7-2 Road Improvement Plan and Outline of Existing Routes

The existing roads which will be incorporated in this trunk road are as shown in Table 7-2.

Table 7-2 Existing Road

Section	Length	mile	Standard	Pavement
Miri-Bintula Road ∿ Beluru	18.4 km	(11.4)	Feeder	Gravel
Beluru ∿ Sg. Tinjar	36.3	(22.6)	Feeder & Trunk	Gravel
Ng Medamit ∿ Limbang	41.4	(25.7)	Feeder	Gravel

7-2-1 Improvement of Alignment

1) Miri-Bintulu Road ∿ Beluru Section

The road in this section was designed and constructed in the year 1968-69. The criteria for feeder roads of the State of Sarawak was applied.

Generally there are few problems regarding alignment in this section. However regarding the profile, there are numerous cases of insufficient sight distance. This will be improved by applying the new trunk road design criteria.
Accompanying the upgrading of feeder roads to trunk road standards, the roadwork at the formation level will be widened on one side .

2) Beluru ∿ Sugai Tinjar Section

Design for the roads in this section commenced in 1975. Presently 29 km (18 miles) were completed with gravel pavement, and the remaining 4 km is under construction directly by the road construction office MRCU.10.

Up to 9.7 km (6 miles) from the starting point, the road was constructed according to feeder road criteria and the rest according to trunk road standards.

In this project, sections of existing feeder road will be improved according to the new trunk road design standard, and among the existing trunk road sections in some areas the slopes will be improved in accordance with the new rolling area trunk road design standards to be applied to this area.

3) Ng. Medamit ∿ Limbang Section

The roads in this section were constructed prior to 1966. Because feeder road standards were applied, there are numerous places which have curves with small radii, insufficient sight distance and insufficient shoulder width.

Furthermore as there are areas which become submerged during floods, these will be improved according to the new trunk road design standards.

7-2-2 Outline of Road Sections

1) Miri-Bintulu Road ∿ Beluru Section (Beluru Road; STA 0 ∿ STA 18 + 400)

The project road starts at the junction with the Miri/Bintulu road which is designated as Station 0. The section STA 0 ∿ STA 18 + 400 is an existing gravel road constructed according to feeder road standards. This road is called Beluru Road.

Along the Miri-Bintulu trunk road are extensive oil palm plantations, and along this new trunk road section plantations are also being developed. These oil palm plantations are mostly located on the northern side of the roads, while on the southern side rice paddies are located. At STA 1 + 100 there is a one lane wooden bridge.

According to Sarawak's plan, a permanent bridge will be constructed at the time of change from application of feeder road standards to the application of trunk road standards. At STA 7, the route will merge with the branch road passing through oil palm plantations. From this point on the slope becomes steeper. Roads are in fairly good condition from STA 10 ∿ STA 15 as they are used for the transport of lumber.

2) Beluru ∿ Sungai. Tinjar Section (Beluru - Loagan Bunut road; STA 18+400 ∿ STA 54+700)

At about 1 km (0.6 miles) west of the town of Beluru, the Beluru road meets with the Beluru - Loagan road extending from this junction up to Sg. Tinjar. At present the road is a completed gravel road except for a 6.5 km (4.0 miles) section under construction by MRCU.10. From the junction (STA.18) to a point 4.7 km (2.9 miles) away are located the MRCU.10 office and its motor pool. The road crosses Sg. Teman at STA. 24+100, where a steel girder bridge is now under construction. Test piling of RC pile with 4.0 ton drop hammer found the support layer at a depth of 120 feet. The concrete used is a volume mixed of 1 : 1.5 : 3 proportion, with a design strength of $\sigma_{28} = 264$ kg/cm^2 (3,750 psi).

Crossing of minor rivers is accomplished by culvert pipes of either 800 mm (36") or 1,000 mm (48") in diameter. At STA 36+800 the route crosses Sg. Bakong where a bridge is under construction using cast-in-situ concrete piles and concrete sheet-piles. From this point, the route ascends in elevation to cross a saddle at 50 m (150 feet) in elevation before reaching Sg. Bok. At Sg. Bok, a temporary assembly-type steel bridge of 36.6 m in length is being constructed.

"Slash-and-burn cultivation" is being carried out along the route and residential communities are found scattered sparsely here and there.

The section between STA 48 and Sg. Tinjar is now under construction. It has a wavy profile that is composed of slopes of a 6 % gradient in alternating directions.

3) Ng Medamit ∿ Limbang Section (Kubong Nanga Medamit Road and Berawan Road; STA 0 ∿ STA 41 + 400)

The existing road terminal at the opposite bank of Ng Medamit is the starting point of this road section, and is designated as STA 0. At present, the existing road is used for lumber transport and as commodity supply route to a lumber camp located in Ng.Medamit, as well as for carrying Ng Medamit residents going to Limbang. For a gravel road, it is well maintained, but since it is only one lane, cars must decrease speed as they approach the bridge areas. The gravel which is used is natural cobble stones from the river bank.

At STA 9 + 600 the route is connected to the Ukon Road and up to STA 17 runs parallel northward with Sg. Limbang. Then going eastward it connects to a road going in the direction of Kpg Danau at STA 18 + 900, merges with Berawan Road at STA 31 + 400 and again runs northward to Limbang.

7-3 Geometric Design and Outline of New Road Sections

7-3-1 Geometric Design

1) Location of Routes

The selection of route location for this road project is based on the establishment of an alignment which would measure up to the importance of the role and function of the trunk road in the State of Sarawak, with the following points considered as basic conditions.

a) To connect the Sg. Tinjar Bridge with Long Lama and Ng.Medamit.
b) To pass by large inhabited areas.
c) To carefully locate bridges of major rivers at optimum locations.
d) To avoid traversing the central area of the Gunong Mulu National Park in order to protect the natural environment.
e) To avoid swamps and flooded areas.
f) To avoid large scale earthwork.
g) To avoid getting too close to the border of Brunei.

The major control points of the location of routes are shown in Fig. 7-1.

2) Geometric Design

The alignment must be continuously smooth and adapted to the terrain. Road alignment is the primary element in road design which determines safety, comfort and economy for the travelling vehicles, and should therefore be carefully accomplished.

In this project, alignment was designed with consideration to the following points:

a) comfort and safety for cars based on both kinetics and statics
b) favorable from the point of vision and human confort
c) in harmony with natural environment
d) economical and technically appropriate considering the topography.

Taking the above points into consideration, road sections are classifed by type of terrain as discussed in Chapter 6 as in Table 7-3.

Table 7-3 Road Section Classification by Terrain Type

Station	Length (km)	Terrain
STA 0 + 00 ∿ STA 10 + 100	10.1	Rolling
STA 10 + 100 ∿ STA 27 + 700	17.6	Flat
STA 27 + 700 ∿ STA 33 + 00	5.3	Rolling
STA 33 + 00 ∿ STA 47 + 00	14.0	Flat
STA 47 + 00 ∿ STA 55 + 00	8.0	Rolling
STA 55 + 00 ∿ STA 66 + 00	11.0	Flat
STA 66 + 000 ∿ STA 81 + 650	15.7	Rolling
STA 81 + 650 ∿ STA 141 + 200	59.6	Mountainous

Because the main emphasis of this feasibility study is on the location of routes, transition curves were not used in the horizontal alignment design. The harmony of horizontal alignment and vertical alignment, however, has been fully considered.

For the detailed design stage, transition curves must be used.

The outline of selected routes is given below.

7-3-2 Outline of Routes

1) Sungai Tinjar∿Batang Baram Section (STA 0 ∿ STA 26 + 200)

The left bank of Sg. Tinjar, where a bridge will be constructed under an Australian Government Sponsored Colombo Plan, is designated as STA 0. Avoiding the swamp area which surrounds Loagan Bumut Lake, the route passes the 5 - 10 m high foothills of the northern side of the mountainous area. In the vicinity of STA 5 ∿ STA 10 it enters a tableland where it will run parallel to an existing footpath up to about STA 7. From STA 10 to STA 16 is swamp area.

Although attempts were made to locate the entire section on elevated areas of over 10 m height, crossing of a peat area surrounding Sg. Tru by some 800 m length was found unavoidable.

STA 16 ∿ STA 26 passes through foothills and on the way, it intersects with a main road near STA 19 + 600. Proceeding almost parallel to Sg. Lama the route reaches the only sub-center of the area, Long Lama. In the vicinity of STA 22, rice paddies have been developed but there is still room for further development. For the crossing of Batang Baram, two alternatives are being compared and considered: ferry-boat or bridge.

2) Batang Baram∿Sungai Apoh Section (STA 26 + 200 ∿ STA 51 + 600)

From the Batang Baram bridge location, the route traverses Long Lama, and goes further through rubber plantations into a mountainous area, and via foothills proceeds to STA 47. In the vicinity of STA 33, Batu Gading, which is planned as the source of aggregate supply for this project, is located. There is a lumber camp in the vicinity of STA 36. Also in this vicinity, are some hamlets. The route, passing through table-land from STA 47 to STA 51, crosses Sg. Apoh at the northern side of R. Akam Ajan.

3) Sungai Apoh ∿ Sungai Tutoh Section (STA 51 + 600 ∿ STA 81 + 600)

The route passes through lowlands from the right bank of Sg. Apoh to STA 53. From here up to STA 54 + 600, it traverses tablelands--50 meters above sea level and here numerous drainage structures are used. Between STA 54 + 600 and STA 66 is a flat area. Although efforts were made to locate the route on highland, this was not possible for all areas, and there are places where the route goes through layers of peat. The area between STA 66 to STA 78 lies on highlands. Here there are numerous rivers but the route was located so that it would intersect the rivers a minimum number of times. The site of the bridge of Sg. Tutoh will be planned to pass over the neck portion of the river.

4) Sungai Tutoh∿Sungai Medalam (STA 81 + 600 ∿ STA 114 + 100)

This section runs from Sg. Tutoh to Sg. Medalam via the northern end of Gunong Mulu National Park. Mountains cover this whole section. Values for horizontal alignment and vertical alignment were both influenced by the terrain considerably, but the alignment was made so as to require the least number of river crossings, and so that earthwork volumes could be kept to a minimum.

5) Sungai Medalam∿Ng. Medamit (STA 114 + 100 ∿ STA 141 + 200)

This whole section is covered with mountainous terrain. Sg. Limbang flows along an extremely zigzag path. After sufficient investigation the narrow portion in the vicinity of R. Pakatom was chosen as the site for the bridge.

At R. Nanga Awang the route crosses Sg. Medamit. Going along a private road, it comes to the opposite bank of Ng. Medamit, and reaches Medamit Road.

Though Ng. Medamit is on the left bank of Sg. Limbang, the route was established, after consideration of the number of river crossings.

7-4 Design of Major Structures

7-4-1 Plan of Structures

The major structures for this project are as shown in Tables 7-4 and 7-5.

Total 7-4 Total Length of Bridges (m)

Trunk Road

Span / Section	Short ∿ 20m	Moderate 20 ∿ 40m	Moderate 40 ∿ 60m	Long 60m ∿
1	20	0	0	0
2	0	0	0	0
3	25	180	0	150
4	55	210	0	0
5	120	80	130	0
6	85	120	0	0
7	100	80	130	0
8	200	75	0	0
Total	605	745	260	150

Feeder Road

Span / Name of Road	Short ∿ 20m	Moderate 20 ∿ 40m	Moderate 40 ∿ 60m	Long 60m ∿
Long Laput Rd	20	0	0	0
Long Bedian Rd	10	120	0	0
NP Base Camp Rd	20	0	0	0
Total	50	120	0	0

Table 7-5 Bridge List

Trunk Road Bridges

Section	Name of River	Station	Bridge Length (m)	Type
1.	Sg. Salu	*1) STA 1 + 100	20	RC
3.	Sg. Tru	*2) STA 13 + 100	3 @ 30 = 90	PC
		21 + 00	10	RC
		22 + 500	15	RC
	Batang Baram	26 + 100	30 + 150 + 30 + 30 = 240	PC, Langer
4.		STA 28 + 400	20	RC
	Sg. Besungai	32 + 00	20	RC
	Sg. Temala	35 + 500	3 @ 30 = 90	PC
		38 + 300	15	RC
	Sg. Apoh	51 + 500	4 @ 30 = 120	PC
5.	Sg. Terawan	STA 63 + 900	25 + 30 + 25 = 80	PC
	Sg. Abang	70 + 700	15	RC
		73 + 300	15	RC
		74 + 200	15	RC
		75 + 800	15	RC
		77 + 300	10	RC
	Sg. Gak	77 + 700	20	RC
	Sg. Mayoh	79 + 00	20	RC
		79 + 800	10	RC
	Sg. Tutoh	81 + 600	40 + 50 + 40 = 130	SG
6.		STA 83 + 800	15	RC
		90 + 100	10	RC
		94 + 100	10	RC
	Sg. Putut	96 + 800	20	RC
	Sg. Mentawai	104 + 200	30	PC
		106 + 100	15	RC
		109 + 00	15	RC
	Sg. Medalam	114 + 100	3 @ 30 = 90	PC
7.		STA 116 + 600	10	RC
		118 + 800	15	RC
		122 + 100	15	RC
	Sg. Mentakong	123 + 400	20	RC
	Sg. Limbang	127 + 600	40 + 50 + 40 = 130	SG
	Sg. Medamit	136 + 100	25 + 30 + 25 = 80	PC
	Sg. Siban	136 + 900	20	RC
	Sg. Saliban	139 + 600	20	RC
8.	Sg. Lubang	*3) STA 1 + 900	15	RC
	Sg. Polub Merah	7 + 00	15	RC
	Sg. Meugari	12 + 600	20	RC
	Sg. Palas	19 + 300	20	RC
	Sg. Berleras	22 + 300	10	RC
	Sg. Lubai	23 + 700	3 @ 25 = 75	PC
	Sg. Melaban	25 + 600	20 + 20 = 40	RC
	Sg. Bakol	28 + 200	15	RC
	Sg. Brangas	29 + 200	10	RC
	Sg. Berawan	31 + 100	20 + 20 = 40	RC
	Sg. China	35 + 200	15	RC

Feeder Road Bridges

Name of Road	Name of River	Station	Bridge length (m)	Type
Long Lapat road	Sg. Lama	STA 0 + 300	10	RC
	Sg. Belek	3 + 600	10	RC
Long Bedian road	Sg. Apoh	STA 1 + 900	4 @ 30 = 120	PC
		18 + 200	10	RC
N. P Base Camp road	Sg. Melinau	STA 4 + 600	20	RC

RC: Reinforced concrete girder
PC: Pre-stressed concrete girder
SG: 3-span continuous steel girder
Langer: Langer girder

*1): Miri-Bintulu road ~ Sg. Tinjar
*2): Sg. Tinjar ~ Ng. Medamit
*3): Ng. Medamit ~ Limbang

7-4-2 Requirements for Structure Design

1) Specification Applied

The British Standards will be applied as a specification for structural design. The British specification for bridge design has been the BS 153 : "Steel Girder Bridges" enacted in 1954. In 1967, revision based on the former was started as a common standard under the title of BS 5400: "Steel, concrete and composite bridges." Since the BS 5400 is not yet fully complete as a design specification the preliminary design in this study has been done in accordance with the old version. However, in the detailed design stage, use of BS 5400 would be desirable.

