AFRICAN DEVELOPMENT BANK
GOVERNMENT OF MAURITIUS

BEAU BASSIN-PORT LOUIS LINK ROAD

FEASIBILITY STUDY

FINAL REPORT

VOLUME 1

DECEMBER 1978

Japan International Cooperation Agency

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PREFACE

In response to a request of the Government of Mauritius and the African Development Bank, the Government of Japan decided to conduct a feasibility study on a project for link road construction between Port Louis and Beau Bassin, the North-Western part of Mauritius and Japan International Cooperation Agency (hereinafter referred to as "JICA"), the official agency responsible for the implementation of technical cooperation programs of the Government of Japan, carried out the study.

Noting the importance of this project which constitutes part of the North-South national trunk road of Mauritius and in the light of its being the second project under the technical cooperation programme agreed upon between the African Development Bank and the Government of Japan, JICA dispatched a preliminary survey team headed by Mr. Kimio Chiba, the Director of Toyama Construction Office, Hokuriku Regional Construction Bureau, Ministry of Construction, to Mauritius and the African Development Bank in November 1976 for planning and preparation of the study.

Following the above team, a feasubility study team headed by Mr. Shunji Minami was sent to Mauritius and executed a field survey from November to December in 1977.

After discussions of the Draft Final Report prepared by the study team with the Government of Mauritius and the African Development Bank in September 1978, the team has completed the Final Report for submission.

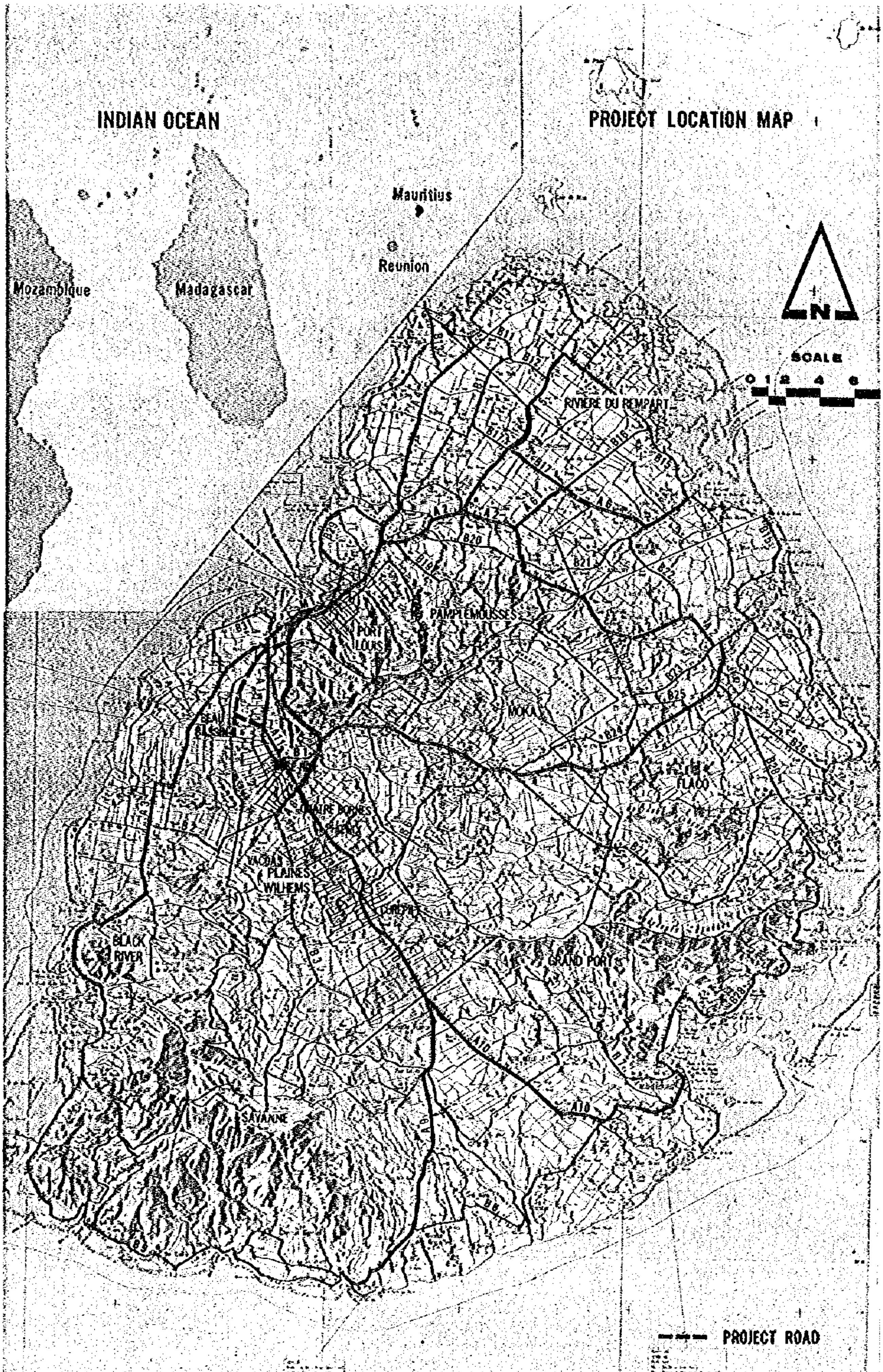
It is my sincere hope that this report will prove to be useful in the link road construction project in Mauritius.

I wish to express my deep appreciation to all the officials and people concerned for their kind cooperation extended to our study teams.

December 1978

Shinsaku Hogen
President

Japan International Cooperation Agency



INDIAN OCEAN
PROJECT LOCATION MAP
Mauritius
Reunion
Mozambique
Madagascar
N
SCALE
0 1 2 4 6
RIVIERE DU REMPART
PAMPLEMOUSSES
PORT LOUIS
MOKA
FLACQ
BLACK RIVER
PLAINES WILHEMS
CUREPIPE
GRAND PORT
SAVANNE
PROJECT ROAD

Currency Equivalents

Currency Unit = Mauritius Rupee

US$ 1.00 = R_S 6.3

R_S 1.00 = US$ 0.16

System of Weights and Measures : Metric

1 meter (m) = 3.28 feet (ft)

1 cubic meter (m^3) = 35.29 cubic feet (ft^3)

1 kilometer (km) = 0.62 mile

1 square kilometer (km^2) = 0.39 square miles

1 hectare (ha) = 2.47 acres

1 metric ton = 2.204 pounds (lbs)

In all figures desimal point is indicated with a dot and thousand, million and billion are marked off with a comma.

Abbreviation

AASHTO	:	American Association of State Highway and Transportation Officials
AASHO	:	American Association of State Highway Officials
ADT	:	Average Daily Traffic
ADB	:	African Development Bank
B/C	:	Benefit/Cost Ratio
BCEOM	:	Bureau Central par des Equipments d'Outre-Mer
BS	:	British Standards
CBR	:	California Bearing Ratio
GDP	:	Gross Domestic Products
G.R.N.W.	:	Grand River North West
JIS	:	Japan Industrial Standards
KPH,Km/h	:	Kilometers per Hour
MOW	:	Ministry of Works
MOHLTCP	:	Ministry of Housing, Lands and Towns & Country Planning
MPH	:	Miles per Hour
O-D	:	Origin-Destination
OECD	:	Organisation for Economic Co-operation and Development
PC	:	Pre-stressed Concrete
p.c.u.	:	Passenger Car Unit
p.c.u./hr	:	Passenger Car Unit per Hour
RC	:	Reinforced Concrete
Rs.	:	Rupees

CONCLUSION AND RECOMMENDATIONS

1. Conclusion

1.1 Outline of Optimum Plan

As shown in Figuar 1, an optimum route has been determined by taking into consideration careful techno-economic studies after selecting two alternative routes from several alternatives by the performance of field survey.

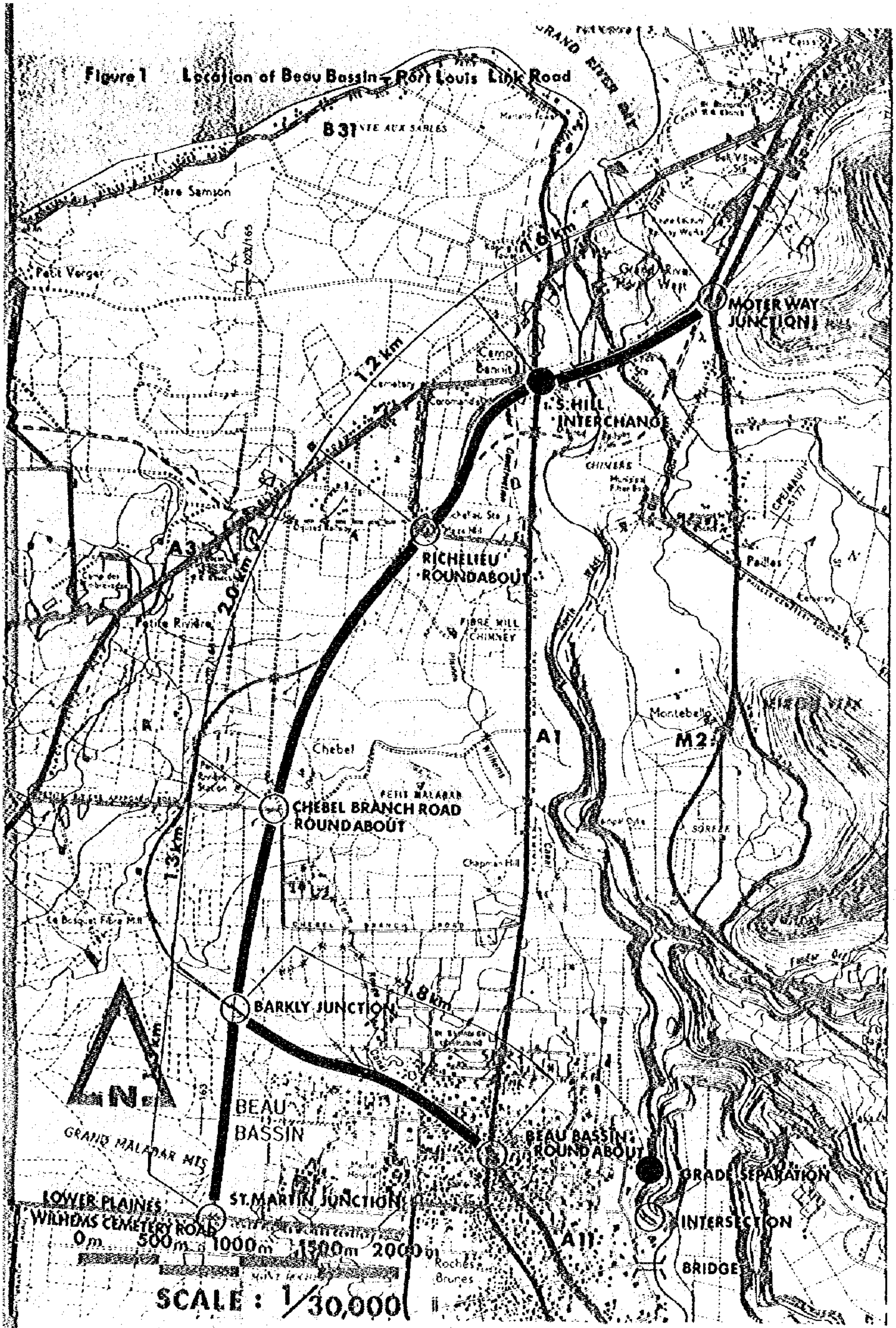
The Project Road starts to divert from the motorway in the vicinity of St. Louis Generating Power Station; passes under the A_1 Road at S. Hill by basically utilizing the disused railway track; goes down southward at the west area of the Coromandel Industrial Estate; and then, diverts from the disused railway track, further goes down southward with an average gradient of 4 %, and again crosses with the disused railway track at Barkly Junction; and further goes down southward and finally reach St. Martin Junction on Lower Plaine Wilhems Cemetery Road, representing the dual 4-lane road of 7.4 km in total length. The Project also includes an access 2-lane road of 1.8 km in its length, branching out from Barkly Junction and reaching to Beau Bassin Roundabout, by partially utilizing the disused railway track.

However, the road of 1.3 km in length between Barkly Junction and St. Martin Junction is planned initially to be 2-lane, with the consideration to make it available in the conditions of structural specifications and land reserves to widen to the dual 2-lane road in the future. The design standards and standard cross sections are shown as follows.

Table 1 Design Standards of Project Road

	Main Road	Access Road
Design Speed	100 km/h	40 km/h
Road Reserve (from edge of road)	15 m	
Width of Carriageway	7.2 m	7.2 m
Minimum Curve Radius	500 m	
Maximum Longitudinal Grade	5 %	4 %
Vertical Clearance	H = 5.5 m	H = 5.5 m

Figure 1 Location of Beau Bassin - Port Louis Link Road



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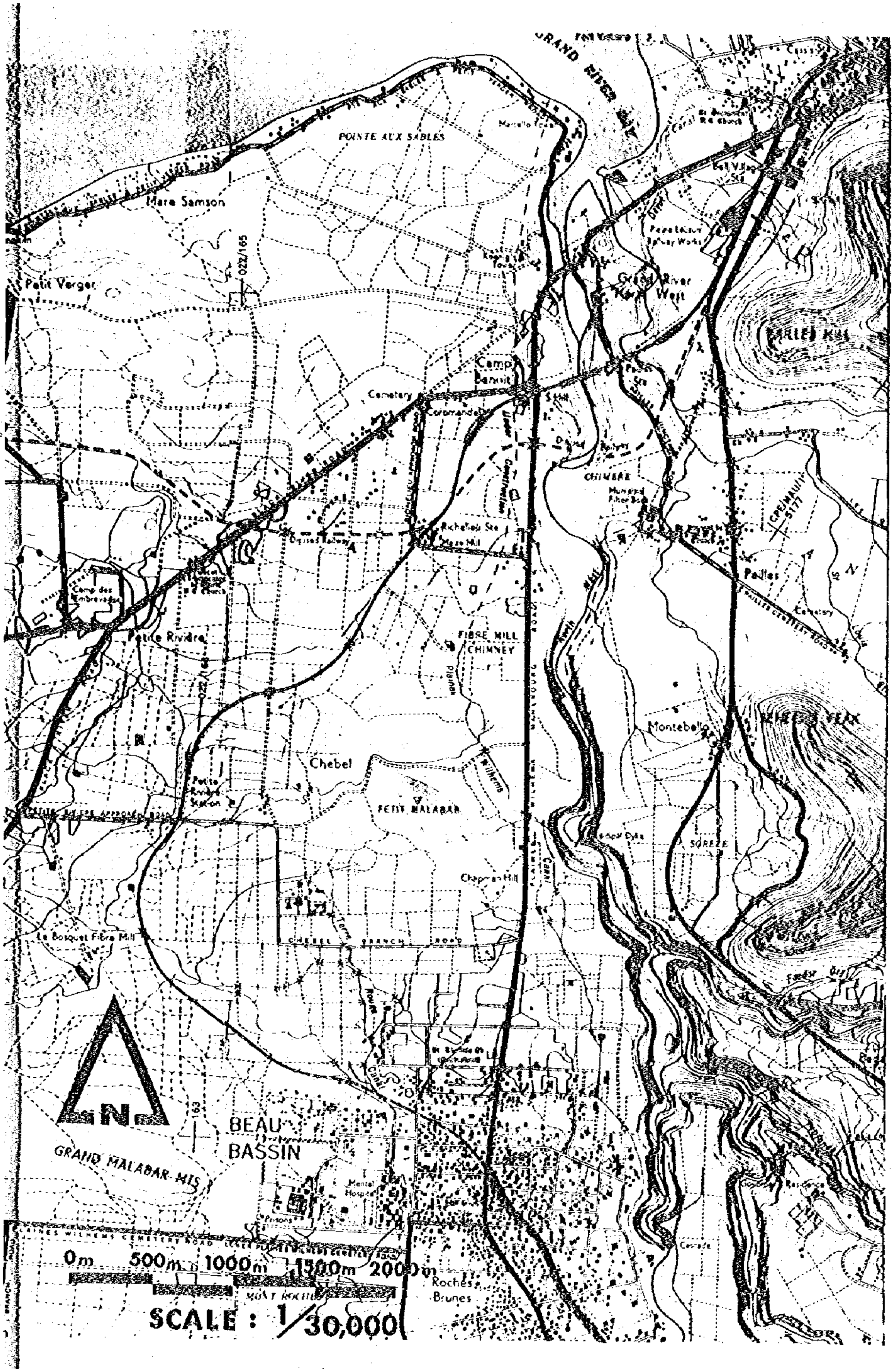
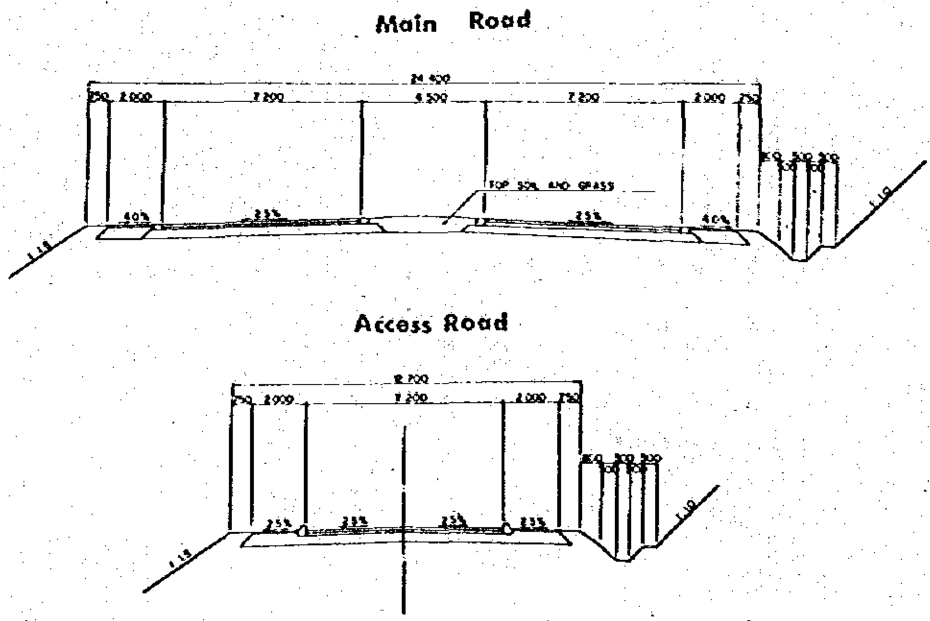


