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Gabinete do Secretário de Estado do Carvão e Hidrocarbonetos

CPRM · MT-GEIPOT · COBRAPI

2026-S

Programa de Desenvolvimento do Carvão de Mucanha - Vuzi

Estudo de Alternativas de Transporte

MINUTA do Relatório em Revisão
DRAFT Report Under Revision

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Contrato

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FOREWORD

The *STUDY OF OUTFLOW ALTERNATIVES* for the Mucanha/Vuzi coal production carried out by the Empresa Brasileira de Planejamento de Transportes - GEIPOT, comprises activity 9 (nine) as prescribed in the contract signed in Vienna on January 12, 1982, between the Secretary of Coal and Hydrocarbon (GSECHI) of the Popular Republic of Mozambique and the Companhia de Pesquisa de Recursos Minerais - CPRM from the Federative Republic of Brazil.

The *STUDY*, at a pre-feasibility level was officially started on August 15, 1982, although GEIPOT has advanced the phase for surveying existing data to ensure the gathering of the whole available information concerned to the project.

Fully conscious of the importance of the project for Mozambique, GEIPOT has developed an additional effort, though limited by budget and timing constraint, aimed at reducing to a minimum the error basis normally accepted in a pre-feasibility level study so as to make possible a conclusive indication of the most economical route and transportation alternative for the coal outflow from the Mucanha/Vuzi mine to a sea port on Mozambique Coast.

9.1 - INTRODUCTION

STUDY OF OUTFLOW ALTERNATIVES FOR THE COAL PRODUCTION OF THE MUCANHA/VUZI REGION

9.1 *INTRODUCTION*

The study of outflow alternatives for the coal production in the Mucanha/Vuzi Region comprises activity 9 (nine) as established in the contract signed in Vienna on January 12, 1982, between the Popular Republic of Mozambique through the Cabinet of the State Secretary for Coal and Hydrocarbon - GSECHI and the Companhia de Pesquisa de Recursos Minerais - CPRM.

The study above, carried out by the Empresa Brasileira de Planejamento de Transportes - GEIPOT was officialy started on August 15, 1982, obeying the terms established by the contract between GSECHI and CPRM. However, the phase for surveying existing data and informations was advanced, starting on May, 1982, due to the following reasons:

- the existence of studies for the Mozambique transport system in a greater number than those initially known by GEIPOT, enlarging from four to eight the possible alternatives for the coal production outflow from the Mucanha/Vuzi region;

- the confirmation that the existing studies did not permit comparison of a greater amount of information since they were carried out for different years and objectives during a period of economical and political change that followed Mozambique's independence on June 25, 1975. It was considered essential to develop an additional effort for enlarging the survey for current data and information, not initially foreseen. These information are dispersed among the Mozambique official organisms and takes a long time to collect.

- finally, in order to ensure the conclusion of the transportation studies in December, 1982, a date that is to coincide with the conclusion by CPRM of the exploratory program and most of sample analysis and tests. Such an advance from the schedule previonsly proposed, aimed at the execution of the "Technical and Economical Feasibility Study" for the coal exploitation in the Mucanha/Vuzi Region, under COBRAPI responsability, in a schedule compatible with the requirements for the beginning of the second phase of the Mucanha/Vuzi program later in 1983, if feasibility is confirmed, in order to attend to the Mozambique Government's objectives of initiating the Mucanha/Vuzi coal production later in 1990.

It must be remarked that the level of the data and informations gathered in Mozambique assured a high degree of reliability to the analysis performed and allowed selection for the most economical transportation alternative for the coal outflow from the Mucanha/Vuzi Region. Based on the reliability granted by the existing informations and on the coal production goals of the government of Mozambique, indicated in the Prospective Indicative Plan - PPI, GEIPOT considered essential to execute the basic engineering design and equipment specification no later than 1983, to allow detailing the engineering design and start the services later in 1984, thus making it possible to complete the construction between 1988 and 1990.

For this, it will be necessary to start the second phase before June 1983, having in mind the extensive field survey to be carried out, which will have to be completed before the rainfall season which starts in November/December, otherwise the field surveys will be subject to a paralyzation during the following months up to March/April, due to problems of access to the areas, with increasing costs.

The proposed program for the second phase will thus differ from the preceding one submitted to OPEC FUND since the preliminary engineering design will no longer be executed in the second phase. The third phase - basic engineering design - will be advanced by one year since GEIPOT has considered the costs unjustifiable and the one year delay in the execution of the preliminary engineering design.

9.2 - PHYSICAL AND GEOGRAPHICAL ASPECTS

9.2 PHYSICAL AND GEOGRAPHICAL ASPECTS

9.2.1 *Geographical Position*

The Popular Republic of Mozambique, which got independence on June 25, 1975, nine months after the agreement signed with Portugal in September 1974, is situated in the southeastern coast of the African Continent, between the parallels of 10º 27' and 26º 52' of latitude south and between the meridians of 30º 12' and 40º 51' of longitude east.

With 2,470 km of eastern coast in the Indian Ocean and 4,330 km of land boundary, the Popular Republic of Mozambique's territory has a total area of 799,380 km^2, of which about 13,000 km^2 is covered by water.

The territory of the Popular Republic of Mozambique borders on the north with the Republic of Tanzania and in the west (and from north to south) with the Malawi, Zambia, Zimbabwe, South Africa (Transvaal Province) and the kingdom of Swazinland. To the south, Mozambique borders with the province of Natál in South Africa (Figure 9.2.1).

9.2.2 *Geological and Geomorphological Aspects* (1)

The geological structure of Mozambique is composed mainly of crystalline soil (about 2/3 of its territory) disturbed by tectonics movements, eruptive actions and sedimentation.

In a broad view, the geomorphological characteristics are similar to most of the other Southern Africa countries, characterized by a central plateau ending in an escarpment from which it steps down up to the litoral plain. About 44% of the Mozambican territory is occupied by litorial plains, with the greatest extent in the southern half of the country. In these lito-

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(1) National Plan Commission - Statistical Informations 1980/81 - Mozambique.

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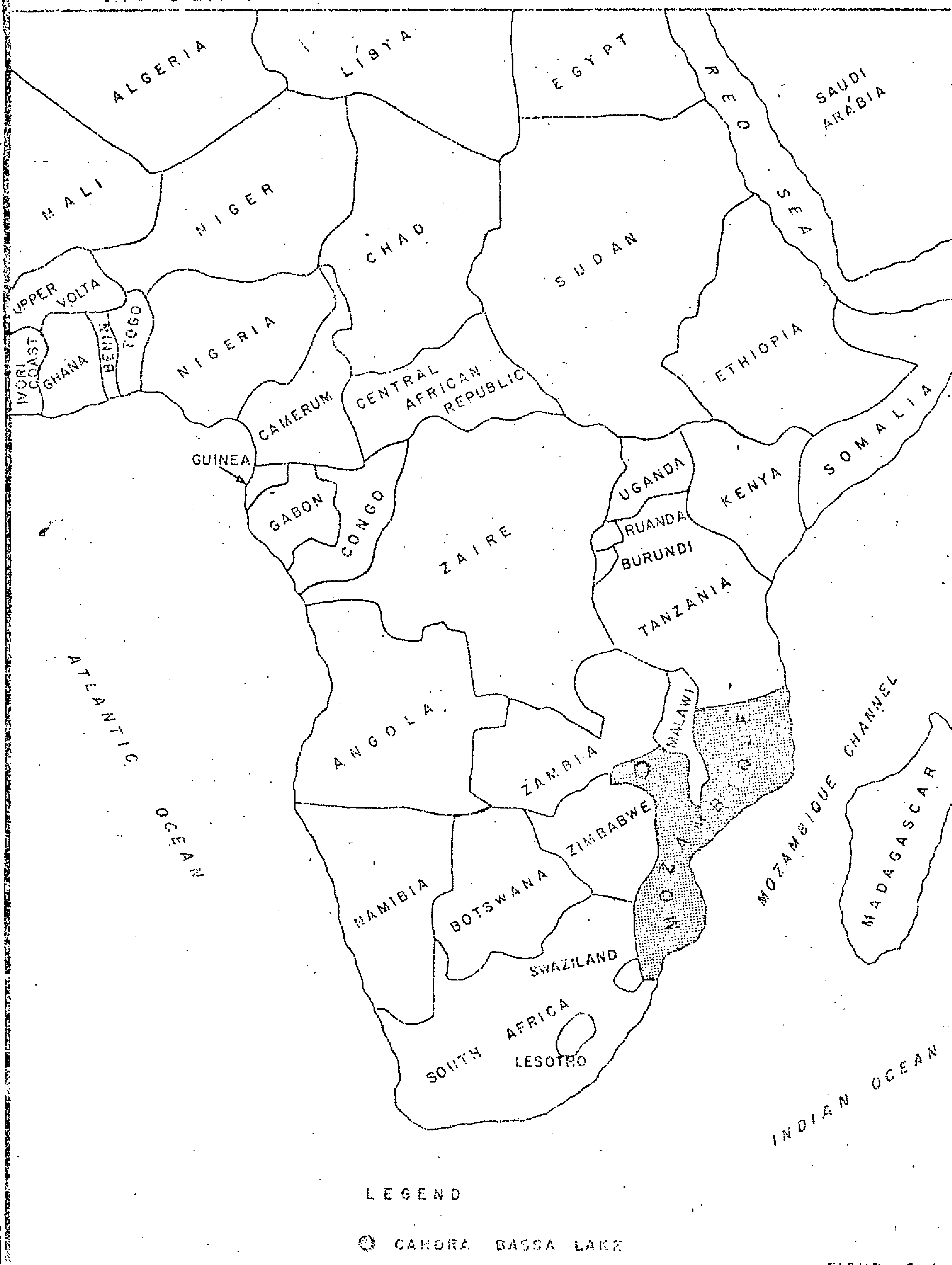

FIGURE 2.1

STUDY OF OUTFLOW ALTERNATIVES

Mozambique – Geographical Situation

ral plains altitudes do not exceed 200 meters. (Fig. 9.2.2).

The plateau zones appear to the greatest extent in the north and center of the country where altitudes vary between 200 to 1,000 meters.

The mountainous zones with altitudes over 1,000 meters occupy about 13% of the territory, occurring in smaller areas of the Niassa, Nampula, Zambézia, Tete and Manica Provinces.

The main mountainous formations are:

- The Limbombos series, which goes for 900 km from the southern border in the south-north direction up to the Pafúri Region.

- The Manica Scarp, which extends to the north until the Zambeze River and to south, until the Púngué and Buzi Rivers, continuing westwards up to Zimbabwe.

  Highest point : Mount Binga with 2,436 meters.

- The Maravia-Angonia Plateau, close to the Malawi and Zambia border.

  Highest point : Mount Domué with 2,096 meters.

- The Chire-Namúli series, in the Zambezia and Nampula (Ribaué district) provinces.

  Highest point : Mount Namúli with 2,419 meters.

- The Maniamba-Amaramba series, close to the Niassa lake and Amaramba Region.

  Highest point : the Jeci elevations with 1,836 meters.

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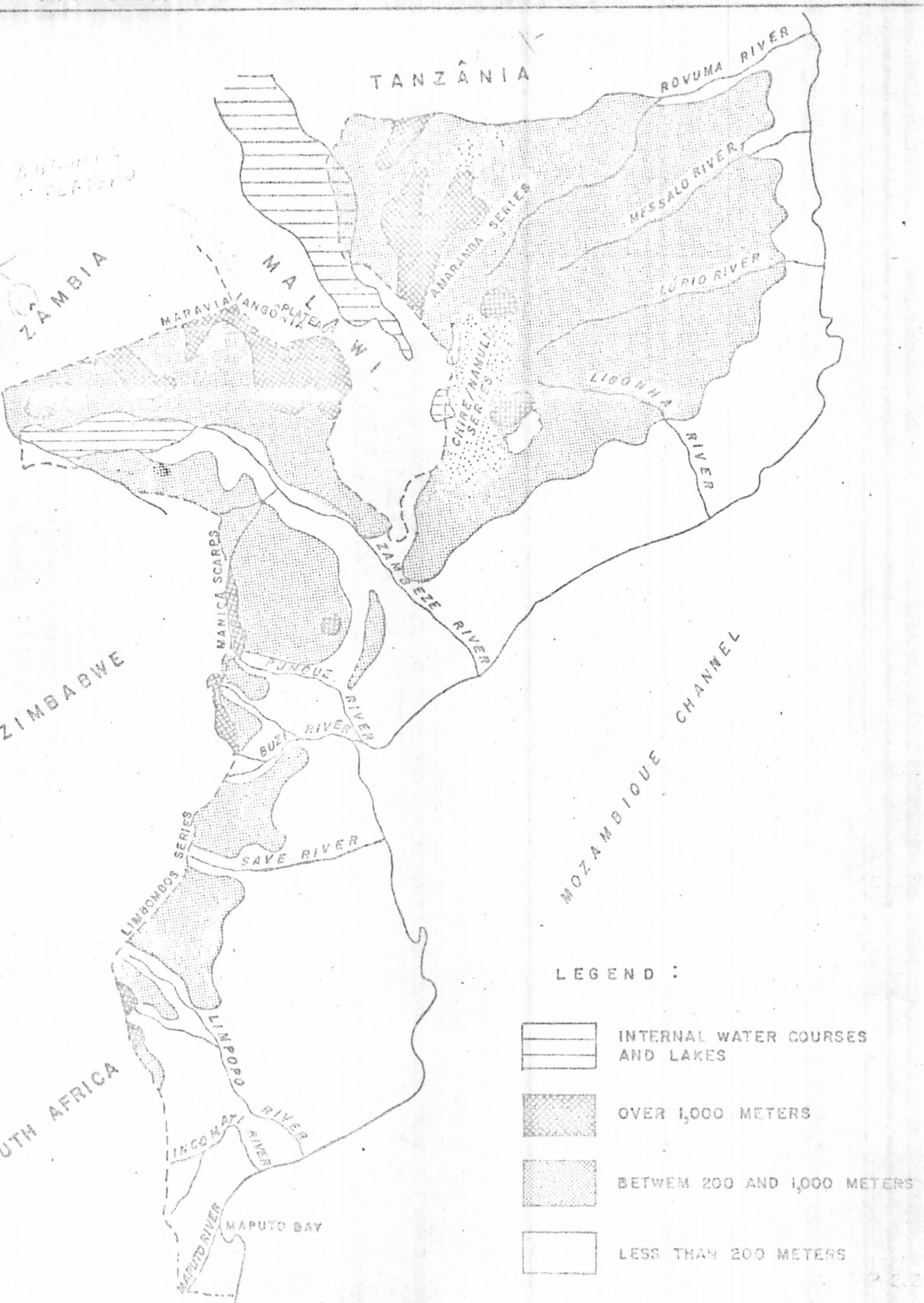

FIGURE 2.2

STUDY OF OUTFLOW ALTERNATIVES

Mozambique – Oro-Hydrographical Map

9.2.3 *Hydrography*

Because of topography arrangements, Mozambique Rivers runs from west to east, toward to the Indian Ocean . By their importance and extension, the main rivers of Mozambique are:

- Rovuma River - which defines a natural border between the Popular Republic of Mozambique and the United Republic of Tanzania.

- Messalo River - which has its origin in the Niassa province and crosses all the way through the Cabo Delgado province.

- Lurio River - 1,100 km in length, forms the border between the Niassa and Nampula provinces, as well as between Cabo Delgado and Nampula. -

- Ligonha River - which forms the border between the Zambezia and Nampula provinces.

- Zambeze River - has its origin in Zambia, close to the Zaire and Angola border, crosses parts of the Angola territory and the Zambia territory forming the border between Zambia and Zimbabwe where is located the Cariba hydroelectric power station and finally it enters the Mozambique territory and runs for about 850 km up to the Idian Ocean south of Chinde. On this part of the river is located the Cahora Bassa hydroeletric power station, one of the biggest in the African Continent.

- Pungué River - has its origin in Zimbabwe and ends at the Beira estuary.

- Buzi River - which also has its origin in Zimbabwe and ends close to Pungue River. Its principal tributary is the Revue River on which is located the Chicamba power station.

- Save River - which also has its origin in Zimbabue and makes a natural boundary between Manica and Sofala provinces on the north and the Gaza and Inhambane on the south.

- Limpopo River - has its origin in South Africa, close to Johan nesburg and ends close to the city of Xai-Xai.

- Incomati River - has its origin in South Africa (Transvaal pro vince), crosses Swaziland territory and ends at the Maputo Bay.

- Maputo River - has its origin in Swaziland and ends at the Ma puto Bay.

9.2.4 *Climate*

The Popular Republic of Mozambique has a tropical climate on the whole with small differences due to varia tions in altitude and the warm stream in the Mozambique Channel, the last one responsible for its coastal climate. Besides those aspects the climate of Mozambique is also influenced by factors li ke the equatorial low pressure zones and the tropical anticiclone which causes the warm climate, the continental depressions from thermal origin which are responsible for the drought weather periods and the polar fronts which give origin to the cool weather in the southern part of the country. The weather in Mozambique (Figure 2.3) may be classified as:

- The Tropical Rainy Weather, which is dominant in the northern half, in the central part and also in the southern coas tal part of the country, characterized by a rainfall weather lasting longer than the drought weather period.

- The Tropical Drought Weather, which is dominant in the southern half of the country and in the upper Zambeze valley in Mozambique, which is characterized by a drought weather lasting longer than the rainfall weather period.

- The Tropical Weather of Altitude, which is characteristic of the mountainous zones, less warmer than the tropical drought weath er and with higher rainfall indicators than the previous one.

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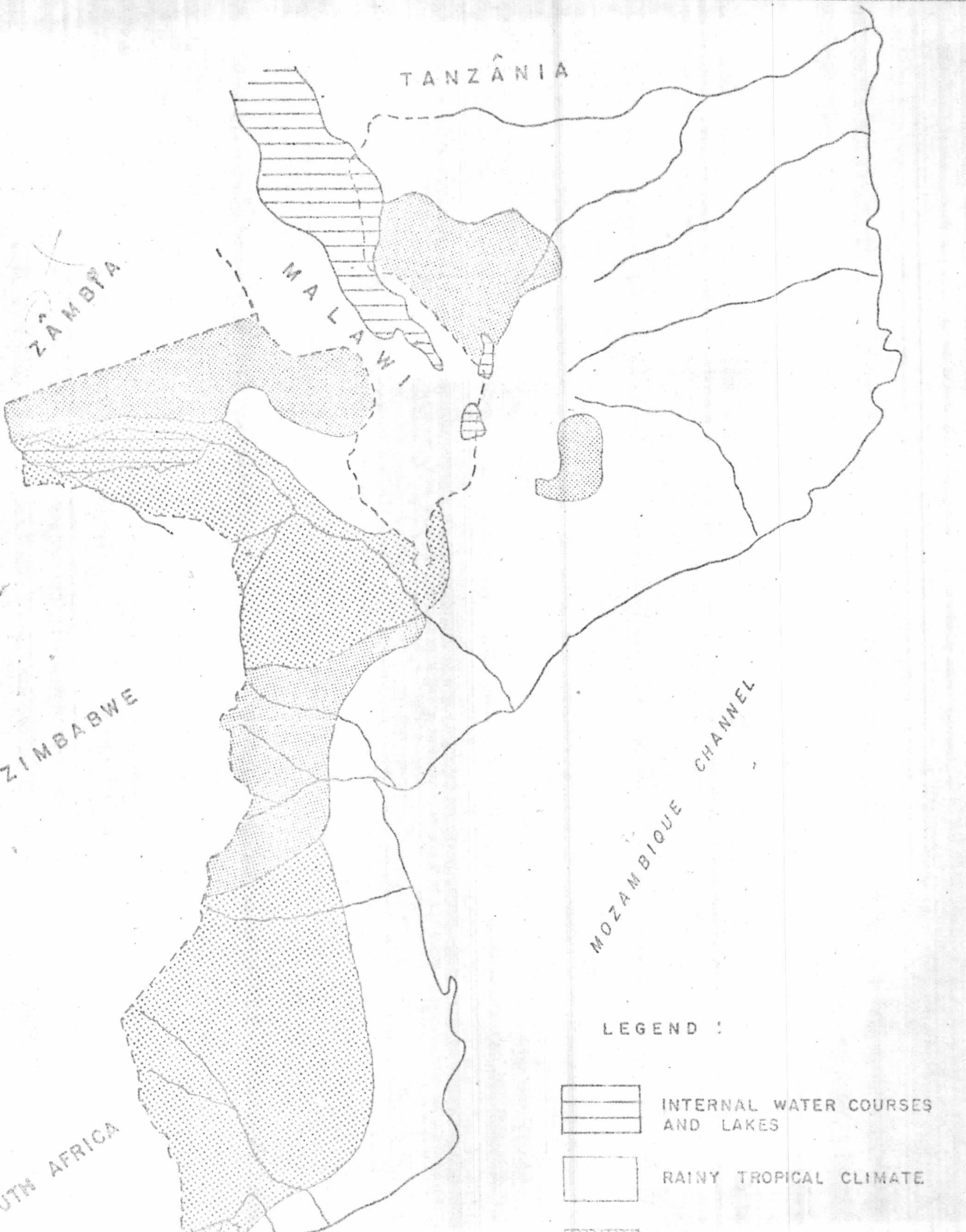

FIGURE 2.3

STUDY OF OUTFLOW ALTERNATIVES

Mozambique - Climates

9.2.5 *Vegetation*

The Popular Republic of Mozambique shows three main types of vegetation:

- The Mixed Thicket Forest - which occupies a small portion of the Mozambique territory, specially in the mountainous areas of the Sofala, Manica, Zambezia, Nampula and Cabo Delgado provinces.

- Open Forests.

- Savanna.

The open forests and the savanna accounts for about 2/3 of the Mozambique territory.

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9.3 - SOCIO-ECONOMICAL ASPECTS

9.3 SOCIO-ECONOMICAL ASPECTS

9.3.1 *Administrative Divisions*

The Popular Republic of Mozambique is divided into 10 (ten) provinces, each one subdivided into districts accounting for a total of 109 districts.

The provinces and respectives districts are, from North to South, the following:

- Cabo Delgado Province: Palma, Mocimboa da Praia, Mueda, Macomia, Ibo, Quissanga, Meluco, Ancuabe, Pemba, Montepuez, Mecufi, Chiure, Namuno.

- Niassa Province: Mecula, Sanga, Lago, Mavago, Marrupa, Majune, Maúa, Mandimba, Amaramba, Mecanhelas.

- Nampula Province: Erati, Memba, Mecuburi, Minguri, Nacala, Muecate, Ribauê, Malema, Nampula, Mossuril, Meconta, Mozambique, Nampula, Murrupala, Mogincual, Mogovolas, Angoche, Moma.

- Tete Province: Angonia, Chiuta, Macanga, Maravia, Zumbo, Cahora Bassa, Magoé, Moatize, Tete, Mutarara.

- Zambezia Province: Gurué, Alto Molocue, Namarroi, Ile, Milange, Gilé, Lugela, Mocuba, Pebane, Manganja da Costa, Morrumbala, Namacurra, Quelimane, Mopéia, Chinde.

- Manica Province: Tambara, Guro, Barue, Manica, Chimoio, Sussundenga, Mossurize.

- Sofala Province: Chemba, Caia, Marromeu, Inhaminga, Gorongosa, Dondo, Beira, Buzi, Chibabava.

- Gaza Province: Chicualacuala, Massingir, Canicado, Limpopo, Chibuto, Manjacaze, Bilene, Gaza.

- Inhambane Province: Govuro, Vilanculos, Massinga, Morrumbene, Maxixe, Homoine, Inhambane, Panda, Inharrime, Zavala.

- Maputo Province: Magude, Manhiça, Moamba, Marracuene, Matola, Cidade de Maputo, Namaacha, Matutuíne.

The urban agglomeration with city ordinance and its populations (august, 1980), are:

- Maputo (755,300 inhabitants)
- Beira (228,783 inhabitants)
- Nampula (158,098 inhabitants)
- Nacala (85,211 inhabitants)
- Chimoio (70,851 inhabitants)
- Inhambane (61,261 inhabitants)
- Quelimane (60,402 inhabitants)
- Tete (48,718 inhabitants)
- Xai-Xai (45,206 inhabitants)
- Pemba (42,827 inhabitants)
- Lichinga (39,121 inhabitants)
- Chokwè (13,195 inhabitants).

9.3.2 *DEMOGRAPHICAL SITUATION*

The total population in Mozambique, according to the first general census of population done on august 1, 1980 was 12,130,000 inhabitants (of which 51.3% were men) in a total of 2,835,500 families which gives an average of 4.28 persons per family. Around 97% of population in Mozambique is distributed between the ethnical groups of the Nyanga, Macua-Yau, Maconde, Sena, Ndau-Nyaua-Shona and Tsonga-Vatsua-Ronga and the 3% left being made up of inhabitants of european and asiatic origins. Also living in the country on a temporary status, were a number of tecnicians from several origins under contract, so called "Cooperantes", and technical teams from a number of countries, developing activities connected with commercial and tecnical cooperation agreements.

Table 9.3.1 shows the area and population by province and total for Mozambique for the years of 1970 and 1980.

TABLE 9.3.1 -AREA AND POPULATION BY PROVINCE - 1970 - 1980

PROVINCES	AREA KM^2	POPULATION (1,000 inhab.)		ANNUAL RATE OF GROWTH % PER YEAR	NUMBER OF FAMILIES IN 1980 (1,000)
		1970	1980		
1-CABO DELGADO	86,625	480	940	4.83	136.1
2-NIASSA	129,056	285	514	6.07	221.9
3-NAMPULA	81,606	1,716	2,403	3.42	640.8
4-TETE	100,724	468	831	5.91	587.0
5-ZAMBEZIA	105,008	1,747	2,500	3.65	192.1
6-MANICA	61,661	427	641	4.15	124.0
7-SOFALA	68,018	652	1,065	5.03	224.5
8-GAZA	75,709	794	991	2.24	233.0
9-INHAMBANE	68,615	748	998	2.93	209.0
10-MAPUTO	26,358	800	1,247	4.54	267.1
TOTAL	799,380	8,185	12,130	4.01	2,835.1

SOURCE: CONSELHO COORDENADOR DE RECENCEAMENTO - 1º Recenceamento Geral da População - 1 de agosto de 1980.

- For population per district see Table 9.3.1-A

It must be pointed out that the 1970 and 1980 census are not representative of a natural growth historical series of Mozambique's population, since the 1970 census had been done during the independence fights and the 1980 census naturally reflects the population loss due to the exodus from Mozambique territory after independence by a number of European origin families, mainly Portuguese.

In both cases, some provinces were more affected than others.

TABLE 9.3.1-A POPULATION PER DISTRICT: MOZAMBIQUE

1970 - 1980

(1,000 inhab.)

ADMINISTRATIVE LIMITS PROVINCE (PROVINCE CAPITAL**) DISTRICT (DISTRICT CAPITAL)	1970	1980	
		TOTAL	AVERAGE PER FAMILY
1 - CADO DELGADO PROVINCE	548	940	4.2
1 - Palma	19	67	4.7
2 - Mocimboa da Praia	23	49	4.4
3 - Mueda	14	139	5.4
4 - Macomia	34	58	4.2
5 - Ibo	7	7	3.8
6 - Quissanga	22	27	3.9
7 - Meluco	15	21	4.9
8 - Ancuabe	31	46	4.1
9 - Pemba (**)	46	70	4.2
10 - Montepuez	108	146	3.7
11 - Mecufi	34	36	4.2
12 - Chiure (Chiure Novo)	92	114	4.0
13 - Namuno	103	160	3.9
2 - NIASSE PROVINCE	285	514	3.8
14 - Mecula	5	7	4.0
15 - Sanga (Macaloge)	10	24	3.8
16 - Lago (Metangula)	13	39	3.8
17 - Mavago (Chiconono)	4	22	3.9
18 - Marrupa	25	33	4.0
19 - Lichinga (**)	52	91	3.7
20 - Majune (Malanga)	16	20	3.8
21 - Maũa	44	58	3.7
22 - Mandimba	46	64	3.6
23 - Amaramba (Cuamba)	68	85	3.7
24 - Mecanhelas	54	71	4.0
3 - NAMPULA PROVINCE	1,716	2,403	3.7
25 - Erati (Namapa)	213	290	3.7
26 - Memba	120	158	3.8
27 - Mecuburi	66	84	4.0
28 - Nacala (Minguri)	52	64	3.4
29 - Maiaia (Nacala)	63	121	3.8
30 - Muecate	39	54	3.9

(1,000 inhab.)

ADMINISTRATIVE LIMITS PROVINCE (PROVINCE CAPITAL**) DISTRICT (DISTRICT CAPITAL)	1970	1980 TOTAL	1980 AVERAGE PER FAMILY
31 - Ribaue	89	136	4.3
32 - Malema	59	90	4.1
33 - Monapo	131	201	3.7
34 - Mossuril	58	72	3.4
35 - Meconta	67	86	3.3
36 - Moçambique	22	33	3.7
37 - Nampula (**)	124	247	3.9
38 - Murrupula	71	90	4.0
39 - Mogincual	82	96	3.7
40 - Mogovolas (Nametil)	173	213	3.5
41 - Angoche	150	192	3.6
42 - Moma	137	176	3.8
4 TETE PROVINCE	468	831	4.4
43 - Angonia (Ulongue)	104	226	4.0
44 - Chiuta (Tembuê)	3	41	4.3
45 - Macanga (Furancungo)	33	61	4.2
46 - Maravia (Fingoé)	10	34	4.3
47 - Zumbo	19	32	4.4
48 - Cahora Bassa (Songo)	26	50	4.6
49 - Magoé	5	10	4.6
50 - Moatize	59	106	3.9
51 - Tete (**) + Changara	93	136	4.6
52 - Mutarara (Nhamalabue)	136	135	5.1
5 ZAMBÉZIA PROVINCE	1,747	2,500	4.3
53 - Gurué	106	171	4.5
54 - Alto Molocue (Molocue)	106	147	4.2
55 - Namarroi	76	91	3.9
56 - Ile (Errego)	184	258	4.7
57 - Milange	171	318	4.5
58 - Gilé	69	99	4.4
59 - Lugela	76	108	4.0
60 - Mocuba	108	149	4.3
61 - Pebane	91	119	4.1
62 - Manganja da Costa (Olinga)	161	213	4.0

(1,000 inhab.)

ADMINISTRATIVE LIMITS PROVINCE (PROVINCE CAPITAL **) DISTRICT (DISTRICT CAPITAL)	1970	1980 TOTAL	1980 AVERAGE PER FAMILY
63 - Morrumbala	141	202	4.4
64 - Namacurra	120	167	4.0
65 - Quelimane (**)	184	244	4.1
66 - Mopeia	56	65	4.3
67 - Chinde	98	149	4.2
5 MANICA PROVINCE	427	641	5.2
68 - Tambara	26	14	4.3
69 - Guro	34	52	5.1
70 - Barue (Cantandica)	52	71	5.7
71 - Manica	40	54	4.9
72 - Chimoio (**)	114	214	4.8
73 - Sussundenga	53	46	5.3
74 - Mossurize (Espungabera)	108	190	5.5
SOFALA PROVINCE	652	1,065	4.7
75 - Chemba	67	63	6.9
76 - Caia	54	85	4.9
77 - Marromeu	45	77	3.9
78 - Cherigoma (Inhaminga)	44	63	4.9
79 - Gorongosa	90	111	6.5
80 - Dondo	55	151	4.3
81 - Beira (**)	130	229	4.1
82 - Buzi	82	145	5.1
83 - Chibabava	85	141	4.8
GAZA PROVINCE	794	991	4.7
84 - Chicualacuala	47	79	6.0
85 - Massingir	37	27	4.9
86 - Caniçado (Guijá)	71	100	5.3
87 - Limpopo (Chókwe)	91	122	5.0
88 - Chibuto	205	220	4.8
89 - Manjacaze	139	174	4.4
90 - Bilene (Macia)	80	103	4.5
91 - Gaza (Xai-Xai) (**)	124	166	4.2

(1,000 inhab.)

ADMINISTRATIVE LIMITS PROVINCE (PROVINCE CAPITAL**) DISTRICT (DISTRICT CAPITAL)	1970	1980 TOTAL	1980 AVERAGE PER FAMILY
9 - INHAMBANE PROVINCE	748	998	4.3
92 - Govuro (Nova Mambone)	60	75	5.2
93 - Vilanculos	97	128	4.9
94 - Massinga	148	223	4.4
95 - Morrumbene	76	110	4.0
96 - Maxixe (Cidade de Inhambane)	40	61	3.3
97 - Homoine	70	95	3.7
98 - Inhambane (**)	84	93	4.2
99 - Panda	35	56	4.3
100 - Inharrime	57	68	4.3
101 - Zavala (Quissico)	81	91	4.5
10 - MAPUTO PROVINCE	800	1,247	4.6
102 - Magude	76	100	5.1
103 - Manhiça	98	145	4.4
104 - Moamba	59	80	4.9
105 - Marracuene	39	47	4.1
106 - Matola	87	40	3.9
107 - Cidade de Maputo (**)	378	755	4.7
108 - Namaacha	17	25	4.7
109 - Matutuine (Bela Vista)	46	55	4.6
TOTAL	8,185	12,130	4.2

SOURCE: CONCEL OF CENSUS COORDINATION - FIRST GENERAL DEMOGRAPHICAL CENSUS - 01-08-1980.

9.3.3 *The Mozambique's Government*

The Popular Republic of Mozambique is an independent state of popular democracy under the Mozambique's Liberation Front (FRELIMO) political orientation, which is responsible for the planning of the state functions as a whole. The Popular Assembly is the state's superior body in the Republic, being the highest legislative organism. Mozambique has been governed by President Samora Moisés Machel since the year of independence, assisted by a Concil of Ministers presided by the President of the Republic.

9.3.4 *Gross Domestic Product*

The GDP in Mozambique offers the following values for the years before and the three years after the independence for which the information is available:

YEARS	VALUE (US$ millions)
1963	965
1967	1,277
1971	2,139
1975	1,410
1976	1,380
1977	1,170

SOURCE: A Economia de Moçambique em números - 1973 also Quartely Economic Review of Tanzania and Mozambique - Annual Supplement - 1981.
- SOUTH AFRICAN DEVELOPMENT CO-ORDINATION CONFERENCE -SADCC- 1981.

The numbers shows the effects of political and economical changes which occurred in the country during the period after independence in 1975, in which the average rate or growth for the period which goes from 1963 to 1971 has decreased from a +10% positive to a -6% negative annual rate of growth in the 1975 to 1977 period. Calculated for the period which goes from 1970 to 1978, the GDP was estimated by the United Nations as having decreased at an average annual rate of 8%.

Recent statistics indicate some recuperation in the Mozambique economy, even though its Balance of Payment Problems and the scarcity of qualified personnel to administrate the economic sectors as a whole..

Concerning the per capita income, reliable information is not available for the period after 1971. From 1967 to 1971, the per capita income level are:

TABLE 9.3.2-PER CAPITA INCOME LEVEL IN MOZAMBIQUE - 1967 - 1971

YEARS	CURRENT PRICES		1963 CONSTANT PRICES	
	ESCUDOS	US$	ESCUDOS	US$
1967	4.695	165	4.240	149
1968	5.180	182	4.668	163
1969	5.450	191	4.960	174
1970	6.280	220	5.504	193
1971	6.810	254	5.748	215

SOURCE: A Economia de Moçambique - 1973.

Although reliable information is not available, the World Bank classified Mozambique in the group of countries with a per capita income level close to US$ 200.00 and the FAO's estimatives gives a value around US$ 160.00.

9.4 - THE MOZAMBIQUE ECONOMY

9.4 THE MOZAMBIQUE ECONOMY

After a period of relatively rapid development in the mid-sixties, the economy of Mozambique had declined in the ten-years colonial war period. The decrease in the rate of growth was higher in the final years of the war, because the country's physical infrastructure was substantially damaged. Since independence in 1975, difficulties were further aggravated by, among other things, the massive departure of technicians and qualified labor force from Mozambique, mainly Portuguese citizens. About 90% of the 240,000 Portuguese citizens living in Mozambique in 1973, have since departed from the country.

The situation was further aggravated due to the former Rhodesian liberation movement which lead the Mozambique Government to close the border with that country in 1976. This put an end to the transit trade and consequently a lost in foreign exchange revenues based on transportation services to that country, and also the resulting damage to the Mozambique's infrastructure caused by Rhodesian Air Force attacks up to 1979. Besides that, the Mozambique economy has had other problems like the floods which occurred in southern part of the country during 1977 and 1978 and the drought in six provinces during 1979 and 1980 which greatly affected the agricultural production in those years.

9.4.1 *Primary Sector*

9.4.1.1 *Agriculture and Fishing*

Even though 88% of the Mozambique's labor force is dedicated to the agricultural and fishing activities, the contribution of the primary sector on the Gross Domestic Product (GDP) is only 25% of the total, being responsible for 50% of the export revenues. This is due to the many difficulties that the Mozambique's primary sector has been subject to in the period that followed the independence war which ended in 1975. Only 4.4% of the total land in Mozambique is cultivated all the year round, with low levels of productivity. The decline in the MOzambican agriculture after the independence in 1975 is particularly noticeable in the Zambeze province, one of the most fertile provinces and where about 20% of the whole population of Mozambique is located.

The whole economical planning strategy of the Mozambique Government considers the agricultural sector as a priority one. In parallel with the Development Plan, whose basic premises were defined in the III FRELIMO CONGRESS (1977), the Government has been developing efforts to change the agriculture property structure by means of:

- Development of the "Machambas": which are large state properties having the objective of producing for domestic consumption and exports.

- Development of the agricultural co-operative societies: which are the assembly of several farm owners with the objective of producing for domestic supply.

The rehabilitation of the primary sector to raise it to the production levels in effect before independence has succeeded only in part. In the "Machambas" in the traditional sector of small land owners and the co-operative societies in processing, resale and consumption societies the supply has increased the organization and communications levels, but the production and the productivity levels are inferior to those established by the III FRELIMO CONGRESS in 1977.

Otherwise, although the fairly good fishing conditions for both the Mozambican's coast and the rivers and lakes, fishing activities have also declined due to the lack of supply of equipment and materials for the traditional fishing activities and difficulties faced by Mozambique with the scarcity of a specialized labor force and spare parts for operation and maintenance of the modern fishing fleet actually available, beeing very active at the present time the fishing activity under commercial agreements with the Spain and the Soviet Union.

For these reasons, it was brought up at the IV FRELIMO CONGRESS in 1981 to establish a directive policy for the eighties. Although details of the established directives ate not available it is known that for the primary sector, the main goal is to reach "the self sufficiency in the agricultural production of the so called people supplying products, through heavy investments in the agroindustrial complex of modern technology, which will absorb at least ten percent of the rural labor force". In complement, the co-operative societies will be encouraged.

A detailed analysis of the defined objectives shows that for it success and, considering the demographical rate of growth in the 1970 to 1980 decade (although not representative of a natural birth growth) which will increase Mozambique's popula tion to 18 million inhabitants by 1990 and 20 million in 1995, the production of grains will have to double at the end of the eighties and almost triple up to 1995.

Although no difficulties are foreseen in what land availa bility is concerned, a large amount of resources will be required for training of a labor force, enlargement of agricultural land, research, import of equipment and fertilizers and improvements in the transport system as well.

In whatever the production is concerned, Mozambique may be characterized as mainly oriented toward agriculture. The decli ne in the agricultural production may be observed in Table 4.1, which shows the variation in Mozambique's production for the main export products and domestic supply.

Even though the actual domestic difficulties, Mozambique is considered as having a fairly good agricultural potential through both the enlargement of cultivated areas or increasing in productivity.

TABLE 9.4.1 - PRODUCTION OF MOZAMBIQUE'S MAIN AGRICULTURAL PRODUCTS FOR EXPORT AND DOMESTIC SUPPLY

(1000 tons)

PRODUCTS	1970	1976	1979
RICE	99	61	56
MAIZE	373	431	66
SORGHUM	226	163	6
WHEAT	5	2	-
COTTON	139	37	30
SISAL	30	13	-
GROUNDNUT	55	25	7
BEAN	72	43	13
CASHEW-NUT	200	119	91
COPRA	68	72	56
TEA	17	14	-

SOURCE: Departamento de Estatística (Statistic Department)

Although it has not been possible to collect updated information concerning the production levels, there is information about the five main commercialized products for domestic supply and export as well as the internal movements in Mozambique based on the harvest forecasts for 1981/82 and transport plan.

Table 9.4.2 shows the execution of the commercialized harvest in 1981 for the main products for domestic supply. It can be observed that the family sector was responsible by 50% of the commercialized surplus in 1981 versus 37.5% from state and 10.3% from private sectors.

The main products for export and domestic supply in Mozambique are:

TABLE 9.4.2 - MAIN PRODUCTS FOR DOMESTIC SUPPLY
- EXECUTION OF THE COMMERCIALIZED SURPLUS - 1981 HARVEST

UNIT: tons

PROVINCES SECTOR	RICE	MAPIRA	MAIZE	CASSAVA	COPRA	GROUND NUT	SUN-FLOWER	SESAME	MAFURRA	BEAN	WHEAT	TOTAL
MAPUTO												
Total	692	53	1,884	-	-	-	184	-	-	9	106	2,928
State	633	53	1,432	-	-	-	180	-	-	-	106	2,404
Cooperative	18	-	39	-	-	-	4	-	-	-	-	61
Private	16	-	293	-	-	-	-	-	-	8	-	317
Family	25	-	120	-	-	-	-	-	-	1	-	146
GAZA												
Total	25,124	-	4,103	-	-	-	18	-	1,300	52	54	30,651
State	23,500	-	739	-	-	-	-	-	-	-	-	24,239
Cooperative	1,041	-	815	-	-	-	18	-	-	9	54	1,937
Private	525	-	370	-	-	-	-	-	-	1	-	896
Family	58	-	2,179	-	-	-	-	-	1,300	42	-	3,579
INHAMBANE												
Total	-	-	523	639	4,024	-	46	-	2,503	-	-	7,735
State	-	-	59	-	-	-	43	-	-	-	-	102
Cooperative	-	-	10	-	-	-	-	-	-	-	-	10
Private	-	-	-	-	-	-	-	-	-	-	-	-
Family	-	-	454	639	4,024	-	3	-	2,503	-	-	7,623
SOFALA												
Total	281	56	1,129	-	-	15	640	27	-	62	-	2,210
State	276	-	787	-	-	15	487	-	-	18	-	1,583
Cooperative	-	-	-	-	-	-	-	-	-	-	-	-
Private	-	40	35	-	-	-	-	1	-	15	-	91
Family	5	16	307	-	-	-	153	26	-	29	-	536
MANICA												
Total	-	57	8,294	-	-	72	1,141	6	-	106	151	9,827
State	-	-	6,924	-	-	-	734	-	-	81	151	7,890
Cooperative	-	-	220	-	-	-	70	-	-	-	-	290
Private	-	-	479	-	-	-	35	-	-	-	-	514
Family	-	57	671	-	-	72	302	6	-	25	-	1,133
TETE												
Total	-	205	21,494	-	-	3	316	-	-	1,463	-	23,481
State	-	-	11,448	-	-	-	88	-	-	-	-	11,536
Cooperative	-	-	126	-	-	-	12	-	-	-	-	138
Private	-	-	1,195	-	-	-	47	-	-	5	-	1,247
Family	-	205	8,725	-	-	3	169	-	-	1,458	-	10,560
ZAMBEZIA												
Total	1,650	205	25,647	6,444	50,375	106	1,501	15	-	10,448	-	96,391
State	312	102	6,852	-	15,000	103	662	-	-	57	-	23,588
Cooperative	206	-	211	-	-	-	29	-	-	20	-	466
Private	25	-	2,110	4	12,734	-	97	-	-	223	-	15,193
Family	607	103	16,474	6,440	22,641	3	713	15	-	10,148	-	57,144
NAMPULA												
Total	645	167	4,639	2,683	-	4,506	4,707	349	-	405	-	18,101
State	-	142	550	-	-	-	569	-	-	303	-	1,564
Cooperative	139	10	50	-	-	-	255	64	-	-	-	518
Private	70	-	350	150	-	-	850	77	-	-	-	1,497
Family	436	15	3,689	2,533	-	4,506	3,033	208	-	102	-	14,522
NIASSA												
Total	91	18	7,068	85	-	-	2,593	-	-	2,195	60	12,110
State	18	-	4,146	-	-	-	185	-	-	35	60	4,444
Cooperative	3	-	108	-	-	-	79	-	-	37	-	227
Private	51	-	154	-	-	-	125	-	-	-	-	330
Family	19	-	2,660	85	-	-	2,204	-	-	2,123	-	7,10[illegible]
CABO DELGADO												
Total	377	216	3,541	1,058	-	250	934	110	-	139	-	6,625
State	355	-	852	-	-	-	337	-	-	3	-	1,547
Cooperative	-	-	123	-	-	-	42	3	-	-	-	168
Private	-	40	1,000	-	-	-	392	7	-	64	-	1,503
Family	22	176	1,566	1,058	-	250	163	100	-	72	-	3,407
NATIONAL TOTAL/81												
Total	28,860	977	78,322	10,909	54,399	4,952	12,080	507	3,803	14,879	371	210,05[illegible]
State	25,594	297	33,789	-	15,000	15	3,285	-	-	497	317	78,79[illegible]
Cooperative	1,407	10	1,702	-	-	-	509	67	-	66	54	3,81[illegible]
Private	687	80	5,985	154	12,734	-	1,546	85	-	316	-	21,58[illegible]
Family	1,172	590	36,845	10,755	26,665	4,937	6,740	355	3,803	14,000	-	105,80[illegible]

SOURCE: DIREÇÃO NACIONAL DO COMÉRCIO INTERNO (NATIONAL DIRECTION FOR INTERNAL TRADE)

Cashew-nut

The production area is located on the coast mainly in Nampula district which is responsible for 80% of the Mozambique's production of about 15,000 tons of cashew-nut.

Cotton

The cotton cultivation in 1981 occupied an area of about 335,000 ha. with a production of raw cotton of about 102,000 tons. The family sector was responsible for 86% of the cultivated area and 55% of the production which represents 50,900 tons of cotton seed of which 15,000 tons for seed-plot and 35,900 tons for the oil industry and 32,600 tons of cotton fibers of which 22,900 tons for export and 9,700 tons for domestic consumption (forecast for the harvest in 1981/82).

Sugar Cane

Mozambique has suitable conditions for growing sugar cane in four provinces: Maputo, Gaza, Sofala and Zambezia, with a total area of 45,000 ha, with a 1981 forecast for a harvest close to 1,800,000 tons.

Tea

The tea is cultivated mainly in the Zambezia Province in the Gurué, Milange and Catuane Districts. The harvest forecast for 1981/82 was close to 22,000 tons of which about 18,000 tons was for export.

Citric Products

The citric products from Mozambique include grape-fruit, orange and lemon. The main production areas include Maputo (1,960 ha) and Manica (700 ha). The production goals for 1981/82 harvest were for about 23,000 tons of which 13,000 tons was for export.

- *Sisal*

Sisal is mainly cultivated in the provinces of Zambezia (Mocuba district), Nampula (Monapo and Angoche districts) and Cabo Delgado (Chiure district). The production goal for the 1981/82 harvest was for about 14,000 tons, of which 8,000 tons was for export.

- *Copra*

The palm tree is found mainly on coastal zones north of Zambeze River and in the regions between the Save and Buzi Rivers, occupying an area of about 87,000 ha. The production goal was for 40,000 tons/year of which about 30% was for export.

- *Timber*

Mozambique has a great variety of hard wood such as the ebony, sandal, pink wood, iron wood and others.

The main production is concentrated in the provinces of Zambezia, Cabo Delgado, Nampula, Sofala, Inhambane and Maputo with a production target of about 131,400 m^3, 40% of which was for export.

9.4.1.2 *Mining Sector*

The Mining sector has performed a relatively small role in the Mozambique's economy. Although some mineral ore reserves of iron, bauxite, asbesto, gold, tantalite, uranium and others are known, the unfavorable location of those reserves has made it possible to exploit only limited quantities, coal being the most important mineral ore under exploitation.

The mineral ore reserves actually known are the following:

- Iron Ore - mineral reserves are known in Guro-Manica province, 200 km north from the Manica Village, close to Machipanda Railway line. There are plans for a future installation of a steel plant.

- Others Minerals

In the Zambeze province beryl, lead, tourmaline, gold and bismuth are produced. Mozambique produces 2/3 of the world's tantalite, used in hard steel alloy and also is the second world producer of beryl.

Although mineral production has increased constantly, coal is the main mineral product from Mozambique, from the Moatize Mine in Tete province, about 200 km east of the Mucanha/Vuzi area which is under study.

The Moatize mines area connected to the port of Beira by railway with a extension of 575 km. The Moatize Coal Basin has nearly 270 km^2 (30 km x 9 km), although with a great incidence of interruptions and fissures.

According to estimates made by the Consulting firm GAS KOMBINAT SCHWARZE PUMPE, from Democratic Republic of Germany, which gives technical assistance to the National Coal Company from Mozambique - CARBOMOC, in the main coal seam of Moatize where actual mines are located, the reserves account for 70 millions tons and 150 millions of tons in probable reserves.

In the three existing mines, mining uses the room and pillar method, without a washing plant, with a 600,000 tons / year capacity and 500,000 tons/year production. A fourth mine will start in operation after rehabilitation with a 2,400 tons/day capacity. Exploitation conditions are very difficult due to:

- occurrency of methane gas associated with the coal, which occurs in dry and friable condition;

- existence of fissures, embankments and insertion of stratified clayish rocks and sandstone;

- existence of thick packs (up to 30 m) of thin seams which result in small resistance above the exploited seam.

The production target fixed by the Mozambique Government is to increase underground production of mineral coal in Moatize up to 2 millions tons/year with the possibility to reach a level of 3 millions tons/year between 1990 and 1995.

From 1985 on, it is planned to begin at Moatize an open pit mining.

As far as the transportation is concerned, the coal produced in Moatize is transported by railway all the way to the port of Beira. The railroad transport is fairly irregular due to the precariousness of the line conditions and the rolling stocks as well. The port of Beira has a terminal with a limited capacity of 3,000 tons/day and a load-draught only for 22,000 TDW vessels. To adjust the transportation system to the export goals, mainly for coal, foreseen from 1985 on, the Mozambique Government is planning to improve the railway infrastructure and equipment as well as to study the enlargement of the Beira Port installations and increase its load capacity for large vessels.

In parallel with the increase in production of the Moatize coal, the Development Program for the Coal Sector foresees the exploitation of the coal reserves situated between the Mucanha and Vuzi rivers, in the coal basin of the Chicoa-Mecucoê, in the middle course of the Zambeze River, upstream of the Cahora Bassa dam, actually in phase of prospection. Non-prospected coal reserves are also found in the Muaradzi and Sanangoê region.

9.4.2 *Secondary Sector*

In the years, before independence, Mozambique's industry showed a growing development being responsible for nearly 10% of the GDP and it was considered fairly developed if compared to the industrial structure of a number of African countries. Amongst the main industries were cigarettes, beverages, textiles and the ones related to sugar, cashew-nut, tea and petroleum processing.

Actually Mozambique's industrial sector is still suffering from the technical and specialized labor force evasion which took place during the independence period.

Among the proposed objectives for the industrial sector are the better use of installed capacity, to bring back into operation the paralyzed industries, to increase the production of beer, sugar, textiles, shoes, fertilizers, cement and to reorganize the metallic-mechanical industry.

The main processing units are:

- Cashew-nut processing industry (capacity in tons)
  - <u>NAMPULA PROVINCE</u>: Ca. C. Angoche (10,000 tons), Ca.do Monapo (16,500 tons), Inducajú (3,500 tons), Socajú (22,500 tons), Angoche I (15,000 tons), Angoche II (15,000 tons).
  - <u>ZAMBEZIA PROVINCE</u>: Namacurra (3,000 tons)
  - <u>SOFALA PROVINCE</u>: Beira (3,000 tons)
  - <u>INHAMBANE PROVINCE</u>: Inhambane (8,000 tons)
  - <u>GAZA PROVINCE</u>: Xai-Xai (19,000 tons) and Manjacaze (4,000 tons)
  - <u>MAPUTO PROVINCE</u>: Chamanculo (12,500 tons), Machava I (16,000 tons) and Machava II (4,000 tons).

The cashew-nut industry had as a target for the years of 1981/82, the production of 18,000 tons of cashew-nut and 7,000 tons of oil.

Informations concerning effective production is not available.

- Cotton seed processing industry (capacity of production)

  - CABO DELGADO PROVINCE: Montepuez (21,000 tons), Mabate (7,200 tons)

  - NIASSA PROVINCE: Cuamba (10,935 tons)

  - NAMPULA PROVINCE: Jeba (16,200 tons), Mutuali (10,080 tons), Namapa (22,000 tons), Monapo (48,987 tons), Namialo (22,050 tons), Nametil (14,760 tons), Nampula (22,500 tons), Ribauê (11,340 tons)

  - ZAMBEZIA PROVINCE: Alto Molocuê (10,800 tons), Mocubela (32,652 tons), Mocuba (21,420 tons), Megaja (11,520 tons)

  - SOFALA PROVINCE: Búzi (8,820 tons), Caia (11,520 tons), Manga (25,200 tons)

  - TETE PROVINCE: Moatize (10,935 tons)

  - INHAMBANE PROVINCE: Jancamo (10,080 tons)

  - GAZA PROVINCE: Xai-Xai (6,480 tons) and Chokwê (10,935 tons).

The production targets for the years of 1981/82 were for 32,600 tons of fibers, 2,503 tons of cotton-seed oil for food and 9,534 tons of husk for food flour and fertilizer.

Information concerning effective production is not available.

- Cement industry - The production target for the cement industry included:

  - <u>MAPUTO PROVINCE</u>: Matola (200,000 tons of cement and 40,000 tons of clinquer), Salamanga (320,000 tons of limestone), Boane (18,800 tons of clay), Umbeluzi (2,900 tons of sand).

  - <u>SOFALA PROVINCE</u>: Dondo (105,000 tons of cement), Muanza (168,000 tons of limestone), Mandruji (25,400 tons of clay).

  - <u>NAMPULA PROVINCE</u>: Nacala (45,000 tons of cement), Relanzapo (72,000 tons of limestone), Quissimanjulo (20,450 tons of clay).

From the cement production the following export goals were foreseen:

- Matola (28% of the cement and 100% of the clinquer).
- Dondo (24% of the cement).
- Nacala (40% of the cement).

The remaining part would be for domestic consumption.

Information concerning effective production is not available.

- Sugar industry

The sugar production target for the 1981/82 harvest by industry and destination for domestic supply was:

TABLE 9.4.3 - SUGAR PRODUCTION TARGET FOR THE 1981/82 HARVEST tons

SUGAR PROCESSING PLANT	QUANTITY	MOLASSES	PROVINCE OF DESTINATION
MARAGRA	22,800	-	MAPUTO
S.A. INCOMATI	26,500	-	MAPUTO, GAZA, INHAMBANE
MAFAMBISE	56,500	33,000	INHAMBANE, SOFALA, MANICA
MARROMEU	61,300	24,300	SOFALA, TETE, ZAMBEZE, NAMPULA, NIASSA
BUJÉ	17,200	-	SOFALA
SSE LUABO	45,500	32,700	ZAMBEZE

SOURCE: Plano Nacional de Transporte (National Transport Plan).

From the 230,000 tons of sugar and 90,000 tons of molasse, nearly 90,000 tons of sugar and 37,000 tons of molasse were for exportation.

- Tea

The processing plants and production targets were the following:

- Emochá (19,700 tons)
- Companhia da Zambezia (1,200 tons)
- Madal (1,600 tons).

From total production, nearly 18,000 tons was for export, 14,000 tons of which through Nacala port and 4,000 tons through Quelimane.

- Sisal

The production target for the years of 1981/82 was the following:

- ZAMBEZIA PROVINCE: Mocuba (3,100 tons)
- NAMPULA PROVINCE: Monapo (8,100 tons), Angoche (2,400 tons).
- CABO DELGADO PROVINCE: Chiúre (800 tons)

Of the total, 8,000 tons was for exportation.

