

No.

INFRASTRUCTURAL SURVEY REPORT
FOR THE DEVELOPMENT OF
THE WOLOGISI IRON MINING
IN THE REPUBLIC OF LIBERIA

PHASE-III
NEW ROAD PLAN

AUGUST 1979

JAPAN INTERNATIONAL COOPERATION AGENCY

MPI

79-67

THE UNIVERSITY OF CHICAGO

1961-1962

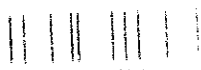
1961-1962

1961-1962

1961-1962

1961-1962

1961-1962



1961-1962

1961-1962

1961-1962

マイクロ
フインゴ作成

国際協力事業団	
受入 月日 84.9.27	517
登録No. 09268	66.2
	MPI

PREFACE

The Government of Japan decided to execute a series of surveys for the development of infrastructures related to the Wologisi Mine in the Republic of Liberia, and entrusted the Japan International Cooperation Agency (JICA) to act as executing agency for the surveys.

Following the previous surveys on improvement of access road to the Wologisi Mine (Phase-I) and preliminary study on port improvement (Phase-II), the surveys and studies have been made at this time on the new road plan between the Wologisi Mine and Bopolu, which appears to be the shortest route for the mine to reach the port.

JICA organized a survey team of nine experts headed by Mr. Y. Hatano of Nippon Koei Co., Ltd. The team stayed in Liberia for the period from November 7 to December 28, 1978 to carry out the field surveys. The results of the field surveys were further studied after the return of the survey team, and the report has been compiled and submitted herein.

It would be our profound pleasure if the survey results could facilitate the development of the Wologisi Mine and contribute to the socio-economic development of Liberia, as well as to further promote the friendship between the Republic of Liberia and Japan.

I should like to take this opportunity to express our deepest gratitude to the personnel concerned in the Government of the Republic of Liberia who extended kind cooperation to the field survey team, and to the personnel concerned in the Embassy of Japan in Liberia, Ministry of Foreign Affairs, Ministry of International Trade and Industry of the Japanese Government, and all other authorities concerned in the surveys.

August 1979



Shinsaku Hogen
President

JAPAN INTERNATIONAL COOPERATION AGENCY

SUMMARY

SUMMARY

1. The surveys and studies have been made on the road construction between the Wologisi Mine and Bopolu which is a center of Lower Lofa County. The road will be planned to serve for the access to the Mine and the maintenance of pipeline to be constructed for ore transport from the Mine to the port, as well as for development of agricultural and forestry resources along the road and for the socio-economic development of the region as a whole.

2. Through the comparative study, alignment of the road has been selected to run from the Mine through Gondolahun, Konehun, Kpelle and Gengba to reach Bopolu. The section from Kpakuta on the Voinjama - Kolahun road to the Wologisi Mine has also be planned for improvement. The total length of the Kpakuta - Wologisi - Bopolu road is 182 km. It is composed of the improvement of existing roads from Kpakuta to Gondolahun (57 km) and from Bopolu to Kpelle National Forest (50 km), and the new road construction of 75 km between Gondolahun and Kpelle.

3. Traffic along the existing road is still small, or about 14-20 vehicles per day. Future traffic along the road has been preliminarily forecasted to be about 160 ADT in 1984 and 330 ADT in 2003 between Wologisi and Bopolu, including increased normal traffic, transportation related to the Wologisi mine operation, traffic to be induced from agricultural and forestry development and possible diverted traffic.

4. Preliminary design of the road has been prepared on the basis of traffic forecast and study on various design criteria. The design speed will be defined to be 40 km/hour, but the alignment will be designed to enable future improvement at minimum additional cost for the design speed of 60 km/hour. Bridges and other structure have also been designed, including 120 m long bridge to cross Lofa river.

5. Since there was no detailed topographic map of the region, the JICA survey team took aerial photographs and prepared topographic map on the scale of 1/20,000. The map has been utilized for final alignment of the road, for plan and profile design and for estimate of work quantities. The salient features of the proposed road are summarized hereunder.

Total length:	181.6 km
Improvement	107.0 km
New Road	74.6 km
Total earth work:	approx. 2.2 million m ³
Laterite pavement:	254,200 m ³
Bridges:	17 nos.
Total bridge length:	400 m

6. The construction plan has been studied in the light of available construction materials, local conditions and estimated work quantities. The construction schedule has been prepared to start the work at the end of 1980 and to complete by the end of 1983, which will be in time for the scheduled commencement of the mining operation at the beginning of 1984.

7. The total construction cost of the Kpaluta - Wologisi - Bopolu road is estimated to be about US\$25.7 million. The cost of annual maintenance and overlay of prime coat after 10 years have also been estimated.

INFRASTRUCTURAL SURVEY REPORT
FOR THE DEVELOPMENT OF
THE WOLOGISI IRON MINING

PHASE-III
NEW ROAD PLAN

TABLE OF CONTENTS

	<u>Page</u>
SUMMARY	i
CHAPTER I INTRODUCTION	
1.1 Background	1
1.2 Objective of Study	2
CHAPTER II PROJECT AREA	
2.1 Geography	5
2.2 Climate	6
2.3 Population	7
2.4 Agriculture	7
CHAPTER III ALIGNMENT OF NEW ROAD	
3.1 Alignment	11
3.2 Existing Roads	14
3.3 Alignment between Gondolahun and TFC Road	16
3.4 Area of Influence	17
CHAPTER IV TRAFFIC	
4.1 Normal Traffic	19
4.2 Traffic of Wologisi Mine Operation ...	21
4.3 Generated Traffic	26
4.4 Diverted Traffic	33
4.5 Total Estimated Traffic	33

	<u>Page</u>
CHAPTER V PRELIMINARY DESIGN	
5.1 Basic Data	37
5.1.1 Topography	37
5.1.2 Soils and Materials	38
5.1.3 Hydrology	38
5.2 Design Criteria	46
5.3 Preliminary Design of Road	47
5.4 Preliminary Design of Bridges	48
CHAPTER VI CONSTRUCTION PLAN	
6.1 Construction Quantity	53
6.2 Construction Plan	61
6.3 Construction Cost	66
6.4 Maintenance Cost	66

ANNEX-I : INVENTORY OF EXISTING ROAD

INVENTORY
SHEET

- 1) Kpakuta - Wologisi
- 2) Wologisi - Gondolahun - Yaselelahun
- 3) Bopolu - TFC - Kpelle National Forest (1), (2), (3)

