.44	2.80	3.4%	2.8%	100	WP25
	WP26	Provincial Road	Kagamuga - Kelua #1	Gravel/Seale	12.2		B	3.50	2.50	3.5%	2.5%	350	WP26
	WP27	Provincial Road	Kom Farm - Ambra	Sealed	8.0		B	2.00	2.32	2.0%	2.3%	600	WP27
	WP28	Provincial Road	Kum - Wurup	Gravel	8.8		C	3.56	3.15	3.6%	3.2%	250	WP28
	WP29	Provincial Road	Wurup - Kom Farm	Gravel	6.3		D	2.95	2.68	3.0%	2.7%	200	WP29
	WP30	Provincial Road	Kotna - Tigi - Baiyer River	Gravel	24.0		D	3.41	2.43	3.4%	2.4%	100	WP30
	WP31	Provincial Road	Kindeng - Kondopina	Gravel	11.3		B	3.42	2.35	3.4%	2.4%	500	WP31
	WP32	Provincial Road	Kudjip - Banz	Sealed	7.0		B	2.76	3.54	2.8%	3.5%	1500	WP32
	WP33	Provincial Road	Banz - Karap	Gravel	36.5		D	2.44	2.52	2.4%	2.5%	100	WP33
	WP34	Provincial Road	Donna - Nondugal - Highlands Hwy	Gravel	7.8		D	2.76	2.90	2.8%	2.9%	200	WP34
			Total Length		517.5	517.5							

HDM TRAFFIC DATA AND TRAFFIC SOURCE DATA

Section Number	Road Name	Vehicle Category by Road Group	HDM TRAFFIC DATA - 1999 Vehicle Numbers (vehs per day)							Present Traffic	Forecast Traffic w/o gen'd traffic		Traffic Count Source Data - *Various sources, Year of coun*						MARESMAN DATA
			Car	Pick-Up	Bus	Light Truck	Med. Truck	Hvy Truck	Artic Truck	Adopted 1999 AADT	Estimated 2010 AADT	Estimated 2020 AADT	ADT	Year of Count	ADT	Year of Count	ADT	Year of Count	Traffic Category one way vpd
WESTERN HIGHLANDS PROVINCE (Sheet 2 of 2)																			
WN01	Highlands Highway	A	243	648	338	41	14	14	54	1350	1771	2290	1253	96	985	82			760-1530
WN02	Highlands Highway	A	315	840	438	53	18	18	70	1750	2448	3104	1352	96	1600	96	1973	96	760-1530
WN03	Highlands Highway	A	540	1440	750	90	30	30	120	3000	4197	5586	[2670]	Carts					760-1530
WN04	Highlands Highway	A	720	1920	1000	120	40	40	160	4000	5902	8166	5619	96	8017	96			760-1530
WN05	Highlands Highway	A	1440	3840	2000	240	80	80	320	8000	10840	14287	[8000]	Est'd					760-1530
WN06	Highlands Highway	A	360	960	500	60	20	20	80	2000	3079	4301	2227	96					760-1530
WN07	Highlands Highway	A	180	480	250	30	10	10	40	1000	1460	2020	1106	96					760-1530
WN08	Enga Highway	A	180	480	250	30	10	10	40	1000	1572	2239	1241	96					250-760
WN09	Enga Highway	A	126	336	175	21	7	7	28	700	1136	1572	715	96	625	96			250-760
WN10	Baiyer Road	C	210	245	126	70	21	14	14	700	899	1128	680	96	555	96			190-250
WN11	Baiyer Road	D	25	113	38	58	8	5	5	250	365	481	[260]	Carts					90-190
WN12	Baiyer Road	D	10	45	15	23	3	2	2	100	146	189	[190]	Carts					90-190
WN13	Kagamuga Airport	C	600	700	360	200	60	40	40	2000	2920	3738	3476	96					250-760
WN14	Ogelbeng-Dona Road	D	28	124	41	63	8	6	6	275	335	408	198	96	158	87			90-190
WN15	Ogelbeng-Dona Road	D	50	225	75	115	15	10	10	500	685	929	345	87					90-190
WN16	Ogelbeng-Dona Road	D	50	225	75	115	15	10	10	500	700	895	312	87	682	87			190-250
WN17	Ogelbeng-Dona Road	C	45	53	27	15	5	3	3	150	217	309							190-250
WN18	Institutional Road	G	13	18	8	8	3	2	1	50	70	92							20-45
WN19	Institutional Road	G	75	105	45	45	18	9	3	300	415	532	280	99	343	87			45-90
WP20	Provincial Road	D	15	68	23	35	5	3	3	150	225	303	93	99	115	96			
WP21	Provincial Road	F	18	53	23	45	9	2	2	150	190	278	13	99	158	87			
WP22	Provincial Road	F	12	35	15	30	6	1	1	100	131	155	[104]	Carts					
WP23	Provincial Road	F	18	53	23	45	9	2	2	150	209	278	177	87					
WP24	Provincial Road	C	75	88	45	25	8	5	5	250	347	454	240	99	120	99	208	99	
WP25	Provincial Road	F	12	35	15	30	6	1	1	100	146	192	[191]	Carts					
WP26	Provincial Road	D	35	158	53	81	11	7	7	350	512	656	348	99	198	96	405	87	
WP27	Provincial Road	F	72	210	90	180	36	6	6	600	747	938	700	99					
WP28	Provincial Road	F	30	88	38	75	15	3	3	250	370	507	50	99	507	87			
WP29	Provincial Road	F	24	70	30	60	12	2	2	200	278	363	200	99					
WP30	Provincial Road	F	12	35	15	30	6	1	1	100	146	185	[112]	Carts					
WP31	Provincial Road	D	50	225	75	115	15	10	10	500	724	917	275	87	[493]	Carts			
WP32	Provincial Road	C	450	525	270	150	45	30	30	1500	2034	2869	1447	96					
WP33	Provincial Road	F	12	35	15	30	6	1	1	100	131	168	180	99					
WP34	Provincial Road	F	24	70	30	60	12	2	2	200	272	362	182	99					

ROAD CHARACTERISTICS AND TRAFFIC GROWTH

Road Number	Section Number	Road Characteristics						CARTS Model Growth Estimates		Adopted Traffic Growth			
		Road Name	Location	Pavement Type	Section Length Km	Road Total Length Km	Road Functional Category	% Growth from 1999	% Growth from 2010	% Growth from 1999	% Growth from 2010	Adopted 1999 AADT	Road Section Number
SOUTHERN HIGHLANDS PROVINCE (Sheet 1 of 2)													
NR07	SN01	Highlands Highway	WHP Bdr - Kisenepoi	Sealed	20.5	83.5	A	3.51	3.57	3.5%	3.6%	650	SN01
NR07	SN02	Highlands Highway	Kisenepoi - Kumbame	Gravel	23 8		A	3.93	3.26	3 9%	3.3%	300	SN02
NR07	SN03	Highlands Highway	Kumbame - Ankura Bridge	Gravel	10.1		A	4.05	3 43	***5.0%***	3.4%	250	SN03
NR07	SN04	Highlands Highway	Ankura Bridge - Mendi	Gravel/Seale	29.1		A	4 09	3.33	***5.0%***	3.3%	300	SN04
NM3701	SN05	Koroba Road	Mendi - Kar Mission	Gravel	35.0	194 9	B	4.48	3.23	4.5%	3 2%	150	SN05
NM3701	SN06	Koroba Road	Kar Mission - Fakandah	Gravel	37 0		B	5.81	5.14	***5.0%***	***4.0%***	100	SN06
NM3701	SN07	Koroba Road	Fakandah - Ambua Lodge	Gravel	54.2		B	5.57	4.61	***5.0%***	***4.0%***	100	SN07
NM3701	SN08	Koroba Road	Ambua Lodge - Tari	Gravel	22.4		B	5.57	4.61	***5.0%***	***4.0%***	300	SN08
NM3701	SN09	Koroba Road	Tari - Koroba	Gravel	38.5		C	5.02	4.50	***5.0%***	***4.0%***	200	SN09
NM3701	SN10	Koroba Road	Koroba- Fugwa T/O	Gravel	7 8		C	3 95	3.83	4.0%	3 8%	100	SN10
NM3702	SN11	Kutubu Road	Poroma T/O - Moro	Gravel	112.0	112.0	C	4.95	3.29	***4.0%***	3.3%	100	SN11
NM3703	SN12	Erave Road	Kisenepoi - Ialibu	Gravel	15.6	87.0	B	4.21	3.52	4.2%	3.5%	200	SN12
NM3703	SN13	Erave Road	Ialibu - Kagua	Gravel	31.8		C	4.01	3.81	4 0%	3.8%	150	SN13
NM3703	SN14	Erave Road	Kagua - Erave	Gravel	39 6		D	3.26	3.55	3.3%	3.6%	100	SN14
ND3701	SN15	Oksapmin Road	Fugwa T/O - Tagobi	Gravel	15.0	68.5	D	5 09	5.35	***4.5%***	***4.5%***	50	SN15
ND3701	SN16	Oksapmin Road	Tagobi - Kopiago	Gravel	53 5		D	5.52	5.11	***4.5%***	***4.5%***	50	SN16
NR05	SN17	Wabag - Mendi Road	Soba - Peane	Gravel	5.0	31 0	C (D)	6.53	3.87	***4.5%***	3 9%	70	SN17
NR05	SN18	Wabag - Mendi Road	Peane - Mendi	Gravel/Seale	26.0		C (D)	4 55	3.38	***4.5%***	3.4%	220	SN18
NM3704	SN19	Sumia - Pinj Road	Peane T/O - Sumia	Gravel	27.0	68.0	Local (D)	4.50	4.50	4.5%	4.5%	40	SN19
NM3705	SN20	Kagua Road	Sumia - Kagua	Gravel	41.0		Local (D)	6.00	4.50	***4.5%***	4.5%	50	SN20
ND3704	SN21	Tambul Road	Koine - Tambul	Gravel	46.0	69.0	C	5.06	3.63	***4.5%***	3.6%	200	SN21
ND3705	SN22	Pangia Road	Ialibu - Pangia	Gravel	23.0		C	4.46	4 62	4.5%	4.6%	200	SN22
	SP23	Provincial Road	Ialibu - Kumbene	Gravel	12.7	64.0	C (D)	4.23	4.09	4 2%	4.1%	150	SP23
	SP24	Provincial Road	Nipa - Munihu	Gravel	20.0		D	6.11	5.30	***4.5%***	***4.5%***	100	SP24
	SP25	Provincial Road	Hiwanda - Nogoli	Gravel	23.0		D	6.00	4 50	***4.5%***	4 5%	100	SP25
	SP26	Provincial Road	Soba - Winza	Gravel	8 3		C (D)	8.21	4.04	***4.5%***	4.0%	40	SP26
			Total Length		777.9	777 9							

Bold, italicised growth rates are set from information outside the C

HDM TRAFFIC DATA AND TRAFFIC SOURCE DATA

Section Number	Road Name	Vehicle Category by Road Group	HDM TRAFFIC DATA - 1999 Vehicle Numbers (vehs per day)							Present Traffic	Forecast Traffic w/o gen'd traffic		Traffic Count Source Data - Various sources, Year of coun						MARESMAN DATA
			Car	Pick-Up	Bus	Light Truck	Med. Truck	Hvy Truck	Artic Truck	Adopted 1999 AADT	Estimated 2010 AADT	Estimated 2020 AADT	ADT	Year of Count	ADT	Year of Count	ADT	Year of Count	Traffic Category one way vpd
SOUTHERN HIGHLANDS PROVINCE (Sheet 2 of 2)																			
SN01	Highlands Highway	B	228	156	98	65	26	26	52	650	949	1352	750	98	615	96	630	93	190-250
SN02	Highlands Highway	B	105	72	45	30	12	12	24	300	457	632	189	99	330	69			190-250
SN03	Highlands Highway	B	88	60	38	25	10	10	20	250	428	597	227	99					190-250
SN04	Highlands Highway	B	105	72	45	30	12	12	24	300	513	710	1142	98	240	90	463	90	190-250
SN05	Koroba Road	E	27	41	23	45	5	5	6	150	243	334	171	99	115	99	131	99	
SN06	Koroba Road	E	18	27	15	30	3	3	4	100	171	253	84	99	80	99			
SN07	Koroba Road	E	18	27	15	30	3	3	4	100	171	253	72	99					
SN08	Koroba Road	E	54	81	45	90	9	9	12	300	513	760	354	98	357	96			
SN09	Koroba Road	E	36	54	30	60	6	6	8	200	342	506	156	96					
SN10	Koroba Road	F	12	35	15	30	6	1	1	100	154	224	[179]	Carts					
SN11	Kutubu Road	F	12	35	15	30	6	1	1	100	154	213	54	99	120	96			
SN12	Erave Road	E	36	54	30	60	6	6	8	200	314	444	417	96	144	96	173	90	
SN13	Erave Road	F	18	53	23	45	9	2	2	150	231	335	74	99	132	98	120	98	
SN14	Erave Road	F	12	35	15	30	6	1	1	100	143	204	115	99			159	90	
																^Section 13	255	90	
SN15	Oksapmin Road	F	6	18	8	15	3	1	1	50	81	126	[33]	Carts					<20
SN16	Oksapmin Road	F	6	18	8	15	3	1	1	50	81	126	[36]	Carts					45-90
SN17	Wabag - Mendi Road	F	8	25	11	21	4	1	1	70	114	167	14	99					<20
SN18	Wabag - Mendi Road	E	40	59	33	66	7	7	9	220	357	499	225	99	34	99	142	96	45-90
																Section 18	166	90	
SN19	Sumia - Pinj Road	F	5	14	6	12	2	0	0	40	65	101	32	99					<20
SN20	Kagua Road	F	6	18	8	15	3	1	1	50	81	126	31	99	40	99	167	90	<20
SN21	Tambul Road	E	36	54	30	60	6	6	8	200	325	462	284	99	258	90			20-45
SN22	Pangia Road	F	24	70	30	60	12	2	2	200	325	509	234	98	158	96	272	90	45-90
SP23	Provincial Road	E	27	41	23	45	5	5	6	150	236	352	36	99					
SP24	Provincial Road	F	12	35	15	30	6	1	1	100	162	252	55	99					
SP25	Provincial Road	F	12	35	15	30	6	1	1	100	162	252	Est'd						
SP26	Provincial Road	F	5	14	6	12	2	0	0	40	65	96	[94]	Carts					
										0									
										0									

ARTS model

Appendix F

Results of HDM Analysis

SUMMARY OF COSTS AND COMPARISONS BY DISCOUNT RATE : BASE

IN MILLION PNG Kina

DISCOUNT RATE = 12.00 %

LINK	ORIG LENGTH (KM)	ALT	GEN TRAF	ECO/ FIN CSTS	CONST RECON UPGRD COSTS	PERIODIC MAINT COSTS	ROUTINE MAINT COSTS	TOTAL CONST & MAINT COSTS	VEHICLE OPERATING COSTS	NET EXOGENOUS COSTS	TOTAL COSTS	COMPARISON	NET PRES VALUE	INTRNAL RATE OF RETURN (%)
MN01	20.9	NULL	NO	ECO	.00	.00	1.09	1.09	206.4	.0	207.5			
				FIN	.00	.00	1.36	1.36	.0	.0	1.4			
		ALT0	NO	ECO	.00	.00	1.09	1.09	206.4	.0	207.5			
				FIN	.00	.00	1.36	1.36	.0	.0	1.4			
		ALT1	NO	ECO	.00	1.79	.42	2.21	197.3	.0	199.6	ALT1 VS ALT0	7.9	MANY
				FIN	.00	1.95	.54	2.49	.0	.0	2.5			
		ALT2	NO	ECO	.00	1.88	.39	2.27	195.1	.0	197.3	ALT2 VS ALT0	10.1	MANY
				FIN	.00	2.05	.50	2.55	.0	.0	2.5			
		ALT3	NO	ECO	.00	1.88	.39	2.27	195.1	.0	197.3	ALT3 VS ALT0	10.1	MANY
				FIN	.00	2.05	.50	2.55	.0	.0	2.5			
MN02	24.6	NULL	NO	ECO	.00	.00	.61	.61	135.0	.0	135.6			
				FIN	.00	.00	.77	.77	.0	.0	.8			
		ALT0	NO	ECO	.00	.00	.61	.61	135.0	.0	135.6			
				FIN	.00	.00	.77	.77	.0	.0	.8			
		ALT1	NO	ECO	.00	1.87	.44	2.31	125.7	.0	128.0	ALT1 VS ALT0	7.6	37.4
				FIN	.00	2.03	.57	2.60	.0	.0	2.6			
		ALT2	NO	ECO	.00	2.22	.38	2.60	124.3	.0	126.8	ALT2 VS ALT0	8.7	38.3
				FIN	.00	2.41	.50	2.91	.0	.0	2.9			
		ALT3	NO	ECO	.00	2.22	.38	2.60	124.3	.0	126.8	ALT3 VS ALT0	8.7	38.3
				FIN	.00	2.41	.50	2.91	.0	.0	2.9			
MN03	38.8	NULL	NO	ECO	.00	.00	.53	.53	100.6	.0	101.1			
				FIN	.00	.00	.69	.69	.0	.0	.7			
		ALT0	NO	ECO	.00	.00	.53	.53	100.6	.0	101.1			
				FIN	.00	.00	.69	.69	.0	.0	.7			
		ALT1	NO	ECO	.00	2.34	.49	2.83	96.5	.0	99.4	ALT1 VS ALT0	1.7	20.0
				FIN	.00	2.54	.64	3.19	.0	.0	3.2			
		ALT2	NO	ECO	.00	2.78	.43	3.20	95.8	.0	99.0	ALT2 VS ALT0	2.1	20.9
				FIN	.00	3.02	.56	3.58	.0	.0	3.6			
		ALT3	NO	ECO	2.29	1.77	.43	4.49	94.0	.0	98.5	ALT3 VS ALT0	2.6	20.7
				FIN	2.79	1.92	.56	5.28	.0	.0	5.3			
MN04	44.3	NULL	NO	ECO	.00	.00	.73	.73	133.0	.0	133.7			
				FIN	.00	.00	.95	.95	.0	.0	1.0			
		ALT0	NO	ECO	.00	.00	.73	.73	133.0	.0	133.7			
				FIN	.00	.00	.95	.95	.0	.0	1.0			
		ALT1	NO	ECO	.00	3.37	.71	4.07	128.2	.0	132.3	ALT1 VS ALT0	1.5	17.3
				FIN	.00	3.66	.93	4.59	.0	.0	4.6			

