Government of Guyana
Inter-American Development Bank

Sheriff Street Mandela Avenue Roadway

Economic Feasibility Report

November 2011
Ministry of Public Works & Communications

Mott MacDonald

Sheriff Street Mandela Avenue Roadway

Economic Feasibility Report

November 2011

Ministry of Public Works & Communications

Fort Street, Kingston, Georgetown, Guyana

Mott MacDonald, Stoneham Place, Stoneham Lane, Southampton SO50 9NW, United Kingdom
T +44(0) 23 8062 8800 F +44(0) 23 8062 8801, W www.mottmac.com

Issue and revision record

Revision	Date	Originator	Checker	Approver	Description
A	12 May 2011	Jan Dytrych	Ondrej Kokes Jamie Roan	Stuart Hughes	First Issue
B	28 November 2011	Jan Dytrych	Ondrej Kokes Jamie Roan	Stuart Hughes	Comments received from client incorporated into document

Mott MacDonald, Stoneham Place, Stoneham Lane, Southampton SO50 9NW, United Kingdom
T +44(0) 23 8062 8800 F +44(0) 23 8062 8801, W www.mottmac.com

Content

Chapter	Title	Page
Executive Summary		i
1.	Economic Evaluation	1
1.1	HDM-4 Analytical Framework	1
1.2	Adaptation and Calibration of the HDM-4 Model	1
1.2.1	Road User Effects (RUE)	2
1.2.2	Road Deterioration and Works Effects	3
1.2.3	Traffic	3
1.2.4	General	4
1.3	Modelled Scenarios	4
1.4	Construction Costs	4
1.5	Results of Economic Assessment	5
1.6	Sensitivity Tests	6
Appendices		8
Appendix A.	Vehicle Operating Costs	9
A.1.	Road User Effects (RUE)	9
A.2.	Vehicle Operating Costs	9
A.2.1.	Economic and financial costs	9
A.2.2.	New vehicle price	9
A.2.3.	Fuel and lubricant costs	10
A.2.4.	Tyre cost	10
A.2.5.	Maintenance labour	10
A.2.6.	Crew wage	11
A.2.7.	Interest rate	11
A.2.8.	Utilisation	11
A.2.9.	Unit Vehicle Operating Costs	12
Appendix B.	Technical and economic parameters and evaluation	14
B.1.	Technical parameters	14
B.1.1.	Four Lane Roadway	14
B.1.2.	Four Lanes at Selected Sections	15
B.1.3.	Traffic Signal Improvements	15
B.2.	Economic Assessment Approach and Methodology	15
B.2.1.	Overview	15
B.2.2.	The HDM-4 Model	16
B.3.	Adaptation and Calibration of the HDM-4 Model	17
B.4.	Road User Effects (RUE)	17
B.5.	Road Deterioration and Works Effects	20
B.6.	Traffic	21
B.7.	Scheme Modelling	22
B.7.1.	Road Network	22
B.8.	Traffic Data	23
B.9.	HDM-4 Economic model calibration	25
B.10.	Capital Costs	25
B.10.1.	Construction Costs	25

B.10.2. Residual value 25
B.11. Economic Assessment 26
B.12. Sensitivity Tests 28
B.13. Conclusions 29
Appendix C. Cash Flow 30
C.1. Option 1 30
C.2. Option 2 32
C.3. Option 3 34
Appendix D. Economic Analysis Summary 37

Executive Summary

The Highways Development and Management Model 4 (HDM-4) the latest version 2.08 was used for the economic modelling. The economic assessment using HDM-4 was conducted for Option 1, Option 2 and Option 3 which represent various scenarios of Sheriff Street / Mandela Avenue improvement. The construction costs for individual packages range from US$ 17.501 million for Option 3 to US$ 27.027 million for Option 1. Used economic cost includes all construction cost, preliminary cost and contingency of 10%.

The average value of basic traffic flows (AADT) used in the HDM-4 model for existing route is about 10 thousand vehicles for each direction (year 2011). The figures are based on the traffic surveys carried out along Sheriff Street / Mandela Avenue. Future traffic flows were imputed into HDM-4 according to traffic forecast based on growth factors which vary from 4% to 5.6% per annum.

The economic assessment was based on a 20 year analysis period (including construction period of 2 years) and a discount rate of 12% was applied. The results of the economic assessment show that the Project in all analysed options generates reasonable economic efficiency benefits (EIRR from 25.8% to 32.7% for individual options).

A sensitivity analysis was carried out taking into account uncertainty regarding the construction costs and traffic forecast and also parameters like the overall time benefits and VOC benefits. The sensitivity tests confirmed the continuing viability of the schemes given a more than 20% increase in scheme costs for all options.

1. Economic Evaluation

The economic appraisal was based on a conventional cost-benefit analysis technique whereby the agency costs (construction and maintenance) and road user costs associated with the existing network (base case) are compared with the costs of the improved network (project case) using a discounted cash-flow analysis technique. The Highways Development and Management Model 4 (HDM-4) the latest version 2.08 was used for the economic modelling.

1.1 HDM-4 Analytical Framework

The HDM-4 analytical framework is based on the concept of pavement life cycle analysis. This is applied to predict the following over the life cycle of a road pavement, which is typically 15 to 40 years:

- Road deterioration;
- Road work effects;
- Road user effects; and
- Socio - Economic and Environmental effects.

Once constructed, road pavements deteriorate as a consequence of several factors (traffic loading, environmental weathering and the effect of inadequate drainage systems). The rate of pavement deterioration is directly affected by the standards of maintenance applied to repair defects on the pavement surface such as cracking, ravelling, potholes, etc., or to preserve the structural integrity of the pavement (for example, surface treatments, overlays, etc.), thereby permitting the road to carry traffic in accordance with its design function. The overall long-term condition of road pavements directly depends on the maintenance or improvement standards applied to the road.

The impacts of the road condition, as well the road design standards, on road users are measured in terms of road user costs, and other social and environmental effects. Road user costs comprise:

- Vehicle operation costs (fuel, tyres, oil, spare parts consumption; vehicle depreciation and utilisation, etc.);
- Costs of travel time; and
- Costs to the economy of road accidents (that is, loss of life, injury to road users, damage to vehicles and other roadside objects).

Road User Costs in HDM-4 are calculated by predicting physical quantities of resource consumption and then multiplying these quantities by the corresponding user specified unit costs.

Economic benefits from road investments are then determined by comparing the total cost streams for various road works and construction alternatives against a base case (without project or do minimum) alternative, usually representing the minimum standard of routine maintenance. HDM-4 is designed to make comparative cost estimates and economic analyses of different investment options. It estimates the costs for a large number of alternatives year-by-year for a user-defined analysis period. All future costs are discounted to the specified base year. In order to make these comparisons, detailed specifications of investment programmes, design standards, and maintenance alternatives are needed, together with unit costs, projected traffic volumes, and environmental conditions.

1.2 Adaptation and Calibration of the HDM-4 Model

Before an economic assessment can be created it is necessary to adapt and calibrate the relationships in the HDM-4 models to reflect local conditions. Three levels of HDM-4 calibration generally exist and Level 1

of the calibration was carried out for EBD Public Road project in the end of year 2010. The calibrated parameters were relevant also for Guyana Sheriff Street / Mandela Avenue Project and therefore were used for the economic evaluation.

A Level 1 calibration is usually based on secondary sources like existing studies, government publications, local statistics and standards. The following input data should be identified for a Level 1 calibration:

- Unit costs (Road User Costs and Road Deterioration and Works Effects);
- Characteristics of representative vehicles;
- Economic analysis data (discount rates and analysis period);
- Traffic data; and
- Regional climate type

Key data, and in particular unit cost data, needed for the calibration was collected from local surveys and other Guyanese sources.

HDM-4 consists of a number of sub-models and relationships, which were grouped together as follows:

- Road User Effects;
- Road Deterioration and Works Effects;
- Traffic; and
- General.

The details concern with the adaptation and calibration of HDM-4 model are described in Appendix E and Appendix F. A brief summary is set out in this chapter.

1.2.1 Road User Effects (RUE)

The RUE model predicts vehicle speeds and operating resources as functions of the characteristics of each type of vehicle and the geometry, surface type and current condition of the road, under both free flow and congested traffic conditions.

HDM-4 allows for two types of costs; economic and financial, although the economic costs are those generally used in analyses. The financial costs are the market costs. The economic costs are the market costs net of (excluding) taxes and subsidies. Only the economic costs were estimated for the purpose of the economic assessment. These economic costs were derived directly from relevant sources and any factors for conversion from financial costs were not therefore used (see Appendix E and Appendix F).

Vehicle Operating Costs

The following components of vehicle operating cost (VOC) are considered in HDM-4, and each has its separate model:

- Fuel consumption;
- Lubricating oil consumption;
- Tyre wear;
- Parts consumption;
- Maintenance labour hours;
- Depreciation;
- Interest;
- Crew hours; and
- Overheads.

VOC unit economic costs used for HDM-4 calibration are set out in Table 1.1. For more details see Appendix E. HDM-4 default values were used for physical characteristic of individual vehicle types.

Table 1.1: Vehicle Operating Costs Input Data

	Motorcycle	Car	Pick up / van	Minibus	Light Truck	Med. Truck	Heavy Truck
New vehicle price less tyres (US $)	2,495	10,042	17,123	13,572	17,712	38,379	88,985
New tyre price (US $)	40	100	200	180	210	310	410
Maintenance labour per hour US $/hour	1.77	1.77	1.77	1.77	1.77	1.77	1.77
Crew wages per hour US $/hour				2.32	1.74	1.74	1.74
Fuel US $/litre	0.58	0.58	0.58	0.58	0.61	0.61	0.61
Lubricant US $/litre	2.7	2.7	2.7	2.7	2.7	2.7	2.7
Interest rate	12%	12%	12%	12%	12%	12%	12%

Travel Time Costs

A resource based approach was used to derive unit travel time costs, using the average employment cost value. The average employment cost for the Guyana was G$ 313.2 per hour in year 2009. This was based on the published average employment cost of G$ 650,114 per year (official statistic data of the Ministry of Labour, Human Services and Social Security). An average of travel time costs was calculated as US$ 0.82 per hour. The calculation sheet is set out in Appendix F (Chapter F.3.1.)

Effect of benefits from accident costs savings were not considered due to lack of input data (types and reasons of the accidents on existing sections on Sheriff Street / Mandela Avenue). However, this fact does not affect the economic assessment results significantly because the proportion of these savings in overall benefits figures is usually relatively low in such type of project.

1.2.2 Road Deterioration and Works Effects

HDM-4 includes relationships for modelling Road Deterioration (RD) and Road Works Effects (WE). These are used for the purpose of predicting annual road condition and for evaluating road works strategies. The relationships link standards and costs for road construction and maintenance to road user costs through road user cost models. The HDM-4 default parameters were used for RDWE modelling. The unit economic costs for maintenance standards were estimated using Guyanese sources and our experience:

- Routine Maintenance Costs;
  - Average cost per km per year on existing road sections is US$ 2,970
  - Average cost per km per year on new road sections is US$ 1,500
- Periodic Maintenance Costs:
  - Unit cost was assumed about US$ 10.4 per square meter

See Appendix F (Chapter F.3.2.) for more details.

1.2.3 Traffic

For calibration of these submodels were used mostly the HDM-4 default values but also previous study carried in Guyana and data from the surveys carried out along the Sheriff Street / Mandela Avenue (the journey time surveys and automatic traffic counts). Total annual traffic volumes were estimated using traffic surveys and other relevant informations. The total annual traffic volumes were capped by the available

capacity available in the improved junctions. This was calculated using calibrated junction modelling software. See the Technical Analysis Report for further details.

1.2.4 General

A Climate Parameters were calibrated in this group of parameters. The statistics data concern with the average temperatures and rainfalls were available in Guiana. For other parameters were used HDM-4 default data relevant for Climate Type. Used parameters are set out in Table 1.2.

Table 1.2: Climate Parameters

Description	Unit	Value
Name	Text	Guyana
Moisture Classification	HDM-4 default classification	Humid
Thornthwaite Moisture Index	Number	60
Duration of Dry Season	Fraction of a year	2
Mean Monthly Precipitation	mm	197
Temperature Classification	HDM-4 default classification	Tropical
Mean Temperature	0C	27
Average Temperature Range	0C	6.2
Days Temperature > 320C	Days	100
Freezing Index	C-days	0
Percentage of Time Driven on Snow Covered Roads	%	0
Percentage of Time Driven on Water Covered Roads	%	15

1.3 Modelled Scenarios

The economic assessment was conducted for Option 1, Option 2 and Option 3 which represent various scenarios of improvement of Sheriff Street / Mandela Avenue. All individual options were modelled independently in HDM-4 software. Each HDM-4 project consists of a Base Case “Do Minimum” and Project Case “Do Something”. The sections of the whole affected existing road network were created in HDM-4 workspace for “Do Minimum” scenario. The sections of new/upgraded road were then considered in a “Do Something” scenarios for individual proposed options. Description of modelled options is set out in Table 1.3.

Table 1.3: Modelled Options

Option	Description
Option 1	Junction improvements, 4-Laning the entire roadway, pavement rehabilitation
Option 2	Junction improvements, selected 4-laning (Duncan Street to Railway Embankment, Durban Street to Homestretch Avenue), pavement rehabilitation
Option 3	Junction improvements, pavement rehabilitation

1.4 Construction Costs

The capital costs used in the assessment included all construction costs, preliminary cost and contingency of 10% (see Table 1.4).

Table 1.4: Cost Summary

No.	Option	Capital Cost (US $)
1	Option 1	27,027,157
2	Option 2	20,708,119
3	Option 3	17,501,981

1.5 Results of Economic Assessment

The economic assessment using HDM-4 was conducted for Option 1, Option 2 and Option 3 as mentioned above. The results of the assessment are set out in Table 1.5 These were based on a 20 year analysis period (including construction period of 2 years) using a discount rate of 12%, assuming all sections will be opened in year 2013. Residual values for the new road sections were included in the last year of appraisal. A summary of economic costs and benefits for each scenario is included in Table 1.6.

The primary calculated economic criteria are the net present value of the investment (NPV), the economic internal rate of return (EIRR) and the benefit cost ratio (BCR).

The results of the economic assessment show that the Project in all analysed options generates reasonable economic efficiency benefits.