- Timber Industry

The main saw-mills are in the following provinces:

- Cabo Delgado (5), Nampula (10), Zambeze (9), Sofala (33), Inhambane (11), Maputo (8).

The production targets were for 130,000 m^3 of total production and 54,600 m^3 of trunks and other products for export.

Most of existing saw-mills suffer from technical problems and consequently, actual effective capacity is bellow the installed capacity of 325,000 m^3/year.

o Iron and Steel Industry

Consumption estimatives of iron and steel for Mozambique show a substantial decline as compared to the independence period, falling from 13 kg/percapita in 1973 to 4 kg/percapita in 1981 (accounting for 50,000 tons).

Under consideration in the Prospective Indicative Plan is the construction of a steel plant with 800,000 tons capacity.

o Aluminium

According to the information from Mozambique officials, an aluminium processing plant is under consideration in the next 10 years, using imported aluminium oxide and the Cahora Bassa electricity. Three locations are under study: Caia, Beira or Nacala. The planned production capacity is of 150,000 tons.

9.4.3 *Tertiary Sector*

Due to its geographical location, Mozambique presents exceptional conditions in transportation services where neighboring countries are concerned.

9.4.3.1 *Physical and Operational Aspects of the Mozambique Transportation System.*

The importance of the Mozambique Transportation System is not only for its own country but also for the six neighboring countries as well (Tanzania, Malawi, Zimbabwe, Zambia, Swaziland and South Africa) and on a smaller scale, but no less important, for the three other countries which do not border Mozam bique (Zaire, Botswana and Lesotho), leading this description to a comprehensive integrating approach of the railway system to the port system of Mozambique (Figures 9.4.1 and 9.4.2).

This type of approach has been used by SATCC - Southern Africa Transport and Communication Commission, from the SADCC - Southern Africa Development Co-Ordination Conference. At this meeting which was held in Blantyre-Malawi from 19 to 20 of November, 1981, a summary of its report is the basis for the descriptions which follows, complemented by information from studies completed or being carried out.

9.4.3.2 *The Port of Maputo Transportation System*

The improvement of the Maputo port installations constitutes the main project for the port of Maputo transportation system. This port renders service to Swaziland, Zimbabwe, Botswana, Lesotho, Zambia and South Africa in such a way that nearly 60% of its movements result from the international through traffic. This port handles about three-fourths of the whole set of Mozambique ports.

Table 9.4.4-MOVEMENT OF FREIGHT HANDLED IN THE PORT OF MAPUTO AND MATOLA TERMINAL

(in 1,000 tons)

COUNTRY OF ORIGIN	1979	%	1980	%
MOZAMBIQUE	3,118	38.3	3,096	40.7
SOUTH AFRICA	3,249	39.9	2,992	39.4
SWAZILAND	1,760	21.6	1,276	16.8
ZIMBABWE	-	-	194	2.5
OTHERS	9	0.1	46	0.5
TOTAL	8,136	100.0	7,604	100.0

SOURCE: DNPCF

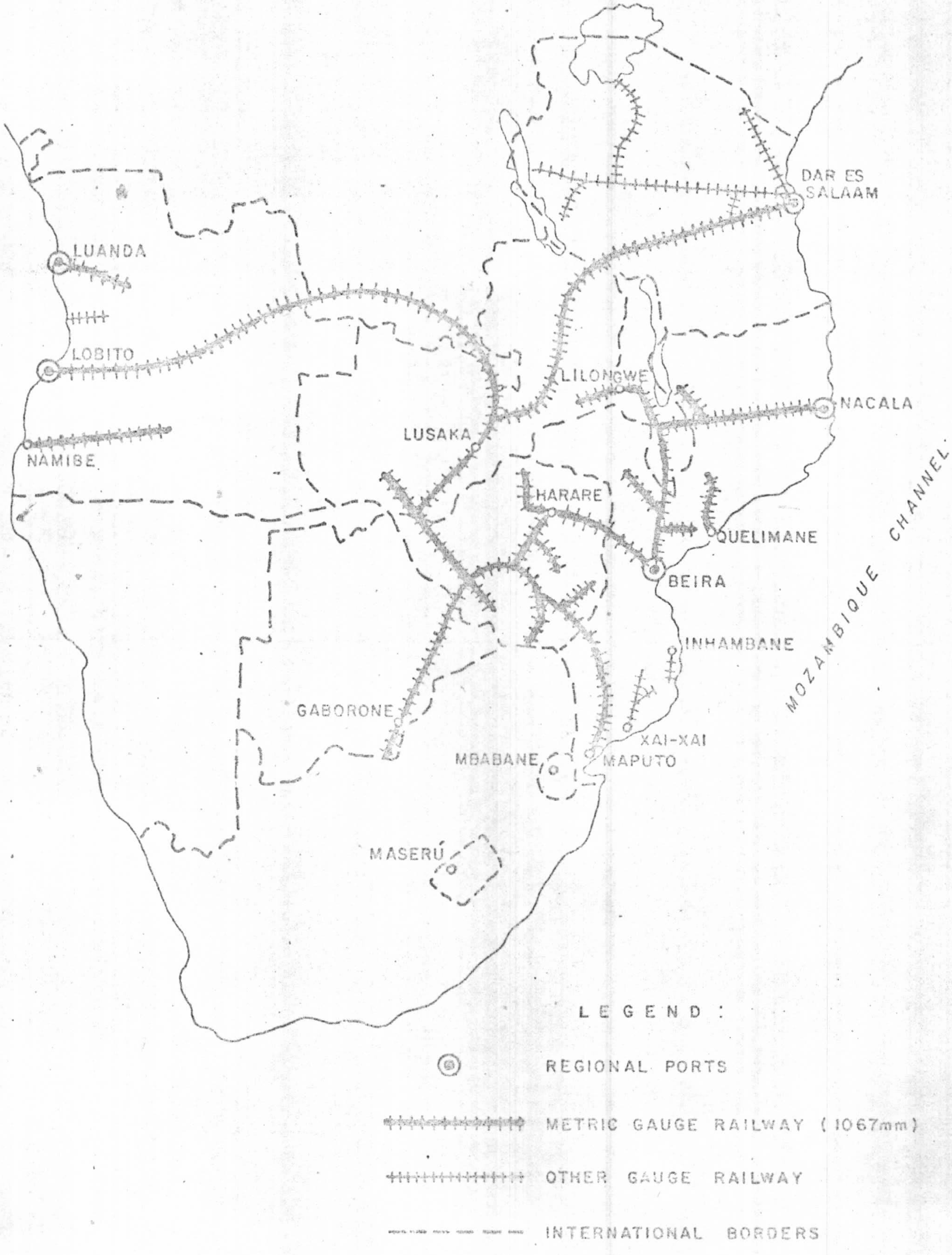

FIGURE 4.1

STUDY OF OUTFLOW ALTERNATIVES

Southern Africa Railway Network and Regional ports

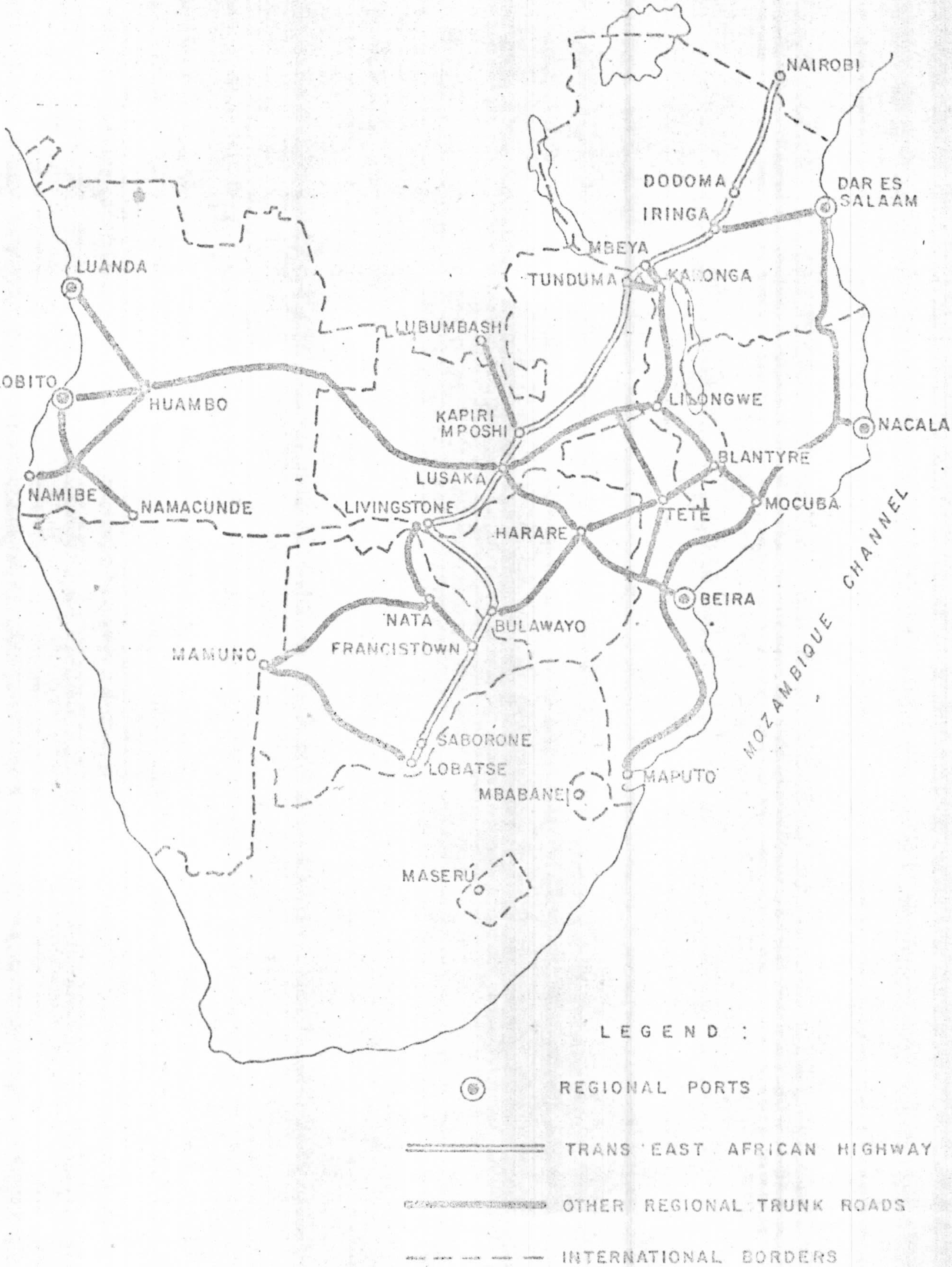

FIGURE 4.2

STUDY OF OUTFLOW ALTERNATIVES

Trunk Regional Highway Network

The total volume of freight handled in the port of Maputo and Matola terminal had declined by 27% between 1975 and 1977, resulting from the border closure in Chicualacuala and consequently the lost of freight with origin and destination in the former Rodesia (now Zimbabwe). This decline in freight services continued until 1980, when the border was opened to Zimbabwe traffic again.

The port is serviced by the Southern System (CFM-S) of the Mozambique Railway (Caminhos de Ferro de Moçambique), with the main routes interconnecting this system with the Swaziland Railway, National Railway of Zimbabwe and South African Railways (Figure 9.4.3).

With a total length of 1,080 km of railway the Southern System from the CFM-S is only connected with the Central System (CFM-C), through Chicualacuala and Zimbabwe with no connection through Mozambique's territory. This system is formed by the following sections:

TABLE 9.4.5 -SECTIONS OF THE RAILWAY SOUTHERN SYSTEM (CFM-S)

SECTIONS	LENGTH (Km)	OBSERVATIONS
1 - ISOLATED SECTIONS		
1.1-INHAMBANE-INHARRIME	90	-
1.2-XAI-XAI - MANJACAZE - CHICOMO	90	-
-MANJACAZE - MARÃO	50	-
SUBTOTAL	140	-
2 - MAPUTO SYSTEM		
2.1-UMPALA - SALAMANGA	61	-
2.2-MOAMBA - INGUBANA	77	-
2.3-UNGUBANA - XINAVANE	16	-
2.4-MAPUTO-RESSANO GARCIA	88	Connection with South Africa
2.5-MAPUTO-GOBA	74	Connection with the Swaziland
2.6-MAPUTO-CHICUALACUALA	534	Connection with the Zimbabwe
TOTAL	1,080	

SOURCE: DIREÇÃO NACIONAL DE PORTOS CAMINHOS DE FERRO - DNPCF.

MT-GEIPOT

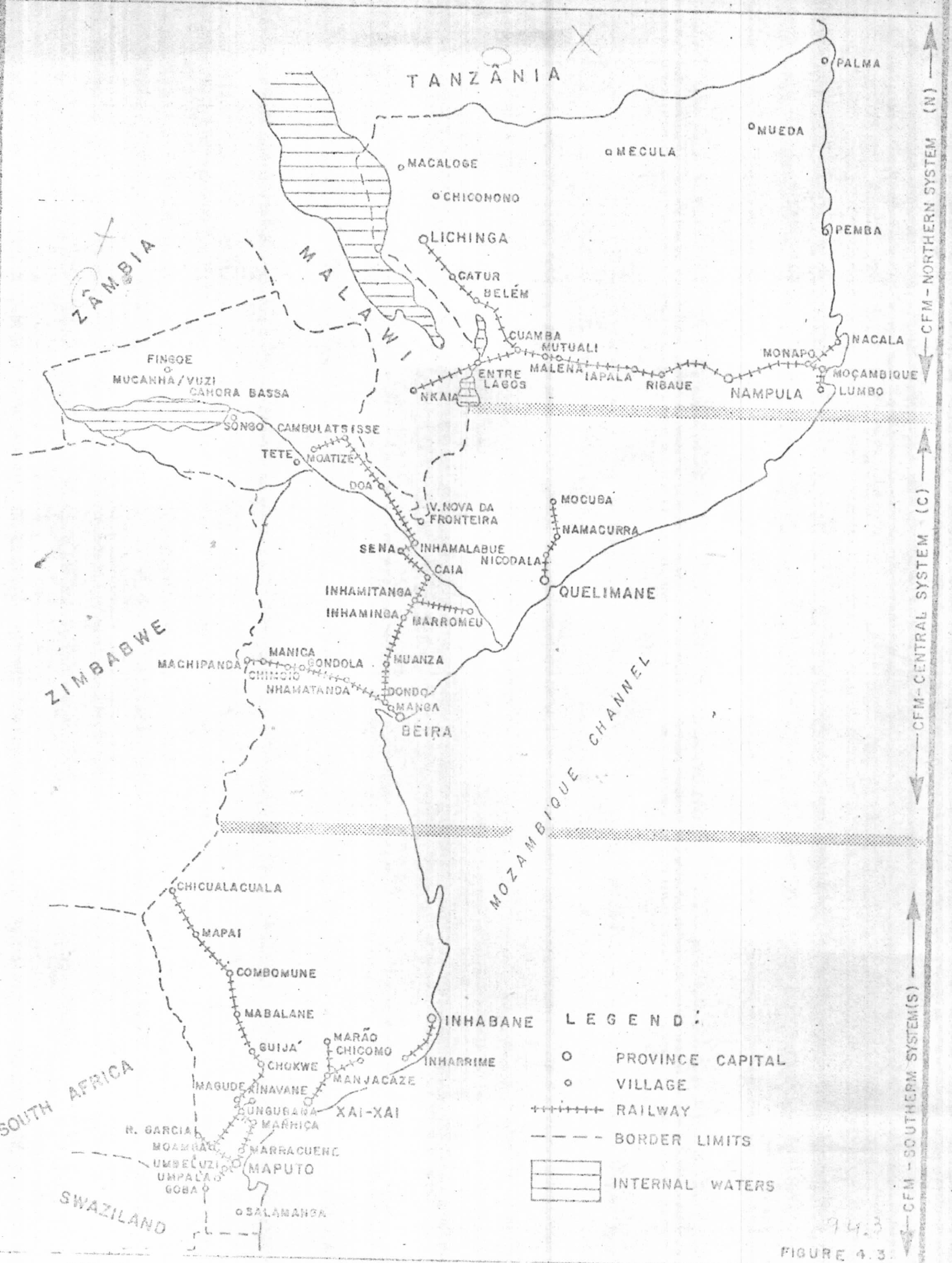

FIGURE 4.3

STUDY OF OUTFLOW ALTERNATIVES

Mozambique Railway

Traffic on the Southern System accounted for a total of 6,117,000 tons in the year of 1980, of which 4,495,000 tons was international through traffic.

TABLE 9.4.6- PORT OF MAPUTO SYSTEM
TOTAL FREIGHT IN THE MOZAMBIQUE SOUTHERN SYSTEM
1980

	1,000 Tons	%
1. INTERNATIONAL THROUGH TRAFFIC	4,945	80.83
1.1 - Ressano Garcia (South Africa)	3,630	59.34
1.2 - Goba (Swaziland)	1,250	20.43
1.3 - Chicualacuala (Zimbabwe)	65	1.06
2. LOCAL TRAFFIC	1,173	19.17
TOTAL	6,117	100.00

9.4.3.3 *The Port of Beira Transportation System*

The geographical location of the port of Beira and its railway connections make this port one of the most important, both for the central region of Mozambique and for Zimbabwe, Malawi, Zambia and others inland countries of the region as well (Figure 4.3).

The port of Beira is located in the mouth of the Pungué River, nearly 20 km from the Indian Ocean. Access to it is through a dredged 27 - foot deep channel. Actual conditions of the access channel permit the entrance of vessels limited to a maximum of 22,000 TDW on the favorable tide, however, it is frequent that even vessels with this tonnage have difficulties in operation and are held up due to unfavorable conditions of tides.

The coal wagons are unloaded in the port by a hopper using a front-end loader and complemented manually. The hopper puts the coal on a belt-conveyor system and with the help of a stacker it is piled up in the port or unloaded directly in the ships.

The stacked coal is loaded by using a front-end loader on another hopper which feeds the belt-conveyor system up to the ship, at a loading speed of 3,000 tons/day with a stock capacity limited to 70,000 tons.

In case of insufficient stock, ships cannot dock one after another due to insufficient capacity of the railway in supplying the port.

In a broad view, actual conditions both of the railway system and of the port are fairly limited in such a way that a program to increase coal exports is not possible.

At the present, most of general freight handled in the port of Beira comes from Malawi (nearly 40% of the total). The 60%

left originates in the Mozambique and Zimbabwe territory. With the restarting of the railway traffic through Machipanda/Umtali in 1980 this has meant considerable increase in the transported tonnage of freight to and from Zimbabwe.

Table 9.4.7 shows the evolution of the freight handled in the port of Beira from 1979 to 1981.

TABLE 9.4.7 - TOTAL FREIGHT HANDLED IN THE PORT OF BEIRA BETWEEN 1979 AND 1981

(in 10^3 tons)

ORIGIN	YEARS		
	1979	1980	1981
1. INTERNATIONAL THROUGH TRAFFIC	689	562	188
1.1 - ZIMBABWE	-	20	23
1.2 - MALAWI	659	513	154
1.3 - OUTROS	30	28	11
2. MOZAMBIQUE	1,034	958	457
TOTAL	1,723	1,520	645

The port of Beira is serviced by the Central Railway System of the Caminhos de Ferro de Moçambique (CFM-C), which is connected with the Railway Systems of Botswana, Zimbabwe, Zambia and Malawi. This system is connected with the Southern System (CFM-S) to Maputo through Machipanda, Zimbabwe and Chicualacuala and with the Northern System (CFM-N), through Vila Nova da Frontei ra, Nkaia (in Malawi) returning to Mozambique territory through Entre Lagos.

Table 9.4.8 shows the several links of the CFM-C, which accounts for a total of 1,132.1 km.

TABLE 9.4.8-CENTRAL SYSTEM OF THE MOZAMBIQUE RAILWAY - (CFM-C)

L I N K S	LENGTH (Km)	OBSERVATIONS
1. BEIRA - DONDO - MACHIPANDA	314,0	Connection with the Zimbabwe
2. DONDO - SENA	287,1	-
3. SENA-VILA NOVA DA FRONTEIRA	44,0	Connection with the Malawi
4. NHAMALABUE (D.ANA)-MOATIZE	254,0	Connection with existing Moatize coal mines
5. INHAMITANGA - MARROMEU	88,0	-
6. QUELIMANE - MOCUBA	145,0	Isolated links
TOTAL	1,132.1	

In general the railway sections of the CFM-C are in bad conditions requiring a heavy program of rehabilitation and upgrading, causing frequent total interruption of traffic for long periods.

The maximum axle load is of 16 tons, signalling and technical security installations do not exist. The traffic in the system is controlled by stations using written orders.

The most important stations for the formation, arrangement and decomposition of convoys are:

Beira - port handling, formation and decomposition of convoys to Machipanda, Vila Nova da Fronteira and Moatize.

Dondo - split of the lines to Machipanda and Moatize/Vila Nova da Fronteira, formation and decomposition of convoys to and from Beira and also rearrangement of other convoys.

Inhaminga - formation, decomposition and rearrangements of convoys to and from Beira, Marromeu and Sena/Vila Nova da Fronteira/Moatize.

Moatize - coal loading at CARBOMOC Terminal, formation and forwarding of consignments to and from Inhaminga/Beira.

9.4.3.4 *The Port of Nacala Transport System*

The access from Malawi to the Indian Ocean is possible by using the ports of Beira and Nacala, both in the Mozambique territory.

The route to Nacala was opened in August 1970, when the Nkaya connection on the Northern-Southern main railway line from Malawi, and Cuamba on the Lichinga Railway line on the Northern System of Mozambique Railway (CFM-N) was completed. The distance between Nacala and Entre Lagos in the Malawi border is 615 km.

The port of Nacala has one of the best natural harbours on the whole eastern african coast, having exceptional conditions of access, shelter and depth for 150,000 TDW load-draught vesselts, although adequate port installations are not existent and the railway access is in a poor condition. In this situation the total cargoes handled in the port did not exceed 800,000 tons per year between 1975 and 1980, declining to less than 600,000 tons/year during the years from 1976 to 1978. Nearly 1/3 of this movement came from Malawi. The port of Nacala handled also 9,730 containers in 1980.

At the present, the port of Nacala has a 1,000m wharf and 372m of deep water battlement at a 15m depth in the Malaia point. There is also another 619m battlement with four berths for docking with a 7.1 to 10.0m depth. One of the deep water battlements is used for container handling and the other for general freight.

The port of Nacala is serviced by the Northern System of the Mozambique Railway (CFM-N), which connects the port with the Malawi Railway through Entre Lagos. The actual condition the lines requires urgent rehabilitation and does not make possible satisfactory services. From MAFERSA 200 ballast wagons have been acquired mostly for helping in the rehabilitation work of the CFM-N and CFM-C. Negotiations have also been held with a French-Portuguese consortium for the rehabilitation project and service.

Related studies and projects with the port of Nacala are:

- Project for construction of the Container terminal-preliminary studies.

- Rehabilitation, renewing and upgrading of the acess railway

9.4.4 *Human Resources Allocated to Transport Sector*

9.4.4.1 *Labor Force*

According to estimates from the Ministry of Ports and Surface Transports provided by Table 9.4.9, which show the growing labor force allocated to transport sector, which involves the ocean, railway, highway and river transport.

TABLE 9.4.9-LABOR FORCE IN THE MINISTRY OF PORTS AND SURFACE TRANSPORT

Labor force in 1980 = 54,386 workers

1 worker p/50,601 t/km and 63,160 pass/km (1980)

NUMBER OF WORKERS	1980	1981	1982	1985	1990
Railway	37,885	38,470	39,811	42,166	49,128
Ocean/River	2,011	2,376	2,799	3,975	6,316
Highway	14,490	14,055	13,722	15,218	23,645
Total workers (%)	100	100	100	100	100
1. Non specialized	85.04	78.50	72.12	47.75	23.09
2. Specialized	14.96	21.50	27.88	52.25	76.91
2.1-Elementary grade	14.00	19.55	25.12	47.56	64.29
2.2-Basic grade	0.78	1.60	2.26	3.87	10.69
2.3-Median grade	0.08	0.21	0.34	0.64	1.62
2.4-Superior grade	0.10	0.14	0.15	0.18	0.31
Productivity and wages					
Value of Production 10^3 MT*	9,564,000	12,618,000	17,611,000	38,721,000	73,092,000
Yearly average numbers of workers	54,386	54,901	56,332	61,359	79,089
Productivity per man/year 10^3 MT	175.9	229.8	312.6	631.00	924.2
Average wage per man/year 10^3 MT	56.7	57.7	59.7	60.5	79.6
Wage Fund 10^6 MT	3,084.3	3,169.6	3,360.6	4,262	6,296.4
Value of Production					
1. Ports and Railways 10^3 MT	4,832,000	6,427,000	7,034,000	16,000,000	23,640,000
2. Highway Transport	4,556,000	4,691,000	6,819,000	9,226,000	18,839,000
3. Ocean and River Transport	176,000	1,500,000	3,758,000	13,495,000	30,613,000
Average Number of workers					
1.Railway and Port (Total 1980)	37,885	38,470	39,811	42,166	49,128
-(Annual average wages)	(50,800)	(51,600)	(52,800)	(52,000)	(63,300)
2.Highways (Total 1980)	14,490	14,055	13,722	15,218	23,645
-(Annual average wages)	(66,000)	(66,000)	(66,000)	(72,000)	(72,000)
3.Ocean and River	2,011	2,376	2,799	3,975	6,316
-(Annual average wages)	(96,000)	(112,000)	(131,000)	(211,000)	(240,000)

* MT = METICAL = LOCAL MONEY.

9.4.4.2 *Wages Policy*

The money unit in the Popular Republic of Mozambique is the Metical (MT).

The considered exchange rate was 36 meticais per US$ dollar (June 1980).

The labor force in Mozambique is divided in four classes and twenty four subclasses according to its qualifications and the wages in each class is shown in Table 9.4.10.

The workers are granted free medical assistance and 30 days vacations.

Private companies pay 8% for insurance and 5% for worker fund assistance.

TABLE 9.4.10 OFFICIAL WAGES IN MOZAMBIQUE (1981)

WAGES LEVELS IN METICAIS			
SUPERIOR GRADE	SKIPPER COMMISSIONER TECHNICAL ASSISTANT MACHINIST	WORKER WITH SOME SPECIALIZATION	NON SPECIALIZED WORKER
B-26,700.00	G-12,350.00	L-8,300.00	X-4,200.00
C-24,000.00	H-11,400.00	M-7,450.00	Y-3,850.00
D-19,900.00	I-10,550.00	N-7,050.00	Z-3,500.00
E-16,800.00	J- 9,800.00	O-6,550.00	- - - -
F-13,400.00	K- 9,000.00	P-6,200.00	- - - -
- - - -	- - - -	Q-5,750.00	- - - -

9.4.5

9.4.5 *Costs of Construction Materials and Services in Mozambique*

9.4.11

TABLE 9.4.11 - COST OF THE CONSTRUCTION MATERIALS IN THE ORIGIN

TYPE OF MATERIALS	UNIT	PRICE IN METICAL
Ballast	m^3	185.00 (1)
Flintstone	m^3	185.00
Stone for sea-wall	m^3	185.00
Cement in sacs	50 kg	63.20
Washed sand	m^3	20.00
Steel for construction (2)	kg.	11.00

(1) Cost in the mine furnished by the Henderson, Busby & Partnership Report.

(2) Square iron bar.

9.4.12

TABLE 4.12 - COST OF SERVICES

TYPE	1971	1973	1978
	NACALA WHARF ESCUDOS	MAPUTO WHARF ESCUDOS	BEIRA WHARF METICAIS
Dredging (m^3)	49.60	35.00	87.60
Hydraulic embankment (m^3)	28.64	-	69.00
Earth (m^3)	24.50	20.00	92.40
Sea-wall (m^3)	160.00	220.00	590.00
Single cement (m^3)	868.00	1,360.70	3,770.30
Bituminous cement (m^2)	115.00	177.50	-
Dolphin	-	32,830.00	68,165.20

MINUTA do Relatório
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DRAFT Report Under
Revision

9.5

9.5. DEMAND STUDIES

9.6

9.5 DEMAND STUDIES

Notwithstanding the main objective of the study which only refers to the Mucanha/Vuzi coal outflow complemented by the coal from the Moatize mines, the traffic demand must be considered for other non coal products in order to determine the capacity and operational characteristics on different routes as well as to relate total costs of investments and operation between coal and non-coal products.

Three types of traffic flow are under consideration:

- Coal from the Mucanha/Vuzi and Moatize Mines for export and domestic consumption.
- Import, export and domestic traffic of other non coal products.
- Through traffic on the alternative routes, with origin or destination in neighboring countries.

Since Popular Republic of Mozambique is a socialist oriented country, inspired on the Marxism-Leninism principles, it is based on a state centralized planning structure.

For that reason, the traffic flow analysis on Mozambique territory in the year base of 1981, was based on the following premises:

- Mozambique does not offer historical data series of population and production which could be accepted as representative of a stable period nor enough to define a tendency of its natural economical growth for the following reasons:
  - The ten years fought for the independence.
  - The exodus of technicians and specialized labor force of european origin in the years which followed the independence

(1975, 1976 and 1977), and not fully replaced up to the moment, in the quantity needed to restore the same production levels existing before 1975.

- The Rhodesian (Now Zimbabwe) fight for independence which lead to the closure of the border between both countries and the frequent raids against Mozambique's infrastructure of transport and production up to 1979.

- The adverse climatic factors of the last years. –

• The Mozambique Government defined the goals for economical development for the ten years period based on the restoration of the existing production levels before the independence. It was considered that the targets defined for the 1981 basis, although it would demand some effort, were coherent with the long run goals and the government considered all problems involved for its success, which meant the limitations of the mozambican productive structure.

In that way, although official statistics show that the production levels for the 1981 year base were below the targets (as an example, the real volume of coal export was only 60% of the target due to problems in the railway system or the total volume of export in the port of Beira which succeeded only in 70% of the programmed exports) it is difficult to characterize the year of 1981 as representative of the mozambican economy.

The lack of stable historical series do not permit a conclusion about the year of 1981, taken as the years basis of the economical forecasts but only that the years before are certainly not representative.

Based on this analysis, the production targets as well as the transportation program proposed in the National Transportation Plan for 1981 were taken for granted as the theoretical data and year to forecast.

9.5.1

9.5.1 *Coal Flows*

- Coal Flows Based on 1981

9.5.1 The coal flow based on the 1981 figures, shown in Table 9.5.1 and Figures 9.5.1 and 9.5.2, are the 1981 programmed traffic for the railway system of CFM-C and CFM-N, toward the ports of Beira and Nacala.

From the 506,000 tons of the production target for Moatize in the 1981 basis, 177,000 tons or 35% would be for domestic supply, 59,000 tons or 12% would be exported to Malawi and 270,000 tons or 53% would be exported through the port of Beira.

- Forecasted coal outflow.

Forecasted coal outflow are approximated values considering the goals of the Mozambique State Secretary of Coal and Hydrocarbon - GSECHI, adjusted for the minimum period of time required for the construction, rehabilitation and upgrading of the railway, water transport and terminals.

By this means, it has been considered as a feasible target to have production levels up to 1,000,000 tons of coal in Mucanha/Vuzi and 2,000,000 tons in Moatize by 1990; 3,000,000 tons in Mucanha/Vuzi and 3,000,000 tons in Moatize by 1995 and finally 6,000,000 tons in Mucanha/Vuzi and 4,000,000 tons in Moatize by 2000.

The targets for the Moatize production are dependant upon the rehabilitation and upgrading of existing railways and the export terminal. In the case of Mucanha/Vuzi, the production depend upon the construction of an access transport to the area.

The definition of the production levels for the Mucanha/Vuzi and Moatize mines had the objective of supporting the transport system evaluation in parallel with the drilling program and sample testings in order to allow the feasibility analysis of the Mucanha/Vuzi coal exploitation as a whole, which means, the mine and the transportation system.

TABLE 9.5.1 - COAL OUTFLOW

DOMESTIC CONSUMPTION AND EXPORT BY ORIGIN

In 10^3 tons

LINKS	1981	1986	1990	1995	2000	2010
1. DOMESTIC CONSUMPTION						
Moatize-Nhamalabue-Vila Nova da Fronteira-Nkaia-Entre Lagos-Nampula	6	7	8	10	13	21
Moatize-Nhamalabue-Vila Nova da Fronteira-Nkaia-Entre Lagos-Nacala	15	17	20	25	32	52
Moatize-Dondo	37	43	48	62	79	128
Moatize-Vila Nova da Fronteira	21	24	27	35	45	73
Moatize-Inhamitanga	18	21	24	30	38	62
Moatize-Beira	75	87	98	125	160	260
Moatize-Caia	5	6	7	8	11	17
SUBTOTAL (INTERNAL CONSUMPTION)	177	205	232	295	378	613
2. EXPORT						
Moatize-Nhamitanga-Vila Nova da Fronteira-Blantyre (Exp.)	59	79	100	133	179	320
Moatize-Beira (Exp.)	270	716	2,668	5,572	9,443	9,067
SUBTOTAL 2 (EXPORT)	329	795	2,768	5,705	9,622	9,387
SUBTOTAL: MOATIZE ORIGIN	506	1,000	2,000	3,000	4,000	4,000
SUBTOTAL: MUCANHA/VUZI ORIGIN	-	-	1,000	3,000	6,000	6,000
TOTAL : MOZAMBIQUE	506	1,000	3,000	6,000	10,000	10,000

OBS.: Coal with origin in Zimbabwe in the MACHIPANDA-BEIRA RAIL SECTION = 55 x 10^3 tons not forecasted since it has not been considered a trade on a permanent basis.

MT-GEIPOT

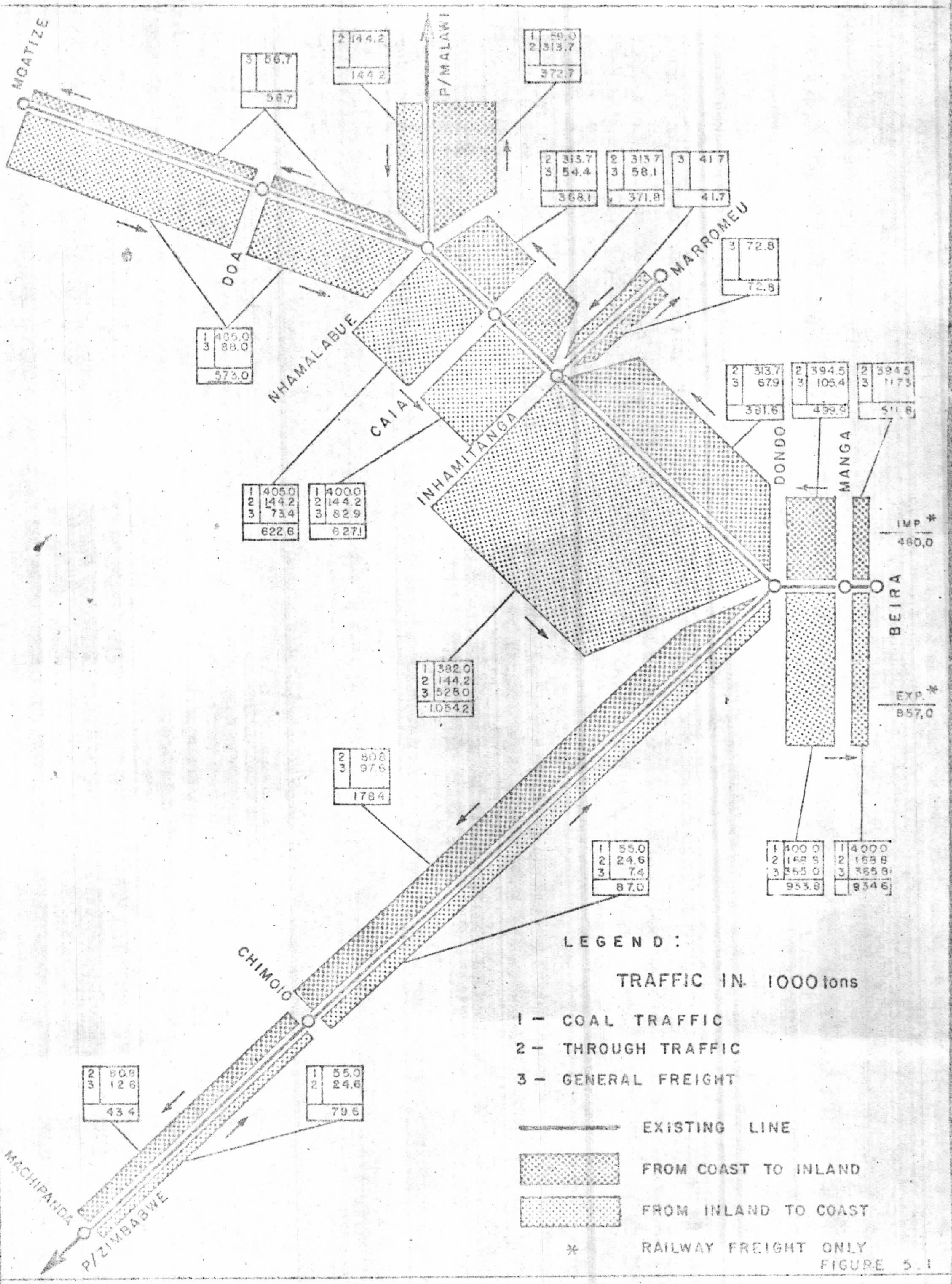

FIGURE 5.1

MOZAMBIQUE C.F.M. - CENTRAL SYSTEM

Allocated Railway Flows

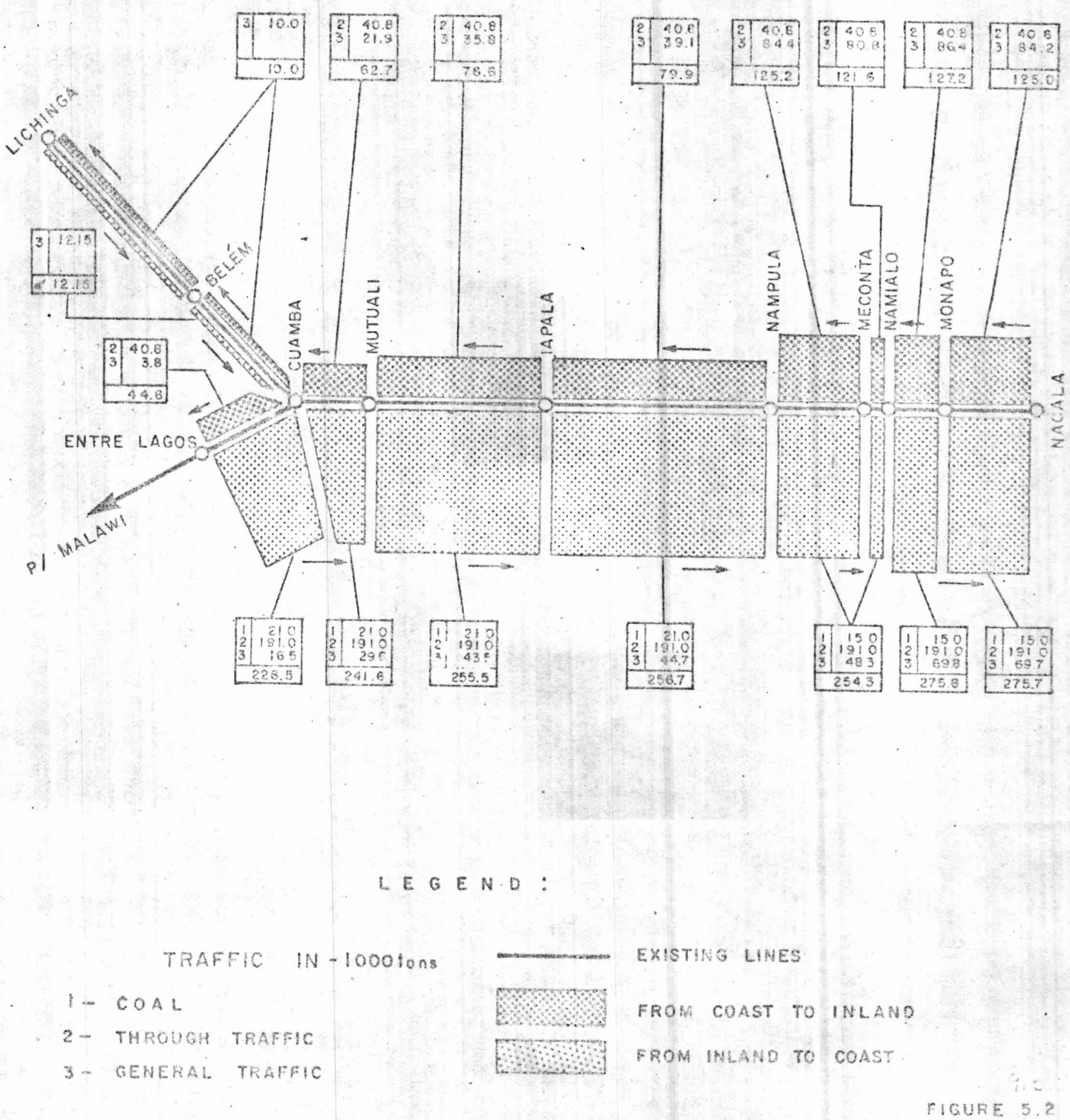

FIGURE 5.2

MOZAMBIQUE C.F.M. NORTHERN SYSTEM

Allocated Flows

9.5.2

9.5.2 *Traffic of other non coal products*

- Flow of other non coal traffic based on 1981 figures.

Information concerning the flows of other non coal products was based on the transport programming of inputs and outputs from the National Transport Plan to fullfil the goals for production and commercialization of the products on 1981 figures. Such as, flows which were allocated by product and link in the transport network permitting the construction of the origin/destination matrix by mode for the 1981 figures. The peak demand period during the year has also been determined by conducting a monthly analysis for all products.

The aggregated origin and destination matrix of non-coal products by mode, as well as the monthly demand and months of peak aggregated demand for traffic on the Mozambique railway are shown in the following Tables:

Table 9.5.2: Aggregated origin and destination Matrix (1981).

Table 9.5.3- A and B: Aggregated origin and destination Matrix on the CFM-C and CFM-N railway line.

Table 9.5.4: Aggregated origin and destination Matrix- River flows.

Table 9.5.5 and Figure 9.5.3 Aggregated origin and destination Matrix - Coastal flows between Mozambique ports.

Table 9.5.6 -A, B, C and D: Monthly transportation demand in the CFM-C, CFM-N and CFM-S.

Table 9.5.7-A and B: Months of peak demand for railway traffic.

- Future Flows of other non-coal traffic

The difficulties of using information concerning the years from 1975 to 1980, did not allow the production function

9.5.2

TABLE 9.5.2 AGGREGATED ORIGIN AND DESTINATION NON COAL MATRIX

- 1981 -

In 10^3 tons

O \ D	CABO DELGADO	NIASSA	NAMPULA	TETE	ZAMBÉZIA	MANICA	SOFALA	GAZA	INHAMBANE	MAPUTO	Σ	EXPORT NACALA	EXPORT BEIRA	EXPORT MAPUTO	[illegible] THROUGH TRAFFIC	[illegible]
CABO DELGADO	126,2	–	15,1	–	–	–	–	–	–	28,6	169,9	–	–	–	–	–
NIASSA	13,0	36,0	48,8	55,0	24,0	–	244,0	–	–	320,0	745,8	1,8	–	–	–	–
NAMPULA (*)	24,1	21,9	621,3	–	118,4	–	3,8	–	1,2	46,2	836,9	60,9	–	–	40,[illegible]	–
TETE	–	–	1,5	143,0	–	7,4	212,5	–	0,5	–	365,0	–	270,4	–	–	–
ZAMBÉZIA	0,1	–	22,4	–	786,0	–	45,0	–	0,5	38,4	892,2	1,0	–	–	–	–
MANICA	–	–	–	0,45	5,2	382,8	171,7	–	–	–	560,1	–	7,4	1,4	–	–
SOFALA (*)	4,5	–	12,2	54,4	71,0	130,9	1,385,6	–	3,5	16,1	1,678,2	–	154,9	–	313,7	–
GAZA	–	–	–	–	–	–	0,7	22,5	0,9	13,6	37,7	–	–	10,6	–	–
INHAMBANE	–	–	–	–	–	–	2,1	1,1	70,9	28,0	102,1	–	–	–	–	–
MAPUTO	13,7	–	72,4	–	24,4	–	61,6	197,6	23,2	1,337,1	1,730,2	–	–	69,4	–	–
Σ	186,[illegible]	57,9	793,7	252,8	1,029,0	521,1	2,127,2	221,2	100,6	1,828,0	7,118,1	63,7	432,7	81,4	–	–
MALAWI EXPORT	–	–	191,0	–	–	–	144,2	–	–	–	–	–	–	–	–	–
ZIMBABWE EXPORT	–	–	–	–	–	–	24,0	–	–	–	–	–	–	–	–	–

(*) IMPORT INCLUDED

[redacted]AB[redacted].5[redacted]

AGGREGATED ORIGIN/DESTINATION MATRIX FOR NON-COAL PRODUCTS TRANSPORTED BY RAIL IN MOZAMBIQUE

C.F.M. – CENTER

– 1981 –

tons x 10^3

O \ D — TRAFFIC ZONE	CODE	51	50	52	72	71	76	77	78	80	82	81	SUB-TOTAL	MALAWI (111)	ZIMBABWE (112)	TOTAL
TETE	51	1,00	1,62									18,04	20,66			20,66
MOATIZE	50	1,00		95,00			5,00	36,00		74,00		345,00	556,00			556,00
VILA NOVA DA FRONTEIRA	52		3,80									0,40	4,20	144,20		148,40
CHIMOIO	72											7,40	7,40			7,40
MACHIPANDA	71											55,00	55,00			55,00
CAIA	76											9,48	9,48			9,48
MARROMEU	77	2,80		1,50	2,00							66,50	72,80			72,80
INHAMINGA	78				36,00			10,00		168,00		190,58	404,58			404,58
DONDO	80	15,50			9,50	12,60						72,60	110,20			110,20
DOZI	82											0,83	0,83			0,83
BEIRA	81	1,37	33,23		37,52		3,74	13,70	0,38	12,42		14,94	117,30		80,80	195,10
		21,67	38,65	96,50	85,02	12,60	8,74	59,70	0,38	254,42	–	780,77	1,358,45			
MALAWI (111)				313,70												313,70
ZIMBABWE (112)												24,60				24,60
TOTAL		21,67	38,65	410,20	85,02	12,60	8,74	59,70	0,38	254,42	–	805,37		144,20	80,80	1,921,75

9.5.3 - B

TABLE 9.5.3-B AGGREGATED ORIGIN/DESTINATION MATRIX FOR NON-COAL PRODUCTS TRANSPORTED BY RAIL IN MOZAMBIQUE

C.F.M - NORTH

tons x 10^3

- 1981 -

O \ D		19	24	23	32	31	30	29	37	33	SUB-TOTAL	MALAWI (111)	TOTAL
LICHINGA	19							7,30	4,25		12,15		12,15
ENTRE LAGOS	24			1,50				30,00	6,00		37,50		37,50
CUAMBA	23							2,50			2,50		2,50
MALEMA	32							13,85			13,85		13,85
IAPALA	31							1,23			1,23		1,23
NAMIALO	30							21,50	3,60		25,10		25,10
NACALA	29	9,49	3,80	5,85	13,93	2,29	5,61		41,19	2,00	84,26	40,80	125,06
NAMPULA	37	0,51						6,04	1,00	1,84	9,39		9,39
MONAPO	33			2,20				1,70	2,00		5,90		5,90
SUBTOTAL		10,0	3,80	9,65	13,93	2,29	5,61	84,72	58,04	3,84	191,89		
MALAWI (111)								191,00					191,00
TOTAL		10,0	3,80	9,65	13,93	2,29	5,61	275,72	58,04	3,84		40,80	423,68

TABLE 9.5.4 AGGREGATED ORIGIN/DESTINATION MATRIX - RIVER FLOWS

tons 10^3

O \ D	42-MOMA	51-TETE	61-PEBANE	64-NAMACURRA	65-QUELIMANE	72-CHIMOIO	77-MARROMEU	81-BEIRA	91-XAI-XAI	98-INHAMBANE	107-MAPUTO	TOTAL
51-TETE		0,3										0,3
61-PEBANE	3,8		2,0									5,8
64-NAMACURRA				3,7								3,7
65-QUELIMANE					2,7							2,7
67-CHINDE							12,8					12,8
72-CHIMOIO						0,4						0,4
74-MOSSURIZE			3,8	1,4								5,2
82-BUZI								14,0				14,0
81-BEIRA								0,8				0,8
88-CHIBUTO									1,0			1,0
98-INHAMBANE										0,6		0,6
107-MAPUTO											5,5	5,5
TOTAL	3,8	0,3	5,8	5,1	2,7	0,4	12,8	14,8	1,0	0,6	5,5	52,8

9.5.5

TABLE 9.5.5 AGGREGATED ORIGIN/DESTINATION MATRIX - FLOWS BETWEEN PORTS

tons 10^3

O \ D	MOCIMBOA DA PRAIA 2	PEMBA 9	NACALA 29	ANGOCHE 41	PEBANE 61	MACUZE 64	QUELIMANE 65	BEIRA 81	INHAMBANE 98	XAI-XAI 91	MAPUTO 107	TOTAL
PEMBA - 9											28.6	28.6
NACALA - 29	1.8	20.4		4.2			0.6	3.8	1.2		33.6	65.6
ANGOCHE - 41											6.8	6.8
MOMA - 42											3.8	3.8
PEBANE - 61											9.6	9.6
MACUZE - 64											13.8	13.8
QUELIMANE - 65		0.1	1.8			1.3		29.7	0.3		15.0	48.2
BEIRA - 81		4.5	12.2		1.9	3.9	56.4		3.5		12.7	95.1
INHAMBANE - 98								0.4			28.0	28.4
XAI-XAI - 91									0.1		0.9	1.0
MATOLA - 106		9.0	36.2				9.2	49.5				103.9
MAPUTO - 107		4.7	15.8		0.3	0.6	14.3	12.3	21.8	1.7		71.5
TOTAL	1.8	38.7	66.0	4.2	2.2	5.8	80.5	95.7	26.9	1.7	154.8	478.3

MT-GEIPOT
MOCIMBOA
PEMBA
NACALA
ANGOCHE
MOMA
PEBANE
MACUSE
QUELIMANE
BEIRA
INHAMBANE
XAI-XAI
MAPUTO
MATOLA
EXPORTS
65.3
40
8.6
20.4
394.8
14.2
169.0
11.4
MOZAMBIQUE CHANNEL
LEGEND:
COUNTRIES CAPITAL
PROVINCE CAPITAL
FLOWS IN 1,000 tons
FIGURE 5.3
MOZAMBIQUE
Coastal Flows

TABLE 9.5.6-A

9.5.6.A

TOTAL AGGREGATED MONTHLY BY RAIL LINE SECTION

C.F.M. - CENTRAL RAILWAY SYSTEM

- 1981 -

In tons

SECTIONS	JAN.	FEB.	MAR.	APR.	MAI.	JUN.	JUL.	AUG.	SEPT.	OCT.	NOV.	DEC.
1 - BEIRA - MOATIZE												
Beira-Manga	8,843	6,849	8,989	9,051	11,135	10,135	9,526	9,704	9,705	9,705	9,746	9,746
Manga Buzi	8,843	8,849	8,989	9,051	9,674	10,091	9,526	9,704	9,705	9,705	9,746	9,746
Buzi-Dondo	8,843	8,849	8,989	9,051	9,674	10,091	9,526	9,704	9,705	9,705	9,746	9,746
Dondo-Muanza	5,691	5,691	5,837	5,899	5,691	5,691	5,491	5,587	5,587	5,587	5,587	5,587
Muanza-Inhaminga	5,691	5,691	5,837	5,899	5,691	5,691	5,491	5,587	5,587	5,587	5,587	5,587
Inhaminga-Inhamitanga	6,499	6,499	7,645	6,707	6,499	6,499	6,299	6,395	6,395	6,395	6,395	6,395
Inhamitanga-Caia	4,541	5,458	6,480	4,622	5,414	5,414	4,341	4,397	4,397	4,397	4,397	4,397
Caia-Sena	4,300	5,173	6,221	5,222	5,173	5,173	4,100	4,136	4,136	4,136	4,136	4,136
Sena-Nhamalabue	4,262	5,129	6,148	4,881	4,862	4,862	4,056	4,092	4,092	4,092	4,092	4,092
Nhamalabue-Mutarara	4,256	4,822	4,814	4,814	4,822	4,822	4,056	4,092	4,092	4,092	4,092	4,092
Mutarara-Doa	4,256	4,822	4,814	4,814	4,822	4,822	4,056	4,092	4,092	4,092	4,092	4,092
Doa-Moatize	4,256	4,822	4,814	4,814	4,822	4,822	4,056	4,092	4,092	4,092	4,092	4,092
2 - DONDO - MACHIPANDA												
Dondo-Mafambise	5,793	5,753	5,753	5,453	5,502	5,753	5,586	5,085	5,085	5,412	5,710	5,801
Mafambise-Nhamatanda	5,410	5,370	5,370	5,070	5,370	5,370	5,203	5,285	5,285	4,985	5,285	5,701
Nhamatanda-Gondola	5,287	5,287	5,287	5,287	5,287	5,287	5,120	5,160	5,160	5,160	5,160	5,160
Gondola-Chimoio	5,287	5,287	5,287	5,287	5,129	5,129	5,120	5,160	5,160	5,160	5,160	5,160
Chimoio-Machipanda	1,050	1,050	1,050	1,050	1,050	1,050	1,050	1,050	1,050	1,050	1,050	1,050
3 - INHAMITANGA-MARROMEU												
Inhamitanga-Marromeu	1,958	2,831	2,831	2,831	2,831	2,831	1,958	1,998	1,998	1,998	1,998	1,998
4 - NHAMALABUE-MALAWI												
Nhamalabue-Vila Nova da Fronteira		307	1,037	307	307	307	-	-		-	-	-
Vila Nova da Fronteira-Malawi	-	-	1,000	-	-	-	-	-	-	-	-	-
1 - MOATIZE-BEIRA												
Moatize-Doa	48,072	48,072	48,072	48,072	48,072	48,072	48,072	48,072	48,072	48,072	48,072	48,072
Doa-Moatize	48,072	48,072	48,072	48,072	48,072	48,072	48,072	48,072	48,072	48,072	48,072	48,072
Mutarara-Nhamalabue	48,139	48,139	48,072	48,072	48,072	48,072	48,072	48,072	48,072	48,072	48,072	48,072
Nhamalabue-Sena	39,905	39,905	39,838	39,838	39,838	39,838	39,838	39,838	39,838	39,838	39,838	39,838
Sena-Caia	39,905	39,905	39,838	39,838	39,838	40,405	40,405	40,405	39,838	39,838	39,838	39,838
Caia-Inhamitanga	39,637	39,637	39,568	39,568	39,568	40,135	40,135	40,135	39,568	39,568	39,568	39,568
Inhamitanga-Inhaminga	41,854	51,847	50,728	46,778	48,172	48,739	42,746	42,746	40,785	40,785	40,785	40,785
Inhaminga-Cundué	58,604	68,597	67,528	63,528	64,922	65,489	59,496	59,496	57,535	57,535	57,535	57,535
Cundué-Muanza	59,604	69,597	68,528	64,528	65,922	66,489	60,496	60,496	58,535	58,535	58,535	58,535
Muanza-Dondo	73,604	83,597	82,528	82,529	65,922	66,489	74,496	74,496	72,535	72,535	72,535	72,535
Dondo-Búzi	61,111	70,677	70,615	69,615	68,076	68,643	62,577	62,577	60,616	59,559	59,559	59,559
Búzi-Manga	61,249	70,815	70,615	69,615	68,076	68,643	62,577	62,577	60,616	59,559	59,559	59,559
Manga-Beira	61,743	71,309	70,615	69,615	68,076	68,643	62,577	62,577	60,616	59,559	59,559	59,559
2 - MACHIPANDA-DONDO												
Machipanda-Chimoio	4,583	4,583	4,583	4,583	4,583	4,583	4,583	4,583	4,583	4,583	4,583	4,583
Chimoio-Gondola	7,583	7,990	9,047	9,047	9,047	9,047	8,640	8,640	8,640	7,583	7,583	7,583
Gondola-Nhamatanda	7,583	7,990	9,047	9,047	9,047	9,047	8,640	8,640	8,640	7,583	7,583	7,583
Nhamatanda-Mafambise	7,583	7,990	9,047	9,047	9,047	9,047	8,640	8,640	8,640	7,583	7,583	7,583
Mafambise-Dondo	8,925	9,332	10,369	10,869	10,869	10,869	9,964	9,964	9,964	8,907	8,907	8,907
3 - MARROMEU-INHAMITANGA												
Marromeu-Inhamitanga	5,550	15,543	15,543	11,543	11,543	11,543	5,550	5,550	5,550	5,550	5,550	5,550
4 - MALAWI-NHAMALABUE												
Malawi-Vila Nova da Fronteira	-	-	-	-	-	-	-	-	-	-	-	-
Vila Nova da Fronteira-Nhamalabue	7,234	7,234	7,234	7,234	7,234	7,234	8,234	8,234	8,234	8,234	8,234	8,234

S.: COAL AND NON-COAL TRAFFIC.