POINTE AUX SABLES
Mare Samson
Petit Verger
Camp Benoit
Cemetery
Coromandel
Grand River North West
GRAND RIVER
CHIMERE
Camp des Embrevades
Petite Rivière
FIBRE MILL CHIMNEY
Pailles
Cemetery
Montebello
Chebel
PETIT MALABAR
SOREZE
Chapman Hill
Le Bosquet Fibre Mill
CHEBEL BRANCH ROAD
BEAU BASSIN
GRAND MALABAR MTS
Mental Hospital
Prisons
Roches Brunes
MONT ROCHES
N
0m 500m 1000m 1500m 2000m
SCALE : 1/30,000

Fig. 2 Standard Cross Sections of Project Road



1.2 Construction Schedule and Costs

Construction schedule and costs for both the package construction and the staged construction are shown as follows:

(1) Construction Schedule

Table 2-1 Package Construction Schedule and
1st Stage of Staged Construction Schedule

Calender Year	1979				1980				1981				1982			
Month	J F M	A M J	J A S	O N D	J F M	A M J	J A S	O N D	J F M	A M J	J A S	O N D	J F M	A M J	J A S	O N D
Detailed Design																
Construction				Preparation												

Table 2-2 2nd Stage of Staged Construction Schedule

Calender Year	1987				1988				1989			
Month	J F M	A M J	J A S	O N D	J F M	A M J	J A S	O N D	J F M	A M J	J A S	O N D
Construction										End of April		

(2) Construction Costs

Table 3-1 Costs for Package Construction (unit: 1,000 Rs.)

Year	Foreign Currency	Local Currency	Taxes and Dudies	Total Cost
1979	3,840	678	418	4,936
1980	25,139	16,296	3,329	44,764
1981	17,597	11,408	2,330	31,335
1982	7,541	4,889	998	13,428
Total	54,117	33,271	7,075	94,463

Note: Foreign exchange rate Rs 1.00 = US $ 0.16
Costs in the table are caluculated on the cost level of December 1997.
Overhead charges of contractors (25%) and contingencies (15%) are included in construction cost without taxes and duties.

Table 3-2 Costs for Staged Construction (unit: 1,000 Rs.)

Year	Foreign Currency	Local Currency	Taxes and Duties	Total Cost
1st Stage				
1979	3,840	678	418	4,936
1980	16,979	11,641	2,279	30,899
1981	11,886	8,148	1,576	21,630
1982	5,093	3,492	684	9,269
sub-total	37,798	23,959	4,977	66,734
2nd Stage				
1983	-	-	-	-
1984	-	-	-	-
1985	-	-	-	-
1986	-	-	-	-
1987	5,712	3,259	734	9,705
1988	8,975	5,122	1,154	15,251
1989	1,632	931	210	2,773
sub-total	16,319	9,312	2,098	27,729
Total	54,117	33,271	7,075	94,463

(3) Maintenance Costs

Apart from the above-mentioned construction costs, the maintenance cost, which are made up of the daily maintenance costs of 278,000 Rs per annum and the overlay costs of 3,158,000 Rs required at regular interval (every 10 years), would be required.

1.3 Economic Evaluation

The economic evaluation in both ways of the package construction (Alternative P4) indentified as the optimum plan and its staged construction (Alternative P4.S) is summarized in Table 4. As seen in Table 4, the internal rates of return for both alternatives shows higher values than 20 %.

Table 4 Results of Cost-Benefit Analysis for the Alternatives

Alternative	Discount Rate(%)	Rs Million Cost	Rs Million Benefit	B/C Ratio	Internal Rate of Return(%)
	10	78.4	238.1	3.04	
P4	12	75.8	182.7	2.41	20.8
	15	72.4	126.1	1.74	
	10	64.7	235.8	3.64	
P4.S	12	61.7	180.8	2.93	23.8
	15	57.7	124.6	2.16	

Note: All the above-mentioned cost figures, which have been calculated in terms of the cost-benefit analysis method, reflect the sum of the construction costs and maintenance costs which has been estimated by adjusting those figures with an adequate discount rate and converting to 1979 value over the project life (20 years).
Foreign exchange rate is Rs. 100 = US$ 0.16
Cost in the table are calculated on the cost level of December 1977.

2. Recommendations

2.1 Package Construction

The resulting figures of the economic evaluation imply that the staged construction (Alternative P4.S) is a bit more economically favoring than the package construction (Alternative P4), but either case has been revealed enough to be economically feasible. Taking account of construction costs, expendiency, convenience to traffic and the current general inflationary trend inherent in the construction industry, splitting the project into different construction phases would not be advisable. Consequently, the package construction (Alternative P4) would be deemed desirable for its adoption.

2.2 Other Related Proposed Roads

The execution of this project would not only widely alleviate the current traffic congestion in between Port Louis and Beau Bassin, but also greatly contribute to the traffic improvement in the areas of Rose Hill and Quatre Bornes. The roads under this project are considered to comprise a part of integral road network in the areas of Port Louis, Coromandel, Rose Hill and Quatre Bornes, and to have a closely organized relationship with all other roads in the area. Even though the project is executed, the total five routes of main road network in the areas will be anticipated to stand still in fear of reappearing congestion at several points after 1992. In order to avoid such situation and to maximize the advantages of the project road in the road network as a whole, accordingly, construction of Port Louis Ring Road and the extension of the project road toward Quatre Bornes and further southward is particularly essential.

2.3 Connection With Port Louis Ring Road

Since the marginal traffic capacity due to at-grade intersection at the junction in between the project road and Motorway will be attained after 1990 and the traffic volume in between Motorway Junction and Port Louis will be also anticipated to exceed its limit, the grade connection of Port Louis Ring Road with the project road is advisable to be materialized as early as possible.

2.4 Replacement of G.R.N.W. Bridge (A_1 Road)

In the overall road network covering the project areas, the A_1 Road will bring a very little of alleviation in the traffic conditions of the project areas and play a crucial role in the future, even if the project road has been constructed. The forward and backward sections of the G.R.N.W. Bridge (A_1 Road) is the narrowest in width among the other sections of the A_1 Road, presenting the biggest bottleneck and the bridge has been superannuated with its advanced deterioration. Further, such sections will gain directly more load after the development at Pointe aux Sables is completed, becoming the shortest routs in between Port Louis and Pointe aux Sables. A new bridge substitutable for the G.R.N.W. Bridge (A_1 Road) should be advisably constructed as early as possible. (Improvement of the sections is represented in Appendix)

2.5 Relationship with Pointe aux Sables Development Plan

The implementation of the development plan for Pointe aux Sables would greatly affect not only the areas of G.R.N.W. Bridge (A_1 Road) mentioned above, but also S. Hill Interchange of the project road. It is quite difficult for S. Hill Interchange to provide enough service to every traffic direction because of its topographical restrictions. Therefore, a careful and sufficient study would be deemed necessary for solving the originating traffic volume arising from the expansion of such development plan.

2.6 Attentions to be Paid to the Construction of Major Structures

A sufficient attention should be paid not to affect the existing substructures of the old G.R.N.W. railway Bridge, when the substructures of a new bridge is constructed. An another attention would be required to made the traffic smooth without any troubles during the construction, when the construction schedule of S. Hill Interchange is worked out.

C O N T E N T S

V. PROJECT EVALUATION

Figures and Tables

Figures

Tables

Tables

I. INTRODUCTION

I. INTRODUCTION

This project is designed to alleviate the current traffic congestion and to provide solutions to the problems arising from future grown in traffic demand, between Port Louis, the capital and socio-economic center of Mauritius, and Coromandel, Beau Bassin, Rose Hill and other areas, the satellite cities of Port Louis.

The purpose of this road construction has twofold; (1) to alleviate traffic congestion of the A_1 Road, the only road now connecting Port Louis and Beau Bassin, whose traffic volume reaches as much as 126 % of the road capacity at peak hours, and (2) to cope with the traffic which is expected to increase considerably with the proposed industrial development of Coromandel and Point aux Sables areas.

The Government of Japan has decided to conduct a feasibility study on this project and the Japan International Cooperation Agency (hereinafter referend to as JICA) concucted an economic and technical feasibility study. JICA in August, 1977, dispatched a pre-feasibility study team for the purpose of discussing the Scope of Work agreed upon among the Government of Mauritius, the African Development Bank and the Government of Japan. In accordance with the Scope of Work agreed upon, JICA has selected a consulting firm composed of Japanese professional consultants and simultaneously set up a supervising committee for the purpose of executing a feasibility study on the project. the field survey in connection with this feasibility study was performed during the period of mid-November to end-December of 1977, with the cooperation rendered by the authority concerned of the Government of Mauritius.

The survey team made the follow-up works in Japan thereafter and completed the draft final report, with the kind cooperation of the counterparts of the Government of Mauritius in March, 1978. The presentation has was provided to the Government of Maurutius at the end of April, 1978.

JICA has recieved some comments on the draft final report from both the Government of Mauritius and the African Development Bank, and completed the final report on the project, after the angle deliberation with the counterparts from the Government of Mauritius. This report is composed of the following four parts: 1) Summary Report, 2) Main Report, 3) Appendix, and 4) Drawings.

II. BACKGROUND

II. BACKGROUND

1. Outline of Mauritius

Mauritius is geographically consisted of a several numbers of islands, and the Mauritius island itself has the most of acreage and poulation and is the center of social and economical activities of the country. Most of the total acreage of 1,865 km^2 is comprised of agricultural and forest lands, and the majority of which is occupied by sugarcane plantation. The population of Mauritius was approximately 868,000 in 1976, and of which 44% is the urban population.

The average increase rate of annual population during a decade between 1962 and 1972 was 1.95 %, and that during four years from 1972 to 1976 was 1.24% which shows a declining trend. Owing to the decrease in emigration after 1977 and the increase in reproducible ages, it again turned to show up-trend. Gross National Product (GNP) of Mauritius was approximately 3.5 billion Rupees in 1976 and its average annual growth rate was 9 % in real terms during six years from 1970 to 1976. The per capita GNP was about 4,100 Rupees in 1976.

The main industry of Mauritius is agriculture, which occupies about 30 % in Gross Domestic Product (GDP) and about 25 % in total employment, either share of which, however, tends to decrease. The manufacturing sector following the agricultural sector occupies about 18 % of GDP, and a recent rate of which shows consecutively a steady growth to become one of the main stays of the Mauritius economy. The other sectors have also achieved steady and favorable development. The Mauritius economy is still highly susceptible in its basic structure to such external factors as the sugar price movements in the international markets, weather conditions and so on, due to the fact that the sugar industry still remains the largest foreign exchange earner.

Port Louis (the capital of Mauritius) having a population of about 140,000 has, for long time, been developing as the center of foreign trade and industrial manufacturing as well as administration. The continuous urban area, which is included within Plaines Wilhems District, is formed southward of Port Louis, and about 47 % of the total population or about 55 % of the total employment is centered in both districts of Port Louis and Plaines Wilhems.

The high concentration of population and industrial functions in such a limited area causes the traffic congestion to appear at every turn and the urban environment to deteriorate.

With the Ministry of Housing, Lands and Towns & Country Planning as an executing agency, the Government of Mauritius is now engaged in working out an integrated development plan covering the whole island. The plan aims at achieving the balanced regional development, having the basic ideas of reforming the existing urban areas as well as to developing and improving a new "Growth Pole", with a complete improvement of road network in such developing and/or reforming areas.

2. Transportation and Roads

The domestic transportation in Mauritius depends mainly upon automobiles now. The railway was widely used, but it has now lost its position as a public transportation, yet existing partly in the sugarcane plantations to carry out sugarcane. Most of it became disused, a part of which is converted to road use, while the rest remains as disused.

Port Louis is the only one major port, while all others are small-scale fishing ports. All the foreign trade is dealt through Port Louis with an annual trading amount of approximately 1.5 million tons.

Plaisance Airport is the only one international airport of Mauritius, located at the southern part of the island, which is at present utilized weekly by 34 international flights as well as by the domestic flights connecting with such major separated islands as Rodriguez and others. This international airport is now undertaken to be moved out from the present location to somewhere northeastward near Belle Vue Maurel (in Flacq District).

The public road network of Mauritius measures 1,770 km in total, consisting of about 16 km of the Motorway, 546.3 km of trunk roads, 584.5 km of urban roads and 642 km of rural roads. All the trunk roads and 448 km of rural roads have been asphalted, which gives a density of paved roads showing 0.86 km/km^2. All the major roads in Mauritius are classified into Classes M, A and B.

Mortorway belonging to Class M connects Port Louis with Phoenix and is an access-controlled dual 2-lane road. Main roads belonging to Class A, radiate from Port Louis to various directions and connect with major townships and areas of the island and usually consist of two lanes with a carriageway width of 24 feet. Class B roads are branched out of Class A roads and connect with other important points on the island and their standards are either comparable to or slightly lower than those of Class A.

Apart from the Motorway, the other roads do not necessarily conform to a given standard; Class A road in some sections is as wide as 10 m, consisting of three lanes, but on the contrary, in some other sections, it is barely wide enough for two-way traffic. The general problems of Mauritius roads are that there are so many sections constructed in direct accordance with the original topography and, therefor, too steep in many sections. Their narrow shoulders are trimmed with plants or shrubs to obstruct side views, thus limiting the traffic capacity of the roads and simultaneously reducing the safety of the traffic movements.