Table 1.5: Results of Economic Appraisal

Option	EIRR (1) %	NPV (2) US$ mil	BCR(3)
Option 1	32.65%	86.90	4.73
Option 2	28.17%	34.13	3.23
Option 3	25.76%	28.95	2.89

Notes: 1. Economic Internal rate of Return, 2. Net Present Value in US$ million at 12% discount rate, 3. Benefit cost ratio

Table 1.6: Summary of Economic Costs and Benefits

	Increase in Road Agency Costs		Savings in VOC	Savings in Travel Time Costs	Net Economic Benefits
	Capital	Recurrent			
Option 1					
Undiscounted	13.76	0.27	269.42	195.19	450.56
Discounted	23.28	-0.17	64.96	45.05	86.90
Option 2					
Undiscounted	10.31	-0.16	118.79	69.62	178.25
Discounted	15.24	-0.28	31.71	17.38	34.13
Option 3					
Undiscounted	10.31	-0.30	109.93	61.98	161.89
Discounted	15.24	-0.32	28.96	14.91	28.95

1.6 Sensitivity Tests

Capital costs and traffic forecast are the most important variables in the economic assessment. A sensitivity analysis, therefore, was carried out taking into account uncertainty regarding these parameters and also the overall time benefits and VOC benefits.

The sensitivity tests were carried out for increase of the key parameters as well as for decrease of these parameters. The tested parameters were as follows:

- Traffic;
- Traffic growth;
- Capital Costs;
- Value of time; and
- Vehicle operating costs.

The results of the sensitivity tests are shown in Table 1.7.

Table 1.7: Sensitivity Tests (Economic Internal Rate of Return %)

Scenario	Central Case	Traffic			
		-10%	-20%	+10%	+20%
Option 1	32.7%	25.5%	19.4%	41.4%	51.9%
Option 2	28.2%	22.7%	18.0%	34.6%	41.4%
Option 3	25.8%	20.6%	16.1%	31.8%	38.2%

Scenario	Central Case	Traffic Growth			
		-10%	-20%	+10%	+20%
Option 1	32.7%	29.5%	26.3%	35.8%	38.8%
Option 2	28.2%	24.2%	20.2%	32.2%	36.0%
Option 3	25.8%	21.7%	17.6%	29.8%	33.7%

Scenario	Central Case	Capital Costs			
		-10%	-20%	+10%	+20%
Option 1	32.7%	34.7%	37.2%	30.9%	29.4%
Option 2	28.2%	30.2%	32.5%	26.5%	25.0%
Option 3	25.8%	27.5%	29.7%	24.2%	22.9%

Scenario	Central Case	Value of Time			
		-10%	-20%	+10%	+20%
Option 1	32.7%	31.9%	31.2%	33.4%	34.0%
Option 2	28.2%	27.6%	27.0%	28.8%	29.3%
Option 3	25.8%	25.3%	24.8%	26.2%	26.7%

Scenario	Central Case	Vehicle Operating Costs			
		-10%	-20%	+10%	+20%
Option 1	32.7%	31.5%	30.3%	33.8%	34.9%
Option 2	28.2%	26.9%	25.7%	29.4%	30.6%
Option 3	25.8%	24.6%	23.5%	26.9%	28.0%

Appendices

Appendix A. Vehicle Operating Costs 9
Appendix B. Technical and economic parameters and evaluation 14
Appendix C. Cash Flow 30
Appendix D. Economic Analysis Summary 37

Appendix A. Vehicle Operating Costs

A.1. Road User Effects (RUE)

The HDM-4 RUE model predicts vehicle speeds and operating resources as functions of the characteristics of each type of vehicle and the geometry, surface type and current condition of the road, under both free flow and congested traffic conditions. The operating costs are obtained by multiplying the predicted quantities for the various resource components by the unit costs or prices, which are specified by the user in financial or economic terms.

A.2. Vehicle Operating Costs

The HDM-4 RUE model operates by predicting the amount of resources consumed and multiplying them by the unit costs. It is therefore necessary to supply unit cost data. These costs will be supplied as financial and economic costs, which are defined below. They should reflect the cost over the life of the project. For most items the current prices can be used as the basis since inflation can be expected to influence the various components similarly so that they maintain the same cost in relation to one another.

The following components of vehicle operating cost (VOC) are considered in HDM-4, and each has its separate model:

- Fuel consumption;
- Lubricating oil consumption;
- Tyre wear;
- Parts consumption;
- Maintenance labour hours;
- Depreciation;
- Interest;
- Crew hours; and
- Overheads.

A.2.1. Economic and financial costs

HDM-4 allows for two types of costs; economic and financial, although the economic costs are those generally used in analyses. The financial costs are the market costs. The economic costs are the market costs net of (excluding) taxes and subsidies. Only economic costs were estimated for the most of items because these are appropriate for the purpose of economic assessment.

A.2.2. New vehicle price

HDM-4 software generally requires the cost of new vehicles to be imputed. However, inasmuch as the used vehicles are mostly bought by users in Guyana the prices of these were used in the assessment.

Because of high sensitivity, the vehicle price should always be quantified as accurately as practical. The new vehicle price is used in calculating the parts, depreciation and interest costs. It is the singularly most important unit cost, and probably data item, in any HDM-4 analysis. The values were those for the vehicle less tyres, since tyres have their costs calculated separately.

Prices were based on the research of sellers from Japan, USA and Europe trading with used vehicles and shipping them to Guyana and survey of local dealers in Guyana as well. The sample of representative vehicles used in Guyana was assumed for each vehicle category. Age of the vehicles included to each

sample was between 1 and 10 years. Economic costs without all taxation were only calculated for purpose of economic assessment. The costs are set out in the Table A.3.

Following representative vehicles were used for the calculation (number of individual vehicles was used for each category):

Category	Vehicles	Vintage
Motorcycle	Yamaha DT 50, Honda Cac Bike	2005 - 2007
Car	Toyota Corola, Suzuki Escudo, Toyota Alion, Nissan Dualis	2001 - 2007
Pick up / van	Toyota Hilux, Toyota Tacoma, Toyota Hiace - VAN	2001 - 2009
Minibus	Toyota Hiace	2001 - 2006
Light Truck	Miltsubishi Canter, Mazda Titan	2002 - 2005
Midle Truck	Isuzu Forward, Iveco 51	2001 - 2008
Heavy Truck	Nissan Dump Truck, Isuzu Giga, Hino Profia, Hino Dolphine, MACK CH613, DAF FTG	2001 - 2009

A.2.3. Fuel and lubricant costs

The similar approach like in previous studies carried out in Guyana was used for fuel economic costs assumption. The costs were derived from the fuel prices published by US Energy Information Agency and next the distribution costs were added.

In HDM-4 the fuel type is defined for each representative vehicle. Table A.1 shows the default costs used for the calculation and resultant fuel costs used in the assessment.

Table A.1: Fuels prices (year 2010)

	US Dollars per barrel	
Low Sulfur Light Price		72.42
Imported Crude Oil Price		69.43
	Gasoline	**Diesel**
Price (US Cents per gallon)	256.9	270.0
Price (US Dollars per litre)	0.57	0.59
Transport and Distribution (US Dollars/barrel)	3	3
Transport and Distribution (US Dollars/litre)	0.019	0.019
Economic Cost used in HDM-4 (US Dollars/litre)	0.58	0.61

US Energy Information Agency Annual Energy Outlook 2010

A.2.4. Tyre cost

The average tyre cost is the cost of the tyre - not the entire wheel. Table A.3 shows the tyre economic costs for representative vehicles derived from Guyanese sources.

A.2.5. Maintenance labour

The maintenance labour costs should reflect the costs of labour, tools and workshop overheads. It is therefore not appropriate to base the costs only on the prevailing wage rates. Transfer payments such as taxes, social security, etc. were also taken into account. The value of maintenance labour was based on the average Guyanese wage of service technician plus social security employer payment and with other transfer payments of 20 per cent for overheads (US$ 1.48 + 20% = US$ 1.77 per hour).

A.2.6. Crew wage

A default value equivalent to the average drivers wage rate (including social security employer payment) of US$ 1.16 per hour is used in the economic assessment (derived from the statistics of the Ministry of Labour, Human Services and Social Security). It was assumed costs remained constant across class. Two crew members were assumed for minibuses and average number of 1.5 for trucks.

A.2.7. Interest rate

HDM-4 requires an annual interest rate for calculating the opportunity cost of vehicle ownership - also called the interest costs. For economic analyses, the interest rate will be the same as the discount rate which is 12 per cent.

A.2.8. Utilisation

The number of kilometres driven per year is used in calculating the parts consumption and the interest costs. In order to determine the annual kilometreage it is necessary to have information detailing the ages of vehicles and the distances that they have travelled. The utilisation of a vehicle generally varies with age. In several studies older vehicles have been found to have lower utilisation than newer ones (Daniels, 1974; Bennett, 1985). Utilisation data assumption was based on the previous studies carried out in Guyana.

Table A.2: Vehicle Utilisation Data

Vehicle	Annual km	Annual hrs	Service Life
Motorcycle	5,000	150	8
Car	12,500	1,800	11
Pick up / van	30,000	1,300	8
Minibus	60,000	2,000	8
Light Truck	32,000	1,200	12
Med. Truck	40,000	1,200	12
Heavy Truck	40,000	1,200	14

Table A.3: Vehicle Operating Costs Input Data

	Motorcycle	Car	Pick up / van	Minibus	Light Truck	Med. Truck	Heavy Truck
New vehicle price less tyres (US $)	2,495	10,042	17,123	13,572	17,712	38,379	88,985
New tyre price (US $)	40	100	200	180	210	310	410
Maintenance labour per hour US $/hour	1.77	1.77	1.77	1.77	1.77	1.77	1.77
Crew wages per hour US $/hour				2.32	1.74	1.74	1.74
Fuel US $/litre	0.58	0.58	0.58	0.58	0.61	0.61	0.61
Lubricant US $/litre	2.7	2.7	2.7	2.7	2.7	2.7	2.7

	Motorcycle	Car	Pick up / van	Minibus	Light Truck	Med. Truck	Heavy Truck
Interest rate	12%	12%	12%	12%	12%	12%	12%

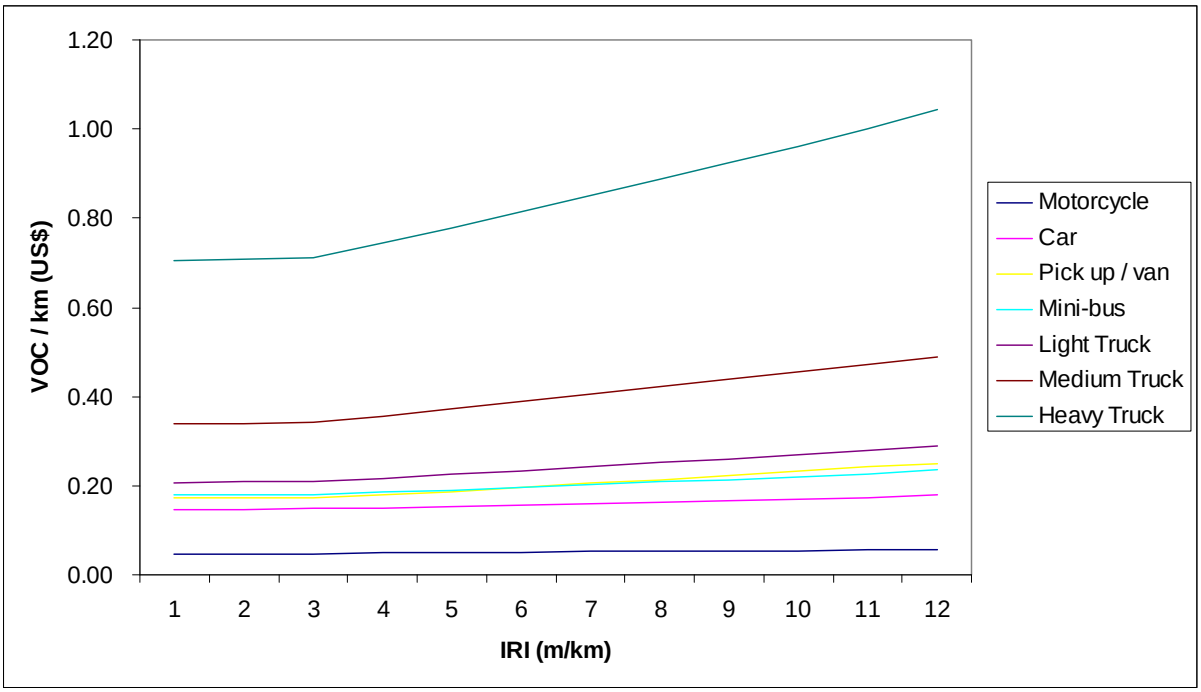
Note: HDM-4 default values were used for physical characteristic of individual vehicle types.

A.2.9. Unit Vehicle Operating Costs

Separate HDM-4 model was created out for demonstration of the VOC unit values per veh-km. HDM-4 predicted unit VOC's are set out in Table A.4. The table shows the sensitivity of VOC to roughness, all other factors being constant, which are also shown graphically in Figure A.1.

IRI (m/km)	Motorcycle	Car	Pick up / van	Mini-bus	Light Truck	Medium Truck	Heavy Truck
1	0.05	0.15	0.17	0.18	0.21	0.34	0.70
2	0.05	0.15	0.17	0.18	0.21	0.34	0.71
3	0.05	0.15	0.17	0.18	0.21	0.34	0.71
4	0.05	0.15	0.18	0.19	0.22	0.36	0.74
5	0.05	0.15	0.19	0.19	0.22	0.37	0.78
6	0.05	0.16	0.20	0.20	0.23	0.39	0.81
7	0.05	0.16	0.20	0.20	0.24	0.40	0.85
8	0.05	0.16	0.21	0.21	0.25	0.42	0.89
9	0.05	0.17	0.22	0.21	0.26	0.44	0.92
10	0.05	0.17	0.23	0.22	0.27	0.45	0.96
11	0.06	0.17	0.24	0.23	0.28	0.47	1.00
12	0.06	0.18	0.25	0.24	0.29	0.49	1.04

Figure A.1: Vehicle Operating Costs and Surface Condition



Appendix B. Technical and economic parameters and evaluation

B.1. Technical parameters

Three main alternative investment options are possible for Sheriff Street - Mandela Avenue namely:

- 4-lane roadway throughout the corridor;
- 4-lanes at selected sections to address capacity issues; or
- 2-lanes with junction improvements only.

For each option, pavement structural improvements of the existing road are recommended. These involve a combination of inlay/overlay and reconstruction of the existing pavement. Details of these areas can be found in the Technical Analysis Report. The Traffic Analysis Chapter highlights key roadway sections that require widening to four lanes. This is recommended due to the current infrastructure being close to or at capacity. However, there are locations where the distance between critical sections is relatively short so for practical purposes it would be preferable to widen the intermediate sections to four lanes sections to remove future bottlenecks along the corridor.