9.5.6-B

TABLE 9.5.6-B

TOTAL AGGREGATED MONTHLY TRANSPORT BY RAIL LINE SECTION

C.F.M. - CENTRAL RAYLWAY AUXILIARY SYSTEM

- 1981 -

In tons

LINKS	JAN.	FEB.	MAR.	APR.	MAI.	JUN.	JUL.	AUG.	SEPT.	OCT.	NOV.	DEC.
1 - QUELIMANE-MOCUBA												
Quelimane-Nicoadala	3,883	3,883	4,331	4,073	3,883	3,883	3,883	3,883	3,883	3,883	3,883	3,883
Nicoadala-Namacurra	3,883	3,883	4,331	4,073	3,883	3,883	3,883	3,883	3,883	3,883	3,883	3,883
Namacurra-Malei	383	383	831	573	383	383	383	383	383	383	383	383
Malei-Mocuba	383	383										
2 - MOCUBA-QUELIMANE												
Mocuba-Malei	993	995	2,254	2,254	2,254	2,254	308	308	308	308	308	308
Malei-Naciaia	837	839										
Naciaia-Namacurra	1,379	1,381	2,796	2,796	2,796	2,796	850	850	850	850	850	850
Namacurra-Nicoadala	1,602	1,604	2,796	2,796	2,796	2,796	850	850	850	850	850	850
Nicoadala-Quelimane	1,652	1,654	2,796	2,796	2,846	2,846	900	900	900	900	900	900

9.5.6-C

TABLE 9.5.6-C

TOTAL AGGREGATED MONTHLY TRANSPORT BY RAIL LINE SECTION

C.F.M. - NORTHERN RAILWAY SYSTEM

- 1981 -

In tons.

SECTIONS	JAN.	FEB.	MAR.	APR.	MAI	JUN.	JUL.	AUG.	SEPT.	OCT.	NOV.	DEC.
1 NACALA - LICHINGA												
Nacala - Monapo	6,562	7,718	7,718	9,413	8,358	8,229	7,134	7,272	7,155	7,174	7,174	7,174
Monapo - Namialo	6,512	7,668	7,668	9,363	8,533	8,639	6,484	7,622	7,497	7,516	7,516	7,516
Namialo - Nampula	6,462	7,618	7,618	8,724	8,483	8,158	7,328	7,366	7,347	7,366	7,366	7,366
Nampula-Ribaué	3,126	3,227	3,227	3,876	4,092	4,092	3,992	3,930	3,910	3,930	3,930	3,930
Ribaué-Iapala	3,126	3,227	3,227	3,876	4,092	4,092	3,992	3,930	3,910	3,930	3,930	3,930
Iapala - Entre Rios	2,941	3,042	3,042	3,691	3,907	3,907	3,817	3,729	3,709	3,729	3,729	3,729
Entre Rios - Mutuali	2,941	3,042	3,042	3,691	3,907	3,907	3,817	3,729	3,709	3,729	3,729	3,729
Mutuali - Cuamba	1,809	1,910	1,910	2,559	2,775	2,775	2,692	2,526	2,506	2,506	2,506	2,506
Cuamba - Belém	884	884	884	884	884	884	801	851	831	851	851	851
Belém - Catur	884	884	884	884	884	884	801	851	831	851	851	851
Catur - Lichinga	884	884	884	884	884	884	801	851	831	851	851	851
2 CUAMBA - MALAWI												
Cuamba - Entre Lagos	317	317	317	1,067	1,067	1,067	1,067	1,067	1,067	1,067	1,067	1,067
Entre Lagos - Malawi	-	-	-	750	750	750	750	750	750	750	750	750
1 LICHINGA - NACALA												
Linchinga - Catur	1,012	1,012	1,012	1,012	1,012	1,012	1,012	1,012	1,012	1,012	1,012	868
Catur - Belém	1,012	1,012	1,012	1,012	1,012	1,012	1,012	1,012	1,012	1,012	1,012	868
Belém - Cuamba	1,012	1,012	1,012	1,012	1,012	1,012	1,012	1,012	1,012	1,012	1,012	868
Cuamba - Mutuali	3,677	3,677	4,070	4,070	4,070	4,070	4,070	4,070	4,070	4,070	4,070	3,926
Mutuali - Entre Rios	4,735	4,735	7,467	7,467	7,467	7,467	4,070	4,070	4,070	4,070	4,070	3,926
Entre Rios - Iapala	4,735	4,735	7,467	7,467	7,467	7,467	4,070	4,070	4,070	4,070	4,070	3,926
Iapala - Ribaué	4,735	4,735	7,467	7,467	7,467	7,467	4,070	4,070	4,070	4,070	4,070	3,926
Ribaué - Nampula	4,940	4,940	7,467	7,467	7,467	7,467	4,070	4,070	4,070	4,070	4,070	3,926
Nampula - Namialo	4,942	4,942	6,763	6,763	6,763	6,763	3,366	3,366	3,366	3,366	3,366	3,366
Namialo - Monapo	6,859	6,850	8,438	8,438	8,438	8,438	5,041	5,041	5,041	5,041	5,041	5,041
Monapo - Nacala	6,826	6,826	8,438	8,438	8,438	8,438	5,041	5,041	5,041	5,041	5,041	5,041
2 - MALAWI — CUAMBA												
Malawi - Entre Lagos	-	-	-	-	-	-	-	-	-	-	-	-
Entre Lagos - Cuamba	3,000	3,307	3,307	3,307	3,307	3,307	3,000	3,000	3,000	3,000	3,000	3,000

TABLE 9.5.6-D TOTAL AGGREGATED MONTHLY TRANSPORT BY RAIL LINE SECTION

9.5.4.5

C.F.M - SOUTHERN RAILWAY SYSTEM
- 1981 -

In tons

SECTIONS	JAN.	FEB.	MAR.	APR	MAI.	JUN.	JUL.	AUG	SEPT.	OCT	NOV.	DEC.
- CHICUALACUALA-MAPUTO												
Chicualacuala-Mapai	583	583	583	583	583	583	583	583	583	583	583	583
Mapai-Combomune	583	583	583	583	583	583	583	583	583	583	583	583
Combomune-Mabalane	583	583	583	583	583	583	583	583	583	583	583	583
Mabalane-Lionde	583	583	583	583	583	583	583	583	583	583	583	583
Lionde-Chokwé	1,291	1,291	1,291	1,291	1,291	1,291	583	583	583	583	583	583
Chokwé - Magude	1,291	1,291	1,291	1,291	1,291	1,291	583	583	583	583	583	583
Magude-Ungubana	1,291	1,291	1,291	1,291	1,291	1,291	583	583	583	583	583	583
Ungubana-Manhiça	6,740	6,740	6,740	6,740	6,740	6,740	6,032	6,032	6,032	6,032	6,032	6,032
Manhiça-Marracuene	2,157	2,617	2,617	2,617	2,617	2,617	1,449	1,449	1,449	1,449	1,449	1,449
Marracuene-Maputo	2,157	2,617	2,617	2,617	2,617	2,617	1,449	1,449	1,449	1,449	1,449	1,449
2 - R.GARCIA-MAPUTO												
R.Garcia-Movene	12,207	12,207	12,207	12,207	12,207	12,207	15,207	15,207	15,207	15,207	15,207	15,207
Movene-Moamba	21,373	21,373	21,373	21,373	21,373	21,373	24,373	24,373	24,373	24,373	24,373	24,373
Moamba Matola	8,041	8,041	8,041	10,124	8,041	8,041	11,041	11,041	11,041	11,041	11,041	11,041
Matola-Maputo	15,098	15,098	19,431	25,031	25,031	21,298	25,739	25,739	25,739	25,739	25,739	17,006
MAPUTO-SWAZILAND												
Maputo-Umpala	-	-	4,333	4,933	4,933	1,200	4,933	4,933	4,933	4,933	4,933	1,200
Umpala-Goba	-	-	4,333	4,933	4,933	1,200	4,933	4,933	4,933	4,933	4,933	1,200
Goba-Swaziland	-	-	4,333	4,933	4,933	1,200	4,933	4,933	4,933	4,933	4,933	1,200
4 UMPALA-SALAMANGA												
Umpala-Salamanga	-		-		-	-	-	-	-	-	-	-
5 MOAMBA UNGUBANA												
Moamba-Ungubana	13,332	13,332	13,332	13,332	13,332	13,332	13.332	13.332	13,332	13,332	13.332	13.332
6 - XINAVANE-UNGUBANA												
Xinavane-Ungubana	633	937	937	937	937	937	633	633	633	633	633	633
1 MAPUTO-CHICUALACUALA												
Maputo-Marracuene	3,814	3,943	3,943	3,943	3,943	3,943	5,515	5,609	5,609	5,609	5,609	5,609
Marracuene-Manhiça	3,814	3,943	3,943	3,943	3,943	3,943	5,515	5,609	5,609	5,609	5,609	5,609
Manhiça-Ungubana	3,573	3,758	3,758	3,758	3.758	3,758	5,274	5,434	5,368	5,368	5,368	5,368
Ungubana-Magude	11,330	11,794	11,794	11,794	11,794	11,794	13,021	13,101	13,101	13,101	13,101	13,101
Magude- Chokwé	11,305	11,490	11,490	11,490	11,490	11,490	12,996	13,056	13,056	13,056	13,056	13,056
Chokwé -Lionde	116	116	116	116	116	116	824	824	824	824	824	824
Lionde-Mabalene	83	83	83	83	83	83	83	83	83	83	83	83
Mabalene-Combomune	25	25	25	25	25	25	25	25	25	25	25	25
Combomune-Mapai	25	25	25	25	25	25	25	25	25	25	25	25
Mapai-Chicualacuala	25	25	25	25	25	25	25	25	25	25	25	25
2 - MAPUTO-R.GARCIA												
Maputo-Matola	29,292	29,292	29,292	29,292	29,292	29,292	28,344	28,354	28,354	28,354	28,354	28,354
Matola-Moamba	275	275	275	275	275	275	35	45	45	45	45	45
Moamba-Movene	-	-	-	-	-	-	-	-	-	-	-	-
Movene-R.Garcia	-	-	-	-	-	-	-	-	-	-	-	-
3 SWAZILAND-MAPUTO												
Swaziland-Goba	-	-	-	-	-	-	-	-	-	-	-	-
Goba-Umpala	-	-	-	-	-	-	-	-	-	-	-	-
Umpala-Maputo	26,667	26,667	26,667	26,667	26,667	26,667	26,667	26,667	26,667	26,667	26,667	26,667
4 SALAMANGA-Umpala												
Salamanga-Umpala	26,667	26,667	26,667	26,667	26,667	26.667	26.667	26.667	26,667	26,667	26,667	26.667
5 UNGUBANA-MOAMBA												
Ungubana-Moamba	-	-	-	-	-	-	-	-	-	-	-	-
6 - UNGUBANA-XINAVANE												
Ungubana-Xinavane	759	759	759	783	759	759	759	783	783	783	783	783

TABLE 9.5.7 - A MONTHS OF [redacted]K D[redacted]D B[redacted]AIL[redacted]TIO[redacted]

C.F.M. - CENTRAL RAILWAY SYSTEM

- 1981 -

L I N K S	MONTHS OF PEAK	TONS/MONTH	L I N K S	MONTHS OF PEAK	TONS/MONTH
MALAWI-VILA NOVA DA FRONTEIRA	-	-	BEIRA-MANGA	MAI.	11,135
VILA NOVA DA FRONTEIRA-NHAMALABUE	JUL/DEC.	8,234	MANGA-BUZI	JUN.	10,091
MOATIZE-DOA	JAN/DEC.	48,072	BUZI-DONDO	JUN.	10,091
DOA-MUTARARA	JAN/DEC.	48,072	DONDO-MAFAMBISSE	DEC.	5,801
MUTARARA-NHAMALABUE	JAN/FEB.	48,139	MAFAMBISSE-NHAMATANDA	DEC.	5,791
NHAMALABUE-SENA	JAN/FEB.	39,905	NHAMATANDA-GONDOLA	JAN/JUN.	5,287
SENA-CAIA	JUN/AUG.	40,405	GONDOLA-CHIMOIO	JAN/APR.	5,287
CAIA-INHAMITANGA	JUN/AUG.	40,135	CHIMOIO-MACHIPANDA	JAN/DEC.	1,050
INHAMITANGA-MARROMEU	FEB/MAR.	15,543	DONDO-MUANZA	APR.	5,899
INHAMITANGA-INHAMINGA	FEB.	51,847	MUANZA-INHAMINGA	APR.	5,899
INHAMINGA-CUNDUÊ	FEB.	68,597	INHAMINGA-INHAMITANGA	MAR.	7,645
CUNDUÊ-MUANZA	FEB.	69,597	INHAMITANGA-MARROMEU	FEB/JUN.	2,831
MUANZA-DONDO	FEB.	83,597	INHAMITANGA-CAIA	MAR.	6,480
MACHIPANDA-CHIMOIO	JAN/DEC.	4,583	CAIA-SENA	MAR.	6,221
CHIMOIO-GONDOLA	MAR/JUN.	9,047	SENA-NHAMALABUE	MAR.	6,148
GONDOLA-NHAMATANDA	MAR/JUN.	9,047	NHAMALABUE-MUTARARA	FEB,MAI, JUN.	4,822
NHAMATANDA-MAFAMBISSÉ	MAR/JUN.	9,047	MUTARARA-DOA	FEB,MAI, JUN.	4,822
MAFAMBISSE-DONDO	MAR/JUN.	10,869	DOA-MOATIZE	FEB,MAI, JUN.	4,822
DONDO-BUZI	FEB.	70,677	NHAMALABUE-VILA NOVA DA FRONTEIRA	MAR.	1,307
BUZI-MANGA	FEB.	70,815	VILA NOVA DA FRONTEIRA-MALAWI	MAR.	1,000
MANGA-BEIRA	FEB.	71,309			

TABLE 9.5.7-B

MONTHS OF PEAK DEMAND BY RAIL SECTION

C.F.M. - NORTHERN RAILWAY SECTIONS

- 1981 -

L I N K S	MONTHS OF PEAK	TONS/MONTH	L I N K S	MONTHS OF PEAK	TONS/MONTH
LICHINGA-CATUR	JAN/NOV.	1,012	NACALA-MONAPO	APR.	9,413
CATUR-BELÉM	JAN/NOV.	1,012	MONAPO-NAMIALO	APR.	9,363
BELÉM-CUAMBA	JAN/NOV.	1,012	NAMIALO-NAMPULA	APR.	8,724
ENTRE LAGOS-CUAMBA	FEB/JUN.	3,307	NAMPULA-RIBAUÊ	MAI/JUN.	4,092
CUAMBA-MUTUALI	MAR/NOV.	4,070	RIBAUÊ-IAPALA	MAI/JUN.	4,092
MUTUALI-ENTRE RIOS	MAR/JUN.	4,767	IAPALA-ENTRE RIOS	MAI/JUN.	3,907
ENTRE RIOS-IAPALA	MAR/JUN,	4,767	ENTRE RIOS-MUTUALI	MAI/JUN.	3,907
IAPALA-RIBAUÊ	MAR/JUN.	4,767	MUTUALI-CUAMBA	MAI/JUN.	2,775
RIBAUÊ-NAMPULA	MAR/JUN.	4,767	CUAMBA-ENTRE LAGOS	APR/DEC.	1,067
NAMPULA-NAMIALO	MAR/JUN.	6,763	ENTRE LAGOS-MALAWI	APR/DEC.	758
NAMIALO-MONAPO	MAR/JUN.	8,438	CUAMBA-BELÉM	JAN/JUN.	834
MONAPO-NACALA	MAR/JUN.	8,438	BELÉM-CATUR	JAN/JUN.	834
			CATUR-LICHINGA	JAN/JUN.	834

applicable to Mozambique. In the same way, the related analysis on production and superavit, as well as the perspectives of the changing consumption pattern due to increases in the income of populations, are not possible to be estimated since information is not available.

Several attempts of a cross-section fitting of the type $Fij = f\ (Pj/Pi,\ 1/dij)$ being i the origin district and j the destination district and F, P and d, respectively the flow, population and distance as well as several derivations of the refered function showed coefficient of fit (r^2) too low.

For forecasting future origin/destination matrix to the years of 1990, 1995, 2000 and 2010 (Tables 9.5.8-A, B, C and D), it was assumed by the simple approach of considering that to succeed in the goals proposed by the government for this decade it will be necessary to guarantee to each district at a minimum, the same production superavit defined as a target for 1981, keeping the same per capita excedent and also assuming that future destinations of the excedent will likely be the same as for the 1981 targets.

Only in two areas the increase in production was considered subject to the transportation projects, assuming that the Mozambique Government would execute agricultural development programs in the most adequate areas of influence of the railway in parallel with the transportation projects. The two areas considered were the Maravia-Angonia Plateau (Tete Province) and in the railway area of influence in the alternatives across the Zambezia Province.

- Future Production in the Maravia-Angonia Plateau, in Tete Province.

The Tete Province, which will directly benefit with the exploitation and transportation of coal from the Mucanha/Vuzi mines has one of the lowest population densities in Mozambique.

TABLE 9.5.8-A AGGREGATED NON COAL ORIGIN/DESTINATION MATRIX

– 1990 –

tons x 10^3

O \ D	CABO DELGADO	NIASSA	NAMPULA	TETE	ZAMBÉZIA	MANICA	SOFALA	GAZA	INHAMBANE	MAPUTO	Σ	EXPORT NACALA	EXPORT BEIRA	EXPORT MAPUTO	MALAWI THROUGH TRAFFIC	ZIMBABWE THROUGH TRAFFIC
CABO DELGADO	180,0	–	21,5	–	–	–	–	–	–	40,7	242,2	–	–	–	–	–
NIASSA	25,8	51,2	69,5	78,3	34,2	–	347,3	–	–	455,5	1,061,6	2,6	–	–	–	–
NAMPULA(*)	34,3	31,2	884,6	–	168,6	–	5,4	–	1,7	65,7	1,191,5	86,8	–	–	95,2	–
TETE	–	–	2,1	203,7	–	10,5	302,5	–	0,9	–	519,7	–	684,0	–	–	–
ZAMBÉZIA	0,1	–	32,0	–	1,119,3	–	65,0	–	0,4	54,7	1,270,5	1,4	–	–	–	–
MANICA	–	–	–	0,6	7,4	544,8	244,4	–	–	–	797,2	–	10,5	2,0	–	–
SOFALA(*)	6,4	–	17,4	227,5	101,1	186,3	1,972,8	–	5,0	22,9	2,539,4	–	220,6	–	500,0	135,5
GAZA	–	–	–	–	–	–	1,0	32,0	1,3	19,4	53,7	–	–	15,1	–	–
INHAMBANE	–	–	–	–	–	–	3,0	1,6	101,0	39,9	145,5	–	–	–	–	–
MAPUTO	19,5	–	103,1	–	34,8	–	88,0	281,3	33,2	1,901,5	2,461,4	–	–	101,6	–	–
Σ	265,9	82,4	1,130,2	510,1	1,465,4	741,6	3,028,4	314,9	143,5	2,600,3	10,282,7	90,8	916,0	118,7	–	–
MALAWI EXPORT	–	–	450,4	–	–	–	243,6	–	–	–	–	–	–	–	–	–
ZIMBABWE EXPORT	–	–	–	–	–	–	41,6	–	–	–	–	–	–	–	–	–

(*) IMPORT INCLUDED

TABLE 9.5.8-B AGGREGATED NON COAL ORIGIN/DESTINATION MATRIX

- 1995 -

tons x 10^3

O \ D	CABO DELGADO	NIASSA	NAMPULA	TETE	ZAMBÉZIA	MANICA	SOFALA	GAZA	INHAMBANE	MAPUTO	Σ	EXPORT NACALA	EXPORT BEIRA	EXPORT MAPUTO	MALAWI THROUGH TRAFFIC	ZIMBABWE THROUGH TRAFFIC
CABO DELGADO	218,6	-	26,1	-	-	-	-	-	-	49,5	294,2	-	-	-	-	-
NIASSA	31,1	62,5	84,7	95,2	41,6	-	422,5	-	-	554,1	1,291,7	3,1	-	-	-	-
NAMPULA(*)	41,6	38,0	1,076,0	-	205,0	-	6,6	-	2,1	80,0	1,449,3	105,5	-	-	154,9	-
TETE	-	-	2,5	247,8	-	12,8	367,9	-	1,0	-	632,0	-	833,2	-	-	-
ZAMBÉZIA	0,2	-	38,8	-	1,361,3	-	77,9	-	0,5	66,5	1,545,2	1,7	-	-	-	-
MANICA	-	-	-	0,8	9,0	662,8	297,2	-	-	-	969,8	-	12,8	2,4	-	-
SOFALA(*)	7,8	-	21,1	276,7	123,0	226,7	2,399,8	-	6,1	27,9	3,089,1	-	268,4	-	709,2	182,5
GAZA	-	-	-	-	-	-	1,2	19,0	1,6	23,5	65,3	-	-	18,3	-	-
INHAMBANE	-	-	-	-	-	-	3,6	1,9	122,9	48,5	176,9	-	-	-	-	-
MAPUTO	23,7	-	125,4	-	42,2	-	107,0	342,2	40,3	2,313,7	2,994,5	-	-	123,6	-	-
Σ	323,0	100,5	1,374,6	620,5	1,782,1	902,3	3,683,7	383,1	174,5	3,163,7	12,508,0	110,3	1,114,4	144,3	-	-
MALAWI EXPORT	-	-	725,4	-	-	-	326,0	-	-	-	-	-	-	-	-	-
ZIMBABWE EXPORT	-	-	-	-	-	-	55,7	-	-	-	-	-	-	-	-	-

(*) IMPORT INCLUDED

TABLE 9.5.8-C AGGREGATED NON COAL ORIGIN/DESTINATION MATRIX

– 2000 –

tons x 10^3

O \ D	CABO DELGADO	NIASSA	NAMPULA	TETE	ZAMBÉZIA	MANICA	SOFALA	GAZA	INHAMBANE	MAPUTO	Σ	EXPORT NACALA	EXPORT BEIRA	EXPORT MAPUTO	MALAWI THROUGH TRAFFIC	ZIMBABWE THROUGH TRAFFIC
CABO DELGADO	265,9	–	31,8	–	–	–	–	–	–	60,3	358,0	–	–	–	–	–
NIASSA	37,9	75,9	102,9	115,9	50,5	–	514,0	–	–	674,1	1,571,3	3,8	–	–	–	–
NAMPULA(*)	50,8	46,2	1,308,9	–	249,5	–	8,0	–	2,5	97,3	1,763,2	128,4	–	–	249,3	–
TETE	–	–	3,1	301,3	–	15,6	447,7	–	1,3	–	769,0	–	1,013,5	–	–	–
ZAMBÉZIA	0,2	–	47,2	–	1,656,2	–	94,8	–	0,6	80,9	1,879,9	2,0	–	–	–	–
MANICA	–	–	–	1,0	10,9	806,4	361,7	–	–	–	1,180,0	–	15,5	2,9	–	–
SOFALA(*)	9,5	–	25,7	336,7	149,4	275,6	2,920,1	–	7,4	33,9	3,758,3	–	326,3	–	349,0	244,5
GAZA	–	–	–	–	–	–	1,5	47,5	1,9	28,6	79,5	–	–	22,3	–	–
INHAMBANE	–	–	–	–	–	–	4,4	2,3	149,4	59,0	215,1	–	–	–	–	–
MAPUTO	28,9	–	152,5	–	51,4	–	130,2	416,3	49,0	2,814,5	3,642,8	–	–	150,2	–	–
Σ	393,2	122,1	1,672,1	754,9	2,168,0	1,097,6	4,482,4	466,1	212,1	3,848,6	15,217,1	134,2	1,355,7	175,4	–	–
MALAWI EXPORT	–	–	1,168,3	–	–	–	436,2	–	–	–	–	–	–	–	–	–
ZIMBABWE EXPORT	–	–	–	–	–	–	74,5	–	–	–	–	–	–	–	–	–

(*) IMPORT INCLUDED

TABLE 9.5.8-D AGGREGATED NON COAL ORIGIN/DESTINATION MATRIX

- 2010 -

tons x 10^3

O \ D	CABO DELGADO	NIASSA	NAMPULA	TETE	ZAMBÉZIA	MANICA	SOFALA	GAZA	INHAMBANE	MAPUTO	Σ	EXPORT NACALA	EXPORT BEIRA	EXPORT MAPUTO	MALAWI THROUGH TRAFFIC	ZIMBABWE THROUGH TRAFFIC
CABO DELGADO	393,5	-	46,9	-	-	-	-	-	-	89,2	529,6	-	-	-	-	-
NIASSA	56,1	112,4	152,4	171,5	74,8	-	760,9	-	-	997,9	2,326,0	5,6	-	-	-	-
NAMPULA(*)	75,1	68,5	1,937,4	-	369,3	-	11,8	-	3,7	144,0	2,609,8	189,9	-	-	647,1	-
TETE	-	-	4,6	448,0	-	23,1	662,8	-	1,9	-	1,140,[illegible]	-	1,500,5	-	-	-
ZAMBÉZIA	[illegible]	-	70,0	-	2,451,4	-	140,2	-	0,[illegible]	119,7	2,782,5	3,0	-	-	-	-
MANICA	-	-	-	1,4	16,3	1,193,7	535,3	-	-	-	1,746,7	-	23,0	4,4	-	-
SOFALA(*)	14,0	-	38,0	498,2	221,3	408,2	4,322,1	-	10,9	50,2	5,562,9	-	483,3	-	1,692,5	[illegible]37,8
GAZA	-	-	-	-	-	-	2,2	70,3	2,[illegible]	42,4	117,7	-	-	33,0	-	[illegible]
INHAMBANE	-	-	-	-	-	-	6,5	3,4	221,[illegible]	87,3	318,3	-	-	-	-	-
MAPUTO	[illegible]	-	225,8	-	76,1	-	192,7	516,1	72,[illegible]	4,166,0	5,392,0	-	-	222,5	-	-
Σ	581,8	180,9	2,475,1	1,119,1	3,209,2	1,625,0	5,634,5	689,8	313,[illegible]	5,696,7	22,525,9	198,5	2,006,8	259,5	-	-
MALAWI EXPORT	-	-	3,030,2	-	-	-	781,1	-	-	-	-	-	-	-	-	-
ZIMBABWE EXPORT	-	-	-	-	-	-	133,4	-	-	-	-	-	-	-	-	-

(*) IMPORT INCLUDED

The Tete Province which covers an area of 90,000 km^2 and represents more than 11% of the total area of the country, has only 5.9% of the Mozambique population and in Maravia, Bene, Zumbo, Cahora Bassa and Magoé districts, which are closer to the coal reserves and/or area of influence from the access transportation system, are extremely thinly populated.

Agricultural and cattle raising production which is highly dependent upon regular transportation, accessible consumption markets and plentifullness of labor force does not present, at the moment, significant values of production. The production values in Tete Province represents less than 2% of the total country's production.

Because of topographical, climatic and soil fecundity in the Maravia-Angonia plateau, it is quite possible to expand the maize, sorghum, groundnut and sunflower production which are in great demand on the international market, with the development of a transport system which connects the area with the ocean ports and also after the increase in the local market consumption due to mining activities.

The introduction of coffee production is also possible after a study of the Maravia-Angonia plateau which may be considered as an important economical and social activity.

A coffee plantation is characterized as labor force intensive and the utilisation of fertile land with an average altitude of 600 meters and by great productivity as well as the guarantee of international demand.

It was estimated at the begining of the nineties an average production of 150,000 tons of maize, sorghum, groundnut and sunflower whose values can easily increase to over 200,000 tons if transportation is available.

A production of 60,000 tons of coffee (1,000,000 sacks) may be reached in a 5 year term and with governmental interest, 100,000 tons of coffee and 20,000 tons of beans could be produced annually in the same cultivation.

Based on this assumption there would be a transport demand towards the ports of Beira or Nacala and vice-versa (output and fertilizer) of approximately 300,000 tons per year.

- The Zambezia Province.

The Zambezia Province which geographical area represents nearly 11% of the Mozambique territory would benefit from the rail connection Cambulatsisse-Nhamalabue-Rio Muelaiva-Muconha-Monapo for the coal transport from Mucanha/Vuzi up to the Nacala terminal.

The Zambezia Province accounts for 80% of cashewnut and 93% of copra production in Mozambique. It also has a significant production of sugar cane, maize, beans and fruits, having a great potential for production if additional regular and convenient transport is supplied connecting inland to the Nacala port.

The continuity in renewing and enlargement of copra and cashewnut plantations will be encouraged by increasing access to the Nacala port making easy the exporting procedures.

A study of agricultural development including industries for cashewnut processing should be carried out in view of natural conditions of topography, soil fecundity, plentifullness of labor force and actual and future transportation facilities.

By the beginning of the nineties, just the local production of copra and cashewnut may reach 300,000 tons independently of stimulation which would naturally occur if a railway through Zambezia under study was constructed.

The other agricultural products, basically destinated for domestic market would also have its production increased due to the new option of transportation.

9.5.3

9.5.3 *International through traffic*

For international through traffic towards the port of Nacala and Beira, the traffic with origin or destination to Malawi and Zimbabwe was considered.

Such estimates were based on the Beira Port Transportation Plan, executed by Nedeco, whose rate of growth were based on 1981 figures.

© Forecasts for traffic demand from Zimbabwe

At the moment the Zimbabwean economy is facing the problem of integration of the black pleople in its modern and diversified economical sector.

In general, however, there can be noticed a considerable potential of growth in the agriculture and industrial sectors while perspectives for mining is being encouraged by the coal exploitations plans in Sengwa and Lusulu regions (in the Zambeze basin) besides the enlargement of production in the Wankie fields.

The export goals from Zimbabwe account for 15.3 millions tons for coal and 2.82 millions tons of other non coal products for the year 2000.

Main export figures in terms of volume will be cotton, tobacco and sugar in agricultural sector and steel, iron alloy and asbestos for industrial and mining sector.

Total import figures are forecasted with a growth of 1.52 million tons to 2.76 millions tons of which approximately 50% consisting of petroleum products.

Zimbabwe is the greatest potential generator of traffic through Mozambique system having five alternative railway routes with neighboring countries, two of them with Mozambique (Machipanda to Beira and Chicualacuala to Maputo).

The greatest part of its traffic through Mozambique rail way system is directed to Maputo since the Harare-Machipanda line has unfavorable geometrical characteristics.

The generated traffic in southern and western part of Zimbabwe, besides traffic to and from Zambia, Zaire and Botswana which goes across Bulawayo, will use the Maputo route, which is the shortest. In the future, the southern route will continue to be preferable since Zimbabwe has started an electrification program on railways which includes the connection to Chicualacuala.

Coal exports from Zimbabwe will be through Maputo. Only the traffic with origin at the eastern part of Sumabula and some traffic from Malawi (sugar and molasses) will use Beira port.

Forecasted traffic to Beira route was based on information from the Direção Nacional de Portos e Caminhos de Ferro de Moçambique, notwithstanding forecasts from Zimbabwe Railway are lower for 1985 and appear to be only a small portion of the total trade from Zimbabwe.

The stimulation traffic allocation was based upon the assumption that Zimbabwe will gradually reduce overseas shipping through South African ports from 30% by 1985 to 10% in 1990 and 0% by the year 2000. The remaining traffic will be allocated between the ports of Beira and Maputo, assuming transport and port operation are gradually normalized.

- Forecasts for future traffic demand from Malawi.

Agriculture will continue to be the main sector in Malawi economy. The country does not have many alternatives but to increase agricultural productivity with the objective of meeting self sufficiency in food and earning some foreign currency from export for supporting the Malawi economical development.

The main Malawian export items will be tobacco, sugar and tea. Exports will have a rate of growth of 3% and 5% and imports, mainly of fertilizers, petroleum products and coal will have a rate of growth of 3.5% and 4% a year.

- Forecasts of Future Transport Demand from other countries.

From the Southern Africa coutries, besides Malawi and Zimbabwe, only Zambia is assumed to ship a representative amount of goods through the port of Beira. For the year 2000, total volume shipped is not espected to exceed 125,000 tons per year.

- Annual rate of growth for international through traffic in CFM-C and in CFM-N.

Based on the analysis carried out, it has been considered the following annual rate of growth for international through traffic to and from the ports of Beira and Nacala:

- CFM-C (Port of Beira) = 6% a year
- CFM-N (Port of Nacala) = 10% a year.

- Passenger Traffic.

As far as passenger traffic is concerned, the average number of trips per inhabitant in Mozambique is extremely low. In 1980 the per capita travel accounted for 15.7 journeys per person with an average distance of 18 km.

Deficiencies in the physical and operational transport infrastructure and the high costs of the air transport in relation to the Mozambique population income are the restrictive factors to the increase in the number of trips per person.

Tables 9.5.9 and 9.5.10 show the forecasts of increasing in passenger traffic up to 1990, estimated by the DNPCF, which increases the per capita travel to nearly 28 trips per person, which means an average annual rate of growth of 6%, which will hardly be reached unless an extensive program for improving existing transport system is executed by the government.

In the analysis of the alternatives the railway passenger traffic was not considered relevant as to interfere with the coal and non-coal traffic.

TABLE 9.5.9
PASSENGER TRAFFIC

in 10^3 Passenger traffic

TRAFFIC \ YEARS	1979	1980	1981	1985	1990
1. DOMESTIC TRAFFIC	153,596	190,867	251,183	293,047	509,043
1.1 - Railway traffic	12,002	14,521	15,118	31,015	57,950
. CFM-Southern	7,492	9,434	9,600	18,800	3,500
. CFM-Central	2,421	2,700	2,800	7,250	14,500
. CFM-Northern	1,352	1,800	2,000	3,500	6,000
1.2 - Highway Traffic	141,594	171,746	230,298	249,795	420,387
. Urban	120,000	145,600	200,710	206,440	354,790
. Interurban	21,594	26,146	29,588	43,355	65,597
1.3 - Ocean-River traffic	-	4,600	5,767	12,328	30,472
Local and Regional Traffic	-	4,162	4,891	9,357	19,769
. Urban	-	438	876	2,971	10,703
. Interurban	-	-	-	109	234
1.4 - Coastal Traffic	-	-	-	109	234
. Interurban	-	-	-	109	234
2. INTERNATIONAL (*)	59	73	93	151	575
2.1 - Railway	59	63	82	135	550
. CFM- Southern	58	62	70	100	300
. CFM-Central	-	-	10	30	200
. CFM-Northern	1	1	2	5	50
2.2 - Highway	-	10	11	16	25

SOURCE: D.N.P.C.F.

9.5.10

TABLE 9.5.10
PASSENGER TRAFFIC

in 10^6 Passenger x km

TRAFFIC \ YEARS	1979	1980	1981	1985	1990
1. DOMESTIC TRAFFIC	2,812	3,428	4,236	5,964	10,281
1.1 - Railway Traffic	422	522	622	1,321	2,455
. CFM-Southern	172	217	288	658	1,225
. CFM-Central	128	143	154	435	870
. CFM-Northern	122	162	180	228	360
1.2 - Highway	2,390	2,883	3,576	4,459	7,079
. Urban	1,008	1,210	1,706	1,858	3,406
. Interurban	1,382	1,673	1,870	2,601	3,673
1.3 - Ocean-River Traffic	-	23	38	110	562
. Urban	-	14	17	30	91
. Interurban	-	9	21	80	147
1.4 - Coastal Traffic	-	-	-	74	185
. Interurban	-	-	-	74	185
2. INTERNATIONAL	6	7	38	68	271
2.1 - Railway	6	6	37	67	269
. CFM- Southern	5	5	33	55	179
. CFM-Central	-	-	3	9	60
. CFM-Northern	1	1	1	3	30
2.2 - Highway	-	1	1	1	2

SOURCE: D.N.P.C.F.

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9.6. TRANSPORTATION STUDIES

9.6 TRANSPORTATION STUDIES

9.6.1 *Area and geographical location of the coal basin in the Mucanha/Vuzi region.*

For the Mucanha/Vuzi region coal outflow transportation studies, the area considered comprises the coal reserves situated between the Mucanha and Vuzi Rivers and the directly and indirectly influenced areas as well.

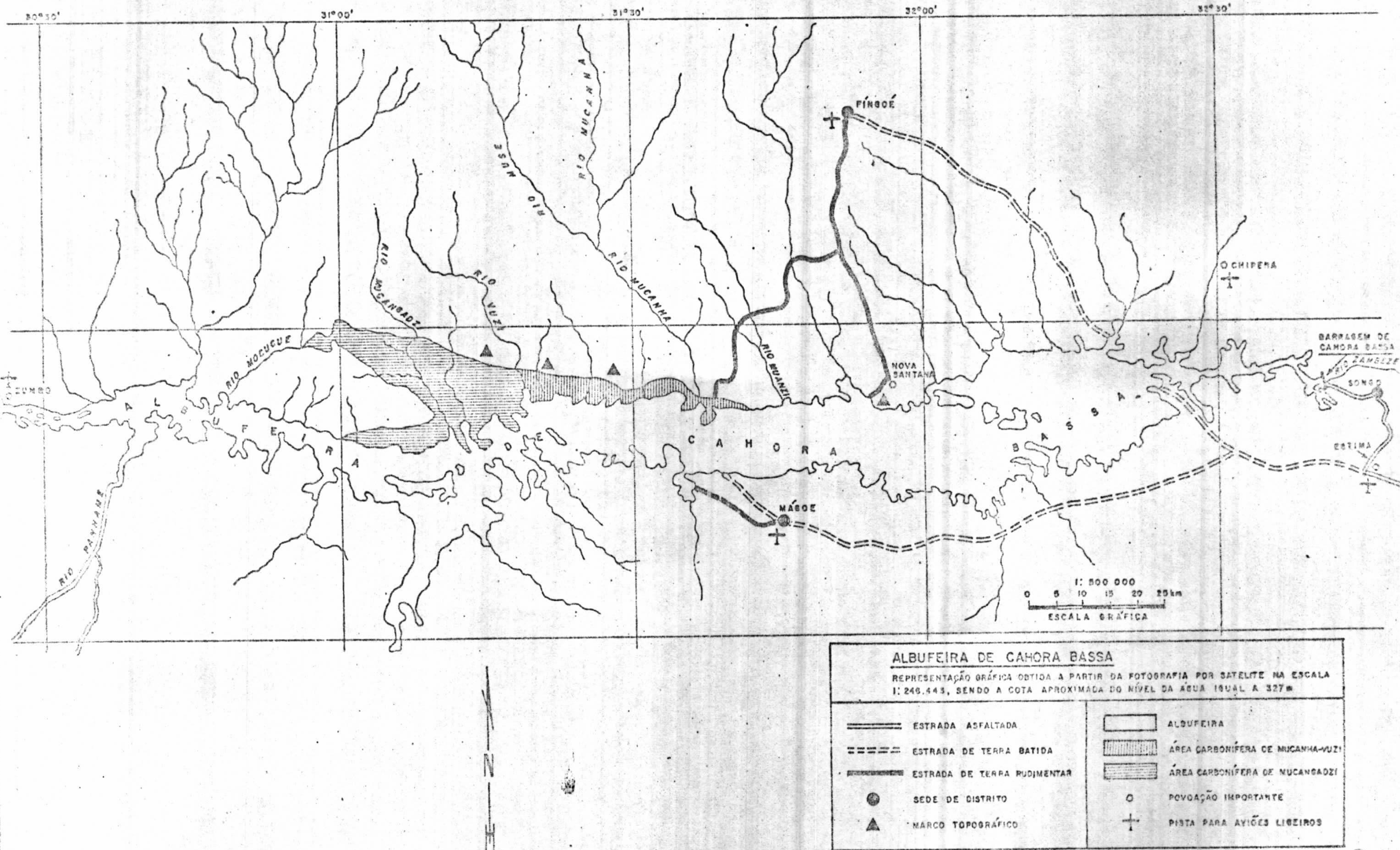
The coal region situated between the Mucanha and Vuzi Rivers is part of the Chicoa-Mecucoê coal basin, in the main course of the Zambeze River, upstream of the Cahora Bassa Hydro-electric dam, in the Tete Province, approximately between 30º55' and 31º40' of longitude east and between 15º20' and 15º50' of latitude south. It is almost totally situated in the Magoê District and in a lesser extent in the Maravia District.

It covers a nearly 300 km^2 surface with 40 km length and 8 km wide, with nearly 40% of the total permanently flooded by the Cahora Bassa reservoir water and in case of maximum floods may have almost 50% of the area flooded.

The graphical representation which follows (Figure 9.6.1) adapted from sattelite photography in 1:246,443 scale allows visualization of the reserves locations.

The area of direct influence has been considered as the districts of Fingoé, Zumbo, Tembué, Furancungo, Moatize, Tete, Songo, Magoê and Maravia in Tete Province.

The indirect area of influence for the transportation studies basically comprises all Mozambique territory, mainly that situated north of the Save River and also including Malawi and Zimbabwe, the latter as origin of through traffic for export and import by using CFM-C and CFM-N Railway Systems and the ports of Beira and Nacala under study.



D.6.1

FIG. 5.1

ESTUDO DE ALTERNATIVAS DE ESCOAMENTO DA PRODUÇÃO DE CARVÃO DE MUCANHA/VUZI "STUDY OF OUTFLOW ALTERNATIVES"

In what the direct area of influence is concerned, the natural climatic conditions are:

TABLE 9.6.1-AVERAGE MONTHLY TEMPERATURE (ºC) IN THE 1978 TO 1982 PERIOD.

YEARS	JAN	FEB	MAR	APR	MAI	JUN	JUL	AUG.	SEPT	OCT	NOV	DEC
1978	28.6	28.8	27.9	26.9	24.8	21.9	20.6	25.2	27.8	30.4	30.6	27.8
1979	28.8	30.1	27.6	27.2	24.8	22.2	22.2	24.9	27.8	30.9	30.2	28.9
1980	29.6	29.2	28.1	28.2	24.7	21.4	21.3	23.5	27.1	28.5	31.9	28.8
1981	29.3	27.9	28.2	26.4	23.6	21.7	21.4	24.0	26.6	27.1	30.5	29.7
1982	28.4	27.6	28.9	27.0	23.7	23.2	22.7	24.0	25.6	-	-	-

SOURCE: CLIMATIC STATION OF TETE

TABLE 9.6.2-PLUVIOMETRIC INDEXES: MONTHLY AVERAGE IN THE 1978 TO 1982 PERIOD (in mm).

YEARS	JAN	FEB	MAR	APR	MAI	JUN	JUL	AUG	SEPT	OCT	NOV	DEC	TOTAL
1978	331.7	95.5	227.4	15.3	0.3	10.0	6.0	0.0	0.0	0.0	11.5	200.6	898.3
1979	48.4	88.7	119.1	3.4	0.1	11.2	1.0	0.0	0.3	7.5	69.8	84.2	433.7
1980	163.3	110.7	53.5	32.6	3.0	1.7	6.9	0.8	2.0	0.8	21.8	156.6	553.7
1981	113.9	171.0	40.6	49.0	8.0	2.5	2.2	0.0	0.3	9.0	33.7	64.8	495.0
1982	146.5	235.3	8.9	47.1	6.1	0.0	4.8	2.6	0.0	-	-	-	-

SOURCE: CLIMATIC STATION OF TETE

TABLE 9.6.3-EVAPORATION: MONTHLY AVERAGE IN THE 1978 TO 1982 PERIOD (in mm)

YEARS	JAN	FEB	MAR	APR	MAI	JUN	JUL	AUG	SEPT	OCT	NOV	DEC	TOTAL
1978	86.9	86.2	80.9	124.4	128.2	135.9	125.0	185.8	219.4	286.7	262.4	93.7	1815.[illegible]
1979	144.5	112.7	102.1	129.7	151.8	119.3	114.3	159.1	240.7	315.2	209.6	206.4	2005.[illegible]
1980	149.8	192.7	124.2	175.1	166.2	119.5	141.7	109.2	187.5	226.7	279.7	145.9	2018,[illegible]
1981	136.5	74.1	131.8	145.8	103.0	123.0	124.8	171.8	202.6	195.3	212.8	151.8	1773.[illegible]
1982	91.9	80.7	103.6	125.5	125.6	126.4	168.6	203.1	205.4	-	-	-	-

SOURCE: CLIMATIC STATION OF TETE

TABLE 9.6.4 - SUNSTROKE: MONTHLY AVERAGE IN THE 1978 TO 1982 PERIOD (in cal./cm^2)

YEARS	JAN	FEB	MAR	APR	MAI	JUN	JUL	AUG	SEPT	OCT	NOV	DEC	TOTAL
1978	232.5	205.3	201.5	219.6	273.3	251.6	273.2	317.1	279.6	289.8	325.4	239.2	3108.1
1979	288.5	229.6	169.4	263.8	301.3	187.3	227.4	286.8	272.2	284.8	273.1	220.2	3004.4
1980	316.1	236.2	243.2	259.6	295.6	265.7	235.9	251.3	221.7	272.4	313.3	218.3	2933.4
1981	261.9	182.3	238.4	217.6	271.7	284.0	256.5	293.4	275.9	260.1	-	-	2306.8
1982	-	189.7	279.6	242.0	183.4	268.2	229.1	276.9	249.7	-	-	-	-

SOURCE: CLIMATIC STATION OF TETE.

9.6.2 *Routes and Alternatives under study*

The analysis carried out by GEIPOT, based on existing information, plans and projects, aims at selecting conclusively the most economical transportation alternative for the coal outflow from the Mucanha/Vuzi Region, complemented by the production outflow from the Moatize mines.

In the study, the following routes and alternatives showed have been considered in the Figures 9.6.2 and 9.6.3 and Volume 9.2 (Figures 9.2.1, 9.2.2 and 9.2.3).

The routes which follows has as starting point the Mucanha / Vuzi coal terminal in a 150 meters of distance at 40º Northeast from the point defined by the UTM coordinates of 8,271,500 North and 334,000 East, in the vicinity of the Bohozi River and the Cahora Bassa Reservoir.

o. ROUTE 1: PORT OF BEIRA

ALTERNATIVE 1.1 - Northern through CFM-Center

Construction of a railway line north of the Cahora Bassa reservoir connecting Mucanha/Vuzi to Cambulatsisse (364 km long); rehabilitation and upgrading work on existing railway line between Cambulatsisse and the port of Beira (517 km long), complemented by rehabilitation and upgrading in the railway section from Cateme to Cambulatsisse (26 km long) and construction of the Moatize to Cateme Variant (32 km long) and the construction of the new coal terminal in the port of Beira and the transportation accesses.

ALTERNATIVE 1.2 - Southern through Cahora Bassa Lake Navigation and CFM - Center.

Navigation in the lake of Cahora Bassa (124 km long) with the construction of a loading terminal close to the Bohozi River and of the unloading terminal at Nhancapirire; construction of the railway section connecting Nhancapirire to Moatize (151 km long); construction of the Moatize to Cateme Variant (32 km long); rehabilitation and upgrading of the existing Cateme to Cambulatsisse and to the port of Beira railway line (543 km long) and construction of the new coal terminal at the port of Beira (Franquia place) and the transportation accesses.

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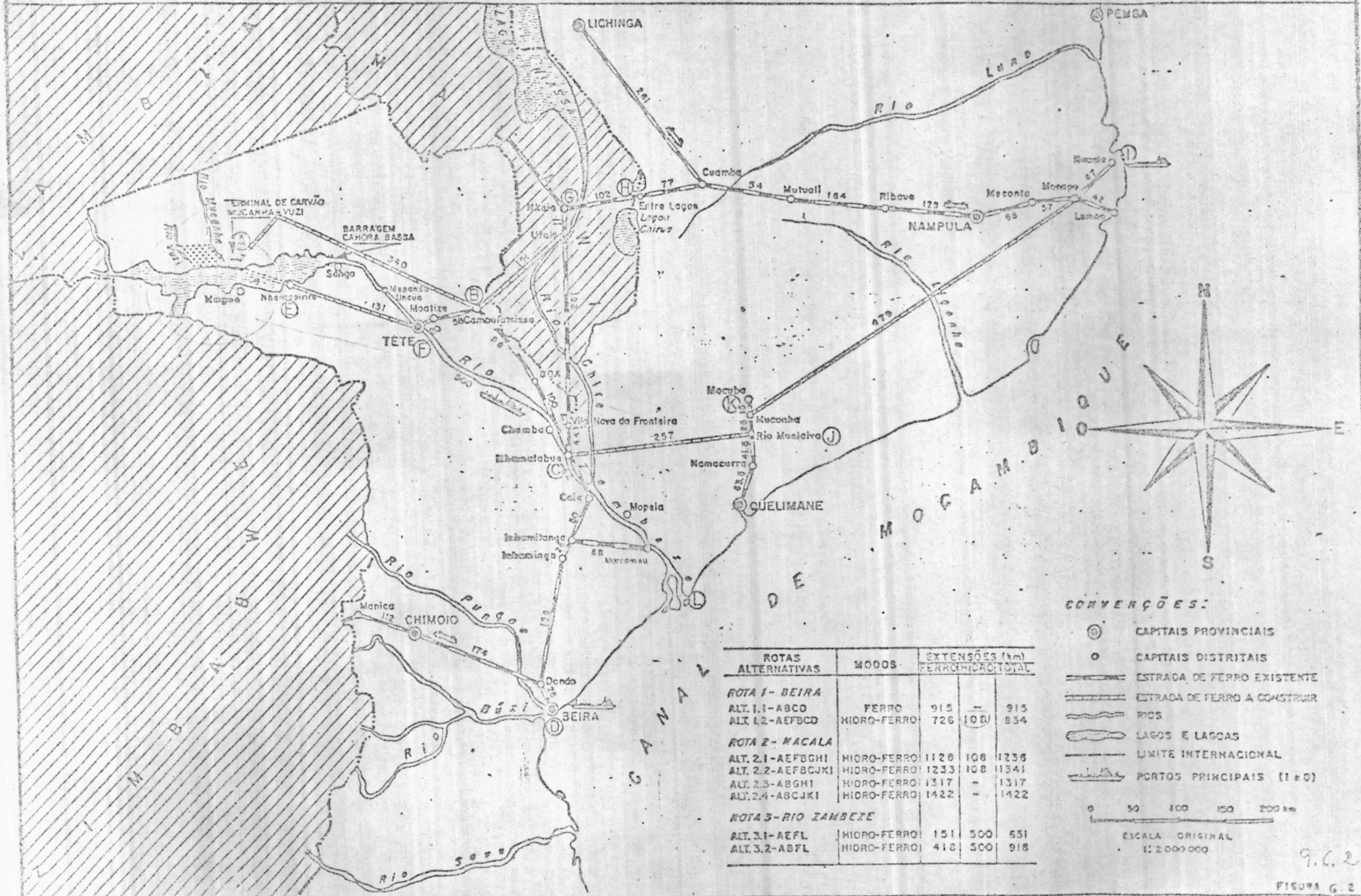

ROTAS ALTERNATIVAS	MODOS	EXTENSÕES (km) FERRO	HIDRO	TOTAL
ROTA 1 - BEIRA				
ALT. 1.1-ABCD	FERRO	915	–	915
ALT. 1.2-AEFBCD	HIDRO-FERRO	726	108	834
ROTA 2 - MACALA				
ALT. 2.1-AEFBGHI	HIDRO-FERRO	1128	108	1236
ALT. 2.2-AEFBCJKI	HIDRO-FERRO	1233	108	1341
ALT. 2.3-ABGHI	HIDRO-FERRO	1317	–	1317
ALT. 2.4-ABCJKI	HIDRO-FERRO	1422	–	1422
ROTA 3 - RIO ZAMBEZE				
ALT. 3.1-AEFL	HIDRO-FERRO	151	500	651
ALT. 3.2-ABFL	HIDRO-FERRO	418	500	918

9.6.2

FIGURA 6.2

ESTUDO DE ALTERNATIVAS DE ESCOAMENTO DA PRODUÇÃO DE CARVÃO DE MUCANHA/VUZI "STUDY OF OUTFLOW ALTERNATIVES"

Rotas e Alternativas Estudadas

MT-GEIPOT

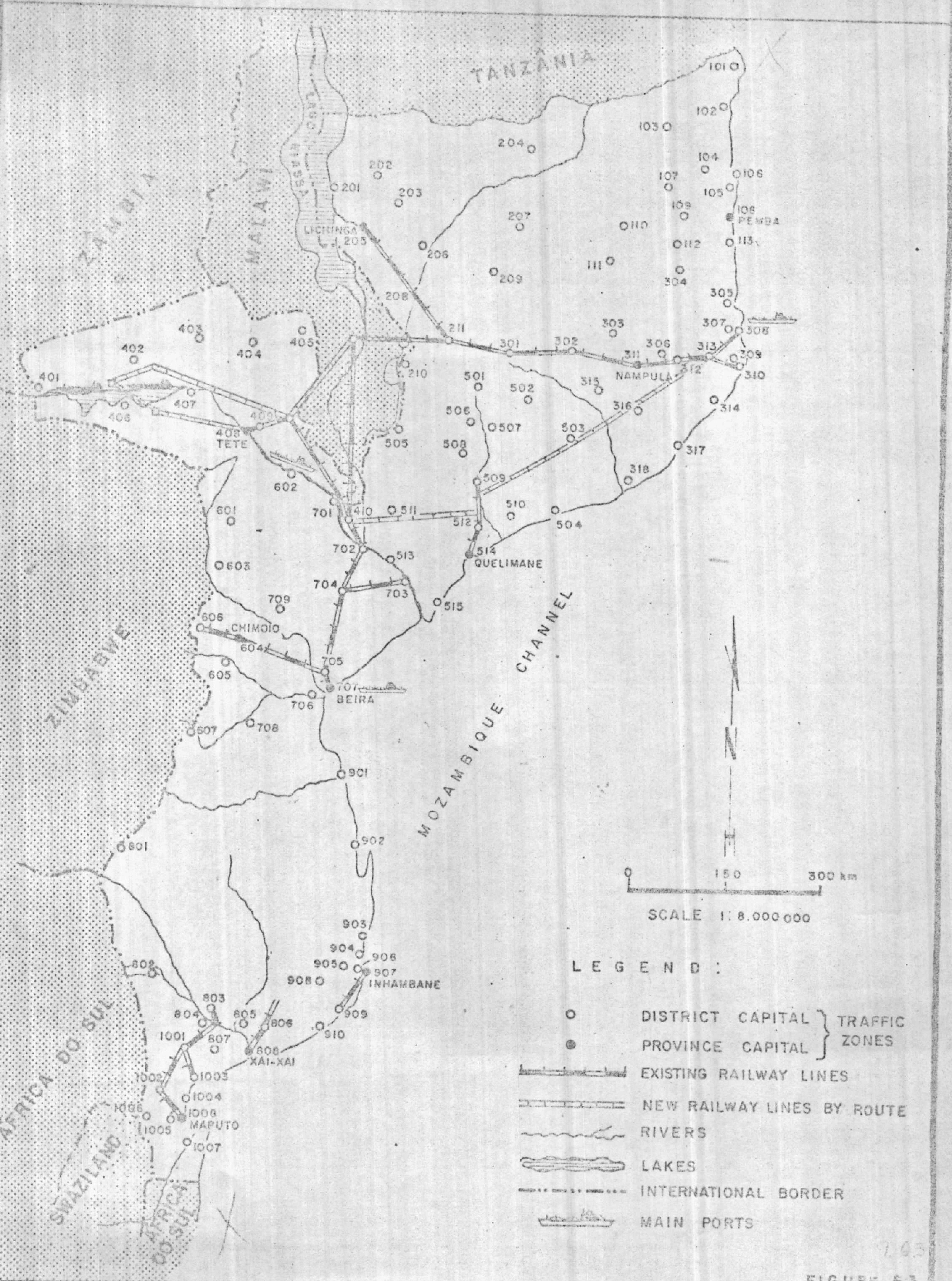

FIGURE 63

MOZAMBIQUE - RAILWAY SISTEM

Existing and new Railway lines per Alternative Route

ROUTE 2: PORT OF NACALA

ALTERNATIVE 2.1 - Southern Malawi and CFM-North

Navigation in the Cahora Bassa lake (124 km long) with the construction of the loading terminal close to the Bohozi River and of the unloading terminal at Nhancapirire; construction of the new railway section connecting Nhancapirire to Moatize (151 km long); construction of the new Moatize to Cateme Variant (32 km long); rehabilitation and upgrading of the existing railway line from Cateme to Cambulatsisse (26 km long); construction of the new railway line connecting Cambulatsisse to Utale (191 km long) in Malawi; operation on the existing Malawian Railway line from Utale to Entre Lagos (113 km long); rehabilitation and upgrading of the existing railway line from CFM-North from Entre Lagos to Nacala (615 km long) and construction of the new coal terminal at Nacala (Namuaxi point) and the transportation accesses.