2) Horizontal Seismic Force

In the State of Sarawak, horizontal seismic force is not taken into consideration in the design of structures. However, according to a distribution of earthquake sources which developed in 1966, in Robert L. Wiegel's "Earthquake Engineering" (Fig. 7-2), the northern part of Borneo and the Brunei vicinity have had earthquakes.

In this survey, horizontal seismic force is not taken into consideration. However, at the time of detailed designing, consideration of the horizontal seismic force will have to be studied.

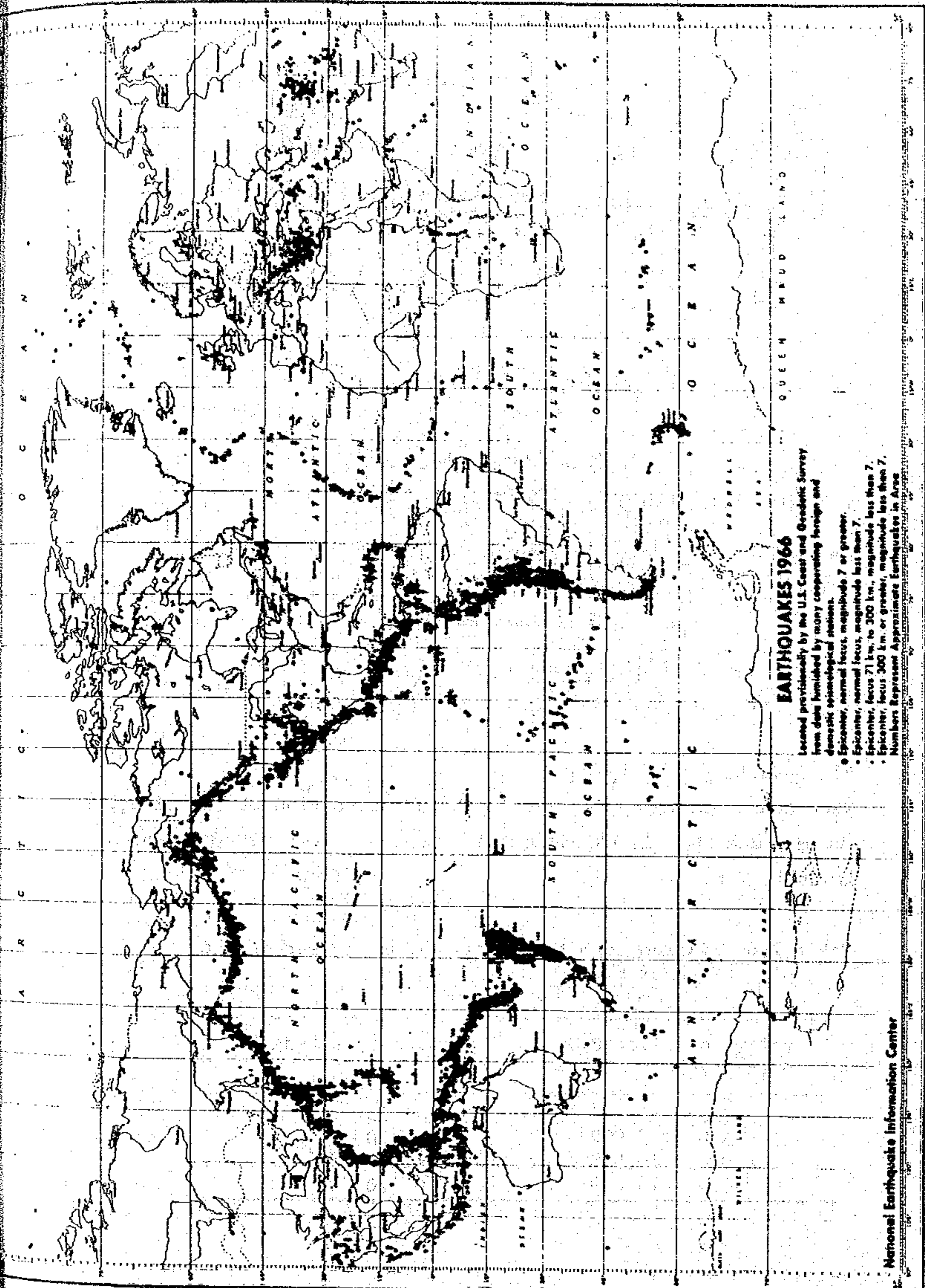
3) Width of Bridges

The construction width of bridges applicable to trunk roads Fig. 7-3 is as follows:

Width of vehicle ———— 7.32 (24')
Width of sidewalk and covered area for one side
———— 1.30 m (4' - 3")
Total ———— 9.92 m (32' - 6")

This applies to the bridge to be constructed at Sg. Sabatang in Tg. Kidurong Road. The drawing for this bridge is the most up to date one which could be obtained from the Sarawak PWD.

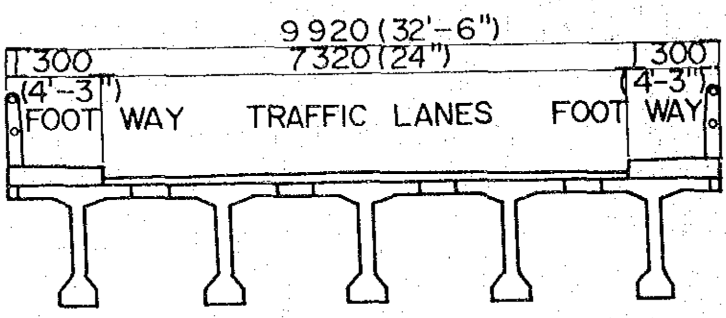
Fig. 7-2 EARTHQUATKES 1966



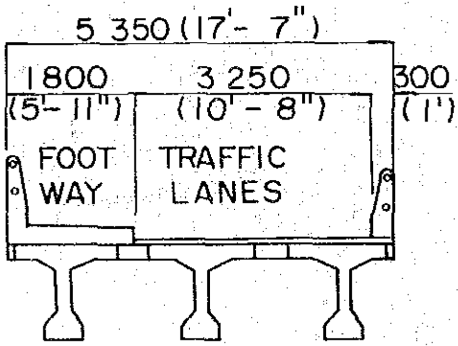
Map showing global seismicity for the year 1966. The epicenters of the earthquakes were calculated by the U.S. Coast and Geodetic Survey from the observed travel times of seismic *P* waves to seismographic stations. The map can be considered almost complete for earthquakes with magnitude above about 4.

Fig. 7-3 TYPICAL CROSS SECTION OF BRIDGE

TRUNK ROAD



FEEDER ROAD



4) Span Length of Bridge

When constructing a pier within the cross section of the river, the minimum span is based on the volume of river flow, as shown in Table 7-6.

Table 7-6 Minimum Span for Construction of Pier in the Path of River

Volume of River Flow Q (m^3/sec)	Minimum Span Length (m)
Under 500	15
500 ∿ 2,000	20
2,000 ∿10,000	20+0.05·Q-5
Over 10,000	70

For single span bridges which do not use a pier, the value can be decreased from those given in the table above.

Because of the passage of rafts used for the transport of lumber and other vessels, the construction of piers at the low flow area of the river is not permitted for the following rivers:

Batang Baram
Sg. Apoh
Sg. Tutoh
Sg. Limbang.

7-4-3 Type of Structure

1) Bridges

In general the following points must be considered in the selection of the type of structure for bridges.

- Conditions of the river at the site of construction of bridge, volume of river flow, terrain, and road planning
- Cost for overall construction, including superstructure, sub-structure, foundation works as well as for maintenance which are to be kept to a minimum.
- Technologically, the structure should be simple, not requiring elaborate techniques for production, construction, etc.
- Aesthetically pleasing.

Considering the above points, the type of structure selected was as follows:

a) Superstructure

The type of superstructure was selected according to the length of span, as shown in Table 7-7.

Table 7-7 Type of Superstructure

Length of Span	Type of Superstructure
Under 20 m	RC T-beam
Over 20 m, Under 40 m	PC Composite Beam
Over 40 m, Under 60 m	Continuous Steel Beam
150 m	Langer beam

Reasons for selection are as follows:

. The RC T-beam is used for span length under 20 m for ease in obtaining raw materials, production and maintenance.

. For span length of over 20 m, and under 40 m, the composite steel beam can be used as well as the PC composite beam. Although its production is more difficult, the PC beam is chosen over the other since it is easier to obtain and transport raw materials and to maintain.

. Generally, in the case of the PC beam, the strength of the concrete is more than $\sigma_{CK} = 400$ kg/cm^2, but considering its ease in quality control the value $\sigma_{CK} = 350$ kg/cm^2 is adopted.

. For central span length of over 40 m and under 60 m, either the 3 span continuous steel girder or the continuous PC girder may be considered.

The steel girder has problems of transportation and maintenance, but as the continuous PC girder is extremely difficult to execute, the steel grider is used.

. For the long span bridge, the Langer beam was chosen for economic reasons, as well as for its comparative ease in execution.

b) Substructure

Considering the flow of the river the oval shaped inverted T type was used for the pier.

Also for the abutment, the inverted T type was used because of easy execution.

c) Foundation Structure

Results of a survey of the subsoil conditions for the bridge foundation show that the supporting layers exist approximately 3 m and 28 m deep. However, since the number of spots surveyed was limited, a sufficient amount of information was not to tell how deep the supporting soil may exist under every spot of the area concerned. In view of this three alternative types of foundation have been selected each being recommended for one of the three classification of the depth of the supporting soil, as shown in Table 7-8.

Table 7-8 Type of Foundation

Depth of Supporting Layers (M)	Type of Foundation
0- 5	Spread foundation
5-12	RC pile □500 mm
12-30	Steel pipe pile ϕ 600 mm

Reasons for selection are as follows:

- In the case of layer depth of 0-5 m, the spread froundation is easy to install. The quality is good and reliable.

- The RC pile and PC pile when joined together have problems at the joint. Also the driving of such piles becomes difficult when the intermediate layer's N Value is 10-20. Thus for a supporting layer of 12-30 m the steel pipe pile is used.

- Because of the single pile structure, the RC pile is used in the case of supporting layer of 5-12 m, for its ease in production and in material procurement.

- Cast-in-situ pile and Caisson are favorable for use in heavy construction but because of the difficulty in installation as well as work performance and quality control, they are not recommended.

- Wooden piles are favorable for small scale structure, but because of their lack of reliability in quality, their use is not recommended.

A comparison of different types of foundations are shown in Table 7-9.

Table 7-9 Comparison of Types of Foundation

Type of Foundation		Depth of Supporting Stratum (m)			Size of Load (ton)			N Value of Intermediate Strata (Viscous Soil)			Quality of Material	Availability of Material	Reliability in Production or execution quality	Workability
		0~5	5~12	12~30	200	200~1500	1500	0~4	4~10	10~20				
Spread Footings		A	B/C	C	A	A	A	–	–	–	A	A	A	A
Driven Pile	Timber Pile	A	A/B	C	A	C	C	A	C	C	B	A	B	A
	RC Pile	B	A	B	A	A	C	A	B	C	A	A	A	A
	PC Pile	B	A	B	A	A	C	A	A	B	B	A	B	A
	Steel Pile	B	B	A	A	A	B	A	A	A	A	B	A	A
Cast-in-Site Pile		C	B	A	B	A	B	A	A	A	B	A	B	B
Caisson Pile		B	B	A	C	B/C	A	A	A	A	A	A	B	B

Note:

A: Complies with requirement in principle

B: Requires particular study as to whether it complies with requirements

C: Does not comply with requirement in principle

As seen in Fig. 5-6 and Table 5-5 (Chapter 5) the bore hole test and standard penetration test were only made at 5 locations on 3 rivers.

Before detailed planning it is necessary to thoroughly investigate and confirm the supporting layers at each construction site, before deciding on the basic foundation structure type.

2) Drainage Structures

Since the project area exists in the Tropical Rain Forest Region, numerous road crossing drainage structures are necessary. Road crossing drainage structures are classified by terrain, quantity of drain, etc. in Table 7-10.

Table 7-10 Road Crossing Drainage Structures

Culvert	Section
Box culvert	2.0 m x 2.0 m 3.0 x 2.0 3.0 x 3.0 2 - 3.0 x 2.0
Pipe culvert	ϕ 900 mm ϕ1,500 mm

7-5 Pavement Design

7-5-1 Design Policy

The pavement design for this project has been done according to the following British Standards currently in use in Malaysia:

1. Road Note 29, A guide to the structural design of pavements for new roads.

2. Road Note 31, A guide to the structural design of bituminous surfaced roads in tropical and sub-tropical countries.

This project involves some sections of improvement work and others of new construction. In designing the pavement structure of the road, therefore, local conditions as well as harmony with existing roads have been taken into consideration.

Twenty (20) years has been taken as the design life of roads. To avoid excessive thickening of the pavement structures, the surfacing construction has been considered in two phases: The initial stage after opening of the road, and the later stage after the cumulative equivalent number of standard axles reaches a certain amount.

7-5-2 Design Conditions

1) Design Traffic Volume

The design traffic volume used to calculate pavement thickness was based on the estimated future traffic volume as previously determined in chapter 4. Table 7-11 shows for each road section, the traffic volume just after the opening in 1985, the number of commercial vehicles in the year 2005, and the cumulative equivalent number of standard 8.2 ton axles load for 20 years.

The conversion factor to be used to obtain the equivalent number of standard axles originated in the AASHO ROAD TEST and is also used in the British Standard. The types of vehicles considered for this project are passenger cars, vans, pick-ups, buses and 6-ton trucks. The conversion factor for each of these vehicle types is as shown in Table 7-12.

Table 7-11 Design Traffic Volume

	Road Section	Traffic Volume in 1985 (Vpd)	Traffic Volume of Commercial Vehicles in 2005 (Vpd)	The year when the Total of passing vehicles in 8.2 ton equivalent single axial load Reaches 500 thousand times	The 20 years Total Traffic Volume in 8.2 ton equivalent
				th year	$\times 10^6$
1	Miri Bintulu Rd. ~ Beluru	600	1,270 < 1,500	13	1.24
2	Beluru ~ Sg. Tinjar	308	632 < "	15	0.90
3	Sg. Tinjar ~ B. Baram	311	618 < "	15	0.96
4,5	B. Baram ~ Sg. Tutoh	134	298 < "	18	0.65
6,7	Sg. Tutoh ~ Ng. Medamit	116	231 < "	18	0.63
8	Ng. Medamit ~ Kubong	440	841 < "	14	1.15
8	Kubong ~ Limbang	1,801	2,197 > 1,500	7	2.70

Note: The commercial vehicle is defined here as a goods or public service vehicle of unladen weight exceeding 1,500 kg.

Table 7-12 Conversion Factor to be Used to Obtain the Equivalent Number of Standard Axles

Vehicle	Coefficient of Conversion
Passenger Car	0.0002
Van, Pick-up	0.0036
Bus	0.0614
6-ton truck	0.3533

2) The Strength of Roadbed

The design CBR value for Roadbed of the new road and the road improvement sections are determined based on the soil test results shown in Fig. 5-4 and Table 5-2 of chapter 5.

Table 7-13 shows the CBR value for roadbed soil.

The CBR value of the existing roadbed is estimated to be about 7.