SUMMARY OF COSTS AND COMPARISONS BY DISCOUNT RATE : BASE

IN MILLION PNG Kina

DISCOUNT RATE = 12.00 %

LINK	ORIG LENGTH (KM)	ALT	GEN TRAF	ECO/ FIN	CONST RECON UPGRD COSTS	PERIODIC MAINT COSTS	ROUTINE MAINT COSTS	TOTAL CONST & MAINT COSTS	VEHICLE OPERATING COSTS	NET EXOGENOUS COSTS	TOTAL COSTS	COMPARISON	NET PRES VALUE	INTRNAL RATE OF RETURN (%)
		ALT2	NO	ECO	.00	3.99	.61	4.60	126.9	.0	131.5	ALT2 VS ALT0	2.3	19.1
				FIN	.00	4.34	.81	5.15	.0	.0	5.2			
		ALT3	NO	ECO	.00	3.99	.61	4.60	126.9	.0	131.5	ALT3 VS ALT0	2.3	19.1
				FIN	.00	4.34	.81	5.15	.0	.0	5.2			
MN05	36.1	NULL	NO	ECO	.00	.00	.60	.60	106.3	.0	106.9			
				FIN	.00	.00	.78	.78	.0	.0	.8			
		ALT0	NO	ECO	.00	.00	.60	.60	106.3	.0	106.9			
				FIN	.00	.00	.78	.78	.0	.0	.8			
		ALT1	NO	ECO	.00	2.74	.61	3.36	102.8	.0	106.2	ALT1 VS ALT0	.7	15.6
				FIN	.00	2.98	.80	3.79	.0	.0	3.8			
		ALT2	NO	ECO	.00	3.25	.54	3.79	101.7	.0	105.5	ALT2 VS ALT0	1.5	17.9
				FIN	.00	3.54	.71	4.24	.0	.0	4.2			
		ALT3	NO	ECO	.00	3.25	.54	3.79	101.7	.0	105.5	ALT3 VS ALT0	1.5	17.9
				FIN	.00	3.54	.71	4.24	.0	.0	4.2			
MN06	7.7	NULL	NO	ECO	.00	.00	.16	.16	28.2	.0	28.4			
				FIN	.00	.00	.21	.21	.0	.0	.2			
		ALT0	NO	ECO	.00	.00	.16	.16	28.2	.0	28.4			
				FIN	.00	.00	.21	.21	.0	.0	.2			
		ALT1	NO	ECO	.00	.59	.16	.75	27.1	.0	27.9	ALT1 VS ALT0	.5	MANY
				FIN	.00	.64	.21	.85	.0	.0	.8			
		ALT2	NO	ECO	.00	.69	.15	.84	26.6	.0	27.5	ALT2 VS ALT0	.9	26.4
				FIN	.00	.75	.19	.94	.0	.0	.9			
		ALT3	NO	ECO	.00	.69	.15	.84	26.6	.0	27.5	ALT3 VS ALT0	.9	26.4
				FIN	.00	.75	.19	.94	.0	.0	.9			
MN07	32.0	NULL	NO	ECO	.00	.00	.43	.43	50.7	.0	51.1			
				FIN	.00	.00	.57	.57	.0	.0	.6			
		ALT0	NO	ECO	.00	.00	.43	.43	50.7	.0	51.1			
				FIN	.00	.00	.57	.57	.0	.0	.6			
		ALT1	NO	ECO	.00	.66	.42	1.08	50.1	.0	51.2	ALT1 VS ALT0	-.1	9.5
				FIN	.00	.72	.56	1.28	.0	.0	1.3			
		ALT2	NO	ECO	.00	.83	.42	1.25	50.1	.0	51.4	ALT2 VS ALT0	-.2	7.1
				FIN	.00	.90	.56	1.46	.0	.0	1.5			
		ALT3	NO	ECO	.00	.66	.42	1.08	50.1	.0	51.2	ALT3 VS ALT0	-.1	9.5
				FIN	.00	.72	.56	1.28	.0	.0	1.3			
MN08	20.0	NULL	NO	ECO	.00	.00	.30	.30	46.8	.0	47.1			
				FIN	.00	.00	.40	.40	.0	.0	.4			

SUMMARY OF COSTS AND COMPARISONS BY DISCOUNT RATE : BASE

IN MILLION PNG Kina

DISCOUNT RATE = 12.00 %

LINK	ORIG LENGTH (KM)	ALT	GEN TRAF	ECO/ FIN CSTS	CONST RECON UPGRD COSTS	PERIODIC MAINT COSTS	ROUTINE MAINT COSTS	TOTAL CONST & MAINT COSTS	VEHICLE OPERATING COSTS	NET EXOGENOUS COSTS	TOTAL COSTS	COMPARISON	NET PRES VALUE	INTRNAL RATE OF RETURN (%)
		ALT0	NO	ECO	.00	.00	.30	.30	46.8	.0	47.1			
				FIN	.00	.00	.40	.40	.0	.0	.4			
		ALT1	NO	ECO	.00	.76	.28	1.05	44.1	.0	45.1	ALT1 VS ALT0	2.0	41.9
				FIN	.00	.83	.37	1.21	.0	.0	1.2			
		ALT2	NO	ECO	.00	.87	.26	1.13	43.7	.0	44.8	ALT2 VS ALT0	2.3	36.6
				FIN	.00	.95	.35	1.30	.0	.0	1.3			
		ALT3	NO	ECO	1.93	.37	.26	2.57	41.5	.0	44.1	ALT3 VS ALT0	3.0	27.5
				FIN	2.35	.41	.35	3.11	.0	.0	3.1			
MN09	56.9	NULL	NO	ECO	.00	.00	.79	.79	97.4	.0	98.1			
				FIN	.00	.00	1.05	1.05	.0	.0	1.1			
		ALT0	NO	ECO	.00	.00	.79	.79	97.4	.0	98.1			
				FIN	.00	.00	1.05	1.05	.0	.0	1.1			
		ALT1	NO	ECO	.00	2.19	.75	2.94	94.6	.0	97.5	ALT1 VS ALT0	.6	16.7
				FIN	.00	2.38	1.00	3.38	.0	.0	3.4			
		ALT2	NO	ECO	.00	2.51	.75	3.26	94.4	.0	97.6	ALT2 VS ALT0	.5	15.0
				FIN	.00	2.73	1.00	3.72	.0	.0	3.7			
		ALT3	NO	ECO	2.89	1.78	.75	5.42	92.8	.0	98.2	ALT3 VS ALT0	.0	11.8
				FIN	3.52	1.94	1.00	6.45	.0	.0	6.5			
MN10	20.0	NULL	NO	ECO	.00	.00	.27	.27	28.2	.0	28.5			
				FIN	.00	.00	.36	.36	.0	.0	.4			
		ALT0	NO	ECO	.00	.00	.27	.27	28.2	.0	28.5			
				FIN	.00	.00	.36	.36	.0	.0	.4			
		ALT1	NO	ECO	.00	.32	.26	.58	28.0	.0	28.6	ALT1 VS ALT0	-.1	6.7
				FIN	.00	.34	.35	.69	.0	.0	.7			
		ALT2	NO	ECO	.00	.36	.26	.62	28.0	.0	28.6	ALT2 VS ALT0	-.1	5.4
				FIN	.00	.39	.35	.74	.0	.0	.7			
		ALT3	NO	ECO	.00	.32	.26	.58	28.0	.0	28.6	ALT3 VS ALT0	-.1	6.7
				FIN	.00	.34	.35	.69	.0	.0	.7			
MN11	38.9	NULL	NO	ECO	.00	.00	.55	.55	46.0	.0	46.5			
				FIN	.00	.00	.67	.67	.0	.0	.7			
		ALT0	NO	ECO	.00	.00	.81	.81	45.9	.0	46.7			
				FIN	.00	.00	1.01	1.01	.0	.0	1.0			
		ALT1	NO	ECO	.00	.27	1.21	1.48	43.3	.0	44.7	ALT1 VS ALT0	2.0	NONE
				FIN	.00	.29	1.48	1.78	.0	.0	1.8			
		ALT2	NO	ECO	.00	1.36	1.12	2.48	38.8	.0	41.3	ALT2 VS ALT0	5.5	115.1
				FIN	.00	1.56	1.37	2.93	.0	.0	2.9			

SUMMARY OF COSTS AND COMPARISONS BY DISCOUNT RATE : BASE

IN MILLION PNG Kina

DISCOUNT RATE = 12.00 %

LINK	ORIG LENGTH (KM)	ALT	GEN TRAF	ECO/ FIN CSTS	CONST RECON UPGRD COSTS	PERIODIC MAINT COSTS	ROUTINE MAINT COSTS	TOTAL CONST & MAINT COSTS	VEHICLE OPERATING COSTS	NET EXOGENOUS COSTS	TOTAL COSTS	COMPARISON	NET PRES VALUE	INTRNAL RATE OF RETURN (%)
		ALT3	YES	ECO	8.21	.53	.51	9.25	38.2	.0	47.4	ALT3 VS ALT0	5.1	20.9
				FIN	9.54	.57	.67	10.79	.0	.0	10.8			
MN12	32.8	NULL	NO	ECO	.00	.00	.76	.76	35.6	.0	36.4			
				FIN	.00	.00	.94	.94	.0	.0	.9			
		ALT0	NO	ECO	.00	.00	.76	.76	35.6	.0	36.4			
				FIN	.00	.00	.94	.94	.0	.0	.9			
		ALT1	NO	ECO	.00	.00	1.30	1.30	32.1	.0	33.5	ALT1 VS ALT0	2.9	NONE
				FIN	.00	.00	1.58	1.58	.0	.0	1.6			
		ALT2	NO	ECO	.00	1.61	1.14	2.75	29.0	.0	31.7	ALT2 VS ALT0	4.7	107.1
				FIN	.00	1.86	1.39	3.25	.0	.0	3.2			
		ALT3	YES	ECO	11.08	.34	.42	11.84	29.6	.0	41.4	ALT3 VS ALT0	4.1	17.8
				FIN	12.88	.37	.55	13.80	.0	.0	13.8			
MN13	51.2	NULL	NO	ECO	.00	.00	1.04	1.04	38.2	.0	39.2			
				FIN	.00	.00	1.31	1.31	.0	.0	1.3			
		ALT0	NO	ECO	.00	.00	1.04	1.04	38.2	.0	39.2			
				FIN	.00	.00	1.31	1.31	.0	.0	1.3			
		ALT1	NO	ECO	.00	.00	1.80	1.80	34.3	.0	36.1	ALT1 VS ALT0	3.1	NONE
				FIN	.00	.00	2.21	2.21	.0	.0	2.2			
		ALT2	NO	ECO	.00	2.26	1.52	3.79	31.5	.0	35.3	ALT2 VS ALT0	3.9	65.3
				FIN	.00	2.62	1.87	4.49	.0	.0	4.5			
		ALT3	YES	ECO	14.84	.47	.68	15.99	33.1	.0	49.1	ALT3 VS ALT0	-1.2	10.8
				FIN	17.26	.51	.89	18.66	.0	.0	18.7			
MN14	8.0	NULL	NO	ECO	.00	.00	.15	.15	8.2	.0	8.3			
				FIN	.00	.00	.19	.19	.0	.0	.2			
		ALT0	NO	ECO	.00	.00	.15	.15	8.2	.0	8.3			
				FIN	.00	.00	.19	.19	.0	.0	.2			
		ALT1	NO	ECO	.00	.10	.22	.32	7.7	.0	8.0	ALT1 VS ALT0	.3	NONE
				FIN	.00	.11	.27	.38	.0	.0	.4			
		ALT2	NO	ECO	.00	.30	.19	.49	7.3	.0	7.8	ALT2 VS ALT0	.5	40.9
				FIN	.00	.34	.24	.58	.0	.0	.6			
		ALT3	YES	ECO	1.02	.14	.11	1.26	7.6	.0	8.9	ALT3 VS ALT0	.6	19.3
				FIN	1.18	.15	.14	1.47	.0	.0	1.5			
MN15	28.7	NULL	NO	ECO	.00	.00	.63	.63	23.7	.0	24.3			
				FIN	.00	.00	.78	.78	.0	.0	.8			
		ALT0	NO	ECO	.00	.00	.63	.63	23.7	.0	24.3			
				FIN	.00	.00	.78	.78	.0	.0	.8			
		ALT1	NO	ECO	.00	.00	1.05	1.05	21.3	.0	22.4	ALT1 VS ALT0	1.9	NONE
				FIN	.00	.00	1.28	1.28	.0	.0	1.3			

SUMMARY OF COSTS AND COMPARISONS BY DISCOUNT RATE : BASE

IN MILLION PNG Kina

DISCOUNT RATE = 12.00 %

LINK	ORIG LENGTH (KM)	ALT	GEN TRAF	ECO/ FIN CSTS	CONST RECON UPGRD COSTS	PERIODIC MAINT COSTS	ROUTINE MAINT COSTS	TOTAL CONST & MAINT COSTS	VEHICLE OPERATING COSTS	NET EXOGENOUS COSTS	TOTAL COSTS	COMPARISON	NET PRES VALUE	INTRNAL RATE OF RETURN (%)
		ALT2	NO	ECO	.00	1.33	.90	2.23	18.6	.0	20.9	ALT2 VS ALT0	3.4	51.1
				FIN	.00	1.54	1.10	2.64	.0	.0	2.6			
		ALT3	YES	ECO	7.94	.30	.36	8.59	16.8	.0	25.4	ALT3 VS ALT0	1.9	15.6
				FIN	9.22	.32	.47	10.02	.0	.0	10.0			
MP16	32.5	NULL	NO	ECO	.00	.00	.55	.55	9.2	.0	9.7			
				FIN	.00	.00	.71	.71	.0	.0	.7			
		ALT0	NO	ECO	.00	.00	.55	.55	9.2	.0	9.7			
				FIN	.00	.00	.71	.71	.0	.0	.7			
		ALT1	NO	ECO	.00	.00	.95	.95	8.2	.0	9.2	ALT1 VS ALT0	.5	NONE
				FIN	.00	.00	1.19	1.19	.0	.0	1.2			
		ALT2	NO	ECO	.00	1.44	.77	2.20	7.5	.0	9.7	ALT2 VS ALT0	.0	12.5
				FIN	.00	1.66	.96	2.62	.0	.0	2.6			
		ALT3	YES	ECO	7.24	.34	.38	7.96	7.7	.0	15.7	ALT3 VS ALT0	-3.6	2.3
				FIN	8.42	.37	.51	9.29	.0	.0	9.3			
MP17	21.0	NULL	NO	ECO	.00	.00	.43	.43	10.8	.0	11.2			
				FIN	.00	.00	.54	.54	.0	.0	.5			
		ALT0	NO	ECO	.00	.00	.43	.43	10.8	.0	11.2			
				FIN	.00	.00	.54	.54	.0	.0	.5			
		ALT1	NO	ECO	.00	.00	.67	.67	9.9	.0	10.6	ALT1 VS ALT0	.6	228.2
				FIN	.00	.00	.82	.82	.0	.0	.8			
		ALT2	NO	ECO	.00	.67	.58	1.25	9.8	.0	11.0	ALT2 VS ALT0	.2	MANY
				FIN	.00	.78	.71	1.49	.0	.0	1.5			
		ALT3	YES	ECO	4.68	.22	.26	5.15	8.5	.0	13.7	ALT3 VS ALT0	-1.1	8.4
				FIN	5.44	.24	.34	6.01	.0	.0	6.0			
MP18	58.6	NULL	NO	ECO	.00	.00	1.17	1.17	35.2	.0	36.4			
				FIN	.00	.00	1.48	1.48	.0	.0	1.5			
		ALT0	NO	ECO	.00	.00	1.17	1.17	35.2	.0	36.4			
				FIN	.00	.00	1.48	1.48	.0	.0	1.5			
		ALT1	NO	ECO	.00	.00	1.95	1.95	32.7	.0	34.6	ALT1 VS ALT0	1.8	NONE
				FIN	.00	.00	2.40	2.40	.0	.0	2.4			
		ALT2	NO	ECO	.00	2.63	1.67	4.30	31.2	.0	35.5	ALT2 VS ALT0	.9	20.9
				FIN	.00	3.04	2.06	5.10	.0	.0	5.1			
		ALT3	YES	ECO	12.63	.54	.77	13.94	28.0	.0	41.9	ALT3 VS ALT0	-1.3	10.3
				FIN	14.68	.59	1.01	16.28	.0	.0	16.3			
MP19	28.5	NULL	NO	ECO	.00	.00	.48	.48	5.3	.0	5.8			
				FIN	.00	.00	.62	.62	.0	.0	.6			

SUMMARY OF COSTS AND COMPARISONS BY DISCOUNT RATE : BASE

IN MILLION PNG Kina

DISCOUNT RATE = 12.00 %

LINK	ORIG LENGTH (KM)	ALT	GEN TRAF	ECO/ FIN CSTS	CONST RECON UPGRD COSTS	PERIODIC MAINT COSTS	ROUTINE MAINT COSTS	TOTAL CONST & MAINT COSTS	VEHICLE OPERATING COSTS	NET EXOGENOUS COSTS	TOTAL COSTS	COMPARISON	NET PRES VALUE	INTRNAL RATE OF RETURN (%)
		ALT0	NO	ECO	.00	.00	.48	.48	5.3	.0	5.8			
				FIN	.00	.00	.62	.62	.0	.0	.6			
		ALT1	NO	ECO	.00	.00	.65	.65	5.0	.0	5.6	ALT1 VS ALT0	.2	53.2
				FIN	.00	.00	.82	.82	.0	.0	.8			
		ALT2	NO	ECO	.00	.63	.56	1.19	4.9	.0	6.0	ALT2 VS ALT0	-.3	-3.6
				FIN	.00	.73	.71	1.44	.0	.0	1.4			
		ALT3	YES	ECO	6.35	.30	.34	6.98	4.1	.0	11.1	ALT3 VS ALT0	-4.6	-3.9
				FIN	7.38	.32	.44	8.15	.0	.0	8.1			
MP20	31.0	NULL	NO	ECO	.00	.00	.58	.58	15.1	.0	15.7			
				FIN	.00	.00	.73	.73	.0	.0	.7			
		ALT0	NO	ECO	.00	.00	.58	.58	15.1	.0	15.7			
				FIN	.00	.00	.73	.73	.0	.0	.7			
		ALT1	NO	ECO	.00	.00	.95	.95	13.6	.0	14.6	ALT1 VS ALT0	1.1	NONE
				FIN	.00	.00	1.18	1.18	.0	.0	1.2			
		ALT2	NO	ECO	.00	1.35	.80	2.15	12.2	.0	14.4	ALT2 VS ALT0	1.3	41.7
				FIN	.00	1.56	.99	2.55	.0	.0	2.6			
		ALT3	YES	ECO	6.90	.32	.37	7.60	10.9	.0	18.5	ALT3 VS ALT0	-.9	9.7
				FIN	8.03	.35	.49	8.87	.0	.0	8.9			
MP21	34.6	NULL	NO	ECO	.00	.00	.71	.71	22.8	.0	23.5			
				FIN	.00	.00	.90	.90	.0	.0	.9			
		ALT0	NO	ECO	.00	.00	.71	.71	22.8	.0	23.5			
				FIN	.00	.00	.90	.90	.0	.0	.9			
		ALT1	NO	ECO	.00	.00	1.06	1.06	20.8	.0	21.8	ALT1 VS ALT0	1.6	NONE
				FIN	.00	.00	1.30	1.30	.0	.0	1.3			
		ALT2	NO	ECO	.00	.79	.93	1.72	19.0	.0	20.8	ALT2 VS ALT0	2.7	MANY
				FIN	.00	.92	1.14	2.06	.0	.0	2.1			
		ALT3	YES	ECO	7.71	.36	.42	8.49	15.9	.0	24.4	ALT3 VS ALT0	1.7	15.1
				FIN	8.96	.39	.56	9.90	.0	.0	9.9			
MP22	62.0	NULL	NO	ECO	.00	.00	1.06	1.06	16.0	.0	17.1			
				FIN	.00	.00	1.35	1.35	.0	.0	1.4			
		ALT0	NO	ECO	.00	.00	1.06	1.06	16.0	.0	17.1			
				FIN	.00	.00	1.35	1.35	.0	.0	1.4			
		ALT1	NO	ECO	.00	.00	1.68	1.68	14.5	.0	16.2	ALT1 VS ALT0	.9	NONE
				FIN	.00	.00	2.09	2.09	.0	.0	2.1			
		ALT2	NO	ECO	.00	2.67	1.38	4.04	12.7	.0	16.8	ALT2 VS ALT0	.3	15.3
				FIN	.00	3.09	1.73	4.82	.0	.0	4.8			
		ALT3	YES	ECO	13.21	.57	.78	14.57	11.9	.0	26.5	ALT3 VS ALT0	-7.6	.3
				FIN	15.37	.62	1.03	17.02	.0	.0	17.0			