ALTERNATIVE 2.2 -Southern through Zambezia Province

Navigation in the Cahora Bassa lake (124 km long) with the construction of the loading terminal close to the Bohozi River and of the unloading terminal at Nhancapirire; construction of the new railway section connecting Nhancapirire to Moatize (151 km long); construction of the new Moatize to Cateme Variant (32 km long); rehabilitation and upgrading of the existing railway section from Cateme to Nhamalabuê (222 km long); construction of the new railway line across the Zambezia Province connecting Nhamalabuê to Muelaiva River (257 km long); upgrading of the existing Rio Muelaiva to Muconha railway section (25 km long) ; construction of the new railway section connecting Muconha to Monapo (479 km long); rehabilitation and upgrading of the existing railway line between Monapo and the port of Nacala (67 km long); construction of the new coal terminal at the port of Nacala (Namuaxi point) and the transportation accesses.

ALTERNATIVE 2.3 - Northern through Malawi and CFM-North

Construction of the new railway line connecting Mucanha/Vuzi to Cambulatsisse (364 km long): rehabilitation and upgrading of the Cateme to Cambulatsisse section (26 km long); construction of the Moatize to Cateme Variant (32 km long); construction of the new railway line connecting Cambulatsisse to Utale (191 km long) in Malawi; operation on the existing Malawian. Railway line from Utale to Entre Lagos (Mozambique border)(113 km long); rehabilitation and upgrading of the existing railway line from CFM-North from entre Lagos to Nacala (615 km long);construction of the new coal terminal in the port of Nacala (Namuaxi point) and the transportation accesses.

ALTERNATIVE 2.4 - Northern through Zambezia Province

Construction of the new railway line connecting Mucanha/Vuzi to Cambulatsisse (364 km long); rehabilitation and upgrading of the Cateme to Cambulatsisse section (26 km long); construction of the Moatize to Cateme Variant (32 km long); rehabilitation and upgrading of the existing line from Cambulatsisse to Nhamalabuê (196 km long); construction of the new railway line across the Zambezia Province connecting Nhamalabuê to Muelaiva River (257 km long); upgrading of the existing Rio Muelaiva to Muconha Railway section (25 km long); construction of the new railway section connecting Muconha to Monapo (479 km long); rehabilitation and upgrading of the existing railway line between Monapo and the port of Nacala (67 km long); construction of the new coal terminal at the port of Nacala (Namuaxi point) and the transportation accesses.

o ROUTE 3: ZAMBEZE RIVER

ALTERNATIVE 3.1 - Southern through Cahora Bassa Lake Navigation

Navigation in the Cahora Bassa Lake (124 km long) with the construction of a loading terminal close to the Bohozi River and of a unloading terminal at Nhancapirire; construction of a new railway line connecting Nhancapirire to Tete (131 km long) and from Moatize to Tete (20 km long); construction of the transhipment river terminal in Tete; navigation in the Zambeze River (500 km long) and construction of the coal terminal in the mouth of the Zambeze River (Chinde).

ALTERNATIVE 3.2 - Northern through Cambulatsisse

Construction of the new railway line connecting Mucanha/Vuzi to Cambulatsisse (364 km long); rehabilitation and upgrading of the existing railway section from Cambulatsisse to Cateme (26 km long); construction of the Cateme to Moatize Variant (32 km long); construction of the new railway line connecting Moatize to Tete (20 km long); construction of the transhipment river terminal in Tete; navigation on the Zambeze River (500 km long) and construction of the coal terminal in the mouth of the Zambeze River (Chinde).

A summary of the studied alternatives is shown in Table 9.6.5.

TABLE 9.6.5-SUMMARY OF THE STUDIED ALTERNATIVES

ROUTES ALTERNATIVES	NEW RAILWAY LINES (km)	RAILWAY REHABILITATION AND UPGRADING (km)	RIVER AND LAKE NAVIGATION (km)	TERMINAL CONSTRUCTION (NUMBER)		
				RAIL	RIVER AND LAKE	OCEAN
. ROUTE 1						
- Alt. 1.1	396**	543	-	1	-	1
- Alt. 1.2	183**	543	124	1*	2*	1
. ROUTE 2						
- Alt. 2.1	374**	754	124	1*	2*	1
- Alt. 2.2	919**	314	124	1*	2*	1
- Alt. 2.3	587**	754	-	1	-	1
- Alt. 2.4	1,132**	314	-	1	-	1
. ROUTE 3						
- Alt. 3.1	151	-	624	1*	3*	1
- Alt. 3.2	416**	26	500	2*	1	1

* Considering the railway terminal separated from the river or lacustrine terminal.

** Moatize to Cateme Variant included (32 km long).

9.6.3 *Future Transportation Demand in the CFM-Central and CFM-Northern Systems.*

Based on the forecasted matrix for the years of 1990, 1995, 2000 and 2010, the traffic demand in the network has been allocated for each year by means of a computer program, considering the eight alternatives under study.

For future traffic allocantion in the transport network, Mozambique was divided into 109 traffic zones (Figure 9.6.4) the main connections for each pair of zones were considered. The districts were considered the traffic zones and the district capitals were choosen for the centroid of each zone, giving each one a code number. (Table 9.6.6).

The links were represented by the highway, railway and coastal connections which is shown in Figure 9.6.5, which includes also three external traffic zones that are Zimbabwe, Malawi and the one which represents the export link on the ocean freight for abroad.

Due to the impossibility for conducting a cost analysis on the Mozambique highways, the basic network was calibrated by using the travel time for each mode, considering a penalty for the transhipment in such a way that time penalty would be equivalent to a transhipment cost and competitivity between modes which were just as likely to reflect reality under normal traffic conditions.

The basic network was processed for the eight railway alternatives. Only the river navigation on the Zambeze River was not considered since in this alternative there would be no competition between coal and non coal traffic due to the fact that the coal terminal, tugs and barges would be different for each traffic and no interference on navigation and capacity constraints between coal and non coal traffic would be expected on the navigation channel.

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FIGURE 6.4

STUDY OF OUTFLOW ALTERNATIVE

Traffic Zones

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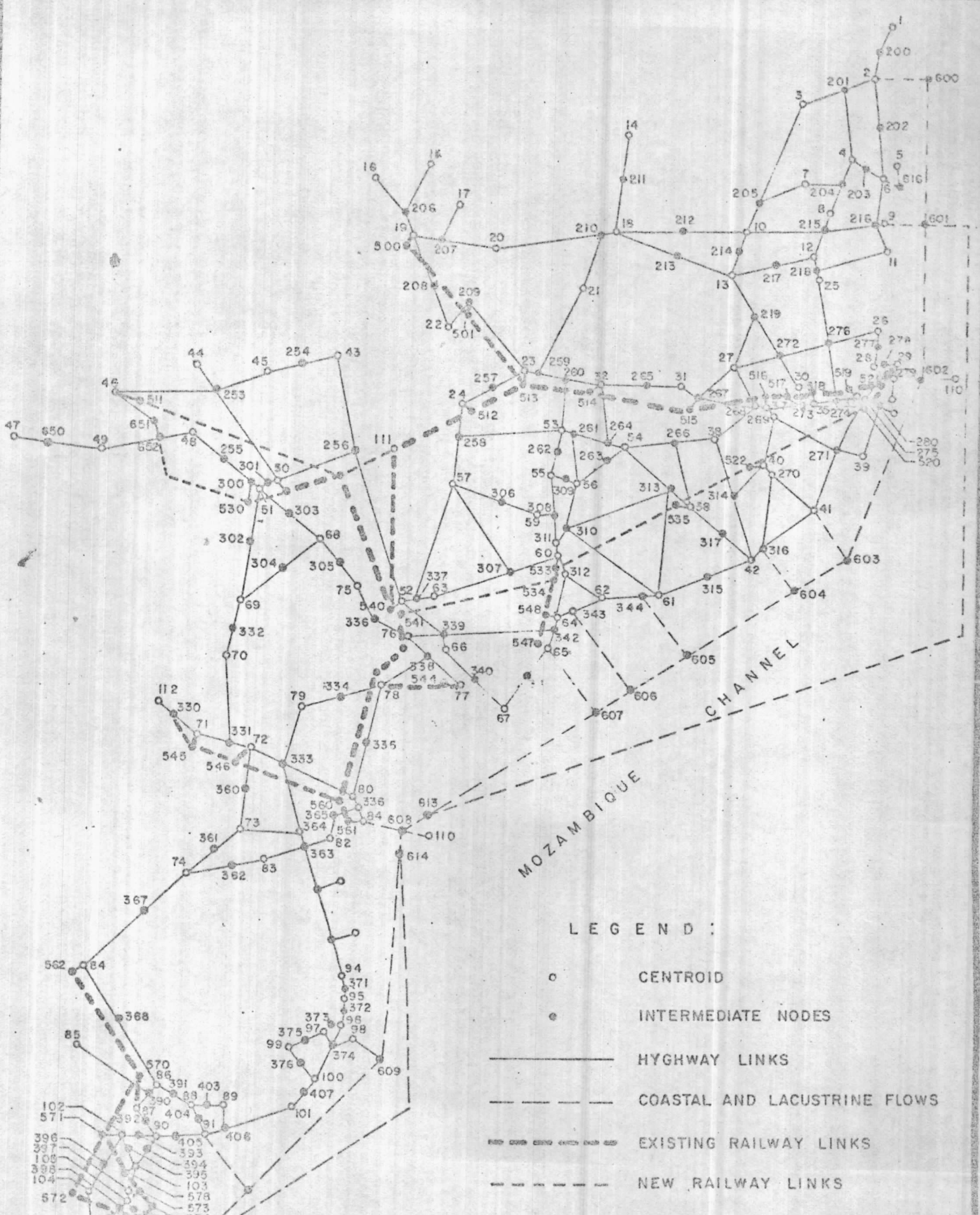

FIGURE 6.5

STUDY OF OUTFLOW ALTERNATIVE

Mozambique Transport Network

TABLE 9.6.6- TRAFFIC ZONES DIVISION

ADMINISTRATIVE LIMITS
PROVINCE (CAPITAL **)
DISTRICT (CAPITAL)

---

1 - CABO DELGADO PROVINCE

1 - Palma
2 - Mocimboa da Praia
3 - Mueda
4 - Macomia
5 - Ibo
6 - Quissanga
7 - Meluco
8 - Ancuabe
9 - Pemba (**)
10 - Montepuez
11 - Mecufi
12 - Chiure (Chiure Novo)
13 - Namuno

---

2 - NIASSA PROVINCE

14 - Mecula
15 - Sanga (Macaloge)
16 - Lago (Metangula)
17 - Mavago (Chiconono)
18 - Marrupa
19 - Lichinga (**)
20 - Majune (Malanga)
21 - Maúa
22 - Mamdimba
23 - Amaramba (Cuamba)
24 - Mecanhelas

---

3 - NAMPULA PROVINCE

25 - Erati (Namapa)
26 - Memba
27 - Mecuburi
28 - Minguri
29 - Nacala
30 - Muecate
31 - Ribaue
32 - Malema
33 - Monapo
34 - Mossuril
35 - Meconta
36 - Moçambique
37 - Nampula (**)
38 - Murrupula
39 - Mogincual
40 - Mogovolas (Nametil)
41 - Angoche
42 - Moma

---

4 - TETE PROVINCE

43 - Angonia (Ulongue)
44 - Chiuta (Tembué)
45 - Macanga (Furancungo)
46 - Maravia (Fingoé)
47 - Zumbo
48 - Cahora Bassa
49 - Magoé
50 - Moatize
51 - Tete (**)
52 - Mutarara (Nhamalabue)

TABLE 9.6.6

(Cont.)

5 - ZAMBEZIA PROVINCE

53 - GURUE	61 - Pebane
54 - Alto Molocue (Molocue)	62 - Manganja da Costa (Olinga)
55 - Namarroi	63 - Morrumbala
56 - Ile (Errego)	64 - Namacurra
57 - Milange	65 - Quelimane (**)
58 - Gilé	66 - Mopeia
59 - Lugela	67 - Chinde
60 - Mocuba	

6 - MANICA PROVINCE

68 - Tambara	72 - Chimoio (**)
69 - Guro	73 - Sussundenga
70 - Barue (Cantandica)	74 - Mossurize (Espungabera)
71 - Manica	

7 - SOFALA PROVINCE

75 - Chemba	80 - Dondo
76 - Caia	81 - Beira (**)
77 - Marromeu	82 - Buzi
78 - Inhaminga	83 - Chibabava
79 - Gorongosa	

8 - GAZA PROVINCE

84 - Chicualacuala	88 - Chibuto
85 - Massingir	89 - Manjacaze
86 - Caniçado (Guijá)	90 - Bilene (Macia)
87 - Limpopo (Chökwe)	91 - Gaza (Xai-Xai) (**)

9 - INHAMBANE PROVINCE

92 - Govuro (Nova Mambone)	97 - Homoine
93 - Vilanculos	98 - Inhambane (**)
94 - Massinga	99 - Panda
95 - Morrumbene	100 - Inharrime
96 - Maxixe	101 - Zavala (Quissico)

10 - MAPUTO PROVINCE

102 - Magude	107 - Cidade de Maputo (**)
103 - Manhiça	108 - Namaacha
104 - Moamba	109 - Matutuine (Bela Vista)
105 - Marracuene	110 - Exportação
106 - Matola	111 - Malawi
	112 - Zimbabwe

Based on the results provided by the allocation program, the future traffic on the railway system was obtained. These aggregated results are shown by alternative in Tables 9.6.7, 9.6.8, 9.6.9 and 9.6.10 (A, B and C), by links in each alternative and in detailed form on Appendix 9-I.

The 1995 flows in Route 1 - Beira, alternative 1.2-South, through Cahora Bassa lake navigation is shown in the Figure 9.6.6 For 1995, it can be also observed in Figure 9.6.7 the area of influence of the Beira port by the traffic flows from traffic zones which directs toward that port in each mode, defining its hinterland.

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ALTERNATIVES	LINKS	LENGTH (KM)	FLOWS (TONS.10^3) 1986						FLOWS (TONS.10^3) 1988					
			EXPORT DIRECTION			IMPORT DIRECTION		TOTAL	EXPORT DIRECTION			IMPORT DIRECTION		TOTAL
			COAL	N+I	SUBTOTAL	N+I	SUBTOTAL		COAL	N+I	SUBTOTAL	N+I	SUBTOTAL	
ALTERNATIVE 1.1-BEIRA (NORTH) THROUGH CFM-CENTER	1.1.1-Mucanha-Cambulatsisse	340	-	-	-	-	-	-	500,0	-	500,0	-	-	500,0
	1.1.2-Moatize-Cambulatsisse	58	1,000,0	706,9	1,706,9	136,0	136,0	1,842,9	1,500,0	764,6	2,264,6	147,1	147,1	2,411,7
	1.1.3-Cambulatsisse-Nhamalábue	196	1,000,0	706,9	1,706,9	136,0	136,0	1,842,9	2,000,0	764,6	2,764,6	147,1	147,1	2,911,7
	1.1.4-Nhamalábue-Inhamitanga	109	1,000,0	1,618,8	2,618,8	705,4	705,4	3,324,2	2,000,0	1,758,9	3,758,9	780,6	780,6	4,539,5
	1.1.5-Inhamitanga-Dondo	184	1,000,0	1,357,5	2,357,5	717,0	717,0	3,074,5	2,000,0	1,476,3	3,476,3	793,2	793,2	4,269,5
	1.1.6-Dondo-Beira	28	1,000,0	1,293,6	2,293,6	853,6	853,6	3,147,2	2,000,0	1,408,6	3,408,6	945,5	945,5	4,354,1
	Σ	915												
ALTERNATIVE 1.2-BEIRA (SOUTH) THROUGH CABORA BASSA LAKE AND CFM-CENTER	1.2.1-Nhancapirire-Moatize	151	-	-	-	-	-	-	500,0	-	500,0	-	-	500,0
	1.2.2-Moatize-Cambulatsisse	58	1,000,0	706,9	1,706,9	136,0	136,0	1,842,9	2,000,0	764,6	2,764,6	147,1	147,1	2,911,7
	1.2.3-Cambulatsisse-Nhamalábue	196	1,000,0	706,9	1,706,9	136,0	136,0	1,842,9	2,000,0	764,6	2,764,6	147,1	147,1	2,911,7
	1.2.4-Nhamalábue-Inhamitanga	109	1,000,0	1,618,8	2,618,8	705,4	705,4	3,324,2	2,000,0	1,758,9	3,758,9	780,6	780,6	4,539,5
	1.2.5-Inhamitanga-Dondo	184	1,000,0	1,357,5	2,357,5	717,0	717,0	3,074,5	2,000,0	1,476,3	3,476,3	793,2	793,2	4,269,5
	1.2.6-Dondo-Beira	28	1,000,0	1,293,6	2,293,6	853,6	853,6	3,147,2	2,000,0	1,408,6	3,408,6	945,5	945,5	4,354,1
	Σ	726												

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MT-GEIPOT

ALTERNATIVES	LINKS	LENGTH (KM)	FLOWS (TONS.10^3) 1990						FLOWS (TONS.10^3) 1995					
			EXPORT DIRECTION			IMPORT DIRECTION		TOTAL	EXPORT DIRECTION			IMPORT DIRECTION		TOTAL
			COAL	N+I	SUBTOTAL	N+I	SUBTOTAL		COAL	N+I	SUBTOTAL	N+I	SUBTOTAL	
ALTERNATIVE 1.1-BEIRA (NORTH) THROUGH CFM-CENTER	1.1.1-Mucanha-Cambulatsisse	340	1,000,0	300,0	1,300,0	150,0	150,0	1,450,0	3,000,0	365,0	3,365,0	182,5	182,5	3,547,5
	1.1.2-Moatize-Cambulatsisse	58	2,000,0	1,127,0	3,127,0	159,1	159,1	3,286,1	3,000,0	1,370,9	4,370,9	193,4	193,4	4,564,3
	1.1.3-Cambulatsisse-Nhamalábue	196	3,000,0	1,127,0	4,127,0	309,1	309,1	4,436,1	6,000,0	1,370,9	7,370,9	375,9	375,9	7,746,8
	1.1.4-Nhamalábue-Inhamitanga	109	3,000,0	2,211,6	5,211,6	1,014,1	1,014,1	6,225,7	6,000,0	2,720,1	8,720,1	1,297,8	1,297,8	10,017,9
	1.1.5-Inhamitanga-Dondo	184	3,000,0	1,906,0	4,906,0	1,027,9	1,027,9	5,933,9	6,000,0	2,348,3	8,348,3	1,314,6	1,314,6	9,662,9
	1.1.6-Dondo-Beira	28	3,000,0	1,834,3	4,834,3	1,197,5	1,197,5	6,031,8	6,000,0	2,266,0	8,266,0	1,537,7	1,537,7	9,803,7
	Σ	915												
ALTERNATIVE 1.2-BEIRA (SOUTH) THROUGH CAHORA BASSA LAKE AND CFM-CENTER	1.2.1-Nhancapirire-Moatize	151	1,000,0	300,0	1,300,0	150,0	150,0	1,450,0	3,000,0	365,0	3,365,0	182,5	182,5	3,547,5
	1.2.2-Moatize-Cambulatsisse	58	3,000,0	1,127,0	4,127,0	309,1	309,1	4,436,1	6,000,0	1,370,9	7,370,9	375,9	375,9	7,746,8
	1.2.3-Cambulatsisse-Nhamalábue	196	3,000,0	1,127,0	4,127,0	309,1	309,1	4,436,1	6,000,0	1,370,9	7,370,9	375,9	375,9	7,746,8
	1.2.4-Nhamalábue-Inhamitanga	109	3,000,0	2,211,6	5,211,6	1,014,1	1,014,1	6,225,7	6,000,0	2,720,1	8,720,1	1,297,8	1,297,8	10,017,9
	1.2.5-Inhamitanga-Dondo	184	3,000,0	1,906,0	4,906,0	1,027,9	1,027,9	5,933,9	6,000,0	2,348,3	8,348,3	1,314,6	1,314,6	9,662,9
	1.2.6-Dondo-Beira	28	3,000,0	1,834,3	4,834,3	1,197,5	1,197,5	6,031,8	6,000,0	2,266,0	8,266,0	1,537,7	1,537,7	9,803,7
	Σ	726												

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MT-GEIPOT

ALTERNATIVES	LINKS	LENGTH (KM)	FLOWS (TONS.10^3) 2000						FLOWS (TONS.10^3) 2010					
			EXPORT DIRECTION			IMPORT DIRECTION		TOTAL	EXPORT DIRECTION			IMPORT DIRECTION		TOTAL
			COAL	N+I	SUBTOTAL	N+I	SUBTOTAL		COAL	N+I	SUBTOTAL	N+I	SUBTOTAL	
ALTERNATIVE 1.1-BEIRA (NORTH) THROUGH CFM-CENTER	1.1.1-Mucanha-Cambulatsisse	340	6,000,0	444,0	6,444,0	222,0	222,0	6,666.0	6,000,0	657,3	6,657,3	328,6	328,6	6,985,9
	1.1.2-Moatize-Cambulatsisse	58	4,000,0	1,667,9	5,667,9	235,4	235,4	5,903,3	4.000,0	2,469,2	6,469,2	348,2	348,2	6,817,4
	1.1.3-Cambulatsisse-Nhamalâbue	196	10,000,0	1,667,9	11,667,9	457,4	457,4	12,125,3	10,000,0	2,469,2	12,469,2	676,8	676,8	13,146,0
	1.1.4-Nhamalâbue-Inhamitanga	109	10,000,0	3,348,8	13,348,8	1,565,1	1,565,1	14,913,9	10,000,0	5,092,9	15,092,9	2,759,6	2,759,6	17,852,5
	1.1.5-Inhamitanga-Dondo	184	10,000,0	2,896,6	12,896,6	1,585,5	1,585,5	14,482,1	10,000.0	4,423,4	14,423,4	2,789,8	2,789,8	17,213,2
	1.1.6-Dondo-Beira	28	10,000,0	2,803,2	12,803,2	1,878,9	1,878,9	14,682,1	10,000.0	4,308,3	14,308,3	3,300,3	3,300,3	17,608,6
	Σ	915												
ALTERNATIVE 1.2-BEIRA (SOUTH) THROUGH CAHORA-BASSA-LAKE- AND CFM-CENTER	1.2.1-Nhancapirire-Moatize	151	6,000,0	444,0	6,444,0	222,0	222,0	6,666,0	6,000,0	657,3	6,657,3	328,6	328,6	6,985,9
	1.2.2-Moatize-Cambulatsisse	58	10,000,0	1,667,9	11,667,9	457,4	457,4	12,125,3	10,000,0	2,469,2	12,469,2	676,8	676,8	13,146,0
	1.2.3-Cambulatsisse-Nhamalâbue	196	10,000,0	1,667,9	11,667,9	457,4	457,4	12,125,3	10,000,0	2,469,2	12,469,2	676,8	676,8	13,146,0
	1.2.4-Nhamalâbue-Inhamitanga	109	10,000,0	3,348,8	13.348,8	1,565,1	1,565,1	14,913,9	10,000,0	5,092,9	15,092,9	2,759,6	2,759,6	17,852,5
	1.2.5-Inhamitanga-Dondo	184	10,000,0	2,896,6	12,896,6	1,585,5	1,585,5	14,482,1	10,000,0	4,423.4	14,423,4	2,789,8	2,789,8	17,213,2
	1.2.6-Dondo-Beira	28	10,000,0	2,803,2	12,803,2	1,878,9	1,878,9	14,682,1	10,000,0	4,308,3	14,308,3	3,300,3	3,300,3	17,608,6
	Σ	726												

TABLE 6.8-A - RAILWAY FLO[redacted]F C[redacted]AND[redacted]ERA[redacted]EIGH[redacted]

ALTERNATIVES	LINKS	LENGTH (KM)	FLOWS (TONS.10^3) 1986						FLOWS (TONS.10^3) 1988					
			EXPORT DIRECTION			IMPORT DIRECTION		TOTAL	EXPORT DIRECTION			IMPORT DIRECTION		TOTAL
			COAL	N+I	SUBTOTAL	N+I	SUBTOTAL		COAL	N+I	SUBTOTAL	N+I	SUBTOTAL	
ALTERNATIVE 2.1 - NACALA (SOUTH) THROUGH MALAWI	2.1.1-Nhancapirire-Moatize	151	-	-	-	-	-	-	500.0	-	500.0	-	-	500.0
	2.1.2-Moatize-Cambulatsisse	58	1,000.0	706.9	1,706.9	264.2	264.2	1,971.1	2,000.0	764.6	2,764.6	285.8	285.8	3,050.4
	2.1.3-Cambulatsisse-Nkaia	202	1,000.0	1.8	1,001.8	66.9	66.9	1,068.7	2,000.0	1.9	2,001.9	72.4	72.4	2,074.3
	2.1.4-Nkaia-Entre Lagos	102	1,000.0	308.4	1,308.4	810.8	810.8	2,119.2	2,000.0	361.4	2,361.4	876.9	876.9	3,238.3
	2.1.5-Entre Lagos-Nampula	423	1,000.0	373.6	1,373.6	101.2	101.2	1,474.8	2,000.0	449.2	2,449.2	109.5	109.5	2,558.7
	2.1.6-Nampula-Nacala	192	1,000.0	384.1	1,384.1	175.5	175.5	1,559.6	2,000.0	448.4	2,448.4	199.8	199.8	2,648.2
	Σ	1,128												
ALTERNATIVE 2.2 - NACALA (SOUTH) THROUGH ZAMBEZIA	2.2.1-Nhancapirire-Moatize	151	-	-	-	-	-	-	500.0	-	500.0	-	-	500.0
	2.2.2-Moatize-Cambulatsisse	58	1,000.0	706.9	1,706.9	136.0	136.0	1,842.9	2,000.0	764.6	2,764.6	147.1	147.1	2,911.7
	2.2.3-Cambulatsisse-Nhamalâbue	196	1,000.0	706.9	1,706.9	136.0	136.0	1,842.9	2,000.0	764.6	2,764.6	147.1	147.1	2,911.7
	2.2.4-Nhamalâbue-Rio Muelaiva	257	1,000.0	117.5	1,117.5	63.1	63.1	1,180.6	2,000.0	127.1	2,127.1	68.2	68.2	2,195.3
	2.2.5-Rio Muelaiva-Muconha	25	1,000.0	128.7	1,128.7	85.7	85.7	1,214.4	2,000.0	139.2	2,139.2	92.7	92.7	2,231.9
	2.2.6-Muconha-Monapo	479	1,000.0	115.1	1,115.1	63.0	63.0	1,178.1	2,000.0	124.4	2,124.4	68.1	68.1	2,192.5
	2.2.7-Monapo-Nacala	67	1,000.0	375.1	1,375.1	154.2	154.2	1,529.3	2,000.0	433.9	2,433.9	166.8	166.8	2,600.7
	Σ	1233												

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MT-GEIPOT

ALTERNATIVES	LINKS	LENGTH (KM)	FLOWS (TONS.10^3) 1990						FLOWS (TONS.10^3) 1995					
			EXPORT DIRECTION			IMPORT DIRECTION		TOTAL	EXPORT DIRECTION			IMPORT DIRECTION		TOTAL
			COAL	N+I	SUBTOTAL	N+I	SUBTOTAL		COAL	N+I	SUBTOTAL	N+I	SUBTOTAL	
ALTERNATIVE 2.1-NACALA (SOUTH) THROUGH MALAWI	2.1.1-Nhancapirire-Moatize	151	1,000.0	300.0	1,300.0	150.0	150.0	1,450.0	3,000.0	365.0	3,365.0	182.5	182.5	3,547.5
	2.1.2-Moatize-Cambulatsisse	58	3,000.0	1,127.0	4,127.0	309.1	309.1	4,436.1	6,000.0	1,370.9	7,370.9	375.9	375.9	7,746.8
	2.1.3-Cambulatsisse-Nkaia	202	3,000.0	302.1	3,302.1	78.3	78.3	3,380.4	6,000.0	302.5	6,302.5	95.2	95.2	6,397.7
	2.1.4-Nkaia-Entre Lagos	102	3,000.0	423.5	3,423.5	948.5	948.5	4,372.0	6,000.0	629.5	6,629.5	1,153.9	1,153.9	7,783.4
	2.1.5-Entre Lagos-Nampula	423	3,000.0	540.1	3,540.1	118.4	118.4	3,658.5	6,000.0	856.0	6,856.0	144.2	144.2	7,000.2
	2.1.6-Nampula-Nacala	192	3,000.0	523.5	3,523.5	236.8	236.8	3,760.3	6,000.0	711.0	6,711.0	321.4	321.4	7,032.4
	Σ	1,128												
ALTERNATIVE 2.2 -NACALA (SOUTH) THROUGH ZAMBEZIA	2.2.1-Nhancapirire-Moatize	151	1,000.0	300.0	1,300.0	150.0	150.0	1,450.0	3,000.0	365.0	3,365.0	182.5	182.5	3,547.5
	2.2.2-Moatize-Cambulatsisse	58	3,000.0	1,127.0	4,127.0	309.1	309.1	4,436.1	6,000.0	1,370.9	7,370.9	375.9	375.9	7,746.8
	2.2.3-Cambulatsisse-Nhamalâbue	196	3,000.0	1,127.0	4,127.0	309.1	309.1	4,436.1	6,000.0	1,370.9	7,370.9	375.9	375.9	7,746.8
	2.2.4-Nhamalâbue-Rio Muelaiva	257	3,000.0	137.5	3,137.5	73.8	73.8	3,211.3	6,000.0	167.2	6,167.2	89.9	89.9	6,257.1
	2.2.5-Rio Muelaiva-Muconha	25	3,000.0	150.6	3,150.6	100.3	100.3	3,250.9	6,000.0	183.1	6,183.1	122.0	122.0	6,305.1
	2.2.6-Muconha-Monapo	479	3,000.0	134.6	3,134.6	73.7	73.7	3,208.3	6,000.0	163.6	6,163.6	89.7	89.7	6,253.3
	2.2.7-Monapo-Nacala	67	3,000.0	501.9	3,501.9	180.4	180.4	3,682.3	6,000.0	723.3	6,722.3	219.5	219.5	6,941.8
	Σ	1233												

TABLE 6.8-C - RAILWAY FLOWS OF COAL AND GENERAL FREIGHT

MT-GEIPOT

ALTERNATIVES	LINKS	LENGTH (KM)	FLOWS (TONS.10^3) 2000						FLOWS (TONS.10^3) 2010					
			EXPORT DIRECTION			IMPORT DIRECTION		TOTAL	EXPORT DIRECTION			IMPORT DIRECTION		TOTAL
			COAL	N+I	SUBTOTAL	N+I	SUBTOTAL		COAL	N+I	SUBTOTAL	N+I	SUBTOTAL	
ALTERNATIVE 2.1 - NACALA (SOUTH) THROUGH MALAWI	2.1.1-Nhancapirire-Moatize	151	6,000.0	444.0	6,444.0	222.0	222.0	6,666.0	6,000.0	657.3	6,657.3	328.6	328.6	6,985.9
	2.1.2-Moatize-Cambulatsisse	58	10,000.0	1,667.9	11,667.9	457.4	457.4	12,125.3	10,000.0	2,469.2	12,469.2	676.8	676.8	13,146.0
	2.1.3-Cambulatsisse-Nkaia	202	10,000.0	303.1	10,303.1	115.9	115.9	10,419.0	10,000.0	304.6	10,304.6	171.5	171.5	10,476.1
	2.1.4-Nkaia-Entre Lagos	102	10,000.0	935.7	10,935.7	1,403.8	1,403.8	12,339.5	10,000.0	2,067.4	12,067.4	2,078.0	2,078.0	14,145.4
	2.1.5-Entre Lagos-Nampula	423	10,000.0	1,356.8	11,356.8	175.3	175.3	11,532.1	10,000.0	3,408.9	13,408.9	259.6	259.6	13,668.5
	2.1.6-Nampula-Nacala	192	10,000.0	1,135.5	11,135.5	463.0	463.0	11,598.5	10,000.0	2,462.8	12,462.8	987.0	987.0	13,449.8
	Σ	1,128												
ALTERNATIVE 2.2 - NACALA (SOUTH) THROUGH ZAMBEZIA	2.2.1-Nhancapirire-Moatize	151	6,000.0	444.0	6,444.0	222.0	222.0	6,666.0	6,000.0	657.3	6,657.3	328.6	328.6	6,985.9
	2.2.2-Moatize-Cambulatsisse	58	10,000.0	1,667.9	11,667.9	457.4	457.4	12,125.3	10,000.0	2,469.2	12,469.2	676.8	676.8	13,146.0
	2.2.3-Cambulatsisse-Nhamalâbue	196	10,000.0	1,667.9	11,667.9	457.4	457.4	12,125.3	10,000.0	2,469.2	12,469.2	676.8	676.8	13,146.0
	2.2.4-Nhamalâbue-Rio Muelaiva	257	10,000.0	203.4	10,203.4	109.3	109.3	10,312.7	10,000.0	301.1	10,301.1	161.7	161.7	10,462.8
	2.2.5-Rio Muelaiva-Muconha	25	10,000.0	222.8	10,222.8	148.3	148.3	10,371.1	10,000.0	329.8	10,329.8	219.6	219.6	10,549.4
	2.2.6-Muconha-Monapo	479	10,000.0	199.1	10,199.1	109.1	109.1	10,308.2	10,000.0	294.7	10,294.7	161.4	161.4	10,456.1
	2.2.7-Monapo-Nacala	67	10,000.0	1,039.3	11,039.3	267.1	267.1	11,726.0	10,000.0	2,152.0	12,152.0	395.3	395.3	12,547.3
	Σ	1,233												

TABLE 6.9-A - RAILWAY FLOWS OF COAL AND GENERAL FREIGHT

ALTERNATIVES	LINKS	LENGTH (KM)	FLOWS (TONS.10^3) 1986						FLOWS (TONS.10^3) 1988					
			EXPORT DIRECTION			IMPORT DIRECTION		TOTAL	EXPORT DIRECTION			IMPORT DIRECTION		TOTAL
			COAL	N+I	SUBTOTAL	N+I	SUBTOTAL		COAL	N+I	SUBTOTAL	N+I	SUBTOTAL	
ALTERNATIVE 2.3-NACALA (NORTH) THROUGH MALAWI-CAM-NORTH	2.3.1-Mucanha-Cambulatsisse	340	-	-	-	-	-	-	500,0	-	500,0	-	-	500,0
	2.3.2-Moatize-Cambulatsisse	58	1,000,0	706,9	1,706,9	136,0	136,0	1,842,9	1,500,0	764,6	2,264,6	147,1	147,1	2,411,7
	2.3.3-Cambulatsisse-Nkaia	202	1,000,0	1,8	1,001,8	66,9	66,9	1,068,7	2,000,0	1,9	2,001,9	72,4	72,4	2,074,3
	2.3.4-Nkaia-Entre Lagos	102	1,000,0	308,4	1,308,4	810,8	810,8	2,119,2	2,000,0	361,4	2,361,4	876,9	876,9	3,238,3
	2.3.5-Entre Lagos-Nampula	423	1,000,0	373,6	1,373,6	101,2	101,2	1,474,8	2,000,0	449,2	2,449,2	109,5	109,5	2,558,7
	2.3.6-Nampula-Nacala	192	1,000,0	384,1	1,384,1	175,5	175,5	1,559,6	2,000,0	448,4	2,448,4	199,8	199,8	2,648,2
	Σ	1317												
ALTERNATIVE 2.4-NACALA (NORTH) THROUGH ZAMBEZIA	2.4.1-Mucanha-Cambulatsisse	340	-	-	-	-	-	-	500,0	-	500,0	-	-	500,0
	2.4.2-Moatize-Cambulatsisse	58	1,000,0	706,9	1,706,9	136,0	136,0	1,842,9	1,500,0	764,6	2,264,6	147,1	147,1	2,411,7
	2.4.3-Cambulatsisse-Nhamalábue	196	1,000,0	706,9	1,706,9	136,0	136,0	1,842,9	2,000,0	764,6	2,764,6	147,1	147,1	2,911,7
	2.4.4-Nhamalábue-Rio Muelaiva	257	1,000,0	117,5	1,117,5	63,1	63,1	1,180,6	2,000,0	127,1	2,127,1	68,2	68,2	2,195,3
	2.4.5-Rio Muelaiva-Muconha	25	1,000,0	128,7	1,128,7	85,7	85,7	1,214,4	2,000,0	139,2	2,139,2	92,7	92,7	2,231,9
	2.4.6-Muconha-Monapo	479	1,000,0	115,1	1,115,1	63,0	63,0	1,178,1	2,000,0	124,4	2,124,4	68,1	68,1	2,192,5
	2.4.7-Monapo-Nacala	67	1,000,0	375,1	1,375,1	154,2	154,2	1,529,3	2,000,0	433,9	2,433,9	166,8	166,8	2,600,7
	Σ	1422												

TABLE 6.9-B - RAILWAY FLOWS OF COAL AND GENERAL FREIGHT

MT-GEIPOT

ALTERNATIVES	LINKS	LENGTH (KM)	FLOWS (TONS.10^3) 1990						FLOWS (TONS.10^3) 1995					
			EXPORT DIRECTION			IMPORT DIRECTION		TOTAL	EXPORT DIRECTION			IMPORT DIRECTION		TOTAL
			COAL	N+I	SUBTOTAL	N+I	SUBTOTAL		COAL	N+I	SUBTOTAL	N+I	SUBTOTAL	
ALTERNATIVE 2.3 -NACALA (NORTH) THROUGH-MALAWI-CFM-NORTH	2.3.1-Mucanha-Cambulatsisse	340	1,000.0	300.0	1,300.0	150.0	150.0	1,450.0	3,000.0	365.0	3,365.0	182.5	182.5	3,547.5
	2.3.2-Moatize-Cambulatsisse	58	2,000.0	1,127.0	3,127.0	159.1	159.1	3,286.1	3,000.0	1,370.9	4,370.9	193.4	193.4	4,564.3
	2.3.3-Cambulatsisse-Nkaia	202	3,000.0	302.4	3,302.1	78.3	78.3	3,380.4	6,000.0	302.5	6,302.5	95.2	95.2	6,397.7
	2.3.4-Nkaia-Entre Lagos	102	3,000.0	423.5	3,423.5	948.5	948.5	4,372.0	6,000.0	629.5	6,629.5	1,153.9	1,153.9	7,783.4
	2.3.5-Entre Lagos-Nampula	423	3,000.0	540.1	3,540.1	118.4	118.4	3,658.5	6,000.0	856.0	6,856.0	144.2	144.2	7,000.2
	2.3.6-Nampula-Nacala	192	3,000.0	523.5	3,523.5	236.8	236.8	3,760.3	6,000.0	771.0	6,771.0	321.4	321.4	7,092.4
	Σ	1317												
ALTERNATIVE 2.4 -NACALA (NORTH) THROUGH ZAMBEZIA	2.4.1-Mucanha-Cambulatsisse	340	1,000.0	300.0	1,300.0	150.0	150.0	1,450.0	3,000.0	365.0	3,365.0	182.5	182.5	3,547.5
	2.4.2-Moatize-Cambulatsisse	58	2,000.0	1,127.0	3,127.0	159.1	159.1	3,286.1	3,000.0	1,370.9	4,370.9	193.4	193.4	4,564.3
	2.4.3-Cambulatsisse-Nhamalábue	196	3,000.0	1,127.0	4,127.0	309.1	309.1	4,436.1	6,000.0	1,370.9	7,370.9	375.9	375.9	7,746.8
	2.4.4-Nhamalábue-Rio Muelaiva	257	3,000.0	137.5	3,137.5	73.8	73.8	3,211.3	6,000.0	167.2	6,167.2	89.9	89.9	6,257.1
	2.4.5-Rio Muelaiva-Muconha	25	3,000.0	150.6	3,150.6	100.3	100.3	3,250.9	6,000.0	183.1	6,183.1	122.0	122.0	6,305.1
	2.4.6-Muconha-Monapo	479	3,000.0	134.6	3,134.6	73.7	73.7	3,208.3	6,000.0	163.6	6,163.6	89.7	89.7	6,253.3
	2.4.7-Monapo-Nacala	67	3,000.0	501.9	3,501.9	180.4	180.4	3,682.3	6,000.0	722.3	6,722.3	219.5	219.5	6,941.8
	Σ	1422												

TABLE 6.9-C - RAILWAY FLOWS OF COAL AND GENERAL FREIGHT

MT-GEIPOT

ALTERNATIVES	LINKS	LENGTH (KM)	FLOWS (TONS.10^3) 2000						FLOWS (TONS.10^3) 2010					
			EXPORT DIRECTION			IMPORT DIRECTION		TOTAL	EXPORT DIRECTION			IMPORT DIRECTION		TOTAL
			COAL	N+I	SUBTOTAL	N+I	SUBTOTAL		COAL	N+I	SUBTOTAL	N+I	SUBTOTAL	
ALTERNATIVE 2.3-NACALA (NORTH) THROUGH MALAWI-CFM-NORTH	2.3.1-Mucanha-Cambulatsisse	340	6,000,0	444,0	6,444,0	222,0	222,0	6,666,0	6,000,0	657,3	6,657,3	328,6	328,6	6,985,9
	2.3.2-Moatize-Cambulatsisse	58	4,000,0	1,667,9	5,667,9	235,4	235,4	5,903,3	4,000,0	2,469,2	6,469,2	348,2	348,2	6,817,4
	2.3.3-Cambulatsisse-Nkaia	202	10,000,0	303,1	10,303,1	115,9	115,9	10,419,0	10,000,0	304,6	10,304,6	171,5	171,5	10,476,1
	2.3.4-Nkaia-Entre Lagos	102	10,000,0	935,7	10,935,7	1,403,8	1,403,8	12,339,5	10,000,0	2,067,4	12,067,4	2,078,0	2,078,0	14,145,4
	2.3.5-Entre Lagos-Nampula	423	10,000,0	1,356,8	11,356,8	175,3	175,3	11,532,1	10,000,0	3,408,9	13,408,9	259,6	259,6	13,668,5
	2.3.6-Nampula-Nacala	192	10,000,0	1,135,5	11,135,5	463,0	463,0	11,598,5	10,000,0	2,462,8	12,462,8	987,0	987,0	13,449,8
	Σ	1317												
ALTERNATIVE 2.4-NACALA (NORTH) THROUGH ZAMBEZIA	2.4.1-Mucanha-Cambulatsisse	340	6,000,0	444,0	6,444,0	222,0	222,0	6,666,0	6,000,0	657,3	6,657,3	328,6	328,6	6,985,9
	2.4.2-Moatize-Cambulatsisse	58	4,000,0	1,667,9	5,667,9	235,4	235,4	5,903,3	4,000,0	2,469,2	6,469,2	348,2	348,2	6,817,4
	2.4.3-Cambulatsisse-Nhamalâbue	196	10,000,0	1,667,9	11,667,9	457,4	457,4	12,125,3	10,000,0	2,469,2	12,469,2	676,8	676,8	13,146,0
	2.4.4-Nhamalâbue-Rio Muelaiva	257	10,000,0	203,4	10,203,4	109,3	109,3	10,312,7	10,000,0	301,1	10,301,1	161,7	161,7	10,462,8
	2.4.5-Rio Muelaiva-Mucorha	25	10,000,0	222,8	10,222,8	148,3	148,3	10,371,1	10,000,0	329,8	10,329,8	219,6	219,6	10,549,4
	2.4.6-Mucorha-Monapo	479	10,000,0	199,1	10,199,1	109,1	109,1	10,308,2	10,000,0	294,7	10,294,7	161,4	161,4	10,456,1
	2.4.7-Monapo-Nacala	67	10,000,0	1,039,3	11,039,3	267,1	267,1	11,306,4	10,000,0	2,152,0	12,152,0	395,3	395,3	12,547,3
	Σ	1422												

TAB[redacted].10[redacted] RAI[redacted] FL[redacted] OF [redacted] AN[redacted]NER[redacted]REI[redacted]

MT-GEIPOT

ALTERNATIVES	LINKS	LENGTH (KM)	FLOWS (TONS.10^3) 1986						FLOWS (TONS.10^3) 1988					
			EXPORT DIRECTION			IMPORT DIRECTION		TOTAL	EXPORT DIRECTION			IMPORT DIRECTION		TOTAL
			COAL	N+I	SUBTOTAL	N+I	SUBTOTAL		COAL	N+I	SUBTOTAL	N+I	SUBTOTAL	
ALTERNATIVE 3.1-ZAMBEZE RIVER (SOUTH) THROUGH CAHORA BASSA LAKE	3.1.1-Nhancapirire-Tete	131	-	-	-	-	-	-	500.0	-	500.0	-	-	500.0
	3.1.2-Moatize-Tete	20	1,000.0	-	1,000.0	-	-	1,000.0	1,500.0	-	1,500.0	-	-	1,500.0
	Σ	151												
ALTERNATIVE 3.2-ZAMBEZE RIVER (NORTH)	3.2.1-Mucanha-Cambulatsisse	340	-						500.0	-	500.0	-	-	500.0
	3.2.2-Cambulatsisse-Moatize	58	-	-	-	-	-	-	500.0	-	500.0	-	-	500.0
	3.2.3-Moatize-Tete	20	1,000.0	-	1,000.0	-	-	1,000.0	2,000.0	-	2,000.0	-	-	2,000.0
	Σ	418												

[redacted] TA[redacted]6.1[redacted]- RA[redacted]Y F[redacted] OF[redacted]L A[redacted]ENE[redacted]FRE[redacted]

MT-GEIPOT

ALTERNATIVES	LINKS	LENGTH (KM)	FLOWS (TONS.10^3) 1990						FLOWS (TONS.10^3) 1995					
			EXPORT DIRECTION			IMPORT DIRECTION		TOTAL	EXPORT DIRECTION			IMPORT DIRECTION		TOTAL
			COAL	N+I	SUBTOTAL	N+I	SUBTOTAL		COAL	N+I	SUBTOTAL	N+I	SUBTOTAL	
ALTERNATIVE 3.1-ZAMBEZE RIVER (SOUTH) THROUGH CAHORA BASSA LAKE	3.1.1-Nhancapirire-Tete	131	1,000.0	300.0	1,300.0	150.0	150.0	1,450.0	3,000.0	365.0	3,365.0	182.5	182.5	3,547.5
	3.1.2-Moatize-Tete	20	2,000.0	-	2,000.0	-	-	2,000.0	3,000.0	-	3,000.0	-	-	3,000.0
	Σ	151												
ALTERNATIVE 3.2-ZAMBEZE RIVER (NORTH)	3.2.1-Mucanha-Cambulatsisse	340	1,000.0	300.0	1,300.0	150.0	150.0	1,450.0	3,000.0	365.0	3,365.0	182.5	182.5	3,547.5
	3.2.2-Cambulatsisse-Moatize	58	1,000.0	-	1,000.0	-	-	1,000.0	3,000.0	-	3,000.0	-	-	3,000.0
	3.2.3-Moatize-Tete	20	3,000.0	-	3,000.0	-	-	3,000.0	6,000.0	-	6,000.0	-	-	6,000.0
	Σ	418												

TABLE 6.10-C – [redacted]LWA[redacted]LOWS [redacted]COA[redacted]D GE[redacted]AL F[redacted]HT

MT-GEIPOT

ALTERNATIVES	LINKS	LENGTH (KM)	FLOWS (TONS.10^3) 2000						FLOWS (TONS.10^3) 2010					
			EXPORT DIRECTION			IMPORT DIRECTION		TOTAL	EXPORT DIRECTION			IMPORT DIRECTION		TOTAL
			COAL	N+I	SUBTOTAL	N+I	SUBTOTAL		COAL	N+I	SUBTOTAL	N+I	SUBTOTAL	
ALTERNATIVE 3.1-ZAMBEZE RIVER (SOUTH) THROUGH CAHORA BASSA LAKE	3.1.1-Nhancapirire-Tete	131	6,000,0	444,0	6,444,0	222,0	222,0	6,666,0	6,000,0	657,3	6,657,3	328,6	328,6	6,985,9
	3.1.2-Moatize-Tete	20	4,000,0	–	4,000,0	–	–	4,000,0	4,000,0	–	4,000,0	–	–	4,000,0
	Σ	151												
ALTERNATIVE 3.2-ZAMBEZE RIVER (NORTH)	3.2.1-Mucanha-Cambulatsisse	340	6,000,0	444,0	6,444,0	222,0	222,0	6,666,0	6,000,0	657,3	6,657,3	328,6	328,6	6,985,9
	3.2.2-Cambulatsisse-Moatize	58	6,000,0	–	6,000,0	–	–	6,000,0	6,000,0	–	6,000,0	–	–	6,000,0
	3.2.3-Moatize-Tete	20	10,000,0	–	10,000,0	–	–	10,000,0	10,000,0	–	10,000,0	–	–	10,000,0
	Σ	418												

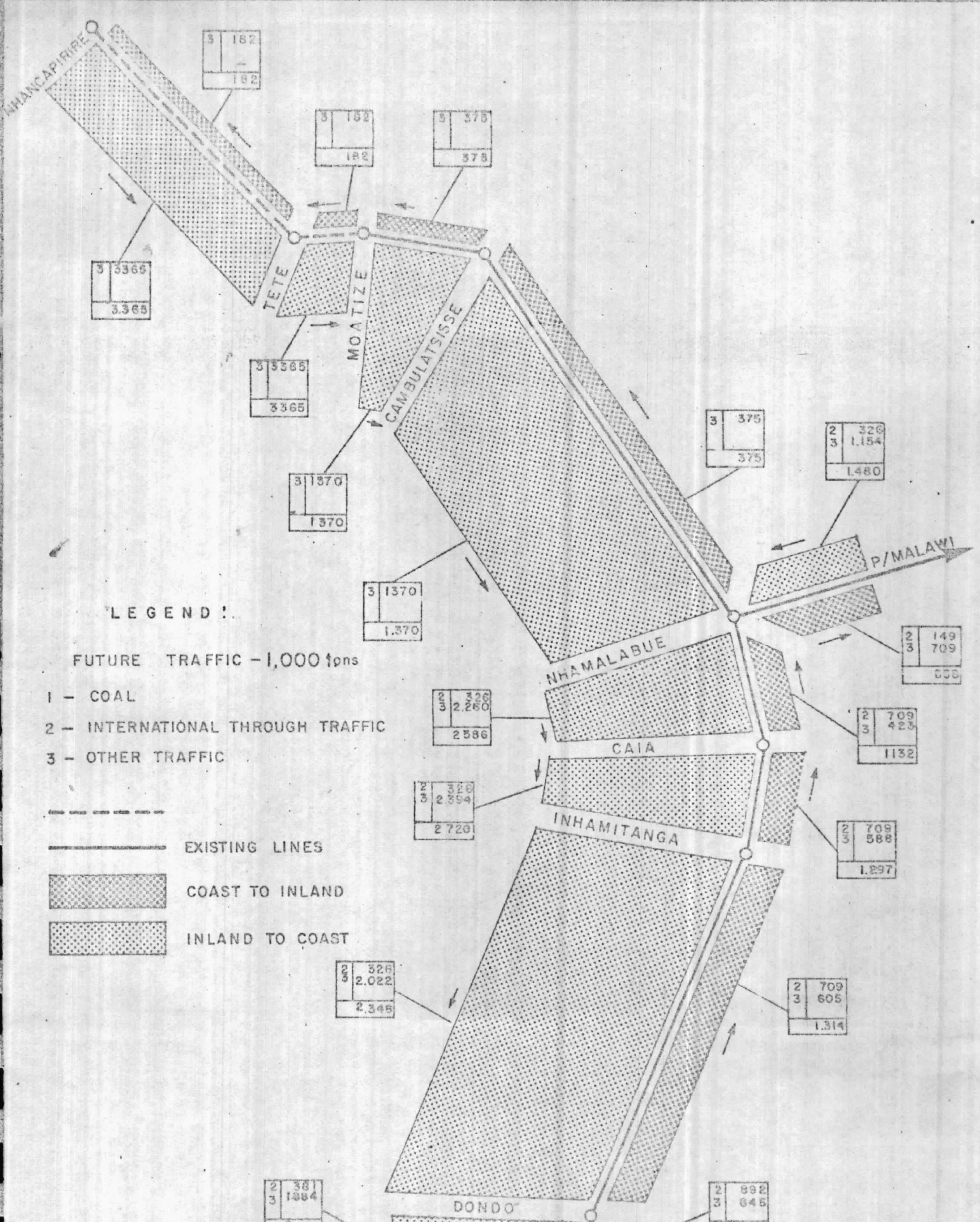

FIGURE 6 6

MOZAMBIQUE - C.F.M. - CENTRAL SYSTEM

Allocated flows in Railway - 1995 - Alternative I. 2

MT-GEIPOT

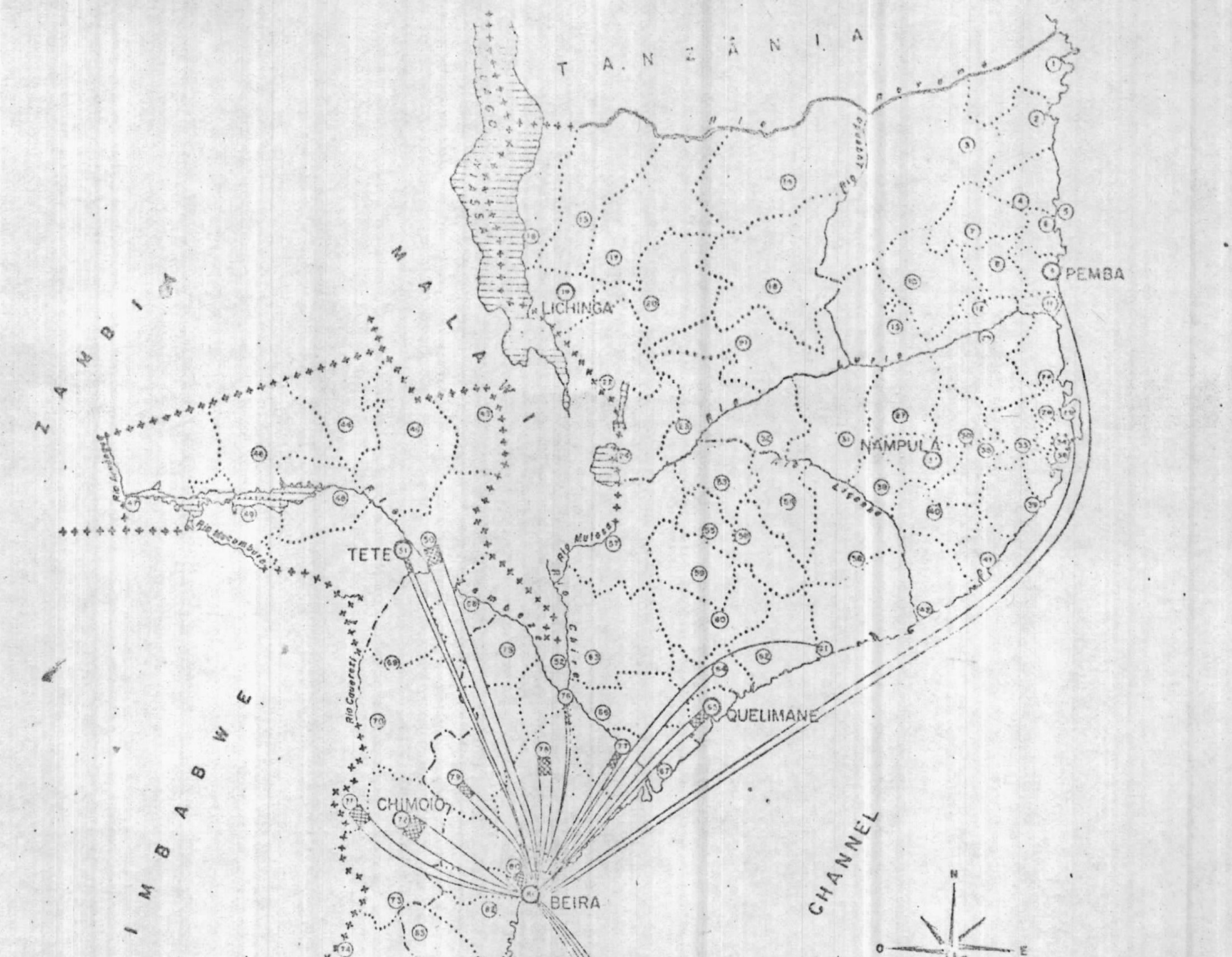

FIGURE 6.7

STUDY OF OUTFLOW ALTERNATIVES

Area of the port of Beira influence — 1995

9.7 - CAPITAL INVESTMENTS IN THE PROPOSED ALTERNATIVES

MINUTA de Relatório
em Revisão
DRAFT Report Under
Revision

9.7.1 - CAPITAL INVESTMENTS IN THE RAILWAY INFRASTRUCTURE AND SUPERSTRUCTURE.