Table 7-13 CBR Values of Road Bed Material

	Construction Section	Subgrade C B R
1	Miri Bintulu Rd - Beluru	3%
2	Beluru - Sg. Tinjar	3
3	Sg. Tinjar - B. Baram	4
4,5	B. Baram - Sg. Tutoh	3
6,7	Sg. Tutoh - Ng. Medamit	4
8	Ng. Medamit - Kubong	4
8	Kubong - Limbang	4

7-5-3 Pavement Cross Section

1) Outline of pavement structure

The pavement is composed of the roadbed, sub-base, base course, and surfacing course in that order. The various layers differ in function, and their materials should be selected accordingly, to form an economical pavement structure. An outline of pavement structure is given below.

a) Surfacing course

This layer is most exposed to the influence of traffic load and weather conditions. It must be able to resist the wear and the shearing force of vehicle loads, and it must be smooth and not slippery so as to allow for comfortable travelling of vehicles. The permeation of surface water into the subsoil must be prevented. Depending on the traffic volume in this project, bituminous surface dressing and dense grade asphalt concrete is recommended.

b) Base Course

The base course has the vital function of dispersing the traffic load sustained by the surface layer and safely transmitting it to the sub-base. For the base course, hard and high quality materials are generally used. In this project well-graded crushed stone will be used. To insure that it will be of well graded, it will be a mix of several classified materials. Well graded materials are easy to spread and compact, and thus suitable for machine execution. In this project generally, crushed stone from Batu Gading and Sg. Tutoh should be used.

c) Sub-base

The sub-base is laid directly on top of the roadbed to prevent rising of underground water and the infiltration of the soil from the roadbed layer. Also, together with the base course, the sub-base distributes the traffic load and safely transmits it to the roadbed.

Generally, for the sub-base, economical local materials are used. In this project, the use of Batu Gading crusher run and Sg. Tutoh river gravel is recommended.

2) Pavement cross section

Pavement design for this project has been accomplished for 2 cases corresponding to the forecast traffic volume presented in Table 7-11 as follows.

Case 1: Where the daily traffic volume of commercial vehicles remain under 1,500 throughout the 20-year design life of the pavement.

Case 2: Where the daily traffic volume of commercial vehicles exceeds 1,500 within the 20-year design life of the pavement.

The following paragraphs give details for these two cases:

a) Case 1

Design of the pavement cross section has been done in accordance with the British Standard Note 31, which is indicated in Appendix Fig. A-7-1. All the road sections except the Kubong-Limbang Section of the 8th design section fall under this category where all roadwork will be constructed with either of the following types of surface structure before the cumulative equivalent number of standard axles reaches 500,000 times, but will be overlaid with a bituminous surfacing after it exceeds this figure.

i) Surface dressing.

ii) Without surface dressing.

While pavement structures in the case of alternative ii) do not fall under any category to which the British Standard applies, their thickness and strength comply with such standard.

The selection from these two should be based on careful comparison of the cost of construction and maintenance, harmony with the existing roads, the cost-benefit ratio, etc., as well as a comprehensive assessment of other factors.

b) Case 2

The Kubong-Limbang section of the 8th design section is represented by this case, where the daily traffic volume of commercial vehicles exceeds 1,500 vehicle per day during the 20-year design life of the pavement, and as such cannot be applied with the same standard as in the above case. Its pavement design therefore has been done in accordance with the British Standard Road Note 29 which is attached herein as appendix Fig. A-7-2 and A-7-3.

In this case the pavement surface will consist of only one layer before the cumulative equivalent number of standard axles reaches 500,000 times, and will be overlaid with an additional layer to complete it as a two layer surface structure after it exceeds that figure.

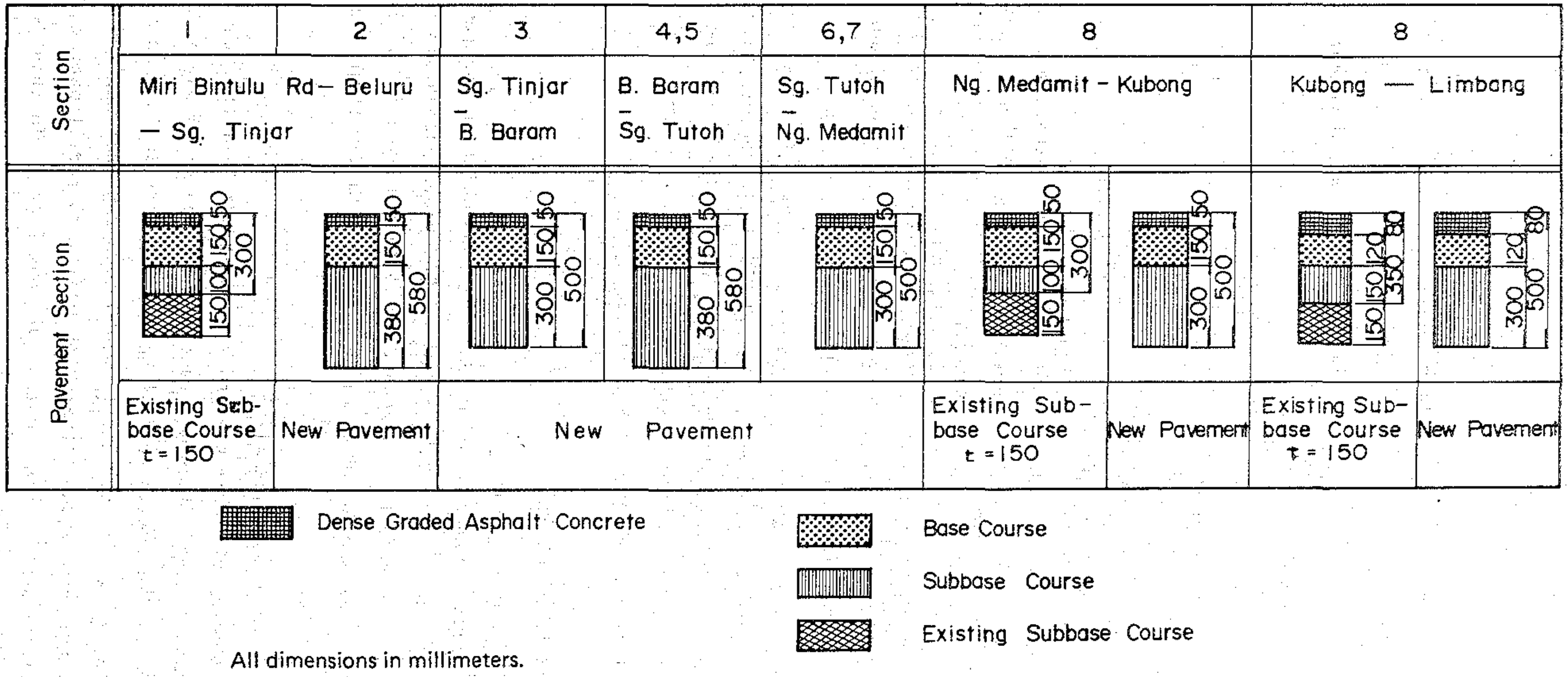
Table 7-14 and Fig. 7-4 present the ultimate pavement structure for each road section.

Table 7-14 Pavement Structures by Designed Road Section

	Designed Road Section	Road Bed CBR (%)	Existing Pavement Thickness (cm)	Subbase Thickness (cm)	Base Course Thickness (cm)	Surface layer Thickness (cm)	Total Thickness (cm)
1	Miri Bintulu Rd. – Beluru	3	–	38	15	5	58
		7	15	10	15	5	30
2	Beluru – Sg. Tingar	3	–	38	15	5	58
		7	15	10	15	5	30
3	Sg. Tingar – B. Baram	4	–	30	15	5	50
4,5	B. Baram – Sg. Tutoh	3	–	38	15	5	58
6,7	Sg. Tutoh – Ng. Medamit	4	–	30	15	5	50
8	Ng. Medamit – Kubong	4	–	30	15	5	50
		7	15	10	15	5	30
8	Kubong – Limbang	4	–	30	12	8	50
		7	15	15	12	8	35

Note: For Road Sections 1, 2, & 8, the upper figure indicates the value for widened portion along existing road pavement and the lower figure indicates that of the existing pavement.

Fig. 7-4 PAVEMENT SECTION COMPOSITION



7-6 Geometric Design and Outline of Feeder Roads

7-6-1 Geometric Design

Feeder roads from trunk roads are being planned to connect the following main hamlets:

1) Long Laput
2) Long Bedian
3) Long Panai
4) Long Terawan
5) NP Base Camp

The routes are so selected to bypass swamp areas, and flood areas and to avoid as much as possible crossing of rivers and large scale road cuts and embankments.

Regarding terrain, feeder roads going to Long Laput, Long Bedian, Long Terawan and the NP Base Camp pass over mountainous area, the Long Panai over rolling areas.

The present task consists mainly of route selection. This has been done with the use of a 1:50,000 scale topographical map. With the minimum curve radius of 500 m being used. In the detailed design stage, however, the use of a minimum radius based on design standards is essential.

7-6-2 Outline of Routes

1) Long Laput Road

This road branches out at STA 25 + 800 which is located before the river site at Batang Baram. The route passes along Batang Baram and ends at Long Laput,its entire length is 5.7 km. The road passes over mountainous terrain with undulations measuring 10m - 60m.

2) Long Bedian Road

Branching off from the trunk road at STA 53 + 100, the road crosses Sungai Apoh and reaches Long Bedian by way of Long Buang. The entire length is 23.4 km and the terrain is classified as a mountainous area. The 1:50,000 topographical map and the 1:10,000 topographical map prepared according to aerial photographs differ with regard to the location of Long Buang. In this design, the location of the latter has been incorporated.

An existing forest road is used for one portion of the road, for a distance of approximately 9 km starting at the junction. Long Atip is on the right bank of Sungai Apoh, but this route avoids crossing the river and passes through the left bank.

3) Long Panai Road

Branching off from the trunk road at STA 55 + 100, the road avoids the swamp area and runs along Sungai Bah to reach Long Panai, located at the left bank of Sungai Tutoh. The entire length is 11.4 km. The terrain is classified as a rolling area.

4) Long Terawan Road

Avoiding the swamp area lying alongside Sungai Terawan, the road branches off from the trunk road at STA 67 + 00, leading to Long Tetawan, using the existing forest road running along the mountain ridge which will be improved. The entire length is 4.7 km, and the terrain is classified as mountainous.

5) NP Base Camp Road

Branching off the trunk road at STA 82 + 900, the road reaches the NP Base Camp lying alongside Sungai Melinau by way of the shortest route. Its length measures 4.6 km. The terrain is classified as mountainous and passes land with many topographic undulations.

Chapter 8

CONSTRUCTION COST ESTIMATES

Chapter 8 CONSTRUCTION COST ESTIMATES

8-1 Standard for Estimatesof Construction Cost

In order to collect data for estimating the construction cost of the project, the study team carried out a reconnaissance in Malaysia in July 1978 and March 1979.

The data collected was used for estimating the construction cost under the following conditions and also for economic evaluation described later in chapter 10 of this report.

8-1-1 Conditions

a) Currency is to be shown in Malaysian Dollar (M$)

b) US$ 1.0 is to be equivalent to M$ 2.25.

c) Equipment, material and labour costs are the present value of March of 1979.

d) Construction cost is to be divided into foreign and domestic currency components.

e) Treatment of tariff and tax component is to be at disretion of Malaysia.

f) Inflation factor is to be ignored in the economic evaluation.

8-1-2 Foreign Currency Components

a) Costs of imported machinery (CIF price), and materials such as steel product, asphalt, etc.

b) A portion of the final engineering and supervision cost.

c) A portion of the overhead, profit and contingency.

8-1-3 Domestic Currency Componente

a) Domestic products such as cement, round steel bar, etc.

b) A portion of final engineering and supervision cost.

c) Labor cost and transportation cost.

d) Cost of land acquisition and compensation.

8-2 Unit Price

8-2-1 Unit Labor Price

Table 8-1 shows the unit labor price by work type obtained from the Phase II investigation conducted in March 1979.

Table 8-1 Labor Cost

Unit: M$

Labor	Wage per Day (A)	Tax (A) x 0.05	(A) - (B)
Foreman	23.19	1.16	22.03
Driver	14.76	0.74	14.02
Operator	15.91	0.80	15.11
Carpenter	18.21	0.91	17.30
Assistant Operator	10.93	0.55	10.38
Earth Worker	10.93	0.55	10.38
Skilled Labor	23.19	1.16	22.03
Iron Reinforce Worker	21.73	1.09	20.64
Scaffolding Man	18.07	0.9	17.17
Mechanic	16.49	0.82	15.67

Source: MRCU-10

The unit price indicated here has been obtained from the State of Sarawak Road Construction Office (MRCU-10). The income tax rate is approximately 5%.

8-2-2 Unit Price of Materials

Data for the price of the construction materials, has been compiled based on the results of Phase I investigation made in July 1978, in the town of Miri supplemented and updated with information obtained in the Phase II investigation in March 1979. This is indicated in Table 8-2.

Cement and steel bars, which are the major materials, are produced domestically by Associated Pan-Malaysia Cement and Malayawata Steel respectively.

Table 8-2 Cost of Materials

As of Mar. 1979 in Miri

Materials	Discription	Unit	Market Price (M$)	Remarks
Portland Cement	B.S. 12	Ton	193.6	Ordinary Portland Cement
Bitumen	Straight Run 80/100	Ton	412.6	
Bitumen Cutback MCO	Shelmac AMC-0	Ton	540.4	
1/2" to 1" Steel Round Bar	B.S. 785	Ton	869.4	
R.C. Pipe ϕ 900	Butt ended Type Class X	m	108.6	Hume Industries Salawak Sdn. Brd.
R.C. Pipe ϕ1500	Butt ended Type Class X	m	267.8	Hume Industries Salawak Sdn. Brd.
Concrete for Gravel		m^3	32.7	
Crushed Stone	Size 3/4"	m^3	32	
Kerosene	Blue Crown	ℓ	1.905	
Diesel (Diesoline)	Shell	ℓ	0.303	
Gasoline	Shell Regular	ℓ	0.607	
Board (timber)	4'x8'x0.5"	piece	29.0	
Rectangular Timber	1"x6"x12' 1"x8"x12' 1"x2"x12'	Ton	450	
Wood Log	ϕ6"x30'	Ton	8 ∿ 10	
Explosive	Gelemite	Kg	18.1	

In regard to the taxes which make up part of the price for the materials: for the imported materials, import tax, sur tax and sales tax are imposed. Import duties are based on the Malaysian tariffs. The sur tax and sales tax are 5% respectively.

8-2-3 Equipment Cost

The following three alternatives (as an introductory method for construction equipment) have been studied to make equipment cost economical and realistic.

1) Using the construction equipment owned by the government of the state of Sarawak.

2) Leasing equipment from a lease company in Singapore.

3) Importing equipment for this project.

With regard to the first alternative, as shown in Table 8-3, equipment owned by the Sarawak State government is limited in quantity and is normally in full operation in the directly controlled state government construction.

Table 8-3 Heavy Earth Moving Equipment in Fourth Division

(As of Mar. 1979)

Type	Miri	MRCU 8	MRCU 10	MRCU 12/Bintulu	Marudi	Total
Caterpillar D6B	4	3	3	3	2	15
D6C	1	0	1	2	0	4
D8H	0	3	9	6	1	19
Komatsu D30	2	0	0	1	0	3
D65	3	0	3	3	3	12
D85	0	3	0	6	0	9
D155	1	0	3	14	0	18
Scraper Michigan/ Caterpillar/ Wabco	0	0	2	10	0	12
Grader (Various sizes)	13	2	7	12	1	35
Shovel-Tyre type	6	4	6	7	1	24
Track type	7	1	6	10	1	25

Source: 4th Division of J.K.R. Mechanical Dept.