- DWG. 1-2 Kpakuta - Wologisi
3-5 Wologisi - Gondolahun
6-10 Kpelle - TFC - Bopolu

ANNEX-II : DRAWINGS

- DWG. 1 General Key Map.
DWG. 2-17 Plan and Profile
DWG. 18 Typical Cross Section
DWG. 19 Pipe Culvert & Cross Ditch
DWG. 20 Box Culvert
DWG. 21 Standard Bridge
DWG. 22 Lofa River Bridge

LIST OF TABLES

<u>Table</u>		<u>Page</u>
2-1	MONTHLY RAINFALL AND TEMPERATURE	6
2-2	POPULATION BY DISTRICT	7
2-3	AGRICULTURAL PRODUCTION IN LOFA COUNTRY	8
2-4	FOREST RESOURCES IN LOFA COUNTRY	9
3-1	AREA OF INFLUENCE	17
4-1	PRESENT TRAFFIC	19
4-2	NORMAL TRAFFIC	20
4-3	MATERIALS FOR MINE OPERATION	21
4-4	WOLOGISI TOWN POPULATION	23
4-5	TRAFFIC OF WOLOGISI MINE	25
4-6	TIMBER RESOURCES IN PROJECT AREA	26
4-7	TIMBER EXTRACTION AND TRAFFIC	27
4-8	CULTIVATION AREA	28
4-9	AREA OF CULTIVATION (RICE)	29
4-10	PRODUCTION OF RICE	30
4-11	AREA AND PRODUCTION (COFFEE)	31
4-12	AREA AND PRODUCTION (COCOA)	31
4-13	TRAFFIC OF AGRICULTURAL PRODUCTS	32
4-14	DIVERTED TRAFFIC	34
4-15	TOTAL TRAFFIC FORECAST	35
5-1	RESULT OF SOIL ANALYSIS	39
5-2	MONTHLY MEAN PRECIPITATION	41
5-3	DISCHARGE	45
5-4	GEOMETRIC DESIGN CRITERIA	46
5-5	LIST OF PROPOSED BRIDGE	50

<u>Table</u>		<u>Page</u>
6-1	SUMMARY OF CONSTRUCTION QUANTITIES	55
6-2	CONSTRUCTION QUANTITIES (I)	57
6-3	CONSTRUCTION QUANTITIES (II)	59
6-4	SUMMARY OF WORK FOR EACH SECTION	61
6-5	SUMMARY OF CONSTRUCTION COSTS	67
6-6	BREAKDOWN OF CONSTRUCTION COSTS	69

LIST OF FIGURES

<u>Figure</u>		<u>Page</u>
3-1	ALTERNATIVE ROUTES	12
3-2	DIAGRAM OF ALTERNATIVE ROUTE	13
5-1	GRADATION ANALYSIS CURVE	40
5-2	CATCHMENT AREA - FLOW AREA DIAGRAM	42
5-3	CATCHMENT AREAS	43
5-4	COMPARATIVE STUDY FOR LOFA RIVER BRIDGE	51
6-1	IMPLEMENTATION SCHEDULE	63
6-2	WORK SCHEDULE (I)	64
6-3	WORK SCHEDULE (II)	65

GLOSSARY

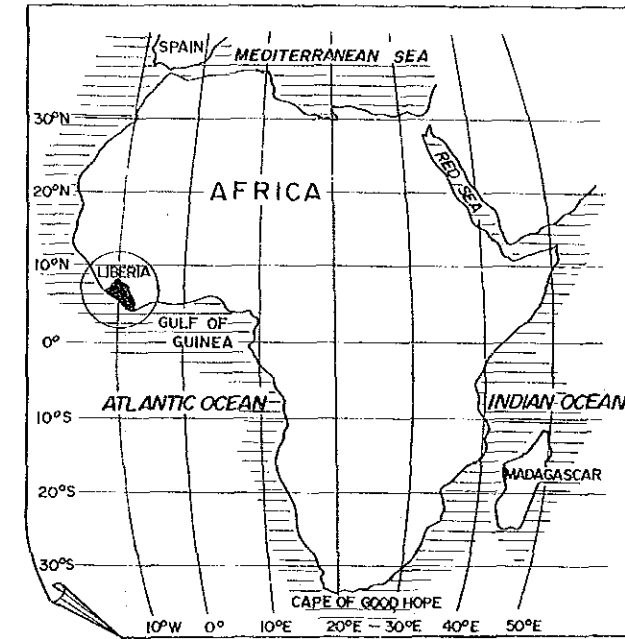
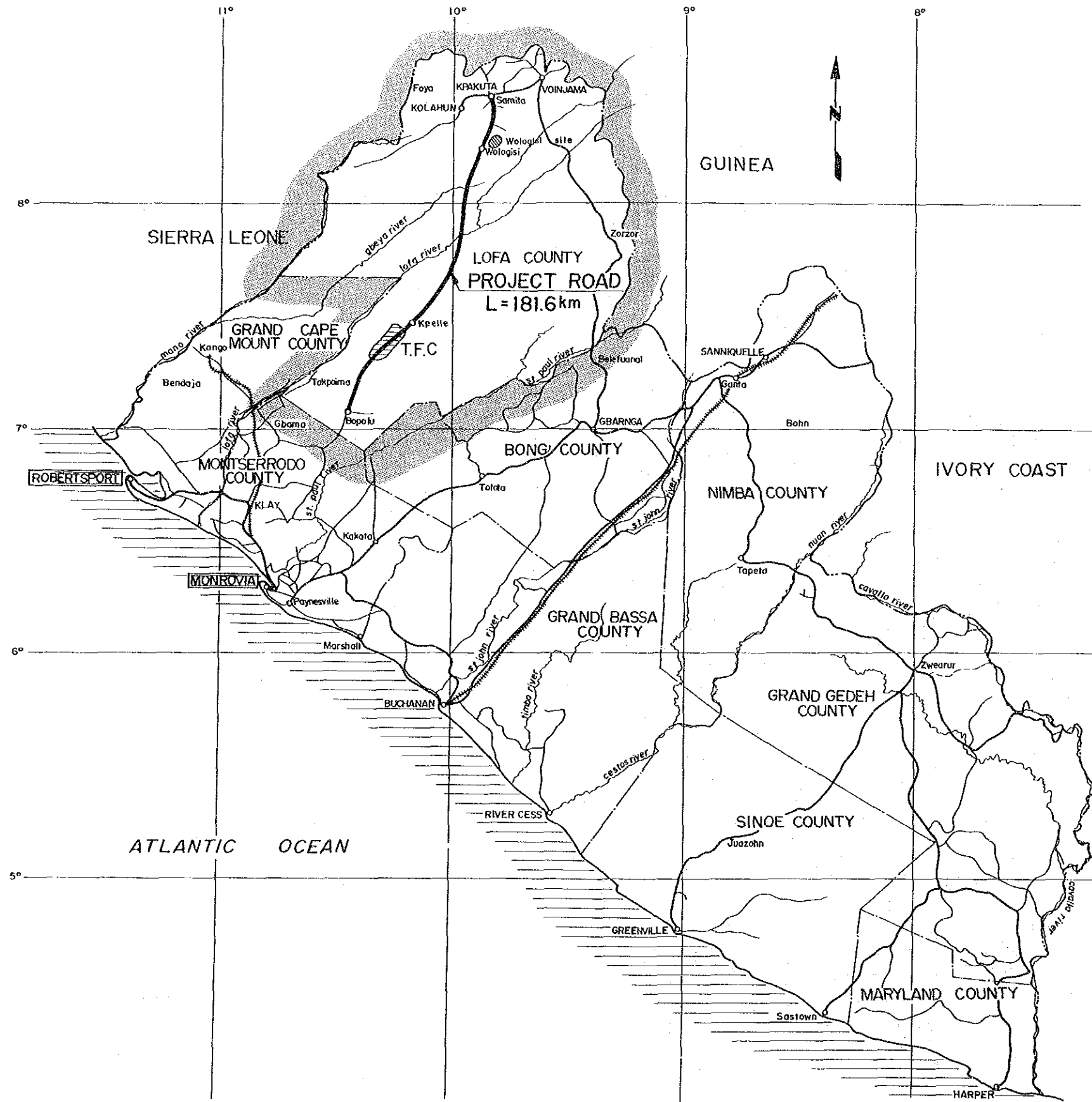
AASHTO	:	American Association of State Highway Transportation Officials
ADT	:	Average Daily Traffic
AMSL	:	Above Mean Sea Level
CBR	:	California Bearing Ratio
DELIMCO	:	German-Liberia Mining Company
GDP	:	Gross Domestic Product
JICA	:	Japan International Cooperation Agency
LISCO	:	Liberia Iron and Steel Corporation
LMC	:	Liberian Mining Company
LPMC	:	Liberian Products Marketing Corporation
MPW	:	Ministry of Public Works
O/D	:	Origin and Destination
RC	:	Reinforced Concrete
Rv.Br.	:	River Bridge
TFC	:	Tropical Farms Corporation
VOC	:	Vehicle Operation Cost