Motor vehicles are classified into passenger cars, taxi cabs, vans, buses, cargo vehicles, motorcycles and others, totaling to about 32,800 (excluding motorcycles) in 1976, and about 48,600, if all motorcycles are included. Every type of vehicles increases rapidly, and the average annual increase rate of automobiles shows about 10 %, while that of motorcycles about 20 %.

III. PROJECT AREA

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1. Natural Conditions

The climate in Mauritius is classified into the rainy season from December to May and the dry season from June to November. Annual rainfall measures 1,095 mm at lower areas and 3,342 mm at higher areas; the monthly average temperature ranges from 22°C to 28°C or 17°C to 22°C, at lower or higher areas, respectively. Weather widely varies among the areas.

The project road is laid on the areas ranging from the lower part to the higher part. Mauritius is exposed to the weather as the cyclones occurring in the Indian Ocean during the period from November to May turn southwestward and change its direction southeastward in the vicinity of Mauritius. The maximum instantaneous wind velocity recorded in the past was 162 mph (72.4 m/sec).

The project area through which the project road, which is located on the lava plateau with an average up-grading of 3 - 4 %, would run from Port Louis, the capital of Mauritius, to Curepipe, the central part of the island via Beau Bassin.

In these areas, the Grand River North West, the longest river in Mauritius, and St. Louis River are flowing in parallel at Port Louis side, i.e. they are located about 2.4 km away from the starting point of the project road. The road is aligned through the sugarcane fields varying their altitudes gradually rising within a range of 20 - 210 m, except the areas where these two rivers are flowing.

Along the project road, older lavas bedrock consisted mainly of olivine basalt underlies the layer of further weathered and degenerated soil of the younger lavas. Along or in the river beds, river deposits are distributed. The older lavas in the project areas, which cope with the geological distribution mentioned above are rather very hard, while the younger ones have many cracks or have been softened or degenerated at many sections with weathering.

2. Social and Economical Conditions

Most of the project areas is urbanized, in which the numbers of population and employment amount to about 151,900 and 48,350, respectively.

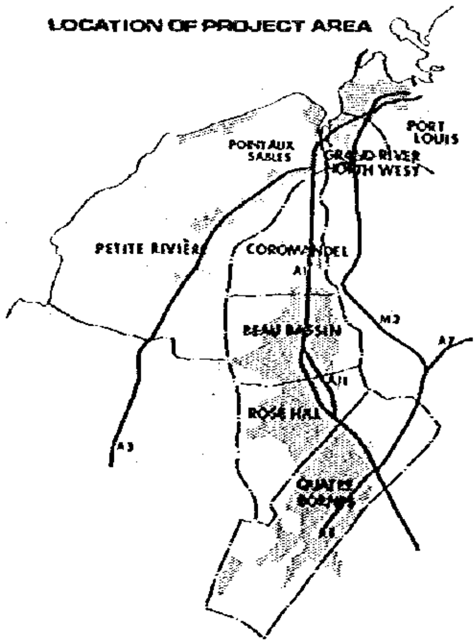
The Grand River North West is situated at the west end part of the Port Louis District, having a population of about 4,600. Plaine Lauzun has the largest industrial estate of the nation in or around which about 50 manufacturing firms and 6,500 workers are concentrated, while about 8,800 workers, if totaled all for the primary, seconday and tertiary industrial sectors.

This area has already been fairly developed likely as has been in the Port Louis District as a whole, thereby limited further development. In particular, there is a bare room for any housing developments, while such movement should considerably be restricted to a maximum extend, if taken account of the living environment.

The Pointe aux Sables/Petite Rivière V.C.A. area is quite a bit urbanized along the trunk roads and has such settlements as Camp Benoit, Richelieu, Petite Rivière, Petit Verger, Pointe aux Sables and so on, but the most of it remains as agricultural lands. This area has a population of about 10,900 and workers of about 5,700, and still offers enough room with desirable conditions for the urbanizing expansion of Port Louis. The Pointe aux Sables Development Plan now being worked out in this area includes a total development area of 89 ha, comprising of 56.7 ha for a residential site of 4,200 and the rest of 32.3 ha for industrial development including marketing. If the plan is implemented, then it will be anticipated to generate an additional population of about 20,000 and an additional employment of about 4,000 for secondary industries, which may probably be supported with further employment of about 4,000 in the tertiary sectors.

The Coromandel District has an industrial estate of about 14 ha in the northern part and forms a lengthy urban area connected with Beau Bassin. Except these, the most area of the Coromandel District is covered with sugarcane fields, having a relatively few population of about 3,900. Of the total industrial estate in Coromandel, about 8 ha remains as unused and still available to be erected by new factories or buildings, and it is anticipated in the future to rise to more than 8,000 workers from the present number of workers of about 1,200. The area covering from Beau Bassin to Quatre Bornes via Rose Hill is the continuous, dense urban area, having a total population of 132,500, which reflects 87 % of the total population of the project areas. Trading firms and light industries are highly concentrated in this area, totaling the number of workers for both secondary and tertiary sectors to be as many as 30,600. This area is highly urbanized, leaving a bare room of development availability in the outskirt at the west side of the existing urban area.

Judging from all the aforementioned, the project areas are predicted to have comparable scale in either population or employment to those of Port Louis. Although the prospective population increase in the existing urban areas is presumably unexpected, the project areas would obviously come to the substantial importance in Mauritius by taking into consideration the industrial estate at Coromandel and the prospective implementation of a new development scheme at Pointe aux Sables.



3. Road Network and Traffic

As shown in Fig. III-2, the road network existing in or around the project areas are comprised of the Motorways, M_1 and M_2, the Class A roads of A_1, A_3, A_7, A_8, A_{10} and A_{11}, and the Class B roads of B_1, B_2, B_3, and B_{31}, further with a great number of lower class roads diverting from such trunk roads, and most of which are asphalted.

The Motorway connecting Harbour Square at Port Louis with Phoenix is an access-controlled dual carriageway with 4 lanes, having a total of 15.7 km in length and of 22.9 m in width, the average longitudinal gradient of which is 2.4 %, except 5 % at some sections. The average daily traffic volume varies at every section, and it shows nearly as high as 12,000 to 17,000 p.c.u. (two-ways for 24 hours). There keeps a quite good flow of vehicles at any sections even at peak hours, except heavy traffic congestion generated in the vicinity of the entrance into the urban area of Port Louis.

The A_1 Road starts from Port Louis, and ends up at Mahebourg, via the Roads, M_2 and A_{10}, longitudinally acrossing from north to south the project areas constituting a part of the important trans-island trunk road. For the project areas, this road is only one of the main roads at present, which means it is very important, but except some parts in Coromandel, the areas along this road are fairly urbanized, and houses and stores are continuously filled up closely to the road.

Ununified standards ranging from 5.7 m to 10 m in the width of the carriageway are applied to this road, having a sidewalk width from 0.8 m to 3.6 m at some parts in the urban areas. Its longitudinal gradient at somewhere exceeds 10 %, such of which is constructed to fit the original topography. The G.R.N.W. Bridge (A_1 Road) constitutes a part of the A_1 Road wit the width of 2-lane. However, owing to its longevity and advanced obsolescence, and further the narrow width of 5.7 m in the carriageway, any of big size vehicles is forced to slow down its speed, when passing through each other. The average daily traffic shows the range between 12,000 and 17,000 p.c.u. (two-ways for 24 hours) and increases it as access toward Port Louis. The traffic has been recorded at 126 % of the capacity in the vicinity of the G.R.N.W. Bridge (A_1 Road) to include the bridge itself, which is the most serious bottleneck at peak hours among the A_1 Road and, in addition, it is reaching as high as the maximum capacity at every turn in between Port Louis and Beau Bassin.

The A_{11} Road plays the role of servicing for the traffic volume of 5,000 p.c.u. (two-ways for 24 hours) as an important route partially to alternate with the A_1 Road in the urban areas between Rose Hill and Beau Bassin, having a width of 9.0 m and a longitudinal gradient of 3 %.

The B_1 Road has a 2-lane width of 8.0 m, linking in between the crossing in Rose Hill and the Reduit Roundabout on the Motorway, which makes it fairly good use of it as a short cut in between such both ends and whose traffic volume is about 5,000 p.c.u. (two-ways for 24 hours).

Except the A_3 Road having the traffic volume of about 2,500 p.c.u. (two-ways for 24 hours), all other roads are not so much important to say as the main roads due to the low volume of their traffic.

Viewing from the current level of population and business activities in or around the project areas, the existing trunk road network centered at the A_1 Road is not only predictably hard to cope with the future growth in traffic demand, but also obviously unexpected to perform the desirable developments of urban areas.

As shown in Fig. III-1, the plan is the one worked out by Mission d'Amenagement du Territoire a l'Ile Maurice (MATIM) and the current improvement of the road network is progressing in accordance with the plan, by taking into consideration the urban development plan for favourable arrangement of trunk road network.

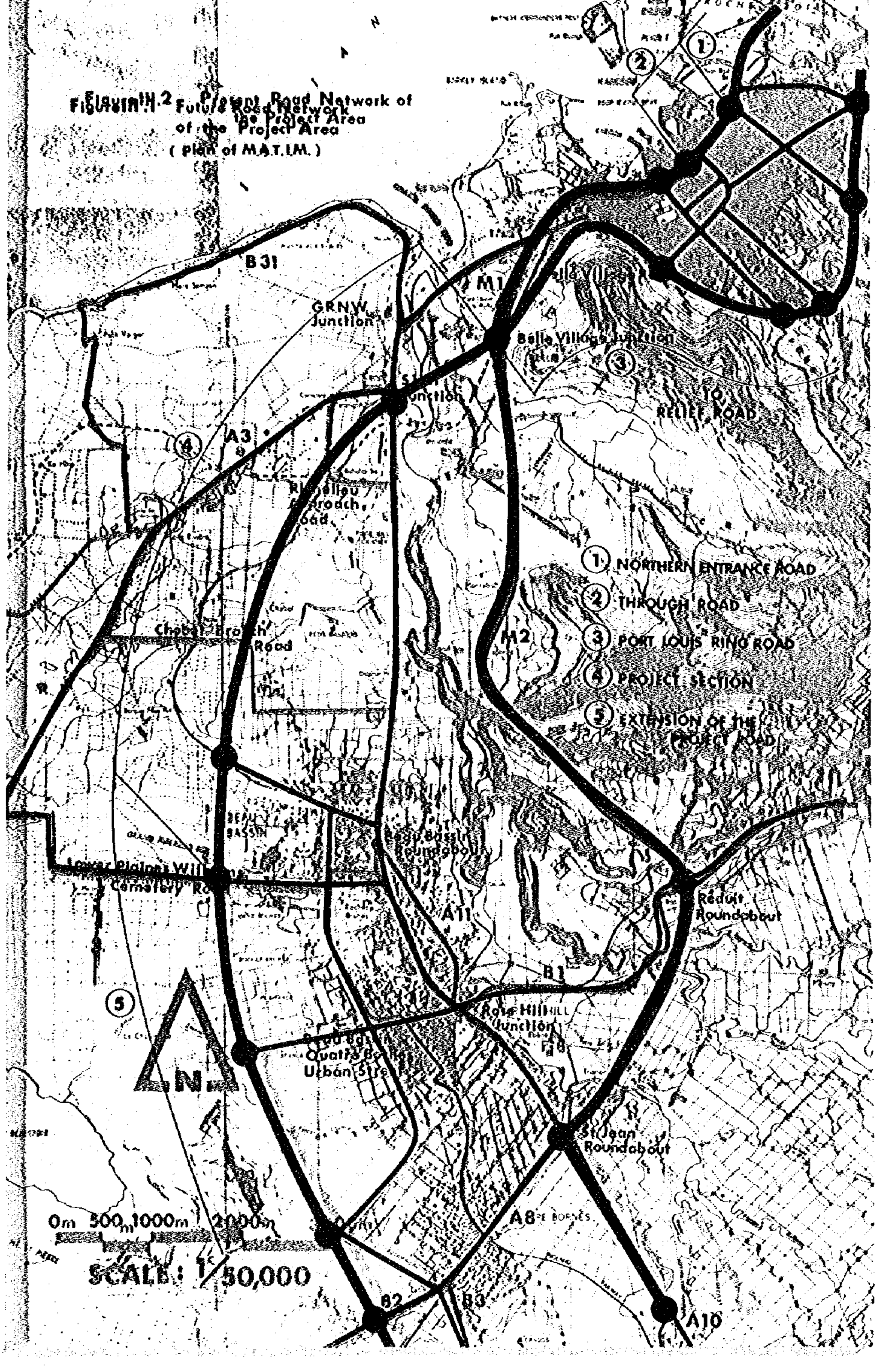


Figure III.2 Present Road Network of the Project Area
Figure III.1 Future Road Network of the Project Area
(plan of M.A.T.I.M.)
B31
GRNW Junction
M1
Belle Village Junction
TO RELIEF ROAD
A3
Richelieu Approach Road
Chebel Branch Road
M2
① NORTHERN ENTRANCE ROAD
② THROUGH ROAD
③ PORT LOUIS RING ROAD
④ PROJECT SECTION
⑤ EXTENSION OF THE PROJECT ROAD
Beau Bassin Roundabout
Lower Plaines Wilhems Cemetery Road
Reduit Roundabout
A11
B1
Rose Hill Junction
Beau Bassin Quatre Bornes Urban Sts
N
St Jean Roundabout
A8
0m 500m 1000m 2000m
SCALE : 1/50,000
B2
B3
A10