B.1.1. Four Lane Roadway

The first option considered is the implementation of a full four lane roadway of Sheriff Street - Mandela Avenue from its junction with the East Coast Highway to the East Bank Road. This will involve the widening of the existing roadway from its current wide single configuration to a divided four lane roadway. The cross section provides 3.3 metre traffic lanes, 1.5 metre median and 2.4 metre sidewalks. The highway corridor is particularly constrained by adjacent properties along the entire length of the road. The purpose of providing a central median in this environment is to restrict right turn movements. This will improve safety along the road by reducing the number of rear shunt and side swipe type accidents associated with stationary/slow moving vehicles in traffic lanes. The median can be removed where it is felt there is little or no risk of turning traffic conflicting with through movements.

The section of Sheriff Street from Rupert Craig Highway (East Coast Road) Avenue to the Railway Embankment is characterised by a large drainage ditch on the east side of the road with a smaller ditch on the west side. The current roadway is wide single carriageway with narrow parking lanes on both sides. The proposed cross section is able to fit within the limits of the existing embankment, if a small retaining wall is used to support the footway on the east side.

From Railway Embankment Road to Lamaha Canal has a mixed of commercial and residential properties adjoining both sides of the road. Most of the properties have erected their own parking areas and structures associated with their businesses. These will require removal to facilitate the construction of a four lane roadway. The structure at Lamaha Canal will require widening to allow a four lane roadway to cross. However, this option does not consider widening of any major structures along the roadway.

From Lamaha Canal to Homestretch, the corridor is slightly wider. However, to construct the four lane road, parking may need to be removed along the corridor. The alignment allows for the four lanes to be constructed without touching adjacent boundaries. From Homestretch to East La Penitance, the road corridor is generally wide. This section has less commercial operations and therefore, the demand on parking is greatly reduced. The construction of four lanes will be generally easier through this section.

From East La Penitance, the corridor is wide. There is however a tight radius through 90°. To prevent landtake at this location, the alignment needs to sweep wider on the outside of the bend to avoid the

housing close to the road on the inside. A Departure from Standard is required to allow the construction of this tight radius.

The last section running in a west-east direction has sufficient width to accomodate four lanes. The alignment is relative straight with few commercial on-street operations. Construction of the four lane cross section will be relatively straight forward in this section.

B.1.2. Four Lanes at Selected Sections

The Traffic Analysis has highlighted three sections requiring urgently widening. These are as follows:

- East Bank Road to Houston Access Road (0.5 km);
- Durban Street to Homestretch Avenue (0.4 km); and
- Duncan Street to Railway Embankment Road (1.3 km).

The section of the road with the most issues associated with widening is the commercial district of Sheriff Street between Duncan Street and Railway Embankment Road.

B.1.3. Traffic Signal Improvements

For both options discussed above it is recommended that improvements are made to the existing traffic management along the corridor. This involves upgrading existing signals to improve through flow and reduce congestion along the road. Preliminary assessment at each junction indicates that is sufficient room to accommodate widening at each location. This will involve the removal of parking areas and structures constructed within the highway boundary built by residents and commercial establishments.

It is recommended that a central median is constructed between Railway Embankment Road and Duncan Street. Many of the congestion issues associated with this stretch of road are in connection with right-turning vehicles turning into commercial properties. Single vehicles can cause several problems on the network by blocking the through traffic and causing major delays on the road.

B.2. Economic Assessment Approach and Methodology

B.2.1. Overview

The economic appraisal was based on a conventional cost-benefit analysis technique whereby the agency costs (construction and maintenance) and road user costs associated with the existing network (base case) are compared with the costs of the improved network (project case) using a discounted cash-flow analysis technique. The Highways Development and Management Model 4 (HDM-4) the latest version 2.08 was used for the economic modelling.

The benefits of the schemes resulted from reduced journey times and delays, and improved road surface conditions which will result in vehicle operating cost savings, accident cost savings and travel time cost savings.

The analysis focused on the direct costs and benefits of the investment to the agency and road users as is the convention, since they can be estimated with some degree of reliability, and are usually the only quantified benefits acceptable to financing institutions when they assess the economic worth of a project.

B.2.2. The HDM-4 Model

HDM-4 predicts road deterioration, road work effects, road user effects and socio-economic and environmental effects over the life cycle of a road pavement.

Road pavements deteriorate due to a number of factors. Most significant among these are traffic loading, environmental weathering and the effect of inadequate drainage systems. The rate of this deterioration is directly affected by the standard of maintenance applied to maintain the structural integrity of and repair defects on the pavement surface.

Figure B.1: Predicted Pavement Performance

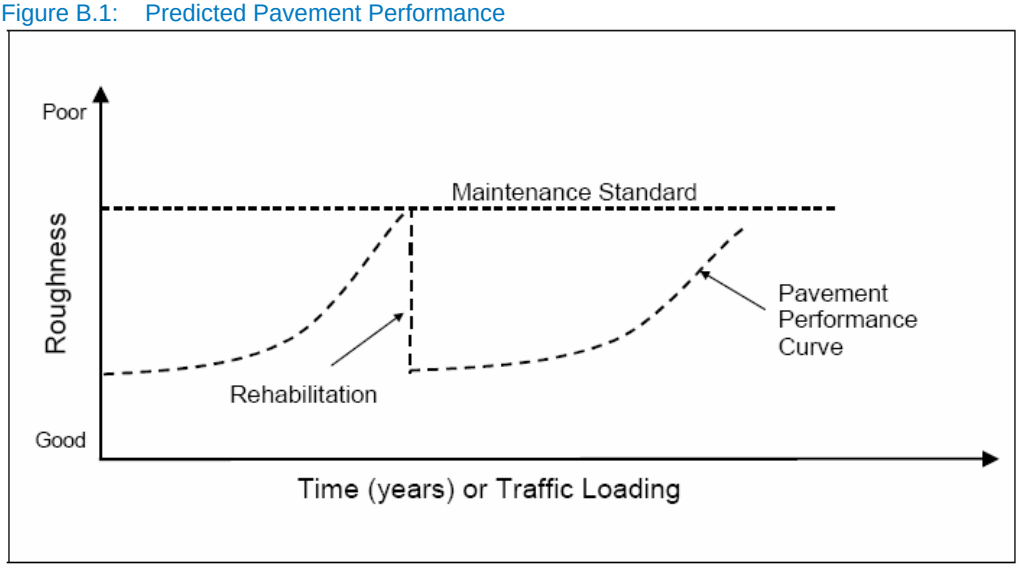


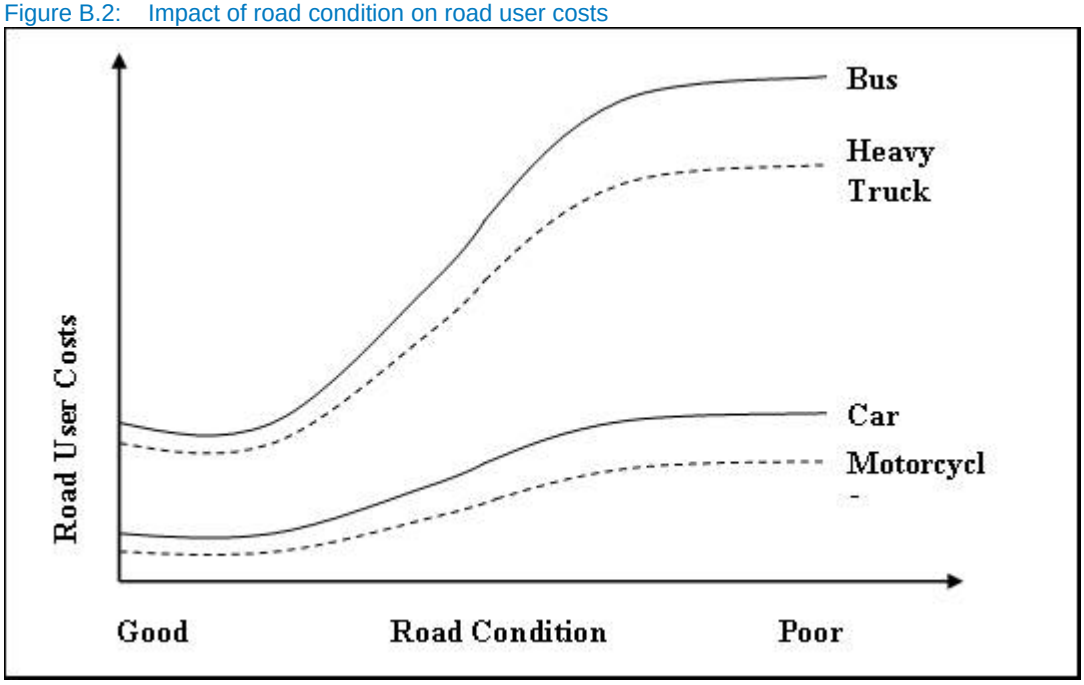
Figure B.1 illustrates the predicted trend in pavement performance. A maintenance standard is a limit to the level of deterioration a road is allowed to attain. Therefore the total costs incurred by road agencies depend on the standard of maintenance and quality of improvement applied to road networks as well as the capital costs of road construction.

Impacts of the road condition and road design standards on road users are measured in terms of road user costs and other social and environmental costs. Road user costs are vehicle operating costs, costs of travel time and costs to the economy of road accidents. These are calculated in HDM-4 by predicting amounts of resource consumption and multiplying these by user specified unit costs.

Figure B.2 shows the impact of road condition on the road user costs of different categories of vehicle.

HDM-4 calculates economic benefits from road investments by comparing cost streams for different road works and construction options against a do minimum case. It forecasts the benefits for many alternatives year-by-year over an analysis period chosen by the user. Future costs are discounted to a base year. To carry out this analysis, detailed specifications of investment programmes, design standards and maintenance options are required. Unit costs, projected traffic volumes and environmental conditions are also necessary inputs into the model.

Figure B.2: Impact of road condition on road user costs



B.3. Adaptation and Calibration of the HDM-4 Model

The HDM-4 model provides a generic framework for assessment, which must be adapted and calibrated to the network under consideration. Key data, and in particular unit cost data, needed for the calibration was collected from local surveys and other Guyanese sources.

HDM-4 consists of a number of sub-models and relationships, which were grouped together as follows:

- Road User Effects;
- Road Deterioration and Works Effects;
- Traffic; and
- General.

B.4. Road User Effects (RUE)

The RUE model predicts vehicle speeds and operating resources as functions of the characteristics of each type of vehicle and the geometry, surface type and current condition of the road, under both free flow and congested traffic conditions. The operating costs are obtained by multiplying the predicted quantities for the various resource components by the unit costs or prices, which are specified by the user in financial or economic terms.

The following components of vehicle operating cost (VOC) are considered, and each has its separate model:

- Fuel consumption;
- Lubricating oil consumption;
- Tyre wear;
- Parts consumption;
- Maintenance labour hours;

- Depreciation;
- Interest;
- Crew hours; and
- Overheads.

The VOC´s are described in Appendix A.

Travel time is considered in terms of passenger-hours during working and non-working time.

Effect of accident costs savings are not considered in this stage of the project due to lack of input data. This fact does not affect the economic assessment results significantly because the proportion of these saving in overall benefits figures is usually small in such type of project.

Travel Time Costs

A resource based approach was used to derive travel time costs, using the average employment cost value. The average employment cost for Guyana is G$ 313.2 per hour according to the latest available data. This was based on the published average employment cost of G$ 650,114 per year (official statistic data of the Ministry of Labour, Human Services and Social Security).

The TTC for an average vehicle occupant was estimated by valuing the proportion of persons travelling on work time by the employment cost rate. Persons travelling on other activities value their time at lesser rate. An average of travel time costs gave an hourly value of US$ 0.82. An example of travel time cost calculation sheet for cars is set out in Table B.1.

Average occupancy for cars and buses was derived from vehicle occupancy survey carried out on East Bank Demerara Public Road by Mott MacDonald in August 2010. Average occupancy was estimated at 2.2 for car and 12.1 for minibus including driver and conductor (i.e. 10.1 passengers). The EBDPR and Sheriff Street Mandela Avenue are on adjacent sections of road with similar sources and destinations. The values used within the EBDPR extensions project are assumed to be suitable to use for the economic appraisal of Sheriff Street / Mandela Avenue Project.

Table B.1: Travel Time Cost Calculation

Travel Time Costs Calculation Sheet					
	Item	Unit	Value	Description	Source
A	B	C	D	E	F
1	Average Employment Cost 2009	G$	650114.0	Average Employment Cost per year 2009	Ministry of Labour, Human Services and Social Security
2	Hours per year	hours	2076.0	Average hours worked per year	Ministry of Labour, Human Services and Social Security
3	Average Cost per hour	G$/hr	313.2	D1/D2	
4	Non-work time value	%	30%	value expressed as % of business time	The Value of Time In Economic Evaluation of Transport Projects, Lessons from Recent Research, Kenneth M. Gwilliam, The World Bank 1997
5	Proportion of work time	%	30%	% of the total trips on roads	Assumption based on previous studies in Guyana
6	Work TTC per hour	G$/hr	313.2	D3	
7	Non - work TTC per hour	G$/hr	93.9	D3*D4	
8	Average TTC per hour	G$/hr	159.7	D6*D5+D7*(1-D5)	
9	Average car occupancy	persons	2.2	average number of persons in each car (including driver)	Mott MacDonald 2010 Survey
10	Average TTC per car	G$/hr	351.4		
11	Correction factor to year 2010	%	4.4%	Assumed Real GDP Growth between years 2009 and 2010	Bureau of Statistics, Guyana
12	Average TTC per hour (2010)	G$/hr	166.7	D8*(1+D11)	
13	Average TTC per car (2010)	G$/hr	366.7	D10*(1+D11)	
14	Average TTC per hour (2010)	US$/hr	0.82	Central Exchange Rate G$204.45 / 1US$ (Bank of Guyana)	
15	Average TTC per car (2010)	US$/hr	1.79		

B.5. Road Deterioration and Works Effects

General

Road deterioration is broadly a function of the original design, material types, construction quality, traffic volume, axle load characteristics, road geometry, environmental conditions, age of pavement, and the maintenance policy pursued. HDM-4 includes relationships for modelling Road Deterioration (RD) and Road Works Effects (WE). These are used for the purpose of predicting annual road condition and for evaluating road works strategies. The relationships link standards and costs for road construction and maintenance to road user costs through road user cost models.

Maintenance Standards

A maintenance standard is applied to both the base and project case road networks. This should reflect the realistic maintenance regime that will be applied over the project life. Each standard consists of a number of work items which are divided into routine and periodic activities and are triggered either by road condition or a set period of time.