With regard to the second alternative, the lease company in Singapore is small and is incapable of supplying much large construction equipment in a wide range or providing various types of equipment. They also do not have any past records or experience of leasing construction equipment to the state of Sarawak. For these reasons, the third alternative has been employed to compute the cost of the construction equipment.

The procured price of the equipment cost is calculated based on C.I.F. Miri. Table 8-4 shows the breakdowns in C.I.F (Miri)

Table 8-4 Acquisition Cost of Equipment

	Equipment	C.I.F. Price	Local Component	Import Duty and Taxes	Total	Daily Rate As % of Cost
1.	Bulldozer 34 Ton	345,840	66,119	35,449	447,408	E = 0.22312
2.	Bulldozer 34 Ton with Ripper	400,989	66,320	41,101	508,410	E = 0.22312
3.	Bulldozer 32 Ton	471,900	23,149	48,370	543,419	E = 0.22312
4.	Bulldozer 32 Ton with Ripper	526,900	41,069	54,000	621,969	E = 0.22312
5.	Bulldozer 32 Ton	325,450	16,640	33,360	375,450	E = 0.22312
6.	Bulldozer 23 Ton with Ripper	365,033	18,400	37,417	420,850	E = 0.22312
7.	Motor Grader 150 HP	228,740	38,797	23,450	290,987	E = 0.20124
8.	Excavator (Back-hoe) 0.6 m^3	304,700	61,317	31,230	397,247	E = 0.22749
9.	Truck Loader 1.6 m^3	185,440	19,098	19,012	223,550	E = 0.20999
10.	Truck Loader 2.1 m^3	262,530	55,390	26,910	344,830	E = 0.20999
11.	Rubber-Tired Roller 8 - 20 ton	79,200	14,850	8,120	102,170	E = 0.18666
12.	Macadam Roller 10 - 12 ton	67,650	13,000	6,930	87,580	E = 0.12054
13.	Dump Truck 8 ton	57,992	11,496	24,220	93,708	E = 0.20999
14.	Dump Truck 11 ton	82,500	15,425	34,450	132,375	E = 0.20998
15.	Flat-Bed-Truck 4 ton	36,700	6,310	6,960	49,970	E = 0.20996
16.	Water Tanker 6000 L	37,000	19,570	7,100	63,670	E = 0.20996
17.	Asphalt Plant 75 ton/hr	1,300,000	212,000	133,250	1,645,250	E = 0.23332
18.	Asphalt Finisher 4.5 m	115,000	20,600	11,800	147,400	E = 0.16100
19.	Asphalt Sprayer 30 L/min	4,337	1,263	499	6,099	E = 0.28339
20.	Generator 50KW	64,740	12,560	6,640	83,940	E = 0.15165
	Tractor-drawn TYPE					
21.	Scraper Truck 10.7 m^3	180,950	31,150	18,550	230,650	E = 0.20561
22.	Scraper 10.7 m^3 (wheel Tractor-Scraper)	522,500	85,810	53,560	661,870	E = 0.20562
23.	Generator 150KW	94,160	17,240	9,660	121,060	E = 0.15165
24.	Generator 205 KW	117,700	21,040	12,070	150,810	E = 0.08557
25.	Generator 250 KVA	112,129	20,463	11,493	144,085	E = 0.17060
26.	Air Compressor 10 m^3/min	36,500	9,230	3,740	49,470	E = 0.19685
27.	Concrete Mixer 0.5 m^3	-	32,900	1,600	34,500	E = 0.3150
28.	Concrete Vibrator	2,004	301	205	2,510	E = 0.3238
29.	Crushing Plant 100 ton/hr	1,600,000	268,590	164,000	2,032,590	E = 0.10966
30.	Crushing Plant 150 ton/hr	920,800	163,710	94,440	1,178,950	E = 0.10966
31.	Truck Crane 10 ton	140,896	25,147	14,442	193,213	E = 0.1551
32.	Wheel Loader 2.3 m^3	182,530	33,785	18,710	235,025	E = 0.20999
33.	Power Shovel 1.2 m^3	191,808	33,440	19,660	244,908	E = 0.22743
34.	Under Water Pump 1.0 m^3/min	2,725	719	279	3,723	E = 0.33137
35.	Bar Bender max 25 mm	2,820	734	289	3,843	E = 0.32393
36.	Bar Cutter max 29 mm	2,171	628	223	3,022	E = 0.32404
37.	Hand Drill 3.1 m^3/min.	1,211	124	182	1,517	E = 0.12469
38.	Crawler Drill (Rod size 38 mm)	81,380	15,230	8,340	104,950	E = 0.19685
39.	Truck Crane 20 T	250,000	42,200	25,630	317,830	E = 0.14168
40.	Crawler Crane 23 T	242,000	40,920	24,810	307,730	E = 0.21437
41.	Vibrating Roller 10 T	150,000	26,200	15,380	191,580	E = 0.20999
42.	Soil Compactor 6.0 T	48,900	10,030	5,020	63,950	E = 0.20997
43.	Piledriver & Diesel Hammer 2.5 T	60,000	11,800	6,150	77,950	E = 0.17850

Price, the local component, and taxes. With the equipment cost, as shown in Table 8-5, calculations have been made by making a division between the cost for retaining equipment and the cost for operation. The necessary assumptions for the calculations are shown in Table 8-6.

Information from the following sources has been used in determining the various assumptions:

Life Span: M.S.A. Contribution Jan. 1, 1976

Rate of Maintenance Cost: Japan Chart of Equipment Rental Cost (1978 edition)

The rate of maintenance cost is based on a percentage of the procured price.

Table 8-5 Hourly Equipment Ownership and Operation Cost (ECONOMIC)

Equipment: Bulldozer 23 Ton

Item		Calculation	Number	Unit
I.	General Data			
	A. Type of Fuel	Diesoline		
	B. Fuel consumption		6.2	GAL/Hr
	C. Fuel Cost		1.51	M$
	D. Economic Life		8,000	Hours
	E. Economic Life		8	Years
II.	Acquisition Costs			
	F. Total Cost CIF		325,450	M$
	G. Cost of Tires		-	
	H. Total Cost Less Tires	F - G	325,450	M$
III.	Hourly Ownership Costs			
	I. Depreciation	H/D	40.681	M$
	J. Major Repairs and Overhaul	$\frac{1.1 \times 325,450}{D}$	44.749	M$
	K. Interest	$\frac{0.1 \times 325,450 \times 0.5625}{D/E}$	18.306	M$
	L. Hourly Ownership Cost (Economic)	I + J + K	103,736	M$
			E = 0.22312 %	
IV.	Hourly Operation Costs			
	M. Cost of Fuels	6.2 x 1.51	9.362	M$
	N. Cost of Lubricants and Filters	M x 0.2	1.872	M$
	O. Cost of Tires, & Point, etc.			
	a. - Depreciation	40.681 x 7 x 0.15	42.715	
	b. - Repairs	-		
	P. Operation Cost	M + N + O	53,949	M$
V.	TOTAL ECONOMIC COST	L + P	157,685	M$

Table 8-6 Economic Life and Repair Coefficient of Mechanical Equipment

Mechanical Equipment	Economic		Repair Coefficient
	Years	Hours	
Bulldozer	8	8,000	1.1
Dump Truck	5	7,000	0.8
Tractor Loader	8	8,000	0.95
Motor Scraper	8	8,000	0.9
Power Shovel	8	8,000	1.15
Excavator (Back hoe)	8	8,000	1.15
Drag Line	8	8,000	1.0
Clam Shell	8	8,000	1.0
Flat-Bed-Truck	5	7,000	0.7
Truck Crane	8	8,800	0.5
Crawler Crane	8	8,800	0.85
Tired Roller	10	9,000	0.85
Macadam Roller	10	9,000	0.85
Asphalt Finisher	8	10,000	0.85
Motor Grader	8	8,000	0.85
Asphalt Plant	10	7,200	0.85
Concrete Mixer	10	5,000	0.7
Asphalt Sprayer	8	4,800	0.5
Asphalt Distributor	8	7,200	0.6
Concrete Vibrator	10	4,000	0.3
Crushing Plant	10	15,000	0.8
Bar Cutter	10	4,000	0.3
Bar Bender	10	4,000	0.3
Generator	10	9,000	0.4
Water Tanker	5	7,000	0.8
Pump	10	6,000	1.3
Batcher Plant	10	8,000	0.8
Arc Welder	10	6,000	0.8
Air Compressor	10	8,000	0.7
Concrete Pump Car	6	6,000	1.1
Diesel Pile Hammer	10	9,000	1.0
Vibro Pile Driver	10	9,000	1.0
Wheel Loader	8	8,000	0.95
Crawler Drill	10	8,000	0.70

† M.S.A. Contribution (Effective on 1st January, 1976)

† The table used for estimating hire of construction equipment 1978 Mar. 3rd, published by Japan Construction Equipment Association.

8-3 The Selection of Equipments by Type and the Quantity of Work per Day

Full Consideration has been given to the following points in studying the selection of the equipment.

Regarding earthwork:

i) Most of this project will involve large scale cut and fill earthwork.

ii) The rainfall is heavy, being in the tropical rain forest zone. (3,500 mm ∿ 4,000 mm per year)

iii) A selection of the type of equipment that can withstand the rainfall and quality of the soil.

Regarding concrete work:

i) Local equipment and materials should be used as much as possible to keep the cost low.

ii) Safety under construction should be fully ensured.

The quantity of work per day is calculated under average working conditions with the combinations outlined in Table 8-7.

Table 8-7 The Equipment of a Work Gang for Major Types of Work

Type of Work	Main Equipment	
1. Clearing & Grabbing		
i. Forest Area	1. Bulldozer 23 ton, 1. Dump Truck 8 ton,	1. Truck Loader 1.6 m^3,
ii. Cultivated Area	1. Bulldozer 23 ton,	
iii. Rubber Plantation Area	1. Bulldozer 23 ton, 1. Dump Truck 8 ton,	1. Truck Loader 1.6 m^3,
2. Excavation & Embankment		
i. Soil (L = 80m)	1. Bulldozer 32 ton,	1. Rubber-Tired Roller 8~20 ton,
ii. Soil (L = 250m)	1. Bulldozer 32 ton,	1. Bulldozer 23 ton,
iii. Soft Rock (L = 250m)	1. Tructor-Drawn Type Scraper 11.0m^3, 1. Rubber-Tired Roller 8~20 ton,	
iv Borrow for Fill (L = 1.0 km)	1. Excavator 0.6 m^3, 1. Truck Loader 1.6 m^3, 1. Bulldozer 23 ton, 1. Water Tanker	1. Bulldozer 32 ton, 3. Dump Truck 8 ton, 1. Rubber-Tired Roller 8~20 ton, 1. Motor Grader,
v. Excavation Disposal	1. Back Hoe 0.6 m^3	3. Dump Truck 8 ton,
3. Sub-grade Preparation	1. Motor Grader, 1. Macadam Roller 10 ~ 12 ton,	1. Rubber-Tired Roller 8~20 ton, 1. Water Tanker,
4. Sub-base course	1. Motor grader, 1. Macadam Roller 10 ~ 12 ton,	1. Rubber-Tired Roller 8~20 ton, 1. Water Tanker,
5. Base course	1. Motor grader, 1. Macadam Roller 10 ~ 12 ton,	1. Rubber-Tired Roller 8~20 ton, 1. Water Tanker,
6. Surface Course		
i. Bituminus Surface Course	1. Macadam Roller 10 ~ 12 ton, 1. Asphalt Finisher,	1. Rubber-Tired Roller 8~20 ton, 1. Truck 4 ton,
7. Bituminous Prime and Surface Dressing	1. Spreader, 1. Distributor,	1. Macadam Roller 10~12 ton, 1. Truck 4 ton,
8. Concrete	1. Concrete Mixer 0.5 m^3, 1. Crawler Crane,	1. Back Hoe 0.6 m^3, 3. Vibrator,

8-4 Unit Cost by Work Type

Table 8-8 shows the unit price by work type and unit cost of structures according to the quantity of work and the combinations of equipment previously mentioned.

Table 8-8 Unit Costs by Type of Work

ITEM NO.	DESCRIPTION	UNIT	UNIT COST FOREIGN IN MD	LOCAL IN MD	TAX IN MD
0101	*Maintenance & Protection of Traffic*	L.S			
0102	Mobilization	L.S			
0201	Clearing & Grubbing (Forest Area)	SQ.M	1.52	0.47	0.21
0202	Clearing & Grubbing (Cultivated)	SQ.M	0.50	0.12	0.05
0203	Clearing & Grubbing (Rubber Plant)	SQ.M	1.83	0.57	0.25
0204	*Common Excavation & Embankment (Soil)*	*CU.M*	*4.85*	*1.19*	*0.53*
0205	Common Excavation & Embankment (Rock)	CU.M	11.24	2.81	1.23
0206	Borrow Excavation & Embankment	CU.M	11.36	3.30	1.56
0207	Excavation Disposal	CU.M	3.71	1.22	0.77
0301	R.C.Pipe Culvert D = 900	L.M	125.55	382.14	32.16
0302	*R.C.Pipe Culvert D = 1500*	*L.M*	*237.00*	*922.67*	*71.08*
0303	R.C.Box Culvert 2.0 x 2.0	L.M	751.71	1,222.80	143.61
0304	R.C.Box Culvert 3.0 x 2.0	L.M	1,034.21	1,692.36	198.57
0305	R.C.Box Culvert 3.0 x 3.0	L.M	801.86	2,110.27	182.55
0306	Multi Box Culvert 2 – 3.0 x 2.0	L.M	1,603.72	4,220.55	365.11
0401	*Subgrade Preparation*	*SQ.M*	*0.33*	*0.17*	*0.04*
0402	Subbase Course	CU.M	22.53	14.62	4.10
0403	Base Course	CU.M	23.75	15.24	4.24
0404	Bituminous Prime Coat	SQ.M	0.76	0.20	0.23
0405	Bituminous Surface Course (Hotmix)	CU.M	99.17	66.11	36.40
0406	Bituminous Surface Dressing (Double)	SQ.M	2.01	1.00	0.55
0501	Short Span Bridge	SQ.M	314.89	844.55	83.17
0502	Moderate Span Bridge (20–40)	SQ.M	446.02	782.96	94.03
0503	Moderate Span Bridge (40–60)	SQ.M	1,254.45	377.72	93.70
0504	Long Span Bridge	SQ.M	2,445.65	394.41	160.36
0505	Ferry Boat & Ferry Facility	L.S			
0601	Stone Masonry	CU.M	16.26	88.57	5.33
0602	Grouted Riprap	SQ.M	7.80	41.53	2.52
0603	Guard Rail	L.M	1.24	49.87	2.79
0604	Traffic Sign	Each	4.01	88.29	2.00
0605	Kilometer Post	Each	6.83	39.21	2.95
0700	Land Compensation	L.S			

8-5 Computation of Land and Compensation Costs

The following are the items of compensation in the vicinity of the project route.

1) fruit trees, rubber trees
2) rice crops
3) private land

The unit price for fruit trees is divided into "bearing fruits" and "not yet bearing fruits", and for rubber trees, "tappable rubber" and "untappable rubber".

Reference has been made to the compensation price list used in the state of Sarawak (shown in Appendix Table A-8-1) in estimating the total compensation for the fruit trees.