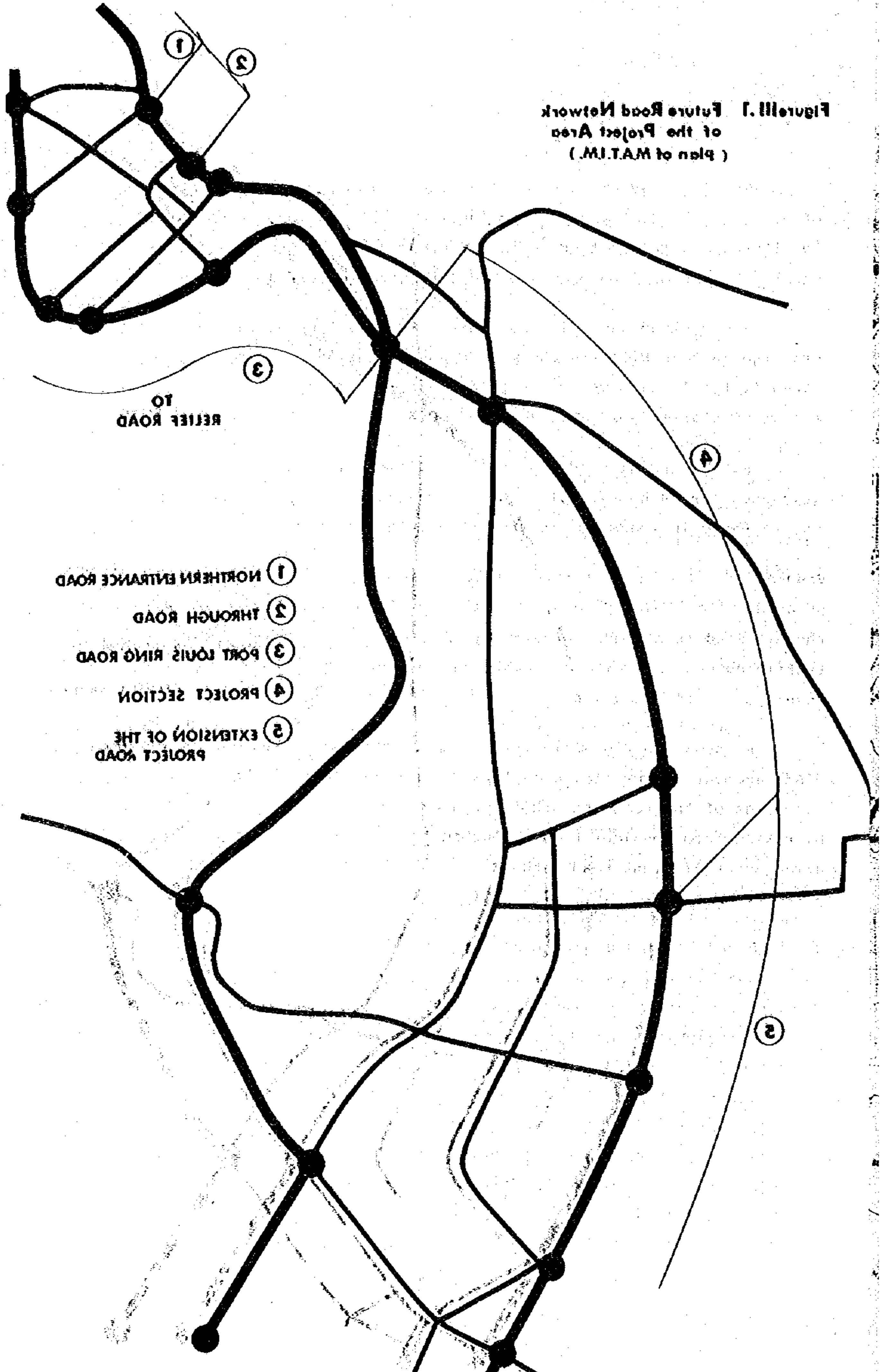
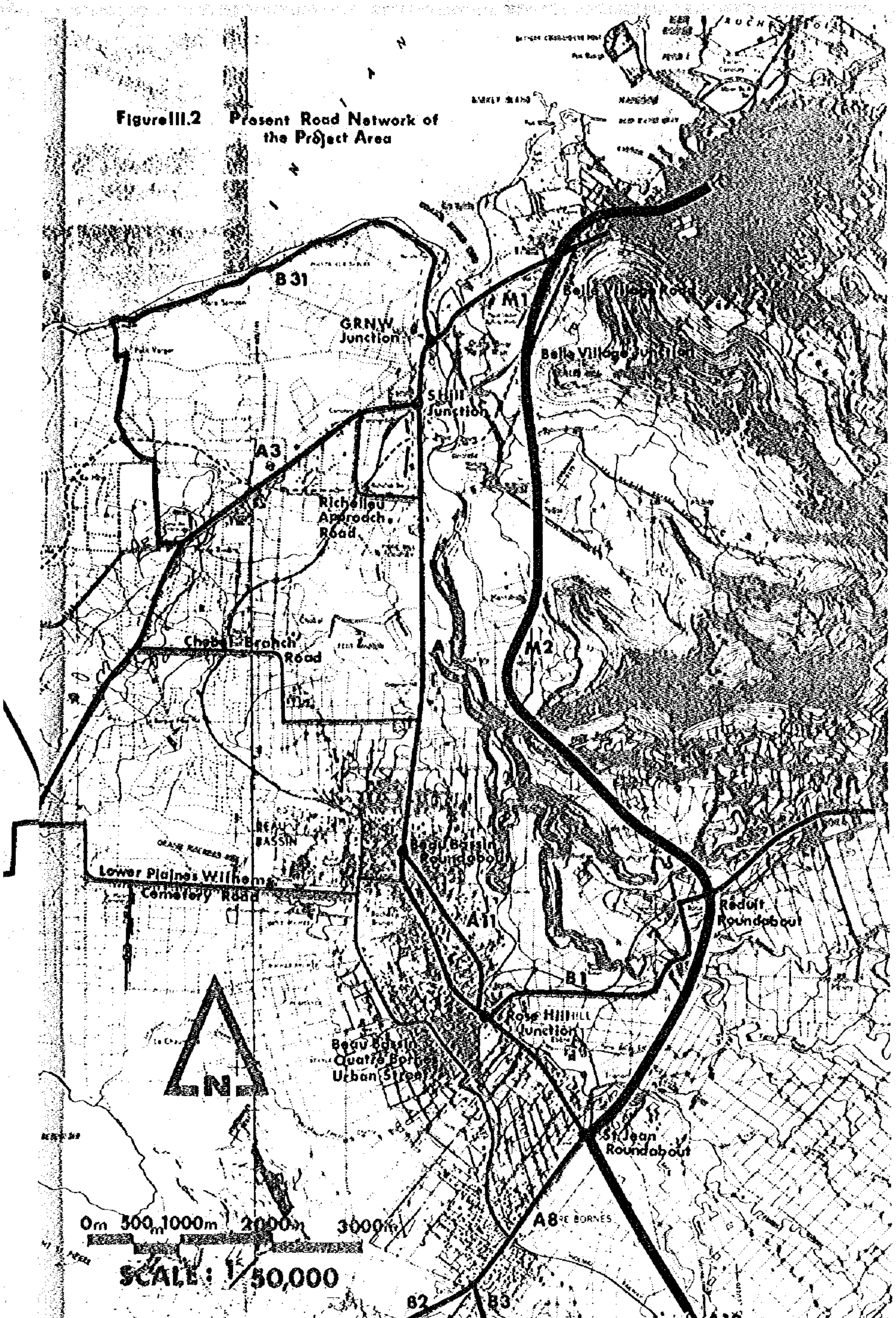


Figure III.1 Future Road Network of the Project Area (plan of M.A.T.I.M.)



FigureIII.2 Present Road Network of the Project Area
B 31
GRNW Junction
M1
Belle Village Road
Belle Village Junction
St Hill Junction
A3
Richelieu Approach Road
Chebel Branch Road
A1
M2
Beau Bassin Roundabout
Lower Plaines Wilhems Cemetery Road
A11
Reduit Roundabout
B1
Rose Hill Junction
Beau Bassin Quatre Bornes Urban Street
St Jean Roundabout
N
0m 500m 1000m 2000m 3000m
SCALE : 1/50,000
A8
B2
B3
A10

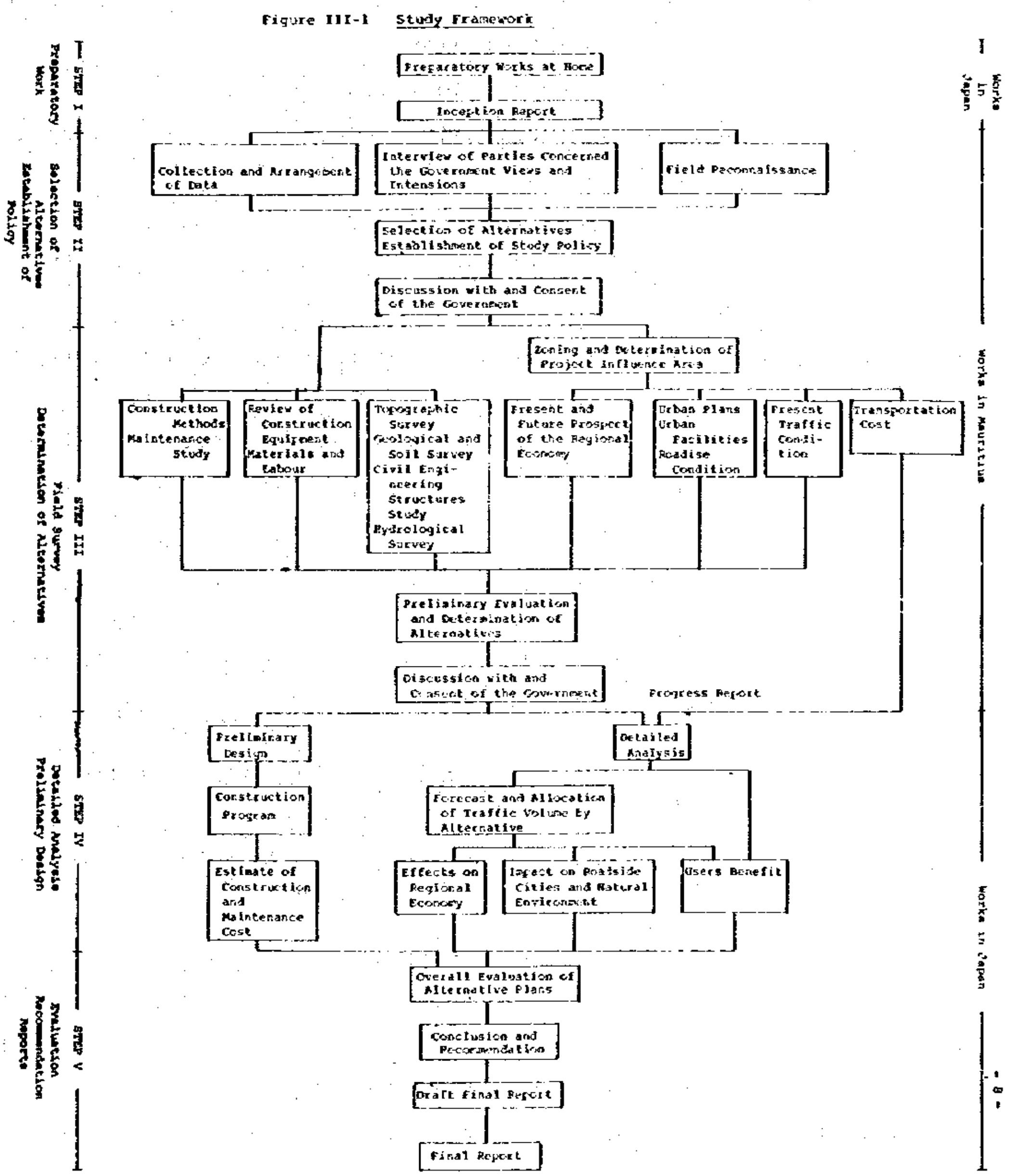
IV. PROJECT

IV. PROJECT

1. Methodology

Surveys have been conducted in accordance with the following procedure:

Figure IV.1 Study Framework



2. Alternative Routes

2.1 Basic Ideas on Selection of Alternative Routes

In selecting alternative routes the following factors as well as the other general matters of technology have been carefully taken into consideration:

(1) To make an optimum utilization of disused railway tracks, from the land aquisition point of view.

(2) To examine the usability of old railway bridges.

(3) To harmonize with such regional development schemes as Pointe aux Sables, Coromandel and others.

(4) To connect with the Port Louis Ring Road, and to connect with M_1 at a junction in consideration of the connection of the Port Louis Ring Road.

(5) To consider the future extension plan of the road in between Beau Bassin and Quatre Bornes.

(6) To consider the junction connecting with the existing A_1 Road.

(7) To consider the availability of widening the existing A_1 Road.

2.2 Comparison of Alternative Routes

As shown in Figure IV-1, comparative studies on alternative have been made on the following two sections:

The First Section; a route from Cassis Flyover Bridge in Port Louis to the S. Hill Junction

The Second Section; a route from the S. Hill Junction to the roundabout in Beau Bassin

Regarding the First Section :

Route ⓐ : Utilization of the existing A_1 Road

Route ⓑ : Utilization of the disused railway track originating from the Motorway Junction

Regarding the Second Section:

Route ⓐ' : Improvement of the existing A_1 Road
Route ⓒ : Utilization of the disused railway track
Route ⓓ : Regional plans by M.O.H.L.T.C.P.
Route ⓔ : Utilization of Chebel Branch Roadbed
Route ⓕ : Route to run closer to the A_1 Road

As the results of the preliminary studies, Route ⓐ proved difficult to expand the width of the A_1 Road having three lanes land, because of land utilization along the existing A_1 Road, and it has steep gradients. In particular, the G.R.N.W. Bridge, which has been superannuated, has a narrow width of 5.5 m, thereby it has constituted the most serious bottleneck in the way of traffic flow.

Route ⓑ proved that the disused railway track has an appropriate alignment for the project road without any troubles for land acquisition. However, the existing railway bridge allows only 2-lane traffic, so that the new construction of an additional 2-lane road bridge is necessarily called for.

Route ⓐ' is presumably expected to have some difficulties in land acquisition for further expansion of the road width, because of steep gradient and continuous density of houses or buildings along the expected route. Further, Route ⓔ is foreseenably expected to have some intersection points, and Route ⓒ has a longer length.

As a consequence, Route ⓑ for the first section and Routes ⓓ and (f) for the second section are finally determined to be made with further division of several links Ⓐ through Ⓕ as shown in Figure IV-2.

Apart from comparative studies on the selection of alternative routes, comparative studies on the effects of staged construction corresponding to the growth of traffic demand must necessarily be made. The study on staged construction has twofold; the one is the staged construction to extend the length of the project road, and the other is that to increase the number of lanes. The former has been excluded from the study due to its intricate construction, while the latter has been studied and, consequently, implies that 2-lane roads are presumably converted into 4-lane ones after completion of construction.

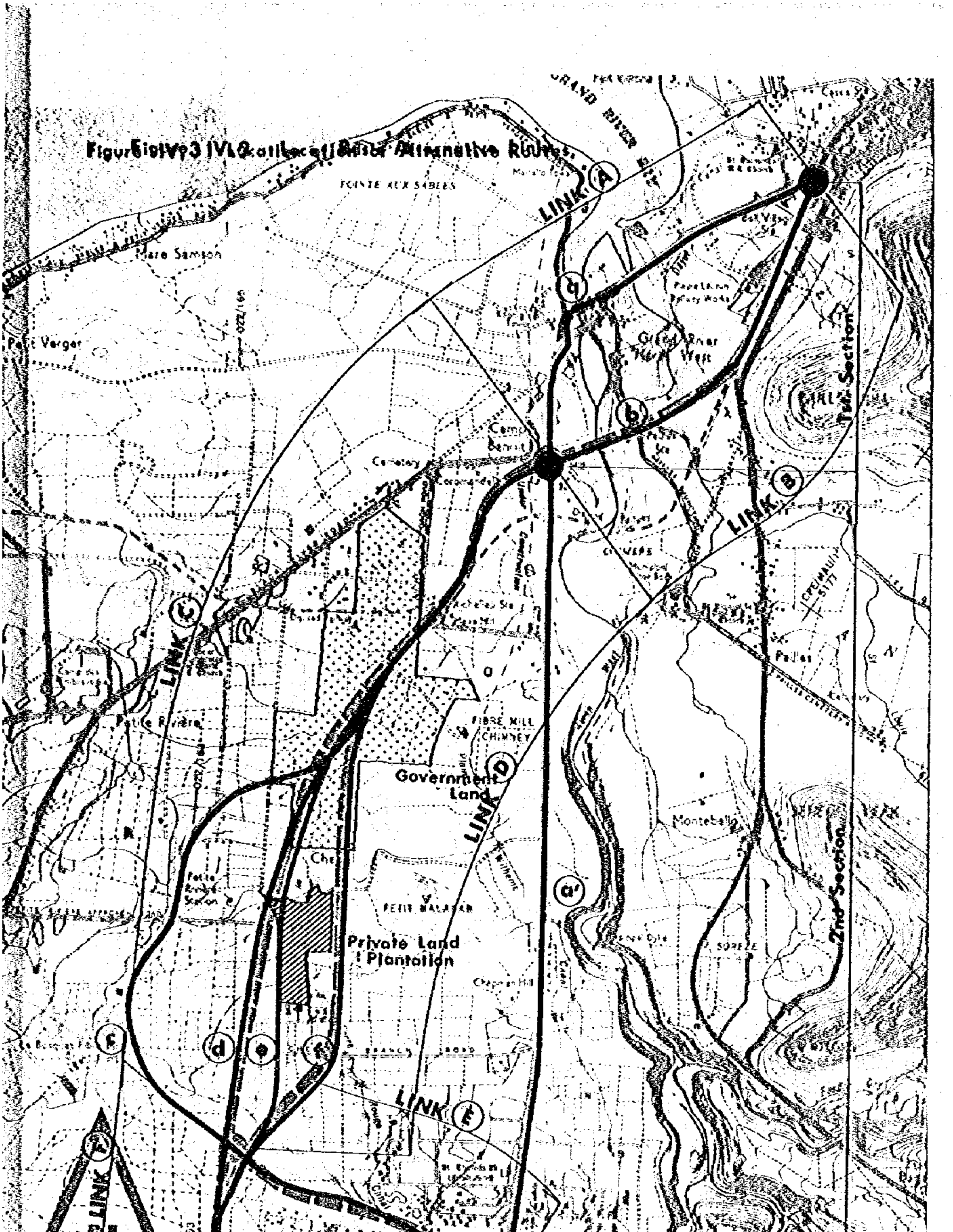
All these studies mentioned above are summaried in Table IV-1, combining basic alternatives with their construction years.