Since there were no data about maintenance available for this project maintenance unit costs from previous studies were used for this project. The unit cost for routine maintenance on existing road was estimated using the data from Maintenance Review Report 2009 published by Ministry of Public Works and Communications. This report highlights the implementation and execution of the Routine Maintenance Management System along with the monitoring and evaluation activities involved in the second round of multi-year contracts execution between December 2007 and December 2009, along named Public Roads of Guyana. The data appropriate for EBD Road were used for the calculation (see Table 3.2.) These data were found suitable to use for the economic appraisal of Sheriff Street / Mandela Avenue Project.

Table B.2: Routine Maintenance Costs

Lot 1 - Ruimveldt Police Station (km0+000) to Relief Village (km23+000)			
Duration (months)	Cost (G$)	Average Cost per Month (G$)	Average Cost per Year (G$)
22	23,472,629	1,066,938	12,803,252
Lot 2 - Relief Village (km23+000) to Timehri (km40+350)			
Duration (months)	Cost (G$)	Average Cost per Month (G$)	Average Cost per Year (G$)
25	24,372,587	974,903	11,698,842
East Bank Demerara Public Road - Ruimveldt Police Station (km 0+000) to Timehri Airport Terminal (km 40+350)			
Total Average Cost per Year (G$)	Length (km)	Average cost per km per year (G$)	Average cost per km per year (US$)
24,502,094	40.35	607,239	2,970

The following routine maintenance works are included in the maintenance standard. Appropriate works were applied also in HDM-4 model.

- Pot holes patching;
- Crack filling;
- Encroachment removal;
- Repairs to local failures;

- Removal of road kills;
- Vegetation control;
- Grade and shape of the shoulder and verge;
- Desilting of roadside drains; and
- Road Safety elements maintenance activities.

The unit cost of routine maintenance for new road sections was estimated about US$ 1,500 per km per year for 2-lane road and US$ 2,000 per km per year for 4-lane road.

The overlay about 25 mm layer is considered for both existing one and new road. Existing road should be overlaid in 5th year of assessment period in Do Minimum scenario, new road in 10th year in Do Something scenario. The unit cost was assumed about US$ 10.4 per square meter.

B.6. Traffic

HDM-4 contains the following traffic relationships:

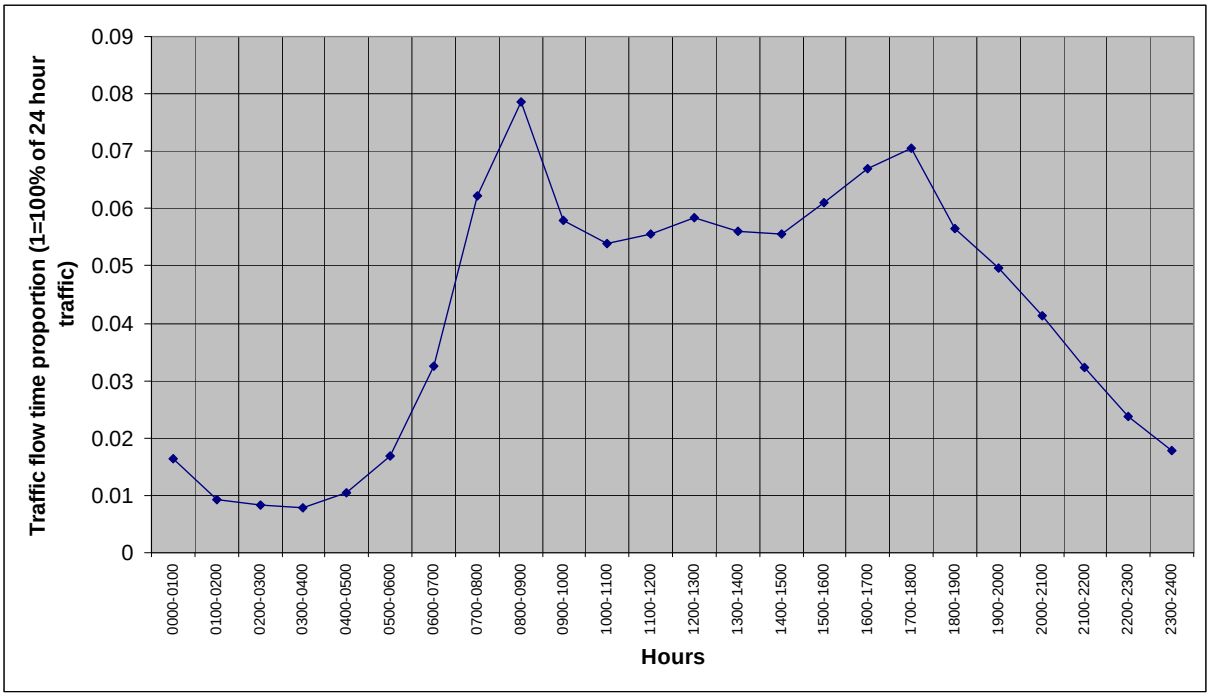
- Prediction of Total Annual Traffic Volumes;
- Axle Loading;
- Speed-Flow (Capacity Restraint) Model;
- Hourly Distribution of Traffic Volume; and
- Speed Prediction in Road User Effects Model.

For calibration of these submodels were used the HDM-4 default values and data from the surveys carried out along Sheriff Street / Mandela Avenue.

The speed-flows parameters are based mainly on HDM-4 default values, however also the data from previous study carried in Guyana (ref. Alternative Southern Approach to Georgetown – Addendum No. 3 to Final Report, March 2006) was considered. Speed on modelled sections was calibrated using the data from the journey time surveys.

Hourly distribution of traffic volume was calculated for HDM-4 purposes using the data from automatic traffic counts (ATC). The results of hourly traffic distributions are set out in Figure B.3.

Figure B.3: Hourly Distribution of Traffic Volumes



B.7. Scheme Modelling

B.7.1. Road Network

Economic assessment was conducted for three different options of Mandela Avenue / Sheriff Street improvement. Individual packages are described in the sheet below.

Table B.3: Modelled Options

Option	Description
Option 1	Junction improvements, 4-Laning the entire roadway, pavement rehabilitation
Option 2	Junction improvements, selected 4-laning (Duncan Street to Railway Embankment, Durban Street to Homestretch Avenue), pavement rehabilitation
Option 3	Junction improvements, pavement rehabilitation

Each HDM-4 project consists of a Base Case “Do Minimum” and a Project Case “Do Something”. The 2-lane sections of the existing road were used in “Do Minimum” scenario. The sections of new/upgraded road were then considered in a “Do Something” scenarios for individual proposed options.

Existing pavement width was set at 4m per one direction, paved shoulders are in width 2m. Each direction of the same section has been modelled separately. Pavement condition is represented by roughness (IRI) in average value 6.3 – 7.4 m/km which is based on Technical Analyses Report. These parameters were used like a base for the HDM-4 modelling. Travel time surveys results were used for a calibration of speeds on each modelled section.

The parameters for new 4-lane and 2-lane road sections were undertaken from preliminary highway design. The new sections were modelled like urban road sections and limited speed was considered

B.8. Traffic Data

Traffic data for the assessment was taken from the traffic analysis undertaken in the Technical Analysis Report. Growth factors used in the HDM-4 were also overtaken from data set out in the Technical Analysis Report. The traffic flows in the base year 2011 considered on the existing routes are set out in Table B.4. For each option the maximum capacity for each link was computed using PICADY calibrated for local conditions. This limit was applied within HDM-4 for calculating the benefits available to be derived for the improvements.

Traffic flows were calculated separately for each direction. Direction Eastbound and Northbound is marked as A (for instance S1A), direction Southbound and Westbound is marked as B (for instance S1B).

Table B.4: Traffic Flows (AADT 2011)

From	To									
Eastbound + Northbound			**MOTOR CYCLE**	**CARS & TAXIS**	**VANS & PICK-UPS**	**MINI-BUS**	**LIGHT TRUCK**	**MED. TRUCK 6W**	**HEAVY TRUCK 3 or 4 axles**	**TOTAL**
S1A	East Bank	Houston Access Road	600	7097	1956	4247	581	588	275	15346
S2A	Houston Access Road	Vlissengen Road	670	6725	1688	1448	718	769	574	12593
S3A	Vlissengen Road	Aubrey Barker Road	389	4062	1007	946	354	576	178	7513
S4A	Aubrey Barker Road	Arapaima Street	395	3740	839	877	345	573	135	6905
S5A	Arapaima Street	Joseph Pollydore Street	602	4885	1115	2402	540	738	524	10806
S6A	Joseph Pollydore Street	Home Stretch Avenue	804	5621	1428	2198	553	765	560	11929
S7A	Home Stretch Avenue	Duncan Street	763	6753	1502	1214	454	607	247	11541
S8A	Duncan Street	Garnett Street	644	6789	1989	1145	518	603	193	11880
S9A	Garnett Street	Campbell Avenue	347	3851	1303	1147	360	440	150	7597
S10A	Campbell Avenue	Railway Embankment Road	411	6159	1508	1468	344	367	173	10430
S11A	Railway Embankment Road	Carifesta Avenue	101	2871	875	337	258	368	129	4939
S12A	East Bank Public Road	East Bank Public Road	1271	11819	2874	4567	908	1194	358	22990
Southbound + Westbound										
S1B	Houston Access Road	East Bank	79	508	130	68	53	78	60	978
S2B	Vlissengen Road	Houston Access Road	635	5696	1488	568	312	681	245	9625
S3B	Aubrey Barker Road	Vlissengen Road	484	4584	730	984	307	555	177	7820
S4B	Arapaima Street	Aubrey Barker Road	396	3933	797	1061	339	602	167	7296
S5B	Joseph Pollydore Street	Arapaima Street	508	5429	1462	1689	381	500	225	10194
S6B	Home Stretch Avenue	Joseph Pollydore Street	633	6299	1586	1635	444	470	233	11301
S7B	Duncan Street	Home Stretch Avenue	670	6297	1566	1050	622	648	414	11266
S8B	Garnett Street	Duncan Street	385	4626	1179	620	419	652	396	8276
S9B	Campbell Avenue	Garnett Street	476	5510	1407	2003	417	750	395	10959
S10B	Railway Embankment Road	Campbell Avenue	498	4905	1840	1609	503	654	378	10387
S11B	Carifesta Avenue	Railway Embankment Road	79	2051	820	303	184	221	78	3737
S12B	East Bank Public Road	East Bank Public Road	793	6923	1743	1152	908	809	695	13023

B.9. HDM-4 Economic model calibration

The overall approach to the economic evaluation of the project was based on a standard comparison of discounted economic benefits and discounted costs. The main economic benefits of this project come from the junction improvements which were proposed and from the road rehabilitation / widening. As HDM-4 is not designed to assess junction improvement or junction signal timing improvements it was necessary to find the most appropriate way how to include these benefits into the evaluation.

Finally the approach based on comparing junction capacities before the improvement and junction capacities after the improvement was taken. The capacities of particular arms of junctions on Sheriff Street / Mandela Avenue were considered as the capacities of the particular road sections on these streets. Hence each direction of every modelled road section had to be modelled separately in HDM-4. It is not a standard procedure in road economic evaluations and it made the assessment more demanding in terms of work difficulty and time consumption.

In order to calibrate the economic model primarily modelled speed on each road section was compared with the observed one which was obtained from the traffic surveys for the Base Case. Consequently the capacities of the sections were amended in a way which ensures as accurate match of modelled and observed speed values as possible. Road side friction factor was adjusted as well. In spite of the section capacities were changed the proportions between capacities before the junction improvement (in the Base Case) and after the junction improvement (in the Project Case) were kept.

B.10. Capital Costs

B.10.1. Construction Costs

The capital costs used in the assessment included all construction costs, preliminary cost and contingency of 10%. The summary of cost for each modelled scenario is set out in Table B.5.

Table B.5: Cost Summary

No.	Option	Capital Cost (US $)
1	Option 1	27,027,157
2	Option 2	20,708,119
3	Option 3	17,501,981

B.10.2. Residual value

The salvage value is the residual value of any asset after the end of the analysis period.

Residual value was calculated using straight-line depreciation method. The formula for calculation is given below.

$$SV = \frac{MAX\{0,[WL-(Y-y^*)]\}}{WL} * UNDISCST$$

Where:

SV = Salvage value of works

WL = Life of works in years

Y = Last year of analysis

y* = The analysis year in which the works was triggered/performed

UNDISCST = The undiscounted economic cost of the works.

The simplified application was used in the assessment to obtain residual value. The overall capital costs for particular options were distributed into categories according to their expected life cycle. Categories of items with 100 years, 50 years and 30 years of life cycle were created. Consequently the residual value for each option was calculated assuming the assessment period of 20 years.

The residual values of particular periods are shown in Table B.6.

Table B.6: Residual Value %

No.	Option	Residual Value (%)
1	Option 1	49%
2	Option 2	46%
3	Option 3	41%

B.11. Economic Assessment

The economic assessment using HDM-4 was conducted for the Options 1, 2 and 3 which represent various scenarios of improvement of Sheriff Street / Mandela Avenue. Sensitivity tests were used to assess the impacts of changes of key parameters in the results.

The results of the assessment are set out in Table B.7. These were based on a 20 year analysis period (including construction period of 2 years) using a discount rate of 12%, assuming all sections will be opened in year 2013. Residual values for the new road sections were included in the last year of appraisal. HDM-4 reports for the project are provided in Appendix D.

The primary calculated economic criteria are the net present value of the investment (NPV), the economic internal rate of return (EIRR) and the benefit cost ratio (BCR).

The Net Present Value (NPV) is the difference between the present value of costs and the present value of benefits and represents the net additional benefits to the economy generated by the project. The Economic Internal Rate of Return (EIRR) is the percentage return on the capital investment of the project generated by the benefit stream and is an easily understood measure of project profitability. The EIRR must exceed the discount rate for the project to be viable. The BCR value must be higher than 1.

The net present value is defined on the basis of the following relation:

$$NPV_{(m-n)} = \sum_{y=1}^{Y} \frac{NB_{y(m-n)}}{(1+0{,}01 \cdot r)^{(y-1)}}$$

NBy(m - n) is the net economic revenue of the investment option (m) compared to the non-investment option, or the compared variant (n) in year y.

r discount rate (%)

y assessed year (y=1,2,……,Y)

Y number of years of assessment

The Economic Inner Rate of Return was calculated using the following formula:

$$\sum_{y=1}^{Y} \frac{NB_{y(m-n)}}{(1+0{,}01 \cdot r)^{(y-1)}} = 0$$

where the unknown is the value r.