SUMMARY OF COSTS AND COMPARISONS BY DISCOUNT RATE : BASE

IN MILLION PNG Kina

DISCOUNT RATE = 12.00 %

LINK	ORIG LENGTH (KM)	ALT	GEN TRAF	ECO/ FIN CSTS	CONST RECON UPGRD COSTS	PERIODIC MAINT COSTS	ROUTINE MAINT COSTS	TOTAL CONST & MAINT COSTS	VEHICLE OPERATING COSTS	NET EXOGENOUS COSTS	TOTAL COSTS	COMPARISON	NET PRES VALUE	INTRNAL RATE OF RETURN (%)
EN01	4.0	NULL	NO	ECO	.00	.00	.06	.06	16.5	.0	16.5			
				FIN	.00	.00	.08	.08	.0	.0	.1			
		ALT0	NO	ECO	.00	.00	.06	.06	16.5	.0	16.5			
				FIN	.00	.00	.08	.08	.0	.0	.1			
		ALT1	NO	ECO	.00	.28	.05	.34	16.3	.0	16.6	ALT1 VS ALT0	-.1	9.1
				FIN	.00	.31	.07	.38	.0	.0	.4			
		ALT2	NO	ECO	.00	.29	.05	.34	16.3	.0	16.6	ALT2 VS ALT0	-.1	9.1
				FIN	.00	.31	.07	.38	.0	.0	.4			
		ALT3	NO	ECO	.00	.28	.05	.34	16.3	.0	16.6	ALT3 VS ALT0	-.1	9.1
				FIN	.00	.31	.07	.38	.0	.0	.4			
EN02	5.7	NULL	NO	ECO	.00	.00	.08	.08	23.0	.0	23.1			
				FIN	.00	.00	.10	.10	.0	.0	.1			
		ALT0	NO	ECO	.00	.00	.08	.08	23.0	.0	23.1			
				FIN	.00	.00	.10	.10	.0	.0	.1			
		ALT1	NO	ECO	.00	.11	.07	.18	22.9	.0	23.1	ALT1 VS ALT0	.0	12.0
				FIN	.00	.11	.10	.21	.0	.0	.2			
		ALT2	NO	ECO	.00	.12	.07	.19	22.9	.0	23.1	ALT2 VS ALT0	.0	11.0
				FIN	.00	.13	.10	.23	.0	.0	.2			
		ALT3	NO	ECO	.00	.11	.07	.18	22.9	.0	23.1	ALT3 VS ALT0	.0	12.0
				FIN	.00	.11	.10	.21	.0	.0	.2			
EN03	33.6	NULL	NO	ECO	.00	.00	.52	.52	95.7	.0	96.3			
				FIN	.00	.00	.69	.69	.0	.0	.7			
		ALT0	NO	ECO	.00	.00	.52	.52	95.7	.0	96.3			
				FIN	.00	.00	.69	.69	.0	.0	.7			
		ALT1	NO	ECO	.00	2.55	.56	3.11	93.5	.0	96.6	ALT1 VS ALT0	-.3	10.0
				FIN	.00	2.78	.73	3.51	.0	.0	3.5			
		ALT2	NO	ECO	.00	3.03	.49	3.52	93.1	.0	96.6	ALT2 VS ALT0	-.3	10.2
				FIN	.00	3.29	.65	3.94	.0	.0	3.9			
		ALT3	NO	ECO	2.80	1.93	.49	5.22	91.7	.0	96.9	ALT3 VS ALT0	-.6	9.6
				FIN	3.41	2.10	.65	6.15	.0	.0	6.2			
EN04	38.5	NULL	NO	ECO	.00	.00	.54	.54	107.8	.0	108.3			
				FIN	.00	.00	.72	.72	.0	.0	.7			
		ALT0	NO	ECO	.00	.00	.54	.54	107.8	.0	108.3			
				FIN	.00	.00	.72	.72	.0	.0	.7			
		ALT1	NO	ECO	.00	2.72	.51	3.23	106.0	.0	109.2	ALT1 VS ALT0	-.9	7.4
				FIN	.00	2.96	.68	3.63	.0	.0	3.6			

SUMMARY OF COSTS AND COMPARISONS BY DISCOUNT RATE : BASE

IN MILLION PNG Kina

DISCOUNT RATE = 12.00 %

LINE	ORIG LENGTH (KM)	ALT	GEN TRAF	ECO/ FIN CSTS	CONST RECON UPGRD COSTS	PERIODIC MAINT COSTS	ROUTINE MAINT COSTS	TOTAL CONST & MAINT COSTS	VEHICLE OPERATING COSTS	NET EXOGENOUS COSTS	TOTAL COSTS	COMPARISON	NET PRES VALUE	INTRNAL RATE OF RETURN (%)
		ALT2	NO	ECO	.00	2.78	.51	3.29	105.9	.0	109.2	ALT2 VS ALT0	-.9	7.5
				FIN	.00	3.02	.68	3.70	.0	.0	3.7			
		ALT3	NO	ECO	2.04	2.21	.51	4.76	105.2	.0	110.0	ALT3 VS ALT0	-1.7	2.8
				FIN	2.48	2.41	.68	5.56	.0	.0	5.6			
EN05	44.2	NULL	NO	ECO	.00	.00	.76	.76	199.1	.0	199.9			
				FIN	.00	.00	.99	.99	.0	.0	1.0			
		ALT0	NO	ECO	.00	.00	.76	.76	199.1	.0	199.9			
				FIN	.00	.00	.99	.99	.0	.0	1.0			
		ALT1	NO	ECO	.00	3.36	.70	4.06	193.2	.0	197.2	ALT1 VS ALT0	2.7	21.1
				FIN	.00	3.65	.92	4.57	.0	.0	4.6			
		ALT2	NO	ECO	.00	3.98	.61	4.59	192.1	.0	196.7	ALT2 VS ALT0	3.2	21.9
				FIN	.00	4.33	.80	5.13	.0	.0	5.1			
		ALT3	NO	ECO	4.13	2.54	.61	7.28	188.8	.0	196.1	ALT3 VS ALT0	3.8	20.4
				FIN	5.02	2.76	.80	8.59	.0	.0	8.6			
EN06	26.7	NULL	NO	ECO	.00	.00	.72	.72	164.0	.0	164.8			
				FIN	.00	.00	.92	.92	.0	.0	.9			
		ALT0	NO	ECO	.00	.00	.72	.72	164.0	.0	164.8			
				FIN	.00	.00	.92	.92	.0	.0	.9			
		ALT1	NO	ECO	.00	2.03	.42	2.45	151.3	.0	153.8	ALT1 VS ALT0	11.0	46.8
				FIN	.00	2.21	.56	2.76	.0	.0	2.8			
		ALT2	NO	ECO	.00	2.41	.36	2.77	149.2	.0	152.0	ALT2 VS ALT0	12.8	47.4
				FIN	.00	2.61	.48	3.10	.0	.0	3.1			
		ALT3	NO	ECO	2.49	1.54	.36	4.39	145.2	.0	149.6	ALT3 VS ALT0	15.2	46.5
				FIN	3.03	1.67	.48	5.19	.0	.0	5.2			
EN07	26.4	NULL	NO	ECO	.46	.03	.41	.89	76.6	.0	77.5			
				FIN	.56	.03	.53	1.12	.0	.0	1.1			
		ALT0	NO	ECO	.46	.03	.41	.89	76.6	.0	77.5			
				FIN	.56	.03	.53	1.12	.0	.0	1.1			
		ALT1	NO	ECO	.46	1.75	.38	2.59	75.8	.0	78.4	ALT1 VS ALT0	-.9	3.5
				FIN	.56	1.90	.50	2.97	.0	.0	3.0			
		ALT2	NO	ECO	.46	1.79	.38	2.63	75.8	.0	78.4	ALT2 VS ALT0	-.9	3.3
				FIN	.56	1.95	.50	3.01	.0	.0	3.0			
		ALT3	NO	ECO	.46	1.75	.38	2.59	75.8	.0	78.4	ALT3 VS ALT0	-.9	3.5
				FIN	.56	1.90	.50	2.97	.0	.0	3.0			
EN08	6.6	NULL	NO	ECO	.00	.00	.12	.12	13.4	.0	13.5			
				FIN	.00	.00	.16	.16	.0	.0	.2			

SUMMARY OF COSTS AND COMPARISONS BY DISCOUNT RATE : BASE

IN MILLION PNG Kina

DISCOUNT RATE = 12.00 %

LINK	ORIG LENGTH (KM)	ALT	GEN TRAF	ECO/ FIN CSTS	CONST RECON UPGRD COSTS	PERIODIC MAINT COSTS	ROUTINE MAINT COSTS	TOTAL CONST & MAINT COSTS	VEHICLE OPERATING COSTS	NET EXOGENOUS COSTS	TOTAL COSTS	COMPARISON	NET PRES VALUE	INTRNAL RATE OF RETURN (%)
		ALT0	NO	ECO	.00	.00	.12	.12	13.4	.0	13.5			
				FIN	.00	.00	.16	.16	.0	.0	.2			
		ALT1	NO	ECO	.00	.54	.13	.66	12.4	.0	13.1	ALT1 VS ALT0	.4	24.3
				FIN	.00	.58	.16	.75	.0	.0	.7			
		ALT2	NO	ECO	.00	.64	.11	.75	12.3	.0	13.0	ALT2 VS ALT0	.5	25.0
				FIN	.00	.69	.14	.84	.0	.0	.8			
		ALT3	NO	ECO	1.64	.09	.09	1.82	10.6	.0	12.4	ALT3 VS ALT0	1.1	20.5
				FIN	1.99	.10	.12	2.21	.0	.0	2.2			
EN09	47.7	NULL	NO	ECO	.00	.00	1.04	1.04	43.1	.0	44.2			
				FIN	.00	.00	1.29	1.29	.0	.0	1.3			
		ALT0	NO	ECO	.00	.00	1.04	1.04	43.1	.0	44.2			
				FIN	.00	.00	1.29	1.29	.0	.0	1.3			
		ALT1	NO	ECO	.00	.00	2.07	2.07	38.4	.0	40.4	ALT1 VS ALT0	3.7	368.1
				FIN	.00	.00	2.52	2.52	.0	.0	2.5			
		ALT2	NO	ECO	.00	2.37	1.64	4.01	36.6	.0	40.6	ALT2 VS ALT0	3.6	43.5
				FIN	.00	2.74	2.00	4.74	.0	.0	4.7			
		ALT3	YES	ECO	13.83	.44	.64	14.91	33.9	.0	48.8	ALT3 VS ALT0	.4	12.5
				FIN	16.07	.48	.84	17.39	.0	.0	17.4			
EN10	6.7	NULL	NO	ECO	.00	.00	.16	.16	7.9	.0	8.1			
				FIN	.00	.00	.20	.20	.0	.0	.2			
		ALT0	NO	ECO	.00	.00	.16	.16	7.9	.0	8.1			
				FIN	.00	.00	.20	.20	.0	.0	.2			
		ALT1	NO	ECO	.00	.00	.29	.29	7.0	.0	7.3	ALT1 VS ALT0	.8	NONE
				FIN	.00	.00	.36	.36	.0	.0	.4			
		ALT2	NO	ECO	.00	.28	.24	.52	6.3	.0	6.9	ALT2 VS ALT0	1.2	75.9
				FIN	.00	.33	.29	.62	.0	.0	.6			
		ALT3	YES	ECO	2.27	.08	.09	2.43	5.5	.0	8.0	ALT3 VS ALT0	1.1	19.3
				FIN	2.63	.08	.11	2.83	.0	.0	2.8			

SUMMARY OF COSTS AND COMPARISONS BY DISCOUNT RATE : BASE

IN MILLION PNG Kina

DISCOUNT RATE = 12.00 %

LINK	ORIG LENGTH (KM)	ALT	GEN TRAF	ECO/ FIN CSTS	CONST RECON UPGRD COSTS	PERIODIC MAINT COSTS	ROUTINE MAINT COSTS	TOTAL CONST & MAINT COSTS	VEHICLE OPERATING COSTS	NET EXOGENOUS COSTS	TOTAL COSTS	COMPARISON	NET PRES VALUE	INTRNAL RATE OF RETURN (%)
EP11	15.0	NULL	NO	ECO	.00	.00	.24	.24	18.8	.0	19.0			
				FIN	.00	.00	.31	.31	.0	.0	.3			
		ALT0	NO	ECO	.00	.00	.24	.24	18.8	.0	19.0			
				FIN	.00	.00	.31	.31	.0	.0	.3			
		ALT1	NO	ECO	.00	.81	.24	1.06	17.7	.0	18.8	ALT1 VS ALT0	.2	16.2
				FIN	.00	.89	.32	1.20	.0	.0	1.2			
		ALT2	NO	ECO	.00	.97	.22	1.18	17.6	.0	18.7	ALT2 VS ALT0	.2	16.2
				FIN	.00	1.05	.29	1.34	.0	.0	1.3			
		ALT3	NO	ECO	2.48	.13	.20	2.80	16.5	.0	19.3	ALT3 VS ALT0	-.3	10.1
				FIN	3.01	.14	.26	3.41	.0	.0	3.4			
EP12	44.0	NULL	NO	ECO	.00	.00	.84	.84	36.4	.0	37.2			
				FIN	.00	.00	1.07	1.07	.0	.0	1.1			
		ALT0	NO	ECO	.00	.00	.84	.84	36.4	.0	37.2			
				FIN	.00	.00	1.07	1.07	.0	.0	1.1			
		ALT1	NO	ECO	.00	.23	1.47	1.70	33.0	.0	34.7	ALT1 VS ALT0	2.5	NONE
				FIN	.00	.25	1.81	2.06	.0	.0	2.1			
		ALT2	NO	ECO	.00	1.78	1.21	2.99	31.4	.0	34.3	ALT2 VS ALT0	2.9	70.8
				FIN	.00	2.04	1.49	3.54	.0	.0	3.5			
		ALT3	NO	ECO	.00	.23	.56	.79	36.3	.0	37.1	ALT3 VS ALT0	.1	NONE
				FIN	.00	.25	.72	.97	.0	.0	1.0			
EP13	49.0	NULL	NO	ECO	.00	.00	.90	.90	26.1	.0	27.0			
				FIN	.00	.00	1.15	1.15	.0	.0	1.1			
		ALT0	NO	ECO	.00	.00	.90	.90	26.1	.0	27.0			
				FIN	.00	.00	1.15	1.15	.0	.0	1.1			
		ALT1	NO	ECO	.00	.13	1.56	1.69	23.7	.0	25.4	ALT1 VS ALT0	1.6	NONE
				FIN	.00	.14	1.93	2.07	.0	.0	2.1			
		ALT2	NO	ECO	.00	2.17	1.26	3.44	21.7	.0	25.2	ALT2 VS ALT0	1.8	40.1
				FIN	.00	2.51	1.57	4.08	.0	.0	4.1			
		ALT3	NO	ECO	.00	.13	.56	.69	26.1	.0	26.8	ALT3 VS ALT0	.2	NONE
				FIN	.00	.14	.72	.86	.0	.0	.9			
EP14	15.0	NULL	NO	ECO	.00	.00	.29	.29	8.4	.0	8.7			
				FIN	.00	.00	.36	.36	.0	.0	.4			
		ALT0	NO	ECO	.00	.00	.29	.29	8.4	.0	8.7			
				FIN	.00	.00	.36	.36	.0	.0	.4			
		ALT1	NO	ECO	.00	.00	.50	.50	7.6	.0	8.1	ALT1 VS ALT0	.5	242.5
				FIN	.00	.00	.62	.62	.0	.0	.6			

SUMMARY OF COSTS AND COMPARISONS BY DISCOUNT RATE : BASE

IN MILLION PNG Kina

DISCOUNT RATE = 12.00 %

LINK	ORIG LENGTH (KM)	ALT	GEN TRAF	ECO/ FIN	CONST RECON UPGRD COSTS	PERIODIC MAINT COSTS	ROUTINE MAINT COSTS	TOTAL CONST & MAINT COSTS	VEHICLE OPERATING COSTS	NET EXOGENOUS COSTS	TOTAL COSTS	COMPARISON	NET PRES VALUE	INTRNAL RATE OF RETURN (%)
		ALT2	NO	ECO	.00	.65	.41	1.06	7.1	.0	8.1	ALT2 VS ALT0	.5	31.6
				FIN	.00	.76	.50	1.26	.0	.0	1.3			
		ALT3	YES	ECO	3.46	.16	.18	3.79	6.4	.0	10.2	ALT3 VS ALT0	-.4	10.1
				FIN	4.02	.17	.24	4.43	.0	.0	4.4			
EP15	32.0	NULL	NO	ECO	.00	.00	.69	.69	23.2	.0	23.9			
				FIN	.00	.00	.86	.86	.0	.0	.9			
		ALT0	NO	ECO	.00	.00	.69	.69	23.2	.0	23.9			
				FIN	.00	.00	.86	.86	.0	.0	.9			
		ALT1	NO	ECO	.00	.00	1.21	1.21	20.5	.0	21.7	ALT1 VS ALT0	2.2	NONE
				FIN	.00	.00	1.48	1.48	.0	.0	1.5			
		ALT2	NO	ECO	.00	1.48	.98	2.46	18.4	.0	20.9	ALT2 VS ALT0	3.1	46.1
				FIN	.00	1.71	1.20	2.91	.0	.0	2.9			
		ALT3	YES	ECO	9.58	.33	.40	10.31	20.8	.0	31.1	ALT3 VS ALT0	2.3	15.7
				FIN	11.14	.36	.52	12.03	.0	.0	12.0			
EP16	13.0	NULL	NO	ECO	.00	.00	.30	.30	13.5	.0	13.8			
				FIN	.00	.00	.37	.37	.0	.0	.4			
		ALT0	NO	ECO	.00	.00	.30	.30	13.5	.0	13.8			
				FIN	.00	.00	.37	.37	.0	.0	.4			
		ALT1	NO	ECO	.00	.00	.63	.63	11.7	.0	12.3	ALT1 VS ALT0	1.5	NONE
				FIN	.00	.00	.76	.76	.0	.0	.8			
		ALT2	NO	ECO	.00	.84	.49	1.33	10.7	.0	12.1	ALT2 VS ALT0	1.7	68.7
				FIN	.00	.97	.59	1.56	.0	.0	1.6			
		ALT3	YES	ECO	3.59	.13	.17	3.89	10.9	.0	14.8	ALT3 VS ALT0	2.6	22.9
				FIN	4.18	.15	.22	4.54	.0	.0	4.5			
EP17	21.0	NULL	NO	ECO	.00	.00	.38	.38	7.9	.0	8.3			
				FIN	.00	.00	.49	.49	.0	.0	.5			
		ALT0	NO	ECO	.00	.00	.38	.38	7.9	.0	8.3			
				FIN	.00	.00	.49	.49	.0	.0	.5			
		ALT1	NO	ECO	.00	.00	.63	.63	7.2	.0	7.9	ALT1 VS ALT0	.4	61.6
				FIN	.00	.00	.78	.78	.0	.0	.8			
		ALT2	NO	ECO	.00	.46	.51	.98	7.0	.0	7.9	ALT2 VS ALT0	.3	MANY
				FIN	.00	.54	.64	1.18	.0	.0	1.2			
		ALT3	YES	ECO	4.84	.22	.25	5.31	6.0	.0	11.3	ALT3 VS ALT0	-2.0	4.7
				FIN	5.63	.24	.33	6.19	.0	.0	6.2			
EP18	29.0	NULL	NO	ECO	.00	.00	.53	.53	11.4	.0	11.9			
				FIN	.00	.00	.67	.67	.0	.0	.7			