Table IV-1 Basic Alternatives for Final Study

Alternatives	Notes	Links
P_2	Belle Village - S. Hill - Beau Bassin	Link Ⓑ+Ⓒ+Ⓔ
P_2'	2-lane road	Link Ⓑ+Ⓓ+Ⓔ
P_4	Belle Village - S. Hill - Bequ Bassin	Link Ⓑ+Ⓒ+Ⓔ+Ⓕ
P_4'	4-lane road	Link Ⓑ+Ⓓ+Ⓔ+Ⓕ

Note: P_2' and P_4' denotes eastern route plans, while P_2 and P_4, western route plans.

The Link Ⓐ plays a critical role for the road network as a whole, but a improved plan, P_A, of the Link Ⓐ is excluded from the basic alternatives. Since the G.R.N.W. Bridge (on the A_1 Road) has a narrow width, forming a serious bottleneck in traffic flow, and has been superannuated, its counterplan of the bridge is being considered in this Report.


Alternative Routes
LINK A
LINK B
LINK C
LINK D
LINK E
LINK F
GRAND RIVER
POINTE AUX SABLES
Mare Samson
Petit Verger
Cemetery
Grand River North West
Petite Rivière
FIBRE MILL CHIMNEY
Government Land
Private Land / Plantation
PETIT MALABAR
Montebello
SOREZE
1st Section
2nd Section
BEAU BASSIN
GRAND MALABAR HTS
Roches Brunes
0m
500m
1000m
1500m
2000m
SCALE : 1/30,000

All these studies mentioned are summarized in Table IV-1 combining basic alternatives with their construction years.

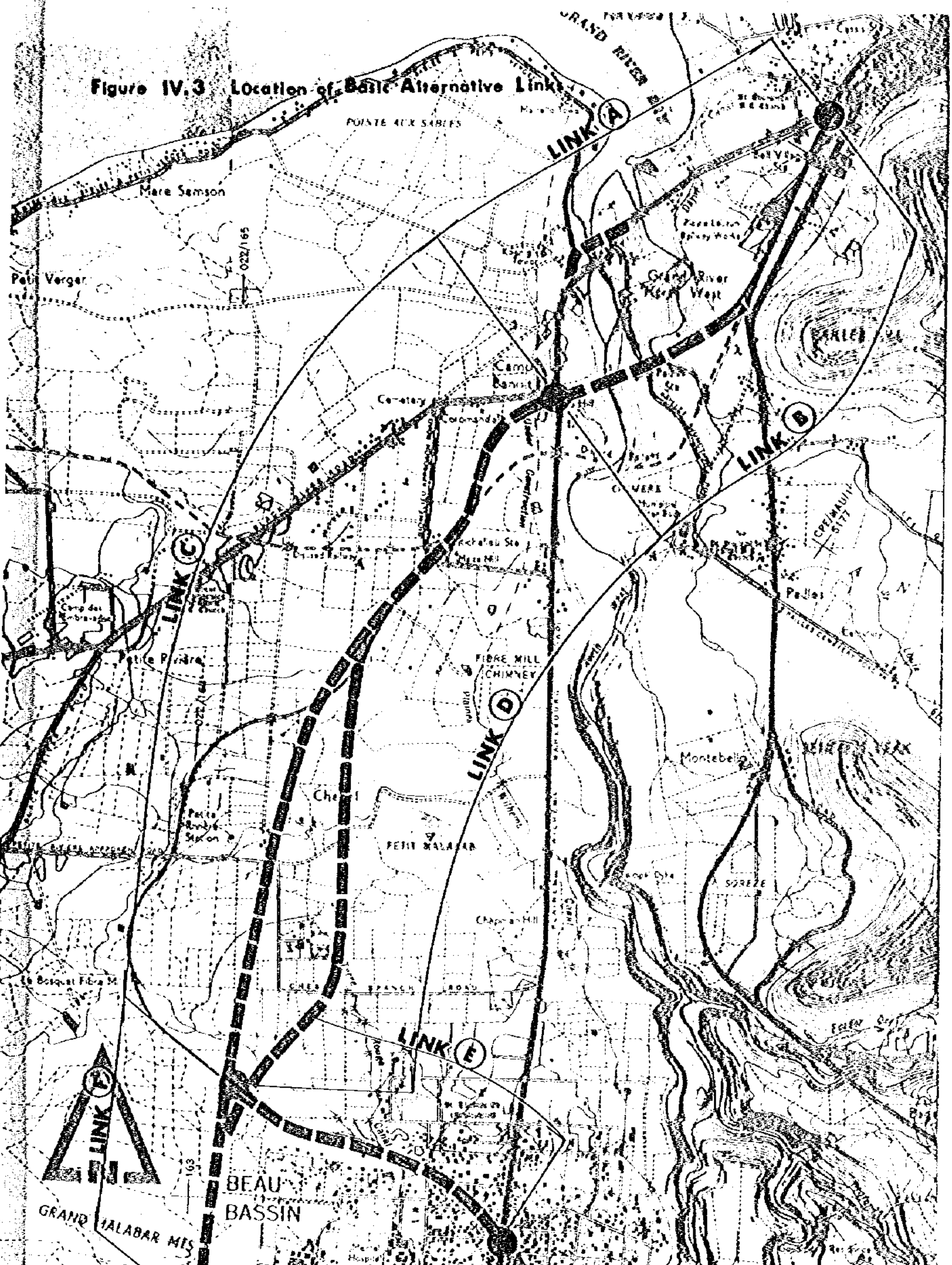
Table IV-1 Basic Alternatives for Final Study

Alternatives	Notes	Links
P_2	Belle Village - S. Hill - Beau Bassin	Link Ⓑ+Ⓒ+Ⓔ
P_2'	2-lane road	Link Ⓑ+Ⓓ+Ⓔ
P_4	Belle Village - S. Hill - Beau Bassin	Link Ⓑ+Ⓒ+Ⓔ+Ⓕ
P_4'	4-lane road	Link Ⓑ+Ⓓ+Ⓔ+Ⓕ

Note: P_2' and P_4' denotes eastern route plans, while P_2 and P_4, western route plans.

The Link Ⓐ plays a critical role for the road network as a whole, but a improved plan, P_A, of the Link Ⓐ is excluded from the basic alternatives. Since the G.R.N.W. Bridge (on the A_1 Road) has a narrow width, forming a serious bottleneck in traffic flow, and has been superannuated, its counterplan of the bridge is being considered in this Report.

Figure IV.3 Location of Basic Alternative Links

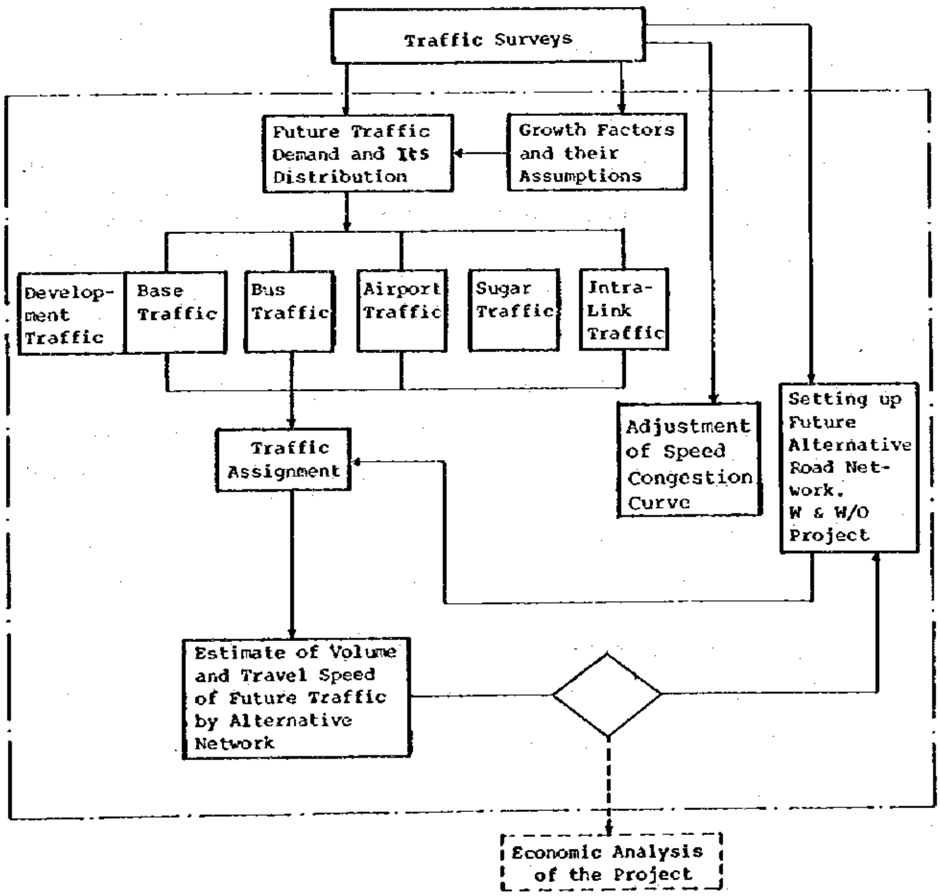


3. Traffic Analyses

3.1 Methodology

As shown in Fig. IV-4, traffic analyses have been carried out on the following procedure; (1) to grasp the current level and characteristics of traffic by the traffic surveys, (2) to forecast the future traffic demand by taking into consideration the results of (1) and of forecasts of major economic indices and regional development schemes, etc., and (3) to assign the estimated future traffic volume to the alternative road network including the project road and then to analyse anticipated problems awaiting for a solution. The overall framework of the above-mentioned procedure is shown in Fig. IV-4.

Figure IV-4 Methodological Flowchart of Traffic Forcast



3.2 Traffic Surveys Conducted

A number of traffic surveys centering at the A_1 Road and the Motorway have been conducted as follows:

Traffic Volume Surveys

- For consecutive one-week count at two points, one at the A_1 Road and the other at the Motorway
- For one-day count at seven points on major roads
- For one-day count at four points on major intersections

It should be noted that a full one-day count (24 hours) has been conducted once within the consecutive one-week count mentioned above.

OD Surveys

- For two days at each of two points, one at the vicinity of the G.R.N.W. Bridge (A_1 Road) and the other at the vicinity of the city boundary of Port Louis on the Motorway, for the purpose of knowing the objective traffic distribution

Personal Interview

- Visited five bus companies to know the route and frequency of travel, etc., for the purpose of knowing the level of bus traffic

Airport Traffic

- For one day at Plaisance International Airport, together with OD survey at shoulder, for the purpose of knowing the level of traffic volume and the characteristics of its traffic distribution at the airport

Others

- Speed surveys at three points on the A_1 Road and the Motorway
- Surveys on vehicle's manufacturer and the age of vehicles, simultaneously with OD survey

The results of the surveys conducted at representative points on the A_1 Road and the Motorway are represented in Table IV-2.

Table IV-2 Hourly Traffic Distribution on A1 Road and Motorway

Station	Direction	12 hour traffic: morning peak	12 hour traffic: evening peak	12 hour traffic: off peak hours	night traffic	24 hour traffic	peak hour rate (%): morning	peak hour rate (%): evening	night traffic rate (%)
Coromandel (A1)	To P. Louis	1,272	658	7,177	2,394	11,501	11.1	5.7	20.8
	From P. Louis	623	1,243	7,038	2,618	11,522	5.4	10.8	22.7
	Total	1,895	1,901	14,215	5,012	23,023	8.2	8.3	21.8
Belle Village (M2)	To P. Louis	1,682	529	6,112	1,361	9,684	17.4	5.5	14.1
	From P. Louis	482	1,536	6,196	1,205	9,419	5.1	16.3	12.8
	Total	2,164	2,065	12,308	2,566	19,103	11.3	10.8	13.4

1/ excludes the traffic of Sundays and bicycle traffic

3.3 The Results of Traffic Forecast

In order to carry out traffic forecast, the total traffic relevant to the project road is classified into base traffic, bus traffic, airport traffic, sugar lorry traffic, and intra-link traffic as shown in Table IV-4. This is chiefly attributed to the facts that the forecasting method would differ by traffic types and the future traffic distribution may presumably be altered entirely from the current one due to the transfer of the present airport to somewhere else.

Base traffic reflects the traffic data obtained from OD surveys conducted at both Coromandel and Belle Village, and also the traffic volume in between Port Louis and the project areas. This does not include any figures for bus traffic, sugar lorry traffic and airport traffic. Intra-link traffic is not included in the above-mentioned traffic figures; and it is defined as a traffic volume obtained by subtracting the total of base traffic, bus traffic, sugar lorry traffic, airport traffic and intre-link traffic from the total number of traffic volume observed at the major points. Generated traffic volume is expected to occur newly in the future, but the generated traffic volume would be deemed inclusive into the base traffic volume by taking into consideration the effect of the development plan on the population and employment which are regarded as a basic factor to determine the generated traffic volume.

The volume and distribution of base, bus, airport, sugar lorry, intra-link and generated traffic, which will be generated in the future, are estimated for the years of 1982, 1987, 1992 and 2002, and such estimation is carried out according to morning peak, evening peak and off-peak. In order to analyze various effects arising from the implementation of the project, the road network used for the analyses and the future traffic volume estimated at the major points are shown in Table IV-3, respectively.

Table IV-3 Estimated Future Traffic at Major Sections of Alternative Network

Alternative Network (Case No.)	Year	Coromandel (A_1)	G.R.N.W. Bridge (A_1)	Belle Village (M_2) to P. Louis	Belle Village (M_2) from P. Louis	G.R.N.W. New Bridge (Project road) to P. Louis	G.R.N.W. New Bridge (Project road) from P. Louis
	1977	18,014	15,829	8,321	8,218		
	1982	22,492	20,902	14,426	13,660		
W.O.	1987	26,118	26,873	20,943	20,504		
(Existing Network)	1992	27,936	34,466	28,973	28,287		
	2002	32,679	59,918	49,623	49,427		
	1977	-	-	-	-	-	
P2	1982	15,897	6,683	13,692	13,150	15,115	
(with two-lane	1987	20,392	9,183	19,298	18,584	22,706	
road between	1992	23,179	12,620	25,612	24,904	32,930	
M2 and Beau Bassin)	2002	29,174	38,447	43,221	43,081	40,058	
	1977	-	-	-	-	-	-
P4	1982	15,897	6,683	13,589	13,018	7,578	7,210
(with dual-carriage	1987	20,368	9,122	19,130	18,407	11,385	11,043
way road between	1992	22,845	10,460	25,542	24,675	17,466	17,044
M2 and Beau Bassin)	2002	29,174	17,221	45,467	42,811	32,814	33,633

1/ 12 hour traffic in P.C.U.

Traffic volume of two lane road includes that of both direction.

3.4 Evaluation of Road Network

Comparative studies on road network have been made on the following assumptions:

(1) All links in which congestion ratio is higher than either 1.3 at peak hours or 1.0 at off-peak hours cannot perform normal functions.

(2) In all links in which congestion ration is higher than either 1.5 at peak hours or 1.3 at off-peak hours, the traffic volume is diminished, because of causing the speed of vehicles to reduce considerably due to traffic congestion.