CONVERSION

1 km	=	0.62 mile	1 mile	=	1.6 km
1 m	=	3.28 feet	1 feet	=	0.3 m
1 km	=	0.6 mile/hr	1 m.p.h	=	1.6 km/hr
1 US¢	=	1 Liberian Dollar			

LOCATION MAP

FIGURE 01



LEGEND

- PROJECT ROAD
- INTERNATIONAL BORDER
- COUNTY BORDER
- PRIMARY ROAD
- SECONDARY ROAD
- RAIL ROAD
- RIVER or CREEK

Fig. 01 LOCATION MAP

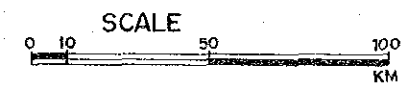
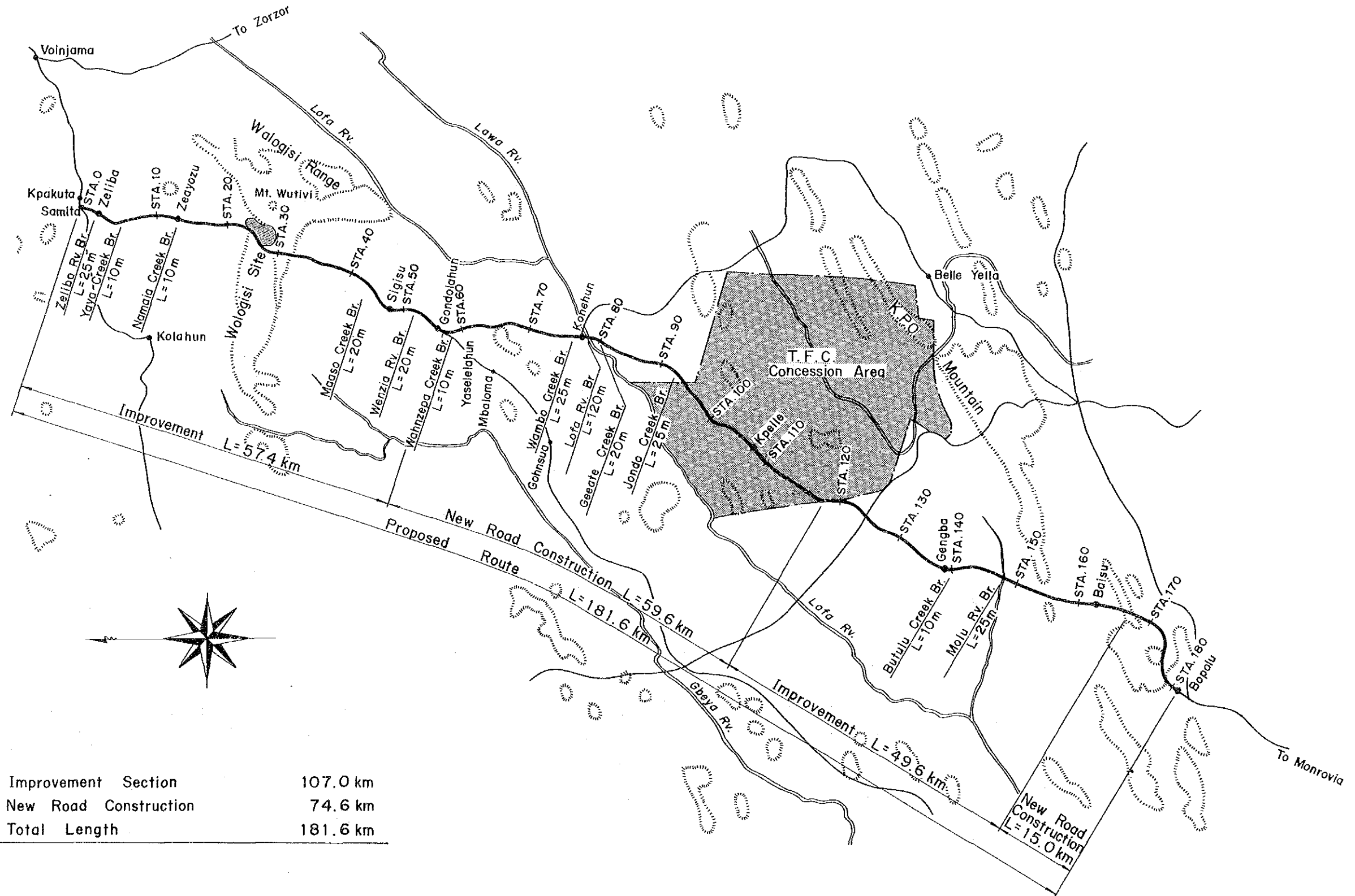