For compensating for the rice crops, according to the information from the Land and Survey Dept. of the state of Sarawak, the figure is 200 ∿ 300 M$/acre. Since the project route crosses public land, the acquisition fee for the land is not taken into consideration.

* The compensation costs to be adopted for this report are

Rice crops, fields	250 M$/acre	- 0.062M$/$m^2$
Orchards, rubber forests		0.838 "
Land near private houses		1.480 "

* An average value of the same items scheduled in the budgets for the construction of Beluru/Teru and Limbang/Brunei road projects.

8-6 Computation of the Estimated Cost of Construction

The estimated construction cost has been computerized for all alternatives based on the quantities of work estimated from the preliminary design and the unit costs by work type estimated in accordance with a quantity estimation standard.

The construction cost has been calculated by road sections for both trunk and feeder roads, including breakdowns in local and foreign currencies.

The results of the calculations for each alternative are shown in Table 8-9 and 8-10. Some computer output data for the representative example of the alternatives are given in Appendix Tables A-8-2 and A-8-3.

Table 8-9 Summary of Construction Cost for Feeder Road

(1000 M$)

Items		Long Laput	Long Bedian	Long Panai	Long Terawan	NP Base Camp	Total
Const-ruction	General	200	767	242	247	197	1,653
	Earth Work	1,017	3,402	688	1,758	1,171	8,036
	Drainage	400	1,643	800	330	323	3,496
	Pavement	459	1,886	919	379	371	4,014
	Bridge	107	739	0	0	107	953
	Miscellaneous	0	0	0	0	0	0
	Sub-Total	2,183	8,437	2,649	2,714	2,169	18,152
Land Compensation		0	0	0	0	0	0
Others		546	2,109	662	679	542	4,538
Total Project Amount		2,729	10,546	3,311	3,393	2,711	22,690

Table 8-10 Summary of Construction Cost of Trunk Road

(1000 M$)

Const. Section	Items		Gravel			Surface Dressing			Bituminous		
			FC	LC	Total	FC	LC	Total	FC	LC	Total
I	Const-ruction	General	600	473	1,073	711	552	1,263	829	695	1,524
		Earth Work	1,586	614	2,200	1,586	614	2,200	1,586	614	2,200
		Drainage	98	346	444	98	346	444	98	346	444
		Pavement	4,255	3,495	7,750	5,364	4,288	9,652	6,544	5,719	12,263
		Bridge	59	172	231	59	172	231	59	172	231
		Miscellaneous	2	100	102	2	100	102	2	100	102
		Sub-Total	6,600	5,200	11,800	7,820	6,072	13,892	9,118	7,646	16,764
	Land Compensation		0	21	21	0	21	21	0	21	21
	Others		1,652	1,301	2,953	1,956	1,520	3,476	2,280	1,912	4,192
	Total Project Amount		8,252	6,522	14,774	9,776	7,613	17,389	11,398	9,579	20,977
II	Const-ruction	General	1,113	790	1,903	1,166	828	1,994	1,223	897	2,120
		Earth Work	4,307	1,679	5,986	4,307	1,679	5,986	4,307	1,679	5,986
		Drainage	279	866	1,145	279	866	1,145	279	866	1,145
		Pavement	2,108	1,732	3,840	2,639	2,111	4,750	3,205	2,797	6,002
		Bridge	4,240	2,463	6,703	4,240	2,463	6,703	4,240	2,463	6,703
		Miscellaneous	194	1,162	1,356	194	1,162	1,356	194	1,162	1,356
		Sub-Total	12,241	8,692	20,933	12,825	9,109	21,934	13,448	9,864	23,312
	Land Compensation		0	4	4	0	4	4	0	4	4
	Others		3,060	2,174	5,234	3,207	2,277	5,484	3,362	2,466	5,828
	Total Project Amount		15,301	10,870	26,171	16,032	11,390	27,422	16,810	12,334	29,144
III	Const-ruction	General	1,821	1,784	3,605	1,936	1,867	3,803	2,058	2,014	4,072
		Earth Work	8,345	3,248	11,593	8,345	3,248	11,593	8,345	3,248	11,593
		Drainage	646	2,010	2,656	646	2,010	2,656	646	2,010	2,656
		Pavement	5,323	4,377	9,700	6,471	5,197	11,668	7,696	6,682	14,378
		Bridge	3,269	4,520	7,789	3,269	4,520	7,789	3,269	4,520	7,789
		Miscellaneous	624	3,682	4,306	624	3,682	4,306	624	3,682	4,306
		Sub-Total	20,028	19,621	39,649	21,291	20,524	41,815	22,638	22,156	44,794
	Land Compensation		0	42	42	0	42	42	0	42	42
	Others		5,010	4,907	9,917	5,326	5,134	10,460	5,660	5,539	11,199
	Total Project Amount		25,038	24,570	49,608	26,617	25,700	52,317	28,298	27,737	56,035
IV	Const-ruction	General	1,886	1,438	3,324	2,004	1,522	3,526	2,129	1,675	3,804
		Earth Work	10,546	4,122	14,668	10,546	4,122	14,668	10,546	4,122	14,668
		Drainage	681	2,122	2,803	681	2,122	2,803	681	2,122	2,803
		Pavement	4,691	3,851	8,542	5,875	4,698	10,573	7,131	6,222	13,353
		Bridge	2,865	3,740	6,605	2,865	3,740	6,605	2,865	3,740	6,605
		Miscellaneous	70	541	611	70	541	611	70	541	611
		Sub-Total	20,739	15,814	36,553	22,041	16,745	38,786	23,422	18,422	41,844
	Land Compensation		0	2	2	0	2	2	0	2	2
	Others		5,185	3,955	9,140	5,510	4,187	9,697	5,856	4,606	10,462
	Total Project Amount		25,924	19,771	45,695	27,551	20,934	48,485	29,278	23,030	52,308
V	Const-ruction	General	677	685	1,362	740	731	1,471	808	813	1,621
		Earth Work	2,039	835	2,874	2,039	835	2,874	2,039	835	2,874
		Drainage	93	347	440	93	347	440	93	347	440
		Pavement	3,676	3,069	6,745	4,312	3,524	7,836	4,991	4,346	9,337
		Bridge	957	2,494	3,451	957	2,494	3,451	957	2,494	3,451
		Miscellaneous	3	109	112	3	109	112	3	109	112
		Sub-Total	7,445	7,539	14,984	8,144	8,040	16,184	8,891	8,944	17,835
	Land Compensation		0	7	7	0	7	7	0	7	7
	Others		1,862	1,885	3,747	2,036	2,011	4,047	2,223	2,236	4,459
	Total Project Amount		9,307	9,431	18,738	10,180	10,058	20,238	11,114	11,187	22,301
Total	Const-ruction	General	6,097	5,170	11,267	6,557	5,500	12,057	7,047	6,094	13,141
		Earth Work	26,823	10,498	37,321	26,823	10,498	37,321	26,823	10,498	37,321
		Drainage	1,797	5,691	7,488	1,797	5,691	7,488	1,797	5,691	7,488
		Pavement	20,053	16,524	36,577	24,661	19,818	44,479	29,567	25,766	55,333
		Bridge	11,390	13,389	24,779	11,390	13,389	24,779	11,390	13,389	24,779
		Miscellaneous	893	5,594	6,487	893	5,594	6,487	893	5,594	6,487
		Sub-Total	67,053	56,866	123,919	72,121	60,490	132,611	77,517	67,032	144,549
	Land Compensation		0	76	76	0	76	76	0	76	76
	Others		16,769	14,222	30,991	18,035	15,129	33,164	19,381	16,759	36,140
	Total Project Amount		83,822	71,164	154,986	90,156	75,695	165,851	96,898	83,867	180,765

Note: FC : Foreign Cost
LC : Local Cost

8-7 Computation of the Road Maintenance Cost

The maintenance cost is computed from the following items.

1) Roadway Maintenance Cost

Maintenance for roadways is computed for individual trunk roads and feeder roads.

2) Bridge Maintenance Cost

The bridge maintenance cost for expansion joints, shoes and handrails is computed.

3) Overhead Cost

This has been assumed to be 10% of the sum of the above maintenance costs 1) and 2)

The unit prices (MD/KM) used in computing the maintenance cost are established in Table 8-11 and Table 8-12 by taking into account the past records of the state of Sarawak.

The calculation of the roadway maintenance cost is based on the following considerations.

i) For gravel roads

° Maintenance requirements:

Quantity of pavement crushed stone supply: 50 m^3/km/year

Average frequency of motor grader operation: 6 times/year,

° Method of operation:

Using a 6-ton dump truck for conveyance and delivery of aggregate to the site, and a motor grader to spread and level the material delivered.

ii) For Bituminous Surface dressing roads

° Maintenance requirements:

Bituminous surface dressing roads will be overlayed when the cumulative equivalent number of standard (8.2t) axles reaches 500,000 times. Until then the yearly amount of patching and other surface maintenance required is estimated to be 5% of the total pavement area.

° Method of operation:

Such maintenance activities are not operated on a large scale but on a piecemeal basis on demand. It is undertaken by a workers gang transported by a vehicle from one site to another to execute the maintenance work required.

iii) For Asphalt pavements

° Maintenance requirement:

The annual rate of maintenance required before and after the accumulated equivalent number of standard axles exceeds 500,000 times are grossly taken as follows:

before exceeding 500,000:	2.5% of the total pavement area	
after " " :	5.0%	"

° Method of operation

For small scale maintenance of asphalt pavements, hot mix asphalt produced at the spot is used, and for large scale maintenance hot mix is delivered to the spot from an asphalt plant by truck.

The maintenance cost estimated taking the above into consideration is as in the follow tables.

Table 8-11 Road Maintenance Cost (M$/km)

Road	Gravel Road	Bituminous Surface Dressing	Bituminous Pavement
Trunk road	2,400	2,300	(1,600) 3,200
Feeder road	1,200	-	-

Note: Figures in brackets: ( ) represent the value before the cumulative equivalent number of standard axles exceeds 500,000.

Table 8-12 Bridge Maintenance Cost

Type / Road	RC.PC. (M$/km)	S.G. (M$)	Langer (M$)
Trunk road	3,600	10,820	30,750
Feeder road	1,800	-	-

Here RC : Reinforced concrete beam
PC : Pre-Stressed concrete beam
SG : 3-span continuous girder
Langer: Langer girder

Chapter 9

CONSTRUCTION SCHEDULE

Chapter 9 CONSTRUCTION SCHEDULE

9-1 Schedule of Construction

9-1-1. Organization of Construction

Generally, for a construction project, there are two forms of operation: Direct execution and contract execution. The form of operation should be decided after evaluation of the client's technical personnel, availability of material and equipment, as well as the ability of the contractor. At present, road construction implemented under the State of Sarawak is, as mentioned earlier in chapter 5, handled by direct execution. Only a portion of this including bridge construction is under contract execution by a local contractor.

In view of the quantity and types of work involved, the implementation of this project should preferably be contracted by international tender.

9-1-2 Plan of Construction

From the information given by the field investigation, it would be best as mentioned in Chapter 6, to divide the whole plan of construction into 5 sections. Sections of construction are as shown in Table 9-1.

Table 9-1 A List of Construction Sections

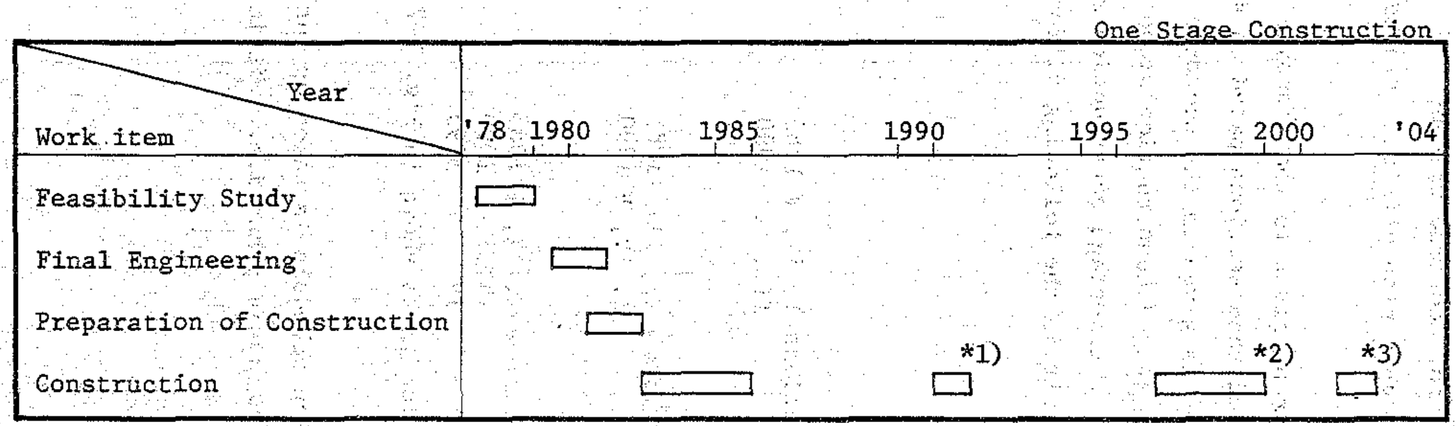
Construction Section	Section	Station	Length (km)	Description
I	1, 2	*1) STA.0~54+700	54.7	Miri-Bintulu Road ∿ Sg. Tingar
II	3	*2) STA.0~26+200	26.2	Sg. Tinger ∿ Batang Baram
III	4, 5	26+200~82+900	56.7	Batang Baram ∿ Junction of NP Base Camp
IV	6, 7	82+900~141+200	58.3	Junction of NP Base Camp ∿ Ng. Medamit
V	8	*3) STA.0~41+400	41.4	Ng. Medamit ∿ Limbang

Note *1), *3): Road Improvement Project
*2): New Road Construction Project

1985 is the planned year for opening of the roads. To meet this target, the following items must proceed on schedule: detailed topographical investigation, geological investigation, detailed design, land acquisition, and the securing of finance. Three years will be necessary between the submission of the final reports in January, 1980 and the commencement of construction (final engineering and preparation of construction).

Since surveying, investigation and detailed design will take a year and a half, the work should proceed according to the schedule shown in Fig. 9-1.

Fig. 9-1 OVERALL SCHEDULE OF PROJECT



*1), 2), 3) Improvement Work

Note: *1) 1991 : Section No. 8 (10.0 km) Bituminous Surfaces Overlay

*2) 1997 : Section No. 1 (18.4 km) Improvement to Bituminous Surface

1998 : Section No. 8 (31.4 km) Improvement to Bituminous Surface

1999 : Section No. 2, 3 (62.5 km) Improvement to Bituminous Surface

*3) 2002 : Section No. 4~7 (115.0 km) Improvement to Bituminous Surface

In case a bituminous surface is used at the initial stage, then the construction of *2) and *3) will not be necessary.

9-2 Single-stage Construction Versus Multi-stage Construction

The construction for this project calls for a combination of an enormous amount of capital and large amounts of machinery and labor. For this reason construction of the total road section all at one time is not recommended for economic reasons. Therefore, it is necessary to draw up a plan utilizing staged construction.