The benefit cost ratio is defined by the following relation:

$$BCR_{(m-n)} = \frac{NPV_{(m-n)}}{C_m} + 1$$

where

BCR(m-n) benefit cost ratio of investment costs

NPV(m-n) net present value with discount rate r

Cm discounted costs

The results show that project generates in the individual options the value of EIRR from 25.8% (Option 3) to 32.7% (Option 1).

Table B.7: Results of Economic Appraisal

Option	EIRR (1) %	NPV (2) US$ mil	BCR(3)
Option 1	32.65%	86.90	4.73
Option 2	28.17%	34.13	3.23
Option 3	25.76%	28.95	2.89

Notes: 1. Economic Internal rate of Return, 2. Net Present Value in US$ million at 12% discount rate, 3. Benefit cost ratio

Traffic signal modelling was used to calculate the travel time savings. The capacity improvements at the junctions varied and only overall benefits were produced. Savings were combined across junctions.

B.12. Sensitivity Tests

Capital costs and traffic forecast are the most important variables in the economic assessment. A sensitivity analysis, therefore, was carried out taking into account uncertainty regarding these parameters and also the overall time benefits and VOC benefits.

The sensitivity tests were carried out for increase of the key parameters as well as for decrease of these parameters. The tested parameters were as follows:

- Traffic;
- Traffic growth;
- Capital Costs;
- Value of time; and
- Vehicle operating costs.

HDM-4 reports for sensitivity tests are also presented in Appendix D.

The results of the sensitivity tests are shown in Table B.8.

Table B.8: Sensitivity Tests

Scenario	Central Case	Traffic			
		-10%	-20%	+10%	+20%
Option 1	32.7%	25.5%	19.4%	41.4%	51.9%
Option 2	28.2%	22.7%	18.0%	34.6%	41.4%
Option 3	25.8%	20.6%	16.1%	31.8%	38.2%

Scenario	Central Case	Traffic Growth			
		-10%	-20%	+10%	+20%
Option 1	32.7%	29.5%	26.3%	35.8%	38.8%
Option 2	28.2%	24.2%	20.2%	32.2%	36.0%
Option 3	25.8%	21.7%	17.6%	29.8%	33.7%

Scenario	Central Case	Capital Costs			
		-10%	-20%	+10%	+20%
Option 1	32.7%	34.7%	37.2%	30.9%	29.4%
Option 2	28.2%	30.2%	32.5%	26.5%	25.0%
Option 3	25.8%	27.5%	29.7%	24.2%	22.9%

Scenario	Central Case	Value of Time			
		-10%	-20%	+10%	+20%
Option 1	32.7%	31.9%	31.2%	33.4%	34.0%
Option 2	28.2%	27.6%	27.0%	28.8%	29.3%
Option 3	25.8%	25.3%	24.8%	26.2%	26.7%

Scenario	Central Case	Vehicle Operating Costs			
		-10%	-20%	+10%	+20%
Option 1	32.7%	31.5%	30.3%	33.8%	34.9%
Option 2	28.2%	26.9%	25.7%	29.4%	30.6%
Option 3	25.8%	24.6%	23.5%	26.9%	28.0%

Possible Risks

The principal risks to the project are:

- Traffic Growth Lower than Predicted

This is not considered a major risk because current trends in Guyana indicate that assumed traffic growth can be realistic.

- Construction Cost Estimates

The risk of cost estimates being exceeded is considered as significant risk. However, sensitivity tests confirmed the continuing viability of the schemes given a more than 20% increase in scheme costs for all options. The contingency of 10% is included in all cases calculation.

B.13. Conclusions

The results of the economic assessment show that the Project in all analysed options generates reasonable economic efficiency benefits and therefore it may be recommended for implementation.

To check the sufficient robustness of results of the economic analysis, extensive sensitivity tests were performed.

Appendix C. Cash Flow

C.1. Option 1

The discounted cash flow for the construction of Option 1 is shown in Table C.1.

Table C.1: Option 1 Discounted Cash Flow

HDM - 4
HIGHWAY DEVELOPMENT & MANAGEMENT

Project Cash Flow Summary (Discounted)

Study Name: **Guyana Sheriff Street - Option 1**
Run Date: **27-04-2011**
Currency: **US Dollar (millions)**

Option: Project Case

Year	Base Case					Project Case					Net Benefit
	Agency Costs	MT VOC	MT Travel Time	Accidents	Total Costs	Agency Costs	MT VOC	MT Travel Time	Accidents	Total Costs	
2011	0.022	11.593	3.579	0.000	15.194	6.747	11.593	3.579	0.00	21.920	-6.73
2012	0.019	11.258	3.597	0.000	14.874	18.073	11.441	3.619	0.00	33.133	-18.26
2013	0.017	10.966	3.660	0.000	14.643	0.012	8.612	2.631	0.00	11.254	3.39
2014	0.015	10.844	3.860	0.000	14.720	0.010	8.173	2.566	0.00	10.749	3.97
2015	0.014	10.735	4.084	0.000	14.833	0.009	7.755	2.513	0.00	10.277	4.56
2016	0.364	10.421	4.144	0.000	14.929	0.008	7.337	2.457	0.00	9.802	5.13
2017	0.011	9.708	4.193	0.000	13.912	0.007	6.973	2.426	0.00	9.406	4.51
2018	0.010	9.403	4.202	0.000	13.615	0.007	6.607	2.373	0.00	8.987	4.63
2019	0.009	9.203	4.297	0.000	13.509	0.006	6.247	2.307	0.00	8.560	4.95
2020	0.008	9.089	4.451	0.000	13.547	0.005	5.951	2.274	0.00	8.230	5.32
2021	0.007	9.250	4.839	0.000	14.096	0.005	5.748	2.310	0.00	8.063	6.03
2022	0.006	10.216	5.862	0.000	16.083	0.004	5.562	2.361	0.00	7.927	8.16
2023	0.006	10.244	6.088	0.000	16.337	0.277	5.437	2.452	0.00	8.166	8.17
2024	0.005	10.440	6.437	0.000	16.882	0.003	5.423	2.635	0.00	8.061	8.82
2025	0.004	10.230	6.425	0.000	16.659	0.003	5.459	2.817	0.00	8.279	8.38
2026	0.004	9.827	6.221	0.000	16.052	0.003	5.247	2.769	0.00	8.018	8.03
2027	0.004	9.364	5.954	0.000	15.321	0.002	5.025	2.700	0.00	7.727	7.59
2028	0.003	8.858	5.647	0.000	14.509	0.002	4.896	2.693	0.00	7.592	6.92
2029	0.003	8.363	5.337	0.000	13.703	0.002	4.829	2.728	0.00	7.559	6.14
2030	0.003	7.952	5.091	0.000	13.046	-1.534	4.685	2.706	0.00	5.857	7.19
Total:	0.533	197.963	97.969	0.000	296.465	23.652	132.998	52.915	0.00	209.565	86.90

NPV: 86.90
IRR: 32.65% (No. of solutions = 1)

HDM-4 Version 2.1 **Page 1 of 1**

Mott MacDonald

C.2. Option 2

The discounted cash flow for the construction of Option 2 is shown in Table C.2.

Table C.2: Option 2 Discounted Cash Flow

HDM - 4
HIGHWAY DEVELOPMENT & MANAGEMENT

Project Cash Flow Summary (Discounted)

Study Name: **Guyana Sheriff Street - Option 2**
Run Date: **27-04-2011**
Currency: **US Dollar (millions)**

Option: Project Case

Year	Base Case					Project Case					Net Benefit
	Agency Costs	MT VOC	MT Travel Time	Accidents	Total Costs	Agency Costs	MT VOC	MT Travel Time	Accidents	Total Costs	
2011	0.022	11.593	3.579	0.000	15.194	4.369	11.593	3.579	0.00	19.542	-4.35
2012	0.019	11.258	3.597	0.000	14.874	11.704	11.441	3.619	0.00	26.763	-11.89
2013	0.017	10.966	3.660	0.000	14.643	0.009	9.316	3.230	0.00	12.555	2.09
2014	0.015	10.844	3.860	0.000	14.720	0.008	9.022	3.275	0.00	12.305	2.41
2015	0.014	10.735	4.084	0.000	14.833	0.007	8.709	3.304	0.00	12.021	2.81
2016	0.364	10.421	4.144	0.000	14.929	0.007	8.455	3.382	0.00	11.843	3.09
2017	0.011	9.708	4.193	0.000	13.912	0.006	8.198	3.446	0.00	11.651	2.26
2018	0.010	9.403	4.202	0.000	13.615	0.005	7.970	3.503	0.00	11.478	2.14
2019	0.009	9.203	4.297	0.000	13.509	0.005	7.796	3.583	0.00	11.384	2.13
2020	0.008	9.089	4.451	0.000	13.547	0.004	7.587	3.625	0.00	11.216	2.33
2021	0.007	9.250	4.839	0.000	14.096	0.004	7.528	3.780	0.00	11.312	2.78
2022	0.006	10.216	5.862	0.000	16.083	0.003	7.576	4.019	0.00	11.598	4.49
2023	0.006	10.244	6.088	0.000	16.337	0.178	7.645	4.284	0.00	12.107	4.23
2024	0.005	10.440	6.437	0.000	16.882	0.003	8.004	4.778	0.00	12.785	4.10
2025	0.004	10.230	6.425	0.000	16.659	0.002	8.126	5.059	0.00	13.188	3.47
2026	0.004	9.827	6.221	0.000	16.052	0.002	8.071	5.134	0.00	13.207	2.84
2027	0.004	9.364	5.954	0.000	15.321	0.002	7.953	5.131	0.00	13.086	2.24
2028	0.003	8.858	5.647	0.000	14.509	0.002	7.479	4.846	0.00	12.326	2.18
2029	0.003	8.363	5.337	0.000	13.703	0.002	7.072	4.610	0.00	11.684	2.02
2030	0.003	7.952	5.091	0.000	13.046	-0.831	6.711	4.406	0.00	10.286	2.76
Total:	0.533	197.963	97.969	0.000	296.465	15.492	166.252	80.593	0.00	262.337	34.13

NPV: 34.13
IRR: 28.17% (No. of solutions = 1)

Mott MacDonald

C.3. Option 3

The discounted cash flow for the construction of Option 3 is shown in

Table C.3: Option 3 Discounted Cash Flow

HDM - 4
HIGHWAY DEVELOPMENT & MANAGEMENT

Project Cash Flow Summary (Discounted)

Study Name: **Guyana Sheriff Street - Option 3**
Run Date: **27-04-2011**
Currency: **US Dollar (millions)**

Option: Project Case

Year	Base Case					Project Case					Net Benefit
	Agency Costs	MT VOC	MT Travel Time	Accidents	Total Costs	Agency Costs	MT VOC	MT Travel Time	Accidents	Total Costs	
2011	0.022	11.593	3.579	0.000	15.194	4.369	11.593	3.579	0.00	19.542	-4.35
2012	0.019	11.258	3.597	0.000	14.874	11.704	11.441	3.619	0.00	26.763	-11.89
2013	0.017	10.966	3.660	0.000	14.643	0.009	9.526	3.433	0.00	12.968	1.68
2014	0.015	10.844	3.860	0.000	14.720	0.008	9.232	3.477	0.00	12.716	2.00
2015	0.014	10.735	4.084	0.000	14.833	0.007	8.917	3.501	0.00	12.425	2.41
2016	0.364	10.421	4.144	0.000	14.929	0.006	8.659	3.574	0.00	12.240	2.69
2017	0.011	9.708	4.193	0.000	13.912	0.006	8.394	3.630	0.00	12.030	1.88
2018	0.010	9.403	4.202	0.000	13.615	0.005	8.150	3.670	0.00	11.825	1.79
2019	0.009	9.203	4.297	0.000	13.509	0.004	7.975	3.747	0.00	11.726	1.78
2020	0.008	9.089	4.451	0.000	13.547	0.004	7.765	3.786	0.00	11.555	1.99
2021	0.007	9.250	4.839	0.000	14.096	0.004	7.704	3.939	0.00	11.646	2.45
2022	0.006	10.216	5.862	0.000	16.083	0.003	7.745	4.169	0.00	11.918	4.17
2023	0.006	10.244	6.088	0.000	16.337	0.147	7.806	4.423	0.00	12.376	3.96
2024	0.005	10.440	6.437	0.000	16.882	0.003	8.156	4.909	0.00	13.068	3.81
2025	0.004	10.230	6.425	0.000	16.659	0.002	8.236	5.153	0.00	13.391	3.27
2026	0.004	9.827	6.221	0.000	16.052	0.002	8.145	5.193	0.00	13.341	2.71
2027	0.004	9.364	5.954	0.000	15.321	0.002	8.032	5.194	0.00	13.228	2.09
2028	0.003	8.858	5.647	0.000	14.509	0.002	7.561	4.911	0.00	12.473	2.04
2029	0.003	8.363	5.337	0.000	13.703	0.001	7.160	4.679	0.00	11.840	1.86
2030	0.003	7.952	5.091	0.000	13.046	-0.831	6.803	4.475	0.00	10.447	2.60
Total:	0.533	197.963	97.969	0.000	296.465	15.456	169.002	83.060	0.00	267.518	28.95

NPV: 28.95
IRR: 25.76% (No. of solutions = 1)

Mott MacDonald

Appendix D. Economic Analysis Summary

HDM-4 was used to undertake the economic analysis on the different options to compare the cost-benefits for each. All options provide a positive investment choice with increasing return on expenditure. The following pages provide details of the analysis undertaken.