FIGURE 02

ROUTE MAP S=1:500,000



Improvement Section	107.0 km
New Road Construction	74.6 km
Total Length	181.6 km

CHAPTER I

INTRODUCTION

CHAPTER 1 |
INTRODUCTION

1.1 BACKGROUND

Development of the Wologisi mine located in the Lofa County in northwestern Liberia has been studied since 1967. According to the survey made so far, the mine has exploitable iron ore deposit of 680 million tons (540 million tons of primary ore and 140 million tons of weathered ore). A Liberia-Japan joint enterprise, Liberia Iron and Steel Corporation - LISCO, is studying to develop and export 4 million tons of ore per annum during the first 5 years of operation and 7 million tons annually thereafter. LISCO contemplates to commence the construction works in 1980 and start the operation in early 1984.

In relation to the Wologisi iron ore development, various facilities and infrastructures are required to be developed. Among others, improvement of the transportation facilities is of primary importance. At the request of the Government of the Republic of Liberia, the Japanese Government decided to cooperate in the studies of such transportation facilities related to the Wologisi mine development, in view of the fact that such transportation improvement will not only facilitate the mine development, but it will contribute to the social and economic development of the region as a whole.

The studies by the Japan International Cooperation Agency (JICA), acting as the executing agency of the Japanese Government, have been made stagewise. Previously, following reports have been prepared and submitted:

Phase-I : Study on improvement of existing road from Monrovia to the Wologisi mine via Gbarnga (Report No. MPI-GR(1), 79-2, prepared in January 1979)

Phase-II : Preliminary study on port development (Report No. MPI-CR(1), 79-31, prepared in March 1979)

In parallel with the Phase-II survey, field investigation and study for the Phase-III have been made on the new road construction between the Wologisi mine and Bopolu, which will be the shortest way to link the mine with the port for ore export. The new road will serve for access to the Wologisi mine and for the development of transportation in the Lofa Country and northwestern Liberia.

1.2 OBJECTIVE OF STUDY

The objectives of this study are to work out plan for the new road construction between the Wologisi mine and Bopolu for the purposes of:

- a) Opening access to the Wologisi mine
- b) Facilitating construction and maintenance of pipeline for ore transport
- c) Developing resources remained undeveloped in the region
- d) Developing socio-economic infrastructures in Lofa Country

The scope of the studies covered, in principle, the field investigation and studies as follows:

- a) General socio-economic study of the region
- b) Selection of route alignment of new road
- c) Topographic and other survey, including aerial photo mapping at 1/20,000 scale along the road alignment and survey at river crossing point (1/500)
- d) Preliminary design of road and other facilities
- e) Estimate of construction cost and schedule

The field survey was conducted by the JICA team from November 7 to December 28, 1978. The aerial photo shooting team stayed further until January 23, 1979. The survey team was composed of the experts as listed up hereunder.

Team Leader	Yasuharu HATANO
Highway Engineer	Yoshimi OKANO
Highway Engineer	Kiyoshi TAKEICHI
Survey Engineer	Michiyasu MURATA
Survey Engineer	Akira HATTORI
Coordinator, JICA (Aerial Photo Team)	Motohiro SUZUKI
Photographer	Yuji YAJIMA
Pilot	Mitsuoki HARADA
Mechanic	Kenji NAGASHIMA

CHAPTER II

PROJECT AREA

2.1 GEOGRAPHY

The Lofa County, which is considered to have impacts of the new road construction, has an area of 23,850 km². The southern part of the County is dissected plateau of 100-300 m AMSL covered with tropical rain forest, while the northern highland of 300-600 m AMSL is of savannah climate. The Wologisi mountain range runs to reach the Grand Cape Mount Country to the southeast and the Kpo mountain range runs through Belle Yella and Bopolu town. Major rivers as Mano river and Lofa river flow parallel to such mountain ranges.

Geological structure is characterized by exposure of rock beds stretching to the direction of NE-SW and predominant faults trending NW-SE. Angular gravel beds with 10-20 m in depth of originally talus deposits are distributed to the west of the Wologisi mountain range. The Lofa river runs through the strip of gneiss zone, presumably due to relative weakness of gneiss against erosion. The tributaries of river system are generally parallel to the minor fault system. The bed rock near at Bopolu is granite-gneiss, of which surfacial weathered zone is relatively thin.

2.2 CLIMATE

The annual mean precipitation ranges from 4,000-5,000 mm in the coastal plain to 2,000 mm in the northern highland. It is about 2,800 mm at Bopolu town and 2,300 mm at Voinjama town. 95 % of the annual rainfall concentrates in the wet season from April to November. The monthly mean temperature is about 24°C, with maximum and minimum temperature ranging from 10°C to 33°C. The monthly mean precipitation and maximum-minimum temperature recorded by the Liberian Products Marketing Corp. in 1969-74 are tabulated below.