However, consideration should first be given to the economic function and priority of the planned road sections based on an economic analysis. This comparison is given in the economic analysis in Chapter 10. Regarding staged construction proposition which was considered in Chapter 6, a two-stage construction and three-stage construction would result in the following different opening years:

(1) Single stage construction

Opening: 1985

(2) Two-stage construction

Opening: construction sections	I, II, V	1985
	III, IV	1990

(3) Two-stage construction

Opening: construction sections	II, III	1985
	I, IV, V	1990

(4) Three-stage construction

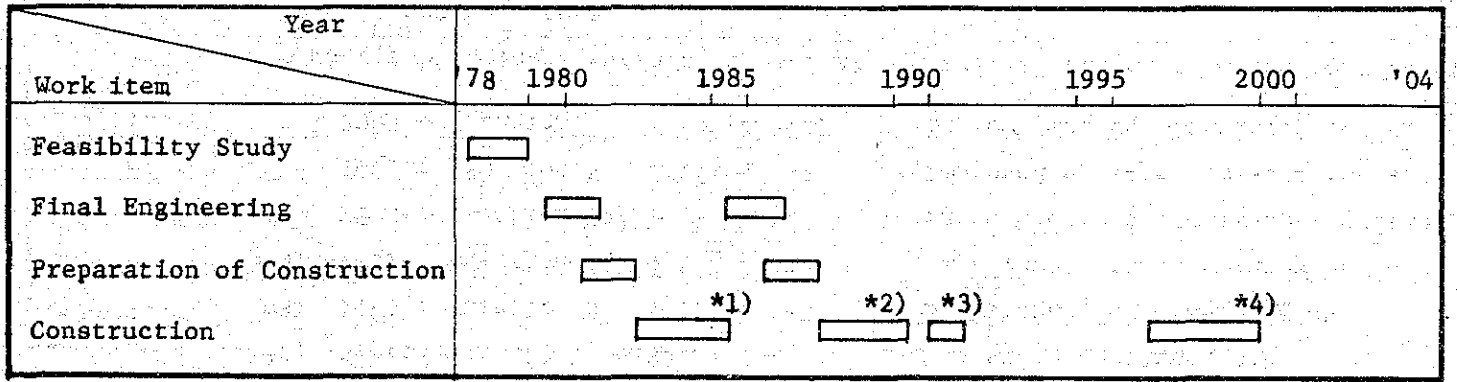
Opening: construction sections	I, II, V	1985
	III,	1990
	IV	1995

The schedule for staged construction is as shown in Fig. 9-2, 9-3 and 9-4.

Number (3) type of the construction schedule is taken up for being analyzed along the time frame of Malaysia plans i.e., within 10 years.

Fig. 9-2 OVERALL SCHEDULE OF PROJECT

Two Stages Construction



*3), 4) Improvement Work

Note: *1) Section No. 1, 2, 3, 8 — 1st stage construction

*2) Section No. 4∿7 — 2nd stage construction

*3) 1991 : Section No. 8 (10.0 km) — Bituminous Surfaces Overlay

*4) 1997 : Section No. 1 (18.4 km) — Improvement to Bituminous Surface

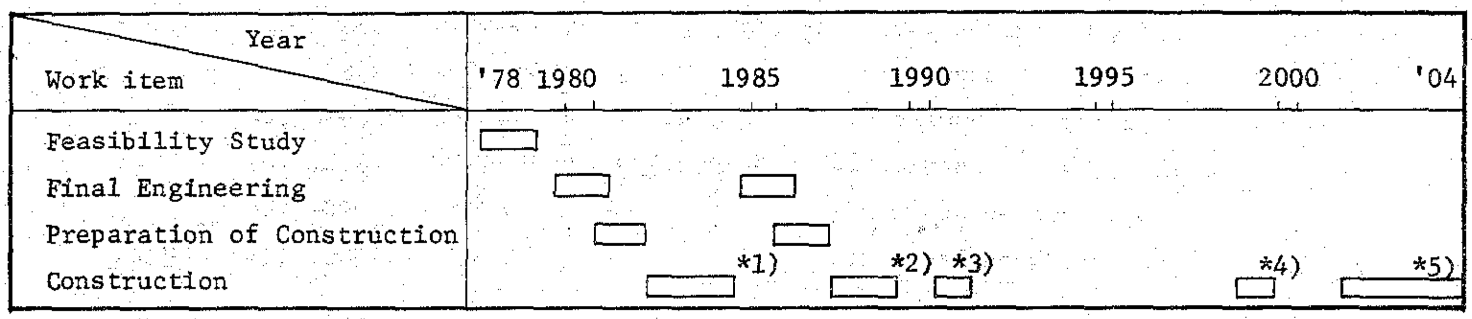
1998 : Section No. 8 (31.4 km) — Improvement to Bituminous Surface

1999 : Section No. 2, 3 (16.5 km) — Improvement to Bituminous Surface

In case a bituminous surface is used at the initial stage, then the construction of *4) will not be necessary.

Fig. 9-3 OVERALL SCHEDULE OF PROJECT

Two Stages Construction



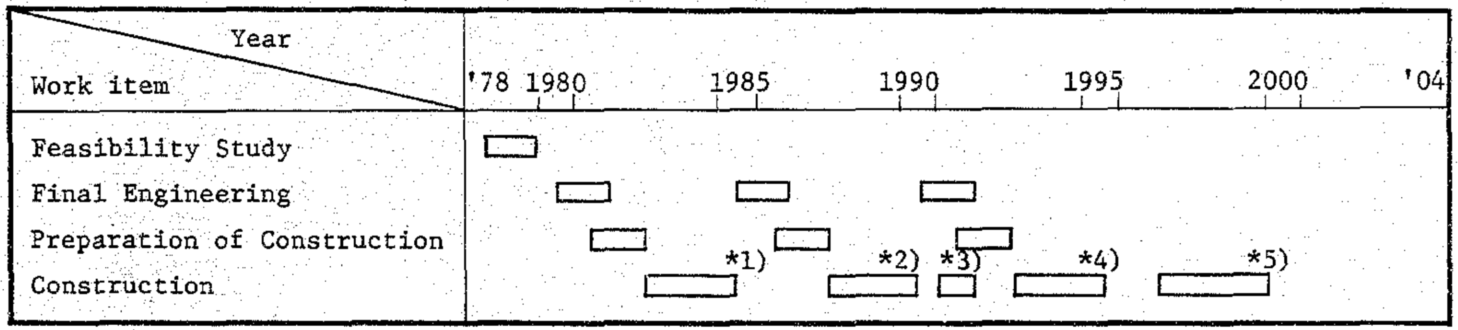
3), 4), 5) Improvement Work

Note: *1) Section No. 3, 4, 5 — 1st stage construction
*2) Section No. 1, 2, 6∿8 — 2nd stage construction
*3) 1991 : Section No. 8 (10.0 km) — Bituminous Surfaces Overlay
*4) 1999 : Section No. 3 (26.2 km) — Improvement to Bituminous Surface
*5) 2002 : Section No. 1, 4, 5 (73.9 km) — Improvement to Bituminous Surface
2003 : Section No. 8 (31.4 km) — Improvement to Bituminous Surface
2004 : Section No. 2 (36.25 km) — Improvement to Bituminous Surface

In case a bituminous surface is used at the initial stage, then the construction of *4) and *5) will not be necessary.

Fig. 9-4 OVERALL SCHEDULE OF PROJECT

Three Stages Construction



*3), 5) Improvement Work

Note: *1) Section No. 1, 2, 3, 8 1st stage construction

*2) Section No. 4, 5 2nd stage construction

*3) 1991 : Section No. 8 (10.0 km) Bituminous Surfaces Overlay

*4) Section No. 6, 7 3rd stage construction

*5) 1997 : Section No. 1 (18.4 km) Improvement to Bituminous Surface

1998 : Section No. 8 (31.4 km) Improvement to Bituminous Surface

1999 : Section No. 2, 3 (62.5 km) Improvement to Bituminous Surface

In case a bituminous surface is used at the initial stage, then the construction of *5) will not be necessary.

Chapter 10

ECONOMIC EVALUATION

Chapter 10 ECONOMIC EVALUATION

10-1 Methodology

10-1-1 Objectives of Economic Evaluation

Discussions heretofore have revealed the various social and economic impacts on the influence areas of the Project. Main objectives of economic evaluation are:

- to determine the economic feasibility of the project implementation by comparing the economic benefits against the project costs both of which are estimated in terms of economic prices, and
- to find out the best alternative road development plan with particular regard to the stage construction, pavement type and introduction of ferry or bridge, and
- to determine the priority ranking of road sub-sections when the Project Road is constructed.

10-1-2 Evaluation Criteria and Pricing

Internal rate of return, benefit cost ratio and net present value are used as evaluation criteria of the project. The discount rate which is believed applicable to this project is approximately 8 to 10 percent based on the economic assessment of similar projects previously implemented in Malaysia.

Shadow pricing for foreign exchange needs to be not considered, because there is almost no difference between official foreign exchange rate and the prevailing rate. The opportunity cost of labor also need not be considered, because of the general shortage of labor in Sarawak, including unskilled laborers; the market price of labor is believed to approximate its economic value.

Therefore, price adjustment necessary for the economic assessment are believed to be limited to customs tax, sales tax, and other internal taxes, and subsidy and other trasfer items which are included in market prices.

10-1-3 Analysis Method

1) Benefits Subject to Analysis

Benefits to result from the project implementation include transportation cost saving, travel time reduction, agricultural production increase, tourism revenue increase, commercial opportunities expansion, betterment of regional social welfare, and improvement of administrative efficiency in the region. Most important of these and that which is quantifiable is the reduction of transportation costs. This Chapter will quantify only this benefit, and will treat other benefits qualitatively.

Evaluation of time is extremely difficult. That is, it is difficult to estimate how much of the time saved will be directed to production activities in the project area and to estimate the value of such time. Estimation of benefits from goods transportation time reduction is even more difficult.

Net increase in agricultural value added and a part of tourism revenue increase due to expansion in the number of visitors, which have been listed as benefits to development traffic, are excluded in order to avoid double counting.

The quantification of other benefits is almost impossible and, therefore, will be treated qualitatively.

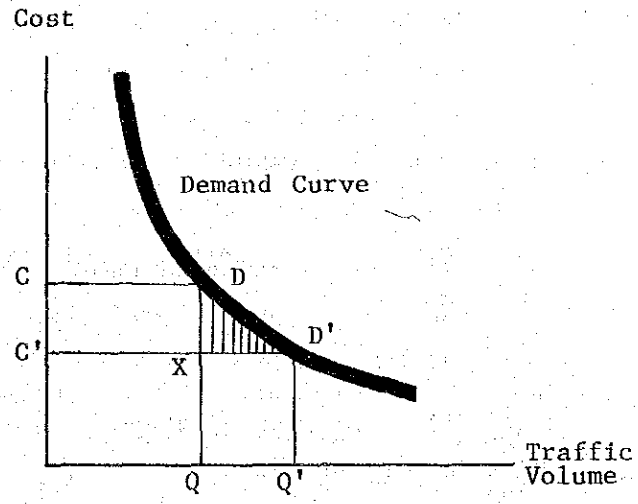
2) Method of Quantifying Benefit

Normal traffic benefit is the amount of reduction in vehicle operation cost resulting from the upgrading of a gravel road to a paved road. Running comfort and safety are also improved at the same time due to the improvement of geometric standard of the road, but the quantification of these benefits is difficult.

As for diverted traffic, difference between the cost of transportation by the mode which was available before the construction of a road and such cost after the construction (and, likewise, reduction in transportation cost) is the benefit to be studied.

As for induced traffic, it is generally accepted that benefit is one-half of normal (or diverted) traffic benefit, as explained by the curve below.

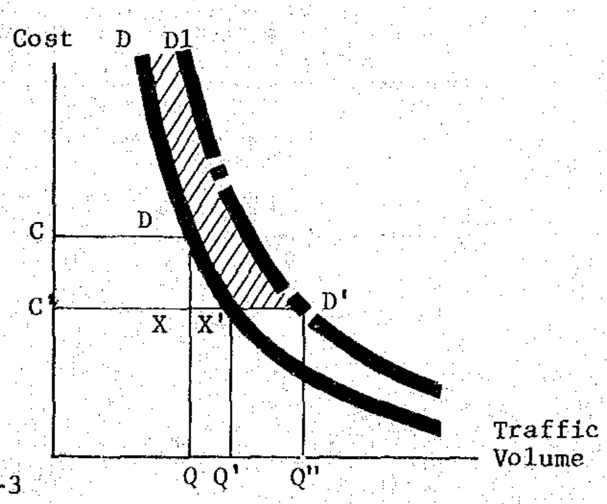
Cost reduction from C to C' results in an increase of Q to Q' where Q' - Q is defined as induced traffic volume.



The area surrounded by C, D, C', and X represents normal (or diverted) traffic benefit, which is the entire amount of transportation cost saving. On the other hand, the benefit to induced traffic is that which is surrounded by X, D, and D', is generally accepted as one-half of transportation cost saving. In the case of this Project, however, transportation cost reduction in most of river basins through which the Project Road will run will be very substantial: it will reduce costs to one-third or one-fourth of the previous level. When this fact is applied to the demand curve of Fig. 4-3, induced traffic benefit will be about one-fourth, rather than one-half.

On the other hand, development traffic is explained by the shifting of the demand curve where Q" - Q' is the development traffic volume. The benefit is represented by the space surrounded by the curve D and the curve D1.

Therefore, the benefit of development traffic is generally accepted as one-half of transportation cost saving.



10-1-4 Alternative Road Development Plans Subject to Economic Analysis

In this Study, various alternative project implementation plans have been formulated and compared from an economic viewpoint in an attempt to identify the most effective plan. The alternatives have been formulated as shown in Table 10-1, taking the following points into considerations:

(1) Road surface pavement structures: three types are assumed: namely, (a) gravel road, (b) surface dressing, and (c) bituminous surfacing, assumed when traffic has increased to a certain level.

(2) Construction stage: three cases are reviewed: namely, (a) full construction in one step, (b) construction in two stages, and (c) construction in three stages.

(3) Road section: In order to estimate the economic consequences due to each of the major road sub-sections, two cases are reviewed additionally: namely, (a) the construction of Miri/Bintulu Road - Long Lama section only and (b) the construction of Miri/Bintulu Road - Long Lama - G. Mulu Junction section only.

Table 10-1 Alternative Development Plans of Project Road for Economic Evaluation

Construction Stage	Description of Work	Initial Type of Road Surfacing	Code of Alternative
One-Stage Construction	Whole section will be opened for traffic in 1985 including the improvement of existing sections	Gravel	A.1
		Surface Dressing	A.2
		Bituminous Surfacing	A.3
Two-Stage Construction	Option A: 1st Stage (1985): New construction of Sg.Tinjar-Long Lama section plus improvement of existing sections 2nd Stage (1990): New construction of Long Lama-N.Medamit section	Gravel	B.1
		Surface Dressing	B.2
		Bituminous Surfacing	B.3
	Option B: 1st Stage (1985): New construction of Sg.Tinjar-Long Lama-G.Mulu Junction section 2nd Stage (1990): New construction of G.Mulu Junc.-N.Medamit section plus improvement of existing sections	Gravel	B.4
		Surface Dressing	B.5
		Bituminous Surfacing	B.6
Three Stage Construction	1st Stage (1985): Same as of the first stage of Option A of two stage construction plan 2nd Stage (1990): New construction of Long Lama-G.Mulu Junc. section 3rd Stage (1995): New construction of G.Mulu Junc.-N.Medamit section	Gravel	C.1
		Surface Dressing	C.2
		Bituminous Surfacing	C.3

10-2 Benefits

10-2-1 Benefit to Normal Traffic

Normal traffic benefit is the difference between vehicle operation cost on the existing road and that on the road after improvement. The existing road is gravel road, which is to be improved by bituminous surface treatment or asphalt pavement. Vehicle running cost on paved roads varies by the kind of vehicle and road condition. It is generally claimed that the cost on asphalt pavement is 25% to 30% lower than the cost on gravel road and that on surface dressed road is about 15% lower than gravel road. Table 10-2 compares vehicle running costs on gravel road and those on asphalt pavement by vehicle type for each existing road section. This comparison is based on vehicle operation cost on level roads by vehicle type presented in Appendix Table A-10-1 and the adjustment value by gradient as shown in Appendix Table A-10-2.