SUMMARY OF COSTS AND COMPARISONS BY DISCOUNT RATE : BASE

IN MILLION PNG Kina

DISCOUNT RATE = 12.00 %

LINK	ORIG LENGTH (KM)	ALT	GEN TRAF	ECO/ FIN CSTS	CONST RECON UPGRD COSTS	PERIODIC MAINT COSTS	ROUTINE MAINT COSTS	TOTAL CONST & MAINT COSTS	VEHICLE OPERATING COSTS	NET EXOGENOUS COSTS	TOTAL COSTS	COMPARISON	NET PRES VALUE	INTRNAL RATE OF RETURN (%)
		ALT0	NO	ECO	.00	.00	.53	.53	11.4	.0	11.9			
				FIN	.00	.00	.67	.67	.0	.0	.7			
		ALT1	NO	ECO	.00	.00	.87	.87	10.4	.0	11.3	ALT1 VS ALT0	.7	136.7
				FIN	.00	.00	1.07	1.07	.0	.0	1.1			
		ALT2	NO	ECO	.00	1.10	.70	1.80	9.5	.0	11.3	ALT2 VS ALT0	.6	MANY
				FIN	.00	1.27	.88	2.15	.0	.0	2.2			
		ALT3	YES	ECO	6.68	.30	.38	7.36	8.4	.0	15.7	ALT3 VS ALT0	-2.3	6.0
				FIN	7.77	.33	.50	8.59	.0	.0	8.6			
EP19	20.0	NULL	NO	ECO	.00	.00	.44	.44	16.1	.0	16.6			
				FIN	.00	.00	.55	.55	.0	.0	.5			
		ALT0	NO	ECO	.00	.00	.44	.44	16.1	.0	16.6			
				FIN	.00	.00	.55	.55	.0	.0	.5			
		ALT1	NO	ECO	.00	.00	.73	.73	14.5	.0	15.2	ALT1 VS ALT0	1.4	NONE
				FIN	.00	.00	.89	.89	.0	.0	.9			
		ALT2	NO	ECO	.00	.70	.60	1.31	13.3	.0	14.6	ALT2 VS ALT0	2.0	42.9
				FIN	.00	.81	.74	1.55	.0	.0	1.6			
		ALT3	YES	ECO	5.53	.21	.25	5.98	11.2	.0	17.1	ALT3 VS ALT0	1.4	15.6
				FIN	6.43	.23	.33	6.98	.0	.0	7.0			

SUMMARY OF COSTS AND COMPARISONS BY DISCOUNT RATE : BASE

IN MILLION PNG Kina

DISCOUNT RATE = 12.00 %

LINK	ORIG LENGTH (KM)	ALT	GEN TRAF	ECO/ FIN CSTS	CONST RECON UPGRD COSTS	PERIODIC MAINT COSTS	ROUTINE MAINT COSTS	TOTAL CONST & MAINT COSTS	VEHICLE OPERATING COSTS	NET EXOGENOUS COSTS	TOTAL COSTS	COMPARISON	NET PRES VALUE	INTRNAL RATE OF RETURN (%)
WN01	17.5	NULL	NO	ECO	.00	.00	.31	.31	56.9	.0	57.2			
				FIN	.00	.00	.40	.40	.0	.0	.4			
		ALT0	NO	ECO	.00	.00	.31	.31	56.9	.0	57.2			
				FIN	.00	.00	.40	.40	.0	.0	.4			
		ALT1	NO	ECO	.00	1.33	.34	1.67	54.6	.0	56.3	ALT1 VS ALT0	.9	19.1
				FIN	.00	1.45	.44	1.89	.0	.0	1.9			
		ALT2	NO	ECO	.00	1.58	.31	1.88	54.1	.0	56.0	ALT2 VS ALT0	1.2	20.6
				FIN	.00	1.71	.40	2.11	.0	.0	2.1			
		ALT3	NO	ECO	1.83	1.01	.31	3.14	52.4	.0	55.6	ALT3 VS ALT0	1.6	19.5
				FIN	2.23	1.09	.40	3.72	.0	.0	3.7			
WN02	12.0	NULL	NO	ECO	.00	.00	.23	.23	50.8	.0	51.0			
				FIN	.00	.00	.30	.30	.0	.0	.3			
		ALT0	NO	ECO	.00	.00	.23	.23	50.8	.0	51.0			
				FIN	.00	.00	.30	.30	.0	.0	.3			
		ALT1	NO	ECO	.00	.91	.19	1.10	48.6	.0	49.7	ALT1 VS ALT0	1.3	25.2
				FIN	.00	.99	.25	1.24	.0	.0	1.2			
		ALT2	NO	ECO	.00	1.08	.16	1.25	48.2	.0	49.5	ALT2 VS ALT0	1.5	26.0
				FIN	.00	1.18	.22	1.39	.0	.0	1.4			
		ALT3	NO	ECO	1.00	.69	.16	1.86	47.3	.0	49.2	ALT3 VS ALT0	1.8	25.2
				FIN	1.22	.75	.22	2.19	.0	.0	2.2			
WN03	16.2	NULL	NO	ECO	.00	.00	.46	.46	127.0	.0	127.5			
				FIN	.00	.00	.59	.59	.0	.0	.6			
		ALT0	NO	ECO	.00	.00	.46	.46	127.0	.0	127.5			
				FIN	.00	.00	.59	.59	.0	.0	.6			
		ALT1	NO	ECO	.00	1.23	.34	1.57	117.4	.0	119.0	ALT1 VS ALT0	8.5	59.8
				FIN	.00	1.34	.43	1.77	.0	.0	1.8			
		ALT2	NO	ECO	.00	1.46	.30	1.76	115.4	.0	117.1	ALT2 VS ALT0	10.3	60.5
				FIN	.00	1.59	.39	1.98	.0	.0	2.0			
		ALT3	NO	ECO	2.13	1.08	.30	3.51	109.8	.0	113.3	ALT3 VS ALT0	14.1	56.5
				FIN	2.59	1.18	.39	4.15	.0	.0	4.2			
WN04	25.5	NULL	NO	ECO	.00	.00	1.09	1.09	275.9	.0	277.0			
				FIN	.00	.00	1.36	1.36	.0	.0	1.4			
		ALT0	NO	ECO	.00	.00	1.09	1.09	275.9	.0	277.0			
				FIN	.00	.00	1.36	1.36	.0	.0	1.4			
		ALT1	NO	ECO	.00	2.19	.49	2.68	251.0	.0	253.7	ALT1 VS ALT0	23.3	MANY
				FIN	.00	2.38	.64	3.02	.0	.0	3.0			

SUMMARY OF COSTS AND COMPARISONS BY DISCOUNT RATE : BASE

IN MILLION PNG Kina

DISCOUNT RATE = 12.00 %

LINK	ORIG LENGTH (KM)	ALT	GEN TRAF	ECO/ FIN CSTS	CONST RECON UPGRD COSTS	PERIODIC MAINT COSTS	ROUTINE MAINT COSTS	TOTAL CONST & MAINT COSTS	VEHICLE OPERATING COSTS	NET EXOGENOUS COSTS	TOTAL COSTS	COMPARISON	NET PRES VALUE	INTRNAL RATE OF RETURN (%)
		ALT2	NO	ECO	.00	2.30	.45	2.75	247.8	.0	250.6	ALT2 VS ALT0	26.4	88.1
				FIN	.00	2.50	.59	3.09	.0	.0	3.1			
		ALT3	NO	ECO	3.35	1.71	.45	5.51	234.6	.0	240.1	ALT3 VS ALT0	36.9	84.7
				FIN	4.07	1.85	.59	6.51	.0	.0	6.5			
WN05	2.5	NULL	NO	ECO	.00	.00	.17	.17	52.8	.0	53.0			
				FIN	.00	.00	.21	.21	.0	.0	.2			
		ALT0	NO	ECO	.00	.00	.17	.17	52.8	.0	53.0			
				FIN	.00	.00	.21	.21	.0	.0	.2			
		ALT1	NO	ECO	.00	.23	.05	.27	48.4	.0	48.7	ALT1 VS ALT0	4.4	MANY
				FIN	.00	.24	.06	.30	.0	.0	.3			
		ALT2	NO	ECO	.00	.24	.05	.28	47.6	.0	47.9	ALT2 VS ALT0	5.1	243.7
				FIN	.00	.26	.06	.32	.0	.0	.3			
		ALT3	NO	ECO	.58	.07	.03	.68	43.2	.0	43.9	ALT3 VS ALT0	9.2	151.4
				FIN	.70	.08	.04	.83	.0	.0	.8			
WN06	10.9	NULL	NO	ECO	.00	.00	.23	.23	69.8	.0	70.0			
				FIN	.00	.00	.30	.30	.0	.0	.3			
		ALT0	NO	ECO	.00	.00	.23	.23	69.8	.0	70.0			
				FIN	.00	.00	.30	.30	.0	.0	.3			
		ALT1	NO	ECO	.00	.83	.20	1.03	66.1	.0	67.2	ALT1 VS ALT0	2.8	40.3
				FIN	.00	.90	.26	1.17	.0	.0	1.2			
		ALT2	NO	ECO	.00	.98	.18	1.16	65.4	.0	66.6	ALT2 VS ALT0	3.4	41.2
				FIN	.00	1.07	.24	1.30	.0	.0	1.3			
		ALT3	NO	ECO	1.28	.71	.18	2.17	63.4	.0	65.6	ALT3 VS ALT0	4.4	38.1
				FIN	1.55	.77	.24	2.56	.0	.0	2.6			
WN07	28.1	NULL	NO	ECO	.00	.00	.39	.39	80.0	.0	80.4			
				FIN	.00	.00	.51	.51	.0	.0	.5			
		ALT0	NO	ECO	.00	.00	.39	.39	80.0	.0	80.4			
				FIN	.00	.00	.51	.51	.0	.0	.5			
		ALT1	NO	ECO	.00	1.77	.37	2.14	79.4	.0	81.6	ALT1 VS ALT0	-1.2	.2
				FIN	.00	1.93	.49	2.42	.0	.0	2.4			
		ALT2	NO	ECO	.00	2.03	.37	2.40	79.4	.0	81.8	ALT2 VS ALT0	-1.4	.2
				FIN	.00	2.21	.49	2.70	.0	.0	2.7			
		ALT3	NO	ECO	.00	1.77	.37	2.14	79.4	.0	81.6	ALT3 VS ALT0	-1.2	.2
				FIN	.00	1.93	.49	2.42	.0	.0	2.4			
WN08	13.0	NULL	NO	ECO	.00	.00	.19	.19	31.9	.0	32.1			
				FIN	.00	.00	.25	.25	.0	.0	.2			

SUMMARY OF COSTS AND COMPARISONS BY DISCOUNT RATE : BASE

IN MILLION PNG Kina

DISCOUNT RATE = 12.00 %

LINK	ORIG LENGTH (KM)	ALT	GEN TRAF	ECO/ FIN CSTS	CONST RECON UPGRD COSTS	PERIODIC MAINT COSTS	ROUTINE MAINT COSTS	TOTAL CONST & MAINT COSTS	VEHICLE OPERATING COSTS	NET EXOGENOUS COSTS	TOTAL COSTS	COMPARISON	NET PRES VALUE	INTRNAL RATE OF RETURN (%)
		ALT0	NO	ECO	.00	.00	.19	.19	31.9	.0	32.1			
				FIN	.00	.00	.25	.25	.0	.0	.2			
		ALT1	NO	ECO	.00	.34	.17	.51	31.6	.0	32.1	ALT1 VS ALT0	.1	14.4
				FIN	.00	.37	.23	.60	.0	.0	.6			
		ALT2	NO	ECO	.00	.48	.17	.65	31.6	.0	32.2	ALT2 VS ALT0	-.1	MANY
				FIN	.00	.52	.23	.74	.0	.0	.7			
		ALT3	NO	ECO	.00	.34	.17	.51	31.6	.0	32.1	ALT3 VS ALT0	.1	14.4
				FIN	.00	.37	.23	.60	.0	.0	.6			
WN09	16.9	NULL	NO	ECO	.00	.00	.23	.23	34.3	.0	34.6			
				FIN	.00	.00	.31	.31	.0	.0	.3			
		ALT0	NO	ECO	.00	.00	.23	.23	34.3	.0	34.6			
				FIN	.00	.00	.31	.31	.0	.0	.3			
		ALT1	NO	ECO	.00	1.19	.22	1.42	34.1	.0	35.5	ALT1 VS ALT0	-.9	-2.2
				FIN	.00	1.30	.30	1.59	.0	.0	1.6			
		ALT2	NO	ECO	.00	1.22	.22	1.44	34.0	.0	35.5	ALT2 VS ALT0	-.9	-2.0
				FIN	.00	1.33	.30	1.62	.0	.0	1.6			
		ALT3	NO	ECO	.00	1.19	.22	1.42	34.1	.0	35.5	ALT3 VS ALT0	-.9	-2.2
				FIN	.00	1.30	.30	1.59	.0	.0	1.6			
WN10	21.0	NULL	NO	ECO	.00	.00	.29	.29	34.5	.0	34.8			
				FIN	.00	.00	.38	.38	.0	.0	.4			
		ALT0	NO	ECO	.00	.00	.29	.29	34.5	.0	34.8			
				FIN	.00	.00	.38	.38	.0	.0	.4			
		ALT1	NO	ECO	.00	.33	.28	.61	34.0	.0	34.6	ALT1 VS ALT0	.2	MANY
				FIN	.00	.36	.37	.73	.0	.0	.7			
		ALT2	NO	ECO	.00	.37	.28	.65	34.0	.0	34.6	ALT2 VS ALT0	.2	21.2
				FIN	.00	.41	.37	.77	.0	.0	.8			
		ALT3	NO	ECO	1.50	.00	.28	1.78	33.2	.0	35.0	ALT3 VS ALT0	-.2	9.2
				FIN	1.83	.00	.37	2.19	.0	.0	2.2			
WN11	28.3	NULL	NO	ECO	.00	.00	.67	.67	30.2	.0	30.9			
				FIN	.00	.00	.83	.83	.0	.0	.8			
		ALT0	NO	ECO	.00	.00	.67	.67	30.2	.0	30.9			
				FIN	.00	.00	.83	.83	.0	.0	.8			
		ALT1	NO	ECO	.00	.00	1.23	1.23	26.4	.0	27.6	ALT1 VS ALT0	3.2	NONE
				FIN	.00	.00	1.49	1.49	.0	.0	1.5			
		ALT2	NO	ECO	.00	1.38	1.00	2.38	24.2	.0	26.6	ALT2 VS ALT0	4.3	97.2
				FIN	.00	1.60	1.21	2.81	.0	.0	2.8			

SUMMARY OF COSTS AND COMPARISONS BY DISCOUNT RATE : BASE

IN MILLION PNG Kina

DISCOUNT RATE = 12.00 %

LINK	ORIG LENGTH (KM)	ALT	GEN TRAF	ECO/ FIN CSTS	CONST RECON UPGRD COSTS	PERIODIC MAINT COSTS	ROUTINE MAINT COSTS	TOTAL CONST & MAINT COSTS	VEHICLE OPERATING COSTS	NET EXOGENOUS COSTS	TOTAL COSTS	COMPARISON	NET PRES VALUE	INTRNAL RATE OF RETURN (%)
		ALT3	YES	ECO	7.82	.29	.36	8.47	23.5	.0	32.0	ALT3 VS ALT0	6.2	23.4
				FIN	9.10	.32	.47	9.89	.0	.0	9.9			
WN12	28.9	NULL	NO	ECO	.00	.00	.54	.54	12.2	.0	12.7			
				FIN	.00	.00	.69	.69	.0	.0	.7			
		ALT0	NO	ECO	.00	.00	.54	.54	12.2	.0	12.7			
				FIN	.00	.00	.69	.69	.0	.0	.7			
		ALT1	NO	ECO	.00	.00	.90	.90	11.0	.0	11.9	ALT1 VS ALT0	.8	486.0
				FIN	.00	.00	1.11	1.11	.0	.0	1.1			
		ALT2	NO	ECO	.00	1.03	.57	1.60	10.6	.0	12.2	ALT2 VS ALT0	.5	22.7
				FIN	.00	1.19	.72	1.91	.0	.0	1.9			
		ALT3	YES	ECO	6.44	.30	.35	7.08	8.3	.0	15.4	ALT3 VS ALT0	-1.2	8.8
				FIN	7.48	.33	.46	8.27	.0	.0	8.3			
WN13	1.5	NULL	NO	ECO	.00	.00	.04	.04	8.1	.0	8.2			
				FIN	.00	.00	.06	.06	.0	.0	.1			
		ALT0	NO	ECO	.00	.00	.04	.04	8.1	.0	8.2			
				FIN	.00	.00	.06	.06	.0	.0	.1			
		ALT1	NO	ECO	.00	.10	.03	.12	7.3	.0	7.5	ALT1 VS ALT0	.7	54.3
				FIN	.00	.11	.03	.14	.0	.0	.1			
		ALT2	NO	ECO	.00	.12	.02	.14	7.3	.0	7.4	ALT2 VS ALT0	.8	54.7
				FIN	.00	.13	.03	.16	.0	.0	.2			
		ALT3	NO	ECO	.13	.07	.02	.23	7.0	.0	7.2	ALT3 VS ALT0	1.0	53.2
				FIN	.16	.08	.03	.27	.0	.0	.3			
WN14	9.2	NULL	NO	ECO	.00	.00	.22	.22	8.7	.0	8.9			
				FIN	.00	.00	.27	.27	.0	.0	.3			
		ALT0	NO	ECO	.00	.00	.22	.22	8.7	.0	8.9			
				FIN	.00	.00	.27	.27	.0	.0	.3			
		ALT1	NO	ECO	.00	.00	.37	.37	7.8	.0	8.2	ALT1 VS ALT0	.7	NONE
				FIN	.00	.00	.45	.45	.0	.0	.4			
		ALT2	NO	ECO	.00	.33	.31	.64	7.3	.0	7.9	ALT2 VS ALT0	1.0	46.2
				FIN	.00	.38	.37	.76	.0	.0	.8			
		ALT3	YES	ECO	3.11	.10	.12	3.33	6.3	.0	9.6	ALT3 VS ALT0	.5	14.2
				FIN	3.62	.11	.15	3.88	.0	.0	3.9			
WN15	19.5	NULL	NO	ECO	.00	.00	.54	.54	34.2	.0	34.7			
				FIN	.00	.00	.67	.67	.0	.0	.7			
		ALT0	NO	ECO	.00	.00	.54	.54	34.2	.0	34.7			
				FIN	.00	.00	.67	.67	.0	.0	.7			