9.7.1.1 *Existing Lines*

- *General Aspects*

This study describes the partial or full use of existing railway line section in the alternative routes for the Mucanha/Vuzi mine connection with the port of Beira or Nacala. The sections have already been analysed by several international organizations, whose reports are mentioned in the list of references. A study of the sections has been carried out from the reports summarizing the current situation of the lines and the steps needed for its rehabilitation or upgrading.

By rehabilitation is meant a complete replacement of track components: rails, sleepers and/or ballast. The materials removed are examined and classified as to the possibility of its use in the future, depending on their conditions.

By remodelling is meant the substitution of that portion of materials worn by usage, so as to permit the coexistence of new parts alongside old-ones.

Based on DNPCF informations and on the reports submitted by Consulting Firms, it was agreed that an urgent rehabilitation program is needed to restore various sections currently being used as they are not in good order, so as to obtain normal operating conditions.

In addition to the physical rehabilitation of the lines, there is a need for developing an adequate management and operational system, combined with technological personnel training on railway sector in order to improve the services.

A program will have to be drawn up in several stages in view of the magnitude of the tasks intended and the volume of resources involved in achieving the proposed transport goals.

The services needed for the rehabilitation of the lines in successive stages have been established while meeting the increasing transportation demands, in order to program the corresponding investments along the time.

6 Current Situation, Technical Aspects, Improvements and Adjustments Needed

6.6 Cambulatsisse-Beira Section

It is part of the CFM-Central Organization, Length: 517 km.

Information from various reports demonstrates the need for a rehabilitation of this section independently of the Mucanha/Vuzi coal production in order to meet the needs for future increase in traffic as a result of increases in production programmed for the Moatize mine.

Although an analysis of the track's plants and profiles in its general aspects does not reveal any critical situation, it will be of greater importance to take into an effective action for changing the geometrical configuration in order to accommodate greater volume of traffic. It can be seen that the current line was built by fitting topographical configuration of the terrain apparently to avoid greater costs of earthworks. Probably this conception had the objective of transporting only the low volumes verified at the time the project was made, under low speed traffic conditions in order to reduce the costs of implementation.

The importance of reducing costs is felt mainly in Dondo to Caia section. Instead of running alongside Pungué River, the lines crosses it upwards, and goes down afterwards, which causes an unmistakeable increase in length. It may have happened that this was executed in a fashion to avoid the constrution of bridges across the several water courses on the hillside.

There are a very few 300 m radius curves, and two curves with 200 m radius between Beira and Dondo and there are also some grades with 1.6% slope and a few with 1.8% and 2.0%. These aspects show the track's acceptable characteristics in its general configuration. A very few sections need substantial changes, which can be programmed in stages for the future with the objective of operational optimization.

The general terrain configuration is mostly even and it does not suggest greater difficulties. Low excavations work can improve technical characteristics for the track, with wider radius and smooth gradients. This would result in increased transportation capacity, higher operational speeds and reduced operational costs.

It is, nevertheless, of greater importance to keep investments in step in order to match the investments with the sequence of the services needed for the required capacity in each stage of traffic demand.

It can be seen that, in some of the sections the critical problem is the absence of platform drainage, which needs to be executed urgently as it concerns the stability of the line and speeds up ballast deterioration. There will be an initial need to restore the drainage system, followed by the improvement of the embankment platform, with the introduction of a sub-ballast layer. It is not recommended that the improvements planned be implemented before platform problems have been removed.

On the other hand, as there will be heavier weight convoys on the line, it is vitally important that a structural investigation on the existing bridges and viaducts be carried out, specially on the 3,160 m bridge over the Zambeze River, which is a sizeable metal structure. Despite its 50 years usage, this bridge is in good structural condition, however its load capacity is not known. Metal bridges should, nevertheless, be painted over with some frequency to ensure its condition through the years.

It is also needed to renew the ballast thoroughly, in view of its poor current condition . Existing ballast must be cleaned and reclassified in order to be used again.

Despite the fact that many wooden sleepers of good quality type were used, many of them will have to be replaced in cases where they are rotten,cracked or demaged by derailments. Current wooden sleepers are engraved to settle down the rail bases.

In some station yards there are metal sleepers instead of wooden ones. It would be advisable to replace them by wooden ones for the sake of unity.

The 30 kg/m rails are in poor general condition, whereas the 40 kg/m ones can be considered acceptable even though in some cases they are deformed as a result of poor conditions in the platform.

Table 9.7.1, below, illustrates the conditions of the tracks.

TABLE 9.7.1 - CURRENT CONDITIONS OF TRACKS IN CAMBULATSISSE TO BEIRA LINE

SECTION	LENGTH (km)	RAIL (kg/m)	SLEEPER	FASTENING	BALLAST
Cambulatsisse-Nhamalabue	196	30		Screwspikes	Not adequate
Nhamalabue -Sena	6	30		Elastic (*) Spikes	
Sena-Inhamitanga	94	40		Srewspikes With Spring Clips	Generally fair
	10	30		Screwspikes	Not adequate
Inhamitanga-Inhaminga	26	30	POOR	Screwspikes	Not adequate
Inhaminga- Mazamba	19	40		Screwspikes With Springs Clips	Not adequate
Mazamba-Muanza	34	30		Pandrol and Base plates	Not adequate
Muanza-Derunde	21	40		Screwspikes	Not adequate
Derunde-Dondo	70	30		Screwspikes and elastic spikes	Not adequate
Dondo-Beira (**)	28	40		Screwspikes	Not adequate

(*) Base plates and rail-anchor needed.
(**) To be duplicated in 17 km.

A program was made up to improve conditions in these lines according to the stages forecasted in the transportation demand.

From the beginning, improving the embankment plateau has been considered, with improvements in drainage, introduction of a sub-ballast layer and renewal of ballast, using part of the existing ballast after cleaning.

In the first stage, the 30 km/m rails will be replaced by 45 kg/m ones, as well as the sleepers, using the ballast compatible with the corresponding transport demand.

For the second stage the complementary substitution of the 40 kg/m rails and strengthening of ballast to meet increased transport demands has been planned.

It is intended to use the 40 kg/m rails for yard sidings, after selecting the bars which are in better conditions. After reading the reports on the track conditions it has been noticed that a great deal of rails are deformed as a result of poor platform conditions.

The preceeding table 9.7.1 presented the length of rails to be replaced during both stages. As the conditions of the sleepers are not known, it was considered the full replacement, but future analysis of the materials removed will be in consideration, so as to evaluate if some or all of it can be used again.

Nacala-Entre Lagos-Utale Section

The line section between Nacala and Entre Lagos, is under CFM-Northern control and the Nayuci to Utale Section, is part of the Malawi Railways network. Total length for both section is 729 km long.

In one of the alternatives analized, it is intended to use the whole section, whereas for other, it is intended to use the Nacala-Monapo subsection only.

Between Nacala and Cuamba, 538 km long, the line configuration is in a harsh condition for operation with steep gradients as far as 2,0% and 300 m minimum radius.

DNPCF has already planned to introduce several changes in design to ensure greater transport capacity with the improvement of existing conditions. Some of these alterations have already been executed and the remaining ones still depend upon financial resources.

Between Cuamba and Entre Lagos, at Mozambique's border with Malawi, there is a 77 km section, completed in 1972, with 1% maximum grade and 500 m minimum radius. Technical aspects are, consequently, far better than in the former section.

The following connection, already in Malawi's territory between Nayuci and Nkaia, 102 km long, presents 0.9% ramps and curves with a minimum of 244 m radius. It was completed in 1970, and the line is in good conditions. At Nkaia there is a connection with the main trunk of the Malawi Railways, which was used for the alternatives, in the section up to Utale, 11.0 km long. The line is in fair conditions but needs rehabilitation.

On the Malawi Railways, the line has 40 kg/m rails on metal sleepers, with pandrol fastenings. In the CFM it was used 30 kg/m rails fastened to wooden sleepers by screwspikes.

There is a need to improve the Nacala-Cuamba track and to restore platform drainage all along CFM line.

The line is to be renewed between Utale and Nkaia and from Entre Lagos to Nacala. The 30 kg/m rails are to be replaced by 45 kg/m rails, initially between Nacala to Entre Lagos and Nkaia to Utale. The 40 kg/m rails are to be replaced by 45 kg/m ones at a later stage. Rails removed from the main line may be used on sidings.

Table 9.7.2 depicts the conditions of the track.

TABLE 9.7.2 ACTUAL CONDITIONS IN THE NACALA-ENTRE LAGOS-UTALE SECTION.

SECTION	LENGTH (km)	RAIL (kg/m)	SLEEPER	FASTENING	BALLAST
Nacala-Monapo	67	30	Wooden	Screwspike	Not adequate
Monapo-Nampula	125	30	Wooden	Screwspike	Not adequate
Nampula-Cuamba	346	30	Wooden	Screwspike	Not adequate
Cuamba-Entre Lagos	77	30	Wooden	Screespike	Not adequate
Entre Lagos-Nkaia	102	40	Concrete	Pandrol	Good
Nkaia-Utale	11	30	Metal and concrete	Pandrol	Good

Cambulatsisse-Moatize

This section (58 km long) is an access line to the Moatize mine which can also be a part of the alternative connection to the Mucanha/Vuzi mine. The profile shows a set of steep gradients in the Moatize to Cambulatsisse direction. The critical section which imposes limitations of tractive performance is on the Moatize to Cateme subsection, where a 300 m radius curve's resistance is added to that of a 1,6% ramp. DNPCF has already developed a relocation project to improve tractive conditions over the section. The present study introduces some modifications to this project considering that it will become a part of the connection to the Mucanha/Vuzi mine.

Platform conditions are to be improved by introducing a sub-ballast layer and drainage structures.

The 30 kg/m rails are to be replaced by 45 kg/m welded rails and sleepers are also to be replaced. Ballast is to be renewed, with the usage of the existing materials only after cleaning.

9.7.1.2 *Study of Interconnection of Existing Lines*

- *General Aspects - Technical Characteristics*

Studies done for the coal export from Moatize through Nacala port have considered two possibilities of interconnecting existing lines. The first one is through Malawi, connecting Cambulatsisse, in CFM-Central, to Utale, on the Malawi Railways, through which Entre Lagos on CFM-Northern is reached and, consequently, the Nacala port. The second interconnection is proposed through Zambezia, departing from Nhamalabue, in CFM-Central, and reaching Monapo, in CFM-Northern, thus reaching Nacala port.

Maximum declivity adopted in the studies of the two links is of 1,25%. Minimum radius was of 300 m, for the Cambulatsisse - Utale alternative, and 600 m, for the Nhamalabue-Monapo connection.

The project and constructive criteria are shown a further chapter.

- *Cambulatsisse-Utale Section*

In 1969, Consultant Engineers Brian Colquhoun, Hugh O'Donell and Partners submitted a study for the railway link between Cambulatsisse, in Mozambique, and Utale, in Malawi, which would wind up with the interconnection of the Mozambique Railways with the Malawi Railways. Thus, there would be a more direct access to the Nacala port, to flow out the Zambeze valley products, especially coal, and at the same time helping Malawi's interests in the development of the area to be crossed by the railway lines.

After studying seven possible alternatives for the tracks, consultants recommended the one starting at a point 3.7 km south of Cambulatsisse, on the actual line in operation. From there, the tracks goes smootly down as far as the Macambezi River and then, goes up to the border between the two Countries, from which they proceed alongside the southbound course of the Mwanza River. They cross the river by a bridge, whose construction will be problematic and then goes up a gorge to the Northern scarp from the Mwanza River.

From its beginning, the track follows southeast bound, but just before crossing the Mwanza River, it takes a northbound direction.

After crossing the northbound course of Mwanza River, the design follows along Chire River's valley up to a point where it is articulated with the actual line in operation, 2,3 km south of Utale. There is an 11 km line between Utale and Nkaia, which needs to be restored; it is a section of the railway which crosses Malawi from North to South.

The new link's full length is 187,3 km.

In spite of the fact that this section crosses an area of more difficult topographical accidents than the one for the Nhamalabue-Monapo design, the consultants costs estimates are smaller than those for the latter one. Since they cannot be checked, the consultant's estimates have been adopted as the figures submitted by the study, taking into consideration the referred discrepancy.

- *Nhamalabue-Monapo (Via Zambezia) Section-Volume 9.2 (Figures 9.2.5, 9.2.6, 9.2.7 and 9.2.8).*

It is an alternative submitted in 1981 by The Henderson Busby Partnership in their study for the coal outflow from Moatize, 761 km in length, used up to 25 km of existing line.

The track initially runs over a low ground, subject to floods on the Zambeze and Chire Rivers, along Inhangoma Island, where a long and tall embankment is projected, as well as 6 bridges 100 m in lenght. After crossing Chire River, the ground becomes very rough and, later, evens out. It reaches the railway that connects Quelimane to Macuba (CFM-Zambezia) near the Muelaiva River. It was used 25 km of this railway, upgrading the existing line. Then, it reaches the point called Muconha, from which the track heads eastward, through a favorable area, as far as Monapo, where it becomes articulated with the CFM-Northern railway, towards Nacala.

Several water courses are to be crossed, which results in 9,560 m of bridges, the main ones being the following:

Local	Length
Chire River	320 m
Munguzi River	200 m
Licungo River	240 m
Ligonha River	280 m
Melela River	280 m
Meluli River	200 m
Monapo River	240 m.

9.7.1.3 *Studies for the Railway Connection with the Mucanha/Vuzi future mines.*

General Aspects

Considering the geographical situation of the CFM-Central Railway and the future Mucanha/Vuzi mines, close to the northern side of the Cahora Bassa reservoir, two possible alternatives connections have been proposed with the existing railway system: one of them by-passing Zambeze River on the northern side and the other going across the Cahora Bassa reservoir and by-passing Zambeze River on the southern side. The northern alternative is totally by railway while the southern alternative includes a stretch of lake navigation to cross the Cahora Bassa reservoir, by constructing a coal terminal close to the Bohozi River on northern side of the reservoir and another coal terminal at Nhancapirire on the southern side and from this point on, connecting Nhancapirire by railway with the existing CFM-Central system in Moatize.

At the final stretch of each railway alternative a loading railway terminal is projected.

Technical Aspects

The design study of the lines was developed by adopting circular curves of 300m minimum radius with transition spirals in accordance with the technical specifications of the DNPCF project for the Cambulatsisse to Mucanha/Vuzi connection.

Maximum grade in both ways is 1.25%, taking into consideration compensation in curves.

Typical cross section was defined to meet the specifications of the Mozambique Road and Works Department Regulation (Act Nº 5/75) for wooden sleepers (see Figure 9.7.1).

Also taken into consideration was the use of welded rails as well as the traffic volumes forecasted in two stages: the first one for 6×10^6 tons/year of coal transported and the second, for 10×10^6 tons/year of coal besides the non coal traffic.

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MINES OF MUCANHA/VUZI-STUDY OF OUTFLOW ALTERNATIVES

Typical cross section

CAMINHOS DE FERRO DE MOÇAMBIQUE

TYPICAL CROSS SECTION

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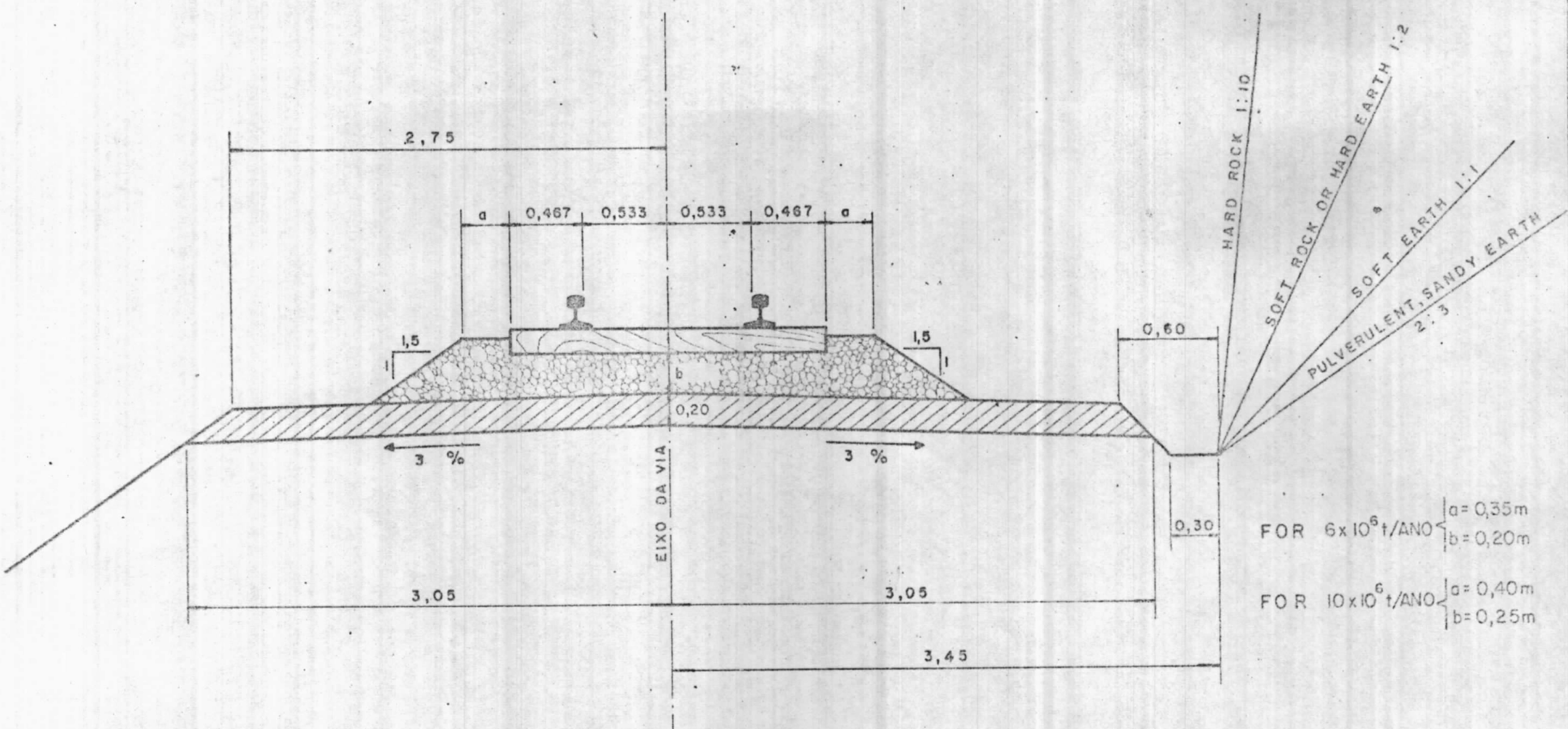


NOTA: BASED ON REGULAMENTO DO SERVIÇO DE VIAS E OBRAS / 75

FIG. 7.1

? Ver se há alterações de descrição

Cambulatsisse to Mucanha/Vuzi-Northern Connection.

The project has a total length of 364 km.

Leaving Cambulatsisse, the track takes on a northwest bound course of the existing line. The initial section goes for 155 km over terrain of smooth configuration. There are bridges to cross the Condezi (120 m), Revuboé (160 m), Nhambia (120 m), Mavuzi (120 m) and Lumazi (120 m) Rivers.

Leaving the previous section, the track takes on a definite west bound course, generally towards Mucanha mines and, after crossing EN 221, starts to run over rougher terrain, which forces the presence of greater sinuosity in the geometry. It crosses River Cherize (200 m), Luia (440 m) and Capoche (440 m).

After these three rivers valley terrain takes on a smooth configuration up to the township of Chipera.

Near Cahora Bassa Reservoir, the terrain becomes full of accidents, which results in a very tortuous track, with greater volume of excavation.

The track crosses Rivers Mefidze (120 m), Muamba - Zana (200 m), Capuadzi (120 m), Muanga (120 m), Sisa (240 m), Sangere (200 m), Messamba (200 m), Manga (200 m) and Muansi (200 m).

For the study of this alternative the project drawn by CFM (1:2,500 scale) along 225 km was used. The extension as far as the mine, was studied in chart sheets of 1:50,000.

A railway terminal is proposed at the end of the link, close to the Bohozi River border, in order to load the convoy through carrier belts, from the stacks of washed coal.

Moatize-Nhancapirire - Southern Connection.

Leaving Moatize the track, with 151 km total length, initially follows EN 103; after crossing it, it goes over Revuboé River, by passes Tete airport and heads west, to cross Zambeze River, South of Boroma. Ground topography between Moatize and Zambeze River is very favorable to the track.

Zambeze River is a great obstacle to be overcome with a large bridge construction.

After crossing Zambeze River, the track becomes full of accidents for 15 km, when it reaches smooth terrain as far as the Nhancapirire River borders.

The track crosses the Tchirodri, Tsacoco, Zuequequê and Nhancapirire Rivers.

At the left hand border of the Nhancapirire River was projected the construction of a railway terminal, interconnected with Cahora Bassa reservoir which is described in a later chapter.

The track crosses the transmission lines coming from Cahora Bassa Lake and the road to Songo, which will have to be taken into account on the datailed project.

Project and Constructive Criteria

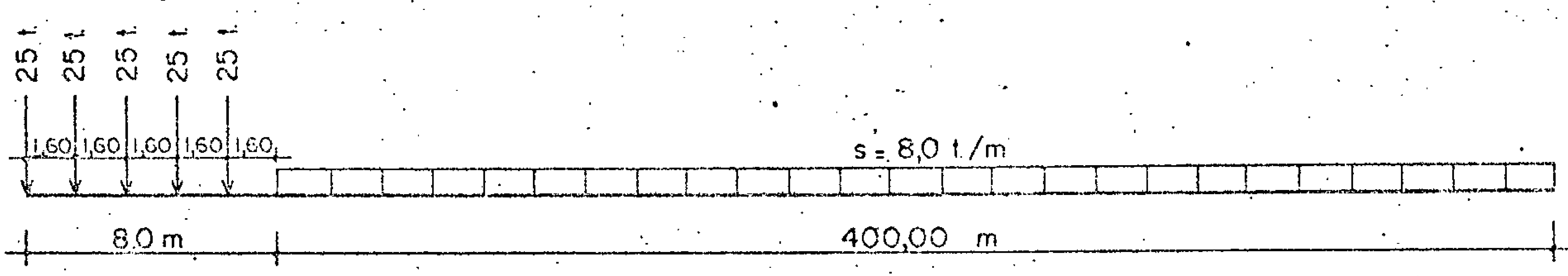
- *Bridges and Viaducts*

For special civil works the Regulation on Buildings and Bridges Stress, from 1961, which determines the Typical railway convoy has been considered.

It was learned from experience that the standardization of structures for civil works provide simplicity and speed up structural projects and increases quality of the works, besides greater speed as a result of labour training.

The choice of standard spans is dependent upon equipment available to lift premolded beams or upon the supporting capacity of the bracing equipment.

In this study special civil works were classified in three groups depending upon the length of each. Therefore they are classified in small, median and large ones.



Typical Railway Convoy

The small constructions are the ones short in length, which uses conventional reinforced concrete. They should be performed to cross rivulets or over passes. They are constructed with direct bracing and the concrete blocks are manufactured in situ.

The median sized construction will be executed to cross small rivers and not too long valleys. They will have articulated spans in order to standardize projects and to simplify the execution.

It is recommended that they are projected with pre-molded beams in prestressed concrete.

It is believed that nearly 35m articulated spans could be attained with two pre-molded prestressed concrete beams held in place by cross beams molded in situ and reinforced concrete box slab.

Whenever needed the articulated difference can be projected with spans specially detailed for each case.

Knowledge of local topography for the implementation of pre-molded bridges is very important in view of the need to build level work sites to serve as yards for the construction of beams without the need to have large scale earth-moving activities.

Large scale works will serve for the transposition of valleys or wide rivers.

Depending upon technical demands it can be used, either articulated spans with pre-molded beams or large spans in cantilever.

For the typical convoy used, in the case of pre-molded beams, it can cover 40 meter spans and if it is employed cantilever, it is likely to cover 80 meter spans.

Should metal structures be promoted in the choice it is possible to cover longer spans.

If the choice is for metal structures, NIOCOR-type steel should be employed. The recommendation of the NIOCOR steel is due to its high quality and resistivity to stresses and corrosion, with minimum maintenance costs.

Determining factors for the choice of various structural alternatives for the bridges are obviously the constructive costs and time required for construction.

Once such criteria have been set and depending upon the transposition of each valley,we have chosen the type of work which is considered the most adequate at this stage.

There will be a future revaluation of the solutions herein,in future stages, after more precise topographical surveys are available.

Figures 9.7.2 to 9.7.5 shows typical exemples of the various types of large special works.

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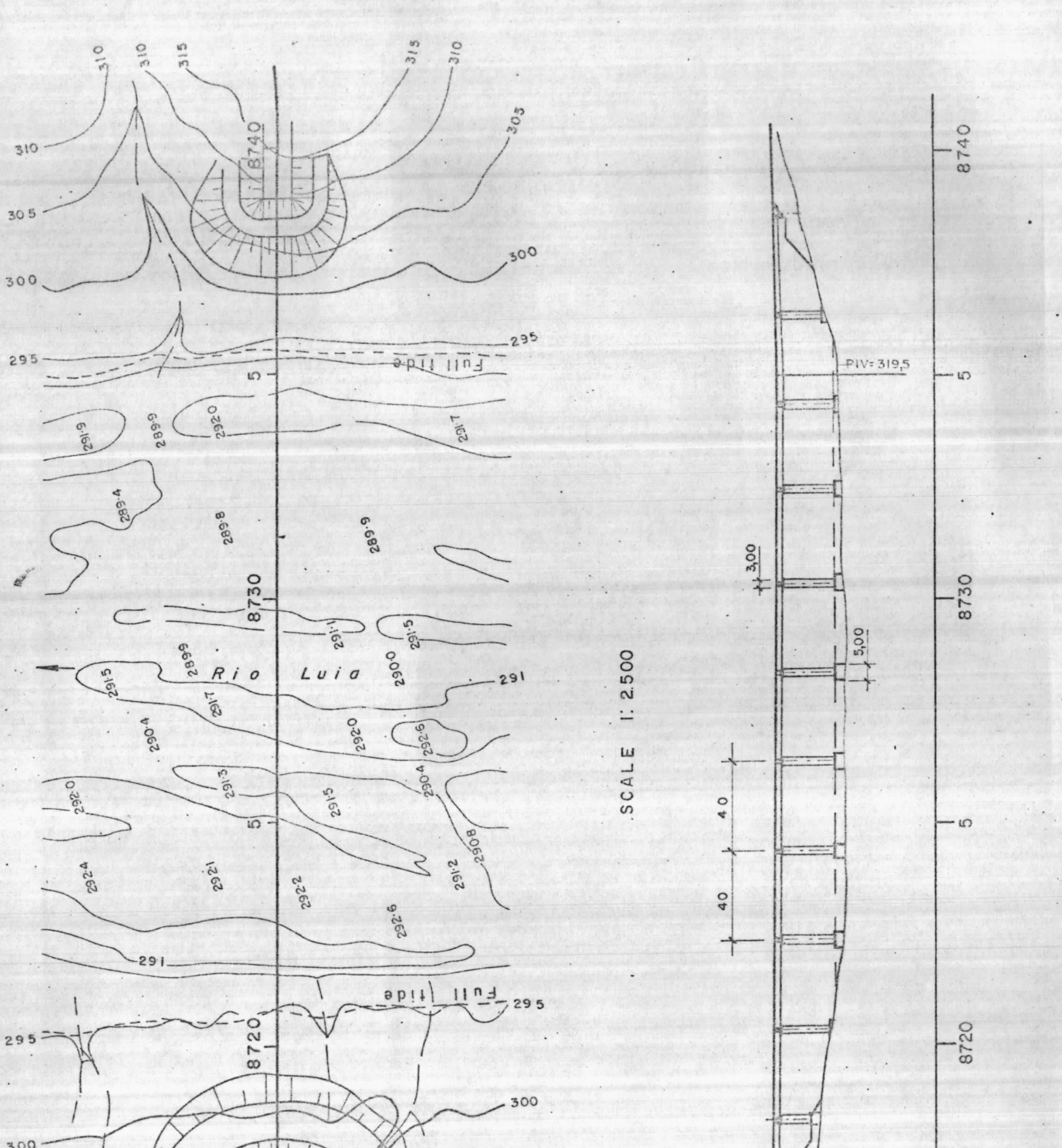

FIG. 7.2

MINES OF MUCANHA / VUZI – STUDY OF OUTFLOW ALTERNATIVES

Bridge with premolded, cast beams

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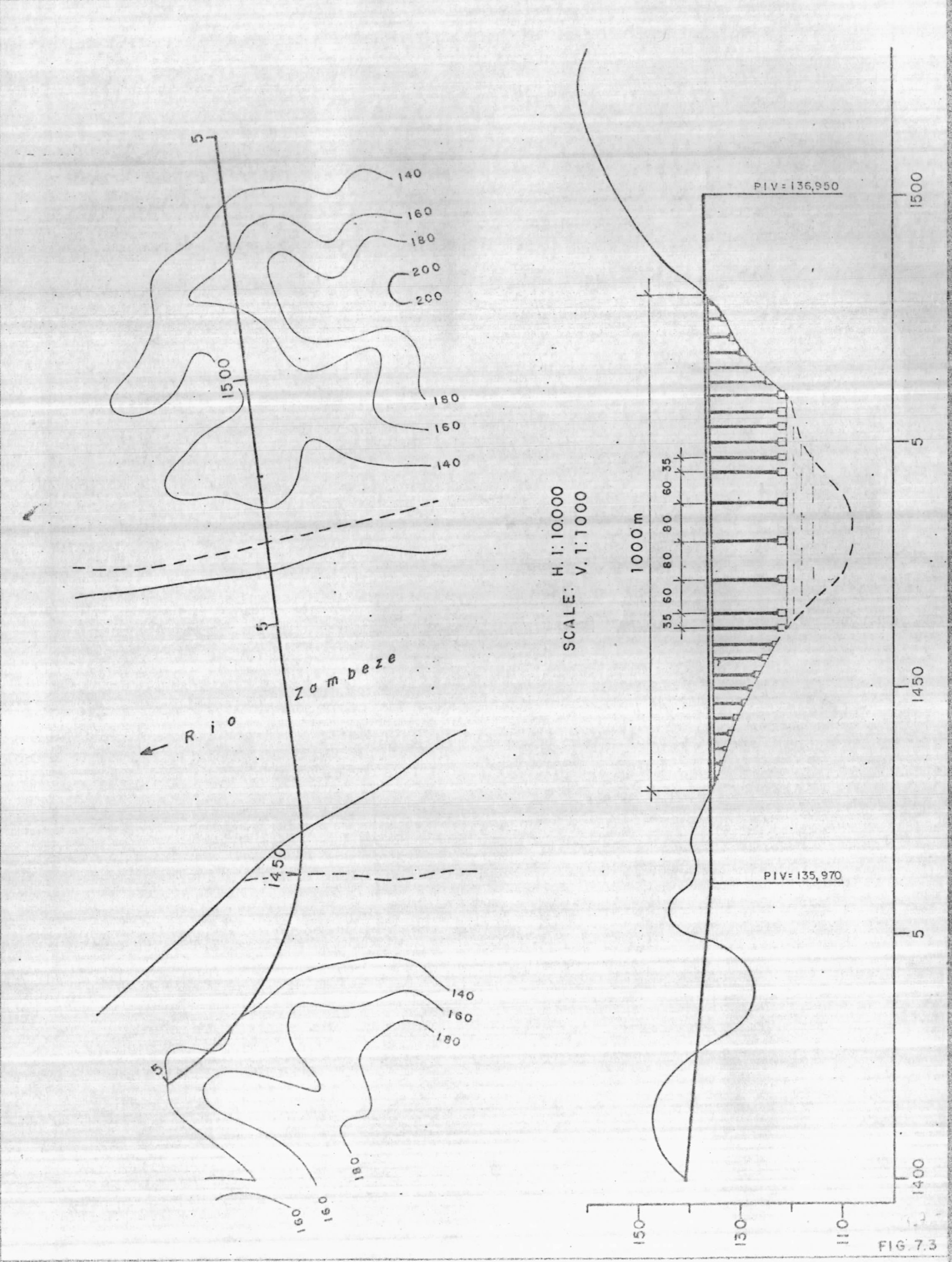

FIG. 7.3

MINES OF MUCANHA/VUZI - STUDY OF OUTFLOW ALTERNATIVES

Bridge with precasted beams and successives cantilevers for large spans

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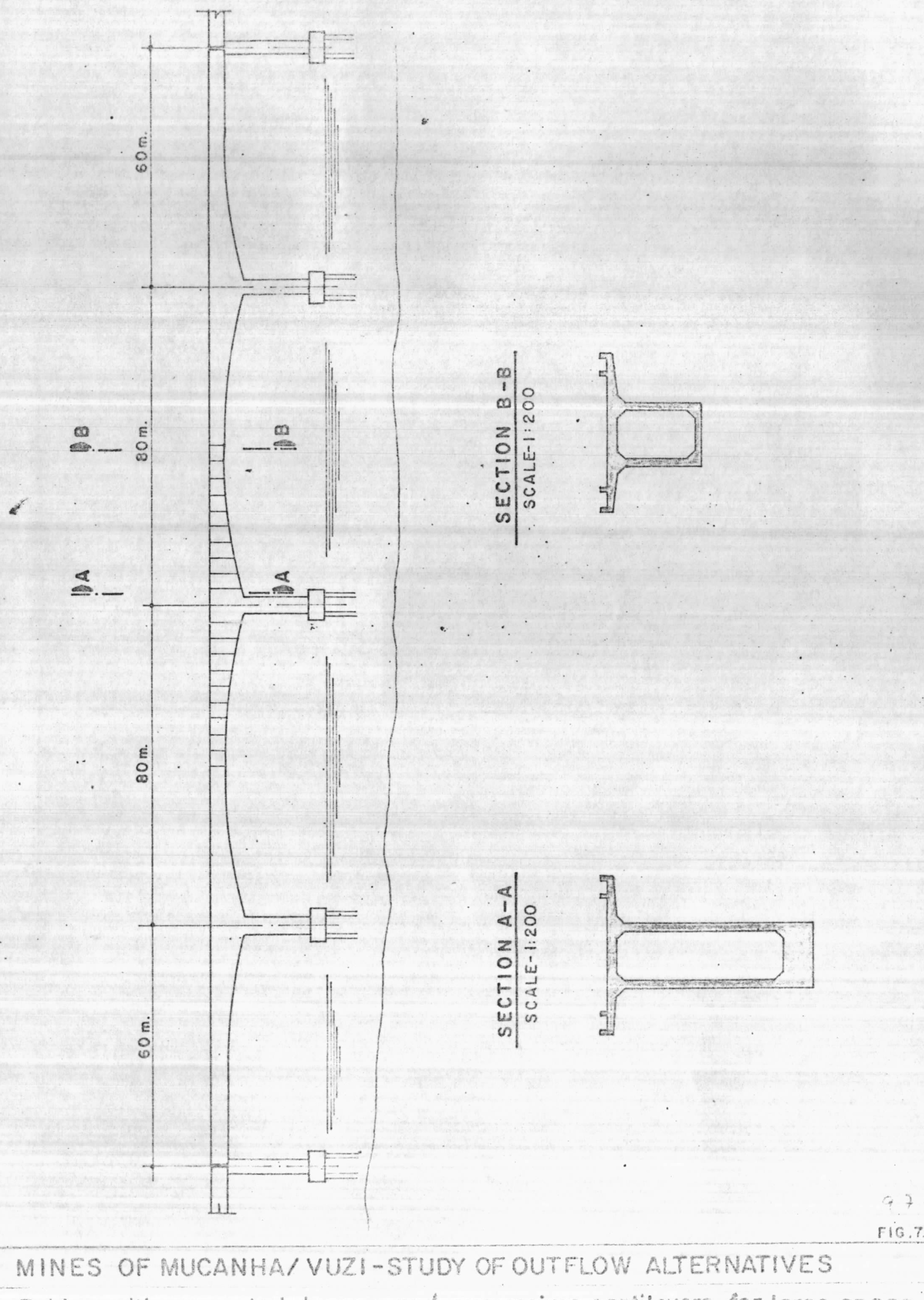

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FIG. 7.4

MINES OF MUCANHA/ VUZI - STUDY OF OUTFLOW ALTERNATIVES

Bridge with precasted beams and successives cantilevers for large spans

7. ... Superstructure

• Sub-ballast

... constituted of a layer of granular material inserted between ballast and the surface of the platform, in order to stop ballast stones going into the ground, besides providing insulation against moisture, which provides better support and a reduction in ballast thickness. It was estimated a volume of about 1210 m^3/km.

In the case of renovation of line in traffic, it has been contemplated to renovate elements of the line, laying the sub-ballast layer, compacting and then the placement of a first layer of ballast and installation of the grid.

For new lines, sub-ballast layer is laid immediately following the completion of earth-moving services.

• *Ballast*

The figure of 0.20m for ballast thickness on a vertical line under the rails has been used, for a total of 6 x 10 tons per year with 0.35 wide shoulders for lateral holding of welded line.

With increased transport volume up to 10 x 10^6 tons per year 0.25m ballast thickness and 0.45m shoulders width has been adopted.

The ballast thicknesses considered are for a good quality sub-ballast type.

With the ballast section projected on typical profile, it should have a compacted volume of 1067 m^3/km for the first stage (up to 6 x 10^3 tons) of construction. In view of the fact that the access links to the Mucanha/Vuzi mines will be limited to this transport volume, this will be the ballast adopted.

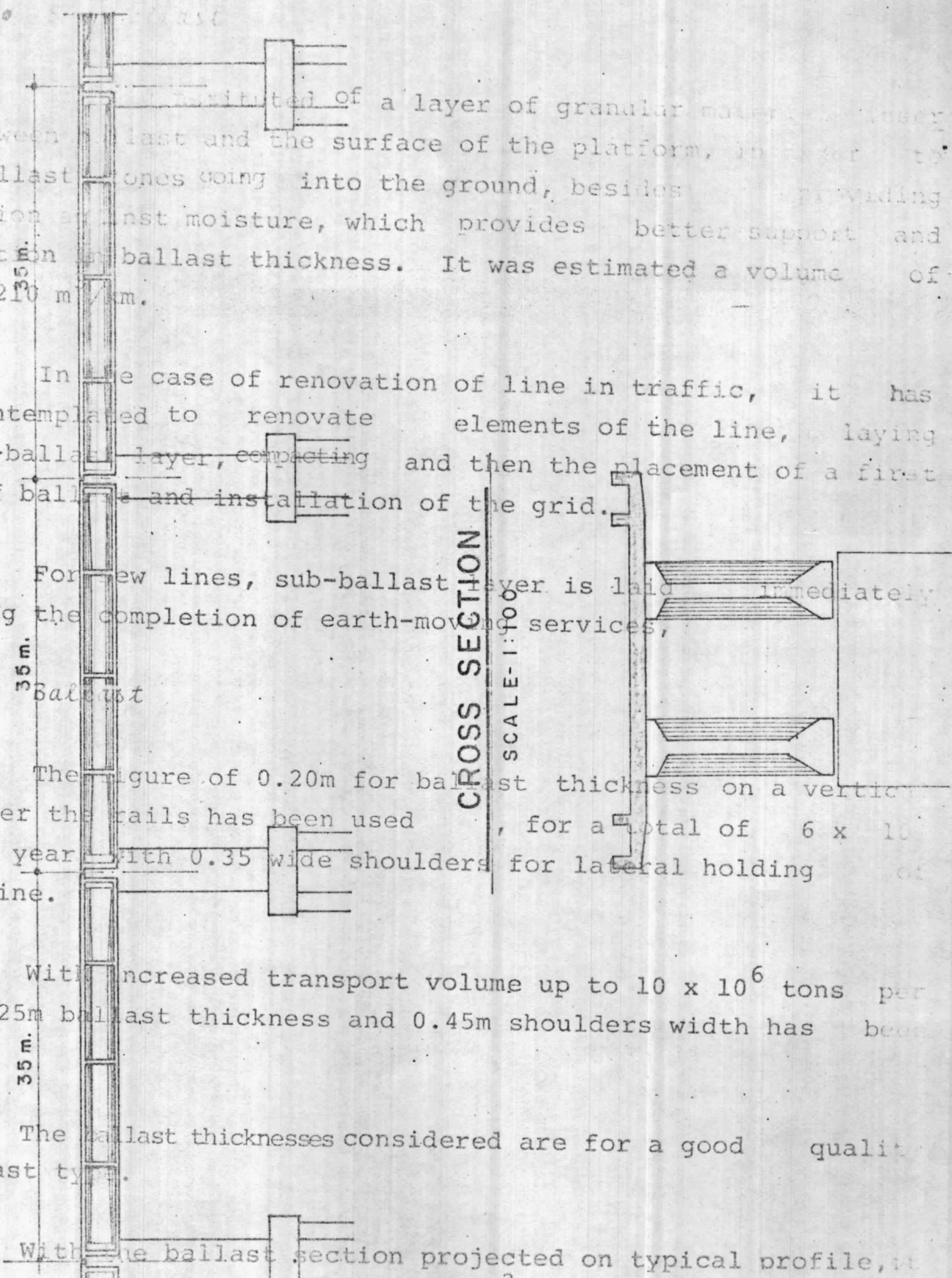


FIG. 7.5

MINES OF MUCANHA/VUZI-STUDY OF OUTFLOW ALTERNATIVES

Premolded beam bridges

9.7.1.4 *Railway Superstructure*

- *Sub-Ballast*

It is constituted of a layer of granular material inserted between ballast and the surface of the platform, in order to stop ballast stones going into the ground, besides providing insulation against moisture, which provides better support and a reduction in ballast thickness. It was estimated a volume of about 1210 m^3/km.

In the case of renovation of line in traffic, it has been contemplated to renovate elements of the line, laying the sub-ballast layer, compacting and then the placement of a first layer of ballast and installation of the grid.

For new lines, sub-ballast layer is laid immediately following the completion of earth-moving services,

- *Ballast*

The figure of 0.20m for ballast thickness on a vertical line under the rails has been used , for a total of 6×10^6 tons per year, with 0.35 wide shoulders for lateral holding of welded line.

With increased transport volume up to 10×10^6 tons per year 0.25m ballast thickness and 0.45m shoulders width has been adopted.

The ballast thicknesses considered are for a good quality sub-ballast type.

With the ballast section projected on typical profile, it should have a compacted volume of 1067 m^3/km for the first stage (up to 6×10^3 tons) of construction. In view of the fact that the access links to the Mucanha/Vuzi mines will be limited to this transport volume, this will be the ballast adopted.

For lines to be renewed or upgraded, it has been considered for the first construction stage to use 50% of existing ballast and adding new ballast to reach the specified rate.

The rate of 1067 m^3/km will be adopted for the first stage for the interconnection of existing lines.

For the second construction stage, that is, for the transportation volumes from 6 to 10 x 10^6 tons, it will be needed to add some 255 m^3/km to the ballast section.

- *Sleepers*

It has been decided in favour of wooden sleepers as it was found that there is a strong corrosion of metal components in coal transporting railways, caused by sulphurous agents. The matter will have to be more thoroughly studied together with CFM officers, as there are other intervenient elements.

For the transportation up to 6 x 10^6 tons/year, it has taken the rate of 1600 sleepers/km (0.625m spacing between sleepers) and 1754 sleepers/km (o.57m spacing between sleepers) for the second stage of 10 x 10^6 tons/year, to meet increased stress. This will mean a reduction in initial costs for the renovation of existing lines.

In view if the fact that new access links to Mucanha/ Vuzi mines will have at most 6 x 10^6 tons, the initial rate of 1600 sleepers/km be maintained, even for the second stage.

- *Rails*

It was assumed that maximum rail stresses will be in the order of 20 tons per axle. For the volume of transport to be carried on the rails, it was found that 45 Kg/m rails would be a correct choice.

In view of the increase in future traffic volumes, it was found that the existing 40 kg/m rails in existing sections of the lines can be used until it reaches the 6 x 10^6 tons scenario, which will allow programming the investments in steps.

There has been a suggestion to replace of the 30 kg/m rails with 45 kg/m ones in view of the projected stresses and also due to the poor conditions encountered.

For all new lines it has been recommended immediate use of 45 kg/m rails.

e Laying of the line

The supplying of rails in 12m long bars has been assumed.

If CFM has a welding post in Beira, the pre-fabrication of long welded rails could be thought about , before laying on the ground, with sizeable economy of fishplate.

Should CFM have a mobile electric welding unit as appears to be the case, or even aluminothermic, the laying could be carryed on 12 m grids, already mounted in the mills interconnected on the line by sets of fishplates initially. The welding is then applied and the fishplates removed.

Ballast is to be laid in two layers.

Telecommunication System

There are two conceptions for the Communications System in the various alternatives considered for the transportation of the coal production from the Moatize and Mucanha/Vuzi mines. The main difference between the alternative systems is an connection with the transmission system. Only after more detailed studies and more consistent data, will it be possible to evaluate which is the most advisable system to be adopted in each case.

The communications system suggested for each of the alternatives antecipates the following subsystems:

- Administration Telephone Subsystem
- Operations Telephone Subsystem
- Radio-telephone Subsystem (Station-to-train)
- Licensing Subsystem
- Telegraph Subsystem
- Transmission Subsystem with the alternative in which either physical lines or radio are used.

- Administrative Telephone Subsystem

The installation of telephone posts should be projected for the most important points on the railway network.

Interconnection between telephone posts will be accomplished by the transmission subsystem.

- Operational Telephone Subsystem

The installation of the selective telephone posts to support the operational communications of the railway should be antecipated.

The selective posts should be installed at the future operational control centers. Users will be located at strategic operating points and will be connected to the post through the transmission subsystem.

- Radio Telephone Subsystem (Station-to-train)

This subsystem will permit communication between train drivers and the posts located at strategic points of the railway (where the selective posts are also located).

The subsystem projected will provide more reliable railway operation and will contribute to speeding up train circulation.

Licensing Subsystem

There will be a communications system for dispatching trains between the yards to be operated in the future.

Telegraph Subsystem

The installation of teleprinter terminals in the most important points as regards the administration and operation of the railway is to be projected.

This subsystem will support the necessary written messages for traffic between operational posts.

Transmission Subsystem

As it was mentioned earlier, during this stage of the study two alternatives will be considered and the selection of either will rely on the ability to fit local conditions and the peculiarities of the railway operation to be defined in the next phase of the study.

Overhead Lines

Open overhead lines with aluminium conductors or ACSR is proposed at this stage of the study. The posts to be adopted can be of concrete, rail or compressed plates of galvanized iron. The choice for one particular type can only be defined after a more detailed discussion with CFM officers.

Carrier wave equipment which permit the interconnection of telephone posts and telegraph equipment are also included in the subsystem.

The survey of costs is also assumed for the overall implementation of the systems without using any of the existing supports. Only a more thorough check up will permit a better evaluation of the use of existing supports.

- Via Radio

The use of a middle capacity radio which is widely adopted in rural telephone systems, on the UHF band, is proposed to interconnect the most important points as regards the administration and operational aspects. Repeating stations along the line should be installed.

If necessary VHF radios can be installed between the operational centers and others specific points of the line. This link will operate on a frequency band which is not the same as the one for the radio-telephone system.

It was assumed that inter-yard dispatch is to be accomplished by electrical staff, via radio, coherent with the signalling system.

The possibility of personal connection at points with radio facilities has not been considered. In case of communication needs, the station-to-train system will be used.

The main advantage of adopting this system, besides being more sophisticated than physical lines is the fact that maintenance is easier due to the concentration of equipment which reduces the movements of maintenance teams. It is worth emphasizing that this option has the advantage of not requiring personnel to work in desolate regions, besides being less vulnerable to vandalism which would be harmful to the railway operation.

Signalling System

A study of the existing railway system in Mozambique and the alternatives for transportation of coal for exportation through the ports of Beira and Nacala, taking into consideration the traffic projections foreseen for each level until the year 2010, leads to the need to construct the following new railway segments:

- Mucanha-Cambulatsisse, with 340 km, or Nhancapirire-Moatize, with 151 km.
- Cambulatsisse-Utale, with 191 km, if the route via Malawi is to be used.
- Nhamalabue-Muelaiva River, with 257 km, and Muconha-Monapo, with 479 km, if the route through Zambezia is chosen.

Any of the sections to be built, depend on the alternative to be taken up, should be part of the railway system for the exportation of coal from the Mucanha/Vuzi and Moatize mines and as such, this should have together with the existing segments, a standard licensing system and control of trains dislocation.

Taking into account the predicted traffic volumes considered, the number of crossing loops to be constructed and local conditions of the areas to be crossed by the railway, it is suggested for the licensing and control of dislocation that a staff system be implemented which should be efficient enough for a single line with low traffic density.

The projections shows that by 1995, the most overloaded segments will have around 20 trains per day, both ways and from that level, to the year 2010, it is expected 32 trains. As a consequence, it can be recommended the use of a staff system, or similar (token).

Aiming at the simplification and less expensive system operation, connection by radio (VHF) should be used for the transmission of the codes between licensing apparatures, instead of communication through physical circuits. Additionally to their higher cost and maintenance, they are subjected to weather conditions, acts of vandalism and others problems. Communication between control centres and trains drivers via radio which should be adopted will also contribute towards a better control of the dislocation.

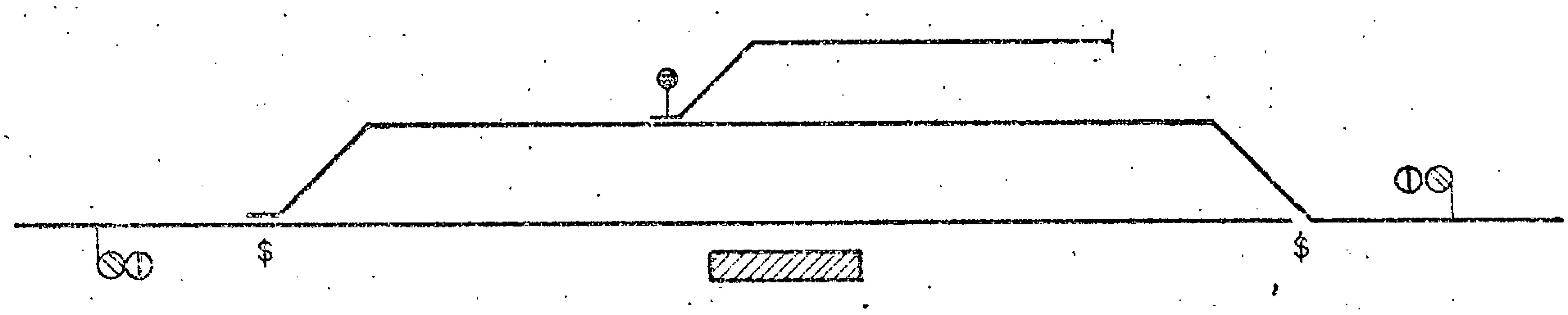
For the Beira-Dondo section which is to be duplicated, for 17 km, and where is expected the future greater density of traffic, there should be a central electrically-controled system, the Control Centre of which should be in Beira. It should have track circuits along its length, electric switch machines and color light type signals and eventually a safety system of the ATS, ATC type and others.

It is advisable to notice that in any of the existing segments or in those to be constructed, the proposed system can be altered and improved with the inclusion of electrical devices for the control of the switches, centralized controls, track circuits and electrical signal, all in keeping with an eventual increase in the traffic flow.

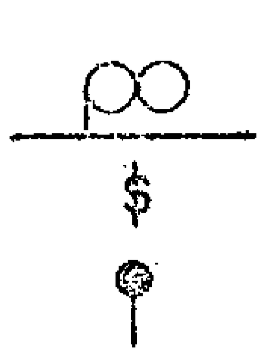
Figure 9.7.6 shows the typical scheme of a crossing loop with the use of spring switches.

TYPICAL LAYOUT

CROSSING LOOP, USING "SPRING SWITCH" IN THE INCOMING SWITCHES



CODE SIGNS



Switch point checking signal.
Spring switch.
Manual switch operation device.

FIG. 7.6

9.7.1.5 *Loading Modular Yard*

- *General Aspects*

The Conceptual project for the "coal loading modular yard" in Mozambique is intended to meet the loading of trains, in order to execute the transport expansion program with levels of 1, 3, 6 and 9 million tons of coal per year.

Its basic principle is to avoid the advance of disbursement dates in relation to actual demand so as not to increase the system's operational costs or produce capacities which are very much in excess of the actual needs. We are assuming three stages of increasing levels of productivity and complexity, on order to ensure the projected flows.

- *Storage project demand*

The yard's capacity will be to ensure the storage of the volume of 15 days production, which creates the following project demands for the storage and loading.

YEARLY PROGRAM (10^6 tons)	"IN YARD" STORAGE (tons)	STACK VOLUME (m^3) (*)	LOAD (tons/day) (**)
1.0	42,000	46,700	3,125
3.0	125,000	138,900	9,375
6.0	250,000	277,800	18,750
9.0	375,000	416,700	28,125

* = $\gamma \cong 0.9$ tons/m^3

** = operational year = 320 days/year

Coal Stacks Measurements

For the level of 1×10^6 tons/year, it was assumed railcar loading by loading shovel the layout of which is included in the drawing represented by the first stage (A). (Figure 9.7.7).