Table D.1: Option 1 Economic Analysis

HDM-4
HIGHWAY DEVELOPMENT & MANAGEMENT

Economic Analysis Summary

Study Name: **Guyana Sheriff Street - Option 1**
Run Date: **27-04-2011**
Currency: **US Dollar (millions)**
Discount: **12.00%**
Analysis Mode: **Analysis-by-Project**

Alternative: Project Case vs Alternative: Base Case
Sensitivity Scenario: Base Sensitivity Scenario

	Increase in Road Agency Costs			Savings in MT VOC	Savings in MT Travel Time Costs	Savings in NMT Travel & Operating Costs	Reduction in Accident Costs	Net Social / Exogenous Benefits	Net Economic Benefits (NPV)
	Capital	Recurrent	Special						
Undiscounted	13.76	0.27	0.00	269.42	195.19	0.00	0.00	0.00	450.56
Discounted	23.28	-0.17	0.00	64.96	45.05	0.00	0.00	0.00	86.90

Economic Internal Rate of Return (EIRR) = 32.7% (No. of solutions = 1)

Alternative: Project Case vs Alternative: Base Case
Sensitivity Scenario: Traffic +20%

	Increase in Road Agency Costs			Savings in MT VOC	Savings in MT Travel Time Costs	Savings in NMT Travel & Operating Costs	Reduction in Accident Costs	Net Social / Exogenous Benefits	Net Economic Benefits (NPV)
	Capital	Recurrent	Special						
Undiscounted	13.76	0.27	0.00	353.43	261.35	0.00	0.00	0.00	600.75
Discounted	23.28	-0.17	0.00	103.41	76.07	0.00	0.00	0.00	156.36

Economic Internal Rate of Return (EIRR) = 51.9% (No. of solutions = 1)

HDM-4 **Economic Analysis Summary**

Alternative: Project Case vs Alternative: Base Case
Sensitivity Scenario: Traffic +10%

	Increase in Road Agency Costs			Savings in MT VOC	Savings in MT Travel Time Costs	Savings in NMT Travel & Operating Costs	Reduction in Accident Costs	Net Social / Exogenous Benefits	Net Economic Benefits (NPV)
	Capital	Recurrent	Special						
Undiscounted	13.76	0.27	0.00	322.79	237.30	0.00	0.00	0.00	546.06
Discounted	23.28	-0.17	0.00	84.85	61.03	0.00	0.00	0.00	122.76

Economic Internal Rate of Return (EIRR) = 41.4% (No. of solutions = 1)

Alternative: Project Case vs Alternative: Base Case
Sensitivity Scenario: Traffic -10%

	Increase in Road Agency Costs			Savings in MT VOC	Savings in MT Travel Time Costs	Savings in NMT Travel & Operating Costs	Reduction in Accident Costs	Net Social / Exogenous Benefits	Net Economic Benefits (NPV)
	Capital	Recurrent	Special						
Undiscounted	13.76	0.27	0.00	204.59	143.42	0.00	0.00	0.00	333.97
Discounted	23.28	-0.17	0.00	46.16	30.03	0.00	0.00	0.00	53.08

Economic Internal Rate of Return (EIRR) = 25.5% (No. of solutions = 1)

Alternative: Project Case vs Alternative: Base Case
Sensitivity Scenario: Traffic -20%

	Increase in Road Agency Costs			Savings in MT VOC	Savings in MT Travel Time Costs	Savings in NMT Travel & Operating Costs	Reduction in Accident Costs	Net Social / Exogenous Benefits	Net Economic Benefits (NPV)
	Capital	Recurrent	Special						
Undiscounted	13.76	0.27	0.00	135.37	88.06	0.00	0.00	0.00	209.39
Discounted	23.28	-0.17	0.00	30.15	17.44	0.00	0.00	0.00	24.47

Economic Internal Rate of Return (EIRR) = 19.4% (No. of solutions = 1)

Alternative: Project Case vs Alternative: Base Case
Sensitivity Scenario: Traffic Growth +20%

	Increase in Road Agency Costs			Savings in MT VOC	Savings in MT Travel Time Costs	Savings in NMT Travel & Operating Costs	Reduction in Accident Costs	Net Social / Exogenous Benefits	Net Economic Benefits (NPV)
	Capital	Recurrent	Special						
Undiscounted	13.76	0.27	0.00	325.57	237.10	0.00	0.00	0.00	548.63
Discounted	23.28	-0.17	0.00	83.49	59.18	0.00	0.00	0.00	119.55

Economic Internal Rate of Return (EIRR) = 38.8% (No. of solutions = 1)

HDM-4 **Economic Analysis Summary**

Alternative: Project Case vs Alternative: Base Case
Sensitivity Scenario: Traffic Growth +10%

	Increase in Road Agency Costs			Savings in MT VOC	Savings in MT Travel Time Costs	Savings in NMT Travel & Operating Costs	Reduction in Accident Costs	Net Social / Exogenous Benefits	Net Economic Benefits (NPV)
	Capital	Recurrent	Special						
Undiscounted	13.76	0.27	0.00	302.87	220.44	0.00	0.00	0.00	509.27
Discounted	23.28	-0.17	0.00	74.79	52.57	0.00	0.00	0.00	104.24

Economic Internal Rate of Return (EIRR) = 35.8% (No. of solutions = 1)

Alternative: Project Case vs Alternative: Base Case
Sensitivity Scenario: Traffic Growth -10%

	Increase in Road Agency Costs			Savings in MT VOC	Savings in MT Travel Time Costs	Savings in NMT Travel & Operating Costs	Reduction in Accident Costs	Net Social / Exogenous Benefits	Net Economic Benefits (NPV)
	Capital	Recurrent	Special						
Undiscounted	13.76	0.27	0.00	231.59	166.07	0.00	0.00	0.00	383.62
Discounted	23.28	-0.17	0.00	54.92	37.32	0.00	0.00	0.00	69.12

Economic Internal Rate of Return (EIRR) = 29.5% (No. of solutions = 1)

HDM-4 **Economic Analysis Summary**

Alternative: Project Case vs Alternative: Base Case
Sensitivity Scenario: Traffic Growth -20%

	Increase in Road Agency Costs			Savings in MT VOC	Savings in MT Travel Time Costs	Savings in NMT Travel & Operating Costs	Reduction in Accident Costs	Net Social / Exogenous Benefits	Net Economic Benefits (NPV)
	Capital	Recurrent	Special						
Undiscounted	13.76	0.27	0.00	189.52	133.01	0.00	0.00	0.00	308.50
Discounted	23.28	-0.17	0.00	44.90	29.54	0.00	0.00	0.00	51.32

Economic Internal Rate of Return (EIRR) = 26.3% (No. of solutions = 1)

Alternative: Project Case vs Alternative: Base Case
Sensitivity Scenario: Capital costs +20%

	Increase in Road Agency Costs			Savings in MT VOC	Savings in MT Travel Time Costs	Savings in NMT Travel & Operating Costs	Reduction in Accident Costs	Net Social / Exogenous Benefits	Net Economic Benefits (NPV)
	Capital	Recurrent	Special						
Undiscounted	16.52	0.27	0.00	269.42	195.19	0.00	0.00	0.00	447.81
Discounted	27.94	-0.17	0.00	64.96	45.05	0.00	0.00	0.00	82.24

Economic Internal Rate of Return (EIRR) = 29.4% (No. of solutions = 1)

HDM-4 **Economic Analysis Summary**

Alternative: Project Case vs Alternative: Base Case
Sensitivity Scenario: Capital costs +10%

	Increase in Road Agency Costs			Savings in MT VOC	Savings in MT Travel Time Costs	Savings in NMT Travel & Operating Costs	Reduction in Accident Costs	Net Social / Exogenous Benefits	Net Economic Benefits (NPV)
	Capital	Recurrent	Special						
Undiscounted	15.14	0.27	0.00	269.42	195.19	0.00	0.00	0.00	449.19
Discounted	25.61	-0.17	0.00	64.96	45.05	0.00	0.00	0.00	84.57

Economic Internal Rate of Return (EIRR) = 30.9% (No. of solutions = 1)

Alternative: Project Case vs Alternative: Base Case
Sensitivity Scenario: Capital Costs -10%

	Increase in Road Agency Costs			Savings in MT VOC	Savings in MT Travel Time Costs	Savings in NMT Travel & Operating Costs	Reduction in Accident Costs	Net Social / Exogenous Benefits	Net Economic Benefits (NPV)
	Capital	Recurrent	Special						
Undiscounted	12.39	0.27	0.00	269.42	195.19	0.00	0.00	0.00	451.94
Discounted	20.96	-0.17	0.00	64.96	45.05	0.00	0.00	0.00	89.23

Economic Internal Rate of Return (EIRR) = 34.7% (No. of solutions = 1)

Alternative: Project Case vs Alternative: Base Case
Sensitivity Scenario: Capital Costs -20%

	Increase in Road Agency Costs			Savings in MT VOC	Savings in MT Travel Time Costs	Savings in NMT Travel & Operating Costs	Reduction in Accident Costs	Net Social / Exogenous Benefits	Net Economic Benefits (NPV)
	Capital	Recurrent	Special						
Undiscounted	11.01	0.27	0.00	269.42	195.19	0.00	0.00	0.00	453.32
Discounted	18.63	-0.17	0.00	64.96	45.05	0.00	0.00	0.00	91.56

Economic Internal Rate of Return (EIRR) = 37.2% (No. of solutions = 1)

Alternative: Project Case vs Alternative: Base Case
Sensitivity Scenario: VOC +20%

	Increase in Road Agency Costs			Savings in MT VOC	Savings in MT Travel Time Costs	Savings in NMT Travel & Operating Costs	Reduction in Accident Costs	Net Social / Exogenous Benefits	Net Economic Benefits (NPV)
	Capital	Recurrent	Special						
Undiscounted	13.76	0.27	0.00	323.30	195.19	0.00	0.00	0.00	504.45
Discounted	23.28	-0.17	0.00	77.96	45.05	0.00	0.00	0.00	99.89

Economic Internal Rate of Return (EIRR) = 34.9% (No. of solutions = 1)

HDM-4 Economic Analysis Summary

Alternative: Project Case vs Alternative: Base Case
Sensitivity Scenario: VOC +10%

	Increase in Road Agency Costs			Savings in MT VOC	Savings in MT Travel Time Costs	Savings in NMT Travel & Operating Costs	Reduction in Accident Costs	Net Social / Exogenous Benefits	Net Economic Benefits (NPV)
	Capital	Recurrent	Special						
Undiscounted	13.76	0.27	0.00	296.36	195.19	0.00	0.00	0.00	477.51
Discounted	23.28	-0.17	0.00	71.46	45.05	0.00	0.00	0.00	93.40

Economic Internal Rate of Return (EIRR) = 33.8% (No. of solutions = 1)

Alternative: Project Case vs Alternative: Base Case
Sensitivity Scenario: VOC -10%

	Increase in Road Agency Costs			Savings in MT VOC	Savings in MT Travel Time Costs	Savings in NMT Travel & Operating Costs	Reduction in Accident Costs	Net Social / Exogenous Benefits	Net Economic Benefits (NPV)
	Capital	Recurrent	Special						
Undiscounted	13.76	0.27	0.00	242.47	195.19	0.00	0.00	0.00	423.62
Discounted	23.28	-0.17	0.00	58.47	45.05	0.00	0.00	0.00	80.40

Economic Internal Rate of Return (EIRR) = 31.5% (No. of solutions = 1)

HDM-4 **Economic Analysis Summary**

Alternative: Project Case vs Alternative: Base Case
Sensitivity Scenario: VOC -20%

	Increase in Road Agency Costs			Savings in MT VOC	Savings in MT Travel Time Costs	Savings in NMT Travel & Operating Costs	Reduction in Accident Costs	Net Social / Exogenous Benefits	Net Economic Benefits (NPV)
	Capital	Recurrent	Special						
Undiscounted	13.76	0.27	0.00	215.53	195.19	0.00	0.00	0.00	396.68
Discounted	23.28	-0.17	0.00	51.97	45.05	0.00	0.00	0.00	73.91

Economic Internal Rate of Return (EIRR) = 30.3% (No. of solutions = 1)

Alternative: Project Case vs Alternative: Base Case
Sensitivity Scenario: Travel Time +20%

	Increase in Road Agency Costs			Savings in MT VOC	Savings in MT Travel Time Costs	Savings in NMT Travel & Operating Costs	Reduction in Accident Costs	Net Social / Exogenous Benefits	Net Economic Benefits (NPV)
	Capital	Recurrent	Special						
Undiscounted	13.76	0.27	0.00	269.42	234.22	0.00	0.00	0.00	489.60
Discounted	23.28	-0.17	0.00	64.96	54.07	0.00	0.00	0.00	95.91

Economic Internal Rate of Return (EIRR) = 34.0% (No. of solutions = 1)

HDM-4 **Economic Analysis Summary**

Alternative: Project Case vs Alternative: Base Case
Sensitivity Scenario: Travel Time +10%

	Increase in Road Agency Costs			Savings in MT VOC	Savings in MT Travel Time Costs	Savings in NMT Travel & Operating Costs	Reduction in Accident Costs	Net Social / Exogenous Benefits	Net Economic Benefits (NPV)
	Capital	Recurrent	Special						
Undiscounted	13.76	0.27	0.00	269.42	214.70	0.00	0.00	0.00	470.08
Discounted	23.28	-0.17	0.00	64.96	49.56	0.00	0.00	0.00	91.41

Economic Internal Rate of Return (EIRR) = 33.4% (No. of solutions = 1)

Alternative: Project Case vs Alternative: Base Case
Sensitivity Scenario: Travel Time -10%

	Increase in Road Agency Costs			Savings in MT VOC	Savings in MT Travel Time Costs	Savings in NMT Travel & Operating Costs	Reduction in Accident Costs	Net Social / Exogenous Benefits	Net Economic Benefits (NPV)
	Capital	Recurrent	Special						
Undiscounted	13.76	0.27	0.00	269.42	175.67	0.00	0.00	0.00	431.05
Discounted	23.28	-0.17	0.00	64.96	40.55	0.00	0.00	0.00	82.39

Economic Internal Rate of Return (EIRR) = 31.9% (No. of solutions = 1)

HDM-4 **Economic Analysis Summary**

Alternative: Project Case vs Alternative: Base Case
Sensitivity Scenario: Travel Time -20%

	Increase in Road Agency Costs			Savings in MT VOC	Savings in MT Travel Time Costs	Savings in NMT Travel & Operating Costs	Reduction in Accident Costs	Net Social / Exogenous Benefits	Net Economic Benefits (NPV)
	Capital	Recurrent	Special						
Undiscounted	13.76	0.27	0.00	269.42	156.15	0.00	0.00	0.00	411.53
Discounted	23.28	-0.17	0.00	64.96	36.04	0.00	0.00	0.00	77.89

Economic Internal Rate of Return (EIRR) = 31.2% (No. of solutions = 1)

Table D.2: Option 2 Economic Analysis

HDM-4
HIGHWAY DEVELOPMENT & MANAGEMENT

Economic Analysis Summary

Study Name: **Guyana Sheriff Street - Option 2**
Run Date: **27-04-2011**
Currency: **US Dollar (millions)**
Discount: **12.00%**
Analysis Mode: **Analysis-by-Project**

Alternative: Project Case vs Alternative: Base Case
Sensitivity Scenario: Base Sensitivity Scenario

	Increase in Road Agency Costs			Savings in MT VOC	Savings in MT Travel Time Costs	Savings in NMT Travel & Operating Costs	Reduction in Accident Costs	Net Social / Exogenous Benefits	Net Economic Benefits (NPV)
	Capital	Recurrent	Special						
Undiscounted	10.31	-0.16	0.00	118.79	69.62	0.00	0.00	0.00	178.25
Discounted	15.24	-0.28	0.00	31.71	17.38	0.00	0.00	0.00	34.13