TABLE 2-1 MONTHLY RAINFALL AND TEMPERATURE

Month	Rainfall (mm)	Temperature	
		Max. (°C)	Min. (°C)
Jan.	10.4	31.2	10.6
Feb.	55.5	31.3	15.5
Mar.	82.4	33.9	18.0
Apr.	169.3	33.1	19.3
May	234.8	30.7	19.4
Jun.	206.7	30.9	19.7
Jul.	270.3	29.4	20.2
Aug.	425.2	27.8	14.6
Sep.	276.7	28.2	14.3
Oct.	384.0	28.7	15.5
Nov.	138.6	30.2	18.3
Dec.	51.7	29.9	13.1

2.3 POPULATION

According to the 1974 census, the Lofa Country has population of 180,737, which accounted from about 12 % of the national population. The density of the population in the Lofa County is 7.6 persons/km². The population by districts in the Lofa County is tabulated hereunder.

TABLE 2-2 POPULATION BY DISTRICT

District	Area (km ²)	Population	(1974 census)		Density (prs/km ²)
			Male	Female	
Kolahun	3,400	56,369	26,476	29,893	16.6
Zorzor	5,640	47,247	21,409	25,838	8.4
Voinjama	3,010	35,637	16,755	18,879	11.8
Bopolu	7,970	22,471	10,614	11,857	2.8
Gbarma	2,720	17,450	10,488	6,962	6.4
Guma	1,110	1,566	751	815	1.4
Lofa County	23,850	180,737	86,493	94,244	7.6

The economically active population is about 62,500, of which some 84 % are agricultural.

2.4 AGRICULTURE

The cultivated land in the Lofa Country is about 56,000 ha., with rice, coffee, cocoa, oil palm and sugar cane as main crops. The acreage of cultivation and production of such major crops in the County are summarized as follows:

TABLE 2-3 AGRICULTURAL PRODUCTION IN LOFA COUNTY

(1975)		
Crop	Land (ha.)	Production (t)
Rice	33,620	40,360
Coffee	6,860	1,270
Cocoa	13,670	860
Sugar Cane	1,400	15,650
Oil Palm	8,530	3,810 (Palm Oil)

Despite the fact that some 33 % of the cultivated land in Liberia is cropped by rice, Liberia had to import about 20 % of the increasing national demand for rice.

Agricultural development in the Lofa Country is the major target for the balanced socio-economic development under the 5-year Development Plan (1976-80) of Liberia. The upper Lofa County Agricultural Development Project was initiated in 1976 with the objective to accelerate expansion of cultivable lands and increase productivity. The Project aims to develop 7,500 ha. for rice cultivation by 1981, and 2,800 ha of coffee and 2,300 ha. of cocoa cultivation by 1980.

Lofa Country has the largest potential of forest resources in Liberia. Table 2-4 shows the exploitable forest resources of the Lofa County. At present, the Associated Liberia Timber Corp. and Tropical Farm Corp. are exploiting timbers of Moist semi-deciduous and moist evergreen species for export.

TABLE 2-4 FOREST RESOURCES IN LOFA COUNTY

Forest	Area (10 ³ ha.)	Exploitable Area (10 ³ ha.)	Commercially Exploitable (10 ⁶ m ³)
National Forest	572	124	2.2
National Park	28	-	-
Private	288	-	-
Total	888	124	2.2

CHAPTER III

ALIGNMENT OF NEW ROAD

3.1 ALIGNMENT

To link the Wologisi mine with the ore exporting port (Monrovia port or Robertsport), three alternative alignments have been compared from technical and economic points of view.

- Route-I : Wologisi - Tahn - Madina - Robertsport
(or Monrovia)
- Route-II : Wologisi - Konehun - TFC - Bopolu - Monrovia
(or Robertsport)
- Route-III : Wologisi - Konehun - Belle Yella - Bopolu -
Monrovia (or Robertsport)

The Route-I runs through the highland between the Lofa river and Gbeya river to reach Robertsport (255 km in total). The area to the north of Tohn is scarcely populated, though it has abundant forest resources. In case the pipeline for ore transport is directed to Monrovia Port, the route will branch off at Tohn to run along the primary road between Monrovia and Kongo. The total length from Wologisi to Monrovia via Tohn is 280 km.

The Route-II will be the shortest way to reach Monrovia from Wologisi (236 km). It runs along the existing feeder road from Wologisi to Gondolahun (29 km) and from Kpelle to Bopolu (50 km). The section between Gondolahun and Kpelle should be newly connected. The pipeline for ore transport may