In order to avoid a very long cycle for the shovels the width of the base was limited to 21m and the height to 4m, for unloading safety reasons, having, thus, 3 stacks of 240m long, at 10m spacing, so as to avoid the propagation of fire.

It is anticipated for this level a simple traction train, with a 23 car modulum, the stacks having parallel loading, with the overall length corresponding to two simple traction trains. This would give us an average transportation distance in the order of 15m by the shovels and it is estimated a full cycle (loading/transportation/unloading/return) of 80 seconds, computing the displacement from one car to another, but with the decrease in production as the day progresses we would arrive at an average figure of 120 seconds. Consequently, an average 8 $yard^3$ loading shovel would produce 165 tons/hour, 2 shovels would meet the needs of a 12-hour working day, with an average of 2.30 trains/day and if maintenance was difficult, 3 would afford a more than adequate safety margin.

Using an analog method for the 3×10^6 tons/year and double traction train with 46 cars and a loading capacity of 9,375 tons/day, it can be projected a second loading line parallel to the first one, which is included in the second-stage drawing (B) (Figure 9.7.7), forming between them a 6 stacks to be handled by 8 $yard^3$ loading shovels. 4 shovels and a safety margin of 5 are needed for a 16-hour day. The length is kept at 240m each but width increases from 21m to 26m, and height from 4m to 5m.

As regards the levels of 6 and 9×10^6 tons/year it have been changed the coal dislocation technology by constructing the railway complex and with the loading performed by a reclaimed device in both loading sidings. Stack measurements would change and could reach the figures of 40m for the base and 12m high, in the final stages. This evolution is represented in its final stage by the third stage (C). (Figure 9.7.7).

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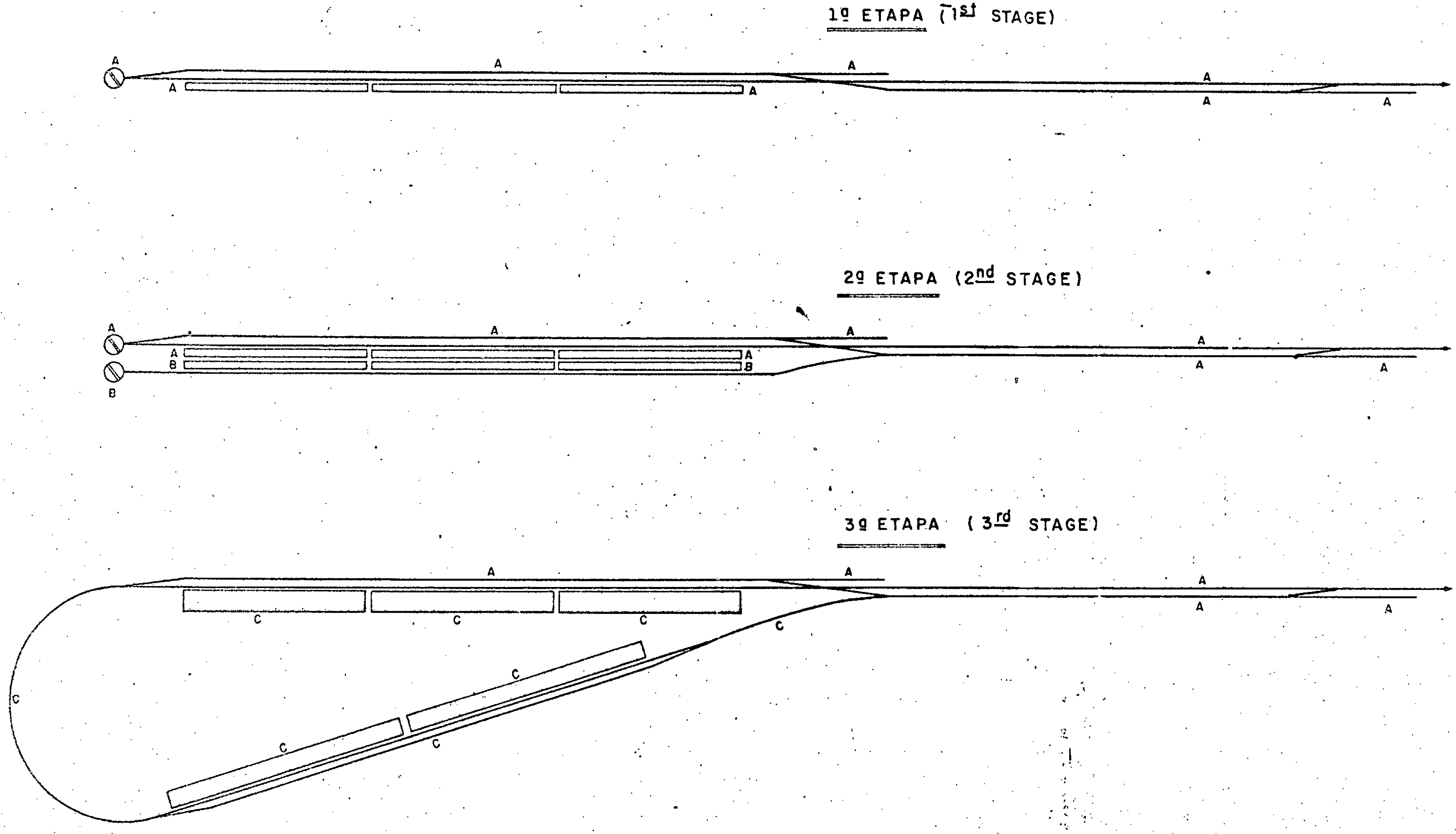

FIG. 7.7

ESTUDO DE ALTERNATIVAS DE ESCOAMENTO DA PRODUÇÃO DE CARVÃO DE MUCANHA / VUZI *"STUDY OF OUTFLOW ALTERNATIVES"*

Pátio modular de carregamento de carvão — Coal loading modular yard

9.7.1.6 *Hydrological Configuration of the Area under Study*

Alternative routes for the Moatize-Tete-Nhancapirire and Cambulatsisse-Mucanha / Vuzi railways are, respectively, the ones going round the southern and northern borders of Cahora Bassa Lake. Their hydrological conditions are obviously dependent upon the rivers which feed the middle course of the Zambeze River, amongst which it is noticed the Revuboê, Mavuzi, Cherize, Luia and Capoche Rivers, all of them north from the Zambeze River, whereas on the south border the important crossing is the Revuboê River, as well as the Zambeze River near Tete, besides crossing over other less important rivers, such as, for instance, the Nhancapirire.

For this preliminary appraisal information was based on the data from studies done for the Zambeze River by Direção Nacional de Águas (DNA), in order to implement the Flood Warning System for the Zambeze River.

Zambeze River is the main course of water in the southern section of Africa. It starts at the border between Zambia and Angola and Zaire, and runs for 2,700 km to end on the Indian Ocean, near Chinde, in Mozambique.

Of its entire course, the section between Zumbo and its end, measuring some 850 km, that is, 31% of its total, is in Mozambique and represents 10% of its hydrological basin, with an area of 1,200,000 km^2. At the point where it crosses the Zambia-Mozambique border, downstream from Kariba Reservoir, the Zambeze is 330m above sea level and runs directly onto Cahora Bassa Reservoir, with a 220 km long reservoir.

The dam, about 120 km upstream from Tete, was built in a gorge of very tall borders, which permits the storage of up to 326.0m and on flood levels of up to 329.0m.

Dam's effective height, with an elevation of 102.5m sheer drop permits accumulation of an effective volume of 40×10^9 m^3 of water, to which we can add 8.3×10^9 m^3 superelevation.

For some 30 km downstream from the dam, the Zambeze River runs inside the gorge, after which it goes into the plains where the river's course presents gentle curves, its width varying between 800 and 1,000m.

Within the area of the studies the Zambeze basin in Cahora Bassa reaches 900,000 km^2, to which are added the Luia and Revuboẽ areas, with 27,634 and 15,540 km^2, respectively.

After-crossing at Lupata another gorge in lot 95, the Zambeze goes into its full tide plane which includes around 350 km of its length to its mouth.

During this final stretch, the river shows varying widths of 3 to 5 km with many intricacies and poorly defined borders, which give rise to periodical floods during the summer which seriously affect in an adverse manner the Country's economy.

Weather conditions are extremely varied in this area, with long periods of drought. The rainy season goes from November to March, with cycles of heavy stormy rainfalls for short periods, followed by dry weather.

Based on Cahora Bassa area it can be seen that the rainfalls are heavier, in North, in the areas dependent on Luia and Revuboẽ Rivers, with an yearly average of 1,500 mm at the Vila Vasco da Gama pluviometric station.

At Vila Mouzinho, in the Revuboẽ basin, at the Malawi border, the yearly average is 1,250 mm, with a maximum of 2,680 mm.

In view of the uneven rain distribution the rivers can dry up as a result of the duration of the rain season, and become strong streams.

We can see from the above that the running conditions of the water courses involved in both track alternatives are closely connected with rainfalls.

Taking the Zambeze River in Cahora Bassa as a basis, it can be seen that the downpour varies between 250 and 1,800 m^3/s, with the heavy falls between January and April, and the peak periods in February or March.

This delay of full tide in relation to the fall peaks, obviously is the result of the buffering action in the plateaus of Central Africa and in the Kariba and Cahora Bassa dams.

The Luia and Revuboê Rivers, on the other hand are very dependent upon the level of rainfalls and present extremely varied discharges, which are hardly permanent during the dry periods, with highly substantial peak volumes.

The following data was gathered in connection with the rivers encompassed by the tracks, from data used in the studies for the Planning of the Flood Warning Systems for the Zambeze River:

RIVER	STATION	DISCHARGE	PERIOD
Luia	E 322	1,791 m^3/s	Feb. 1965
Capoche	E 359	776 m^3/s	Mar. 1963
Revuboê	E 356	1,870 m^3/s	Feb. 1970
Luenha	E 348	3,210 m^3/s	Dec. 1969

The preliminary information is that the full tide movements are very heavy in the water courses crossed by both track alternatives, dispite the fact that their discharge during the dry seasons are of little significance.

With regard to the crossing of the Zambeze, on the south alternative it can be expected a heavy project discharge in view of the fact that we should add the sum of the maximum discharges in the Luia and Revuboê, which accounts for aproximately 3,670 m^3/s, to that of Cahora Bassa, of 1,800 m^3/s.

It have been also considered as a conditioning hydrological factor for the sections, that it will have to satisfy the figure of 329.00 m, which is the level of full tide superelevation at the dam.

9.7.1.7 *Geological Features of the Areas Under Study*

- *Geomorphological Data on the Region*

The Zambeze River basin within Mozambique borders occupies approximately 137,000 km^2 area, which is the area drained by the lower course of the river and its affluents between Vila do Zumbo and its mouth.

The course in the area of Cahora Bassa is dependent upon great indentations of NNW-SSE and WNW-ESE orientation, which are conditioned by the Nhimbe and Cahora Bassa tectonic systems.

Hydrographic network in the Zambeze Basin runs through morphological areas which are highly diversified.

The erosion cycles to which the area has been subjected are in general the same as the main cycles described by L.C. King (1961)(*) for Central and Meridional Africa. These cycles are uniform in Zimbabwe, Zambia, South Africa, Angola and Mozambique.

L.C. King considers the presence of several main stripping periods, with consequent plane formation, occuring after the separation of the Gonduana Super-Continent, at the end of the Jurassic or in the beginning of the Cretaceous.

The area included by the alternatives is basically located in two erosion cycles, the Congo Cycle, for the surfaces of up to 200m in height indented mostly over sedimentary rocks of the Cretaceous and Tertiary, and The Zumbo Cycle, for an intermediate section between the coastal plane and the great plateau's area, between 200 and 500m heights.

* King L.C. - South African, Scenery. A TEXT BOOK OF GEOMORPHOLOGY - London - 1961 pg. 361 - Second Edition.

The 1:1,000,000 geological chart provides a picture of the geological formations crossed by the track alternatives (Volume 9-2 - Figure 9.2.9).

Cambulatsisse - Mucanha/Vuzi Alternative

This alternative starts at the Cambulatsisse Railway Station in a plane area where are found gabhro-amorphositic complex rocks and ultrabasic rocks up to around km 210. It is being expected for this section a strong predominance of ground excavation. Between km 202 and 209, approximately the track should intercept compressive soils areas.

The sequence gives us the presence of sandy rocks, of Karroo Formation, which prevail up to km 254, characterized by peculiar dentritic and subdentritic draining. It is believed that there will be ample predominance of soil excavation.

In order to cross the Condezi River which is conditioned to litho-structural aspects near the track, it is believed there will be rock foundation, sandstone in this case.

Near the Revuboẽ River sandstone rocks of the unspecified Karroo Formation prevail which makes it understood this river should be crossed over exposed rock on the ground, despite the various "sandybanks" evident in its lesser sections.

After crossing the Revuboẽ, this alternative follows the major Nhembia River axle through an area of schist or metasedimentary rocks, Pre-Cambrian, Fingoẽ Formation, of well developed schistosity, which influences even the standard of local draining. There will be ample predomination of soil excavation for this section, as evidenced by the presence of relatively gentle relief.

Near km 257 the track should intercept bodies of compressible soil.

This formation is present up to km 282 level.

The stretch which follows shows sedimentary rock charac teristics and ends at km 312. It is believed that there will be interceptions with some compressible soil blocks and a global pre dominance of soil.

This section will need a field geological verification be cause the charts studied shows the area as a granitoid geologi cal province whereas photointerpretation suggests a typically sedi mentary area.

Beyond the aforementioned level, the alternative is laid on an area of crystalline rock characteristics, where can be found a predominance of gently sloped ground with soil excavation prevailing.

There should not be any compressible soils along this section.

Beyond km 339, this alternative runs through an area which presents heavier geographical accidents and is mostly rocky, which there are evidence of the intense tectonism which affected the area.

Under the lithological viewpoint, the alternative cros ses a sequence of basic rocks of the Gabric type are likely rocks, granitoid complex rocks and schists or metasediments or even quartz of the Fingõe Formation, all belonging to the Pre-Cambrian Era.

Existing drainage facilities are entirely conditioned to the litho-structural regional aspects, that is, macro-failings, various bending systems such as anticlinal, sinclinal, etc. The presence of 50% rock is assumed.

This situation is practically continuous up to around 18 km at it ends, near the Mucanha River, where the track runs over sedimentary rocks of the lower Karroo Formation, with Tillite and soft rocks of the Productive series.

o Moatize - Nhancapirire Alternative

The track is to be laid over Tillical sedimentary rocks and Productive Series rocks, named after the fact that it encompasses carbonic complexes, both of them being of lower Karroo Formation.

Its morphological aspects is of gentle undulation.

After crossing the Revuboẽ River there is a predominance of sandstone rocks (grẽs) of unspecified Karroo Formation. Gentleness in relief is noticeable. Subdentritical standard draining is dense, though, with a predominance of temporary rivers. This lithological type is found up to the area of km 279. It is expected that there will be an overall predominance of soil excavation in this section.

In this sequence, the track runs along the left hand border of the Zambeze River, where there are gabbro-anortositical complex and ultra-basic rocks, evidenced by the notable differentiation of the relief, which goes sharply from gentle to slightly full of accidents of definite V-shaped Valleys of well-defined peak lines. There is a possibility that the upper heights should intercept rock.

The Zambeze River Crossing, located at km 283 should present an alluvium upper coverage for the left-hand side border, in view of the sandy accumulation presented on this border.

Leaving the right-hand border, the track intercepts a small section of sandstone sedimentary rocks of the unspecified Karroo Formation, already mentioned at an earlier point and with great likelihood of crossing compressible soil blocks around km 284.5. Soon afterwards, near km 287, the track intercepts again basic rocks and eruptive ultrabasic ones, progressing through the valley on which runs the Tete-Marara link, in an area of average relief terrain. The presence of granite-gneiss rocks is likely to occur in this section. It is expected there will be a certain amount of rock excavation.

This situation is maintained as far as the vicinity of km 309, where it can be found once more the presence of rocks of the Lower Karroo Formation, with a predominance of tillites and Carbon Complexes of the Productive Series and of sandstone of the unspecified Karroo Formation in subordinate state.

Such lithologies exist as far as the extreme end of the track, except for the section between km 394 and 396 at the right hand border of the Nhancapirire, where the track crosses the granite-gneiss rocks of the Vuzi Formation.

In the sections where the alternative crosses rocks of sedimentary formations, more susceptible to bad-weather bouts than the crystalline ones, there are peneplain reliefs where there will be a predominance of soil excavation.

The geological graphical situation of the railway sections under study is shown in the Volume 9.2 (from 9.2.10 to 9.2.25).

9.7.1.8

9.7.1.8 *Natural Construction Materials*

Photogeological analysis, added to bibliographical data studied helped to state with reasonable certainty that both alternatives are favourable as regards obtaining aggregates, such as crushing apparatus for the composition of concrete and of ballast, granular materials to be used for the sub-ballast and small aggregates to be used for the concrete, filtering layers, etc.

Following are presented, in very abridged manner, some points potentially favourable for the supply of such aggregates.

- *Cambulatsisse - Mucanha / Vuzi Alternative*

- *Quaries*

Rocks of granitoid complex located some 4 km north of Muchena, near km 446.

Granite-gneiss province near Chinta.

Other spots nearly up to the end of the section.

- *Sandpits*

Alluvium deposits on Condezi, Revuboẽ, Luia and other rivers.

- *Granular Materials*

Lateritic materials existing in the area.

Possible gravel pits from the alternative of granite-gneiss rocks.

- *Moatize - Nhancapirire Alternative*

- *Quaries*

Basic Province around km 281. Presence of Gabbro Rock, well resistive, which can be used as gravel.

Basic province around km 289 - Gabbro Rock.

Right hand border of the Nhancapirire - km 396- presence of granite-gneiss rocks of the Vuzi Formation.

- *Sandpits*

Alluvium deposits of the Zambeze (downstream from Cahora Bassa), Mufa, Nhancapirire and other rivers.

- *Granular Materials*

Bibliography studied mentions the presence of lateritic deposits in the area.

We could encourage the researches of "pebbly soils" which are likely to be present.

9.7.1.9

9.7.1.9 *Railway Investment Costs*

- *General Aspects*

In order to establish unit costs, it was set up a variable criteria, according to the difficulties of each service, specially considering the lack of skilled labour in Mozambique.

Reports from organisms which conducted former studies allowed us to gather some data on costs. There were also consultations on organisms and companies in charge of works. Material suppliers and transportation firms were also consulted, which have permitted to make up a general structure of costs.

There is a certain degree of uncertainty as regards the figures taken up, as a result of the fact that it has not been able to measure them against similar works already under progress and which could reflect the present conjuncture.

The currency reference is from the month of July, 1982, considering the exchange rate of 36 meticais/dollar.

- *Works and Services Unit Costs*

- *Earth-moving*

SERVICE	UNIT	METICAL	DOLLAR
Soil Excavation	m^3	70.00	1.94
Rock Excavation	m^3	680.00	18.89
Compaction	m^3	60.00	1.67

- *Draining*

Except for the case of platform gutters where the work is very specific, draining was taken as a percentage of earth-moving, which varies with the topography, based on that already implemented.

In order to meet the need of platform recuperation, there was a cost composition of the gutter which gave us the sum of US$ 12.40/m.

- *Sub-ballast*

Unit cost composition was done considering excavation costs of material in beds, transportation and compaction. We obtained a figure of US$ 6.76/m^3.

- *Ballast*

It have been taken the cost estimated from CFM of US$ 9.75/m^3.

- *Sleepers*

Also the estimation of the cost collected from CFM of US$ 12.80.

- *Rails*

It have been taken into consideration rails and other metal materials as coming from South Africa, as it is customary with CFM. This transported materials, coming by rail transport from Johannesburg and through Zimbabwe, to reach Umtali and Dondo. From Dondo, the distance of the gravity center on the sections studied has been taken as an average.

Based on the above criterion, the following prices were arrived at and used for the studies:

- 45 kg/m rail (12m bars) .... US$ 81,784.00/km
- Fishplate and accessories sets ..... US$ 4,035.00/km

- *Fastenings*

Pandrol fastenings, composed of plate, clip and screw-spike were taken as basis.

- for 1 754 sleepers/km .... US$ 47,324.00/km
- for 1 600 sleepers/km .... US$ 44,698.00/km

- *Track laying*

From the prices of component parts, gathered as above, we have made up the cost of laying and arrived at:

- new line construction .... US$ 196,380.00/km
- complete renovation .... US$ 200,000.00/km

For existing lines with 40 kg/m rails, the recuperation has been separated into two stages. For the first one, it projects the use of 40 kg/m rails up to the transportation of 6×10^6 tons/year, replacing it at a second stage:

- First renovation stage	US$	94,967.00/km
- Second renovation stage	US$	105,033.00/km

As a result of the variation in ballast volume and in the number of sleepers with increased transport, it has been considered a complementation of the track's superstructure during a second stage, at the unit cost of US$ 4,445.00/km.

- *Systems*

As mentioned before, in telecommunication system two possible transmission systems were considered: one by means of overhead or underground line and other by radio. For the matter of cost estimations the most expensive system was taken into consideration - overhead lines

If radio system is adopted, estimations will be:

ALTERNATIVE	ESTIMATIVE (US$ 10^3)
1.1 Mucanha / Vuzi-Cambulatsisse-Beira	4,815
1.2 Nhancapirire-Cambulatsisse-Beira	5,763
2.1 Nhancapirire-Cambulatsisse-Nacala (Through Malawi)	5,558
2.2 Nhancapirire-Cambulatsisse-Nacala (Through Zambezia)	5,212
2.3 Mucanha/Vuzi-Cambulatsisse-Nacala (Through Malawi)	5,438
2.4 Mucanha/Vuzi-Cambulatsisse-Nacala (Through Zambezia)	5,079
3.1 Nhancapirire-Tete and Moatize-Tete (to Chinde) (River navigation)	1,547
3.2 Mucanha/Vuzi-Cambulatsisse-Tete (To Chinde) (River navigation)	1,980

If overhead or underground line is adopted, considered is the total length in each alternative, besides yards, corresponding to US$ 13,735.00/km.

For the signalling system it was assumed two types of yards; shunting yards and crossing loops. Due to differences of train length it was also assumed shunting yards from 900m to 1,200m according to the alternative considered.

In cost composition to implement signalling system the following values were obtained for each patio:

- crossing loop US$ 32,000.00
- shunting yard
  - 900 m. yard US$ 62,450.00
  - 1200 m. yard US$ 72,400.00

In cases of stepwise investment in two phases, it was assumed:

1st phase - US$ 62,450.00
2st phase - US$ 9,950.00

For the Dondo to Beira section, assuming duplication it was considered the CTC needs due to foreseeable traffic. This system is estimated at US$ 12,500,000.00

- *Railway Terminal*

With the proposed location for the terminal it was estimated the quantitatives of services to be executed. Due to the terminal conception in successive stages services were added.

A better reconnaissance of the local topography will allow in the future a better location of terminal and cost reduction.

Tables 9.7.3-A to G shows aggregated railway investment estimates for each alternative and table 9.7.4 the railway terminal costs. Full details in costs are shown in Appendix II.

TABLE 9.7.3-A

AGGREGATED COSTS OF RAILWAY INVESTMENTS PER ALTERNATIVE

ROUTE 1. ALTERNATIVE 1.1

US$ 10^3 OF JUL., 82

ALTERNATIVE	LENGTH (km)	SCENARIO		
		3,000,000 tons	6,000,000 tons	10,000,000 tons
ROUTE 1 - BEIRA PORT				
Alternative 1.1 (North) *Mucanha-Cambulatsisse-Beira*				
Sections:				
1.1.1 - *Mucanha-Cambulatsisse* (N)	340	315,205	315,205	315,205
1.1.2 - *Moatize-Cateme* (N)	32	11,940	11,940	12,103
1.1.3 - *Cateme-Cambulatsisse* (R+M)	26	6,886	6,886	7,268
1.1.4 - *Cambulatsisse-Nhamalabue* (R+M)	196	51,773	51,778	54,538
1.1.5 - *Nhamalabue-Inhamitanga* (R+M)	110	17,938	17,938	30,890
1.1.6 - *Inhamitanga-Dondo* (R+M)	183	41,913	41,913	50,214
1.1.7 - *Dondo-Beira*	28	18,206	18,206	18,206
TOTAL ALTERNATIVE 1.1 - (North)	915	463,866	463,866	488,365

N = NEW LINE
M = UPGRADING
R = REHABILITATION

TABLE 9.7.3-B

AGGREGATED COSTS OF RAILWAY INVESTMENTS PER ALTERNATIVE

ROUTE 1: ALTERNATIVE 1.2

US$ 10^3 OF JUL., 82

ALTERNATIVE	LENGTH (km)	SCENARIO		
		3,000,000 tons	6,000,000 tons	10,000,000 tons
<u>ROUTE 1 -PORTO DA BEIRA</u>				
Alternative 1.2 (South) *Nhancapirire-Cambulatsisse-Beira*				
Sections:				
1.2.1 - *Nhancapirire-Moatize* (N)	151	151,235	151,235	151,235
1.2.2 - *Moatize-Cateme* (N)	32	11,940	11,940	12,103
1.2.3 - *Cateme-Cambulatsisse* (R+M)	26	6,886	6,886	7,268
1.2.4 - *Cambulatsisse-Nhamalabue* (R+M)	196	51,778	51,778	54,538
1.2.5 - *Nhamalabue-Inhamitanga* (R+M)	110	17,938	17,938	30,830
1.2.6 - *Inhamitanga-Dondo* (R+M)	183	41,913	41,913	50,214
1.2.7 - *Dondo-Beira*	28	18,206	18,206	18,206
TOTAL ALTERNATIVE 1.2 - (South)	726	299,896	299,896	299,896

9.13-C

TABLE 9.7.3-C

AGGREGATED COSTS OF RAILWAY INVESTMENTS PER ALTERNATIVE

ROUTE 2: ALTERNATIVE 2.1

US$ 10^3 OF JUL., 82

ALTERNATIVE	LENGTH (km)	SCENARIO		
		3,000,000 tons	6,000,000 tons	10,000,000 tons
ROUTE 2 - NACALA PORT				
Alternative 2.1 (South) *Via Malawi e CFM-NORTH*				
Sections:				
2.1.1 - *Nhancapirire-Moatize* (N)	151	151,235	151,235	151,235
2.1.2 *Moatize-Cateme* (N)	32	11,940	11,940	12,104
2.1.3 *Cateme-Cambulatsisse* (R+M)	26	6,886	6,886	7,268
2.1.4 *Cambulatsisse-Nkaia* (N+R+M)	202	108,935	108,935	114,615
2.1.5 *Nkaia-Entre Lagos* (M)	102	2,221	2,221	16,120
2.1.6 *Entre Lagos-Nampula* (R+M)	423	111,856	111,856	114,517
2.1.7 *Nampula-Monapo* (R+M)	126	33,555	33,555	34,199
2.1.8 *Monapo-Nacala* (R+M)	66	17,497	17,497	17,834
TOTAL ALTERNATIVE 2.1 (South)	1,128	444,125	444,125	467,892

TABLE 9.7.3-D

AGGREGATED COSTS OF RAILWAY INVESTMENTS PER ALTERNATIVE

ROUTE 2: ALTERNATIVE 2,2

US$ 10^3 OF JUL., 82

ALTERNATIVE	LENGTH (km)	SCENARIO		
		3,000,000 tons	6,000,000 tons	10,000,000 tons
ROUTE 2 - NACALA PORT				
Alternative 2.2 (South) *Via Zambezia*				
Sections:				
2.2.1 - *Nhancapirire-Moatize* (N)	151	151,235	151,235	151,235
2.2.2 - *Moatize-Cateme* (N)	32	11,940	11,940	12,104
2.2.3 - *Cateme-Cambulatsisse* (R+M)	26	6,886	6,886	7,268
2.2.4 - *Cambulatsisse-Nhamalabue* (R+M)	196	51,778	51,778	54,112
2.2.5 - *Nhamalabue-Rio Muelaiva* (N)	257	338,082	338,082	339,396
2.2.6 - *Rio Muelaiva-Muconha* (R+M)	25	6,596	6,596	7,186
2.2.7 - *Muconha-Monapo* (N)	479	291,051	291,051	293,500
2.2.8 - *Monapo-Nacala* (R+M)	66	17,497	17,497	17,834
TOTAL ALTERNATIVE 2.2 (South)	1,232	875,065	875,065	882,635

TABLE 9.7.3-E

AGGREGATED COSTS OF RAILWAY INVESTMENTS PER ALTERNATIVE

ROUTE 2: ALTERNATIVE 2.3

US$ 10^3 OF JUL., 82

ALTERNATIVE	LENGTH (km)	SCENARIO		
		3,000,000 tons	6,000,000 tons	10,000,000 tons
<u>ROUTE 2</u> - <u>NACALA PORT</u>				
Alternative 2.3 - (North) *Via Malawi e CFM North*				
Sections:				
2.3.1 - *Mucanha-Cambulatsisse* (N)	340	315,205	315,205	315,205
2.3.2 - *Moatize-Cateme* (N)	32	11,940	11,940	12,103
2.3.3 - *Cateme-Cambulatsisse* (R+M)	26	6,886	6,886	7,269
2.3.4 - *Cambulatsisse-Nkaia* (N+R+M)	202	108,935	108,935	114,615
2.3.5 - *Nkaia-Entre Lagos* (R+M)	102	2,221	2,221	16,120
2.3.6 - *Entre Lagos-Nampula* (R+M)	423	111,856	111,856	114,517
2.3.7 - *Nampula-Monapo* (R+M)	126	33,555	33,555	34,199
2.3.8 - *Monapo-Nacala* (R+M)	66	17,497	17,497	17,834
TOTAL ALTERNATIVE 2.3 (North)	1,317	608,096	608,096	631,863

9.7.3-F

TABLE 9.7.3-F AGGREGATED COSTS OF RAILWAY INVESTMENTS PER ALTERNATIVE

ROUTE 2: ALTERNATIVE 2.4

US$ 10^3 OF JUL., 82

ALTERNATIVE	LENGTH (km)	SCENARIO		
		3,000,000 tons	6,000,000 tons	10,000,000 tons
ROUTE 2 - NACALA PORT				
Alternative 2.4 (North) *Via Zambezia*				
Sections:				
2.4.1 - *Mucanha-Cambulatsisse* (N)	340	315,205	315,205	315,205
2.4.2 - *Moatize-Cateme* (N)	32	11,940	11,940	12,103
2.4.3 - *Cateme-Cambulatsisse* (R+M)	26	6,886	6,886	7,269
2.4.4 - *Cambulatsisse-Nhamalabue* (R+M)	196	51,778	51,778	54,112
2.4.5 - *Nhamalabue-Rio Muelaiva* (N)	257	338,082	338,082	339,396
2.4.6 - *Rio Muelaiva-Muconha* (R+M)	25	6,596	6,596	7,186
2.4.7 - *Mucanha-Monapo* (N)	479	291,051	291,051	293,500
2.4.8 - *Monapo-Nacala* (R+M)	66	17,497	17,497	17,835
TOTAL ALTERNATIVE 2.4 (North)	1,421	1,039,034	1,039,034	1,046,606

TABLE 9.7.3-G

AGGREGATED COSTS OF RAILWAY INVESTMENTS PER ALTERNATIVE
ROUTE 3: ALTERNATIVES 3.1 AND 3.2

US$ 10^3 OF JUL., 82

ALTERNATIVE	LENGTH (km)	SCENARIO		
		3,000,000 tons	6,000,000 tons	10,000,000 tons
ROUTE 3 - ZAMBEZE RIVER				
Alternative 3.1 - (South) *Via Reservoir Cahora Bassa*				
Sections:				
3.1.1 - *Nhancapirire-Tete* (N)	123	127,356	127,356	127,356
3.1.2 - *Moatize-Tete* (N)	29	23,195	23,195	23,343
TOTAL ALTERNATIVE 3.1 - (South)	152	150,551	150,551	150,699
Alternative 3.2 (North) *Via Cambulatsisse*				
3.2.1 - *Mucanha-Cambulatssse* (N)	340	315,205	315,205	315,205
3.2.2 - *Cambulatsisse-Cateme* (R+M)	26	6,886	6,886	7,269
3.2.3 - *Cateme-Moatize* (N)	32	11,940	11,940	12,103
3.2.4 - *Moatize-Tete* (N)	29	23,195	23,195	23,343
TOTAL ALTERNATIVE 3.2 - (North)	427	357,226	357,226	357,920

TABLE 9.7.4 ESTIMATED COSTS OF THE RAILWAY TERMINAL

SERVICE DISCRIMINATION	UNIT.	QUANTITIES	UNIT. COSTS (US$ JUL 82)	TOTAL COST (US$ JUL 82)
1st Stage: 1×10^6 t/year				
1 - EARTHWORKS				
Soil	m^3	1,107,745	1,94	2,149,025.30
Hard Material	m^3	91,110	18,89	1,721,067.90
Compaction	m^3	290,970	1,67	485,919.90
2 - TRACK WORKS				
Sub ballast	m^3	3,850	6,76	26,026.00
Track construction	km	3,18	196,380,00	624,488.40
Turnout	un	6	25,000,00	150,000.00
3 - EQUIPMENT				
Power generator	un	1	60,000,00	60,000.00
Sub total				5,216,527.50
Eventualities				782,479.12
TOTAL				5,999,006.62
2nd. Stage: 3×10^6 t/year				
1 - EARTHWORKS				
Soil	m^3	313,515	1,94	608,219.10
Hard Material	m^3	25,790	18,89	487,173.10
Compaction	m^3	82,350	1,67	137,524.50
2 - TRACK WORKS				
Sub ballast	m^3	1,090	6,76	7,368.40
Track construction	km	0,9	196,380,00	176,742.00
Turnout	un	1	25,000,00	25,000.00
3 - EQUIPMENT				
Power generator	un	1	60,000,00	60,000.00
Sub total				1,502,027.10
Eventualities				225,304.06
TOTAL				1,727,331.16

cont.

TABLE 9.7.4 ESTIMATED COSTS OF THE RAILWAY TERMINAL

cont.

SERVICE DISCRIMINATION	UNIT.	QUANTITIES	UNIT. COSTS (US$ JUL 82)	TOTAL COST (US$ JUL 82)
3rd. Stage: 6×10^6 t/year				
1 - EARTHWORKS				
Soil	m^3	763,240	1,94	1,480,685.60
Hard Material	m^3	62,780	18,89	1,185,914.20
Compaction	m^3	200,480	1,67	334,801.60
2 - TRACK WORKS				
Sub ballast	m^3	2,650	6,76	17,914.00
Track construction	km	2,2	196,380,00	432,036.00
Sub total				3,451,351.40
Eventualities				517,702.70
TOTAL				3,969,054.11

9.7.1.10

9.7.1.10 *Train Operation Studies*

General Aspects

The train operation studies in this chapter have the objective of defining the characteristics, quantities and costs of operation and maintenance for the different proposed alternatives, so as to meet the demands anticipated for the coal production of the Mucanha/Vuzi and Moatize mines complementing these demands with the other railway transportation flows. These studies cover the several sections in operation of the Northern and Central Systems of the Caminhos de Ferro de Moçambique (Mozambique Railways), as well as the new proposed lines to connect these existing lines with each other and with the Mucanha/Vuzi mines, making possible the interconnection with the Beira and Nacala ports or with the fluvial terminal of the Zambeze River, in the case of the fluvial coal outflow alternative as far as for the Chinde terminal.

The studies developed were based on the reports prepared by consultants included in the list of references, as well as on additional data collected from technical departments of the Mozambique National Direction of Ports and Railways.

The analysis of the information in the various reports showed that due to the diversity of years and objectives to which the studies were done, in a period of deep social, political and economical changes that followed the independence of Mozambique in 1975, it wouldn't be possible to achieve the same level of uniformity in detailing the reports' information and, in many cases, they are also incomparable.

In order to use the information obtained in the railway operation studies, an additional effort of actualization was required, through which it was tried to submit them to a homogeneous treatment and presentation, in order to minimize distortions in the comparison and selection of the alternatives.

This homogeneous treatment required some hypothesis to be developed concerning train operation and the introduction of simplifications, in order to maintain these studies in a level consistent with the pre-feasibility requirements. On the other hand, once enough consistent data were available, it was possible to apply a more sophisticated methodology of calculation, more than it is usually required in a pre-feasibility study, as in the case of the simulation of train operation for obtaining travel times for the different railway alternatives. (Appendix I).

The analysis has been made for eight outflow alternatives toward the ocean ports of Beira and Nacala and the river port of Tete in the Zambeze River as well, considering the several productions levels proposed for Mucanha/Vuzi and Moatize mines.

- *Analysis of the Transportation Demand*

Based on the allocation studies as anticipated in the - Study of the Traffic Demand - an analysis of the network loading was carried out taking into account the outflows of coal and general freight for each alternative and production level.

From these flows the towed gross tonnages were calculated and based on the lengths of each link, the corresponding net or gross ton x km were determined.

The results obtained for the coal, arranged in accordance with its origins, either from Mucanha/Vuzi or from Moatize, are shown in Table 9.7.5.

The tables in which the results related to coal or to general freight domestic or international, in both export or import directions, are included in Appendix I.

The tables in Appendix shows that there is a great disparity between the flows in the export and import directions and that the coal participation in total flow is much greater than that of general freight. This disparity is more conspicuous in the inland links, where the amount of general freight is unexpressive.

[redacted] TABLE 9.7.5-COA[redacted]LOW[redacted]WED[redacted]OSS [redacted]NAG[redacted]ET [redacted] GRO[redacted]TON [redacted]km. [redacted]

ROUTES / YEARS	TU (ton.x 10^3)		TB_r (ton.x 10^3)		TKU(ton.km x 10^6)		TKB_r (ton.km x 10^6)	
	MUCANHA	MOATIZE	MUCANHA	MOATIZE	MUCANHA	MOATIZE	MUCANHA	MOATIZE
ROUTE 1-Beira								
ALT.1.1-(NORTH) THROUGH CFM-C								
1986	-	1,000.0	-	1,560.0	-	575.0	-	897.0
1988	500.0	1,500.0	780.0	2,340.0	428.5	862.5	668.5	1,345.5
1990	1,000.0	2,000.0	1,560.0	3,120.0	857.0	1,150.0	1,337.0	1,794.0
1995	3,000.0	3,000.0	4,680.0	4,680.0	2,571.0	1,725.0	4,010.6	2,691.0
2000	6,000.0	4,000.0	9,360.0	6,240.0	5,142.0	2,300.0	8,021.6	3,583.0
2010	6,000.0	4,000.0	9,360.0	6,240.0	5,142.0	2,300.0	8,021.6	3,588.0
ROUTE 1-Beira								
ALT.1.2-(SOUTH) THROUGH CAHORA BASSA LAKE AND CFM-C								
1986	-	1,000.0	-	1,560.0	-	575.0	-	897.0
1988	500.0	1,500.0	780.0	2,340.0	363.0	862.5	566.2	1,345.5
1990	1,000.0	2,000.0	1,560.0	3,120.0	726.0	1,150.0	1,132.6	1,794.0
1995	3,000.0	3,000.0	4,680.0	4,680.0	2,178.0	1,725.0	3,397.4	2,691.0
2000	6,000.0	4,000.0	9,360.0	6,240.0	4,356.0	2,300.0	6,795.4	3,588.0
2010	6,000.0	4,000.0	9,360.0	6,240.0	4,356.0	2,300.0	6,795.4	3,588.0

TU = Net tons.
TB = Gross tons.
TKU= Net tons. x km
TKB= Gross ton. x km

[redacted] TABLE 9.7.5- COAL FL[redacted], G[redacted] TO[redacted]E, [redacted] AN[redacted]OSS [redacted]. x [redacted]

(continuação)

ROUTES / YEARS	TU (ton. x 10^3)		TB_r (ton.x 10^3)		TKU (ton.km x 10^6)		TKB_r (ton.km x 10^6)	
	MUCANHA	MOATIZE	MUCANHA	MOATIZE	MUCANHA	MOATIZE	MUCANHA	MOATIZE
ROUTE 2 - Nacala								
ALT.2.1-(SOUTH) THROUGH MALAWI								
1986	-	1,000.0	-	1,560.0	-	977.0	-	1,524.2
1988	500.0	1,500.0	780.0	2,340.0	629.5	1,465.5	982.0	2,286.2
1990	1,000.0	2,000.0	1,560.0	3,120.0	1,259.0	1,954.0	1,964.2	3,048.2
1995	3,000.0	3,000.0	4,680.0	4,680.0	3,777.0	2,931.0	5,892.2	4,572.4
2000	6,000.0	4,000.0	9,360.0	6,240.0	7,554.0	3,908.0	11,784.3	6,096.5
2010	6,000.0	4,000.0	9,360.0	6,240.0	7,554.0	3,908.0	11,784.3	6,096.5
ROUTE 2 - Nacala								
ALT. 2.2-(SOUTH) THROUGH ZAMBEZIA								
1986	-	1,000.0	-	1,560.0	-	1,082.0	-	1,688.0
1988	500.0	1,500.0	780.0	2,340.0	682.0	1,623.0	1,063.9	2,531.9
1990	1,000.0	2,000.0	1,560.0	3,120.0	1,364.0	2,164.0	2,128.0	3,375.8
1995	3,000.0	3,000.0	4,680.0	4,680.0	4,092.0	3,246.0	6,383.6	5,063.8
2000	6,000.0	4,000.0	9,360.0	6,240.0	8,184.0	4,328.0	12,767.1	6,751.7
2010	6,000.0	4,000.0	9,360.0	6,240.0	8,184.0	4,328.0	12,767.1	6,751.7

TU = Net tons.
TB = Gross tons.
TKU = Net tons. x km
TKB = Gross tons. x km

[redacted] TABLE 9.7.5 [redacted] – COAL FLOWS, TOWED GROSS TONNAGE, NET AND GROSS TON. x km [redacted]

(continuação)

ROUTES / YEARS	TU (ton.x 10^3)		TB_r (ton.x 10^3)		TKU(ton.km x 10^6)		TKB_r (ton.km x 10^6)	
	MUCANHA	MOATIZE	MUCANHA	MOATIZE	MUCANHA	MOATIZE	MUCANHA	MOATIZE
ROUTE 2 – Nacala								
ALT. 2.3-(NORTH) THROUGH MALAWI-CFM-NORTH								
1986	–	1,000.0	–	1,560.0	–	977.0	–	1,524.2
1988	500.0	1,500.0	780.0	2,340.0	629.5	1,465.5	982.0	2,286.2
1990	1,000.0	2,000.0	1,560.0	3,120.0	1,259.0	1,954.0	1,964.2	3,048.2
1995	3,000.0	3,000.0	4,680.0	4,680.0	3,777.0	2,931.0	5,892.2	4,572.4
2000	6,000.0	4,000.0	9,360.0	6,240.0	7,554.0	3,908.0	11,784.3	6,096.5
2010	6,000.0	4,000.0	9,360.0	6,240.0	7,554.0	3,908.0	11,784.3	6,096.5
ROUTE 2 – Nacala								
ALT.2.4-(NORTH) THROUGH ZAMZEZIA								
1986	–	1,000.0	–	1,560.0	–	1,082.0	–	1,688.0
1988	500.0	1,500.0	780.0	2,340.0	682.0	1,623.0	1,063.9	2,531.9
1990	1,000.0	2,000.0	1,560.0	3,120.0	1,364.0	2,164.0	2,128.0	3,375.8
1995	3,000.0	3,000.0	4,680.0	4,680.0	4,092.0	3,246.0	6,383.6	5,063.8
2000	6,000.0	4,000.0	9,360.0	6,240.0	8,184.0	4,328.0	12,767.1	6,751.7
2010	6,000.0	4,000.0	9,360.0	6,240.0	8,184.0	4,328.0	12,767.1	6,751.7

TU = Net tons.
TB = Gross tons.
TKU = Net tons. x km
TKB = Gross tons. x km

[redacted] TABLE 9.[redacted] - [redacted] FL[redacted] TO[redacted] GR[redacted] TON[redacted], N[redacted]ND [redacted]S [redacted] x [redacted]

(continuação)

ROUTES / YEARS	TU (ton. x 10^3)		TB_r (ton.x 10^3)		TKU (ton.km x 10^6)		TKB_r (ton.km x 10^6)	
	MUCANHA	MOATIZE	MUCANHA	MOATIZE	MUCANHA	MOATIZE	MUCANHA	MOATIZE
ROUTE 3 - Rio Zambeze								
ALT. 3.1-(SOUTH) THROUGH CAHORA BASSA LAKE								
1986	-	1,000,0	-	1,560,0	-	20,0	-	31,2
1988	500,0	1,500,0	780,0	2,340,0	65,5	30,0	102,1	46,8
1990	1,000,0	2,000,0	1,560,0	3,120,0	131,0	40,0	204,4	62,4
1995	3,000,0	3,000,0	4,680,0	4,680,0	393,0	60,0	613,0	93,6
2000	6,000,0	4,000,0	9,360,0	6,240,0	786,0	80,0	1,226,2	124,8
2010	6,000,0	4,000,0	9,360,0	6,240,0	786,0	80,0	1,226,2	124,8
ROUTE 3 - Rio Zambeze								
ALT. 3.2-(NORTH)								
1986	-	1,000,0	-	1,560,0	-	20,0	-	31,2
1988	500,0	1,500,0	780,0	2,340,0	209,0	30,0	326,0	46,8
1990	1,000,0	2,000,0	1,560,0	3,120,0	418,0	40,0	652,0	62,4
1995	3,000,0	3,000,0	4,680,0	4,680,0	1,254,0	60,0	1,956,2	93,6
2000	6,000,0	4,000,0	9,360,0	6,240,0	2,508,0	80,0	3,912,4	124,8
2010	6,000,0	4,000,0	9,360,0	6,240,0	2,508,0	80,0	3,912,4	124,8

TU = Net tons.
TB = Gross tons.
TKU = Net tons, x km
TKB = Gross tons. x km

Table 9.7.6 shows the gross traffic densities for coal and general freight, on the basis of which the participation of the coal relative to the total flows was calculated for each alternative and production level.

Basic Hypothesis

From the hypothesis on railway operation found in the reports included in the list of references, and from the analysis of the information obtained from the Mozambique Railways, a set of basic hypothesis was stablished in order to discipline and guide the development of the preliminary design of the new lines, the establishment of improvements for the existing sections and the operational characteristics for each alternative route, with the objective of assessing operating costs.

First it was sought to identify the characteristics of the existing system and its deficiencies, as well as to peruse governmental programs of railroad rehabilitation and improvement for, based on these considerations, start formulating new physical and operational requirements which would be introduced gradually to meet future coal flows. It was taken for granted, in general, that the railways will operate efficiently after these requirements and other complementary measures are implemented.

For the study of new lines the following conditions were established:

- Compensated maximum grade of 1.25% in both directions;
- Minimum radius of 300 m;
- Maximum axle load of 20 tons;
- Maximum speed of 60 km/h for coal train, either loaded or unloaded;
- Distance of about 20 km between crossings;

TABLE 9.7.6 - TRAFFIC GROSS DENSITY

– COAL –

(Towed Gross Tonnage x 10^3)

ITENS / ALTERNATIVES	1986			1988			1990			1995			2000			2010		
	COAL	GENERAL FREIGHT	COAL %	COAL	GENERAL FREIGHT	COAL %	COAL	GENERAL FREIGHT	COAL %	COAL	GENERAL FREIGHT	COAL %	COAL	GENERAL FREIGHT	COAL %	COAL	GENERAL FREIGHT	COAL %
1.1	1,559.7	2,385.2	40	2,201.1	2,597.7	46	3,421.9	2,435.0	58	7,324.2	3,003.3	71	12,688.1	3,673.8	78	12,688.1	5,489.1	70
1.2	1,559.7	2,385.2	40	2,633.2	2,597.7	50	4,031.1	2,907.4	58	8,386.2	3,588.7	70	14,302.2	4,391.5	77	14,302.2	6,804.1	68
2.1	1,560.1	776.0	67	2,806.6	889.0	76	4,262.4	1,084.0	80	8,733.5	1,482.2	85	14,764.7	2,072.1	88	14,764.7	4,268.4	78
2.2	1,560.1	552.4	74	2,833.3	600.4	83	4,298.0	791.8	84	8,786.9	973.4	90	14,835.8	1,199.3	93	14,835.8	1,832.9	89
2.3	1,560.1	768.5	67	2,481.5	880.8	74	3,805.9	1,021.3	79	7,945.8	1,377.7	85	13,576.9	1,906.5	88	13,576.9	3,850.7	78
2.4	1,560.1	552.4	74	2,528.7	600.4	81	3,870.5	769.0	83	8,050.2	954.4	89	13,726.3	1,161.9	92	13,726.3	1,769.8	89
3.1	1,560.0	–	100	986.1	–	100	1,766.9	665.6	75	4,679.5	809.9	85	8,947.0	985.5	90	8,947.0	1,458.8	86
3.2	1,560.0	–	100	891.9	–	100	1,709.1	666.2	72	4,903.8	810.3	86	9,658.4	985.6	91	9,658.4	1,459.1	87

- Length of the crossing sidings, at the beginning of the operation, equivalent to that required by a single-traction train for transporting as much as 3 million tons/year of coal;
- Gradual enlargement of the crossings length in order to permit double and triple traction trains to transport as much as 6 to 10 million tons/year of coal;
- Opening of 1:12 for the turnouts from the main line to the crossings.

As to the existing sections, it was assumed that they would meet the following basic requirements:

- Infrastructure entirely rehabilitated, with an efficient drainage system and bridges for as much as 20tons./axle;
- Superstructure rehabilitated and improved, with long welded tracks weighing 45 kg/m each, and elastic rail fastenings, as well as crossties and ballast compatible with the expected demand (up to 20 tons./axle);
- New turnouts from the main line to the crossing sidings, with a minimum opening of 1:12;
- Maximum speed of 60 km/h for coal trains either loaded or unloaded on sections of good geometric characteristics.

As for the Beira route, it was anticipated that the section Beira-Dondo would be entirely duplicated by 1990 and thus would not cause any bottleneck to the transportation of coal. As to the route Entre Lagos-Nacala, it was foreseen that the rehabilitation program to be started in 1983 would be fully completed by 1988.

Regarding the train operation as a whole, besides the conditions described above the following hypothesis were established:

- From the mines to the port, unit trains formed by the same type of wagons will be used and the wagons will return unloaded with the same locos. The locomotives and wagons rolling stocks will be specialized and used solely for coal transport.

- In the selection of the trains, taken into consideration is the maxi mum use of the locos tractive efforts, as well as the minimization of investments in rolling stocks and maximum fuel saving.
- For the circulation of trains, moderate speeds were adopted. The times for stops at intermediate crossings, and changing of crews will be reduced to a minimum.
- The number of days of operation per year will be of 320 days, with constant traffic all over the year.
- After unloading the coal at the port, the locomotives will return towing the same group of cars. When double or triple traction is needed to tow the loaded cars from the mines to the port, only one locomotive will be used in the return trip to tow the empty cars and the other inactive locomotives.
- For the composition of the coal train the gradual introduction of double and triple traction according to demand volumes will be considered, having in view the need to maintain this number of trains within the limits consistent with the capacity of the routes and with the frequency of the other trains of goods and passengers.
- For simulating all coal transportation alternatives a 3000/2700 HP diesel-electric locomotive was adopted, which has a maximum of 120 tons Co-Co type, tractive effort of 252 kgf at a minimum continuous speed of 20 km/h and maximum of 90 km/h.
- Likewise, in the simulations of all alternatives only one type of railroad car was adopted for the transportation of coal. This car has the following characteristics: steel open-hopper with unloading door at the botton, total weight of 80 tons, distance of 15 m between couplings, net load/tara ratio of 3.6 (net load of 62.6 tons and tara of 17.4 tons).
- The priorities for the circulation of trains will be the follow ing, in this order:

passenger trains

trains loaded with petroleum by-products

trains loaded with international freight

trains loaded with coal

empty coal trains

other trains loaded and unloaded.

- It was assumed that the total waiting time of trains at the terminals, either for loading or unloading, should not exceed 3 hours. It was also assumed that the terminals will have the means to perform all operations in optimized period of time.
- Due to the assumption of unit trains, no arrangements were made for train shuntings at the terminals, nor for trains remaking along the route. This 3 hours period would include the times required for inspecting cars, removing defective cars, fuelling and daily maintenance of locomotives.

Turn-round Times of Locomotives and Wagons

Based on the Basic Hypothesis for the railroad transportation of coal, an optimum regularity of traffic during the year was assumed, as well as that both loaded and unloaded trains would circulate at moderate speeds.

Although the characteristics of a prefeasibility study defined for the coal transportation study would not require detailed simulations for determining the travel times and speeds of train operations, the simulation of train operation were carried out for each alternative in order to obtain travel time and speeds.

The plani-altimetrics profiles of the new lines in each alternative were used in simulations. In case of those lines in operation, the profiles of the CFM-N and CFM-C systems of the Mozambique Railways were used. From the 1180 km of railway actualy in operation, only the Beira-Dondo (28 km) in CFM-C and Ribauê-Riane (60 km) in CFM-N was left out from simulation due to the lack of available profiles so as the running time of the convoy in those links has been estimated in an average speed basis. For the existing section within the Malawi territory the travel times and speeds were estimated on the basis of studies reported by Consultants included in the list of references since the profiles for this section were not available.

The travel time results for each alternative route plus the waiting times at intermediate patios and at loading and unloading terminals are shown in Table 9.7.7 - Travel Times and Turn-round Times of Locomotives and Wagons. Since the locomotives do the return trip with the same cars, their turn-round times are the same for each alternative.

An additional 6 hours in every direction was added to the travel times to compensate for stops at intermediate crossings, crew changing , and other events. Due to their small length , this addition of time for the alternatives 3.1 (Southern) through Cahora Bassa Reservoir and 3.2 (Northern) through Cambulatsisse in the route 3 - Zambeze River was of 0,5 and 1,5 hours, respectivelly.

For the alternatives via Malawi an additional time of 8 hours was introduced in the round trips, to compensate for stops at international borders and time of circulation within that neighboring country.

As mentioned above, manoeuvers of decomposition and composition of trains are not expected to occur at the terminals, due to the adoption of unit trains. However, it was admitted that the 3 hours period for loading and unloading would also include operations for inspection of cars, end-of-trip maintenance and locomotive fuelling.

c. Trains Selected for Transporting Coal

For the selection of trains for the transportation of coal the movement of trains was simulated, thus permitting critical section to be analyzed in terms of traction and gross weights of compositions to be established for round-trips.