Economic Internal Rate of Return (EIRR) = 28.2% (No. of solutions = 1)

Alternative: Project Case vs Alternative: Base Case
Sensitivity Scenario: Traffic +20%

	Increase in Road Agency Costs			Savings in MT VOC	Savings in MT Travel Time Costs	Savings in NMT Travel & Operating Costs	Reduction in Accident Costs	Net Social / Exogenous Benefits	Net Economic Benefits (NPV)
	Capital	Recurrent	Special						
Undiscounted	10.31	-0.16	0.00	139.12	80.48	0.00	0.00	0.00	209.45
Discounted	15.24	-0.28	0.00	44.25	26.52	0.00	0.00	0.00	55.81

Economic Internal Rate of Return (EIRR) = 41.4% (No. of solutions = 1)

HDM-4 **Economic Analysis Summary**

Alternative: Project Case vs Alternative: Base Case
Sensitivity Scenario: Traffic +10%

	Increase in Road Agency Costs			Savings in MT VOC	Savings in MT Travel Time Costs	Savings in NMT Travel & Operating Costs	Reduction in Accident Costs	Net Social / Exogenous Benefits	Net Economic Benefits (NPV)
	Capital	Recurrent	Special						
Undiscounted	10.31	-0.16	0.00	134.88	80.07	0.00	0.00	0.00	204.79
Discounted	15.24	-0.28	0.00	38.69	22.55	0.00	0.00	0.00	46.28

Economic Internal Rate of Return (EIRR) = 34.6% (No. of solutions = 1)

Alternative: Project Case vs Alternative: Base Case
Sensitivity Scenario: Traffic -10%

	Increase in Road Agency Costs			Savings in MT VOC	Savings in MT Travel Time Costs	Savings in NMT Travel & Operating Costs	Reduction in Accident Costs	Net Social / Exogenous Benefits	Net Economic Benefits (NPV)
	Capital	Recurrent	Special						
Undiscounted	10.31	-0.16	0.00	99.02	55.57	0.00	0.00	0.00	144.44
Discounted	15.24	-0.28	0.00	24.79	12.22	0.00	0.00	0.00	22.06

Economic Internal Rate of Return (EIRR) = 22.7% (No. of solutions = 1)

Alternative: Project Case vs Alternative: Base Case
Sensitivity Scenario: Traffic -20%

	Increase in Road Agency Costs			Savings in MT VOC	Savings in MT Travel Time Costs	Savings in NMT Travel & Operating Costs	Reduction in Accident Costs	Net Social / Exogenous Benefits	Net Economic Benefits (NPV)
	Capital	Recurrent	Special						
Undiscounted	10.31	-0.16	0.00	76.86	39.36	0.00	0.00	0.00	106.07
Discounted	15.24	-0.28	0.00	18.51	7.67	0.00	0.00	0.00	11.22

Economic Internal Rate of Return (EIRR) = 18.0% (No. of solutions = 1)

Alternative: Project Case vs Alternative: Base Case
Sensitivity Scenario: Traffic Growth +20%

	Increase in Road Agency Costs			Savings in MT VOC	Savings in MT Travel Time Costs	Savings in NMT Travel & Operating Costs	Reduction in Accident Costs	Net Social / Exogenous Benefits	Net Economic Benefits (NPV)
	Capital	Recurrent	Special						
Undiscounted	10.31	-0.16	0.00	152.77	92.01	0.00	0.00	0.00	234.63
Discounted	15.24	-0.28	0.00	43.30	25.59	0.00	0.00	0.00	53.92

Economic Internal Rate of Return (EIRR) = 36.0% (No. of solutions = 1)

HDM-4 **Economic Analysis Summary**

Alternative: Project Case vs Alternative: Base Case
Sensitivity Scenario: Traffic Growth +10%

	Increase in Road Agency Costs			Savings in MT VOC	Savings in MT Travel Time Costs	Savings in NMT Travel & Operating Costs	Reduction in Accident Costs	Net Social / Exogenous Benefits	Net Economic Benefits (NPV)
	Capital	Recurrent	Special						
Undiscounted	10.31	-0.16	0.00	139.19	83.67	0.00	0.00	0.00	212.72
Discounted	15.24	-0.28	0.00	37.86	21.79	0.00	0.00	0.00	44.70

Economic Internal Rate of Return (EIRR) = 32.2% (No. of solutions = 1)

Alternative: Project Case vs Alternative: Base Case
Sensitivity Scenario: Traffic Growth -10%

	Increase in Road Agency Costs			Savings in MT VOC	Savings in MT Travel Time Costs	Savings in NMT Travel & Operating Costs	Reduction in Accident Costs	Net Social / Exogenous Benefits	Net Economic Benefits (NPV)
	Capital	Recurrent	Special						
Undiscounted	10.31	-0.16	0.00	98.08	54.97	0.00	0.00	0.00	142.90
Discounted	15.24	-0.28	0.00	25.84	13.14	0.00	0.00	0.00	24.02

Economic Internal Rate of Return (EIRR) = 24.2% (No. of solutions = 1)

Mott MacDonald

HDM-4 **Economic Analysis Summary**

Alternative: Project Case vs Alternative: Base Case
Sensitivity Scenario: Traffic Growth -20%

	Increase in Road Agency Costs			Savings in MT VOC	Savings in MT Travel Time Costs	Savings in NMT Travel & Operating Costs	Reduction in Accident Costs	Net Social / Exogenous Benefits	Net Economic Benefits (NPV)
	Capital	Recurrent	Special						
Undiscounted	10.31	-0.16	0.00	79.35	41.39	0.00	0.00	0.00	110.58
Discounted	15.24	-0.28	0.00	20.57	9.33	0.00	0.00	0.00	14.94

Economic Internal Rate of Return (EIRR) = 20.2% (No. of solutions = 1)

Alternative: Project Case vs Alternative: Base Case
Sensitivity Scenario: Capital Costs +20%

	Increase in Road Agency Costs			Savings in MT VOC	Savings in MT Travel Time Costs	Savings in NMT Travel & Operating Costs	Reduction in Accident Costs	Net Social / Exogenous Benefits	Net Economic Benefits (NPV)
	Capital	Recurrent	Special						
Undiscounted	12.37	-0.16	0.00	118.79	69.62	0.00	0.00	0.00	176.19
Discounted	18.29	-0.28	0.00	31.71	17.38	0.00	0.00	0.00	31.08

Economic Internal Rate of Return (EIRR) = 25.0% (No. of solutions = 1)

HDM-4 **Economic Analysis Summary**

Alternative: Project Case vs Alternative: Base Case
Sensitivity Scenario: Capital Costs +10%

	Increase in Road Agency Costs			Savings in MT VOC	Savings in MT Travel Time Costs	Savings in NMT Travel & Operating Costs	Reduction in Accident Costs	Net Social / Exogenous Benefits	Net Economic Benefits (NPV)
	Capital	Recurrent	Special						
Undiscounted	11.34	-0.16	0.00	118.79	69.62	0.00	0.00	0.00	177.22
Discounted	16.77	-0.28	0.00	31.71	17.38	0.00	0.00	0.00	32.60

Economic Internal Rate of Return (EIRR) = 26.5% (No. of solutions = 1)

Alternative: Project Case vs Alternative: Base Case
Sensitivity Scenario: Capital Costs -10%

	Increase in Road Agency Costs			Savings in MT VOC	Savings in MT Travel Time Costs	Savings in NMT Travel & Operating Costs	Reduction in Accident Costs	Net Social / Exogenous Benefits	Net Economic Benefits (NPV)
	Capital	Recurrent	Special						
Undiscounted	9.28	-0.16	0.00	118.79	69.62	0.00	0.00	0.00	179.29
Discounted	13.72	-0.28	0.00	31.71	17.38	0.00	0.00	0.00	35.65

Economic Internal Rate of Return (EIRR) = 30.2% (No. of solutions = 1)

HDM-4 **Economic Analysis Summary**

Alternative: Project Case vs Alternative: Base Case
Sensitivity Scenario: Capital Costs -20%

	Increase in Road Agency Costs			Savings in MT VOC	Savings in MT Travel Time Costs	Savings in NMT Travel & Operating Costs	Reduction in Accident Costs	Net Social / Exogenous Benefits	Net Economic Benefits (NPV)
	Capital	Recurrent	Special						
Undiscounted	8.25	-0.16	0.00	118.79	69.62	0.00	0.00	0.00	180.32
Discounted	12.19	-0.28	0.00	31.71	17.38	0.00	0.00	0.00	37.18

Economic Internal Rate of Return (EIRR) = 32.5% (No. of solutions = 1)

Alternative: Project Case vs Alternative: Base Case
Sensitivity Scenario: VOC +20%

	Increase in Road Agency Costs			Savings in MT VOC	Savings in MT Travel Time Costs	Savings in NMT Travel & Operating Costs	Reduction in Accident Costs	Net Social / Exogenous Benefits	Net Economic Benefits (NPV)
	Capital	Recurrent	Special						
Undiscounted	10.31	-0.16	0.00	142.54	69.62	0.00	0.00	0.00	202.01
Discounted	15.24	-0.28	0.00	38.05	17.38	0.00	0.00	0.00	40.47

Economic Internal Rate of Return (EIRR) = 30.6% (No. of solutions = 1)

HDM-4 Economic Analysis Summary

Alternative: Project Case vs Alternative: Base Case
Sensitivity Scenario: VOC +10%

	Increase in Road Agency Costs			Savings in MT VOC	Savings in MT Travel Time Costs	Savings in NMT Travel & Operating Costs	Reduction in Accident Costs	Net Social / Exogenous Benefits	Net Economic Benefits (NPV)
	Capital	Recurrent	Special						
Undiscounted	10.31	-0.16	0.00	130.66	69.62	0.00	0.00	0.00	190.13
Discounted	15.24	-0.28	0.00	34.88	17.38	0.00	0.00	0.00	37.30

Economic Internal Rate of Return (EIRR) = 29.4% (No. of solutions = 1)

Alternative: Project Case vs Alternative: Base Case
Sensitivity Scenario: VOC -10%

	Increase in Road Agency Costs			Savings in MT VOC	Savings in MT Travel Time Costs	Savings in NMT Travel & Operating Costs	Reduction in Accident Costs	Net Social / Exogenous Benefits	Net Economic Benefits (NPV)
	Capital	Recurrent	Special						
Undiscounted	10.31	-0.16	0.00	106.91	69.62	0.00	0.00	0.00	166.38
Discounted	15.24	-0.28	0.00	28.54	17.38	0.00	0.00	0.00	30.96

Economic Internal Rate of Return (EIRR) = 26.9% (No. of solutions = 1)

HDM-4 **Economic Analysis Summary**

Alternative: Project Case vs Alternative: Base Case
Sensitivity Scenario: VOC -20%

	Increase in Road Agency Costs			Savings in MT VOC	Savings in MT Travel Time Costs	Savings in NMT Travel & Operating Costs	Reduction in Accident Costs	Net Social / Exogenous Benefits	Net Economic Benefits (NPV)
	Capital	Recurrent	Special						
Undiscounted	10.31	-0.16	0.00	95.03	69.62	0.00	0.00	0.00	154.50
Discounted	15.24	-0.28	0.00	25.37	17.38	0.00	0.00	0.00	27.79

Economic Internal Rate of Return (EIRR) = 25.7% (No. of solutions = 1)

Alternative: Project Case vs Alternative: Base Case
Sensitivity Scenario: Travel Time +20%

	Increase in Road Agency Costs			Savings in MT VOC	Savings in MT Travel Time Costs	Savings in NMT Travel & Operating Costs	Reduction in Accident Costs	Net Social / Exogenous Benefits	Net Economic Benefits (NPV)
	Capital	Recurrent	Special						
Undiscounted	10.31	-0.16	0.00	118.79	83.54	0.00	0.00	0.00	192.18
Discounted	15.24	-0.28	0.00	31.71	20.85	0.00	0.00	0.00	37.60

Economic Internal Rate of Return (EIRR) = 29.3% (No. of solutions = 1)

HDM-4 **Economic Analysis Summary**

Alternative: Project Case vs Alternative: Base Case
Sensitivity Scenario: Travel Time +10%

	Increase in Road Agency Costs			Savings in MT VOC	Savings in MT Travel Time Costs	Savings in NMT Travel & Operating Costs	Reduction in Accident Costs	Net Social / Exogenous Benefits	Net Economic Benefits (NPV)
	Capital	Recurrent	Special						
Undiscounted	10.31	-0.16	0.00	118.79	76.58	0.00	0.00	0.00	185.22
Discounted	15.24	-0.28	0.00	31.71	19.11	0.00	0.00	0.00	35.87

Economic Internal Rate of Return (EIRR) = 28.8% (No. of solutions = 1)

Alternative: Project Case vs Alternative: Base Case
Sensitivity Scenario: Travel Time -10%

	Increase in Road Agency Costs			Savings in MT VOC	Savings in MT Travel Time Costs	Savings in NMT Travel & Operating Costs	Reduction in Accident Costs	Net Social / Exogenous Benefits	Net Economic Benefits (NPV)
	Capital	Recurrent	Special						
Undiscounted	10.31	-0.16	0.00	118.79	62.66	0.00	0.00	0.00	171.29
Discounted	15.24	-0.28	0.00	31.71	15.64	0.00	0.00	0.00	32.39

Economic Internal Rate of Return (EIRR) = 27.6% (No. of solutions = 1)

HDM-4 **Economic Analysis Summary**

Alternative: Project Case vs Alternative: Base Case
Sensitivity Scenario: Travel Time -20%

	Increase in Road Agency Costs			Savings in MT VOC	Savings in MT Travel Time Costs	Savings in NMT Travel & Operating Costs	Reduction in Accident Costs	Net Social / Exogenous Benefits	Net Economic Benefits (NPV)
	Capital	Recurrent	Special						
Undiscounted	10.31	-0.16	0.00	118.79	55.70	0.00	0.00	0.00	164.33
Discounted	15.24	-0.28	0.00	31.71	13.90	0.00	0.00	0.00	30.65

Economic Internal Rate of Return (EIRR) = 27.0% (No. of solutions = 1)

Table D.3: Option 3 Economic Analysis

HDM-4
HIGHWAY DEVELOPMENT & MANAGEMENT

Economic Analysis Summary

Study Name: **Guyana Sheriff Street - Option 3**
Run Date: **27-04-2011**
Currency: **US Dollar (millions)**
Discount: **12.00%**
Analysis Mode: **Analysis-by-Project**

Alternative: Project Case vs Alternative: Base Case
Sensitivity Scenario: Base Sensitivity Scenario