SUMMARY OF COSTS AND COMPARISONS BY DISCOUNT RATE : BASE

IN MILLION PNG Kina

DISCOUNT RATE = 12.00 %

LINK	ORIG LENGTH (KM)	ALT	GEN TRAF	ECO/ FIN CSTS	CONST RECON UPGRD COSTS	PERIODIC MAINT COSTS	ROUTINE MAINT COSTS	TOTAL CONST & MAINT COSTS	VEHICLE OPERATING COSTS	NET EXOGENOUS COSTS	TOTAL COSTS	COMPARISON	NET PRES VALUE	INTRNAL RATE OF RETURN (%)
		ALT1	NO	ECO	.00	.06	1.00	1.06	30.0	.0	31.1	ALT1 VS ALT0	3.6	NONE
				FIN	.00	.07	1.20	1.26	.0	.0	1.3			
		ALT2	NO	ECO	.00	.64	.83	1.47	28.9	.0	30.3	ALT2 VS ALT0	4.4	MANY
				FIN	.00	.73	1.00	1.73	.0	.0	1.7			
		ALT3	YES	ECO	5.24	.24	.27	5.75	25.9	.0	31.6	ALT3 VS ALT0	7.4	29.4
				FIN	6.09	.27	.35	6.70	.0	.0	6.7			
WN16	33.0	NULL	NO	ECO	.00	.00	1.04	1.04	63.4	.0	64.4			
				FIN	.00	.00	1.27	1.27	.0	.0	1.3			
		ALT0	NO	ECO	.00	.00	1.04	1.04	63.4	.0	64.4			
				FIN	.00	.00	1.27	1.27	.0	.0	1.3			
		ALT1	NO	ECO	.00	.00	2.02	2.02	54.6	.0	56.6	ALT1 VS ALT0	7.8	NONE
				FIN	.00	.00	2.41	2.41	.0	.0	2.4			
		ALT2	NO	ECO	.00	1.21	1.67	2.87	52.2	.0	55.1	ALT2 VS ALT0	9.4	MANY
				FIN	.00	1.40	1.98	3.38	.0	.0	3.4			
		ALT3	YES	ECO	11.15	.37	.46	11.98	44.3	.0	56.3	ALT3 VS ALT0	15.9	29.6
				FIN	12.96	.41	.59	13.96	.0	.0	14.0			
WN17	22.0	NULL	NO	ECO	.00	.00	.41	.41	12.7	.0	13.1			
				FIN	.00	.00	.52	.52	.0	.0	.5			
		ALT0	NO	ECO	.00	.00	.41	.41	12.7	.0	13.1			
				FIN	.00	.00	.52	.52	.0	.0	.5			
		ALT1	NO	ECO	.00	.33	.61	.93	11.6	.0	12.6	ALT1 VS ALT0	.5	31.1
				FIN	.00	.35	.75	1.11	.0	.0	1.1			
		ALT2	NO	ECO	.00	.79	.52	1.31	11.1	.0	12.4	ALT2 VS ALT0	.7	26.0
				FIN	.00	.89	.65	1.54	.0	.0	1.5			
		ALT3	YES	ECO	5.45	.20	.25	5.90	8.8	.0	14.7	ALT3 VS ALT0	-.1	11.8
				FIN	6.39	.22	.33	6.94	.0	.0	6.9			

SUMMARY OF COSTS AND COMPARISONS BY DISCOUNT RATE : BASE

IN MILLION PNG Kina

DISCOUNT RATE = 12.00 %

LINK	ORIG LENGTH (KM)	ALT	GEN TRAF	ECO/ FIN	CONST RECON UPGRD COSTS	PERIODIC MAINT COSTS	ROUTINE MAINT COSTS	TOTAL CONST & MAINT COSTS	VEHICLE OPERATING COSTS	NET EXOGENOUS COSTS	TOTAL COSTS	COMPARISON	NET PRES VALUE	INTRNAL RATE OF RETURN (%)
WN18	4.0	NULL	NO	ECO	.00	.00	.07	.07	.9	.0	1.0			
				FIN	.00	.00	.09	.09	.0	.0	.1			
		ALT0	NO	ECO	.00	.00	.07	.07	.9	.0	1.0			
				FIN	.00	.00	.09	.09	.0	.0	.1			
		ALT1	NO	ECO	.00	.00	.10	.10	.8	.0	.9	ALT1 VS ALT0	.0	57.1
				FIN	.00	.00	.13	.13	.0	.0	.1			
		ALT2	NO	ECO	.00	.14	.09	.22	.7	.0	1.0	ALT2 VS ALT0	.0	12.9
				FIN	.00	.16	.11	.27	.0	.0	.3			
		ALT3	YES	ECO	.92	.04	.05	1.01	.6	.0	1.7	ALT3 VS ALT0	-.6	.3
				FIN	1.07	.05	.06	1.18	.0	.0	1.2			
WN19	11.3	NULL	NO	ECO	.00	.00	.28	.28	12.2	.0	12.5			
				FIN	.00	.00	.35	.35	.0	.0	.3			
		ALT0	NO	ECO	.00	.00	.28	.28	12.2	.0	12.5			
				FIN	.00	.00	.35	.35	.0	.0	.3			
		ALT1	NO	ECO	.00	.00	.49	.49	10.9	.0	11.4	ALT1 VS ALT0	1.0	NONE
				FIN	.00	.00	.59	.59	.0	.0	.6			
		ALT2	NO	ECO	.00	.13	.42	.55	10.8	.0	11.4	ALT2 VS ALT0	1.1	NONE
				FIN	.00	.15	.51	.66	.0	.0	.7			
		ALT3	YES	ECO	3.13	.12	.15	3.39	9.4	.0	12.8	ALT3 VS ALT0	1.2	17.0
				FIN	3.63	.13	.19	3.95	.0	.0	4.0			
WP20	31.0	NULL	NO	ECO	.00	.00	.63	.63	18.7	.0	19.4			
				FIN	.00	.00	.80	.80	.0	.0	.8			
		ALT0	NO	ECO	.00	.00	.63	.63	18.7	.0	19.4			
				FIN	.00	.00	.80	.80	.0	.0	.8			
		ALT1	NO	ECO	.00	.00	1.15	1.15	16.8	.0	18.0	ALT1 VS ALT0	1.4	207.2
				FIN	.00	.00	1.41	1.41	.0	.0	1.4			
		ALT2	NO	ECO	.00	1.35	.92	2.27	15.4	.0	17.7	ALT2 VS ALT0	1.7	32.9
				FIN	.00	1.57	1.13	2.70	.0	.0	2.7			
		ALT3	YES	ECO	3.69	.17	.37	4.23	17.6	.0	21.8	ALT3 VS ALT0	.2	12.8
				FIN	4.29	.18	.48	4.95	.0	.0	4.9			
WP21	15.3	NULL	NO	ECO	.00	.00	.26	.26	3.8	.0	4.0			
				FIN	.00	.00	.33	.33	.0	.0	.3			
		ALT0	NO	ECO	.00	.00	.26	.26	3.8	.0	4.0			
				FIN	.00	.00	.33	.33	.0	.0	.3			
		ALT1	NO	ECO	.00	.00	.43	.43	3.4	.0	3.9	ALT1 VS ALT0	.2	461.1
				FIN	.00	.00	.54	.54	.0	.0	.5			

SUMMARY OF COSTS AND COMPARISONS BY DISCOUNT RATE : BASE

IN MILLION PNG Kina

DISCOUNT RATE = 12.00 %

LINK	ORIG LENGTH (KM)	ALT	GEN TRAF	ECO/ FIN CSTS	CONST RECON UPGRD COSTS	PERIODIC MAINT COSTS	ROUTINE MAINT COSTS	TOTAL CONST & MAINT COSTS	VEHICLE OPERATING COSTS	NET EXOGENOUS COSTS	TOTAL COSTS	COMPARISON	NET PRES VALUE	INTRNAL RATE OF RETURN (%)
		ALT2	NO	ECO	.00	.71	.34	1.05	3.0	.0	4.1	ALT2 VS ALT0	.0	11.0
				FIN	.00	.82	.43	1.25	.0	.0	1.3			
		ALT3	YES	ECO	3.41	.16	.18	3.75	2.6	.0	6.4	ALT3 VS ALT0	-1.9	1.0
				FIN	3.96	.17	.24	4.38	.0	.0	4.4			
WP22	6.4	NULL	NO	ECO	.00	.00	.11	.11	1.4	.0	1.5			
				FIN	.00	.00	.14	.14	.0	.0	.1			
		ALT0	NO	ECO	.00	.00	.11	.11	1.4	.0	1.5			
				FIN	.00	.00	.14	.14	.0	.0	.1			
		ALT1	NO	ECO	.00	.00	.15	.15	1.3	.0	1.4	ALT1 VS ALT0	.1	117.1
				FIN	.00	.00	.19	.19	.0	.0	.2			
		ALT2	NO	ECO	.00	.21	.13	.34	1.1	.0	1.4	ALT2 VS ALT0	.0	15.8
				FIN	.00	.24	.16	.40	.0	.0	.4			
		ALT3	YES	ECO	1.43	.07	.08	1.57	.9	.0	2.5	ALT3 VS ALT0	-.8	.1
				FIN	1.66	.07	.10	1.83	.0	.0	1.8			
WP23	16.4	NULL	NO	ECO	.00	.00	.33	.33	10.4	.0	10.7			
				FIN	.00	.00	.42	.42	.0	.0	.4			
		ALT0	NO	ECO	.00	.00	.33	.33	10.4	.0	10.7			
				FIN	.00	.00	.42	.42	.0	.0	.4			
		ALT1	NO	ECO	.00	.00	.52	.52	9.4	.0	9.9	ALT1 VS ALT0	.8	NONE
				FIN	.00	.00	.63	.63	.0	.0	.6			
		ALT2	NO	ECO	.00	.55	.43	.99	8.4	.0	9.4	ALT2 VS ALT0	1.3	43.3
				FIN	.00	.64	.53	1.17	.0	.0	1.2			
		ALT3	YES	ECO	3.65	.17	.20	4.02	7.0	.0	11.0	ALT3 VS ALT0	1.0	15.9
				FIN	4.25	.18	.26	4.69	.0	.0	4.7			
WP24	10.0	NULL	NO	ECO	.00	.00	.13	.13	6.1	.0	6.2			
				FIN	.00	.00	.18	.18	.0	.0	.2			
		ALT0	NO	ECO	.00	.00	.13	.13	6.1	.0	6.2			
				FIN	.00	.00	.18	.18	.0	.0	.2			
		ALT1	NO	ECO	.00	.13	.13	.26	6.0	.0	6.3	ALT1 VS ALT0	-.1	-15.0
				FIN	.00	.14	.18	.32	.0	.0	.3			
		ALT2	NO	ECO	.00	.15	.13	.28	6.0	.0	6.3	ALT2 VS ALT0	-.1	-13.3
				FIN	.00	.16	.18	.33	.0	.0	.3			
		ALT3	NO	ECO	.00	.13	.13	.26	6.0	.0	6.3	ALT3 VS ALT0	-.1	-15.0
				FIN	.00	.14	.18	.32	.0	.0	.3			
WP25	13.0	NULL	NO	ECO	.00	.00	.22	.22	3.3	.0	3.6			
				FIN	.00	.00	.28	.28	.0	.0	.3			

SUMMARY OF COSTS AND COMPARISONS BY DISCOUNT RATE : BASE

IN MILLION PNG Kina

DISCOUNT RATE = 12.00 %

LINK	ORIG LENGTH (KM)	ALT	GEN TRAF	ECO/ FIN	CONST RECON UPGRD COSTS	PERIODIC MAINT COSTS	ROUTINE MAINT COSTS	TOTAL CONST & MAINT COSTS	VEHICLE OPERATING COSTS	NET EXOGENOUS COSTS	TOTAL COSTS	COMPARISON	NET PRES VALUE	INTRNAL RATE OF RETURN (%)
		ALT0	NO	ECO	.00	.00	.22	.22	3.3	.0	3.6			
				FIN	.00	.00	.28	.28	.0	.0	.3			
		ALT1	NO	ECO	.00	.00	.39	.39	3.0	.0	3.4	ALT1 VS ALT0	.2	167.7
				FIN	.00	.00	.48	.48	.0	.0	.5			
		ALT2	NO	ECO	.00	.64	.31	.95	2.7	.0	3.6	ALT2 VS ALT0	-.1	9.6
				FIN	.00	.74	.38	1.13	.0	.0	1.1			
		ALT3	YES	ECO	2.89	.13	.15	3.18	2.4	.0	5.5	ALT3 VS ALT0	-1.6	1.4
				FIN	3.37	.15	.20	3.72	.0	.0	3.7			
WP26	12.2	NULL	NO	ECO	.00	.00	.28	.28	14.3	.0	14.5			
				FIN	.00	.00	.35	.35	.0	.0	.4			
		ALT0	NO	ECO	.00	.00	.28	.28	14.3	.0	14.5			
				FIN	.00	.00	.35	.35	.0	.0	.4			
		ALT1	NO	ECO	.00	.06	.45	.51	13.0	.0	13.5	ALT1 VS ALT0	1.1	NONE
				FIN	.00	.06	.55	.61	.0	.0	.6			
		ALT2	NO	ECO	.00	.39	.39	.77	12.0	.0	12.8	ALT2 VS ALT0	1.8	60.0
				FIN	.00	.44	.47	.91	.0	.0	.9			
		ALT3	YES	ECO	2.40	.15	.16	2.71	11.3	.0	14.0	ALT3 VS ALT0	2.4	24.0
				FIN	2.79	.16	.21	3.17	.0	.0	3.2			
WP27	8.0	NULL	NO	ECO	.00	.00	.11	.11	10.1	.0	10.2			
				FIN	.00	.00	.15	.15	.0	.0	.1			
		ALT0	NO	ECO	.00	.00	.11	.11	10.1	.0	10.2			
				FIN	.00	.00	.15	.15	.0	.0	.1			
		ALT1	NO	ECO	.00	.48	.11	.59	9.9	.0	10.5	ALT1 VS ALT0	-.3	3.2
				FIN	.00	.53	.14	.67	.0	.0	.7			
		ALT2	NO	ECO	.00	.50	.11	.60	9.9	.0	10.5	ALT2 VS ALT0	-.3	3.1
				FIN	.00	.54	.14	.68	.0	.0	.7			
		ALT3	NO	ECO	.00	.48	.11	.59	9.9	.0	10.5	ALT3 VS ALT0	-.3	3.2
				FIN	.00	.53	.14	.67	.0	.0	.7			
WP28	8.8	NULL	NO	ECO	.00	.00	.21	.21	9.4	.0	9.6			
				FIN	.00	.00	.26	.26	.0	.0	.3			
		ALT0	NO	ECO	.00	.00	.21	.21	9.4	.0	9.6			
				FIN	.00	.00	.26	.26	.0	.0	.3			
		ALT1	NO	ECO	.00	.00	.39	.39	8.2	.0	8.6	ALT1 VS ALT0	1.0	NONE
				FIN	.00	.00	.47	.47	.0	.0	.5			
		ALT2	NO	ECO	.00	.32	.32	.64	7.7	.0	8.3	ALT2 VS ALT0	1.3	64.9
				FIN	.00	.37	.38	.76	.0	.0	.8			

SUMMARY OF COSTS AND COMPARISONS BY DISCOUNT RATE : BASE

IN MILLION PNG Kina

DISCOUNT RATE = 12.00 %

LINK	ORIG LENGTH (KM)	ALT	GEN TRAF	ECO/ FIN CSTS	CONST RECON UPGRD COSTS	PERIODIC MAINT COSTS	ROUTINE MAINT COSTS	TOTAL CONST & MAINT COSTS	VEHICLE OPERATING COSTS	NET EXOGENOUS COSTS	TOTAL COSTS	COMPARISON	NET PRES VALUE	INTRNAL RATE OF RETURN (%)
		ALT3	YES	ECO	2.43	.09	.11	2.63	6.6	.0	9.2	ALT3 VS ALT0	1.5	19.8
				FIN	2.83	.10	.15	3.08	.0	.0	3.1			
WP29	6.3	NULL	NO	ECO	.00	.00	.14	.14	4.2	.0	4.3			
				FIN	.00	.00	.17	.17	.0	.0	.2			
		ALT0	NO	ECO	.00	.00	.14	.14	4.2	.0	4.3			
				FIN	.00	.00	.17	.17	.0	.0	.2			
		ALT1	NO	ECO	.00	.00	.22	.22	3.9	.0	4.1	ALT1 VS ALT0	.3	NONE
				FIN	.00	.00	.26	.26	.0	.0	.3			
		ALT2	NO	ECO	.00	.05	.19	.24	3.8	.0	4.1	ALT2 VS ALT0	.3	NONE
				FIN	.00	.06	.23	.29	.0	.0	.3			
		ALT3	YES	ECO	1.46	.07	.08	1.60	3.3	.0	4.9	ALT3 VS ALT0	.0	12.0
				FIN	1.69	.07	.10	1.86	.0	.0	1.9			
WP30	24.0	NULL	NO	ECO	.00	.00	.41	.41	5.8	.0	6.2			
				FIN	.00	.00	.53	.53	.0	.0	.5			
		ALT0	NO	ECO	.00	.00	.41	.41	5.8	.0	6.2			
				FIN	.00	.00	.53	.53	.0	.0	.5			
		ALT1	NO	ECO	.00	.00	.59	.59	5.3	.0	5.8	ALT1 VS ALT0	.4	NONE
				FIN	.00	.00	.74	.74	.0	.0	.7			
		ALT2	NO	ECO	.00	.83	.49	1.32	4.5	.0	5.8	ALT2 VS ALT0	.4	22.6
				FIN	.00	.96	.62	1.58	.0	.0	1.6			
		ALT3	YES	ECO	5.35	.25	.33	5.92	3.8	.0	9.7	ALT3 VS ALT0	-2.8	1.6
				FIN	6.21	.27	.43	6.91	.0	.0	6.9			
WP31	10.3	NULL	NO	ECO	.00	.00	.33	.33	18.4	.0	18.7			
				FIN	.00	.00	.40	.40	.0	.0	.4			
		ALT0	NO	ECO	.00	.00	.33	.33	18.4	.0	18.7			
				FIN	.00	.00	.40	.40	.0	.0	.4			
		ALT1	NO	ECO	.00	.00	.57	.57	16.6	.0	17.1	ALT1 VS ALT0	1.6	NONE
				FIN	.00	.00	.68	.68	.0	.0	.7			
		ALT2	NO	ECO	.00	.17	.50	.67	16.1	.0	16.7	ALT2 VS ALT0	2.0	NONE
				FIN	.00	.19	.60	.79	.0	.0	.8			
		ALT3	YES	ECO	3.48	.12	.14	3.74	13.5	.0	17.3	ALT3 VS ALT0	3.7	24.6
				FIN	4.04	.13	.19	4.36	.0	.0	4.4			
WP32	7.0	NULL	NO	ECO	.00	.00	.12	.12	26.2	.0	26.4			
				FIN	.00	.00	.16	.16	.0	.0	.2			
		ALT0	NO	ECO	.00	.00	.12	.12	26.2	.0	26.4			
				FIN	.00	.00	.16	.16	.0	.0	.2			