9.7.7 Vai mudar ?

TABLE 7.7 - TIME ON ROUTE AND TURNOVER OF LOCOS AND WAGONS

(hours)

ALTERNATIVES	GOING				RETURNING				TURNOVER	
	TIME ON ROUTE		TOTAL TRAVEL TIME		TIME ON ROUTE		TOTAL TRAVEL TIME			
ROUTE 1 - PORT OF BEIRA	M/V	MO	M/V	MO	M/V	MO	M/V	MO	M/V	MO
- Alternative 1.1: (North) Mucanha - Cambuslatsisse - Beira	20.0	12,8	26.0	18,8	16.1	10.6	26.0	18.8	58.0	43.6
. SECTION										
1.1.1-Mucanha - Cambulatsisse	8,7	-			6.6	-				
1.1.2-Moatize - Cateme	-	0,9			-	0,6				
1.1.3-Cateme - Cambulatsisse	-	0.6			-	0.5				
1.1.4-Cambulatsisse - Nhamalábuè	4,0	4.0			3,5	3,5				
1.1.5-Nhamalábuè - Inhamitanga	2.6	2.6			2.1	2.1				
1.1.6-Inhamitanga - Dondo	4.1	4.1			3.3	3,3				
1.1.7-Dondo - Beira	0,6	0,6			0,6	0,6				
- Alternative 1.2: (South) Nhancapirire - Cambuslatsisse - Beira	16,1	12,8	22.1	18.8	13,6	10.6	22.1	18.8	50.2	43.6
. SECTION										
1.2.1-Nhancapirire - Moatize	3,3	-			3,0	-				
1.2.2-Moatize - Cateme	0,9	0,9			0,6	0.6				
1.2.3-Cateme - Cambulatsisse	0,6	0,6			0,5	0,5				
1.2.4-Cambulatsisse - Nhamalábuè	4,0	4,0			3,5	3,5				
1.2.5-Nhamalábuè - Inhamitanga	2,6	2.6			2,1	2,1				
1.2.6-Inhamitanga - Dondo	4.1	4,1			3,3	3,3				
1.2.7-Dondo - Beira	0,6	0.6			0,6	0.6				
ROUTE 2 - PORT OF NACALA										
- Alternative 2.1 - (South) through Malawi e CFM-North	30,1	26.8	44.1	40.8	27.4	24.4	44,1	40.8	94.2	87.6
. SECTION										
2.1.1-Nhancapirire - Moatize	3.3	-			3.0	-				
2.1.2-Moatize - Cateme	0.9	0,9			0.6	0,6				
2.1.3-Cateme - Cambulatsisse	0,6	0,6			0.5	0,5				
2.1.4-Cambulatsisse - Nkaia	4.3	4,3			3.7	3.7				
2.1.5-Nkaia-Entre Lagos	3.5	3,5			3.0	3.0				
2.1.6-Entre Lagos - Nampula	13.4	13.4			13.1	13.1				
2.1.7-Nampula - Nacala	4.1	4.1			3.5	3.5				
- Alternative 2.2 - (South) through Zambezia	28.0	24.7	34.0	30.7	25.4	22.4	34.0	30.7	74.0	67.4
. SECTION										
2.2.1-Nhamcapirire - Moatize	3,3	-			3.0	-				
2.2.2-Moatize - Cateme	0,9	0.9			0.6	0.6				
2.2.3-Cateme - Cambulatsisse	0,6	0,6			0.5	0,5				
2.2.4-Cambulatsisse - Nhamalábuè	4.0	4.0			3,5	3,5				
2.2.5-Nhamalábuè - Rio Muelaíva	5.5	5.5			4,9	4.9				
2.2.6-Rio Mulaiva-Muconha	0.5	0.5			0.4	0.4				
2.2.7-Muconha - Monapo	11.3	11.3			10,3	10,3				
2.2.8-Monapo - Nacala	1.9	1.9			2,2	2,2				

9.7.7 Vai mudar?

TABLE 7.7 - TIME ON ROUTE AND TURNOVER OF LOCOS AND WAGONS

(Continuation)

(hours)

ALTERNATIVES	GOING				RETURNING				TURNOVER	
	TIME ON ROUTE		TOTAL TRAVEL TIME		TIME ON ROUTE		TOTAL TRAVEL TIME			
	M/V	MO	M/V	MO	M/V	MO	M/V	MO	M/V	MO
- Alternative 2.3 - (North) through Malawi e CFM	34.0	26.8	48.0	40.8	29.9	24.4	48.0	40.8	102.0	87.6
. SECTION Vuzi										
2.3.1-Mucanha - Cambulatsisse	8.7	-			6.6	-				
2.3.2-Moatize - Cateme	-	0.9			-	0.6				
2.3.3-Cateme - Cambulatsisse	-	0.6				0.5				
2.3.4-Cambulatsisse - Nkaia	4.3	4.3			3.7	3.7				
2.3.5-Nkaia - Entre Lagos	3.5	3.5			3.0	3.0				
2.3.6-Entre Lagos - Nampula	13.4	13.4			13.1	13.1				
2.3.7-Nampula - Nacala	4.1	4.1			3.5	3.5				
- Alternative 2.4 (North) through Zambezia	31.9	24.7	37.9	30.7	27.9	23.5	37.9	30.7	81.8	67.4
. SECTION Vuzi										
2.4.1-Mucanha - Cambulatsisse	8.7	-			6.6	-				
2.4.2-Moatize - Cateme	-	0.9			-	0.6				
2.4.3-Cateme - Cambulatsisse	-	0.6			-	0.5				
2.4.4-Cambulatsisse - Nhamalábuè	4.0	4.0			3.5	4.0				
2.4.5-Nhamalábuè - Rio Muelaiva	5.5	5.5			4.9	5.5				
2.4.6-Rio Muelaiva - Muconha	0.5	0.5			0.4	0.4				
2.4.7-Muconha - Monapo	11.3	11.3			10.3	10.3				
2.4.8-Monapo - Nacala	1.9	1.9			2.2	2.2				
● ROUTE 3 - ZAMBEZE RIVER										
- Alternative 3.1 - (South) through Lake Cahora Bassa	3.0	0.3	3.5	0.3	2.7	0.3	3.5	0.3	13.0	6.6
. SECTION										
3.1.1-Nhancapirire - Tete	3.0	-			2.7	-				
3.1.2-Moatize - Tete	-	0.3			-	0.3				
- Alternative 3.2-(North) through Cambulatsisse	10.5	0.3	12.0	0.3	8.0	0.3	12.0	0.3	30.0	6.6
SECTION Vuzi										
3.2.1-Mucanha - Cambulatsisse	8.7	-			6.6	-				
3.2.2-Cambulatsisse - Cateme	0.6	-			0.5	-				
3.2.3-Cateme - Moatize	0.9	-			0.6	-				
3.2.4-Moatize - Tete	0.3	0.3			0.3	0.3				

M/V = MUCANHA/VUZI

MO = MOATIZE

The selected trains will be homogeneous, having the same type of wagons and the same type of freight(coal), so as mixed train or trains with different types of freight,or trains with some cars loaded and others unloaded are excluded. The trains will be unit trains from the mines to the port and will leave the point of origin already complete and will continue with the same formation up to the destination and then will return unloaded also with the same formation.

The predicted demand levels are to be met by the operation of single, double and triple-traction trains, which will be introduced gradually as the total number of trains and flows of coal and other goods get closer to the maximum capacity of the line. The trains of multiple traction will be divided in modules as specified in Table 9.7.8.

The trains selected for the transportation of coal in each alternative and level of production are shown in Table 9.7.9.

The used equations in dimensioning the trains were:

NORMAL RESISTANCES

They have the following itens:

- air resistance
- bearing flange resistances
- resistances due to oscilation

The normal resistance (R_N) is based on Davis formula modified for locos and wagons:

$$R'_N = 0.3 + \frac{9.072}{P} + 0.00311 + \frac{0.01226\ v^2}{P.n} \text{(metric system)}.$$

Being:

R'_N = normal resistance in kgf/ton.

P = weight per axle in tons.

9.7.8

TABLE 9.7.8-TRAIN - MODULE LOAD (SIMPLE TRACTION) AND WAGONS BY TRAIN

ALTERNATIVES	DIRECTION											
	EXPORT						IMPORT					
	COAL			GENERAL FREIGHT			COAL			GENERAL FREIGHT		
	GROSS LOAD tons	NET LOAD tons	WOAGONS PER TRAIN	GROSS LOAD tons	NET LOAD tons	WAGONS PER TRAIN	GROSS LOAD tons	NET LOAD tons	WAGONS PER TRAIN	GROSS LOAD tons	NET LOAD tons	WAGONS PER TRAIN
1.1	1840	1440	23	1440	1080	27	400	–	23	1500	1120	28
1.2	1840	1440	23	1440	1080	27	400	–	23	1500	1120	28
2.1	1200	940	15	980	720	18	260	–	15	950	720	18
2.2	1840	1440	23	1170	880	22	400	–	23	1150	840	21
2.3	1200	940	15	980	720	18	260	–	15	950	720	18
2.4	1840	1440	23	1170	880	22	400	–	23	1150	840	21
3.1	1680	1315	21	1470	1080	27	365	–	21	1470	1080	27
3.2	1680	1315	21	1470	1080	27	365	–	21	1470	1080	27

TABLE 7.9 - CAPACITY OF TRANSPORT AND TRAINS NEEDED

ALTERNATIVES/SECTIONS	CRITICAL SECTION		FREIGHT TRAIN CAPACITY IN EACH DIRECTION	TRAINS NEEDED 1988			TRAINS NEEDED 1990			TRAINS NEEDED 1995			TRAINS NEEDED 2000			TRAINS NEEDED 2010		
	SUB-SECTION	HEADWAY (t_i+t_v)+5 (min)		COAL	GENERAL CARGO	AVAILABLE CAPACITY	COAL	GENERAL CARGO	AVAILABLE CAPACITY	COAL	GENERAL CARGO	AVAILABLE CAPACITY	COAL	GENERAL CARGO	AVAILABLE CAPACITY	COAL	GENERAL CARGO	AVAILABLE CAPACITY
ROUTE 1-PORT OF BEIRA																		
Alternative 1.1: (North) Mucanha-Cambulatsisse - Beira SECTION																		
1.1.1-Mucanha-Cambulatsisse	P.08-P.09	73.8	12.0	1.1	-	10.9	2.2	0.9	8.9	6.5	1.1	4.4	6.5*	1.3	4,2	6.5*	1.9	3.6
1.1.2-Moatize-Cateme	P.01-Cateme	65.6	13.8	3.3	2,2	8.3	4.3	2,4	7.1	6.5	2,9	4,4	8,7	3.5	1,6	8.7	5.2	0
1.1.3-Cateme-Cambulatsisse	-	68.0	13.2	3.3	2,2	7.7	4.3	2.4	6.5	6.5	2,9	3.8	8.7	3.5	1.0	8.7	5.2	0
1.1.4-Cambulatsisse-Nhumalábuè	Sinjal-Chavundira	69.0	13.0	4.4	2.2	6.4	6.5	3,3	3.2	6.5*	4.0	2.5	7.2**	4,8	1,0	7.2**	3.6*	2.2
1.1.5-Nhumalábuè - Inhamitanga	Nangue-Lavos	65.0	14.0	4.4	5.1	4.5	6.5	6.4	1.1	6.5*	4.0*	3,5	7,2**	4,9*	1,9	7.2**	4.9**	1.9
1.1.6-Inhamitanga - Dondo	Mazamba-Cundúe	69.0	13,0	4.4	4.3	4.3	6.5	5.5	1.0	6.5*	3.4*	3.1	7,2**	4,2*	1,6	7.2**	4.3**	1.5
1.1.7-Dondo-Beira	-	73.0	≅30.0	4,4	4,1	≅21,5	6.5	5.3	≅18,2	6.5*	6.6	16,9	7.2**	8,0	≅14.8	7.2**	12.6	≅10.2
Alternative 1.2: (South) Nhancapirire-Cambuslarsisse-Beira SECTION																		
1.2.1-Nhancapirire-Moatize	Nhancapirire-P.007	69.7	12,9	1.1	-	11.8	2,2	0.9	9.8	6.5	1.1	5.3	6,5*	1.3	5.1	6.5*	1,9	4.5
1.2.2-Moatize-Cateme	P.01-Cateme	65.6	13.8	4.4	2,2	7,2	6.5	3.3	4.0	6,5*	4.0	3.3	7,2**	4.8	1.8	7.2**	3.6*	3.0
1.2.3-Cateme-Cambulatsisse	-	68.0	13,2	4.4	2.2	6.6	6.5	3.3	3.4	6,5*	4,0	2.7	7.2**	4,8	1.2	7,2**	3.6*	2.4
1.2.4-Cambulatsisse-Nhamalábuè	Sinjal-Chavundira	69.0	13,0	4.4	2.2	6.4	6.5	3.3	3.2	6,5*	4.0	2,5	7,2**	4.8	1.0	7,2**	3,6*	2.2
1.2.5-Nhamalábuè-Inhamitanga	Nangue - Lavos	65.0	14.0	4.4	5.1	4.5	6,5	6,4	1,1	6,5*	4.0*	3,5	7.2**	4,9*	1.9	7.2**	4.9**	1.9
1.2.6-Inhamitanga-Dondo	Mazamba-Cundue	69.0	13.0	4.4	4.3	4.3	6,5	5.5	1,0	6.5*	3.4*	3.1	7.2**	4,2*	1.6	7.2**	4,3**	1.5
1.2.7-Dondo-Beira	-	73.0	≅30.0	4.4	4.1	≅21.5	6.5	5.3	≅18,2	6.5*	6.7	≅16.8	7.2**	8.1	≅14.7	7.2**	12.6	≅10,2
ROUTE 2 - PORT OF NACALA																		
-Alternative 2.1-(South) through Malawi e CFM- North SECTION																		
2.1.1-Nhancapirire-Moatize	Nhancapirire-P.007	69,7	12.9	1.7	-	11,2	3.3	1.3	8.3	10.0	1.6	1.3	10,0*	1,9	1,0	10.0*	1.5*	1,4
2.1.2-Moatize-Cateme	P.01-Cateme	65,6	13.8	6.6	3.3	3,9	5.0*	4.9	3.9	6.6**	3.0*	4.2	11.1**	2.4**	0,3	11.1**	3.6**	0
2.1.3-Cateme-Cambulatsisse	-	68,0	13.2	6.6	3.3	3.3	5,0*	4.9	3,3	6.6**	3.0*	3.6	11.1**	2.4**	0	11.1**	3.6**	0
2.1.4-Cambulatsisse-Nkaia	Loop. 7-Station 6	52.6	17.7	6.6	0.3	10.8	5.0*	0.3	12.4	6,6**	0.4	10.7	11.1**	0.7	5.9	11.1**	0.7	5.9
2.1.5-Nkaia-Entre Lagos	Kwitanda-Liwonde	90.0	9.5	6.6	3.8	-	5.0*	4,2	9.8	6.6**	5.1	7.3	11.1**	6.0	1.9	11.1**	4.5*	3,4
2.1.6-Entre Lagoas-Nampula	Ribaue-Iapala	139.0	5.5	6.6	1.0	-	5,0*	1,0	5.0	6,6**	1,2	3.2	11.1**	1.5	-	11.1**	2.4	8.5
2.1.7-Nampula-Nacala	Metocheria-Monapo	63,2	14.4	6.6	0.9	6,9	5.0*	1.0	8.4	6.6**	1.2	6.6	11.1**	1.4	1,9	11.1**	2,1	1.2
-Alternative 2.2 - (South) through Zambezia SECTION																		
2.2.1-Nhancapirire-Moatize	Nhancapirire-P.007	69.7	12.9	1.1	-	11,8	2,2	1,1	9,6	6.5	1.3	5.1	6,5*	1,6	4.8	6.5*	2.3	4.1
2.2.2-Moatize-Cateme	P.01-Cateme	65.6	13.8	4.4	2.7	6.7	6.5	4,0	3,3	6.5*	4.9	2.4	10.8*	3,0*	0	10.8*	4.4*	0
2.2.3-Cateme-Cambulatsisse	-	68.0	13.2	4.4	2.7	6.1	6,5	4.0	2,7	6,5*	4.9	1.8	10.8*	3.0*	0	10.8*	4.4*	0
2.2.4-Cambulatsisse-Nhamalábuè	Sinjal-Chavundira	69.0	13.0	4.4	2.7	5.9	6.5	4,0	2,5	6.5*	4.9	1.6	10.8*	3,0*	-	10.8*	8.8	6,4
2.2.5-Nhamlábuè-Rio Muelaiva	P.038-P.039	61.2	14,9	4.4	0.5	10.0	6.5	0,5	7,9	6.5*	0,6	7.8	10,8*	0.7	3.4	10.8*	1.1	3,0
2.2.6-Rio Muelaiva-Muconha	-	59.0	15.6	4,4	0.5	10.7	6,5	0.5	8.6	6.5*	0.7	8.4	10.8*	0.8	4.0	10.8*	1,2	3.6
2.2.7-Muconha-Monapo	P.013-P.014	65.7	13.8	4.4	0.4	9.0	6,5	0.5	6,8	6.5*	0.6	6.7	10,8*	0.7	2.3	10.8*	1.0	2.0
2.2.8-Monapo-Nacala	Namarral-Serra da Mesa	56.5	16.4	4.4	0.7	11,3	6.5	0.7	9.2	6.5*	0.9	9.0	10,8*	1.1	4.5	10,8*	1,6	4.0

TABLE 7.9 - CAPACITY OF TRANSPORT AND TRAINS NEEDED

Continuation

ALTERNATIVES/SECTIONS	CRITICAL SECTION: SUB-SECTION	CRITICAL SECTION: HEADWAY (t_r+t_v) +5 (min)	FREIGH TRAIN CAPACITY IN EACH DIRECTION	TRAINS NEEDED 1988: COAL	1988: GENERAL CARGO	1988: AVALIABLE CAPACITY	TRAINS NEEDED 1990: COAL	1990: GENERAL CARGO	1990: AVALIABLE CAPACITY	TRAINS NEEDED 1995: COAL	1995: GENERAL CARGO	1995: AVALIABLE CAPACITY	TRAINS NEEDED 2000: COAL	2000: GENERAL CARGO	2000: AVALIABLE CAPACITY	TRAINS NEEDED 2010: COAL	2010: GENERAL CARGO	2010: AVALIABLE CAPACITY
-Alternative 2.3-(North) through Malawi e CFM																		
SECTION																		
2.3.1-Mucanha-Cambulatsisse	P.08-P.09	73.8	12.0	1.7	-	10.3	3.3	1,3	7.4	5.0*	1,6	5.4	10,0*	1,0*	1.0	10.0*	1.5*	0.5
2.3.2-Moatize-Cateme	P.01-Cateme	65.6	13.8	4,9	3,3	5.6	6.6	3.6	3.6	5.0*	4,4	4,4	6,7*	5,3	1.8	6.7*	4.0*	3.1
2.3.3-Cateme-Cambulatsisse	-	68.0	13.2	4.9	3.3	5.0	6.6	3.6	3.0	5.0*	4.4	3,8	6.7*	5,3	1.2	6.7*	4.0*	2.5
2.3.4-Cambulatsisse-Nkaia	Loop.7-Station.6	52.6	17.7	6.6	0.3	10.8	5.0*	0,3	12,4	10.0*	0,4	7.3	11.1**	0,5	6.1	11.1**	0,7	5.9
2.3.5-Nkaia-Entre Lagos	Kwitanda-Liwonde	90.0	9.5	6.6	3.8	-	5,0*	4,2	9,8	10.0*	5,1	3,9	11,1**	6,0	1.9	11.1**	4.5*	3.4
2.3.6-Entre Lagos-Nampula	Ribaue-Iapala	139.0	5.5	6.6	1.0	-	5,0*	1,0	5,0	10.0*	1.2	0	11.1**	1,5	-	11.1**	2.4	8.5
2.3.7-Nampula-Nacala	Metocheria Monapo	63.2	14.5	6.6	0,9	7,0	5.0*	1.0	8,5	10,0*	1.2	3.3	11.1**	1,4	2,0	11.1**	2.1	1.3
-Alternative 2.4 (North) through Zambezia																		
SECTION																		
2.4.1-Mucanha-Cambulatsisse	P.08-P.09	73.8	12.0	1.1	-	10.9	2.2	1.1	8.7	6.5	1.3	4,2	6.5*	1.6	3.9	6.5*	2.3	3.2
2.4.2-Moatize-Cateme	P.01-Cateme	65.6	13.8	3,3	2.7	7.8	4.3	2.9	6.6	6.5	3.6	3,7	4,3*	4.4	5,1	4.4*	6,4	3.0
2.4.3-Cateme-Cambulatsisse	-	68.0	13.2	3,3	2.7	7,2	4.3	2.9	6.0	6,5	3.6	3.1	4.3*	4,4	4.5	4.4*	6,4	2.4
2.4.4-Cambulatsisse-Nhamalábuè	Sinjal-Chavundira	69.0	13.0	4,4	2.7	5.9	6.5	4.0	2.5	6.5*	4.9	1.6	10,8*	6.0	-	10.9*	8,8	6.3
2.4.5-Nhamalábuè-Rio Muelaiva	P.038-P.039	61.2	14.9	4.4	0.5	10,0	6.5	0.5	7.9	6.5*	0.6	7.8	10.8*	0,7	3.4	10.9*	1.1	2.9
2.4.6-Rio Muelaiva-Muconha	-	59.0	15.6	4.4	0.5	10,7	6.5	0.5	8.6	6,5*	0,7	8.4	10.8*	0.8	4.0	10.9*	1.2	3.5
2.4.7-Muconha-Monapo	P.013-P.014	65.7	13.8	4.4	0,4	9.0	6.5	0.5	6.8	6,5*	0.6	6.7	10.8*	0.7	2.3	10.9*	1.1	1.8
2.4.8-Monapo-Nacala	Namarral-Serra da Mesa	56.5	16.4	4.4	0.7	11,3	6.5	0.7	9.2	6.5*	0.9	9.0	10.8*	1.1	4.5	10,9*	1.6	3.3
ROUTE 3 - RIO ZAMBEZE																		
-Alternative 3.2-(South) through Lake Cahora Bassa																		
SECTION																		
3.1.1-Nhancapirire-Tete	Nhancapirire-P.007	69.7	12.9	1.2	-	11.7	2,4	0,9	9.6	7.1	1.1	4.7	7.1*	1.3	4,5	7.1*	1.9	3.9
3.1.2-Moatize-Tete	-	38.9	24,7	3.6	-	21.1	4.7	-	20.0	7.1	-	17.6	9.6	-	15,1	9,5	-	15.2
Alternative 3.2-(North) through Cambulatsisse																		
SECTION																		
3.2.1-Mucanha-Cambulatsisse	P.08-P.09	73.8	12.0	1,2	-	10.8	2,4	0,9	8.7	7,1	1.1	3.8	7,1*	1,3	3.6	7.1*	1.9	3,0
3.2.2-Cambulatsisse-Cateme	-	68.0	13.2	1.2	-	12,0	2.4	-	10.8	7.1	-	6.1	7,1*	-	6.1	7.1*	-	6.1
3.2.3-Cateme-Moatize	Cateme-P.01	65.6	13.8	1.2	-	12.6	2,4	-	11.4	7.1	-	6,7	7,1*	-	6,7	7.1*	-	6.7
3.2.4-Moatize-Tete	-	38.9	24.7	4.8	-	19.9	7,1	-	17.6	14.2	-	10,5	11,9*	-	12.8	11,9*	-	12.8

* Double traction

** Triple traction

-- Insuficient capacity to be overcomed with the construction of a new crossing loop

n = number of axles

v = speed in km/hour

Resistance coefficient from Davis formula for the adopted rolling stock:

- Locos

P_L = Loco's weight = 120 tons.

P = axle load = $\frac{120}{6}$ = 20 tons.

n = number of axle = 6

$$R'_N = 0.75360 + 0.00311 . v + 0.0001022 . v^2$$

v = speed in km/hour.

- Loaded Wagons

P_V = wagon weight = 80 tons.

n = number of axle = 4

P = axle load = $\frac{80 \text{ tons}}{4}$ = 20 tons.

$$R'_{N_{vc}} = 0.7536 + 0.00311\ v + 0.000153\ v^2$$

v = speed in km/hour

- Unloaded Wagons

Empty weight (tare) = 17.4 tons.

n = number of axles = 4

P = axle load = $\frac{17.4}{4}$ tons. = 4.35 tons.

$$R'_{N_{V_V}} = 2.38552 + 0.00311\ v + 0.0007\ v^2$$

v = speed in km/hour

- GREIDE RESISTANCE - (Rg)

$R'_{(g)} = 10.i$ (kg.f/tons.)

Being:

i = grade in %

- CURVE RESISTANCE - (R_c)

Locos:

$$R'_{C_L} = 0.3 + \frac{100}{R} \quad (P + b + 3.8)$$

Being

P = rigid base of the bogie in meters

b = gauge = 1.067

R = minimun radius in meters

Wagons:

$$R'_{C_V} = \frac{500.b}{R}$$

Being:

b = gauge = 1.067 m.

R = minimun radius in meters.

- TRACTOR EFFORTS

On Departure.

$$F = P_L \times f_o$$

Being:

F = departure tractor effort (kgf)

P_L = Loco's weight in kg

f_o = adherence coefficient on departure (0.25)

In movement:

It was gotten in the graphic TRACTOR EFFORT x SPEED in which branch the curve has the following equations:

ADHERENCE ZONES (between o and 20 km/hour speed)

$$E_t = -8.639\ v + 300$$

Being:

v = speed in m/s

E_t = tractor effort correspondence in tons.f/10

From a 20 km/hour speed (minimun continuous speed)

$$E_t . v = 1400.12$$

Being:

v = speed in m/s

E_t = tractor effort correspondence in tons.f/10

- NET TRACTOR EFFORT: available in the loco's coupling

$$E_{t_u} = E_t - P_L . R'_{T_L}$$

Being

E_{t_u} = net tractor effort in kgf

E_t = tractor effort in the loco's wheel (obttained in the tractor effort x speed curve) in kgf.

P_L = Loco's weight in tons.

$R'_{T_L} = R'_{N_L} + R'_{i_L} + R'_{C_L}$ already defined in kgf/tons.

- TRAIN LOAD

Loaded:

$$L_C = \frac{E_{t_u}}{R'_{T_{V_C}}}$$

L_C = Train load or gross tow tonnage(loaded wagons)

E_{t_u} = net tractor effort in kgf

$R'_{T_{V_C}} = R'_{N_V} + R'_{i_V} + R'_{C_V}$, already defined in kgf/ton.

Unloaded:

$$L_C = \frac{E_{t_u}}{R'_{T_{V_V}}}$$ equal before specified for loaded wagons

- NUMBER OF CARS

Loaded Wagons

$$N = \frac{L_C}{L_B}$$

Being:

N = number of loaded wagons

L_C = net load of the train

L_B = gross load of the wagons (tare + net load)

Processing reports by computer on Appendix I *o Transportation Capacity*

Aiming at evaluating the investments required to adjust existing lines of each alternative to the transportation needs for predicted flows, an analysis of the railway capacity and demand was carried out for the differents production levels considered in the study.

This analysis was carried out in the following steps:

- Calculation of the theoretical capacity of the railway, for each section and alternative, in order to identify the critical sections, according to the methodology described before;

- Balance of predicted transportation demands, expressed in terms of trains/day, with the values obtained for the capacity offered by the railway; and

- Determination of services required to eliminate bottlenecks from line sections of the Northern and Central Systems of the Mozambique Railways.

For the capacity analysis at the prefeasibility level carried out at the present study and in order to adequate the lines actually in operation and determining the amount of investments required, the coal out flows considered were those generated at Mucanha/Vuzi and Moatize mines as well as all other traffic predicted in the Traffic Demand Studies.

A simplified methodology was used and the calculation of the theoretical capacity of the railway was the start point. The maximum number of daily freight trains was determined for each section, and the critical section identified for each level of transport service.

The theoretical capacity for each section of the railway line was calculated through the following expression:

$$N = \frac{1440}{t_i + t_v + t_c} K_1 . K_2 - N_p$$

where:

N = Number of trains per day and direction;

t_i = average travel time (going), in minutes;

t_v = average travel time (returning), in minutes;

t_c = average time required for crossing trains at a station or post (t_c = 5 min was adopted):

K_1 = coefficient of the line availability which is the percentual of time during the day that can be used for commercial traffic, after deducting the times required for the line maintenance, and other activities (K_1 = 0.85 was adopted):

K_2 = coefficient of effective use of the lines, which accounts for time losser, circulation irregularities and time-schedule irregularities (K_2 = 0,85 was adopted):

N_p = number of passenger trains in the section, per traffic direction (a minimum of 2 trains/day was adopted).

Demand/Capacity Balance

The balance between predicted capacities and demands for the several levels of transport was carried out by comparing the maximum number of trains that would be in traffic through the critical section in a single or multiple traction, with the number of trains required to meet the predicted demand. The results of the capacity-demand balance is shown in Table 9.7.9 together with the residual capacities of each section.

The results in Table 9.7.9 and the analysis of the critical sections allow the following conclusions to be drawn:

- The increase in daily transportation demand up to the year of 2010 for coal and other goods will require a great number of trains/day, which will cause the saturation of several links of the routes considered; and

- In order to maintain the frequency of trains within the limite of saturation and to prevent the needs for increasing the investments costs, it is convenient to gradually introduce double and triple traction for coal trains, and double traction for general-freight trains with the increase in demand. The number of trains predicted according to this criteria is show in Table 9.7.9.

Works and Services Required in the Existing Lines

A number of studies (included in the list of reference) were carried out for the routes of Port of Beira and Port of Nacala, taking into account the increase in production of the Moatize mines, and other domestic and international flows of goods and passengers as well.

Besides the flow increases referred, there may occur a substantial increase in transportation demand due to the coal exports possibilities from the Mucanha/Vuzi mines, which will require additional investments.

In order to meet the predicted traffic demands, it has been estimated the rehabilitation and upgrading works needed in the Railway Northern and Central Systems, where the operation is actually deficient particularly because of the bad conditions of their infrastructure and superstructure, as well as the low productivity of the personnel.

The needs for services to rehabilitate and upgrading the existing lines which is part of the railway alternatives for the transportation of coal both from Mucanha/Vuzi and Moatize mines were determined on the basis of the available information and on the analysis carried out in this study.

The quantities and budgets corresponding to these needs are specified in the Railway Costs of Investments for each of the sections which is part of each alternative. (Tables 9.7.3-A to G, and Table 9.7.4 and Appendix II).
9.7.3-A
9 7 4

The main services recommended include drainage of the lines, rehabilitation of the superstructure with the construction of subgrade, enlargement of crossings construction of intermediate crossing stations, modernization of the signalling system and telecommunication system (selective telephone and station-to-train radio). These are investments required for the line Cateme-Cambulatsisse - Dondo, in the Central System, and for the line Entre Lagos-Nacala, in the Northern System.

In the Central System it is also necessary to construct a variant between Moatize and Cateme with 32 km length, and to complete the duplication currently in progress of the 17 km left in the section Dondo-Beira, after which the latter section will have 28 km of duplicated track.

With the construction of the Moatize-Cateme variant there will be a substantial reduction in the grade and curve resistan ces, whose present maximum value of 18 kg/tons will be reduced to 12 kg/ton. This means that a better use will be made up for the tractive effort of the locomotives which according to the results of simulations, will be able to tow three additional wagons with 63 tons of coal per train. In this way lower operating costs are obtained as compared to those resulting from the use of helpers on this 32 km section, or else from the present practice of dividing the train into two parts which would be towed one at a time from Moatize to Cateme by the same locomotive. However, it is worth stressing that the technical conditions suggested for the variant (i = 1.1% and minimum radius of 400 m) have the purpose of smoothing the maximum grade and curve resistances along the route of Beira, with the attendant load uniformization of the coal trains and the adjustment of line capacity to demand by the construction of a crossing between Moatize and Cateme. In the development of the final project for the selected alternative, both the variant and the other limiting section in terms of traction (like the section Bencanta-Inhaminga) should be carefully calculated in order to optimize the costs of operation and investments, what happens to be impractible at this point of study.

As to the system of signalling and telecommunication it was considered that a system of the tokenless-block-system type would be sufficient for a traffic levels of 30 trains/day and that the installation of a centralized traffic control system (CTC) would not be advisable, due to its high costs and the need for highly trained personnel required only for the traffic forecasted. However, the section Dondo-Beira, which is also in common with the Beira-Machi panda line, is an exception, where a substantial increase in the daily frequency of trains is expected.

For some operating sections in the Northern and Central Systems, no reliable information about installations such as maintenance workshops and inspection of locomotives and wagons, as well for its capacities is available; so the eventual require ments in terms of improvements could not be determined. However, it is known that these workshops and posts are well equipped although personnel productivity is very low. In order to meet expected de mands an extensive program of personnel training is required all together with small expansions in the installations.

Since the expenses for these enlargements and for the trainning program are in the same magnitude for both Northern and Central Systems and since reliable data were difficult to obtain, no budget was submitted in this respect. The same holds in rela tion to the personnel and residences for the maintenance of the permanent way and fixed installations; so it is not possible to evaluate required investments at this point of the study.

- *Rolling Stock*

The number of railroad cars needed for coal transporta tion, per year and alternative considered, was determined through the following expression:

$$NV = K \times \frac{TU \times RV}{P \times CV}$$

where:

NV = number of cars required;

K = factor to cover the needs of spare wagons at terminals and for maintenance requirements (K=1.15 was adopted);

TU = annual tonnage;

RV = wagon turn-round time, in days;

P = number of days in operation during the year (= 320);

3

CV = average load per car (= 63 tons)

The number of locomotives required was calculated on the basis of towed gross tonnage (for export) on the links considered, through the following expression:

$$NL = K \times \frac{TB \times RL}{P \times CL}$$

where:

NL = number of locomotives required;

K = reserved coefficient to cover needs for spare locomotives at terminals and for maintenance needs (K = 1.10);

TB = gross tonnages to be transported during the year (for export);

RL = locomotive turn-round time, in days, calculated on the basis of round trip travel time (including stops);

P = number of working days during the year (320 days);

CL = maximum locomotive tow capacity in export direction.

It has been taken as unit costs per wagon the value of US$ 56,000.00 in Jul. 1982 prices from which US$ 10,000.00 for freight costs from abroad.

For the locos, it has been assumed the unit cost of US$ 1,380,000.00 in Jul. 1982 prices, plus US$ 50,000.00 for freight costs from abroad.

9 7 10

The resulting values are showed in the Table 9.7.10.

For the depreciation of the rolling stocks, it has been taken 30 years for wagons and 25 years for locos.

[redacted]BLE [redacted]10 [redacted]L TRANSPORTATION: NECESSITY AND TOTAL COST OF WAGONS AND LOCOMOTIVES

US$ 1,000.00

ROUTES / YEARS	WAGONS				LOCOMOTIVES			
	MUCANHA		MOATIZE		MUCANHA		MOATIZE	
	QUANT.	COST	QUANT.	COST	QUANT.	COST	QUANT.	COST
ROUTE 1 - Beira								
ALT.1.1-(NORTH) THROUGH CFM-C								
1986	-	-	105	5,880	-	-	4	5,720
1988	70	3,920	158	8,848	3	4,290	6	8,580
1990	140	7,840	210	11,760	6	8,580	8	11,440
1995	420	23,520	315	17,640	18	25,740	12	17,160
2000	840	47,040	420	23,520	36	51,480	16	22,880
2010	-	-	-	-	-	-	4	5,720
ROUTE 1 - Beira								
ALT.1.2-(SOUTH) THROUGH CAHORA BASSA LAKE AND CFM-C								
1986	-	-	105	5,880	-	-	4	5,720
1988	61	3,416	158	8,848	3	4,290	6	8,580
1990	121	6,776	210	11,760	5	7,150	8	11,440
1995	363	20,328	315	17,640	15	21,450	12	17,160
2000	726	40,656	420	23,520	30	42,900	16	22,880
2010	-	-	-	-	-	-	4	5,720

9.7.10

TABLE 9.7.10-COAL TRANSPORTATION: NECESSITY AND TOTAL COST OF WAGONS AND LOCOMOTIVES

US$ 1,000.00

ROUTES YEARS	WAGONS				LOCOMOTIVES			
	MUCANHA		MOATIZE		MUCANHA		MOATIZE	
	QUANT.	COST	QUANT.	COST	QUANT.	COST	QUANT.	COST
ROUTE 2 - Nacala								
ALT. 2.1-(SOUTH) THROUGH MALAWI								
1986	–	–	212	11,872	–	–	13	18,590
1988	114	6,384	318	17,808	7	10,010	20	28,600
1990	228	12,768	424	23,744	14	20,020	26	37,180
1995	684	38,304	636	35,616	42	60,060	39	55,770
2000	1,368	76,608	848	47,488	84	120,120	52	74,360
2010	–	–	–	–	–	–	13	18,590
ROUTE 2 - Nacala								
ALT.2.2-(SOUTH) THROUGH ZAMBEZIA								
1986	–	–	163	9,128	–	–	7	10,010
1988	90	5,040	245	13,720	5	7,150	11	15,730
1990	179	10,024	326	18,256	8	11,440	14	20,020
1995	537	30,072	489	27,384	22	31,460	21	30,030
2000	1,074	60,144	652	36,512	43	61,490	28	40,040
2010	–	–	–	–	–	–	7	10,010

TABLE 9.7.10- COAL TRANSPORTATION: NECESSITY AND COST TOTAL OF WAGONS AND LOCOMOTIVES

US$ 1,000.00

ROUTES / YEARS	WAGONS				LOCOMOTIVES			
	MUCANHA		MOATIZE		MUCANHA		LOCOMOTIVES	
	QUANT.	COST	QUANT.	COST	QUANT.	COST	QUANT.	COST
ROUTE 2 - Nacala ALT. 2.3-(NORTH) THROUGH MALAWI-CFM-NORTH								
1986	–	–	212	11,872	–	–	13	18,590
1988	123	6,888	318	17,808	8	11,440	20	28,600
1990	246	13,776	424	23,744	16	22,880	26	37,180
1995	738	41,328	636	35,616	24	34,320	39	55,770
2000	1,476	82,656	848	47,488	48	68,640	52	74,360
2010	–	–	–	–	–	–	13	18,590
ROUTE 2 - Nacala ALT. 2.4 -(NORTH) THROUGH ZAMBEZIA								
1986	–	–	163	9,128	–	–	7	10,010
1988	99	5,544	245	13,720	5	7,150	11	15,730
1990	198	11,088	326	18,256	9	12,870	14	20,020
1995	594	33,264	489	27,384	25	35,750	21	30,030
2000	1,188	66,528	652	36,512	49	70,070	28	40,040
2010	–	–	–	–	–	–	7	10,010

[redacted] [redacted] [redacted] [redacted] [redacted]TAB[redacted].7[redacted] COA[redacted]RANS[redacted]TATI[redacted]NEC[redacted]TY [redacted] COS[redacted]OTAL[redacted] WA[redacted] AN[redacted]COMO[redacted]VES [redacted] [redacted] [redacted]

US$ 1,000.00

ROUTES / YEARS	WAGONS				LOCOMOTIVES			
	MUCANHA		MOATIZE		MUCANHA		MOATIZE	
	QUANT.	COST	QUANT.	COST	QUANT.	COST	QUANT.	COST
ROUTE 3 – Zambeze River								
ALT. 3.1 – (SOUTH) THROUGH CAHORA BASSA LAKE								
1986	–	–	16	896	–	–	1	1,430
1988	16	896	24	1,344	1	1,430	2	2,860
1990	31	1,736	32	1,792	2	2,860	2	2,860
1995	93	5,208	48	2,688	6	8,580	3	4,290
2000	186	10,416	64	3,584	12	17,160	4	5,720
2010	–	–	–	–	–	–	1	1,430
ROUTE 3 – Zambeze River								
ALT. 3.2 – (NORTH)								
1986	–	–	16	896	–	–	1	1,430
1988	36	2,016	24	1,344	2	2,860	2	2,860
1990	72	4,032	32	1,792	3	4,290	2	2,860
1995	216	12,096	48	2,688	9	12,870	3	4,290
2000	432	24,192	64	3,584	18	25,740	4	5,720
2010	–	–	–	–	–	–	1	1,430

7.1.11 *Railway Operating Costs*

In this item is proposed the procedure for estimating the railway operational costs for coal transport from the Mucanha/Vuzi and Moatize mines up to the alternative shipping ports.

9.7.11-A

Tables 9.7.11-A,B, C, D, E, F, G and H shows the railway operational costs for each alternative and production level.

In what the general structure of costs is concerned, they were separated into DIRECT COSTS which means the costs directly related with the production of transport services (trains crew, maintenance, fuel and lubricants besides "other" direct costs), and INDIRECT COSTS which means the fixed costs which are independent of the production level of transport services, within the limits of capacity for which scale is the system dimensioned, which includes the administration and depreciation costs.

Disaggregated costs are shown in Appendix II, which were calculated as a function of the operational parameters for maintenance of permanent way, locos and wagons costs as well as for fuel and lubricant consumption.

Basic information considered in the estimations for the operational cost items is next described in a summmarized form:

- *Direct Costs*

- *Train Crew*

Train crew is compounded of 1 (one) loco's driver and 1 (one) assistant working 200 (two hundreds) hours per month plus 25% for vacation, holidays and sickness plus 8% for eventual time losses in crew changings and others reasons.

TABLE 9.7.11-A-RAILWAY OPERATIONAL COSTS FOR COAL TRANSPORT
ROUTE: BEIRA - ALTERNATIVE: 1.1 - THROUGH NORTHERN

in US$ 1,000.00/year

		1986	1988	1990	1995	2000
MUCANHA/VUZI	tons	-	0.5×10^6	1×10^6	3×10^6	6×10^6
MOATIZE	tons	1×10^6	1.5×10^6	2×10^6	3×10^6	4×10^6
TOTAL	tons	1×10^6	2.0×10^6	3×10^6	6×10^6	10×10^6
SECTION: MOATIZE - BEIRA	NTK.10³	575	862	1,150	1,725	2,300
a) DIRECT COSTS		3,363	4,613	5,792	8,068	10,254
a.1-TRAIN CREW		94	140	183	140	123
- TRAIN DRIVER.......		61	91	119	91	80
- ASSISTANT..........		33	49	64	49	43
a.2- MAINTENANCE		1,795	2,319	2,786	3,771	4,657
- LOCOS		204	306	399	612	807
- WAGONS		558	837	1,092	1,674	2,205
- PERMANENT WAY		1,033	1,176	1,295	1,485	1,645
a.3- FUEL AND LUBRICANTS		1,035	1,552	2,068	3,105	4,137
a.4- OTHER DIRECT COSTS		439	602	755	1,052	1,337
b) INDIRECT COSTS		1,061	1,419	1,732	2,360	3,010
b.1- ADMINISTRATION		504	692	869	1,210	1,538
b.2- DEPRECIATION		557	727	863	1,150	1,472
SUB-TOTAL 1		4,424	6,032	7,524	10,428	13,264
SECTION MUC./VUZI- BEIRA	NTK.10³		428	857	2,571	5,142
a) DIRECT COSTS			3,026	4,925	11,801	21,442
a.1-TRAIN CREW		-	62	124	187	243
-TRAIN DRIVER........			40	81	121	158
- ASSISTANT..........			22	43	66	85
a.2- MAINTENANCE		-	1,811	2,643	5,525	9,313
- LOCOS		-	136	271	815	1,592
- WAGONS		-	417	831	2,496	4,878
- PERMANENT WAY		-	1,258	1,541	2,214	2,843
a.3- FUEL AND LUBRICANTS		-	758	1,516	4,550	9,089
a.e- OTHER DIRECT COSTS		-	395	642	1,539	2,797
b) INDIRECT COSTS		-	802	1,363	3,467	6,368
b.1- ADMINISTRATION		-	454	739	1,770	3,216
b.2- DEPRECIATION		-	349	624	1,697	3,152
SUB-TOTAL 2		-	3,828	6,288	15,268	27,810
ANNUAL TOTAL COST		4,424	9,860	13,812	25,696	41,074
COST/TON-MOATIZE ORIGIN		4.42	4.02	3.76	3.48	3.32
COST/TON-MUC/VUZI ORIGIN		-	7.66	6.29	5.09	4.63
COST/TON-WEIGHTED AVERAGE		4.42	5.22	4.84	4.44	4.23

TABLE 9.7.11-B RAILWAY OPERATIONAL COSTS FOR COAL TRANSPORT
ROUTE: BEIRA - ALTERNATIVE: 1.2 - THROUGH SOUTHERN

in US$ 1,000.00/year

		1986	1988	1990	1995	2000
MUCANHA/VUZI	tons	-	0.5×10^6	1×10^6	3×10^6	6×10^6
MOATIZE	tons	1×10^6	1.5×10^6	2×10^6	3×10^6	4×10^6
TOTAL	tons	1×10^6	2.0×10^6	3×10^6	6×10^6	10×10^6
SECTION: MOATIZE - BEIRA	NTK.10^3	575	862	1,150	1,725	2,300
a) DIRECT COSTS		3,363	4,613	5,792	8,068	10,254
a.1-TRAIN CREW		94	140	183	140	123
- TRAIN DRIVER.......		61	91	119	91	80
- ASSISTANT..........		33	49	69	49	43
a.2- MAINTENANCE		1,795	2,319	2,786	3,771	4,657
- LOCOS		204	306	399	612	807
- WAGONS		558	837	1,092	1,674	2,205
- PERMANENT WAY		1,033	1,176	1,295	1,485	1,645
a.3- FUEL AND LUBRICANTS		1,035	1,552	2,068	3,105	4,137
a.4- OTHER DIRECT COSTS		439	602	775	1,052	1,337
b) INDIRECT COSTS		1,061	1,419	1,732	2,360	3,010
b.1- ADMINISTRATION		504	692	869	1,210	1,538
b.2- DEPRECIATION		557	727	863	1,150	1,472
SUB-TOTAL 1		4,424	6,032	7,524	10,428	13,264
SECTION MUC./VUZI- BEIRA	NTK.10^3	-	363	726	2,178	4,356
a) DIRECT COSTS		-	2,578	4,205	10,096	18,334
a.1-TRAIN CREW		-	54	108	161	211
-TRAIN DRIVER........		-	35	70	105	137
- ASSISTANT..........		-	19	38	56	174
a.2- MAINTENANCE		-	1,537	2,245	4,706	7,918
- LOCOS		-	118	235	705	1,378
- WAGONS		-	354	705	2,118	4,131
- PERMANENT WAY		-	1,065	1,305	1,883	2,409
a.3- FUEL AND LUBRICANTS		-	651	1,304	3,912	7,814
a.e- OTHER DIRECT COSTS		-	336	548	1,317	2,391
b) INDIRECT COSTS		-	695	1,146	3,030	5,413
b.1- ADMINISTRATION		-	387	631	1,514	2,750
b.2- DEPRECIATION		-	308	515	1,416	2,663
SUB-TOTAL 2		-	3,273	5,351	13,126	23,747
ANNUAL TOTAL COST		4,424	9,305	12,875	23,554	37,011
COST/TON-MOATIZE ORIGIN		4.42	4.02	3.76	3.48	3.32
COST/TON-MUC/VUZI ORIGIN		-	6.54	5.35	4.37	3.96
COST/TON-WEIGHTED AVERAGE		4.42	4.77	4.39	3.98	3.73

TABLE 9.7.11-C RAILWAY OPERATIONAL COSTS FOR COAL TRANSPORT
ROUTE: NACALA — ALTERNATIVE: 2.1 - THROUGH SOUTHERN AND MALAWI

in US$ 1,000.00/year

		1986	1988	1990	1995	2000
MUCANHA/VUZI	tons	-	$0,5\times10^6$	1×10^6	3×10^6	6×10^6
MOATIZE	tons	1×10^6	$1,5\times10^6$	2×10^6	3×10^6	4×10^6
TOTAL	tons	1×10^6	$2,0\times10^6$	3×10^6	6×10^6	10×10^6
SECTION: MOATIZE - NACALA	$NTK.10^3$	977	1,465	1,954	2,931	3,908
a) DIRECT COSTS		6,465	8,925	11,076	15,546	20,069
a.1-TRAIN CREW		282	419	282	282	376
- TRAIN DRIVER.......		183	272	183	183	244
- ASSISTANT..........		99	147	99	99	132
a.2- MAINTENANCE		3,318	4,312	5,307	7,171	8,989
- LOCOS		615	914	1,230	1,845	2,460
- WAGONS		927	1,380	1,857	2,784	3,714
- PERMANENT WAY		1,776	2,018	2,220	2,542	2,815
a.3- FUEL AND LUBRICANTS		2,022	3,030	4,042	6,065	8,086
a.4- OTHER DIRECT COSTS		843	1,164	1,445	2,028	2,618
b) INDIRECT COSTS		2,120	2,926	3,608	5,187	6,766
b.1- ADMINISTRATION		970	1,339	1,661	2,332	3,010
b.2- DEPRECIATION		1,150	1,587	1,947	2,855	3,756
SUB-TOTAL 1		8,585	11,851	14,684	20,733	26,835
SECTION MUC./VUZI- NACALA	$NTK.10^3$	-	564	1,128	3,384	6,768
a) DIRECT COSTS		-	4,453	7,256	17,679	33,165
a.1-TRAIN CREW		-	156	156	303	616
-TRAIN DRIVER........		-	101	101	197	400
- ASSISTANT..........		-	55	55	106	216
a.2- MAINTENANCE		-	2,557	3,837	8,134	14,333
- LOCOS		-	340	681	1,954	4,029
- WAGONS		-	552	1,104	3,213	6,528
- PERMANENT WAY		-	1,665	2,052	2,937	3,776
a.3- FUEL AND LUBRICANTS		-	1,159	2,317	6,936	13,890
a.e- OTHER DIRECT COSTS		-	581	946	2,306	4,326
b) INDIRECT COSTS		-	1,237	2,320	5,772	11,067
b.1- ADMINISTRATION		-	668	1,088	2,652	4,975
b.2- DEPRECIATION		-	569	1,132	3,120	6,092
SUB-TOTAL 2		-	5,690	9,576	23,451	44,232
ANNUAL TOTAL COST		8,585	17,541	24,260	44,184	71,066
COST/TON-MOATIZE ORIGIN		8.58	7.90	7.34	6.91	6.71
COST/TON-MUC/VUZI ORIGIN		-	11.38	9.58	7.82	7.37
COST/TON-WEIGHTED AVERAGE		8.58	8.88	8.16	7.40	7.12

TABLE 9.7.11-D RAILWAY OPERATIONAL COSTS FOR COAL TRANSPORT
ROUTE: NACALA - - ALTERNATIVE: 2.2 - THROUGH SOUTHERN AND ZAMBEZIA

in US$ 1,000.00/year

		1986	1988	1990	1995	2000
MUCANHA/VUZI	tons	-	0.5×10^6	1×10^6	3×10^6	6×10^6
MOATIZE	tons	1×10^6	1.5×10^6	2×10^6	3×10^6	4×10^6
TOTAL	tons	1×10^6	2.0×10^6	3×10^6	6×10^6	10×10^6
SECTION: MOATIZE - NACALA	$NTK.10^3$	1,082	1,623	2,164	3,246	4,328
a) DIRECT COSTS		6,172	8,450	10,589	14,772	18,809
a.1-TRAIN CREW		145	217	283	217	283
- TRAIN DRIVER.......		94	141	184	141	184
- ASSISTANT..........		51	76	99	76	99
a.2- MAINTENANCE		3,311	4,265	5,109	6,897	8,441
- LOCOS		316	473	616	946	1,234
- WAGONS		1,050	1,578	2,055	3,156	4,110
- PERMANENT WAY		1,945	2,214	2,438	2,795	3,097
a.3- FUEL AND LUBRICANTS		1,911	2,866	3,816	5,731	7,632
a.4- OTHER DIRECT COSTS		805	1,102	1,381	1,927	2,453
b) INDIRECT COSTS		1,773	2,371	2,869	4,047	5,205
b.1- ADMINISTRATION		926	1,267	1,588	2,216	2,821
b.2- DEPRECIATION		847	1,104	1,281	1,831	2,384
SUB-TOTAL 1		7,945	10,821	13,458	18,819	24,014
SECTION MUC./VUZI- NACALA	$NTK.10^3$	-	616	1,233	3,699	7,398
a) DIRECT COSTS		-	4,314	7,016	16,796	30,791
a.1-TRAIN CREW		-	79	159	238	469
-TRAIN DRIVER........		-	51	103	155	305
- ASSISTANT..........		-	28	56	83	164
a.2- MAINTENANCE		-	2,581	3,759	7,818	13,215
- LOCOS		-	173	346	1,040	2,047
- WAGONS		-	600	1,197	3,594	7,080
- PERMANENT WAY		-	1,808	2,216	3,184	4,088
a.3- FUEL AND LUBRICANTS		-	1,091	2,183	6,549	13,091
a.e- OTHER DIRECT COSTS		-	563	915	2,191	4,016
b) INDIRECT COSTS		-	1,099	1,854	4,507	8,410
b.1- ADMINISTRATION		-	647	1,052	2,519	4,619
b.2- DEPRECIATION		-	452	802	1,988	3,791
SUB-TOTAL 2		-	5,412	8,870	21,303	39,201
ANNUAL TOTAL COST		7,945	16,233	22,327	40,122	63,215
COST/TON-MOATIZE ORIGIN		7.94	7.21	6.73	6.27	6.00
COST/TON-MUC/VUZI ORIGIN		-	10.82	8.87	7.10	6.53
COST/TON-WEIGHTED AVERAGE		7.94	8.22	7.50	6.71	6.33

TABLE 9.7.11-E-RAILWAY OPERATIONAL COSTS FOR COAL TRANSPORT
ROUTE: NACALA — ALTERNATIVE: 2.3 THROUGH NORTHERN AND MALAWI

in US$ 1,000.00/year

		1986	1988	1990	1995	2000
MUCANHA/VUZI	tons	–	0.5×10^6	1×10^6	3×10^6	6×10^6
MOATIZE	tons	1×10^6	1.5×10^6	2×10^6	3×10^6	4×10^6
TOTAL	tons	1×10^6	2.0×10^6	3×10^6	6×10^6	10×10^6
SECTION: MOATIZE – NACALA	NTK.10^3	977	1,465	1,954	2,931	3,908
a) DIRECT COSTS		6,465	8,925	11,076	15,546	20,069
a.1-TRAIN CREW		282	419	282	282	376
- TRAIN DRIVER.......		183	270	183	183	244
- ASSISTANT..........		99	147	99	199	132
a.2- MAINTENANCE		3,318	4,312	5,307	7,171	8,989
- LOCOS		615	914	1,230	1,845	2,460
- WAGONS		927	1,380	1,857	2,784	3,714
- PERMANENT WAY		1,776	2,018	2,220	2,542	2,815
a.3- FUEL AND LUBRICANTS		2,022	3,030	4,042	6,065	8,086
a.4- OTHER DIRECT COSTS		843	1,164	1,445	2,028	2,618
b) INDIRECT COSTS		2,120	2,926	3,608	5,187	6,766
b.1- ADMINISTRATION		970	1,339	1,661	2,332	3,010
b.2- DEPRECIATION		1,150	1,587	1,947	2,855	3,756
SUB-TOTAL 1		8,585	11,851	14,684	20,733	26,835
SECTION MUC./VUZI- NACALA	NTK.10^3	–	629	1,259	3,777	7,554
a) DIRECT COSTS		–	4,912	7,990	19,653	36,416
a.1-TRAIN CREW		–	169	169	498	667
-TRAIN DRIVER........		–	110	110	328	433
- ASSISTANT..........		–	59	59	170	234
a.2- MAINTENANCE		–	2,843	4,261	9,037	15,884
- LOCOS		–	369	738	2,171	4,363
- WAGONS		–	615	1,233	3,588	7,287
- PERMANENT WAY		–	1,859	2,290	3,278	4,214
a.3- FUEL AND LUBRICANTS		–	1,259	2,518	7,555	15,115
a.e- OTHER DIRECT COSTS		–	641	1,042	2,563	4,750
b) INDIRECT COSTS		–	1,389	2,482	5,331	10,115
b.1- ADMINISTRATION		–	737	1,198	2,948	5,462
b.2- DEPRECIATION		–	652	1,284	2,386	4,653
SUB-TOTAL 2		–	6,301	10,472	24,984	46,531
ANNUAL TOTAL COST		8,585	18,152	25,156	45,717	73,366
COST/TON-MOATIZE ORIGIN		8.58	7.90	7.34	6.91	6.71
COST/TON-MUC/VUZI ORIGIN		–	12.60	10.47	8.33	7.75
COST/TON-WEIGHTED AVERAGE		8.58	9.31	8.56	7.70	7.39

TABLE 9.7.11-F RAILWAY OPERATIONAL COSTS FOR COAL TRANSPORT
ROUTE: NACALA – ALTERNATIVE: 2.4 – THROUGH NORTHERN AND ZAMBEZIA

in US$ 1,000.00/year

		1986	1988	1990	1995	2000
MUCANHA/VUZI	tons	–	0.5×10^6	1×10^6	3×10^6	6×10^6
MOATIZE	tons	1×10^6	1.5×10^6	2×10^6	3×10^6	4×10^6
TOTAL	tons	1×10^6	2.0×10^6	3×10^6	6×10^6	10×10^6
SECTION: MOATIZE – NACALA	NTK.10^3	1,082	1,623	2,164	3,246	4,328
a) DIRECT COSTS		6,172	8,450	10,589	14,772	18,809
a.1-TRAIN CREW		145	217	283	217	283
– TRAIN DRIVER.......		94	141	184	141	184
– ASSISTANT..........		51	76	99	76	99
a.2– MAINTENANCE		3,311	4,265	5,109	6,897	8,441
– LOCOS		316	473	616	946	1,234
– WAGONS		1,050	1,578	2,055	3,156	4,110
– PERMANENT WAY		1,945	2,214	2,438	2,795	3,097
a.3– FUEL AND LUBRICANTS		1,911	2,866	3,816	5,731	7,632
a.4– OTHER DIRECT COSTS		805	1,102	1,381	1,927	2,453
b) INDIRECT COSTS		1,773	2,371	2,869	4,047	5,205
b.1– ADMINISTRATION		926	1,267	1,588	2,216	2,821
b.2– DEPRECIATION		847	1,104	1,281	1,831	2,384
SUB-TOTAL 1		7,945	10,821	13,458	18,819	24,014
SECTION MUC./VUZI– NACALA	NTK.10^3	–	682	1,364	4,092	8,184
a) DIRECT COSTS		–	4,757	7,736	18,498	33,893
a.1-TRAIN CREW		–	88	176	263	519
-TRAIN DRIVER........		–	57	114	171	337
– ASSISTANT..........		–	31	62	92	182
a.2– MAINTENANCE		–	2,854	4,160	8,649	14,616
– LOCOS		–	191	383	1,149	2,263
– WAGONS		–	663	1,326	3,978	7,830
– PERMANENT WAY		–	2,000	2,451	3,522	4,523
a.3– FUEL AND LUBRICANTS		–	1,195	2,391	7,173	14,337
a.e– OTHER DIRECT COSTS		–	620	1,009	2,413	4,421
b) INDIRECT COSTS		–	1,197	2,011	5,021	9,348
b.1– ADMINISTRATION		–	713	1,160	2,774	5,084
b.2– DEPRECIATION		–	484	851	2,247	4,264
SUB-TOTAL 2		–	5,951	9,747	23,519	43,241
ANNUAL TOTAL COST		7,945	16,775	23,205	42,338	67,285
COST/TON-MOATIZE ORIGIN		7.94	7.21	6.73	6.27	6.00
COST/TON-MUC/VUZI ORIGIN		–	11.91	9.75	7.84	7.21
COST/TON-WEIGHTED AVERAGE		7.94	8.63	7.90	7.15	6.79

BLE 9.7.11-G-RAILWAY OPERATIONAL COSTS FOR COAL TRANSPORT
ROUTE: ZAMBEZE RIVER - ALTERNATIVE: 3.1 - THROUGH SOUTHERN

in US$ 1,000.00/year

		1986	1988	1990	1995	2000
MUCANHA/VUZI	tons	-	0.5×10^6	1×10^6	3×10^6	6×10^6
MOATIZE	tons	1×10^6	1.5×10^6	2×10^6	3×10^6	4×10^6
TOTAL	tons	1×10^6	2.0×10^6	3×10^6	6×10^6	10×10^6
SECTION: MOATIZE - TETE	NTK.10^3	20	30	40	60	80
a) DIRECT COSTS		161	228	289	415	509
a.1-TRAIN CREW		16	23	30	46	31
- TRAIN DRIVER.......		10	15	19	30	20
- ASSISTANT..........		6	8	11	16	11
a.2- MAINTENANCE		89	122	151	210	272
- LOCOS		34	50	66	100	135
- WAGONS		18	30	39	57	78
- PERMANENT WAY		37	42	46	53	59
a.3- FUEL AND LUBRICANTS		35	53	70	105	140
a.4- OTHER DIRECT COSTS		21	30	38	54	66
b) INDIRECT COSTS		100	181	197	279	364
b.1- ADMINISTRATION		24	34	43	62	76
b.2- DEPRECIATION		76	147	154	217	288
SUB-TOTAL 1		261	409	486	694	873
SECTION MUC./VUZI- TETE	NTK.10^3	-	65	131	393	786
a) DIRECT COSTS		-	479	788	1,940	3,498
a.1-TRAIN CREW		-	15	30	90	90
-TRAIN DRIVER........		-	9	19	58	58
- ASSISTANT..........		-	6	11	32	32
a.2- MAINTENANCE		-	288	427	910	1,576
- LOCOS		-	33	66	196	392
- WAGONS		-	63	126	375	750
- PERMANENT WAY		-	192	235	339	434
a.3- FUEL AND LUBRICANTS		-	114	228	687	1,376
a.e- OTHER DIRECT COSTS		-	62	103	253	456
b) INDIRECT COSTS		-	169	288	738	1,462
b.1- ADMINISTRATION		-	72	118	291	525
b.2- DEPRECIATION		-	97	170	447	937
SUB-TOTAL 2		-	648	1,076	2,678	4,960
ANNUAL TOTAL COST		261	1,057	1,562	3,372	5,875
COST/TON-MOATIZE ORIGIN		0.26	0.27	0.24	0.23	0.22
COST/TON-MUC/VUZI ORIGIN		-	1.29	1.07	0.89	0.82
COST/TON-WEIGHTED AVERAGE			0.97	0.87	0.80	0.77

ABLE 5.7.11-II-RAILWAY OPERATIONAL COSTS FOR COAL TRANSPORT
ROUTE: ZAMBEZE RIVER - ALTERNATIVE: 3.2 - THROUGH NORTHERN

in US$ 1,000.00/year

		1986	1988	1990	1995	2000
MUCANHA/VUZI	tons	-	$0,5\times10^6$	1×10^6	3×10^6	6×10^6
MOATIZE	tons	1×10^6	$1,5\times10^6$	2×10^6	3×10^6	4×10^6
TOTAL	tons	1×10^6	$2,0\times10^6$	3×10^6	6×10^6	10×10^6
SECTION: MOATIZE - TETE	NTK.10^3	20	30	40	60	80
a) DIRECT COSTS		161	228	289	415	509
a.1-TRAIN CREW		16	23	30	46	31
- TRAIN DRIVER.......		10	15	14	30	20
- ASSISTANT.........		6	8	11	16	11
a.2- MAINTENANCE		89	122	151	210	272
- LOCOS		34	50	66	100	135
- WAGONS		18	30	39	57	78
- PERMANENT WAY		37	42	46	53	59
a.3- FUEL AND LUBRICANTS		35	53	70	105	140
a.4- OTHER DIRECT COSTS		21	30	38	54	66
b) INDIRECT COSTS		100	181	197	279	364
b.1- ADMINISTRATION		24	34	43	62	76
b.2- DEPRECIATION		76	147	154	217	288
SUB-TOTAL 1		261	409	486	694	873
SECTION MUC./VUZI- TETE	NTK.10^3	-	204	418	1,254	2,508
a) DIRECT COSTS		-	1,485	2,426	5,904	10,671
a.1-TRAIN CREW		-	35	70	208	208
-TRAIN DRIVER........		-	23	45	135	135
- ASSISTANT.........		-	12	25	73	73
a.2- MAINTENANCE		-	891	1,310	2,733	4,688
- LOCOS		-	76	153	453	906
- WAGONS		-	201	405	1,197	2,394
- PERMANENT WAY		-	614	752	1,083	1,388
a.3- FUEL AND LUBRICANTS		-	365	730	2,193	4,383
a.e- OTHER DIRECT COSTS		-	194	316	770	1,392
b) INDIRECT COSTS		-	495	736	1,718	3,181
b.1- ADMINISTRATION		-	223	364	886	1,601
b.2- DEPRECIATION		-	272	372	832	1,580
SUB-TOTAL 2		-	1,980	3,162	7,622	13,852
ANNUAL TOTAL COST		261	2,389	3,648	8,316	14,725
COST/TON-MOATIZE ORIGIN		0.26	0.27	0.24	0.23	0.22
COST/TON-MUC/VUZI ORIGIN		-	3.96	3.16	2.54	2.31
COST/TON-WEIGHTED AVERAGE		0.26	3.47	2.90	2.42	2.25

Monthly wages were estimated in 11,400.00 MT (Meticais) per loco's driver and 6,200.00 MT per assistant which leads to an average of 118.8 MT or US$ 3.05 per crew/hour which is a function of the number of locos/hour.