FIG. 3-1 ALTERNATIVE ROUTES

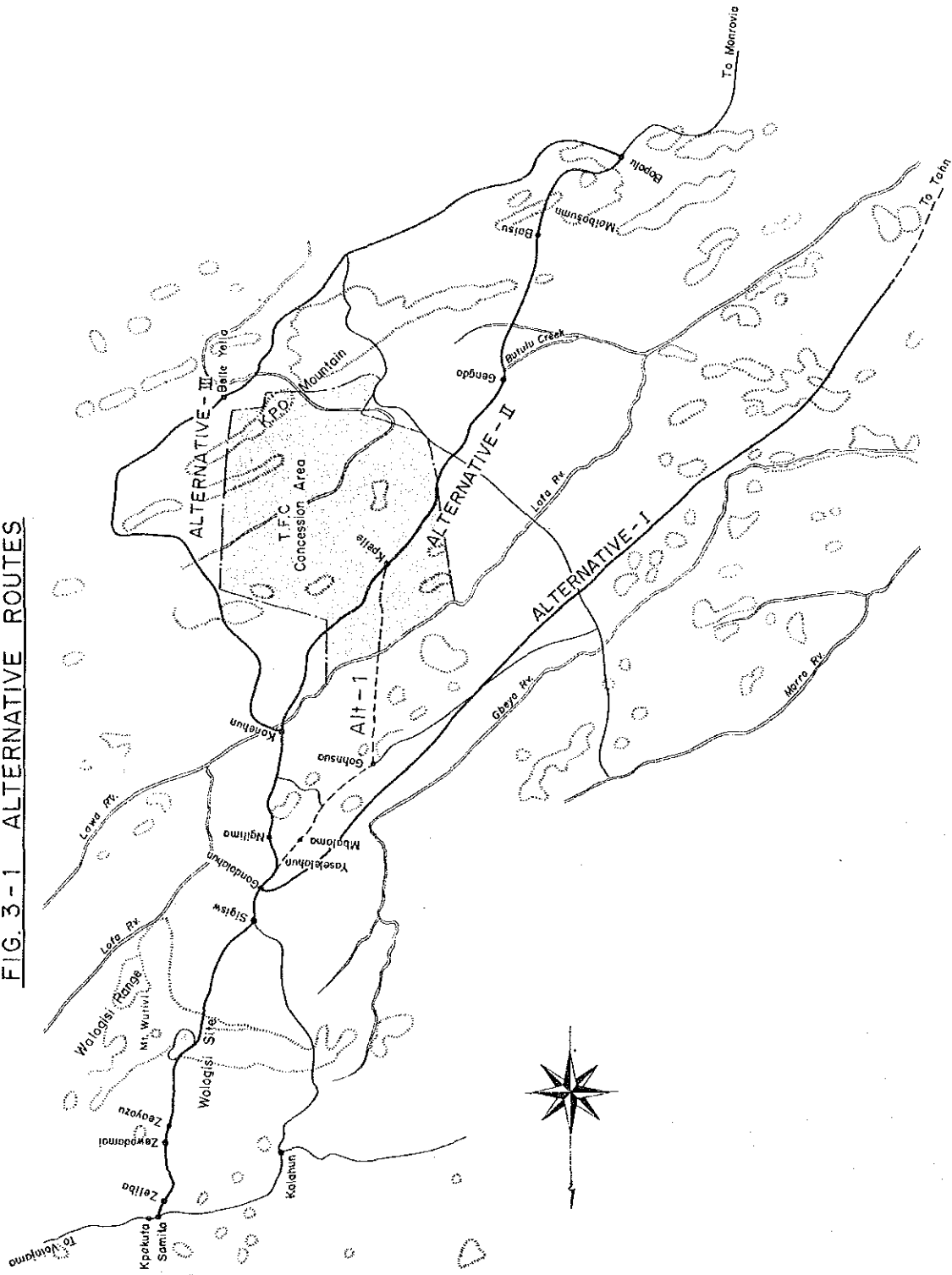
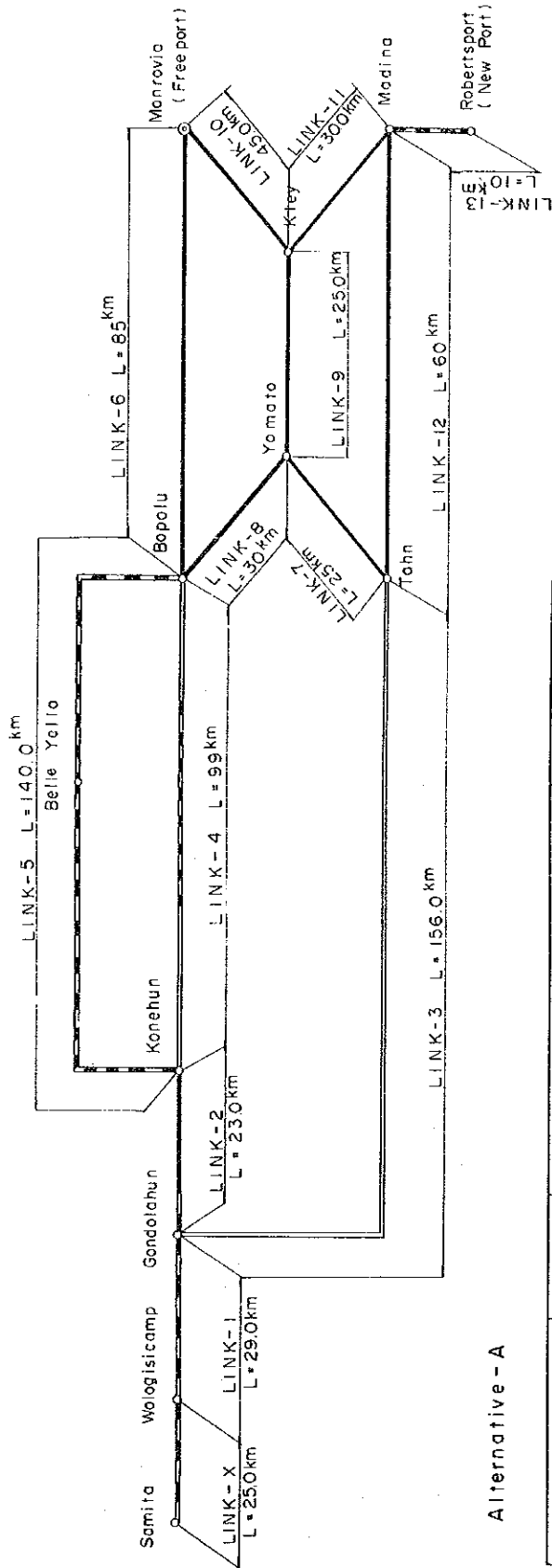


Fig 3-2 Comparative Study for Alternative Route



Alternative - A

Port	Site	Case	Route Combinations (LINK + LINK+...)	Total Route Length
Monrovia (Free Port)	Case - 1	1 + 2 + 5 + 6	277 km	
	Case - 2	1 + 2 + 4 + 6	236 km	
	Case - 3	1 + 3 + 7 + 9 + 10	280 km	

Alternative - B

Port	Site	Case	Route Combinations (LINK + LINK+...)	Total Route Length
Robertsport (New Port)	Case - 1	1 + 2 + 5 + 8 + 9 + 11 + 13	287 km	
	Case - 2	1 + 2 + 4 + 8 + 9 + 11 + 13	246 km	
	Case - 3	1 + 3 + 12 + 13	255 km	

LEGEND

- All weather road
- Unimproved road
- To be constructed road/newly

alternatively planned to reach Robertsport, branching off at Bopolu. This Route-II has been studied by LISCO group for the pipeline alignment, and the road can serve, as well, for construction and maintenance of the pipeline. The Route will also contribute for the development of forest resources along the Bopolu - Gondolahun new road and agricultural development in the region.

The Route-III is an alternative to run from Bopolu to Gondolahun via Belle Yella, where a feeder road is to be developed to link small villages scattered to the east of Kpo mountain range. This Route is longer than the Route-II by 41 km, and the construction cost of the road and pipeline will be much higher.

The Fig. 3-1 and 3-2 illustrate the alignment of the alternative routes.

As a result of comparative study, the Route-I and Route-III have been evaluated as less attractive to meet the objectives enumerated in Chapter I, and the Route-II is selected from technical and economic points of view, for the new road construction between the Wologisi mine and Bopolu.