SUMMARY OF COSTS AND COMPARISONS BY DISCOUNT RATE : BASE

IN MILLION PNG Kina

DISCOUNT RATE = 12.00 %

LINK	ORIG LENGTH (KM)	ALT	GEN TRAF	ECO/ FIN CSTS	CONST RECON UPGRD COSTS	PERIODIC MAINT COSTS	ROUTINE MAINT COSTS	TOTAL CONST & MAINT COSTS	VEHICLE OPERATING COSTS	NET EXOGENOUS COSTS	TOTAL COSTS	COMPARISON	NET PRES VALUE	INTRNAL RATE OF RETURN (%)
		ALT1	NO	ECO	.00	.43	.10	.53	24.9	.0	25.4	ALT1 VS ALT0	.9	24.6
				FIN	.00	.47	.13	.60	.0	.0	.6			
		ALT2	NO	ECO	.00	.44	.09	.54	24.8	.0	25.3	ALT2 VS ALT0	1.0	25.2
				FIN	.00	.48	.12	.61	.0	.0	.6			
		ALT3	NO	ECO	.63	.34	.09	1.06	23.7	.0	24.8	ALT3 VS ALT0	1.5	25.7
				FIN	.76	.37	.12	1.26	.0	.0	1.3			
WP33	36.5	NULL	NO	ECO	.00	.00	.68	.68	15.5	.0	16.2			
				FIN	.00	.00	.86	.86	.0	.0	.9			
		ALT0	NO	ECO	.00	.00	.68	.68	15.5	.0	16.2			
				FIN	.00	.00	.86	.86	.0	.0	.9			
		ALT1	NO	ECO	.00	.00	1.23	1.23	13.8	.0	15.1	ALT1 VS ALT0	1.1	146.1
				FIN	.00	.00	1.51	1.51	.0	.0	1.5			
		ALT2	NO	ECO	.00	1.73	.97	2.70	12.7	.0	15.4	ALT2 VS ALT0	.8	MANY
				FIN	.00	2.00	1.20	3.20	.0	.0	3.2			
		ALT3	YES	ECO	8.41	.38	.47	9.26	11.3	.0	20.5	ALT3 VS ALT0	-2.4	7.2
				FIN	9.78	.41	.62	10.81	.0	.0	10.8			
WP34	5.0	NULL	NO	ECO	.00	.00	.11	.11	4.3	.0	4.4			
				FIN	.00	.00	.14	.14	.0	.0	.1			
		ALT0	NO	ECO	.00	.00	.11	.11	4.3	.0	4.4			
				FIN	.00	.00	.14	.14	.0	.0	.1			
		ALT1	NO	ECO	.00	.00	.21	.21	3.7	.0	3.9	ALT1 VS ALT0	.5	NONE
				FIN	.00	.00	.25	.25	.0	.0	.3			
		ALT2	NO	ECO	.00	.28	.17	.44	3.4	.0	3.9	ALT2 VS ALT0	.6	60.6
				FIN	.00	.32	.20	.53	.0	.0	.5			
		ALT3	YES	ECO	1.79	.08	.09	1.96	4.2	.0	6.2	ALT3 VS ALT0	-1.1	-1.3
				FIN	2.09	.09	.12	2.29	.0	.0	2.3			

SUMMARY OF COSTS AND COMPARISONS BY DISCOUNT RATE : BASE

IN MILLION PNG Kina

DISCOUNT RATE = 12.00 %

LINK	ORIG LENGTH (KM)	ALT	GEN TRAF	ECO/ FIN CSTS	CONST RECON UPGRD COSTS	PERIODIC MAINT COSTS	ROUTINE MAINT COSTS	TOTAL CONST & MAINT COSTS	VEHICLE OPERATING COSTS	NET EXOGENOUS COSTS	TOTAL COSTS	COMPARISON	NET PRES VALUE	INTRNAL RATE OF RETURN (%)
SN01	20.5	NULL	NO	ECO	.35	.02	.30	.66	57.1	.0	57.8			
				FIN	.42	.02	.39	.83	.0	.0	.8			
		ALT0	NO	ECO	.35	.02	.30	.66	57.1	.0	57.8			
				FIN	.42	.02	.39	.83	.0	.0	.8			
		ALT1	NO	ECO	.35	.67	.31	1.33	56.0	.0	57.3	ALT1 VS ALT0	.5	26.8
				FIN	.42	.73	.41	1.56	.0	.0	1.6			
		ALT2	NO	ECO	.35	.80	.27	1.41	55.7	.0	57.1	ALT2 VS ALT0	.7	25.7
				FIN	.42	.87	.36	1.65	.0	.0	1.6			
		ALT3	NO	ECO	1.47	.51	.29	2.28	54.9	.0	57.2	ALT3 VS ALT0	.6	21.0
				FIN	1.79	.56	.39	2.74	.0	.0	2.7			
SN02	23.8	NULL	NO	ECO	.00	.00	.61	.61	40.6	.0	41.2			
				FIN	.00	.00	.75	.75	.0	.0	.8			
		ALT0	NO	ECO	.00	.00	.61	.61	40.6	.0	41.2			
				FIN	.00	.00	.75	.75	.0	.0	.8			
		ALT1	NO	ECO	.00	.00	1.33	1.33	35.2	.0	36.5	ALT1 VS ALT0	4.7	NONE
				FIN	.00	.00	1.60	1.60	.0	.0	1.6			
		ALT2	NO	ECO	.00	.93	1.04	1.97	33.9	.0	35.8	ALT2 VS ALT0	5.4	NONE
				FIN	.00	1.08	1.25	2.33	.0	.0	2.3			
		ALT3	YES	ECO	17.00	.31	.31	17.62	34.6	.0	52.2	ALT3 VS ALT0	-5.8	7.0
				FIN	19.76	.34	.40	20.50	.0	.0	20.5			
SN03	10.1	NULL	NO	ECO	.00	.00	.25	.25	15.1	.0	15.3			
				FIN	.00	.00	.31	.31	.0	.0	.3			
		ALT0	NO	ECO	.00	.00	.25	.25	15.1	.0	15.3			
				FIN	.00	.00	.31	.31	.0	.0	.3			
		ALT1	NO	ECO	.00	.00	.43	.43	13.4	.0	13.9	ALT1 VS ALT0	1.5	NONE
				FIN	.00	.00	.52	.52	.0	.0	.5			
		ALT2	NO	ECO	.00	.25	.38	.62	13.0	.0	13.6	ALT2 VS ALT0	1.7	NONE
				FIN	.00	.28	.46	.74	.0	.0	.7			
		ALT3	YES	ECO	7.21	.13	.14	7.49	11.0	.0	18.5	ALT3 VS ALT0	-1.4	9.2
				FIN	8.38	.14	.18	8.71	.0	.0	8.7			
SN04	29.1	NULL	NO	ECO	.00	.00	.39	.39	36.6	.0	37.0			
				FIN	.00	.00	.52	.52	.0	.0	.5			
		ALT0	NO	ECO	.00	.00	.39	.39	36.6	.0	37.0			
				FIN	.00	.00	.52	.52	.0	.0	.5			
		ALT1	NO	ECO	.00	.54	.38	.92	36.3	.0	37.2	ALT1 VS ALT0	-.3	-.6
				FIN	.00	.59	.51	1.09	.0	.0	1.1			

SUMMARY OF COSTS AND COMPARISONS BY DISCOUNT RATE : BASE

IN MILLION PNG Kina

DISCOUNT RATE = 12.00 %

LINK	ORIG LENGTH (KM)	ALT	GEN TRAF	ECO/ FIN CSTS	CONST RECON UPGRD COSTS	PERIODIC MAINT COSTS	ROUTINE MAINT COSTS	TOTAL CONST & MAINT COSTS	VEHICLE OPERATING COSTS	NET EXOGENOUS COSTS	TOTAL COSTS	COMPARISON	NET PRES VALUE	INTRNAL RATE OF RETURN (%)
		ALT2	NO	ECO	.00	.60	.38	.99	36.3	.0	37.3	ALT2 VS ALT0	-.3	-.4
				FIN	.00	.66	.51	1.17	.0	.0	1.2			
		ALT3	NO	ECO	.00	.54	.38	.92	36.3	.0	37.2	ALT3 VS ALT0	-.3	-.6
				FIN	.00	.59	.51	1.09	.0	.0	1.1			
SN05	35.0	NULL	NO	ECO	.00	.00	.73	.73	33.4	.0	34.2			
				FIN	.00	.00	.91	.91	.0	.0	.9			
		ALT0	NO	ECO	.00	.00	.73	.73	33.4	.0	34.2			
				FIN	.00	.00	.91	.91	.0	.0	.9			
		ALT1	NO	ECO	.00	.00	1.61	1.61	29.5	.0	31.1	ALT1 VS ALT0	3.0	199.7
				FIN	.00	.00	1.97	1.97	.0	.0	2.0			
		ALT2	NO	ECO	.00	2.21	1.27	3.49	27.7	.0	31.2	ALT2 VS ALT0	3.0	34.4
				FIN	.00	2.56	1.56	4.12	.0	.0	4.1			
		ALT3	YES	ECO	11.82	.40	.47	12.68	32.2	.0	44.9	ALT3 VS ALT0	2.5	15.0
				FIN	13.75	.43	.61	14.79	.0	.0	14.8			
SN06	37.0	NULL	NO	ECO	.00	.00	.71	.71	22.3	.0	23.0			
				FIN	.00	.00	.89	.89	.0	.0	.9			
		ALT0	NO	ECO	.00	.00	.71	.71	22.3	.0	23.0			
				FIN	.00	.00	.89	.89	.0	.0	.9			
		ALT1	NO	ECO	.00	.00	1.43	1.43	19.6	.0	21.1	ALT1 VS ALT0	1.9	267.0
				FIN	.00	.00	1.76	1.76	.0	.0	1.8			
		ALT2	NO	ECO	.00	2.39	1.13	3.52	17.5	.0	21.0	ALT2 VS ALT0	2.0	28.5
				FIN	.00	2.76	1.40	4.16	.0	.0	4.2			
		ALT3	YES	ECO	12.50	.42	.48	13.40	19.8	.0	33.2	ALT3 VS ALT0	-1.8	9.8
				FIN	14.54	.45	.63	15.62	.0	.0	15.6			
SN07	54.2	NULL	NO	ECO	.00	.00	1.03	1.03	37.3	.0	38.3			
				FIN	.00	.00	1.31	1.31	.0	.0	1.3			
		ALT0	NO	ECO	.00	.00	1.03	1.03	37.3	.0	38.3			
				FIN	.00	.00	1.31	1.31	.0	.0	1.3			
		ALT1	NO	ECO	.00	.00	2.20	2.20	32.5	.0	34.7	ALT1 VS ALT0	3.6	NONE
				FIN	.00	.00	2.70	2.70	.0	.0	2.7			
		ALT2	NO	ECO	.00	3.45	1.72	5.17	30.1	.0	35.3	ALT2 VS ALT0	3.0	36.7
				FIN	.00	3.99	2.12	6.12	.0	.0	6.1			
		ALT3	YES	ECO	17.72	.55	.80	19.07	35.6	.0	54.7	ALT3 VS ALT0	-3.2	9.3
				FIN	20.61	.59	1.05	22.25	.0	.0	22.3			
SN08	22.4	NULL	NO	ECO	.00	.00	.59	.59	35.6	.0	36.2			
				FIN	.00	.00	.73	.73	.0	.0	.7			

SUMMARY OF COSTS AND COMPARISONS BY DISCOUNT RATE : BASE

IN MILLION PNG Kina

DISCOUNT RATE = 12.00 %

LINK	ORIG LENGTH (KM)	ALT	GEN TRAF	ECO/ FIN CSTS	CONST RECON UPGRD COSTS	PERIODIC MAINT COSTS	ROUTINE MAINT COSTS	TOTAL CONST & MAINT COSTS	VEHICLE OPERATING COSTS	NET EXOGENOUS COSTS	TOTAL COSTS	COMPARISON	NET PRES VALUE	INTRNAL RATE OF RETURN (%)
		ALT0	NO	ECO	.00	.00	.59	.59	35.6	.0	36.2			
				FIN	.00	.00	.73	.73	.0	.0	.7			
		ALT1	NO	ECO	.00	.00	.99	.99	32.2	.0	33.2	ALT1 VS ALT0	3.1	NONE
				FIN	.00	.00	1.19	1.19	.0	.0	1.2			
		ALT2	NO	ECO	.00	.94	.89	1.83	27.9	.0	29.7	ALT2 VS ALT0	6.5	77.9
				FIN	.00	1.09	1.07	2.16	.0	.0	2.2			
		ALT3	YES	ECO	7.57	.25	.32	8.14	30.8	.0	38.9	ALT3 VS ALT0	10.7	28.1
				FIN	8.80	.28	.41	9.49	.0	.0	9.5			
SN09	38.5	NULL	NO	ECO	.00	.00	.88	.88	41.1	.0	42.0			
				FIN	.00	.00	1.09	1.09	.0	.0	1.1			
		ALT0	NO	ECO	.00	.00	.88	.88	41.1	.0	42.0			
				FIN	.00	.00	1.09	1.09	.0	.0	1.1			
		ALT1	NO	ECO	.00	.00	1.43	1.43	37.1	.0	38.5	ALT1 VS ALT0	3.4	NONE
				FIN	.00	.00	1.74	1.74	.0	.0	1.7			
		ALT2	NO	ECO	.00	1.62	1.25	2.87	32.1	.0	34.9	ALT2 VS ALT0	7.0	58.6
				FIN	.00	1.87	1.53	3.40	.0	.0	3.4			
		ALT3	YES	ECO	10.64	.40	.52	11.57	35.3	.0	46.8	ALT3 VS ALT0	10.5	23.9
				FIN	12.38	.43	.69	13.49	.0	.0	13.5			
SN10	7.8	NULL	NO	ECO	.00	.00	.15	.15	3.4	.0	3.6			
				FIN	.00	.00	.19	.19	.0	.0	.2			
		ALT0	NO	ECO	.00	.00	.15	.15	3.4	.0	3.6			
				FIN	.00	.00	.19	.19	.0	.0	.2			
		ALT1	NO	ECO	.00	.00	.21	.21	3.1	.0	3.3	ALT1 VS ALT0	.2	NONE
				FIN	.00	.00	.26	.26	.0	.0	.3			
		ALT2	NO	ECO	.00	.26	.18	.45	2.7	.0	3.2	ALT2 VS ALT0	.4	33.6
				FIN	.00	.30	.23	.53	.0	.0	.5			
		ALT3	YES	ECO	1.79	.08	.10	1.98	2.9	.0	4.9	ALT3 VS ALT0	.0	11.8
				FIN	2.09	.09	.13	2.31	.0	.0	2.3			
SN11	112.0	NULL	NO	ECO	.00	.00	2.11	2.11	44.7	.0	46.8			
				FIN	.00	.00	2.67	2.67	.0	.0	2.7			
		ALT0	NO	ECO	.00	.00	2.11	2.11	44.7	.0	46.8			
				FIN	.00	.00	2.67	2.67	.0	.0	2.7			
		ALT1	NO	ECO	.00	.00	3.97	3.97	39.6	.0	43.5	ALT1 VS ALT0	3.2	53.5
				FIN	.00	.00	4.88	4.88	.0	.0	4.9			
		ALT2	NO	ECO	.00	1.67	3.19	4.86	39.1	.0	44.0	ALT2 VS ALT0	2.8	NONE
				FIN	.00	1.93	3.95	5.88	.0	.0	5.9			

SUMMARY OF COSTS AND COMPARISONS BY DISCOUNT RATE : BASE

IN MILLION PNG Kina

DISCOUNT RATE = 12.00 %

LINK	ORIG LENGTH (KM)	ALT	GEN TRAF	ECO/ FIN CSTS	CONST RECON UPGRD COSTS	PERIODIC MAINT COSTS	ROUTINE MAINT COSTS	TOTAL CONST & MAINT COSTS	VEHICLE OPERATING COSTS	NET EXOGENOUS COSTS	TOTAL COSTS	COMPARISON	NET PRES VALUE	INTRNAL RATE OF RETURN (%)
		ALT3	YES	ECO	16.74	.92	1.70	19.36	38.5	.0	57.8	ALT3 VS ALT0	-2.1	10.4
				FIN	20.16	1.00	2.22	23.39	.0	.0	23.4			
SN12	15.6	NULL	NO	ECO	.00	.00	.36	.36	16.2	.0	16.6			
				FIN	.00	.00	.45	.45	.0	.0	.4			
		ALT0	NO	ECO	.00	.00	.36	.36	16.2	.0	16.6			
				FIN	.00	.00	.45	.45	.0	.0	.4			
		ALT1	NO	ECO	.00	.00	.72	.72	14.9	.0	15.6	ALT1 VS ALT0	.9	177.5
				FIN	.00	.00	.87	.87	.0	.0	.9			
		ALT2	NO	ECO	.00	.15	.60	.74	14.9	.0	15.6	ALT2 VS ALT0	.9	NONE
				FIN	.00	.17	.72	.89	.0	.0	.9			
		ALT3	YES	ECO	5.27	.16	.21	5.64	16.7	.0	22.4	ALT3 VS ALT0	.8	14.0
				FIN	6.13	.18	.28	6.58	.0	.0	6.6			
SN13	31.8	NULL	NO	ECO	.00	.00	.66	.66	22.2	.0	22.9			
				FIN	.00	.00	.82	.82	.0	.0	.8			
		ALT0	NO	ECO	.00	.00	.66	.66	22.2	.0	22.9			
				FIN	.00	.00	.82	.82	.0	.0	.8			
		ALT1	NO	ECO	.00	.00	1.16	1.16	19.7	.0	20.9	ALT1 VS ALT0	2.0	304.6
				FIN	.00	.00	1.43	1.43	.0	.0	1.4			
		ALT2	NO	ECO	.00	1.23	.97	2.20	18.2	.0	20.4	ALT2 VS ALT0	2.4	40.1
				FIN	.00	1.42	1.19	2.62	.0	.0	2.6			
		ALT3	YES	ECO	8.79	.33	.42	9.55	20.2	.0	29.8	ALT3 VS ALT0	1.7	14.7
				FIN	10.22	.36	.56	11.14	.0	.0	11.1			
SN14	39.6	NULL	NO	ECO	.00	.00	.74	.74	16.4	.0	17.1			
				FIN	.00	.00	.94	.94	.0	.0	.9			
		ALT0	NO	ECO	.00	.00	.74	.74	16.4	.0	17.1			
				FIN	.00	.00	.94	.94	.0	.0	.9			
		ALT1	NO	ECO	.00	.00	1.34	1.34	14.6	.0	15.9	ALT1 VS ALT0	1.2	103.7
				FIN	.00	.00	1.65	1.65	.0	.0	1.7			
		ALT2	NO	ECO	.00	1.59	1.09	2.68	13.4	.0	16.1	ALT2 VS ALT0	1.1	24.0
				FIN	.00	1.84	1.35	3.19	.0	.0	3.2			
		ALT3	YES	ECO	9.12	.41	.51	10.04	14.8	.0	24.8	ALT3 VS ALT0	-1.3	9.9
				FIN	10.61	.45	.68	11.73	.0	.0	11.7			
SN15	15.0	NULL	NO	ECO	.00	.00	.26	.26	3.9	.0	4.1			
				FIN	.00	.00	.33	.33	.0	.0	.3			
		ALT0	NO	ECO	.00	.00	.26	.26	3.9	.0	4.1			
				FIN	.00	.00	.33	.33	.0	.0	.3			