	Increase in Road Agency Costs			Savings in MT VOC	Savings in MT Travel Time Costs	Savings in NMT Travel & Operating Costs	Reduction in Accident Costs	Net Social / Exogenous Benefits	Net Economic Benefits (NPV)
	Capital	Recurrent	Special						
Undiscounted	10.31	-0.30	0.00	109.93	61.98	0.00	0.00	0.00	161.89
Discounted	15.24	-0.32	0.00	28.96	14.91	0.00	0.00	0.00	28.95

Economic Internal Rate of Return (EIRR) = 25.8% (No. of solutions = 1)

Alternative: Project Case vs Alternative: Base Case
Sensitivity Scenario: Traffic +20%

	Increase in Road Agency Costs			Savings in MT VOC	Savings in MT Travel Time Costs	Savings in NMT Travel & Operating Costs	Reduction in Accident Costs	Net Social / Exogenous Benefits	Net Economic Benefits (NPV)
	Capital	Recurrent	Special						
Undiscounted	10.31	-0.30	0.00	129.54	72.74	0.00	0.00	0.00	192.27
Discounted	15.24	-0.32	0.00	40.88	23.66	0.00	0.00	0.00	49.61

Economic Internal Rate of Return (EIRR) = 38.2% (No. of solutions = 1)

HDM-4 **Economic Analysis Summary**

Alternative: Project Case vs Alternative: Base Case
Sensitivity Scenario: Traffic +10%

	Increase in Road Agency Costs			Savings in MT VOC	Savings in MT Travel Time Costs	Savings in NMT Travel & Operating Costs	Reduction in Accident Costs	Net Social / Exogenous Benefits	Net Economic Benefits (NPV)
	Capital	Recurrent	Special						
Undiscounted	10.31	-0.30	0.00	124.90	71.77	0.00	0.00	0.00	186.65
Discounted	15.24	-0.32	0.00	35.53	19.79	0.00	0.00	0.00	40.40

Economic Internal Rate of Return (EIRR) = 31.8% (No. of solutions = 1)

Alternative: Project Case vs Alternative: Base Case
Sensitivity Scenario: Traffic -10%

	Increase in Road Agency Costs			Savings in MT VOC	Savings in MT Travel Time Costs	Savings in NMT Travel & Operating Costs	Reduction in Accident Costs	Net Social / Exogenous Benefits	Net Economic Benefits (NPV)
	Capital	Recurrent	Special						
Undiscounted	10.31	-0.30	0.00	91.48	48.83	0.00	0.00	0.00	130.29
Discounted	15.24	-0.32	0.00	22.51	10.11	0.00	0.00	0.00	17.70

Economic Internal Rate of Return (EIRR) = 20.6% (No. of solutions = 1)

HDM-4 **Economic Analysis Summary**

Alternative: Project Case vs Alternative: Base Case
Sensitivity Scenario: Traffic -20%

	Increase in Road Agency Costs			Savings in MT VOC	Savings in MT Travel Time Costs	Savings in NMT Travel & Operating Costs	Reduction in Accident Costs	Net Social / Exogenous Benefits	Net Economic Benefits (NPV)
	Capital	Recurrent	Special						
Undiscounted	10.31	-0.30	0.00	70.12	33.17	0.00	0.00	0.00	93.28
Discounted	15.24	-0.32	0.00	16.64	5.90	0.00	0.00	0.00	7.62

Economic Internal Rate of Return (EIRR) = 16.1% (No. of solutions = 1)

Alternative: Project Case vs Alternative: Base Case
Sensitivity Scenario: Traffic Growth +20%

	Increase in Road Agency Costs			Savings in MT VOC	Savings in MT Travel Time Costs	Savings in NMT Travel & Operating Costs	Reduction in Accident Costs	Net Social / Exogenous Benefits	Net Economic Benefits (NPV)
	Capital	Recurrent	Special						
Undiscounted	10.31	-0.30	0.00	143.63	84.41	0.00	0.00	0.00	218.02
Discounted	15.24	-0.32	0.00	40.42	23.07	0.00	0.00	0.00	48.57

Economic Internal Rate of Return (EIRR) = 33.7% (No. of solutions = 1)

HDM-4 **Economic Analysis Summary**

Alternative: Project Case vs Alternative: Base Case
Sensitivity Scenario: Traffic Growth +10%

	Increase in Road Agency Costs			Savings in MT VOC	Savings in MT Travel Time Costs	Savings in NMT Travel & Operating Costs	Reduction in Accident Costs	Net Social / Exogenous Benefits	Net Economic Benefits (NPV)
	Capital	Recurrent	Special						
Undiscounted	10.31	-0.30	0.00	129.84	75.77	0.00	0.00	0.00	195.60
Discounted	15.24	-0.32	0.00	35.01	19.26	0.00	0.00	0.00	39.35

Economic Internal Rate of Return (EIRR) = 29.8% (No. of solutions = 1)

Alternative: Project Case vs Alternative: Base Case
Sensitivity Scenario: Traffic Growth -10%

	Increase in Road Agency Costs			Savings in MT VOC	Savings in MT Travel Time Costs	Savings in NMT Travel & Operating Costs	Reduction in Accident Costs	Net Social / Exogenous Benefits	Net Economic Benefits (NPV)
	Capital	Recurrent	Special						
Undiscounted	10.31	-0.30	0.00	89.73	47.62	0.00	0.00	0.00	127.34
Discounted	15.24	-0.32	0.00	23.19	10.74	0.00	0.00	0.00	19.01

Economic Internal Rate of Return (EIRR) = 21.7% (No. of solutions = 1)

Mott MacDonald

HDM-4 **Economic Analysis Summary**

Alternative: Project Case vs Alternative: Base Case
Sensitivity Scenario: Traffic Growth -20%

	Increase in Road Agency Costs			Savings in MT VOC	Savings in MT Travel Time Costs	Savings in NMT Travel & Operating Costs	Reduction in Accident Costs	Net Social / Exogenous Benefits	Net Economic Benefits (NPV)
	Capital	Recurrent	Special						
Undiscounted	10.31	-0.30	0.00	71.18	34.09	0.00	0.00	0.00	95.25
Discounted	15.24	-0.32	0.00	18.00	6.97	0.00	0.00	0.00	10.04

Economic Internal Rate of Return (EIRR) = 17.6% (No. of solutions = 1)

Alternative: Project Case vs Alternative: Base Case
Sensitivity Scenario: Capital Costs +20%

	Increase in Road Agency Costs			Savings in MT VOC	Savings in MT Travel Time Costs	Savings in NMT Travel & Operating Costs	Reduction in Accident Costs	Net Social / Exogenous Benefits	Net Economic Benefits (NPV)
	Capital	Recurrent	Special						
Undiscounted	12.37	-0.30	0.00	109.93	61.98	0.00	0.00	0.00	159.83
Discounted	18.29	-0.32	0.00	28.96	14.91	0.00	0.00	0.00	25.90

Economic Internal Rate of Return (EIRR) = 22.9% (No. of solutions = 1)

HDM-4 Economic Analysis Summary

Alternative: Project Case vs Alternative: Base Case
Sensitivity Scenario: Capital Costs +10%

	Increase in Road Agency Costs			Savings in MT VOC	Savings in MT Travel Time Costs	Savings in NMT Travel & Operating Costs	Reduction in Accident Costs	Net Social / Exogenous Benefits	Net Economic Benefits (NPV)
	Capital	Recurrent	Special						
Undiscounted	11.34	-0.30	0.00	109.93	61.98	0.00	0.00	0.00	160.86
Discounted	16.77	-0.32	0.00	28.96	14.91	0.00	0.00	0.00	27.42

Economic Internal Rate of Return (EIRR) = 24.2% (No. of solutions = 1)

Alternative: Project Case vs Alternative: Base Case
Sensitivity Scenario: Capital Costs -10%

	Increase in Road Agency Costs			Savings in MT VOC	Savings in MT Travel Time Costs	Savings in NMT Travel & Operating Costs	Reduction in Accident Costs	Net Social / Exogenous Benefits	Net Economic Benefits (NPV)
	Capital	Recurrent	Special						
Undiscounted	9.28	-0.30	0.00	109.93	61.98	0.00	0.00	0.00	162.92
Discounted	13.72	-0.32	0.00	28.96	14.91	0.00	0.00	0.00	30.47

Economic Internal Rate of Return (EIRR) = 27.5% (No. of solutions = 1)

HDM-4 Economic Analysis Summary

Alternative: Project Case vs Alternative: Base Case
Sensitivity Scenario: Capital Costs -20%

	Increase in Road Agency Costs			Savings in MT VOC	Savings in MT Travel Time Costs	Savings in NMT Travel & Operating Costs	Reduction in Accident Costs	Net Social / Exogenous Benefits	Net Economic Benefits (NPV)
	Capital	Recurrent	Special						
Undiscounted	8.25	-0.30	0.00	109.93	61.98	0.00	0.00	0.00	163.95
Discounted	12.19	-0.32	0.00	28.96	14.91	0.00	0.00	0.00	32.00

Economic Internal Rate of Return (EIRR) = 29.7% (No. of solutions = 1)

Alternative: Project Case vs Alternative: Base Case
Sensitivity Scenario: VOC +20%

	Increase in Road Agency Costs			Savings in MT VOC	Savings in MT Travel Time Costs	Savings in NMT Travel & Operating Costs	Reduction in Accident Costs	Net Social / Exogenous Benefits	Net Economic Benefits (NPV)
	Capital	Recurrent	Special						
Undiscounted	10.31	-0.30	0.00	131.91	61.98	0.00	0.00	0.00	183.88
Discounted	15.24	-0.32	0.00	34.75	14.91	0.00	0.00	0.00	34.74

Economic Internal Rate of Return (EIRR) = 28.0% (No. of solutions = 1)

Alternative: Project Case vs Alternative: Base Case
Sensitivity Scenario: VOC +10%

	Increase in Road Agency Costs			Savings in MT VOC	Savings in MT Travel Time Costs	Savings in NMT Travel & Operating Costs	Reduction in Accident Costs	Net Social / Exogenous Benefits	Net Economic Benefits (NPV)
	Capital	Recurrent	Special						
Undiscounted	10.31	-0.30	0.00	120.92	61.98	0.00	0.00	0.00	172.88
Discounted	15.24	-0.32	0.00	31.86	14.91	0.00	0.00	0.00	31.84

Economic Internal Rate of Return (EIRR) = 26.9% (No. of solutions = 1)

Alternative: Project Case vs Alternative: Base Case
Sensitivity Scenario: VOC -10%

	Increase in Road Agency Costs			Savings in MT VOC	Savings in MT Travel Time Costs	Savings in NMT Travel & Operating Costs	Reduction in Accident Costs	Net Social / Exogenous Benefits	Net Economic Benefits (NPV)
	Capital	Recurrent	Special						
Undiscounted	10.31	-0.30	0.00	98.93	61.98	0.00	0.00	0.00	150.90
Discounted	15.24	-0.32	0.00	26.06	14.91	0.00	0.00	0.00	26.05

Economic Internal Rate of Return (EIRR) = 24.6% (No. of solutions = 1)

HDM-4 **Economic Analysis Summary**

Alternative: Project Case vs Alternative: Base Case
Sensitivity Scenario: VOC -20%

	Increase in Road Agency Costs			Savings in MT VOC	Savings in MT Travel Time Costs	Savings in NMT Travel & Operating Costs	Reduction in Accident Costs	Net Social / Exogenous Benefits	Net Economic Benefits (NPV)
	Capital	Recurrent	Special						
Undiscounted	10.31	-0.30	0.00	87.94	61.98	0.00	0.00	0.00	139.91
Discounted	15.24	-0.32	0.00	23.17	14.91	0.00	0.00	0.00	23.16

Economic Internal Rate of Return (EIRR) = 23.5% (No. of solutions = 1)

Alternative: Project Case vs Alternative: Base Case
Sensitivity Scenario: Travel Time +20%

	Increase in Road Agency Costs			Savings in MT VOC	Savings in MT Travel Time Costs	Savings in NMT Travel & Operating Costs	Reduction in Accident Costs	Net Social / Exogenous Benefits	Net Economic Benefits (NPV)
	Capital	Recurrent	Special						
Undiscounted	10.31	-0.30	0.00	109.93	74.38	0.00	0.00	0.00	174.29
Discounted	15.24	-0.32	0.00	28.96	17.89	0.00	0.00	0.00	31.93

Economic Internal Rate of Return (EIRR) = 26.7% (No. of solutions = 1)

HDM-4 **Economic Analysis Summary**

Alternative: Project Case vs Alternative: Base Case
Sensitivity Scenario: Travel Time +10%

	Increase in Road Agency Costs			Savings in MT VOC	Savings in MT Travel Time Costs	Savings in NMT Travel & Operating Costs	Reduction in Accident Costs	Net Social / Exogenous Benefits	Net Economic Benefits (NPV)
	Capital	Recurrent	Special						
Undiscounted	10.31	-0.30	0.00	109.93	68.18	0.00	0.00	0.00	168.09
Discounted	15.24	-0.32	0.00	28.96	16.40	0.00	0.00	0.00	30.44

Economic Internal Rate of Return (EIRR) = 26.2% (No. of solutions = 1)

Alternative: Project Case vs Alternative: Base Case
Sensitivity Scenario: Travel Time -10%

	Increase in Road Agency Costs			Savings in MT VOC	Savings in MT Travel Time Costs	Savings in NMT Travel & Operating Costs	Reduction in Accident Costs	Net Social / Exogenous Benefits	Net Economic Benefits (NPV)
	Capital	Recurrent	Special						
Undiscounted	10.31	-0.30	0.00	109.93	55.78	0.00	0.00	0.00	155.69
Discounted	15.24	-0.32	0.00	28.96	13.42	0.00	0.00	0.00	27.46

Economic Internal Rate of Return (EIRR) = 25.3% (No. of solutions = 1)

HDM-4 **Economic Analysis Summary**

Alternative: Project Case vs Alternative: Base Case
Sensitivity Scenario: Travel Time -20%

	Increase in Road Agency Costs			Savings in MT VOC	Savings in MT Travel Time Costs	Savings in NMT Travel & Operating Costs	Reduction in Accident Costs	Net Social / Exogenous Benefits	Net Economic Benefits (NPV)
	Capital	Recurrent	Special						
Undiscounted	10.31	-0.30	0.00	109.93	49.58	0.00	0.00	0.00	149.50
Discounted	15.24	-0.32	0.00	28.96	11.93	0.00	0.00	0.00	25.97

Economic Internal Rate of Return (EIRR) = 24.8% (No. of solutions = 1)