3.2 EXISTING ROADS

Inventory survey of the existing roads along the selected Route-II has been made in the field, including:

- a) Wologisi - Gondolahun - Yaselelahun (36 km)
- b) Kpelle - TFC (Gengba) - Bopolu (62 km)

The road from Kpakuta on the Voinjama - Kolahun road to the Wologisi site (29 km) has also been surveyed, as it is necessary to improve this road to open the mine and to link the new Wologisi - Bopolu road with the road network in the northern region.

The Wologisi - Gondolahun - Yaselelahun Road is a small tract to reach the villages of Sigizu (population 350), Gondolahun (pop. 500), Yaselelahun (pop. 350), Ngilima, etc. The soil around the route is clastic deposits composed of ferruginous rock fragments cemented by iron oxides. The rolling hills in Sigizu and Gondolahun are covered by sandy and clayey laterite derived from weathered granite and granitic gneiss, which is partly overlain by layers of pebbles of the same origin with 0.5-1 m in thickness.

The section between Wologisi and Gondolahun (28.4 km) is undulated with road width of 3.7-7.9 m. The steepest gradient is 15 % and the minimum radius curve is about 35 m. Seven streams and creeks are crossed by timber bridges in this section. The Gondolahun - Yaselelahun section (8.0 km) was under construction at the moment with forest clearance width of about 15 m. The road is jeepable only during the dry season.

The Kpelle - TFC (Gengba) - Bopolu road was developed by TFC for timber extraction. It runs through the rolling terrain of mainly brown or yellowish brown laterite and clayey and sandy soils with patches of gravel beds of about 0.5 m in thickness. Granite-gneiss is exposed in the river beds. The Gengba - Bopolu road section is a laterite paved two-lane road maintained by TFC. The road has continuous curves of 50-100 m in radius with gradient of 6-8 % (max. 10 % at 4 sections). All bridges are temporary structure constructed by timbers. Along the road between Bopolu and Molbosumu, some part of lands are cultivated by rice, cassava, etc. but the major part is still covered by tropical forest.

The existing road between Wologisi and Kpakuta located on the Voinjama - Kolahun primary road has been surveyed and reported in the Phase-I Study Report (MPI-CR(1)-79-2).

The inventory of the existing roads mentioned above is illustrated in ANNEX-I appended hereto.

3.3 ALIGNMENT BETWEEN GONDOLAHUN AND TFC ROAD

For the new road construction between Gondolahun and TFC road, it is possible to plan two alternative alignments as follows:

Alt.-1 : Gondolahun - Mbaloma - Gohnsua - TFC Road

Alt.-2 : Gondolahun - Konehun - TFC Road

Alternative 1 has the characteristics that:

- a) Topographic condition to cross the Wologisi range is favorable
- b) The route passes through more villages scattered
- c) Belle Yella road (under construction by Government) crosses Lofa river at 20 km upstream of this alternative route.

While, the Alternative 2 has the characteristics that:

- a) The route crosses the Wologisi range at hilly site, but the other section has rolling topography
- b) The route passes through less number of villages
- c) The route joins with Belle Yella road at Konehun, and the Konehun - Gondolahun road can serve for Belle Yella road as well.

Although there is little difference between the Alternative 1 and 2, it is considered that the Alternative 2 will be recommendable to have multiple effects to the region in combination with the Belle Yella Road.

3.4 AREA OF INFLUENCE

The new Kpakuta - Wologisi - Bopolu road will serve for the development of the Wologisi mine, as well as for the improvement of regional transportation. The area that the new road will have impacts will be defined from the concept that about a 10-mile corridor width extending from each side of the road is a reasonable approximation of the primary zone of influence. It is assumed that the area and population of such area of influence by the construction of the new road will be as tabulated below.

TABLE 3-1 AREA OF INFLUENCE

	(1974 census)	
<u>District</u>	<u>Population</u>	<u>Area</u>
Guma	783	225
Kolahun	28,185	584
Voinjama	8,909	222
Gbarma	8,725	519
Bopolu	22,471	2,750
<u>Total</u>	<u>69,073</u>	<u>4,300</u>

CHAPTER IV

TRAFFIC

4.1 NORMAL TRAFFIC

The present traffic of the roads to be improved in the Kpakuta - Wologisi - Gondolahun section and the Bopolu - Gengba - Kpelle National Forest section was counted in the course of the field investigation, as summarized hereunder.

TABLE 4-1 PRESENT TRAFFIC

Type of Vehicle	(1978)	
	A D T	
	Kpakuta-Wologisi -Gondlahun	Bopolu-Gengba -Kpelle
Passenger Car (P/C)		4
Light Bus (L/B)	6	4
Light Truck (L/T)	8	4
Heavy Truck (H/T)		8
Total	14	20

The normal traffic in future is expected to increase as forecasted hereunder.

Passenger traffic increase:

$$\begin{aligned}
 &= (\text{population increase}) + (\text{increase in income}) \times (\text{coefficient}) \\
 &= 3.2 \% + 2.4 \% \times 1.5 = 6.8 \%
 \end{aligned}$$

TABLE 4-2 NORMAL TRAFFIC

Year	Kpamta-Wolpisi-Gondlahun					Kpelle-Gengba-Bopolu				
	P/C	L/B	L/T	H/T	Total	P/C	L/B	L/T	H/T	Total
1984	--	9	12	--	21	6	6	6	12	30
85	--	9	13	--	22	6	6	6	12	30
86	--	10	13	--	23	7	7	7	14	35
87	--	10	14	--	24	7	7	7	14	35
88	--	11	15	--	26	8	8	8	16	40
89	--	12	16	--	28	8	8	8	16	40
90	--	12	17	--	29	8	8	8	16	40
91	--	13	18	--	31	9	9	9	18	45
92	--	14	19	--	33	9	9	9	18	45
93	--	14	20	--	34	10	10	10	20	50
94	--	15	21	--	36	10	10	10	20	50
95	--	16	22	--	38	11	11	11	22	55
96	--	17	23	--	40	11	11	11	22	55
97	--	17	24	--	41	12	12	12	24	60
98	--	18	25	--	43	13	13	13	26	65
99	--	19	27	--	46	13	13	13	26	65
2000	--	20	28	--	48	14	14	14	28	70
1	--	21	29	--	50	15	15	15	30	75
2	--	22	30	--	52	15	15	15	30	75
3	--	23	32	--	55	16	16	16	32	80

P/C: Passenger car

L/T: Light truck

L/B: Light bus

H/T: Heavy truck

Freight traffic increase:
 = GDP increase = 6.8 %

Accordingly, future normal traffic is presumed to increase at the rate of 6.8 % in 1978-80 and gradually decrease the rate thereafter as follows:

1978-1980	6.8 % per annum
1981-1990	6.0 %
1991-2000	5.0 %
2001-	4.0 %

The estimated normal traffic increase up to 2003 is tabulated in Table 4-2.