SUMMARY OF COSTS AND COMPARISONS BY DISCOUNT RATE : BASE

IN MILLION PNG Kina

DISCOUNT RATE = 12.00 %

LINK	ORIG LENGTH (KM)	ALT	GEN TRAF	ECO/ FIN CSTS	CONST RECON UPGRD COSTS	PERIODIC MAINT COSTS	ROUTINE MAINT COSTS	TOTAL CONST & MAINT COSTS	VEHICLE OPERATING COSTS	NET EXOGENOUS COSTS	TOTAL COSTS	COMPARISON	NET PRES VALUE	INTRNAL RATE OF RETURN (%)
		ALT1	NO	ECO	.00	.00	.44	.44	3.5	.0	3.9	ALT1 VS ALT0	.2	81.2
				FIN	.00	.00	.54	.54	.0	.0	.5			
		ALT2	NO	ECO	.00	.76	.35	1.11	3.0	.0	4.1	ALT2 VS ALT0	.1	13.2
				FIN	.00	.88	.44	1.32	.0	.0	1.3			
		ALT3	YES	ECO	2.45	.16	.19	2.79	3.2	.0	6.0	ALT3 VS ALT0	-.4	9.1
				FIN	2.95	.17	.25	3.37	.0	.0	3.4			
SN16	53.5	NULL	NO	ECO	.00	.00	.93	.93	13.1	.0	14.0			
				FIN	.00	.00	1.18	1.18	.0	.0	1.2			
		ALT0	NO	ECO	.00	.00	.93	.93	13.1	.0	14.0			
				FIN	.00	.00	1.18	1.18	.0	.0	1.2			
		ALT1	NO	ECO	.00	.00	1.18	1.18	12.1	.0	13.3	ALT1 VS ALT0	.8	NONE
				FIN	.00	.00	1.49	1.49	.0	.0	1.5			
		ALT2	NO	ECO	.00	1.02	1.04	2.06	11.1	.0	13.2	ALT2 VS ALT0	.9	24.8
				FIN	.00	1.18	1.31	2.49	.0	.0	2.5			
		ALT3	YES	ECO	8.35	.49	.77	9.61	11.6	.0	21.2	ALT3 VS ALT0	-2.7	7.0
				FIN	10.06	.54	1.01	11.60	.0	.0	11.6			
SN17	5.0	NULL	NO	ECO	.00	.00	.09	.09	1.7	.0	1.8			
				FIN	.00	.00	.11	.11	.0	.0	.1			
		ALT0	NO	ECO	.00	.00	.09	.09	1.7	.0	1.8			
				FIN	.00	.00	.11	.11	.0	.0	.1			
		ALT1	NO	ECO	.00	.00	.14	.14	1.5	.0	1.7	ALT1 VS ALT0	.1	315.2
				FIN	.00	.00	.17	.17	.0	.0	.2			
		ALT2	NO	ECO	.00	.17	.11	.29	1.3	.0	1.6	ALT2 VS ALT0	.2	28.2
				FIN	.00	.20	.14	.34	.0	.0	.3			
		ALT3	YES	ECO	.81	.05	.06	.92	1.3	.0	2.2	ALT3 VS ALT0	.0	11.8
				FIN	.98	.06	.08	1.12	.0	.0	1.1			
SN18	25.0	NULL	NO	ECO	.00	.00	.58	.58	32.4	.0	33.0			
				FIN	.00	.00	.72	.72	.0	.0	.7			
		ALT0	NO	ECO	.00	.00	.58	.58	32.4	.0	33.0			
				FIN	.00	.00	.72	.72	.0	.0	.7			
		ALT1	NO	ECO	.00	.00	1.08	1.08	28.8	.0	29.9	ALT1 VS ALT0	3.1	NONE
				FIN	.00	.00	1.31	1.31	.0	.0	1.3			
		ALT2	NO	ECO	.00	1.41	.91	2.32	25.3	.0	27.7	ALT2 VS ALT0	5.3	110.9
				FIN	.00	1.64	1.11	2.74	.0	.0	2.7			
		ALT3	YES	ECO	6.91	.26	.32	7.48	25.4	.0	32.9	ALT3 VS ALT0	7.7	27.1
				FIN	8.04	.28	.41	8.73	.0	.0	8.7			

SUMMARY OF COSTS AND COMPARISONS BY DISCOUNT RATE : BASE
IN MILLION PNG Kina

DISCOUNT RATE = 12.00 %

LINK	ORIG LENGTH (KM)	ALT	GEN TRAF	ECO/ FIN CSTS	CONST RECON UPGRD COSTS	PERIODIC MAINT COSTS	ROUTINE MAINT COSTS	TOTAL CONST & MAINT COSTS	VEHICLE OPERATING COSTS	NET EXOGENOUS COSTS	TOTAL COSTS	COMPARISON	NET PRES VALUE	INTRNAL RATE OF RETURN (%)
SN19	27.0	NULL	NO	ECO	.00	.00	.45	.45	6.2	.0	6.6			
				FIN	.00	.00	.58	.58	.0	.0	.6			
		ALT0	NO	ECO	.00	.00	.45	.45	6.2	.0	6.6			
				FIN	.00	.00	.58	.58	.0	.0	.6			
		ALT1	NO	ECO	.00	.00	.74	.74	5.5	.0	6.2	ALT1 VS ALT0	.4	NONE
				FIN	.00	.00	.92	.92	.0	.0	.9			
		ALT2	NO	ECO	.00	1.08	.60	1.68	4.9	.0	6.6	ALT2 VS ALT0	.1	13.7
				FIN	.00	1.25	.75	2.00	.0	.0	2.0			
		ALT3	YES	ECO	4.40	.28	.32	5.00	4.9	.0	9.9	ALT3 VS ALT0	-1.8	4.2
				FIN	5.30	.30	.42	6.03	.0	.0	6.0			
SN20	41.0	NULL	NO	ECO	.00	.00	.71	.71	11.1	.0	11.8			
				FIN	.00	.00	.90	.90	.0	.0	.9			
		ALT0	NO	ECO	.00	.00	.71	.71	11.1	.0	11.8			
				FIN	.00	.00	.90	.90	.0	.0	.9			
		ALT1	NO	ECO	.00	.00	1.17	1.17	10.0	.0	11.2	ALT1 VS ALT0	.6	53.9
				FIN	.00	.00	1.46	1.46	.0	.0	1.5			
		ALT2	NO	ECO	.00	1.44	.98	2.42	9.2	.0	11.6	ALT2 VS ALT0	.2	MANY
				FIN	.00	1.67	1.23	2.90	.0	.0	2.9			
		ALT3	YES	ECO	6.69	.42	.48	7.60	8.9	.0	16.5	ALT3 VS ALT0	-2.0	7.0
				FIN	8.05	.46	.64	9.15	.0	.0	9.2			
SN21	64.0	NULL	NO	ECO	.00	.00	1.44	1.44	77.0	.0	78.4			
				FIN	.00	.00	1.79	1.79	.0	.0	1.8			
		ALT0	NO	ECO	.00	.00	1.44	1.44	77.0	.0	78.4			
				FIN	.00	.00	1.79	1.79	.0	.0	1.8			
		ALT1	NO	ECO	.00	.00	2.57	2.57	68.5	.0	71.0	ALT1 VS ALT0	7.4	NONE
				FIN	.00	.00	3.13	3.13	.0	.0	3.1			
		ALT2	NO	ECO	.00	3.14	2.19	5.32	61.4	.0	66.7	ALT2 VS ALT0	11.7	119.2
				FIN	.00	3.63	2.66	6.29	.0	.0	6.3			
		ALT3	YES	ECO	17.69	.66	.80	19.15	61.3	.0	80.4	ALT3 VS ALT0	16.1	24.6
				FIN	20.57	.72	1.05	22.34	.0	.0	22.3			
SN22	23.0	NULL	NO	ECO	.00	.00	.52	.52	19.8	.0	20.3			
				FIN	.00	.00	.65	.65	.0	.0	.6			
		ALT0	NO	ECO	.00	.00	.52	.52	19.8	.0	20.3			
				FIN	.00	.00	.65	.65	.0	.0	.6			
		ALT1	NO	ECO	.00	.00	.93	.93	17.5	.0	18.5	ALT1 VS ALT0	1.8	NONE
				FIN	.00	.00	1.13	1.13	.0	.0	1.1			
		ALT2	NO	ECO	.00	.40	.82	1.22	17.0	.0	18.2	ALT2 VS ALT0	2.0	NONE
				FIN	.00	.47	1.00	1.46	.0	.0	1.5			
		ALT3	YES	ECO	6.36	.24	.29	6.88	18.9	.0	25.8	ALT3 VS ALT0	2.0	15.8
				FIN	7.39	.26	.38	8.03	.0	.0	8.0			

SUMMARY OF COSTS AND COMPARISONS BY DISCOUNT RATE : BASE

IN MILLION PNG Kina

DISCOUNT RATE = 12.00 %

LINK	ORIG LENGTH (KM)	ALT	GEN TRAF	ECO/ FIN CSTS	CONST RECON UPGRD COSTS	PERIODIC MAINT COSTS	ROUTINE MAINT COSTS	TOTAL CONST & MAINT COSTS	VEHICLE OPERATING COSTS	NET EXOGENOUS COSTS	TOTAL COSTS	COMPARISON	NET PRES VALUE	INTRNAL RATE OF RETURN (%)
SP23	12.7	NULL	NO	ECO	.00	.00	.26	.26	8.5	.0	8.8			
				FIN	.00	.00	.33	.33	.0	.0	.3			
		ALT0	NO	ECO	.00	.00	.26	.26	8.5	.0	8.8			
				FIN	.00	.00	.33	.33	.0	.0	.3			
		ALT1	NO	ECO	.00	.00	.42	.42	7.7	.0	8.1	ALT1 VS ALT0	.7	NONE
				FIN	.00	.00	.52	.52	.0	.0	.5			
		ALT2	NO	ECO	.00	.13	.36	.49	7.7	.0	8.1	ALT2 VS ALT0	.6	NONE
				FIN	.00	.15	.45	.60	.0	.0	.6			
		ALT3	YES	ECO	2.93	.13	.16	3.22	7.4	.0	10.6	ALT3 VS ALT0	.2	13.2
				FIN	3.40	.14	.20	3.75	.0	.0	3.7			
SP24	20.0	NULL	NO	ECO	.00	.00	.38	.38	10.0	.0	10.4			
				FIN	.00	.00	.48	.48	.0	.0	.5			
		ALT0	NO	ECO	.00	.00	.38	.38	10.0	.0	10.4			
				FIN	.00	.00	.48	.48	.0	.0	.5			
		ALT1	NO	ECO	.00	.00	.59	.59	9.0	.0	9.6	ALT1 VS ALT0	.7	NONE
				FIN	.00	.00	.73	.73	.0	.0	.7			
		ALT2	NO	ECO	.00	.66	.50	1.16	8.2	.0	9.3	ALT2 VS ALT0	1.0	43.0
				FIN	.00	.77	.62	1.39	.0	.0	1.4			
		ALT3	YES	ECO	3.96	.21	.24	4.41	8.1	.0	12.5	ALT3 VS ALT0	.2	12.9
				FIN	4.61	.23	.32	5.15	.0	.0	5.1			
SP25	23.0	NULL	NO	ECO	.00	.00	.44	.44	10.4	.0	10.9			
				FIN	.00	.00	.55	.55	.0	.0	.6			
		ALT0	NO	ECO	.00	.00	.44	.44	10.4	.0	10.9			
				FIN	.00	.00	.55	.55	.0	.0	.6			
		ALT1	NO	ECO	.00	.00	.64	.64	9.5	.0	10.2	ALT1 VS ALT0	.7	313.2
				FIN	.00	.00	.79	.79	.0	.0	.8			
		ALT2	NO	ECO	.00	.77	.55	1.32	8.3	.0	9.6	ALT2 VS ALT0	1.2	34.1
				FIN	.00	.90	.69	1.58	.0	.0	1.6			
		ALT3	YES	ECO	3.75	.24	.28	4.26	7.8	.0	12.1	ALT3 VS ALT0	1.2	16.5
				FIN	4.52	.26	.36	5.14	.0	.0	5.1			

SUMMARY OF COSTS AND COMPARISONS BY DISCOUNT RATE : BASE

IN MILLION PNG Kina

DISCOUNT RATE = 12.00 %

LINK	ORIG LENGTH (KM)	ALT	GEN TRAF	ECO/ FIN CSTS	CONST RECON UPGRD COSTS	PERIODIC MAINT COSTS	ROUTINE MAINT COSTS	TOTAL CONST & MAINT COSTS	VEHICLE OPERATING COSTS	NET EXOGENOUS COSTS	TOTAL COSTS	COMPARISON	NET PRES VALUE	INTRNAL RATE OF RETURN (%)
SP26	8.3	NULL	NO	ECO	.00	.00	.14	.14	1.7	.0	1.8			
				FIN	.00	.00	.18	.18	.0	.0	.2			
		ALT0	NO	ECO	.00	.00	.14	.14	1.7	.0	1.8			
				FIN	.00	.00	.18	.18	.0	.0	.2			
		ALT1	NO	ECO	.00	.00	.20	.20	1.6	.0	1.8	ALT1 VS ALT0	.1	115.1
				FIN	.00	.00	.25	.25	.0	.0	.2			
		ALT2	NO	ECO	.00	.28	.17	.44	1.3	.0	1.8	ALT2 VS ALT0	.1	15.5
				FIN	.00	.32	.21	.53	.0	.0	.5			
		ALT3	YES	ECO	1.36	.08	.10	1.54	1.3	.0	2.8	ALT3 VS ALT0	-.6	4.2
				FIN	1.63	.08	.14	1.85	.0	.0	1.9			

Appendix G

Terms of Reference for
Detailed Design

TERMS OF REFERENCE

FOR

DETAILED DESIGN OF

ROAD UPGRADING WORKS

TABLE OF CONTENTS

1 INTRODUCTION

1.1 PROJECT DESCRIPTION

The Government of Papua New Guinea intends to carry out the upgrading of about ..... kilometres of .....in .....Province to provide a ..... metre sealed carriageway with ..... metre sealed shoulders and appropriate surface drainage. The road is a gravel pavement of varying widths. The ..... bridges along this route will be replaced or strengthened.

This design consultancy will cover the full design of the roadworks and the bridges. It is expected that the bulk of the road design will be an overlay of the existing roadway with improvements to the horizontal and vertical alignment, where appropriate, within the existing reserve.

1.2 PROJECT COORDINATION

All written communication with the Department of Transport Works and Civil Aviation (DOTWCA) should be addressed to the Secretary, and marked for the attention of the ..... although responsibility for most of the day to day communications will be delegated to a Project Engineer.

Where communications with the approvals from the DOTWCA are referred to in this document, the Consultant should read this as meaning the Secretary or the Secretary's Representative unless otherwise noted.

The Secretary's Representative shall be kept fully informed as to the conclusions reached during the progress of the work in respect of any factors, considerations or circumstances which may influence the development by the Consultant of design concept or details.

1.3 PROJECT SCHEDULE

Proposed commencement date	.....
Submission of Preliminary Design and Report	.....
Completion of Final Design and Documentation	.....
Submission of Final Design Report	.....

2 DESIGN PROCESS

The breakdown of the Design Process is listed below, together with the documents to be produced, and the timing for each part of the design and for each document.

2.1 INVESTIGATION

2.1.1 Purpose

To gather and collate all the information needed for the design.

2.1.2 Timing

As required for Preliminary and Final Design and Report Deadlines.

2.2 PRELIMINARY DESIGN

2.2.1 Purpose

Road: To determine and fix standards for all of the parameters for the Final Design, including but not necessarily limited to:

- Horizontal Alignment
- Vertical Alignment
- Pavement Design
- Drainage
- Typical Cross-Sections

Bridge: To collect and review all data appropriate to the Scope of Works set out in the Bridge Replacement and Rehabilitation Programme, Invitation for Consultant's Proposals, march 1994."

2.2.2 Reviews

DOTWCA shall regularly review the designs during the preliminary design phase. The Consultant shall coordinate regular meetings for this purpose. Reviews for the road should occur at about 10 km sections and for the bridge prior to the final decision on the horizontal and vertical alignments and during the abutment and deck design. The Preliminary Design will also be reviewed prior to final printing. The Consultant shall allow a two (2) week period for this review.

2.2.3 Timing

To be completed by the .....

2.2.4 Approval

Approval to proceed to the Final Design will not be given until the Preliminary Design is approved.

2.2.5 Reports

Preliminary Design Report to be submitted by .....

2.3 FINAL DESIGN

2.3.1 Purpose

To prepare and document:

- the design
- the quantity calculations; and
- the bridge contract documents

2.3.2 Timing

To be completed by the .....

2.3.3 Review

DOTWCA will review the Final Design Report prior to final printing so that any final amendments can be made.

2.3.4 Approval

The design will only be accepted when it is approved by DOTWCA.

2.3.5 Reports

Final Design Report to be submitted by .....

2.4 DOCUMENTATION

The following table outlines the formal reports to be generated from this project.

Stages	Report Name	No Copies	Required by
All	Monthly Report	Four	15th of each month
Preliminary	Preliminary Design Report	Six	.....
Final Design	Final Design Report	Six	.....

The Preliminary and Final Design Reports shall each be neatly bound in one or more volumes (s). Monthly reports need not be bound.