Table 10-2 Comparison of Vehicle Operation Costs by Types of Road and Vehicle on Existing Road Sections (M$/veh-km)

Road Section	Dist. (kms)	Car		Van/Pick-up		Bus		Med. Truck (6ton)	
		Grav.	Paved	Grav.	Paved	Grav.	Paved	Grav.	Paved
Miri/Bintulu Rd. - Beluru	(18.4)	5.98	4.18	8.79	6.02	15.60	10.58	12.19	8.96
Beluru - Sg. Tinjar	(36.3)	11.42	7.97	16.58	11.36	29.29	19.87	22.90	16.82
N. Medamit - Ukong	(9.7)	3.39	2.36	4.93	3.38	8.70	5.90	6.80	5.00
Ukong - B. Danau J.	(9.3)	2.63	1.83	3.82	2.62	6.75	4.58	5.28	3.88
B. Danau - Kubong	(12.5)	4.24	2.96	6.17	4.23	10.89	7.39	8.52	6.26
Kubong - Limbang	(9.8)	2.72	1.90	3.96	2.71	6.99	4.74	5.47	4.02

From the foregoing, normal traffic benefits due to the improvement of the existing roads by asphalt pavement are as shown in Table 10-3; benefit from the bituminous surface treatment of these roads will be one-half of the indicated benefits.

Table 10-3 Vehicle Operation Cost Reductions due to the *Improvement of Gravel Roads*

Road Section	Car	Van/ Pickup	Truck	Bus	Total
	1985 (M$000/year)				
Miri/Bintulu Rd. - Beluru	82.1	36.4	219.3	20.2	358.0
Beluru - Sg. Tinjar	44.1	19.1	115.4	10.3	188.9
N. Medamit - Ukong Junc.	21.4	4.5	23.7	11.2	60.8
Ukong Junc. - B. Danau Junc.:	19.6	3.9	23.0	7.9	54.4
B. Danau Junc. - Kubong Junc.:	51.6	10.6	57.7	19.2	139.1
Kubong Junc. - Limbang	319.4	35.6	199.5	38.6	593.1
Total	538.2	110.1	638.6	107.4	1,394.3

Road Section	Car	Van/ Pickup	Truck	Bus	Total
	1995 (M$000/year)				
Miri/Bintulu Rd. - Beluru :	242.4	74.8	304.2	67.8	689.2
Beluru - Sg. Tinjar :	123.4	38.1	159.8	20.6	341.9
N. Medamit - Ukong Junc. :	32.7	7.4	30.9	11.2	82.2
Ukong Junc. - B. Danau Junc.:	29.8	6.6	28.1	10.3	74.8
B. Danau Junc. - Kubong Junc.:	85.1	18.4	80.0	28.1	211.6
Kubong Junc. - Limbang :	617.2	53.8	358.3	72.3	1,101.6
Total	1,130.6	199.1	961.3	210.3	2,501.3

Road Section	Car	Van/ Pickup	Truck	Bus	Total
	2005 (M$000/year)				
Miri/Bintulu Rd. - Beluru :	477.0	146.6	598.9	133.8	1,356.3
Beluru - Sg. Tinjar :	231.7	70.5	301.8	37.8	641.8
N. Medamit - Ukong Junc. :	46.2	10.2	44.0	15.3	115.7
Ukong Junc. - B. Danau Junc.:	42.0	9.2	39.9	14.3	105.4
B. Danau Junc. - Kubong Junc.:	132.0	28.3	124.6	44.7	329.6
Kubong Junc. - Limbang :	1,105.0	96.3	642.0	129.8	1,973.1
Total	2,033.9	361.1	1,751.2	375.7	4,521.9

10-2-2 Benefit to Diverted Traffic

Benefit to diverted traffic is expressed as the difference between passenger and/or cargo transportation cost by the existing mode of transportation via the existing route, and such cost by the mode and route between the same origin and destination which becomes available upon the completion of the Project Road. Table 10-4 shows such benefit in 1985 in terms of passenger transportation cost, and Table 10-5 shows the benefit for cargo transportation, assuming asphalt pavement for the Project Road.

As these Tables clearly indicate, the amount of benefits are substantial even for the small relative traffic volumes indicated.

This is because the cost of existing river transportation is very high, and therefore, cost reduction to result from the Project Road will be very substantial.

Benefits in 1995 and in 2005 have been estimated by applying passenger and cargo traffic growth rates to the 1985 benefit.

Table 10-4 Benefits due to the Savings of Diverted Passenger Traffic from River, 1985

Traffic Between		Number of Pass-engers per Day 1/	Transport Cost by River (M$/pass.)	Transport Cost by 2/ Road (M$/pass.)	Reduction in Transport Cost (M$/pass.)	Benefits (M$000/year)
01. Miri	- 05	10	27.10	2.76	24.34	88.84
	- 06	14	45.37	4.21	41.16	210.33
	- 08	(62)	(13.63)	5.26	8.37	189.41
	- 09	6	72.46	5.26+27.72	39.48	86.46
	- 10	22	53.77	7.46	46.31	371.87
05. Bakong	- 06	4	40.11	1.44	38.67	56.46
	- 08	6	41.37	2.49	38.88	85.15
	- 10	4	37.59	4.70	32.89	48.02
06. Tinjar	- 07	23	21.42	3.58	17.84	149.77
	- 08	6	28.98	1.04	27.94	61.19
	- 09	2	54.81	1.04+27.72	26.05	19.02
07. L. Baram	- 08	41	22.68	5.26	17.42	260.69
		(105)	(6.48)	5.26	1.22	46.76
(Marudi)	- 09	22	48.51	5.26+27.72	15.53	124.71
	Upper Baram	(11)	(34.20)	5.26+27.72	1.22	4.90
	- 10	27	29.82	3.63	26.19	258.10
	Tutoh/ Apoh	(5)	(21.42)	3.63	17.79	32.47
08. Baram M. (Long Lama)	-10	(9)	(21.18)	2.20	18.98	62.35
TOTAL						2,156.50

1/ figures in parenthesis are passengers moving by express launches wholley or partly.

2/ calculated based on the assumption that 35% of passengers use cars with an average number of 3.0 passengers while 65% use buses with an average of 25 passengers.

Table 10-5 Benefits due to the Savings of Diverted Cargo Traffic from River, 1985

Traffic Between	Tonnage per year	Transport Cost by River (M$/ton)	Transport Cost by Road (M$/ton)	Reduction in Transport Cost (M$/ton)	Benefits (M$000/year)
Incoming:					
01.Miri - 06.Tinjar	7,280	176.46	8.11	168.35	1,225.6
- 08.Baram M.	5,544	26.43	10.13	16.30	90.4
- 09.U. Baram	2,898	239.22	10.13+212.79	16.30	47.2
- 10.Tutoh/Apoh	4,322	245.66	14.37	231.29	1,002.3
Outgoing 1/:					
08.Baram. M - 01.Miri	3,400	26.43	10.13	16.30	55.4
TOTAL					2,420.9

1/ it was assumed that all the outgoing cargo is shipped from Long Lama.

10-2-3 Benefit to Development Traffic

Benefit to development traffic in 1990 has been estimated in Table 10-6. The unit value of the benefit per vehicle-kilometer has been estimated for each vehicle type based on the amount of reduction in transportation cost per passenger-kilometer or per ton-kilometer for OD pairs of diverted traffic shown in Table 10-4 and Table 10-5. Unit benefit to van/pickup which pertains to passenger traffic is considered to be one-third of the unit benefit to passenger cars and that which pertains to cargo is considered to be one-sixth of the unit benefit to 6-ton trucks. No traffic currently exists in Tutoh/Apoh - Limbang section, but Miri - Tutoh/Apoh route can substitute for the section and, therefore, the unit benefit for this route has been used. Benefits in 1995 and 2005 are projected based on the increase in traffic volume in these years.

Table 10-6 Benefit to Development Traffic, 1990

Road Section	Road Length (kms)	ADT: Car	ADT: Van/ Pickup	ADT: Mini-Bus	ADT: 6 ton Truck	Unit Benefit (M$/Veh. km): Car	Van/ Pickup	Mini-Bus	6 ton-Truck	Benefits (M$/000)
Miri - Long Lama (01) (08)	132.0	5	12	1	6	0.095	0.031	0.473	0.185	117.1
Miri - Tutoh/Apoh (01) (10)	187.0	11	20	3	6	0.372	0.180	1.86	1.86	1,667.6
Tutoh/Apoh - Limbang (10) (12)	100.5	7	9	2	–	0.372	0.124	1.86	–	272.9
N. Medamit - Limbang (11) (12)	41.0	–	40	–	40	–	0.036	–	0.042	46.7
TOTAL										2,104.3

10-2-4 Benefit to Induced Traffic

It is expected that, upon the Project Road completion, induced traffic will be generated in all of OD pairs within the Study Area. Since almost no means of transportation exists in some of the OD pairs and since it is nearly impossible to estimate transportation cost reduction for every OD pair, the following method has been adopted for the estimation of benefit to induced traffic:

For passenger traffic, average transportation distance per trip-end has been obtained for each traffic zone from Table 4-27, the amount of transportation cost reduction per trip-end in Zone 08 and Zone 10 which are considered to best represent the Study Area has been obtained from Table 4-26, and benefit (saving) per kilometer per trip-end has been computed as follows:

Traffic Zone	Average Transport Distance per Trip-end	Average Transportation Cost Reduction per Trip-end	Saving per Kilometer per Trip-end
Long Lama (08)	76.6 km	9.5 M$	0.248 M$/trip
Tutoh/Apoh (10)	109.5	25.2	0.460

Zone 08 (Long Lama) is one of the zones in which the benefit will be the smallest, while Zone 10 (Tutoh/Apoh) will receive the largest benefit from the Project Road construction.

Unit benefit to passenger traffic has been estimated based on the value for Long Lama (Zone 08), where regular express launch service is currently available, since traffic generation will mostly gravitate to this area and in order to avoid overestimation since induced traffic benefits involve more elements of uncertainty than benefits to other types of traffic.

Unit benefit to passenger car traffic:

M$0.248/man·kilometer x 1/4 x 3 passenger/car
= M$0.186/car·kilometer

Unit benefit to bus traffic:

M$0.248/man·kilometer x 1/4 x 25 passenger/bus
= M$1.55/bus·kilometer

Although the lack of adequate data makes the estimation of benefit to cargo traffic difficult, benefit to induced truck traffic has been obtained by multiplying the ratio between (a) transportation cost reduction per kilometer per trip in Zone 08 (Long Lama) and (b) the reduction in passenger traffic per man-kilometer for 01 - 08 Zone times (c) the benefit for cargo traffic per ton-kilometer for Miri (01) - Long Lama (08) section, as follows:

$$M\$0.123^{(c)} \times \frac{M\$0.248^{(a)}}{M\$0.063^{(b)}} = M\$0.484/\text{ton}\cdot\text{kilometer}$$

Then, unit benefit to induced truck traffic is calculated as follows (using an average load of three tons in view that trucks usually return empty):

$$M\$0.484 \times 1/4 \times 6 \text{ ton} \times 1/2 = M\$0.363 \text{ truck}\cdot\text{kilometer}$$

Unit benefit to induced van/pickup traffic has been estimated at M$0.077/vehicle-kilometer, based on the ratio of average load tonnage or the number of passenger van/pickup and trucks or passenger cars.

By multiplying these unit benefit values by the length of road section and traffic volume, benefit to induced traffic has been obtained for each type of vehicle and for each road section as presented in Table 10-7.

Table 10-7 Benefit to Induced Traffic

		1985 (M$000/year)				
	Road Section	Car	Van/ Pickup	Truck	Bus	Total
1	Miri/Bintulu Rd. - Beluru	71.6	4.7	117.7	303.5	497.5
2	Beluru - Sg. Tinjar	122.9	7.1	177.5	327.7	635.2
3	Sg. Tinjar - Long Lama	194.6	11.1	257.9	357.1	820.7
4	Long Lama - Tutoh/Apoh	194.2	11.0	252.7	349.1	807.0
5	Tutoh/Apoh - N. Medamit	202.0	11.7	268.0	370.3	852.0
6	N. Medamit - Ukong Junc.	63.9	3.6	86.5	127.1	281.1
7	Ukong Junc. - B. Danau Junc.	49.6	2.8	67.1	98.6	218.1
8	B. Danau Junc. - Kubong Junc.	80.1	4.5	108.3	159.2	352.1
9	Kubong Junc. - Limbang	51.4	2.9	69.5	102.2	226.0
	Total	1,030.3	59.4	1,405.2	2,194.8	4,689.7

- Continued

Table 10-7 (Cont.)

Road Section	1995 (M$000/year) Car	Van/ Pickup	Truck	Bus	Total
1. Miri/Bintulu Rd. - Beluru	140.5	9.9	230.2	596.1	976.7
2. Beluru - Sg. Tinjar	240.6	14.2	345.0	634.3	1,234.1
3. Sg. Tinjar - Long Lama	381.8	21.4	504.8	698.7	1,606.7
4. Long Lama - Tutoh/Apoh	380.5	20.5	505.0	697.6	1,603.6
5. Tutoh/Apoh - N. Medamit	395.5	21.7	527.7	739.9	1,684.8
6. N. Medamit - Ukong Junc.	125.6	7.2	168.6	248.0	549.4
7. Ukong Junc. - B. Danau Junc.	97.4	5.6	130.8	192.4	426.2
8. B. Danau Junc. - Kubong Junc.	157.3	9.0	211.1	310.6	688.0
9. Kubong Junc. - Limbang	100.9	5.8	135.5	199.3	441.5
Total	2,020.1	115.3	2,758.7	4,316.9	9,211.0

Road Section	2005 (M$000/year) Car	Van/ Pickup	Truck	Bus	Total
1. Miri/Bintulu Rd. - Beluru	251.9	17.6	411.0	1,065.4	1,745.9
2. Beluru - Sg. Tinjar	431.7	26.4	617.5	1,144.6	2,220.2
3. Sg. Tinjar - Long Lama	684.3	38.4	907.7	1,262.2	2,892.6
4. Long Lama - Tutoh/Apoh	684.2	37.8	905.0	1,235.3	2,862.3
5. Tutoh/Apoh - N. Medamit	709.5	40.1	936.2	1,310.2	2,996.0
6. N. Medamit - Ukong Junc.	224.7	12.9	301.4	447.1	986.1
7. Ukong Junc. - B. Danau Junc.	174.3	10.0	233.8	346.8	764.9
8. B. Danau Junc. - Kubong Junc.	281.4	16.2	377.4	559.9	1,234.9
9. Kubong Junc. - Limbang	180.6	10.4	242.2	359.3	792.5
Total	3,622.6	209.8	4,932.2	7,730.8	16,495.4

10-2-5 Summary of Benefits for Alternative Road Development Plans

Discussions so far have pertained to benefits arising from one-step construction of asphalt-paved roads. Other alternative road plans will result in different benefit values and different timing of benefit generation. Tables 10-8 (1) through (3) show the benefits in each road section for each alternative. These benefit values have been estimated using basically the same method of quantification. For the benefit to induced traffic it was assumed that only 1/4 of the potential benefit will be realized in the initial year of the road service and that the benefit will gradually increase to reach 100% potential benefit within the subsequent three years. Outlines of calculation under each alternative plan are as follows:

Alternatives A-1, A-2, and A-3:

Alternative A-3 has been discussed in detail already for estimation of benefits. Alternatives A-1 and A-2 are same as A-3 except for road surface structure, and as a result, the benefit values differ somewhat.