4.2 TRAFFIC OF WOLOGISI MINE OPERATION

After the commencement of operation of the Wologisi mine, the traffic is generated for transport of materials, spareparts and fuel, as well as consumable goods for the mining town.

a) Transport of Materials:

Necessary materials, spareparts and fuel for the operation of the mine was estimated as tabulated below.

TABLE 4-3 MATERIALS FOR MINE OPERATION

Year	Ore Production	Materials & Spareparts	Fuel
1- 5	4 MLTPY	22,000 t/yr	54,000 t/yr
6-20	7 MLTPY	36,000 t/yr	110,000 t/yr

Source: LISCO

Daily traffic for transport of materials and spare-parts between Wologisi and Monrovia by 5-ton truck is estimated at:

$$\begin{aligned} \text{1st - 5th year} & : (22,000/5) \times 1/365 \times 2 \\ & = 24.1 \text{ vehicles/day} \end{aligned}$$

$$\begin{aligned} \text{6th -20th year} & : (36,000/5) \times 1/365 \times 2 \\ & = 39.4 \text{ vehicles/day} \end{aligned}$$

For fuel transport, the daily traffic of 10-ton oil tank lorry is estimated at:

$$\text{1st - 5th year} : (54,000/10) \times 1/365 \times 2 = 29.5$$

$$\text{6th -20th year} : (116,000/10) \times 1/365 \times 2 = 63.5$$

For transport of consumable goods, it is presumed to use 5-ton and 2-ton truck as follows:

$$\begin{aligned} \text{1st - 5th year} & : (\text{town population}) \times \\ & \quad (\text{consumption per capita}) \\ & = 2,100 \times 4 \text{ kg/day} = 8.4 \text{ ton/day} \end{aligned}$$

$$\text{5-ton truck} = 2 \quad \text{vehicles/day}$$

$$\text{2-ton truck} = 3.4 \quad \text{"} \quad \text{"}$$

$$\text{6th -20th year} : 2,733 \times 4 \text{ kg/day} = 10.9 \text{ ton/day}$$

$$\text{5-ton truck} = 2 \quad \text{vehicles/day}$$

$$\text{2-ton truck} = 5.9 \quad \text{"} \quad \text{"}$$

b) Traffic induced from Mining Town:

Staff and labors required for the mining operation was estimated as tabulated in Table 4-4 hereunder.

TABLE 4-4 WOLOGISI TOWN POPULATION

			1st - 5th year		6th - 20th year	
			Employee	Town Pop.	Employee	Town Pop.
STAFF A	Family		1	4	1	4
	Single		4	4	4	4
STAFF B	Family		3	12	3	12
	Single		13	13	11	11
STAFF C	Family		3	15	3	15
STAFF D,E	Family		93	465	99	495
	Single		31	31	25	25
STAFF F	Family		13	78	21	126
	Total		161	622	167	692
LABOR 1	Family		57	285	69	345
	Single		46	46	45	45
LABOR 2	Family		44	264	73	438
	Single		15	15	19	19
LABOR 3,4	Family		138	828	191	1,146
	Single		46	46	48	48
Total			346	1,484	445	2,041
Total			507	2,106	612	2,733

Source: LISCO

It is assumed that Staff A, B, C and a half of Staff D, E, F will make a round trip to Monrovia once a week, and all families will travel to Voinjama once a month and to Monrovia once a year by bus. Thus, traffic is estimated at:

To Monrovia:

$$\begin{aligned} \text{1st - 5th year} &: (24 + 137 \times 0.5) \times 1/7 \times 2 \\ &= 26.4 \text{ vehicle/day} \end{aligned}$$

$$\begin{aligned} &(2,100/15) \times 1/365 \times 2 \\ &= 0.8 \text{ vehicle/day} \end{aligned}$$

$$\begin{aligned} \text{6th -20th year} &: (22 + 145 \times 0.5) \times 1/7 \times 2 \\ &= 27.0 \text{ vehicle/day} \end{aligned}$$

$$\begin{aligned} &(2,730/15) \times 1/365 \times 2 \\ &= 1.0 \text{ vehicle/day} \end{aligned}$$

To Voinjama:

$$\text{1st - 5th year} : (2,100/15) \times 1/30 \times 2 = 9.4$$

$$\text{6th -20th year} : (2,730/15) \times 1/30 \times 2 = 12.2$$

The traffic related to the Wologisi mine operation is summarized as shown on Table 4-5.

TABLE 4-5 TRAFFIC OF WOLOGISI MINE

Year	Wologisi-Kpakuta					Wologisi-Kpelle-Bopolu				
	P/C	L/B	L/T	H/T	Total	P/C	L/B	L/T	H/T	Total
1984	-	9	-	-	9	26	1	3	56	86
85	-	9	-	-	9	26	1	3	56	86
86	-	9	-	-	9	26	1	3	56	86
87	-	9	-	-	9	26	1	3	56	86
88	-	9	-	-	9	26	1	3	56	86
89	-	12	-	-	12	27	1	6	105	139
90	-	12	-	-	12	27	1	6	105	139
91	-	12	-	-	12	27	1	6	105	139
92	-	12	-	-	12	27	1	6	105	139
93	-	12	-	-	12	27	1	6	105	139
94	-	12	-	-	12	27	1	6	105	139
95	-	12	-	-	12	27	1	6	105	139
96	-	12	-	-	12	27	1	6	105	139
97	-	12	-	-	12	27	1	6	105	139
98	-	12	-	-	12	27	1	6	105	139
99	-	12	-	-	12	27	1	6	105	139
2000	-	12	-	-	12	27	1	6	105	139
1	-	12	-	-	12	27	1	6	105	139
2	-	12	-	-	12	27	1	6	105	139
3	-	12	-	-	12	27	1	6	105	139

P/C: Passenger car

L/T: Light truck

L/B: Light bus

H/T: Heavy truck