2.5 MONTHLY REPORT

A monthly report shall be submitted, in an approved format, in duplicate by the 15th of the month following the month the report is to cover. The purpose of the report is to enable DOTWCA management to monitor the Consultant's progress. The report should detail progress of the design, difficulties encountered, decisions made and the expected programme for completion of each stage of the work. It is expected that the Consultant's monthly claims will accompany these reports and these must be in the format indicated.

3 INVESTIGATION

The purpose of the Investigation is to gather and collate all the information needed for the design. Where possible the DOTWCA will make available to the Consultant any relevant information and will assist the Consultant in obtaining information from other departments. All the relevant information shall be included in the Final Design Report, its appendices or a sub-report.

3.1 DESKTOP STUDY

All relevant plans, survey, aerial photography and previous reports will be made available to the Consultant. The Consultant should also liaise with the Office of Works in ..... Province.

3.2 MATERIALS INVESTIGATION

The purpose of the materials investigation work is to:

- Review and assess existing reports including ..... regarding existing and potential sources of road making materials and the bearing strengths of the existing pavement and/or the sub-grade.
- Assess slope stabilities throughout the route. A minimum requirement is that the standard earthworks batter slopes are checked for suitability for use on this project.

Where the DOTWCA has other reports on existing sources, these will be made available to the Consultant.

The Consultant's program for sub-surface site investigations and testing shall be submitted to the DOTWCA for approval before commencement.

All laboratory testing of materials shall be carried out by the DOTWCA Materials Testing Laboratory. Responsibility for the proper execution of this work and interpretation of the results will however rest solely with the Consultant.

If, as a result of the materials investigation, further testing is considered necessary, the type and location of this testing should be clearly shown in the Preliminary Design Report.

3.3 SURVEY

A survey of the entire route within the existing road reserve has already been carried out and this will be made available to the Consultant. However, it is the Consultant's responsibility to ensure that the details shown are accurate. Should the Consultant consider that additional survey is required, whether through changed conditions since the original survey was completed or to cover areas of anticipated realignment, then this should be indicated and costed in the Consultant's submission.

3.4 CONSTRUCTION COSTS

The Consultant should gather sufficient data on relevant, recent construction costs so as to enable him to derive rates for use in an estimate of cost in Bill of Quantities format. Typical sources of data for road construction would include recent Provincial works contracts and local contractors and for bridge construction recent DOTWCA contracts.

4 PRELIMINARY DESIGN

The purpose of the Preliminary Design is to determine and fix the standards for all of the parameters for the Final Design. It is incumbent upon the Consultant to liaise closely with the DOTWCA, since the Final Design will not be allowed to start until the Preliminary Design (as embodied in the Preliminary Design Report) is approved.

4.1 ROADS

4.1.1 Geometric Design

The geometric design is to be carried out in accordance with Part 2 of the Department of Works Road Design Manual and the desired parameters as defined by DOTWCA. These should be reviewed and assessed, by the Consultant, in the light of a detailed route inspection to develop the preliminary horizontal and vertical alignments. The comments, by the Consultant, on where he feels these standards should be altered in any location shall form part of the Preliminary report.

The preliminary design process should involve frequent liaison with, and regular reviews by DOTWCA.

4.1.2 Pavement Design

A pavement design shall be carried out as part of this contract.

In almost all situations where the new route location occupies the existing alignment, an overlay design should be used with the existing construction incorporated into the new pavement as sub-base, and with an increased thickness as appropriate to confirm to the pavement design. Total pavement thicknesses shall be based on the existing pavement/subgrade strengths determined by the materials investigation.

The Consultant shall carry out pavement design in accordance with 'Road Note 31. 'A Guide to the Structural Design of bitumen Surfaced Roads in Tropical Countries'. The pavement design traffic loading shall be .....ESA's.

4.1.3 Environmental Impact Study

The Consultant shall carry out an assessment of the environmental implications of the upgrading work, with recommendations for measures which should be considered to mitigate adverse effects wherever possible.

4.2 BRIDGES

It is expected that the investigation phase for the bridge will lead to a recommended solution which can be taken to final design without further consideration.

In line with current DOTWCA policy, piled abutments should be considered for all permanent bridges (expect where they are founded on rock). Designs should be such that abutment protection works are avoided if possible.

The following references should be used in making the assessments of and carrying out any designs for the bridges:

- ..... (AusRoads or NAASRA). Design loads are to be used in accordance with "PNG" Design Standards, Section 2 – Design Loads". Live loading is to be T44 and checked for PNG overload.
- "Earthquake Engineering for Bridges in PNG", 1985 revised edition.
- PNG "Flood Estimation Manual" Revised edition 1990.
- Application of Earthquake Engineering to Bridge Construction, 1985.
- Commentary on the design of specific bridges in PNG with respect to Earthquake 1976.
- Department of Works Guide-lines for Bridge Works Design Brief October, 1990.

It is expected that these preliminary bridge designs will be sufficient to establish the appropriate dimensions of the main bridging components and hence to make an estimate of cost in accordance with Section 4.7.

4.3 DRAINAGE STRUCTURES

The Consultant shall report on the present condition of all culverts, their anticipated residual life and any maintenance or repair work necessary if the culverts are to be retained. The Consultant shall be expected to carry out the following as a minimum:

- Assess the surface runoff from the areas discharging into the drainage structure compared with its capacity.
- Investigate the present condition and recommend if the culvert is to be replaced or extended.
- Identify and recommend the type of any new drainage structure to be designed.
- Assess and indicate if the Department of Works Standard design can be utilised in the construction (Standard designs should be used wherever possible).

The Preliminary Design Report should contain a list of proposals for drainage structures – possibly in the form of a culvert schedule (a draft of that to be produced for the Final Design Report).

All design shall be according to the guide-lines contained in the following:

- "Flood Estimation Manual – 1990"
- "Manual for the Design of Drainage Structures for Rural Roads – Volumes 1 & 2."

4.4 SPECIAL DESIGN ASPECTS

The Consultant will incorporate the need for the provision of PMV stops and/or pedestrian walkways, particularly around the local market areas throughout the length of the Project. The aim is to try to avoid heavy pedestrian traffic and the congregation PMV"s on the carriageway.

4.5 PRELIMINARY ESTIMATE

The Consultant shall review those rates for road and bridge works items which he has compiled as part of the investigation and shall prepare an estimate of cost for the Project using the Bill of Quantities format.

The quantities to be used shall be those derived from the preliminary design. Where BOQ items have not been quantified, the Consultant shall make his best estimate of these quantities based on the work done.

4.6 DRAWINGS

The Consultant shall propose the Drawing List and the format for each type of drawing based on the list in Section 5.6 – Final Design, Drawings. The Preliminary Design Report will show this information as modified and approved by the DOTWCA.

Drawings to be presented with the Preliminary Design Report should include –

4.6.1 Roads

1. Plans showing the surveyed detail and the preliminary horizontal alignment.

2. Preliminary longitudinal sections showing existing and finished levels and vertical curve details.

3. Preliminary cross sections without annotations except for chainages. These are intended to give an indication of position only. It is expected that on an A1 sheet, there will be 8 to 10 columns, each with 10 to 15 cross sections.

4.6.2 Bridges

As set out in "BRRP Invitation for Consultants Proposals, March 1994".

Drawings should be presented in a form requiring little or no drafting involvement beyond normal computer aided design output.

4.7 BRIDGE TENDER DOCUMENTS

The Consultant shall propose the format for the Bridge Tender Documents. The approved Table of Contents for each volume of the Tender Documents and a draft Bill of Quantities shall be included in the Preliminary Design Report.

4.8 SITE INSPECTION

The Consultant is expected to become completely familiar with every aspect of the site. He will be expected to carry out informal site inspections with DOTWCA from time to time to clarify proposed alternatives for the Preliminary Design.

The Consultant shall organise an official site inspection with appropriate officials from Department of Works and the Provincial Government when he has received substantial approval from the Preliminary Design. The draft report is to incorporate the decisions stemming from the site inspection.

4.9 PRELIMINARY DESIGN REPORT

The Preliminary Design Report shall be in an approved format and shall contain at least all the parameters determined under sections 4.1 to 4.6. The Consultant is to prepare the report in consultation with the DOTWCA regularly reviewing the parameters and objectives throughout the period leading up to the submission of the report.

5 FINAL DESIGN

The purpose of the Final Design is to implement and complete all engineering and quantity calculations based on the parameters established in the Preliminary Design; to prepare the drawings; to completely document all aspects of the design; and to prepare the bridge contract documents for tendering.

5.1 ROADS

The Consultant shall carry out final design of the road in accordance with the standards detailed in the preliminary design report. The Consultant will be required to produce construction tables and drawings.

5.1.1 Alignment

This is the stage where the Cross Sections are applied and the Horizontal and Vertical Alignments are refined in accordance with the standards and parameters established in the Preliminary Design. Any requirement for significantly altering those alignments or parameters must be approved by the Department of Works.

5.1.2 Cross Section

The typical cross sections will be defined by the DOTWCA or as subsequently amended in the Preliminary Design Report.

5.2 BRIDGES

After the DOTWCA review of the recommendations in the Preliminary Design Report and any further discussions with the Consultant, the DOTWCA will give approval for the final Design to proceed.

It is expected that final bridge design will consist of:

- Production of detailed design drawings for each bridge including reinforcement schedules.
- Detailed structural calculations.
- Foundation design.

The bridge component of the Final Design Report should include at least the following:

- Reference to the Preliminary Design Report.
- Schedule of quantities and rates prepared in accordance with Department of Works" "Specification for Road and Bridge Works."

- A resume of limiting design criteria, especially, earthquake design.
- Construction notes.

5.3 DRAINAGE STRUCTURES

The final culvert design should consists only of a refinement of the recommendations of the Preliminary Design Report and presentation of them in the form of a culvert schedule.

5.4 SPECIFIC DESIGN ASPECTS

This section shall consist of a refinement of the recommendations in the Preliminary Design Report and DOTWCA comments.

5.5 ESTIMATE

The DOTWCA will review the Consultant's estimate and complement, as required, those rates for roadwork items derived from similar projects carried out recently. Consideration shall be given to the suitability of the rates in the light of any special construction requirements. The Consultant will then prepare an estimate of cost for the Project utilising the Bill of Quantities format prepared for the Preliminary Estimate.

All rates and quantities shall be justified with appropriate documentation and calculations. These shall be ordered/indexed in a manner so as to make for easy checking and reference. It is not necessary that this be typed, however it should be presented in a neat, legible, clear and concise format.

5.6 DRAWINGS

Drawings shall be prepared on standard DOTWCA sheets to the agreed format and scales. Drawings to be prepared for the Project should include but not necessarily be restricted to the following:

5.6.1 Road Drawings

1. List of drawings with legend for symbols used.
2. Location Plan/Site Plan drawing.
3. Engineering Layout Plan/Longitudinal Section, matched for each sheet with the plan shown at the top, (1:2000).
4. Typical cross-sections, (1:100).
5. Drainage and culvert details including culvert schedule.
6. Detailed cross-sections, (1:250).
7. Miscellaneous details including guardrails, traffic signs, accesses etc.
8. Construction tables in an approved format.

5.6.2 Bridge Drawings

As set out in 'BRRP Invitation for Consultants Proposals, March 1994".

All drawings are to be prepared on A1 size standard DOTWCA sheets to an agreed format and recommended scales.

Drawing numbers will be issued by DOTWCA to the Consultant as required.

Standard DOTWCA details should be used (eg inlet pits, headwalls, etc).

5.7 BRIDGE CONTRACT DOCUMENTATION

The Consultant shall prepare contract documents for construction implementation of each bridge, suitable for bidding in accordance with the DOTWCA standard practice. The Contract document description shall include:

- Instructions to Tenderers.
- Conditions of Contracts (Part 2).
- The Specification shall be the Department of Works 'Specification for Road and Bridge Works', November 1978 including amendments.
- Drawings.
- Materials Investigation.
- Bill of Quantities.
- Other Special Considerations.

An original complete set of contract documents plus 20 bound copy sets with drawings reduced to A3 size shall be submitted, at the same time as the Final Design Report, to the DOTWCA.

5.8 SITE INSPECTION

The Consultant will undertake a site inspection of the Project with the DOTWCA immediately prior to the submission of the draft Final Design Report. Comments and recommendations resulting from this site inspection shall be incorporated into the report.

5.9 FINAL DESIGN REPORT

The purpose of the Final Design Report is to fully describe and justify every aspect of the design. It is to be a compilation of:

- All the information gathered during the investigation.
- All the design parameters selected and decisions made during the Preliminary Design Report.
- A complete description and justification for every design aspect, decision and quantity.
- A full copy of all correspondence generated during the Consultancy.

The format for the Final Design Report shall be provided by the DOTWCA.

6 INFORMATION TO BE SUPPLIED TO THE CONSULTANT

6.1 GENERAL

The DOTWCA will co-operate with the Consultant to provide reasonable assistance to facilitate the provision of the consultancy services and achieve the objectives of the Project. In particular, where the co-operation of other Government Departments or public agencies is required, the Department of Works will provide liaison to ensure wherever possible, that the Consultant has access to necessary information. The Consultant should not however rely on direct assistance except in those circumstances specified in these Terms of Reference.

6.2 INFORMATION TO BE MADE AVAILABLE

The DOTWCA will make available to the Consultant all relevant Government information for copying or purchase when required including:

- ❑ Any maps, plans, aerial photography and survey or other data.
- ❑ A copy of a typical DOTWCA bridge contract
- ❑ Earthquake Manual.
- ❑ River Training Manual.
- ❑ Department of Works 'Road Design Manual', April 1985 edition.
- ❑ PNG 'Flood Estimation Manual', December 1990.
- ❑ Department of Works 'Standard Survey Instructions', July 1983.
- ❑ Department of Works 'Manual for the Design of Drainage Structures for Rural Roads'.
- ❑ Bridge reports.

Department of Works 'Specification for Road and Bridge Works', November 1978.

6.3 EQUIPMENT AND FACILITIES

All facilities such as computer facilities, accommodation, office, services and vehicles are to be provided by the Consultant.

7 ADMINISTRATION

7.1 TECHNICAL STAFF REQUIREMENTS

It is expected that the Consultant's Staff will be led by a Project Manager with extensive experience of managing detailed design assignments of a similar nature in developing countries.

The assigned team will consist of personnel with engineering skills in road, bridge and drainage design, some of which should have been gained in Papua New Guinea. The person(s) responsible for the technical engineering aspects of the design shall have current Registration with the Society of Professional Engineers, PNG.

The Consultant's team should include person(s) with particular experience in contract documentation and preparation and should show specific provision for quality assurance.

The project team should show participation by Papua New Guinea Nationals at a level appropriate to their previously acquired skills, such that participation in the project will serve to develop these skills.

7.2 TIME SCHEDULE AND ORDER OF WORK

For timing purposes, the first week of the consultancy shall be the week starting on the Monday following the day on which the letter of acceptance is hand delivered, faxed or couriered to the Consultant. It is expected that the contract will be awarded in early .....

To fit in with the proposed start of construction under the DOTWCA Program, the completed and approved Final Design report must be submitted by the .....

In his works schedule, the Consultant should include allowance for:

Two (2) week period for formal review of the Preliminary Design Report by the DOTWCA.

Two (2) week period for formal review of the Final Design Report by the DOTWCA.

The Consultant shall develop his work programme within the constraints given in this TOR.

Appendix H

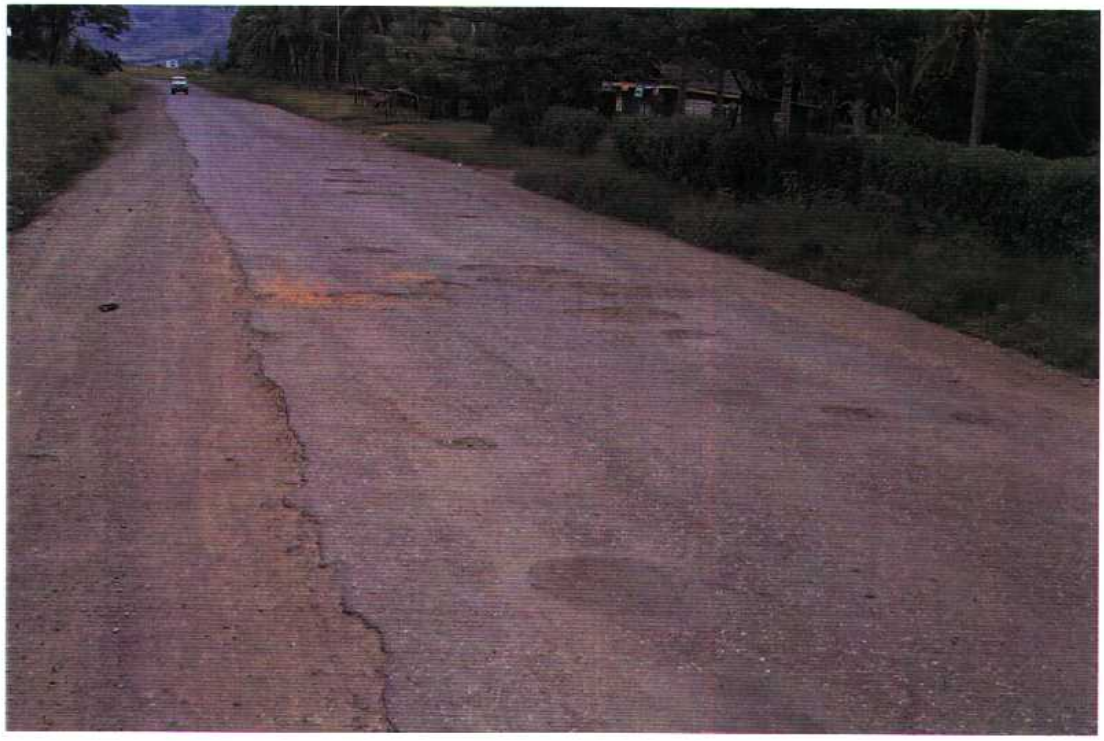
Photographs

MOROBE PROVINCE

Wau Road: Upgrading works underway

Aseki Road-Paruara to Aseki Section: Very poor earth pavement with no drainage in mountainous terrain. Timber placed across road section in an attempt to improve traction.

MOROBE PROVINCE



Highlands Highway near Lae: Poor section of seal

Highlands Highway: Major erosion damage from realigned river

EASTERN HIGHLANDS PROVINCE

Duantina - Dumpu Road: Narrow gravel road with poor side drains and encroachment by housing and gardens

Duantina - Dumpu Road: Vegetation clearing by villagers

EASTERN HIGHLANDS PROVINCE

Asaro - Lapego Road: Deteriorated seal with inadequate drainage and no vegetation clearing

Raipinga - Okapa Road: Bailey bridge in poor condition and not passable by vehicle due to missing deck timbers and failed abutment

SOUTHERN HIGHLANDS PROVINCE

Kutubu Access Road in Southern Highlands Province

Highlands Highway - Mendi - Kisenpoi Section: Widening of existing formation as part of upgrading works

SOUTHERN HIGHLANDS PROVINCE

Highlands Highway - Mendi - Kisenpoi Section: Major quarry used to supply materials for upgrading works underway.

Koroba Road, Mendi - Tari Section: Major bog hole on gravel road