The links satisfying the above-mentioned assumptions constitute serious traffic bottlenecks. The relationships between the number of bottlenecks and different road networks are shown in Table IV-4.

Table IV-4 Number of Bottleneck Links on Major Roads by Alternative

Year	Road	Alternative Network Case W.O.	P2	P4
1982	A_1 Road	2 (1)	0 (0)	0 (0)
	Motorway	0 (0)	0 (0)	0 (0)
	Project Road	- (-)	0 (0)	0 (0)
1987	A_1 Road	7 (1)	0 (0)	0 (0)
	Motorway	0 (0)	0 (0)	0 (0)
	Project Road	- (-)	0 (0)	0 (0)
1992	A_1 Road	10 (4)	5 (2)	2 (0)
	Motorway	1 (0)	0 (0)	0 (0)
	Project Road	- (-)	4 (0)	0 (0)
2002	A_1 Road	18 (16)	18 (15)	16 (13)
	Motorway	6 (3)	6 (1)	3 (1)
	Project Road	- (-)	9 (8)	0 (0)

Note: with () implies the number of bottlenecks under the assumption of (2)
Without () implies the number of bottlenecks under the assumption of (1)

According to the above ovservation, the following can be asserted:

(1) In case of W.O. (the existing road network), the number of bottlenecks will continue to increase each year in the future, if no additions are made to the existing roads. There is little difference compared with other alternatives, but this is because it has been assumed in the traffic assignment that the traffic can pass without limitation where the speed is 5 km/h. Actually, the congestion ratio at bottlenecks is far greater than those of other alternative cases. Therefore, the number of bottlenecks will actually increase in a wider area than shown.

(2) The plan to connect Belle Village - S. Hill - Beau Bassin by a 2-lane road under the case of either P_2, or P_2' is considered sufficient to meet the volume of traffic up to 1987, but bottlenecks will occur not only on the A_1 Road, but also on the project road before 1992. In this case, the congestion ratio of the A_1 Road will be considerably high.

(3) The plan to connect Belle Village - S. Hill - Beau Bassin by a dual 2-lane road under the case P4 or P4' will be sufficient to meet the traffic volume up to 1992, because in 1992 one of the two bottlenecks will be eliminated by making the S. Hill Junction with a separate grade intersection and the other will reach the congestion ratio of 1.4 only at peak hours in Rose Hill city.

(4) All of the cases will be short of meeting the volume of traffic by the year 2002. Therefore, there will be a number of bottlenecks.

Bottlenecks in 2002 under the case of either P_4 or P_4' will occur on the Motorway between Motorway Junction and Cassis Flyover (its congestion ratio being 1.5 at peak hours) and the most of remaining bottlenecks will occur on the A_1 Road and adjacent roads in the areas from Beau Bassin through Rose Hill to St. Jean Roundabout.

(5) In view of the above, at least the following steps have to be taken into consideration in order to materialize this project, while avoiding the occurrence of bottlenecks; (a) completion of the Alternative P_2 or P_2' by 1987 (around 1985), and (b) completion of the Alternative P_4 or P_4' by 1992 (around 1990).

(6) In addition, the following steps have to be taken into consideration in order to maximize the effects of the project road and, simultaneously, to eliminate the traffic congestion generated in the project areas for the long period up to 2002; (a) completion of Port Louis Ring Road connected with the project road and the Motorway by 2002, and (b) materialization of a extension scheme of the project road meant for further southward from Beau Bassin by 2002.

4. Design Standards

With respect to the design standards to be adopted, the following design standards and standard cross sections have been determined by reviewing both the referred design standards mentioned later and the similar projects in Mauritius.

(1) Design Standards

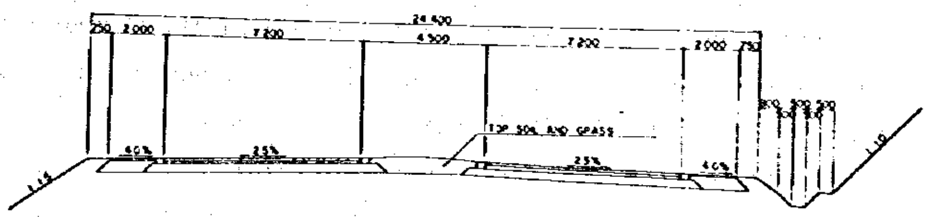
Table IV-5 Design Standards

	Main Road	Access Road
Design Speed	100 km/h	40 km/h
Road Reserve (from edge of road)	15 m	
Width of Carriageway	7.2 m	7.2 m
Width of Shoulder	2.0 m	2.0 m
Sight Distance	200 m	-
Minimum Curve Radius	500 m	-
Maximum Longitudinal Grade	5 %	4 %
Motorway Cross Fall	2.5 %	2.5 %
Vertical Clearance	H = 5.5 m	H = 5.5 m
Design Load for Bridges	BS - 153	-
Width of Carriageway on Bridge	7.2 m	-
Width of Sidewalks on Bridge	0.6 ∿ 1.35 m	-

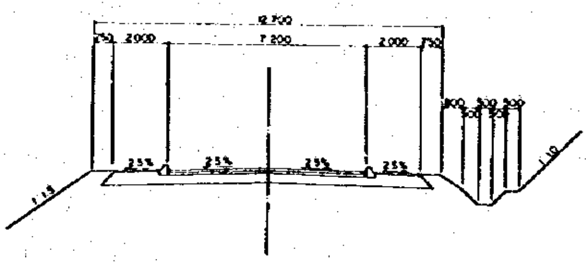
(2) Standard Cross Section

Figure IV.5 Typical Cross Section

Main Road



Access Road



Referred Design Standards and Other Materials:

(1) Roads in Urban Areas (Ministry of Transport Scottish Development Department, The Welse Office)

(2) Layout of Roads in Rural Areas (Ministry of Transport Scottish Development Department, The Welse Office)

(3) A Policy on Geometic Design of Rural Highways (AASHO)

(4) A Policy on Design of Urban Highways and Arterial Streets (AASHTO)

(5) Road Structure Ordinance (Government of Japan)

(6) Technical Memorandam H2/75, Roundabout Design

(7) Roads in Urban Areas (Ministry of Transport)

(8) Capacity of At-Grade Junction (OECD)

5. Preliminary Design

In preparing the preliminary design of the project road, the route location and the geometrical structures for the selected alternative routes have been concretely determined by using a 1/2,500 scale topographical map.

5.1 Route Design

The route locations by different links are outlined below.

Link B: Link B will branch off from the Motorway running near Belle Village (in the vicinity of St. Louis Generating Power Station) and continue to S. Hill on the A_1 Road over the disused railway track. This link will, then, utilize the substructures of the disused railway bridges spanning the St. Louis River and the Grand River North West. In the case of converting the railway bridges, which have enough width to provide only a 2-lane road bridge, into road traffic bridges, another bridge will have to be constructed to provide additional two lanes in the future.

The criteria for selecting the site of a new bridge are 1) to conform exactly with the standard cross section of dual 2-lane road at the Motorway Junction, 2) to be 18 m or more apart at the center lines of each 2-lane bridge in accordance with the results of the engineering study undertaken, if such new bridge is installed in close proximity to the existing bridge, and 3) to make a two-way road to underpass the A_1 Road at S. Hill in parallel as such as possible.

From these, the route location of this link has been determined to almost wholly use the disused railway track.

The vertical alignment of this link begins to match with the surface height of the Motorway at the Motorway Junction and ends up nearly along the height of the railway track. The vertical alignment in between the St. Louis River and the G.R.N.W. must be the same as that of the disused railway track, and the proposed height of this link suface has been determined at about 50 cm higher than that of the disused railway track, by taking account of the thickness of pavement.

The roundabout type will be adopted for the crossing at the Motorway Junction, by holding such constitution as to allow the project road connected with the Ring Road in the form of separate grade, when the Port Louis Ring Road is completed in the future.

Since at present the disused railway track and the A1 Road form a gradeseparated crossing at S. Hill, this link has been also planned to pass under the A_1 Road (S. Hill Interchange). In this case, the A_1 Road and the access road of the link is basically connected by a rampway.

Links C and D: Both Links C and D start at the S. Hill Interchange, pass in their course the back (west side) of the Coromandel Industrial Estate and leave away from the disused railway track, after acrossing the Richelieu Approach Road. Linc C runs westward and Link D eastward therefrom, each of them keeping away from dividing any of privately owned lands and running down southward almost in parallel to each other in sugarcane fields, and both meet again the disused railway track at the Barkly Junction. In addition, both links keeps, to a possible extent bypassing, water reservoirs used for irrigation in sugarcane fields, public facilities and private houses, etc.

Link E: Link E is an access connecting the Barkly Junction with the roundabout of Beau Bassin which is located at the heart of the urban area of Beau Bassin.
It will use the disused railway track throughout. Since many of dwelling houses have been already built along such railway bed, a 2-lane carriageway with a sidewalk is possible considered to be a maximum road structure. It is planned that the height of this link surface is raised to about 50 cm above the existing ground level to allow for a pavement thickness.
This link will, therefore, have an uphill grade of nearly 3.5 % toward Beau Bassin.

Link F: This link will start at the Barkly Junction and end up at the Lower Plaines Wilhems Cemetery Road. By taking into consideration the future extension of the link to the southern part of the urban area of Beau Bassin, it is planned that the link will run 300 - 350 m away from the west side of the CHA Housing Estate and the Central Prison.

The link will ascend southward for about 900 m from the Barkly Junction with a grade of 4.7 %, which will then be decreased to about 0.5 % over the next section of about 400 m in length lending to the Lower Plaines Wilhems Cemetery Road.
The St. Martin Junction when the link is terminated will be a T crossing in the immediate future, but the junction has been designed to have an adequate area to meet future requirements by taking into consideration the future southward extension of the project road.

5.2 Geology and Soil

Earthworks are required for a layer of younger lavas with a thickness of 5 - 10 m and for surface soil of 1 - 2 m thickness. Soil is made up of good quality soil having a design CRB of 9 % and poor quality soil having a design CBR of 1 % with a swelling rate of 7 - 8 %, the latter of which will be thrown away.

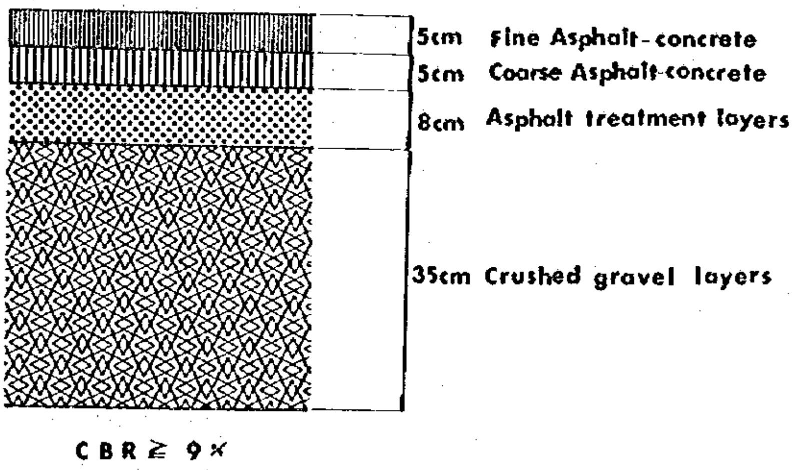
The foundation rocks at the old railway bridge is likely the same, but the riverbed lacks the younger lavas where deposits are placed directly on the layer of the older lavas. Furthermore, river terrace deposits are distributed on the banks of a river.

The older lavas are very hard and should have no problem as the foundation of structures. The younger lavas have been considerably weathered and softened. River deposits are mostly made up of hard and round gravels mixed with sand, silt and clay. The lower part of the river terrace deposits is mostly composed of gravel, while the upper part of it sand, silt and clay. For the distribution and quality of aggregates, a plenty of olivine basalt blocks are available at almost everywhere in the island, large blocks of which are crushed into coarse and fine aggregates. They are quite appropriate for using as aggregates, because of their substantial features in density, specific gravity, high compressive strength and low water absorption rate.

5.3 Pavement Design

For the pavement structural design, a various designing methods of France, UK, USA and Japan as well as those appearing on the past survey reports of Mauritius have carefully been studied. As a consequence, the design has been determined by using "AASHTO Interim Guide for Design of Pavement Structures, 1972", which has gained a remarkable reputation in various countries of Africa.

Figure IV. 6 Pavement Structure



5.4 Design of Drainage Facilities and Irrigation Canals

Side ditches of the project road have been basically designed as a side ditch without timbering, but either of the side ditchs with concrete timbering or the pre-casted concrete U-type ditch is used, in the section where the longitudinal grade is in danger of being scoured by water flow, accounting for 3 % or more. Culverts to be used for irrigation canals running through sugarcane fields are featured by concrete pipe with a diameter of 0.9 m or more and concrete box type.

5.5 Intersection Design

(1) Intersection Alignments and Traffic Control Policy

Intersection designs have been made for the intersections at which the project road crosses the major trunk roads. Structural type and traffic control policy of each intersection are summarized in Table IV-6.

Table IV-6 Traffic Control Policy at Intersections

Name of Intersection	Name of Road	Traffic Control Policy & Structuraly Type
Motorway Junction	Motorway	Roundabout Improvement into a grade separated crossing in anticipation of its possible connection with the Port Louis Ring Road
S. Hill Interchange	A_1 Road	Interchange To provide only in the direction to the main traffic flow to the Motorway Junction - Beau Bassin(via the A_1 Road)
Richelieu Roundabout	Richelieu Approach Road	Roundabout Grade crossing by roundabout
Chebel Branch Road Roundabout	Chebel Branch Road	Roundabout Grade crossing by roundabout
Barkly Junction	Link E	3-leg intersection with channelization
St. Martin Junction	Lower Plaines Wilhems Cemetery Road	3-leg intersection with channelization Planned with a consideration of the future Link Road extension to the south of Beau Bassin
Beau Bassin Foundabout	Link E and A_1 Road	Grade crossing by roundabout To open an new access road to the existing roundabout

(2) Forecast on Future Traffic Volume and Traffic Capacity of Intersections

The traffic volume estimated at intersections varies depending upon the planned year of road construction and the number of serviceable lanes. Here, the following most probable two cases of typical pattern have been selected for studies.

(a) Alternative P_2 or P_2' (1987)
Traffic volume at morning peak hours in the case where the plan will be realized for use with two lanes from the Motorway Junction to the Beau Bassin Roundabout, after opening of the road to public traffic.
(b) Alternative P_4 or P_4' (1992)
Traffic volume at morning peak hours in the case where the plan will be realized for use with four lanes from the Motorway Junction to the Beau Bassin Roundabout and two lanes from the Barkly Junction to the St. Martin Junction, after opening of the road to public traffic.

In each case, the traffic volume (p.c.u.) on the undisturbed portions of traffic flow near the intersections and the traffic volume (p.c.u.) classified by different intersections and directions have been estimated. The traffic volume is estimated for hourly traffic volume during the morning peak. The two typical alternatives to be considered are summarized below.

Studies on the traffic volume estimated at intersections have been made by using both calculation methods of the UK and the OECD.

Congestion ratio at each intersection based on both the traffic volume and its capacity is shown in Table IV-7.