Alternatives B-1, B-2 and B-3:

Under these alternatives, Long Lama - N. Medamit section will not commence its service until 1990, and, therefore, a part (about 40%) of induced traffic, practically all (about 90%) of development traffic, and a part (about 40%) of induced traffic will not occur during the five years from 1985 to 1990.

Alternatives B-4, B-5 and B-6:

Under these alternatives, most of the benefits will be generated by the construction of Sg. Tinjar - G. Mulu Junction section, although G. Mulu Junction - N. Medamit section will not commence its service until 1990. With an exception of a part of benefits to induced traffic (about 30%) and the benefits to normal traffic, all other benefits will be generated by 1985.

Alternatives C-1, C-2 and C-3:

Under these alternatives, the commencement of service in the G. Mulu Junction - N. Medamit section will be 5 years behind alternatives B-1, B-2 and B-3 and occur in 1995. Therefore, in addition to the delay in benefit generation under alternatives B-1, B-2 and B-3, the generation of a part of benefits (about 13%) will be further delayed by five years until 1995. When road to G. Mulu is completed, all of the benefits to development traffic and to diverted traffic will be generated as in the case of alternatives B-1, B-2 and B-3.

Table 10-8-(1) Benefit Stream for Alternative Plans A-1 to A-3

Year	Case: A-1					Case: A-2					Case: A-3				
	Normal	Diverted	Development	Induced	Total	Normal	Diverted	Development	Induced	Total	Normal	Diverted	Development	Induced	Total
1980	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1981	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	593	4,316	0	1,054	5,963	1,004	4,453	0	1,113	6,570	1,394	4,567	C	1,171	7,132
1986	631	4,598	0	2,256	7,485	1,064	4,744	0	2,381	8,189	1,478	4,865	0	2,506	8,849
1987	671	4,897	994	3,621	10,183	1,128	5,053	1,026	3,822	11,029	1,567	5,182	1,052	4,023	11,924
1988	714	5,217	1,253	5,165	12,349	1,196	5,382	1,293	5,452	13,323	1,662	5,520	1,326	5,739	14,247
1989	760	5,557	1,579	5,527	13,423	1,268	5,733	1,629	5,834	14,464	1,762	5,880	1,671	6,141	15,454
1990	808	5,919	1,989	5,913	14,629	1,345	6,107	2,052	6,241	15,745	1,868	6,264	2,104	6,570	16,806
1991	860	6,305	2,284	6,326	15,775	1,426	6,505	2,357	6,678	16,966	1,980	6,672	2,417	7,029	18,098
1992	915	6,716	2,624	6,769	17,024	1,511	6,929	2,707	7,145	18,292	2,099	7,107	2,777	7,521	19,504
1993	973	7,154	3,014	7,242	18,383	1,602	7,381	3,110	7,644	19,737	2,225	7,570	3,190	8,047	21,032
1994	1,036	7,620	3,462	7,748	19,866	1,699	7,862	3,572	8,179	21,312	2,359	8,064	3,664	8,609	22,696
1995	1,102	8,117	3,977	8,290	21,486	1,801	8,375	4,103	8,751	23,030	2,501	8,590	4,209	9,211	24,511
1996	1,175	8,583	3,977	8,787	22,522	1,911	8,856	4,103	9,276	24,146	2,651	9,083	4,209	9,764	25,707
1997	1,254	9,076	3,977	9,315	23,622	2,027	9,365	4,103	9,832	25,327	2,816	9,605	4,209	10,350	26,980
1998	1,338	9,598	3,977	9,873	24,786	2,151	9,903	4,103	10,422	26,579	2,988	10,157	4,209	10,970	28,324
1999	1,427	10,149	3,977	10,466	26,019	2,282	10,471	4,103	11,047	27,903	3,170	10,740	4,209	11,629	29,749
2000	1,523	10,732	3,977	11,094	27,326	2,421	11,073	4,103	11,710	29,307	3,363	11,357	4,209	12,326	31,255
2001	1,625	11,349	3,977	11,759	28,710	2,569	11,709	4,103	12,413	30,794	3,568	12,009	4,209	13,066	32,852
2002	1,733	12,001	3,977	12,465	30,176	2,726	12,382	4,103	13,157	32,368	3,786	12,699	4,209	13,850	34,544
2003	1,849	12,690	3,977	13,213	31,729	2,892	13,093	4,103	13,947	34,035	4,017	13,429	4,209	14,681	36,336
2004	1,973	13,419	3,977	14,006	33,375	3,069	13,845	4,103	14,784	35,801	4,262	14,200	4,209	15,562	38,233
TOTAL	22,960	164,013	56,969	160,889	404,831	37,092	169,221	58,776	169,828	434,917	51,516	173,560	60,291	178,765	464,132

Table 10-8-(2) Benefit Stream for Alternative Plans B-1 to B-3

Year	Case: B-1					Case: B-2					Case: B-3				
	Normal	Diverted	Development	Induced	Total	Normal	Diverted	Development	Induced	Total	Normal	Diverted	Development	Induced	Total
1980	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1981	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	593	2,608	0	626		1,004	2,687	0	661	4,352	1,395	2,757	0	696	4,848
1986	631	3,074	0	1,340	5,045	1,064	3,166	0	1,415	5,645	1,478	3,248	0	1,490	6,216
1987	671	3,662	11	2,151	6,555	1,128	3,731	114	2,271	7,224	1,567	3,828	117	2,391	7,903
1988	714	4,269	139	3,068	8,190	1,196	4,397	144	3,240	8,977	1,662	4,511	147	3,412	9,732
1989	760	5,030	176	3,283	9,249	1,268	5,181	181	3,467	10,097	1,762	5,316	186	3,650	10,914
1990	808	5,928	221	4,001	10,958	1,345	6,106	228	4,225	11,904	1,868	6,265	234	4,449	12,816
1991	860	6,313	221	4,877	12,271	1,426	6,503	228	5,150	13,307	1,980	6,672	234	5,423	14,309
1992	915	6,724	221	5,944	13,804	1,511	6,925	228	6,277	14,941	2,099	7,105	234	6,610	16,048
1993	973	7,160	1,989	7,245	17,367	1,602	7,375	2,048	5,150	18,675	2,225	7,570	2,102	8,056	19,953
1994	1,036	7,626	2,284	7,750	18,696	1,699	7,855	2,353	8,184	20,091	2,359	8,059	2,414	8,617	21,449
1995	1,102	8,121	2,624	8,290	20,137	1,801	8,365	2,702	8,754	21,622	2,501	8,582	2,773	9,218	23,074
1996	1,175	8,588	3,015	8,787	21,565	1,923	8,845	3,105	9,279	23,152	2,654	9,075	3,186	9,771	24,686
1997	1,254	9,081	3,464	9,315	23,114	2,054	9,354	3,568	9,836	24,812	2,816	9,597	3,661	10,357	26,431
1998	1,338	9,603	3,977	9,873	24,791	2,194	9,891	4,096	10,426	26,607	2,988	10,148	4,203	10,979	28,318
1999	1,427	10,155	3,977	10,466	26,025	2,343	10,459	4,096	11,052	27,950	3,170	10,731	4,203	11,638	29,742
2000	1,523	10,738	3,977	11,094	27,332	2,502	11,060	4,096	11,715	29,373	3,363	11,348	4,203	12,336	31,250
2001	1,625	11,355	3,977	11,759	28,716	2,673	11,695	4,096	12,418	30,882	3,568	11,999	4,203	13,076	32,846
2002	1,733	12,007	3,977	12,465	30,182	2,854	12,367	4,096	13,163	32,480	3,786	12,689	4,203	13,860	34,538
2003	1,849	12,697	3,977	13,213	31,736	3,048	13,078	4,096	13,953	34,175	4,017	13,418	4,203	14,692	36,330
2004	1,973	13,426	3,977	14,006	33,382	3,256	13,829	4,096	14,790	35,971	4,262	14,189	4,203	15,574	38,228
Total	22,960	158,125	42,304	149,553	372,942	37,891	162,869	43,571	157,926	402,257	51,520	167,107	44,709	166,295	429,631

Table 10-8-(3) Benefit Stream for Alternative Plans B-4 to B-6

Year	Case: B-4					Case: B-5					Case: B-6				
	Normal	Diverted	Develop-ment	Induced	Total	Normal	Diverted	Develop-ment	Induced	Total	Normal	Diverted	Develop-ment	Induced	Total
1980	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1981	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	593	2,642	0	717	3,952	593	2,726	0	757	4,076	593	2,796	0	796	4,185
1986	631	3,107	0	1,534	5,272	631	3,205	0	1,619	5,455	631	3,288	0	1,704	5,623
1987	671	3,653	994	2,462	7,780	671	3,769	1,026	2,599	8,065	671	3,866	1,052	2,736	8,325
1988	741	4,296	1,253	3,512	9,775	714	4,432	1,293	3,707	10,146	714	4,546	1,326	3,903	10,489
1989	760	5,051	1,579	3,758	11,148	760	5,211	1,629	3,967	11,567	760	5,345	1,671	4,176	11,952
1990	808	5,919	1,989	5,913	14,629	1,345	6,107	2,052	6,241	15,745	1,868	6,264	2,104	6,570	16,806
1991	860	6,305	2,284	6,326	15,775	1,426	6,505	2,357	6,678	16,966	1,980	6,672	2,417	7,029	18,098
1992	915	6,716	2,624	6,769	17,024	1,511	6,929	2,707	7,145	18,292	2,099	7,107	2,777	7,521	19,504
1993	973	7,154	3,014	7,242	18,383	1,602	7,381	3,110	7,644	19,737	2,225	7,570	3,190	8,047	21,032
1994	1,036	7,620	3,462	7,748	19,866	1,699	7,862	3,572	8,179	21,312	2,359	8,064	3,664	8,609	22,696
1995	1,102	8,117	3,977	8,290	21,486	1,801	8,375	4,103	8,751	23,030	2,501	8,590	4,209	9,211	24,511
1996	1,175	8,583	3,977	8,787	22,522	1,911	8,856	4,103	9,276	24,146	2,654	9,083	4,209	9,764	25,710
1997	1,254	9,076	3,977	9,315	23,622	2,027	9,365	4,103	9,832	25,327	2,816	9,605	4,209	10,350	26,980
1998	1,338	9,598	3,977	9,873	24,786	2,151	9,903	4,103	10,442	26,599	2,988	10,157	4,209	10,970	28,324
1999	1,427	10,149	3,977	10,466	26,019	2,282	10,471	4,103	11,047	27,903	3,170	10,740	4,209	11,629	29,748
2000	1,523	10,732	3,977	11,094	27,326	2,421	11,073	4,103	11,710	29,307	3,363	11,357	4,209	12,326	31,255
2001	1,625	11,349	3,977	11,759	28,710	2,569	11,709	4,103	12,413	30,794	3,568	12,009	4,209	13,066	32,852
2002	1,733	12,001	3,977	12,465	30,176	2,726	12,382	4,103	13,157	32,368	3,786	12,669	4,209	13,850	34,514
2003	1,849	12,690	3,977	13,213	31,729	2,892	13,093	4,103	13,947	34,035	4,017	13,429	4,209	14,681	36,336
2004	1,973	13,419	3,977	14,006	33,375	3,069	13,845	4,103	14,784	35,801	4,262	14,200	4,209	15,562	38,233
Total	22,960	158,177	56,969	155,249	393,355	34,801	163,199	58,776	163,895	420,671	47,025	167,357	60,291	172,500	447,173

Table 10-8-(4) Benefit Stream for Alternative Plans C-1 to C-3

Year	Case: C-1					Case: C-2					Case: C-3				
	Normal	Diverted	Develop-ment	Induced	Total	Normal	Diverted	Develop-ment	Induced	Total	Normal	Diverted	Develop-ment	Induced	Total
1980	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1981	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	593	2,608	0	626	3,872	1,004	2,687	0	661	4,352	1,395	2,757	0	696	4,848
1986	631	3,074	0	1,340	5,045	1,064	3,166	0	1,415	5,645	1,478	3,428	0	1,490	6,216
1987	671	3,622	111	2,151	6,555	1,128	3,731	114	2,271	7,244	1,567	3,838	117	2,391	7,903
1988	741	4,269	139	3,068	8,190	1,196	4,397	144	3,240	8,977	1,662	4,511	147	3,412	9,732
1989	760	5,030	176	3,283	9,249	1,268	5,181	181	3,467	10,097	1,762	5,316	186	3,650	10,914
1990	808	5,928	221	3,636	10,593	1,345	6,106	228	3,840	11,519	1,868	6,265	234	4,043	12,410
1991	860	6,313	221	4,027	11,421	1,426	6,503	228	4,253	12,410	1,980	6,672	234	4,478	13,364
1992	915	6,724	221	4,461	12,321	1,511	6,925	228	4,711	13,375	2,099	7,105	234	4,960	14,398
1993	973	7,160	1,989	4,941	15,063	1,602	7,375	2,048	5,218	16,243	2,225	7,570	2,102	5,494	17,391
1994	1,036	7,626	2,284	5,287	16,233	1,699	7,855	2,353	5,585	17,490	2,359	8,059	2,414	5,879	18,711
1995	1,102	8,121	2,624	6,180	18,027	1,801	8,365	2,702	6,526	19,394	2,501	8,582	2,773	6,872	20,728
1996	1,175	8,588	3,015	7,225	20,003	1,923	8,845	3,105	7,629	21,502	2,654	9,075	3,186	8,034	22,949
1997	1,254	9,081	3,464	8,446	22,245	2,054	9,354	3,568	8,919	23,895	2,816	9,597	3,661	9,392	25,466
1998	1,338	9,603	3,977	9,873	24,791	2,194	9,891	4,096	1-,426	26,607	2,988	10,148	4,203	10,979	28,318
1999	1,427	10,155	3,977	10,466	26,025	2,343	10,459	4,096	11,052	27,950	3,170	10,731	4,203	11,638	29,742
2000	1,523	10,738	3,977	11,094	27,332	2,502	11,060	4,096	11,715	29,373	3,363	11,348	4,203	12,336	31,250
2001	1,625	11,355	3,977	11,759	28,716	2,673	11,695	4,096	12,418	30,882	3,568	11,999	4,203	13,076	32,846
2002	1,733	12,007	3,977	12,465	30,182	2,854	12,367	4,096	13,163	32,480	3,786	12,689	4,203	13,860	34,538
2003	1,849	12,697	3,977	13,213	31,736	3,048	13,078	4,096	13,953	34,175	4,017	13,418	4,203	14,692	36,330
2004	1,973	13,426	3,977	14,006	33,382	3,256	13,829	4,096	14,790	35,971	4,262	14,189	4,203	15,574	38,228
Total	22,960	158,125	42,304	137,547	360,936	37,891	162,869	43,571	145,250	389,581	51,520	167,107	44,709	152,946	416,282