Table IV-7 Congestion Ratio at Each Intersection

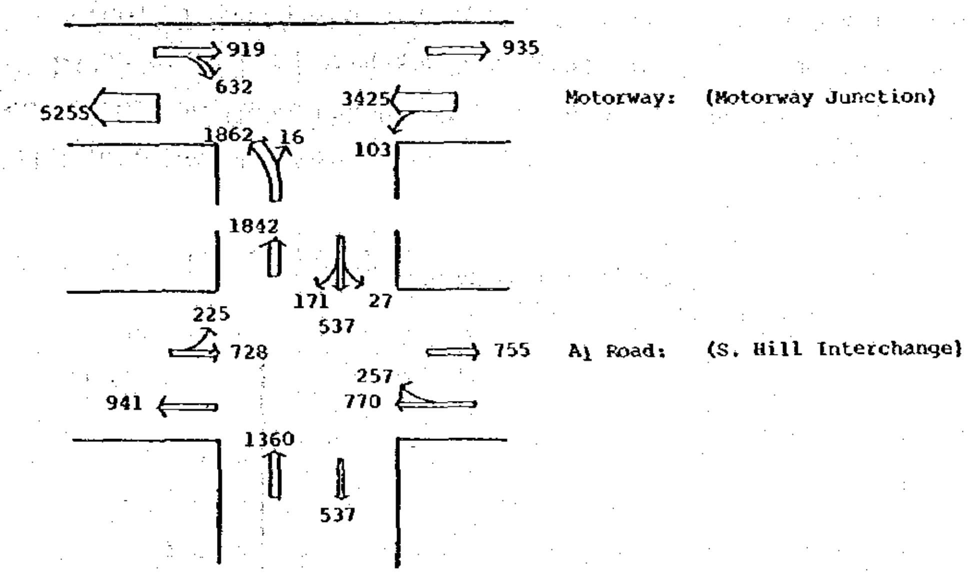
Intersection	Congestion Retio $\left(C = \frac{\text{Traffic Flow}}{\text{Capacity}}\right)$ 1978 (2-lane)	1992 (4-lane)
Motorway J.	$C \fallingdotseq 1.08$	$C \fallingdotseq 1.37$
S. Hill I.	$C < 1.0$	$C < 1.0$
Richelieu R.	$C < 1.0$	$C < 1.0$
Chebel Branch Road J.	$C < 1.0$	$C < 1.0$
Barkly J.	-	$C < 1.0$
St. Martin J.	-	$C < 1.0$
Beau Bassin R.	$C < 1.0$	$C < 1.0$

According to Table IV-7, the traffic volume at the Motorway Junction would reach nearly its full capacity in 1987 and 1.37 times as much as its full capacity by 1992, indicating the ceiling limit of traffic control by grade crossing system.

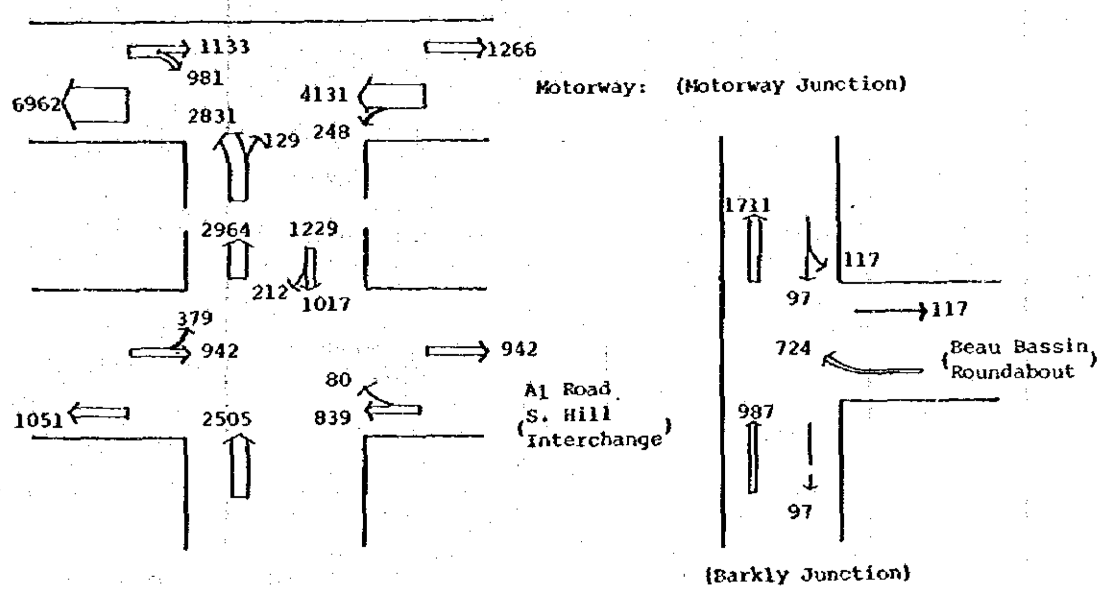
At the Motorway Junction there is a serious problem related to weaving from the traffic flow in the direction from Port Louis to S. Hill and in the direction from Pailles to Port Louis. By 1992 it will become necessary to convert the existing Motorway Junction into a grade separated crossing system for more effective traffic control. In addition, this matter needs to be sufficiently studied in the on-going Port Louis Ring Road Plan.

Figure IV-7 Junction Traffic Flow at Morning Peak Hour (p.c.u.)

<1978 - P2>



<1992 - P4>



5.5 Bridge Design

(1) Selection of Alternatives

Both old railway bridges of the G.R.N.W. River and the St. Louis River as well as over-bridges on old railway track have been taken up to study. The G.R.N.W. Bridge has been taken up as a main item for studies on disused railway bridges. The relationships between assumed conditions and alternatives are shown in Table IV-8.

Tble IV-8 Assumed Conditons and Structural Alternatives of Bridges

Bridges	Assumed conditions	Alternatives
1. Old railway bridge (G.R.N.W bridge)	a. To utilize both superstructure and substructure of the existing bridge Adjustment to vertical alignment profile	Superstructure: Metal (Non-composite girder) Substructure: Rubble concrete Span: 27 m Width: 7.2+0.6 m
	ⓑ New installation for superstructure but the existing structure to be used for substructure Adjustment to vertical alignment profile Comparative study to be made for metal and PC structures of superstructure	Superstructure: ⓑ-1 Metal (Composite girder) ⓑ-2 PC: Post-tensioning T girder Substructure: Rubble concrete Span: 27 m Width: 7.2+1.35 m
	c. New installation for both superstructure and substructure Examination of basic span composition	Superstructure: ⓒ-1 7-span simply-supported girder PC: Post-tensioning T girder Span: 27 m ⓒ-2 5-span simply-supported girder PC: Post-Tensioning T girder Span: 38 m ⓒ-3 3-span continuous girder PC: Dywidage box girder Span: 59+73.8+59 m Substructure: Reinforced concrete Width: 7.2+1.35 m
	d. Additional installation separately for 2-lane bridge	By use of compared results between above alternatives, b and c
2. St. Louis Bridge	Additional installation separately for 2 lanes corresponding to the preceding 1. d.	Type: Single span with high abutment. 3 spans with low abutments
3. Overbridges pailles S. Hill Coromandell	Preparation of one common plan for standard type	Type: Simply-supported pre-tensioning slab girder

(2) Selection of the Optimum Plan

In order to identify an optimum plan for bridges, an intensive study under the alternatives mentioned in Table IV-8 has been made for initial investment, maintenance costs, foreign and local currencyies. As a consequence, Plan ⓑ-2 has been adopted as an optimum structural type for the G.R.N.W. Bridge and the St. Louis Bridge and Plan ⓒ-1 adopted for bridges with a newly constructed 2-lane portion.

(3) Design Standards

The design standards used for the preliminary design of bridges are as follows:

(a) Load

Live Load: HA loading at B.S. 153

Wind Load: The value of the probable mean wind speed for the duration of 10 minutes has been estimated from the maximum instantaneous wind speed for 85 years, which nearly approximates to the value provided in the Specification for Highway Bridge Design, Japan. Therefore, the same is applied to this case.

(b) Material: B.S. or its equivalent standards

(c) Allowable Stress: In principle, to conform with B.S. 153 or B.S.-C.P. 110

6. Construction Schedule and Costs

The construction schedule and costs in each alternative are shown below.

6.1. Construction Period

The construction periods by the package construction plan (P4) and the staged construction plan (P4.S) are represented in Tble IV-9.

Alternative P4
Alternative P4.S First Stage

Table IV 9-1 WORK SCHEDULE

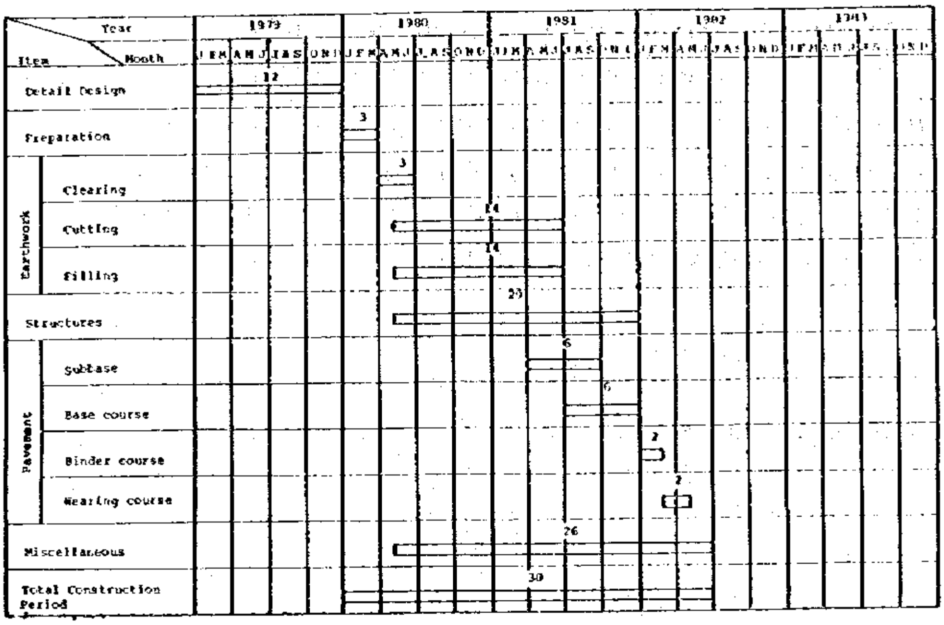
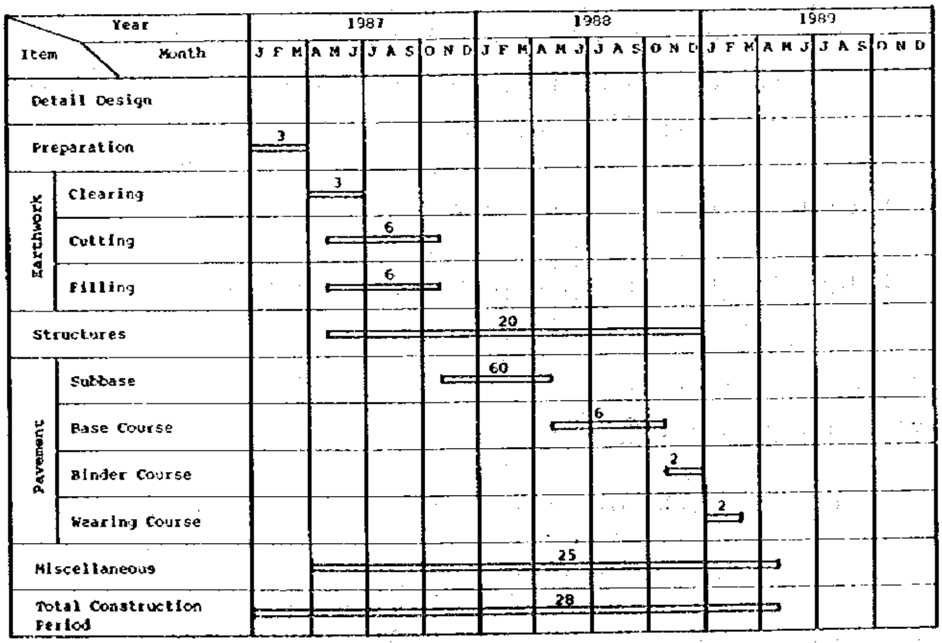


Table IV 9-2 WORK SCHEDULE

Alternative P4.S Second Stage



6.2. Construction Cost

The construction costs by different alternatives are shown in Tables IV-10 and IV-11.

Table IV-10 Construction Cost of the Project

(Unit: 1,000 Rs in Dec. 1977 Price)

Alternatives	P_4	P_4'	$P_4.S$
Link	B+C+E+F	B+D+E+F	B+C+E+F
Distance	4-lane 6,115 m 2-lane 3,162 m	4-lane 6,215 m 2-lane 3,072 m	4-lane 6,115 m 2-lane 3,162 m
Acquisition	9,184	9,280	9,184
Clearing	3,887	3,896	3,887
Earthwork	11,792	13,852	11,792
Drainage	2,915	3,131	2,915
Pavement	25,469	26,125	25,469
Carriageway Eq.	921	985	921
Bridge	24,531	24,531	24,531
Total (without Acquisition)	69,515	72,520	69,515
Detail Design (6.5 %)	4,518	4,714	4,518
Supervision (6 %)	4,171	4,351	4,171
Grand Total	87,388	90,865	87,388

BREAKDOWN OF CONSTRUCTION COST

	P_4		P_4'		$P_4.S$	
Foreign Currency	54,117	62%	55,054	61%	54,117	62%
Local Currency	33,271	38%	35,811	39%	33,271	38%
Economic Cost	87,388	100%	90,865	100%	87,388	100%
Taxes & Duties	7,075		7,296		7,075	
Financial Cost	94,463		98,161		94,463	

Note: The overhead charges (25 %) of contractors and the contingencies (15 %) are included in the work-wise costs of Table IV-10. Costs in the talbe are calculated on the cost level of December 1977.

Table IV-11 Construction and Maintenance Cost by Year

(Unit: 1,000 Rs)

	Year	Alternatives P4	P_4'	P_4.S
Construction Cost				
1.	1979	4,518	4,714	4,518
2.	1980	41,435	43,076	28,620
3.	1981	29,005	30,153	20,034
4.	1982	12,430	12,922	8,585
sub -total		87,388	90,865	61,757
Maintenance Cost				
1.	1982	139	140	93
2.	1983	278	279	186
3.	1984	-	-	-
4.	1985	-	-	-
5.	1986	-	-	186
6.	1987	-	-	9,157
7.	1988	-	-	14,283
8.	1989	-	-	2,749
9.	1990	-	-	278
10.	1991	278	279	278
11.	1992	3,158	3,179	1,770
12.	1993	278	279	278
13.	1994	-	-	-
14.	1995	-	-	-
15.	1996	-	-	-
16.	1997	-	-	-
17.	1998	-	-	278
18.	1999	-	-	1,770
19.	2000	-	-	278
20.	2001	278	279	278
21.	2002	1,579	1,590	885
sub-total		9,880	9,931	34,231
Grand Total		97,268	100,796	95,988

Note: Additional cost for P_4.S is omitted due to its small share to the total. Costs in the talbe are calculated on the cost level of December 1977.

(1) Conditions for Estimation of Construction Costs

a. Currency is Mauritius Rupee (Rs),
b. The foreign exchange rate is set at Rs 1.00 = US$ 0.16, and
c. The prices of construction materials and labor costs are valued at those of December, 1977.

(2) Unit Cost

Table IV-12 Unit Cost of Materials

Item	Unit of measure	Unit Cost (Rs)
Crushed Stone	ton	32
Crushed Gravel	ton	34
Cement (50 kg/bg)	bg	22.7
Reinforcing Steel	ton	2.225 ∿ 2.635
Bitumen	ton	1,420
Timber (local)	m^3	1,400
Timber (imported)	m^3	2,000

Labor Cost: Unskilled Labor 18 Rs/day
Skilled Labor 30 ∿ 32 Rs/day

Table IV-13 Cost for Land Acquisition

Land	Unit of Measure	Unit Cost (Rs)
Housing Land	ha	648,000
Industrial Land (1)	ha	432,000
Industrial Land (2)	ha	378,000
Agricultural Land (1)	ha	108,000
Agricultural Land (2)	ha	216,000

6.3 Maintenance Costs

The maintenance costs are defined as the sum of the daily maintenance costs and the overlay costs required at regular interval.

6.4 Annual Construction and Maintenance Costs

The annual construction and maintenance costs by different alternatives are summarized in Table IV-11.

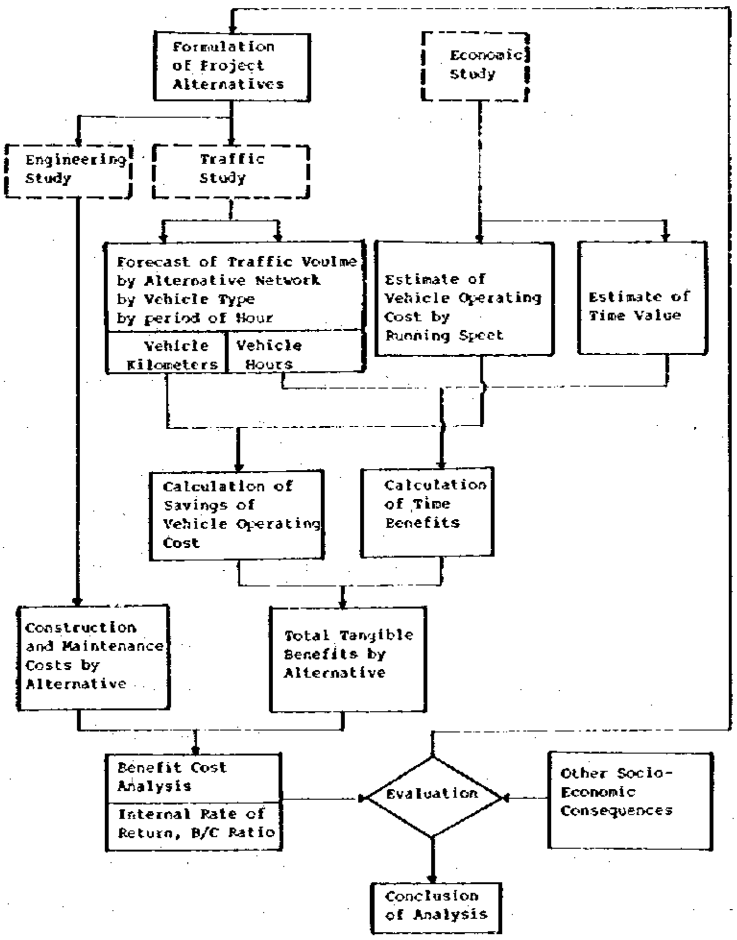
V. PROJECT EVALUATION

V. PROJECT EVALUATION

1. Methodology

The project evaluation can chiefly be performed by use of such Cost Benefit Analysis as to compare the total costs comprising of the construction and the maintenance costs incurrable for implementation of each alternative plan with the total amount of such tangible benefits as savings of vehicle operating costs and time saving benefits. All other socio-economic effects, which may be intangible and can hardly be quantified, are also taken into consideration in evaluating the project. The outline of project evaluation methodology is shown in Fig. V-1.

Fig. V-1 Outline Methodology in Project Evaluation



2. Project Costs by Alternative

As mentioned in Chapter IV.3, every alternative plan examined by the economic evaluation would be deemed executable for opening it to public traffic in 1982. The alternatives P4 and P4' are a dual 2-lane carriageway from Belle Village to Beau Bassin via S. Hill, but the linear alignments of P4 and P4' between S. Hill and Beau Bassin are different, i.e. P4 runs further westward than P4'.

In order to analyze the effects of staged construction, the Alternative P4.S has been examined by the project evaluation, the Alternative P4.S is meant for its total completion with 2 lanes at the first stage in 1982 into a a dual 2-lane road (Alternative P4) at the second stage in 1990.

For each of the project costs by alternative plans, the same figures estimated in the previous chapter have been adopted. The project costs are comprised of design costs, construction costs and maintenance costs.

3. Economic Benefits

Tangible benefits derived from the implementation of the project are conceivably composed of a balance between the sum of total vehicle operating costs and total vehicle running time in the corresponding road network including the project road and the sum of those in the corresponding road network excluding the project road. Namely, tangible benefits are mainly composed of the savings of vehicle operating costs and time benefits.

Vehicle operating costs have been estimated through the estimated unit costs(Rs/km) of vehicle operation at different speeds for each type of vehicle at different certain natural conditions on the road, multiplying such values by the estimated traffic volume in each link.

In evaluating the value of time saved, time value has been estimated based on the monthly average salaries and working hours of such road users as drivers and passengers of private cars and bus passengers, due to difficulties in estimating accurate time values. Further, in the view that all of the saved time would not necessarily be spent on re-production of economic activities, a half of the time value estimated has been adopted for the application of this purpose.

The economic benefits derived from the implementation of the project cover not only the traffic volume diverted from the existing roads to the project road, but the traffic volume remaining in the existing roads. This is because the traffic volume remaining in the existing roads has been reduced and their traffic conditions has been improved due to traffic diversion to the project road. However, the tangible benefits quantified in this analysis are restrictively derived from the traffic volume of the A_1 Road and the Motorway on the ground that the detailed conditions of complicated road network in urban areas would not necessarily be reflected in traffic volume forecast.

The total tangible benefits estimated by using the above-mentioned method are presented in Table V-1.

It should be noted that the tangible benefits deriverd from P_4 is nearly equivalent to that from P_4'.

Table V-1 Benefits by Alternative Case

(Rs million/year)

	Alternative Case	
	P_4 , P_4'	P_4.S
Savings due to the Reduction of Vehicle Operating Cost		
1982	3.43	3.34
1987	11.00	10.84
1992	28.44	28.44
2002	77.58	77.58
Time Benefits due to the Reduction of Vehicle Running Hours		
1982	2.40	2.29
1987	6.89	6.56
1992	17.93	17.93
2002	79.15	79.15
Total		
1982	5.83	5.63
1987	17.89	17.40
1992	46.37	46.37
2002	156.73	156.73

Note: Savings of minor roads are excluded and time benefits are 50 % included.

4. Economic Evaluation

4.1 Cost Benefit Analysis

The economic evaluation of the project is subject to cost benefit analysis which is arrived at comparison of costs and benefits. As the costs and benefits, however, appear at different points of time, they must be measured and compared with common criteria. Both the B/C ratio and the internal rate of return have been adopted as indices for judging the economic viability of the project. In addition, the construction costs and the benefits estimated have been discounted in terms of the values in 1979. The results of cost benefit analysis adopted for alternatives are shown in Table V-2.

Table V-2 Results of Cost Benefit Analysis for the Alternatives

Alternatives	Discount Rate (%)	Rs million Cost	Rs million Benefit	B/C Ratio	Internal Rate of Return (%)
	10	78.4	238.1	3.04	
P4	12	75.8	182.7	2.41	20.8
	15	72.4	126.1	1.74	
	10	81.4	238.1	2.93	
P4'	12	78.8	182.7	2.32	20.4
	15	75.2	126.1	1.68	
	10	64.7	235.8	3.64	
P4.S	12	61.7	180.8	2.93	23.8
	15	57.7	124.6	2.16	

Consequantly, the cost benefit analysis ensures that the economic feasibility of the project is very high in the order of Alternatives P4.S, P4 and P4'. The economic effects of the staged construction of the project is also prominent. For all cases, the internal rates of return exceed more than 20 %. The Alternatives P4 and P4' show exactly the same benefits while the costs for P4 are less than that for P4'. As there are no differences between P4 and P4' in the matters of road structure, the Alternatives P4 and P4.S have been identified as optimum plans. The costs and benefits for both cases of P4 and P4.S are represented in Tables V-3 and V-4, respectively.

Table V-3 Flow of Costs and Benefits for Selected Alternative, P4
(Unit: 1,000 Rs)

	Cost					Benefit		
	r=0%				r= 12%	r= 0%	r= 12%	% of Time Benefit
	Const. Cost	Overlay Cost	Maint. Cost	Total				
1979	4,518	-	-	4,518	4,518	-	-	
1980	41,435	-	-	41,435	36,996	-	-	
1981	29,005	-	-	29,005	23,123	-	-	
1982	12,430	-	139	12,569	8,946	2,914	2,074	41.1
1983	-	-	278	278	177	7,293	4,635	
1984	-	-	278	278	158	9,127	5,179	
1985	-	-	278	278	141	11,423	5,787	
1986	-	-	278	278	126	14,296	6,467	
1987	-	-	278	278	112	17,892	7,226	38.5
1988	-	-	278	278	100	21,645	7,805	
1989	-	-	278	278	90	26,186	8,431	
1990	-	-	278	278	80	31,680	9,107	
1991	-	-	278	278	71	38,326	9,837	
1992	-	2,880	278	3,158	724	46,366	10,626	38.7
1993	-	-	278	278	57	52,371	10,716	
1994	-	-	278	278	51	59,155	10,807	
1995	-	-	278	278	45	66,817	10,899	
1986	-	-	278	278	40	75,471	10,992	
1997	-	-	278	278	36	85,246	11,085	
1998	-	-	278	278	32	96,288	11,180	
1999	-	-	278	278	29	108,759	11,275	
2000	-	-	278	278	26	122,846	11,371	
2001	-	-	278	278	23	138,758	11,467	
2002	-	1,440	139	1,579	117	78,365	5,782	50.5
Total	87,388	4,320	5,560	97,268	75,818	1,111,224	182,748	

Table V-4 Flow of Costs and Benefits for Selected Alternative, P_4.S

(Unit: 1.000 Rs)

	Cost					Benefit		
	r=0%							
	Const. Cost	Overlay Cost	Maint. Cost	Total	r= 12%	r= 0%	r= 12%	% of Time Benefit
1979	4,518	-	-	4,518	4,518	-	-	
1980	28,620	-	-	28,620	25,554	-	-	
1981	20,034	-	-	20,034	15,971	-	-	
1982	8,585	-	93	8,678	6,177	2,840	2,021	40.3
1983	-	-	186	186	118	7,105	4,515	
1984	-	-	186	186	106	8,887	5,043	
1985	-	-	186	186	94	11,115	5,631	
1986	-	-	186	186	84	13,903	6,289	
1987	-	-	186	186	75	17,390	7,024	37.7
1988	8,971	-	186	9,157	3,302	20,482	7,386	
1989	14,097	-	186	14,283	4,599	24,124	7,767	
1990	2,563	-	232	2,795	803	31,680	9,107	
1991	-	-	278	278	71	38,326	9,837	
1992	-	1,492	278	1,770	406	46,366	10,626	38.7
1993	-	-	278	278	57	52,371	10,716	
1994	-	-	278	278	51	59,155	10,807	
1995	-	-	278	278	45	66,817	10,899	
1996	-	-	278	278	40	75,471	10,992	
1997	-	-	278	278	36	85,246	11,085	
1998	-	-	278	278	32	96,288	11,180	
1999	-	-	278	278	29	108,759	11,275	
2000	-	1,388	278	1,666	154	122,846	11,371	
2001	-	-	278	278	23	138,758	11,467	
2002	-10,252	746	139	-9,367	- 690	78,365	5,782	50.5
Total	77,136	3,626	4,824	85,586	61,655	1,106,294	180,820	

4.2. Sensitivity Analyses

Sensitivity analyses have been applied to the alternatives of P4.S and P4 with a various combination of cases. The results of such sensitivity analyses are represented in Table V-5. Under the assumption of a 20 % increase in construction and maintenance costs, the project has been found to be economically feasible even in the most conservative case ②, except the alternative of P_4 with a discount rate of 15 %.

Table V-5 Results of Sensitivity Analysis for the Selected Alternatives

[P_4.S]

Sensitivity Case1/	Cost : ±0%				⑧ Cost : +20%		
	B/C Ratio			Internal Rate of Return(%)	B/C Ratio		
	r=10%	r=12%	r=15%		r=10%	r=12%	r=15%
①	see Table V-2				3.0	2.4	1.8
②	2.1	1.7	1.3	17.5	1.7	1.4	1.0
③	5.2	4.2	3.1	28.5	4.3	3.5	2.6
④	4.1	3.3	2.4	24.3	3.4	2.7	2.0
⑤	6.7	5.3	3.8	30.2	5.6	4.4	3.2
⑥	9.3	7.3	5.2	34.8	7.7	6.1	4.4

[P_4]

Sensitivity Case1/	Cost : ±0%				⑧ Cost : +20%		
	B/C Ratio			Internal Rate of Return(%)	B/C Ratio		
	r=10%	r=12%	r=15%		r=10%	r=12%	r-15%
①	see Table V-2				2.5	2.0	1.5
②	1.7	1.4	1.0	15.1	1.4	1.2	0.8
③	4.3	3.4	2.5	24.9	3.6	2.9	2.1
④	3.4	2.7	1.9	21.4	2.8	2.2	1.6
⑤	5.6	4.4	3.1	26.8	4.7	3.6	2.6
⑥	7.8	6.0	4.2	30.9	6.5	5.0	3.5

1/: The cases used in the sensitivity analyses are defined as follows:

Case ① when the savings of vehicle operating costs and time benefits for the traffic volume on the minor roads are excluded and only 50 % of the time benefits are included. (This is the case adopted for our analysis.)

② when the benefits for the traffic volume on the minor roads and time benefits are excluded

③: when the savings of vehicle operating costs and time benefits for the traffic volume on the minor roads are excluded, but 100 % of time benefits on major roads are included.

④: when only the savings of vehicle operating costs are included

⑤: when the total of the savings of vehicle operating costs and 50 % of the time benefits are included

⑥: when the total of the savings of vehicle operating costs and of the time benefits are all included

⑦: when different discount rates of 10 %, 12 % and 15 % are applied for each case of 1 through 6

⑧: when the construction costs increased by 20 % for each case of 1 through 7.

5. Other Socio-economic Effects

Implementation of this project will give not only direct benefits to the road users, but also the following favourable socio-economic effects.

(1) Environmental conditions along the existing roads, particularly those along the A_1 Road, can be expected to be improved due to the diversion of traffic to the project road.

In addition, this project road has been so designed as to facilitate an easy extension to Quatre Bornes, further south of Beau Bassin, and a smooth connection with the Port Louis Ring Road from the Motorway Junction, all of which makes the aforementioned effects more significant after the completion of such a plan.

(2) A further development of the project areas would be disturbed, as the A_1 Road is the only inter-regional trunk road which penetrates the densely-populated areas with its limited traffic capacity. Also, the adverse effects of lowering the urban functions and deteriorating the urban environment due to the traffic congestion would be inevitable, if nothing is done.

Implementation of this project would materialize a new inter-regional trunk road around the western outskirts of the existing urban areas and, in particular, such urban areas as Coromandel, Beau Bassin and so on would have two inter-regional trunk roads in the east and west, with which it is anticipated that the desirable development of urban areas would be promissed.

(3) There is no alternative main roads available to cope with the traffic volume which may be generated by the implementation of the Pointe aux Sables Development Plan, unless this project is implemented. Not only the Pointe aux Sables Development Plan, but also all future development schemes in the project areas would be greatly influenced by the implementation of the project road.

6. Comprehensive Evaluation of the Project

Both P_4 and P_4.S selected under the project evaluation have been so designed as to have the same road structures in the event. However, there would be multifarious factors difficult to be quantified under the project evaluation, depending upon whether the project is implemented by package construction or by staged construction.

Namely, there are such advantages as to be able to invest effectively in the project in accordance with traffic demands when the project is implemented by staged construction, and to initially invest a smaller amount in the project when some restrictions on the original budget are anticipated. On the other hand, if there exists an increase in the unanticipated rate of inflation during the period from the first stage works to the second stage works, then the construction costs will be increased and its construction period be longer and, thereby, simultaneously prolonging the period of diminishing traffic services.

When foreign contractors receive a contract for the works of the project, additional costs would be required for mobilization or idle machinery unless materials, equipment and labourers are assigned to the other works during the period from between the first stage works and the second stage works. This is very destrimental to implementation of the project.

The package construction would be deemed desirable for implementation of the project on the following grounds: (1) the length of the project road is as short as about 9 km; (2) its scale is not so large; and (3) there is little difference between the two methods of construction in accordance with the results of the project evaluation.

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