- *Locos Maintenance.*

Related costs for inspections, revisions, repairing, refuelling and fuel oil, lubricant and sand were also considered. Basic index taken was locos/hour per year which is in turn a function of the train/hour per year considering the used tractive system - single or multiple locos per train.

Using accepted values both in Brazilian and American railway system as US$ 37,140 per loco/year and considering the availability rate of 85% and the utilization rate of 75% it is obtained the US$ 6.65 value per loco/hour.

365 x 24 x 0.85 x 0.75 = 5,585 hours per year

$$\frac{\text{US\$ } 37{,}140}{5{,}585} = \text{US\$ } 6.65\text{/loco.hour}$$

or 259.30 MT/loco.hour

- *Wagon Maintenance*

Used basic index is the wagon/km and accepted maintenance cost 1.17 MT or US$ 0.03 per wagon/km which is coherent with the obtained value in the Brazilian railways (which varies from US$ 0.02 to US$ 0.05) and the american railways.

- *Permanent way maintenance*

For the maintenance of permanent way it has been adopted the A.R.E.A. (American Railway Engineering Association) formula which supplies the annual maintenance cost for 1 mile of permanent way.

Per mile: $A = 1{,}623\ (0.5 + D^{0.435})$ in US$/mile/year

Per Km : $A = 1{,}010\ (0.5 + D^{0.435})$ in US$/Km/year

In the value of D (10^6 GT/year), it has been taken into consideration total load train on the line on going direction and unloaded return (unit trains).

Total annual maintenance cost of the permanent way is:

CMVP = A . E = US$/year

being:

E. = equalized distance for the link or section in the line under study.

The equalized distance takes into consideration the maintenance of crossing loops and changing of track devices. The accepted value for equalization was 2.3%.

- *Fuel Consumption*

- *Adopted Methodology*

The curves used were those of consumption as a function of the resistance to the movement of the train as adjusted by ERNEST C. POOLE(*) to the various experiments of fuel-consumption measurement carried out by the American railways Southern Pacific, Santa Fé and Great Northern.

Taking *i* as the compensated equivalent grade (straight slope with a resistance equivalent to the sum of the values of the resistances to the movement), the curves are given by the following expressions:

(*) COST - A TOOL FOR RAILROAD MANAGEMENT BY ERNEST C. POOLE - SIMMONS BOARDMAN PUBLISHING CORPORATION - New York - 1962 - Accepted by the A.R.E.A. (American Railroad Engineering Association) in 1970 in the section /Economics of Plant Equipment and Operation".

G.T. = Gross ton.

$$i \geq 0 \qquad C = 8.2i + 2.45$$
$$-0.3 \leq i < 0 \qquad C = 7.37i + 2.87$$
$$i < -0.3 \qquad C = 0.66$$

C = fuel consumption in ℓ/1000 GTK (Gross Ton x Km)

To determine the rate of the compensated equivalent grade (i) the following procedures were adopted:

- *Resistance on a grade - Ra - (kg/ton)*

The positive and negative grades (direction of circulation) were considered separately. Designating i, as the corresponding rate, the resistance (Ra) was taken as $10.i$, and the sign of i, (+ or -) was observed.

The level sections were aggregated to the positive-grade sections and the rate was calculated by using their lengths as weights.

- *Resistance on curves - Rc - (kg/ton)*

To calculate resistance on curves the following formula was adopted:

$$R_{c_1} = \frac{500b}{R}$$

where:

b = gauge in meters

R = radius in meters

The mean radius of a section or subsection was taken as the radius value (R), since the sensibility tests showed that the determination of R_{c_1} for each curve would result in just a slight variation in the final value of the resistance on curves, particularly for a design good characteristics as those of the railways in Mozambique.

On the other hand, having in view that R_{c_1} has an effect only when the train is on a curve, the final value adopted for R_c was obtained by multiplying R_{c_1} by a coefficient k_1 equivalent to the percent of the curved extension relatively to the total extension of the section or subsection.

- *Normal resistance - Rn - (kg/ton)*

Davis formula updated by AREA was adopted, whose expression is as follows:

$$Rn = 0.3 + \frac{9.072}{p} + 0.00311v + \frac{0.01226v^2}{p^n}$$

, which is applicable to railroad cars and locomotives, where:

p = axle weight in tons

v = speed in km/hours

n = number of axles

- *Resistance to acceleration and effect of the kinetic energy*

Considering that these two actions produce opposite effects in terms of fuel consumption, it was assumed that one could compensate for the other, and for this reason they were not considered in the determination of the total resistance.

Once Ra, Rc and Rn are determined, the rate of the compensated equivalent grade i was obtained by:

$$i = \frac{Ra + Rn + Rc}{10}$$

The experiments of fuel-consumption measurement mentioned before were applied to the locomotives then used in the railroads. From then to this time, significant improvements in terms of energy efficiency were introduced in the locomotives and because of this it was deemed convenient to accept as a final consumption 0.90 (90%) of the value calculated by the methodology discribed.

- *Other Costs*

To the costs previously mentioned it was added "other costs" which refers to traffic personnel (from the stations, control centers and yards), communications and signalling maintenance personnel and refuelling posts personnel.

At this phase of the study it is not possible to detail costs for all that items to end up with real costs.

Available informations from other railways leads to a participation of the indicated as "other costs" up to 40% of the direct operational costs.

Considering a more efficient operation due to foreseen demand levels and proposed improvements it has been accepted a minimum value of 15% of total direct costs.

- *Indirect Costs*

- *Administration Costs*

For the administration cost it was accepted a value of 15% of the direct operational costs.

- *Depreciation of Equipment*

It was only considered the depreciation of rolling stocks (locos and wagons), signalling and telecommunications equipment.

For all other equipment depreciation was included in the maintenance costs which considered the costs for substitution of parts in order to keep it in permanent usage.

It has been accepted a linear depreciation for the whole economical life of the equipment considering the 20% residual value. Even in case of signalling and telecommunication equipment which has almost no scrap value, it was accepted the 20% residual value since it was assumed the its obsolescence would be only in terms of technology to fulfil future requirements for the foreseeable demands being otherwise adequate to operate in other railway sections of smaller traffic density.

9.7.2

9.7.2 - Investment in Terminals and Navigation in the Cahora Bassa Reservoir and Zambeze River

9.7.2.1 *General Description*

In the following chapters is exposed the preliminary study for the components of the proposed alternatives, including:

- Sea port facilities for coal loading on the Mozambique cost including 3 (three) alternatives:
  - Beira
  - Nacala in the bay
  - Off shore terminal in the mouth of the Zambeze River

- Transportation on the Cahora Bassa reservoir for a distance of 124 km including the loading facilities in Mucanha/Vuzi, near the coal mines and the unloading facilities in Nhancapirire a transfer point for the railway system to be used for the transportation of coal to the sea ports or to transfer it on Tete in view of the fluvial transportation alternative on the Zambeze River.

- Fluvial transportation on the Zambeze River from loading facilities near Tete to the river mouth in Chinde on a total extension of 500 km.

For each one of these studies, it has been prepared:

- A description of the flows and the respectives capacities of the system for transportation, as well as a brief description of the civil works and electrical facilities.

- Basic information on the equipments, ships and the necessary protections to be foreseen on the navigable ways.

- An estimate of the investments required and operational costs.

- Drawings of each transfer facility including flow diagrams and preliminary layout.

These studies have been prepared on a pre-feasibility level in order to estimate the costs which would permit to select the best economical solution. In the Beira case, the alternative in the river mouth is undoubtedly the most economical with a additional better guaranty for a continuous operation.

In the alternative of the Zambeze River mouth the costs have been also estimated for the transportation of the coal as far as Beira and Nacala considering in that case loading facilities for ships of 35,000 TDW, on the Chinde river and the respective unloading facilities in Beira and Nacala. These alternatives have shown higher costs than the others. To determine the most economical overall alternative this study should be evaluated in accordance with the railway transportation alternative.

In order to allow an easier analysis of the following chapters, it is recommended to read the text altogether with the corresponding drawings.

The yearly flows of coal considered in this study are the following:

	1st. Stage	2d. Stage	3d. Stage
- Reservoir transportation	1,000,000	3,000,000	6,000,000
- River transportation and port facilities	3,000,000	6,000,000	10,000,000

The suplementary flows of coal which have been considered in the case of the river transportation and port facilities are due to the consumption of the steam power stations of Moatize located at about 20 km of Tete.

9.7.2.2 *Sea port facilities*

In the case of the sea port facilities, in any of the selected sites, the various stages of the yearly flows and the flow diagram of the port may be the same for the three alternatives and also the layout will be similar, exception made to the coal reception in the port on the Zambeze river mouth where the unloading will be done by barges, differently from the other alternatives where the unloading will be done by the railway (Volume 2 - numbers 2.26, 2.27 and 2.28).

Stages of enlargement of the ports

For a better understanding of the stepwise enlargement of the facilities, three functions have been considered: reception, storage yard and loading.

Reception

The coal would arrive at the port by railway cars of 63 net tons capacity and 57 averaged loading with the exception of the Zambeze mouth port where the coal will arrive on barges described afterwards.

The estimated number of railway cars for each of the stages is the following:

<u>1st. Stage</u>

$$\frac{3{,}000{,}000 \text{ tons/year}}{320 \text{ days}/_{\text{year}} \times 57 \text{ tons}/_{\text{car}}} = 165 \text{ cars}/_{\text{day}}$$

<u>2d. Stage</u>

$$\frac{6{,}000{,}000 \text{ tons/year}}{320 \text{ days}/_{\text{year}} \times 57 \text{ tons}/_{\text{car}}} = 329 \text{ cars}/_{\text{day}}$$

<u>3d. Stage</u>

$$\frac{10{,}000{,}000 \text{ tons/year}}{320 \text{ days}/_{\text{year}} \times 57 \text{ tons}/_{\text{car}}} = 549 \text{ cars}/_{\text{day}}$$

Assuming that one third of the available time will be spent in shunting and waiting of the trains, the real unloading period will be of 13.4 hours/day (assuming 20 hours of work per day). The unloading capacity of the equipment will therefore be of

$$\frac{549 \text{ cars/day} \times 57 \text{ tons/car}}{13.4 \text{ hours/day}} = 2,335 \text{ tons/day}$$

In order to better adjust this capacity with the necessary capacity for loading the ship, a nominal capacity of 2,600 tons/hour with a maximum of 3,200 tons/hour has been selected to the 2nd. Stage.

To enable the use of belt conveyors, the cars will be unloaded by groups of three, by using discharge hoppers with three inlets each one equiped with a feeder of 870 tons/hour.

oo *Storage Yard*

- <u>1st. Stage</u>: The equipment foreseen will consist of two piles, one stacker, two mobile hoppers each one fed by two shovel trucks and three belt conveyors, one of which used for piling and two for reclaiming. These equipments have been sized to move a maximum of 3,000,000 tons/year.

- <u>2d. Stage</u>: The two piles will be increased in height with the same initial width. In addition to the equipment of stage one, two other reclaimers have been foreseen to provide the yard capacity to move up to 6,000,000 tons/year.

- <u>3d. Stage</u>: With the addition of one more pile in this stage, the yard will consist of three piles, all of them higher than in the second stage, two stackers, two reclaimers, four belt conveyors, two of them used for piling up and the two others for reclaiming. These equipment have been sized to move up to 10,000,000 tons/year.

Loading

In the first stage a system of reclaiming by means of shovel trucks and mobile hoppers has been selected. This system will allow a reclaiming capacity of 1,000 tons/hour which will permit an annual loading capacity of 2 x 1,000 tons/hour x 320 days/year x 20 hours/day x 0.7 (efficiency) x 0.55 (operation rate) = 4,930,000 tons/year.

In the second stage the reclaiming of the coal will be by means of a reclaimer with a capacity of 2,600 tons/hour. The yearly transfer of coal through the shiploader will therefore be of 2,600 tons/hour x 320 days/year x 20 hours/day x 0.7 x 0.55 = 6,400,000 tons/year maximum.

For the third stage two reclaimers feeding two shiploaders have been foreseen all with the same capacity. That way the yearly maximum shipment will be:

2 x 2,600 Ton/hour x 320 days/year x 20 hours/day x 0.7 x 0.55=15,150,000 tons/year.

The shiploader might be of a lower capacity in the first stage, but the difference in cost would not justify that solution since a larger loader would be necessary in the second stage.

In addition, in the case of a direct flow from the railway cars unloading station to the shiploader it will be necessary to have the same capacity for the unloading facilities as for the belt conveyors feeding them.

Civil Works

They will include the following:

- Earthworks for the stockyard.
- Railway access with a section of the track at a higher level to avoid expensive works on excavation and civil works for the discharging hoppers.

- Ballast and tracks for the equipments of the yard. Due to the reasonable conditions of the soil, it should not be necessary to use deep foundation for these equipments.

- Building for the administration and social facilities which will be as simple as possible since these facilities already exist in the ports of Beira and Nacala. Only in the case of the port on the Zambeze river mouth larger accommodation has been provided together with facilities for the repair and maintenance of the equipments.

- Water system, sewers and drains.

- Internal roads and urbanization of the area.

- Civil works for all electrical equipment such as transformers, electrical cables, illumination.

- Foundations of the mechanical equipment (belt conveyors, transfer tower, etc). In the case of the Beira port, where the belt conveyor between the stockyard and the access bridge to the pier cross the port and part of the city, a bigger structural support has to be provided to avoid its interference with the normal operation of the port. This solution looks more convenient than the extending the railway tracks up to the loading pier which would cross the old part of the town and would lead to create a stockyard close to the city in an area which should be reserved for loads such as containers.

- Pier and access bridge - should be constructed in all the facilities on a standard design, with vertical and inclined metalic piles of 80 cm to 90 cm of diameter and about 40 m length and with the superstructure made of prefabricated concrete pieces filled up in situ with reinforced concrete. The pier would have a length of 300 meter per 21 meter width. The ships will be anchored to two dolphins of 15 meters by 21 meters at a distance of 25 m from the pier. The access bridge between the pier and the back area will be L shaped. The shorter section will connect one of the dolphins to the pier. The longer section variable in each case will be of 100 meters for Beira Estuary, 400 meters for Nacala and 1,600 meters for the port on the Zambeze river mouth. Both the pier and the access bridge in the off shore solution, will have to take into account in addition to the tide, waves of up to 4 meters which might occur in that area of the Mozambique channel, while in the solutions of the estuary the waves should not exceed 1 meter.

Dredging

The port facilities of Nacala and Zambeze river will be located in waters at a depth of 18.5 meters, or less, in relation to the lowest spring tide allowing ships of up to 150,000 TDW.

The port facilities of Beira will be located in an area with a depth of 6 meters with a channel of about 20 km of length. In order not to hardly increase the initial and first stage investments costs, it will be dredged to allow ships of 70,000 TDW which will be able to enter with a minimum high tide of 4 meters with natural depth of 11.8 meters and 200 meters of width. In the second step the channel will be dredged down to 13 meters in depth and to 230 meters width to receive ships of up to 100,000 TDW and finally in the third stage down to 15 meters depth and 250 meters width to attend ships of up to 125,000 TDW. Obviously when comparing the various solutions it shall be taken into account: (1) The difference in cost of the freight which will have to be paid for the ships visiting the Beira port due to their lower sea gauge (2) in the case of the off shore facilities the additional cost which might occur when the ships wait for waves lower than 1.5 meters (minimum allowable for operation of the facilities). On the basis of data collected in 1981, nearby Beira port, it has been estimated that the port would not be operational during 16% of the year, which means that the ships will have to stay during the same additional period in the port, increasing its occupation rate and the respective waiting time. That way, while at the second stage, in the facilities within the estuary the occupation ra te will be about 51,6%, the same occupation rate will be increased up to 59,8% in the off shore facilities. The last figure is the next to the limit of the admissible waiting time.

⊙ *Mechanical System - Equipments*

⊙⊙ *Unloading of the railway cars*

The unloading facilities of the cars will be sized to attend trains of 63 tons cars and may consist of a discharge hopper with 3 outlets each one discharging on a belt feeder.

⊙⊙ *Belt conveyors systems.*

In the first stage the belt conveyors of the TC-1 and TC-2 type will transfer the material from the hopper to the storage yard. From these, the conveyors TC-4 and TC-6 will be used as reclaimer lines and TC-5 for piling up of the material. The belt conveyors TC-8 and TC-9 will transfer the coal to the TC-10 and this to TC-12. The transport band of the pier (TC-14) will receive the material from the conveyor TC-12 and feed the ship loader. In this stage when the flow of coal will be transfered from the storage yard to the ships, the conveyors TC-4, TC-6, TC-8 and TC-9 will operate at a capacity of 1,000 tons/hour and TC-10, TC-12 and TC-14 at a capacity of 2,000 tons/hour, due to the reclaiming system.

In the second stage since the reclaiming of the coal will be made by reclaimers, the belt conveyors will operate at a full capacity and the transport bands TC-8 and TC-9 will not discharge simultaneously on TC-10.

In the third stage since the stockyard will be increased by one more pile and will dispose of an additional ship loader, the number of conveyors will be increased as follows:

TC-3 will receive the coal from TC-2 and will discharge on the piling conveyor TC-7.

The sequential transport bands TC-11, TC-13 and TC-15 which will receive the material from TC-9 will feed the second ship loader.

Some of the conveyors will be equiped with magnetic separators and weighting devices.

oo *Piling*

In the initial and second stages the piling up of coal will be made by one stacker and in the third stage by an additional stacker for the third pile.

Compacting of the pile will be done by mean of tractors on tracks (one by stacker).

oo *Storage Yard*

The width of the piles has been fixed in 35 meters for the three stages. Their length will vary to attend the volume of coal to be stored.

Each pile may be divided in 3 sections to allow the storage of three different types of coal.

Free areas around the sections will be provided to allow the circulation of shovel cars and tracks for cleaning, and to spread incandescent coal from the spontaneous burning which might occur.

Coal piles have a rest angle of 35º. However when compacted in layers of 0.5 to 1 meter, this angle can be increased up to 45º, and the corresponding specific gravity increases by approximatly 20%. A fire warning should be considered.

The sizes of the piles have been determined to attend the foreseen shipment of coal corresponding to about one month storage.

In the initial stage two piles of 3.5 meters will be formed corresponding to a total maximum storage of 254,000 tons.

In the second stage the lenght th of the piles will be increased to 8.5 meters corresponding to a maximum storage of 508,000 tons.

In the third stage the storage yard will be increased by a third pile and all of them to a length of 15 meters corresponding to a total storage of 1,000,000 tons maximum.

c) *Reclaiming*

In the first stage there will be two lines of reclaiming by the means of four shovel cars and two mobile hoppers, in such a way that each hopper will feed a belt conveyor of a 1,000 tons/hour capacity in this first stage. This capacity is limited by the system of reclaiming using front-end-loaders shovel cars and mobile hoppers.

The hoppers will be fitted on the same track as of the future reclaimers. They will not be motorized and will be moved by the shovel cars through wire ropes.

In the second phase two reclaimers of bucket wheel type will be installed and the mobile hoppers will then be used in case of emergency or to load the coal which would not be picked up by the reclaimer.

oo *Ship Loading*

In the first and second phases the loading facilities will consist of one ship loader to attend ships from 20,000 TDW to 150,000 TDW . In the third phase a second identical loader will be installed. In the first stage the loader will operate a capacity of 2,000 tons/hour when the coal flows from the stockyard to the ships, and at a full capacity when the flow goes directly from the unloading station to the ships.

oo *Electrical Installations*

The electrical installations will include a main high voltage substation for reducing to medium voltage (probably 13.8 Kv). This main substation will feed various secondary substations to be located as near as possible of the consuming points, the unloading station, the stockyard equipment and the pier equipment . In addition a low voltage network will be provided for the illumination in the various areas especially in the stockyard to allow night operation.

For that purpose high lamp posts (from 25 to 30 meters) will be installed. The distribution network will be partly aerial line and partly underground depending upon the case (considering both the economical and operacional factors).

The heavy power equipment will be feed with medium voltage current from 4.16 Kv to 6.6 Kv in order to avoid large diameter cables and excessive energy losses in the distribution. In addition, a central control system as well as radio and telephone networks will be provided.

In the case of the off shore and Nacala facilities, an additional budget item will have to be considered for the installation of a high voltage line (138 Kv or 220 Kv). In the Zambeze river mouth facilities of that line will be of about 90 km long and of about 15 km for Nacala. As far as Beira Estuary facilities is concerned, such a provision will not be necessary since a high voltage line exists close to it.

7.2.3 Lacustrine Terminals

Consist of two terminals on the Cahora Bassa Lake, named:

- Loading terminal in Mucanha (Volume 2 - 2.29)
- Unloading terminal in Nhancapirire (Volume 2 - 2.30)

The coal reclaimed from the washing unit gets into the loading terminal by a belt conveyor where loaders feed barges that carry the product as far as the Nhancapirire terminal. The latter one has the purpose of receiving the coal and load it into the rail wagons that carry the product up to the sea terminal already described.

o Construction Steps of the Terminals

- Loading in the Mucanha Terminal

In the initial phase it was foreseen an annual handling of 1,000,000 tons increasing up to 3,000,000 tons/year in the second phase and up to 6,000,000 tons/year in third phase.

Due to the short distance between the coal treatment unit and the terminal (about 2 km) the stockyard of this unit will serve also the terminal. The characteristics of the yard will be described in the study related to the washing unit.

From this yard the coal will be carried up to the terminal through a belt conveyor and loaded in 4 barges convoys of 2,200 tons of coal each.

For the calculation of the different equipment capacities in the terminal it was taken into account the third phase handling and it was applied the following calculations criteria:

$$\frac{6{,}000{,}000 \text{ tons/year}}{8{,}800 \text{ tons/convoy} \times 300 \text{ days/year}} = 2.3 \text{ convoy/day}$$

Thus, the maximum loading time would be:

$$\frac{20 \text{ h}}{2.3} - 2\text{h (General shiftings)} = 6.7 \text{ h}$$

The nominal loading capacity would be:

$$\frac{8{,}800 \text{ tons}}{0.7 \text{ (efficiency)} \times 6.7} = 1{,}900 \text{ tons/hour}$$

It was foreseen 2 (two) twin boom barges loaders for this loading with nominal capacity of 950 tons/hour, that is, 475 tons/hour in each boom. Each equipment will be able to operate two barges simultaneously.

In the first two phases it will be employed only one loader that will serve a minor number of barges per day in an average of 1.15 convoys/day.

- *Nhancapirine unloading*

Such as in the loading of 6,000,000 tons/yearly of coal in the second phase, the unloading terminal will be able to receive 2.3 convoys/day in average and the maximum unloading time would be of 6,7 hours. In that way the nominal capacity would be:

$$\frac{8{,}800 \text{ tons}}{0.5 \text{ (efficiency)} \times 6.7\text{h}} = 2{,}600 \text{ tons/hour}$$

This operation could be made for 2 (two) twin boom unloaders barges, with 1,300 tons/hour nominal capacity, that is, 650 tons/hour in each boom. Each equipment will operate 2 barges simultaneously, and the bucket control operation will be independent.

In the first two phases will be employed only one unloader which will serve a minor number of barges per day in an average of 1.15 convoys/day.

- *Nhancapirire stackyard*

1st. and 2d. phases: with 2 (two) piles, 1 (one) stacker, 2 (two) belt conveyors for piling and rail wagons feeding directly from the piles by 3 (three) wheel loaders, handling up to 3,000,000 tons/year.

3d. phase: the 2 (two) piles will have its lengths increased with the same initial width. In addition to the equipment that have already been foreseen in the first phase, it will be necessary to get one more stacker to permit handling up to 6,000,000 tons/year in the yard.

- *Reclaiming in Nhancapirire*

If similar premises to the unloading wagons in the Sea Terminal are adopted, the reclaiming capacity will be:

3d. phase:

$$\frac{329 \text{ wagons/day} \times 57 \text{ tons/wagon}}{13.4 \text{ h/day}} = 1,400 \text{ tons/hour (3 wheel loaders)}$$

In the two first phases will be employed the same wheel loaders to avoid an increase in the train waiting time in the terminal. Due to the low investment cost it is recommended to buy one more wheel loader to stand by.

- *Civil Works*

In both Mucanha loading and Nhancapirire unloading station the civil works are simple and consist basically of:

- Floating pontoons (one in the first and second phase and two in the third one) of about 100 meters long and 12 meters wide in which the barges will be berthed. The loading and unloading equipments will be mounted on these pontoons.

- Access bridge including three independent half mobile sections to fit with the large variations of level in the reservoir (from 306.4 meters to 329.0 meters, that is, difference of level of 22.6 meters). These numbers have been computed by mathematical simulation based on data collected during the last 50 years (1930-1979) and taking into account the water fall statistics, the flow of the upper rivers including the Cariba reservoir on the Zambia-Zimbabwe border, the consumption for the power generation units and flooding downward the dam.

In that way, each section will be free to incline up to 21.5% (7.53/35) which is lower than the maximum allowable inclination for coal belt conveying systems. Such a solution is not a new one and has already been used in various river and lagoon ports, particularly in Brazil on the Amazonas River where the level differences during the year are also important.

- Structural steel support for the transport bands which level will have to be of 330 m up to the access bridge. In order to reduce the weight of this structure part of it will be mounted on an earth embankment protected by rip-rap.

- Administration and operation building and facilities.

- Civil works of the electrical equipments (base of transformers, underground cable ducts, post lamps, etc.).

- Water distribution network, drains.

- Earth moving of the stockyard area in the Nhancapirire port (the railway line is included in the Nhancapirire-Tete- Moatize junction).

- Dragging of a small part of the port down to 304 meters deep.

- Access roads to the port.

- In the case of the Nhancapirire unloading port, it will be necessary to build a shipyard for assembling and repairing the barges and pontoons since it will not be possible to transfer them to another place.

The mechanical workshops of the shipyard will also be used for the maintenance of port equipments. In the Mucanha port case, the maintenance will be done in the same mechanical shop of the mine and upgrading units equipments.

Mechanical System - Equipment

Belt conveyors

- *Mucanha loading port*

For all stages the belt conveyor TC-1 will run the stock yard in the upgrading unit to the port.

In the port the coal will be transfered on the transport band TC-2 up to the access bridge. The flow of coal will then be divided in two belt conveyors (TC-3 and TC-4) feeding various others transport bands (TC-5/7 and TC-6/8). Just one line of conveyors will be installed during phase 1 and 2.

On the floating pier, the transport band TC-9 fed by TC-7 will transfer the coal on TC-11 which will feed the ship loader CB-2. The ship loader CB-2 will be fed by the transport band TC-10.

In both stages the belt conveyor TC-1 and TC-2 will run at a capacity of 1,900 tons/hour and the TC-3/11 at 950 tons/hour. Some of the belt conveyors will be equipped with weighing and magnetic separation devices.

- *Nhancapirire unloading facilities*

In all stages the belt conveyors TC-1 and TC-2 will be fed by the ship unloaders DB-1 and DB-2 and then the product will be transfered in two lines of belt conveyors (TC-3/5/7/9/11 and TC-4/6/8/10) up to the stockyard. From these the belt conveyors TC-12 and 13 will respectively operate together with the stacker E-1 and E-2. In the first and second stage only one line will be installed.

All the transport bands will run at a nominal capacity of 1,300 tons/hour.

Some of the belt conveyors will also be equipped with weighing and magnetic separation devices.

Muge

oo *Mucanha barge loading facilities*

In the first and second stages the port will be equipped with one ship loader to attend barges of 2,200 tons and in the third stage with two. The capacity of each loader is 475 tons/hour and they will be able to load two barges at the same time.

oo *Nhancapirire barge unloading facilities*

In the first and second stages the port will be equipped with one unloader and a second one will be added in the third stage. They will be sized to attend 2 barges (2,200 tons) at the same time and will have a lowly capacity of 650 tons/hour.

oo *Stacking in Nhancapirire*

In the first and second phase there will be one stacker of 1,300 tons/hour and in the third phase there will be two more with the same capacity.

It will be used track tractor to compact the coal piles. It was foreseen 1(one) tractor operating with each stacker.

∞ *Stockyard in Nhancapirire*

The width of piles was fixed in 35m to the first two initial phases, and its length will change according to the coal hanling increase.

Each pile could be subdivided into 3 sections to permit stocking of different kinds of coal.

There will be adequate spaces around the piles to permit their cleaning by wheel loaders and tractors and also to make possible to spread the incandescent coal in case of spontaneous firing.

When in piles the coal permits a rest angle of about 35º. However, when compacted by layers of 0.5m to 1.0m, it can reach 45º or more and the specific weight is increased in about 20%.

The piles dimensions were stablished according the estimated handling of coal to stocks of about 10(ten) days.

At first and second phases it will be formed into 2(two)piles of 5m high and 340m long. That will correspond to a maximum stock of 83,300 tons.

In the third phase the 2(two) piles will have their length increased to 670m corresponding to a maximum total stock of 166,600 tons.

Reclaiming in Nhancapirire

The foreseen reclaiming will be made by wheels loaders directly to the wagons. This system permit each wheel to handle 500 tons/hour in average.

Due to the low investment and to avoid a bigger trains permanence time it was foreseen that for the first phase 3 (three) wheel loaders will be bought in order to achieve an operation capacity of 1,400 tons/hour and in the third phase one more should be bought to stand by.

Electrical Instalations

- *Loading Terminal*

Considering that the main substation will serve the Mining Complex the terminal will need just a substation that will feed in medium voltage the belt conveyors and the loaders and in low voltage the illumination area and the building. The comunications system by radio and telephone will be linked to the Mining Complex.

- *Unloading Terminal*

It will be necessary one high voltage line (probably 220 Kv) which will receive energy from Cahora Bassa Hidroeletric, a distance of about 25 km. There will be a main substation which will change the energy to medium voltage (probably 13.8 Kv) distributing it to the auxiliary substations that will serve the stockyard equipments to the pontoons and shipyard, as well in low voltage to the area illumination and the buildings. There will be a system of radio and telephone communications.

7.2.4 RIVER TERMINALS

- *Construction Steps of the Terminals*

- *Introduction*

As the lake terminals, the fluvial terminals have 3 phases for handling; the first to 3,000,000 tons/year, the second to 6,000,000 tons/year and the third to 10,000,000 tons/year, identical to the sea terminal, because the coal from Mucanha will be joined to the Moatize Coal.

- *Loading terminal near Tete*

Both Mucanha and Moatize coal will get to this terminal by wagons, the first directly from Moatize and the second from Nhancapirire terminal which transfers the coal from the barges to the wagons.

In that way the unloading of wagons will be made as it was described before to the sea terminals. The capacity of the stockyard however will be smaller, because while in the sea terminal the stock was calculated for 1 month, here it is identical to the Nhancapirire terminal, that is, 10 days.

The loading will be similar to the Mucanha terminal, that is, the reclaiming of piles will be made by wheel loaders.

The convoys composed of 6 barges with capacity of 1,500 tons each will transport 9,000 tons in average. The calculations will be as follows:

$$\frac{10,000,000 \text{ tons/year}}{9,000 \text{ tons/convoy} \times 320 \text{ days/year}} = 3.5 \text{ convoys/days}$$

Thus, the maximum loading time will be:

$$\frac{20 \text{ h}}{3.5} - 2 = 3.7 \text{ hours.}$$

And the nominal capacity will be:

$$\frac{9{,}000 \text{ tons.}}{0.7 \text{ (efficiency)} \times 3.7 \text{ hours}} = 3{,}475 \text{ tons/hour}$$

For the loading operation, it was foreseen 3 (three) twin boom barge loaders with nominal capacity of 1,200 tons/hour each or 600 tons/hour for each boom. Each equipment can work 2 barges simulta neously.

In the first and second phase, it will be used 1 (one) and 2 (two) loaders respectively.

- *Unloading at Zambeze estuary in Chinde River*

It will be made as in Nhancapirire. If we consider a yearly volume of 10,000,000 tons and a efficiency of 50% (that is less than in loading terminals), we will have:

$$\frac{9{,}000 \text{ tons}}{0.5 \text{ (efficiency)} \times 3.7 \text{ hour}} = 4{,}865 \text{ tons/hour}$$

This operation can be made by 3 (three) twin boom barge unloa ders with one grab per boom, and nominal capacity of 1,650 tons/ hour or 825 tons/hour each boom. Each equipment can operate 2 barges si multaneously and the operation controls to each grab will be independent. In the first and second phases it will be used 1 (one) and 2 (two) unloaders, respectively.

The stockyard of the unloading terminal is identical to the sea terminal.

- *CIVIL WORKS*

There will be present different structural characteristics from the lake terminals because they will be of fixed type, and in the third phase 3 berths will be necessary, because the river level va riation should not exceed 5 m near the loading terminal and 2 m in the unloading terminal.

• Mechanical System - Equipments

•• Loading Terminal in Tete

- *Wagons unloading*

The wagons unloading station will be designed to handle trains formed by wagons with 63 tons capacity and will constitute one receiving hopper with 3 (three) outlets where under each one a belt feeder was foreseen.

- *Belt Conveyors*

From the stockyard the coal will be reclaimed by wheel loaders and mobile hoppers to a belt conveyor system of one line in the first phase, 2 (two) in the second phase and 3 (three) in the third phase, each one ending in the respective loader located on an independent pier.

The railway system will be similar to the lake terminal in Mucanha.

- *Stacking*

In the initial phase there will be 1 (one) stacker and in the third phase it is foreseen to install one more stacker of the same characteristics to form the third pile.

It will use track tractors to compact the coal piles. It is foreseen 1 (one) tractor operating with each stacker.

- *Reclaiming*

In the initial phase there will be 2 (two) lines for reclaiming that will be made by 4 (four) wheel loaders and 2 (two) mobile hoppers, in such a way that each hopper will feed a belt conveyor, that in this phase, will operate with 1,000 tons/hour capacity due to the capacity limitation of the reclaiming system by wheel loaders and mobile hopper.

The hoppers will be installed on the same rails of the future reclaimers. They will not have motorization and will be trailed by the wheel loader through wire ropes.

In the second phase will be installed 2 (two) bucket wheel reclaimers and the mobile hoppers will be used to work in case of emergency, or to load the coal that is not reclaimed.

- *Barges loading*

In the first phase there will be one with 1,200 tons/hour capacity, in the second phase there will be 2 (two) and in the third phase there will be 3 (three), all with the same capacity.

9.2 - Figuras 9.2.31 e 9.2.32)

Unloading Terminal in Chinde (Volume 2-2.31 and 2.32)

- *Barges unloading*

In first phase, there will be one with capacity of 1,650 tons/hour; in the second phase there will be 2 (two) and in the third phase 3 (three) unloaders, always with the same capacity.

- *Belt conveyor*

In the pier it will be installed 3 (three) sequential lines of belt conveyor, one for each unloader, being only one in the access bridge with triplicated capacity. In the stockyard the belt conveyors lines will be identical to those in the sea terminals yards.

- *Stacking*

In the first and second phases there will be one stacker with 4,900 tons/hour capacity and in the third phase there will be 2 (two).

- *Reclaiming*

In the initial phase there will be 2 (two) reclaiming lines of coal that will be made by 4 (four) wheel loaders and 2 (two) mobile hoppers in such a manner that each hopper will feed one belt conveyor, that in this phase will operate at a capacity of 1,000 tons/hour due to the capacity limitation of the reclaiming system by wheel loader and mobile hoppers.

The hoppers will be installed on the same rails of the future reclaimers. They will not be motorized and will be by wheel loaders through wire ropes.

In the second phase will be installed 2 (two) bucket wheel reclaimers and the mobile hoppers will be used to work in case of emergency, or to load the coal that is not reclaimed.

- *Ship loading*

In the first and second phases the terminal will have one ship loader to handle ships of 20,000 TDW to 100,000 TDW capacities. In the third phase should be installed one more shiploader of the same characteristics.

In the initial phase the shiploader will operate at 2,000 tons/hour when the coal flow goes from stockyard to the ships. However, in the case of direct flow from the wagon unloading station to the ships the shiploaders can operate at a full load.

- *Electric Installations*

They will have similar characteristics of the fluvial terminals, and in the terminal near to Tete it will be necessary to install one high voltage line for a estimated extension of 10 km from the existent line and in the unloading terminal this line will be used and the main substation that serves the sea terminal.

9.7.2.5

7.2.5 Barges, TUGS, Navigation aids and Protection Works of Waterways

- *In Cahora Bassa Lagoon*

The coal transport between the load terminal in Mucanha and the unloading one in Nhancapirire should be done by using convoys composed by one tug and 4 (four) barges. The distance to cover is 108 km long being the major part in West-east direction along the course of the Zambeze old river-bed, that is, in deep waters even in dry weather periods when the lagoon level can decrease until 306.4m(the river-bed level is less than 300 m). Only near the terminal will be necessary some dredging to assure the minimum depth of 3 m[1]. The average speed of convoy should be 5.0 Knots (~10 km/h).

The basic characteristics of barges and tugs are as following presented, based in more detailed studies previously made on this transport.

Barges

Type: double hull, with one hold to transport solid bulk materials.

Volume capacity:	2,700 m^3
Load capacity:	2,300 tons (density of 0.85 tons/m^3)
Length:	85 m
Breadth:	12.5 m
Maximum draft:	2.5 m

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(1) The level 306.4 m is the minimum limit which is very unusual to occur; however for practical effects it can be considered the value of 307 or 308 m. The maximum level is 329 m.

Tugs

Length: 41 m

Breadth: 11 m

Depth: 2.7 m

Maximum draft: 1.5 m

Engine output: 2,000 HP

During the project these characteristics can be changed.

The route between the two terminals will be signalized by nautical buoys with flash to permit the nightly navigation and with the help of radar under bad condition of visibility (fog). The la goon has natural areas near the edge to protect the convoys, in case of blowing hard winds. The maximum high wave foreseen de pends upon winds of 18 to 25 km/h is 1.35 m high which might occur during a period time of 5 to 10% of the year.

The number of the necessary convoys for the transport will depend upon loading and unloading speeds, as well as on duration of course and maneuver.

For the first and second phases of 1,000,000 tons/year and 3,000,000 tons/year the loading and unloading times will be 13.4 hours, considering 4 hours for manoeuver (2 hours to each terminal) and 22 hours to the course of 216 km (108 m x 2) at 10 km/hour it will have 13.4 + 13.4 + 4 + 22 = 52.8 hours. Adding 10% for eventual de lays and pauses it will have a total of 58 hours.

In the third phase of 6,000,000 tons/year the loading and unloading times will be the half, that is, 6.7 hours and to give a rounded value for the trip time, we will have 6.7 + 6.7 + 4 + + 22 = 39.4. Adding 10%, we will have 44 hours. Thus, we can do the following numbers of trips by year considering 320 available days for operation.

1st. and 2d. phases

320 days x 24 hours ÷ 58 = 132.41 ≅ 132 trips

3d. phase

320 x 24 ÷ 44 = 174.54 ≅ 174 trips

So, it is needed:

1,000,000 ÷ (132 x 8,800) = 0.86 ≅ 1 convoy for the 1st. phase
0.86 x 3 = 2.58 ≅ 3 convoys for the 2d. phase

6,000,000 ÷ (174 x 8,800) = 3.92 ≅ 4 convoys for the 3d. phase

1st. phase - 1 tug and 4 barges
2d. phase - 3 tugs and 12 barges
3d. phase - 4 tugs and 16 barges

It was assumed that the barges maintenance will be made during the other 45 available days (365-320).

* *In Zambeze River*

The coal transport will be done between the loading terminal near Tete and another in Chinde river, that is, one of the branches of Zambeze estuary, that should be dredged for a total length of 500 km, and also should be rectified and protected. It should have signals along all the route.

In the same manner that the ships that will run on the lake, is presented one preliminary estimate with basic characteristics based on information of more detailed studies already done concerning the same subject.

- Barges

Type:	double hull, with one hold to transport solid bulk materials
Load capacity:	2,500 tons for 3.2 m draft and 1,500 tons for 2.2 m draft
Volumetric capacity:	2,950 m^3 (Specific mass 0.85 tons/m^3)
Length:	79 m
Breadth:	11.4 m
Depth:	4.5 m
Maximum draft:	3.5 m

- Tugs

Length:	28 m
Breadth:	10 m
Height:	8 m
Maximum draft:	1.9 m
Engine output:	2 motors of 1250 HP

The convoy will be long type which best adapts to the route, composed by one tug and 6 barges. The convoy would be 265 m long and 23 m wide.

The channel for this navigation will be 80 m wide in the less sinuous sections and 150 m in the sections with curve ratios less than 500 m. The minimum depth will be 3.0 m for 2,200 m^3/s river flow, and if there is a silting up, the convoy may operate with drafts below 2.2 m once the tug has only 1.9 m draft, transporting less cargo volumes while the maintenance dredging is not made in the silting up plans.

The works to be done to make Zambeze river navigable in this passage will include the area dredging to 80 m width and

3 m depth and the edges protection with jetties that will be made of fixed stem of a tree supported underwater and filled up with dredging sand with the budges formed by rock filles.

The extension that will be corrected was estimated in 400 km and the works number in 300 based on previous studies.

Following the same method applied for determining the convoys quantity in the Cahora Bassa lagoon will have:

Loading and unloading times in the 3 phases:

1st. phase - 10.8 hours x 2 = 21.6 hours
2d. phase - 5.4 hours x 2 = 10.8 hours
3d. phase - 3.6 hours x 2 = 7.2 hours

Manoeuvre - 2 hours / terminal = 4 hours

Course - 100 hours (1,000 km ÷ 10 km/h)

10% for delays, unforeseen, etc.

The total times and the trips number will be:

1st. phase - 139 hours 320 x 24 ÷ 139 = 55.25 ≅ 55
2d. phase - 127 hours 320 x 24 ÷ 127 = 60.47 ≅ 60
3d. phase - 123 hours 320 x 24 ÷ 123 = 62.44 ≅ 52

Therefore, it will be needed:

1st. phase - 3,000,000 ÷ (55 x 9,000t) = 6.06 ≅ 6 convoys
2d. phase - 6,000,000 ÷ (60 x 9,000t) = 11.11 ≅ 11 convoys
3d. phase - 10,000,000 ÷ (62 x 9,000t) = 17.92 ≅ 18 convoys

that is,

1st. phase - 6 tugs and 36 barges

2d. phase - 11 tugs and 66 barges

3d. phase - 18 tugs and 108 barges

7.2.6 *Characteristics of the equipment*

o *Sea Terminal*

\- *Wagon Unloading Station*

. *Hopper*

Average capacity .... 3 wagons
With 3 (three) outlets and provided with wearing plates.

. *Belt Feeder*

Nominal capacity	870 tons/hour
Maximum capacity	1,050 tons/hour
Belt width	72"

. *Belt conveyor*

Nominal capacity	2,600 tons/hour
Maximum capacity	3,200 tons/hour
Belt width	60"
Troughed idler	35º
Maximum speed	4.0 m/s

. *Stacker*

Nominal capacity	2,600 tons/hour
Maximum capacity	3,200 tons/hour
Type	slewing and articulated boom with self motor, travelling portal on rails and trailed tripper
Belt width	60"
Portal gauge	8m
Boom outreach	44m

. *Mobile Hopper*

Average volume	10 m^3
Gauge	8 m
Maximum height	3,2 m

. *Wheel loader*

Capacity	4,5 m^3
Type	on wheels

. *Reclaimer*

Nominal capacity	2,600 tons/hour
Maximum capacity	3,200 tons/hour

Type: bucket wheel at slewing and articulated boom, with self mo mor travelling portal on rails.

Belt width	60"
Portal gauge	8 m
Boom outreach	38 m

. *Shiploader*

Nominal capacity	2,600 tons/hour
Maximum capacity	3,200 tons/hour

Type: travelling portal, articulated telescopic boom with teles copic chute.

Belt width	60"
Portal gauge	12 m

. *Belt Weighter*

Nominal capacity	2,600 tons/hour
Maximum capacity	3,200 tons/hour
Belt width	60"
Troughed idlers	35º

. *Magnetic Separator*

Nominal capacity............................ 2,600 tons/h
Maximum capacity............................ 3,200 tons/h
Belt width.................................. 60"
Troughed idler.............................. 35º

. *Sampling Station*

It is foreseen one sampling station provided with 1(one)crusher 1(one) vibrating screen and belt conveyor with small capacity.

. *Tractor*

Blade width................................. 3m
Type.. on track

. *Truck crane*

To make general services of maintenance it was foreseen 1(one) truck crane on tire with telescopic and slewing boom

. *Truck for lubrication*

For preventive maintenance of the terminal equipments it is foreseen the employment of 1(one) truck for lubrication

. *Workshop truck*

For small maintenance of equipments that can't be transported to the workshop it is foreseen the employment of 1(one) workshop truck.

- Lake Terminal

  - Loading Terminal

    . Belt conveyors

	Type 1	Type 2
Nominal capacity...........................	1,900 tons/hour	950 tons/hour
Maximum capacity...........................	2,300 tons/hour	1,150 tons/hour
Belt width.................................	54"	36"
Troughed idler.............................	35º	35º
Maximum speed..............................	4 m/s	4 m/s

. Barge loader

Nominal capacity by slewing..............	475 tons/hour
Maximum capacity by slewing..............	570 tons/hour
Type.....................................	travelling portal on rails, telescopic slewing telescopic chute
Belt width...............................	30"
Portal gauge	8m

. Belt Wrighter

Nominal capacity.........................	1,900 tons/hour
Maximum capacity.........................	2,300 tons/hour
Belt width...............................	54"
Troughed idler...........................	35º

. Magnetic separator

Nominal capacity.........................	1,900 tons/hour
Maximum capacity.........................	2,300 tons/hour
Belt width	54"
Troughed idlers	35º

. *Truck for Lubrication*

For preventive maintenance of the terminal equipment it is foreseen to use one truck of lubrication.

. *Workshop truck*

For the small maintenance of the equipment that can not be transported to the workshop it was foreseen the employment of one workshop truck

- *Unloading Terminal*

. *Barge Unloader*

Nominal capacity by slewing	650 tons/hour
Maximum capacity by slewing	800 tons/hour
Type	rope trolley with travelling portal on rails
Portal gauge	8m
Outreach (until the center of the equipment)	

. *Belt conveyors*

Nominal capacity	1,300 tons/hour
Maximum capacity	1,600 tons/hour
Belt width	42"
Troughed idlers	35º
Maximum speed	4 m/s

. *Stacker*

Nominal capacity	1,300 tons/hour
Maximum capacity	1,600 tons/hour
Type	telescopic outreach articulated, travelling portal on rails
Belt width	42"
Gauge	8m
Maximum boom outreach	44m

. *Wheel loader*

Capacity..................................	4.5 m^3
Type......................................	on wheels

. *Belt weigher*

Nominal capacity..........................	1,300 tons/hour
Maximum capacity..........................	1,600 tons/hour
Belt width................................	42"
Troughed idler	35º

. *Magnetic separator*

Nominal capacity..........................	1,300 tons/hour
Maximum capacity..........................	1,600 tons/hour
Belt width................................	42"
Troughed idler	35º

. *Tractor*

Blade width...............................	3m
Type......................................	on track

. *Truck crane*

To make general services of maintenance it was foreseen one truck crane on tire with telescopic and slewing bloom.

. *Truck of Lubrication*

For preventive maintenance of the terminal equipment it was foreseen the employment of one truck of lubrication.

. *Workshop truck*

For small maintenance of equipment that can not be transported to the workshop it was foreseen the employment of one workshop truck.

o River terminals

- Loading Terminal

. Belt conveyors

	Type 1	Type 2
Nominal capacity	3,500 tons/hour	1,200 tons/hour
Maximum capacity	4,200 tons/hour	1,440 tons/hour
Belt width	60"	36"
Troughed idlers	35º	35º
Maximum speed	4 m/s	4 m/s

. Barges loader

Nominal capacity by slewing	600 tons/hour
Maximum capacity by slewing	720 tons/hour
Type	travelling portal on rails telescopic slewing, telescopic chute
Belt width	30"
Portal gauge	8m

. Belt weigher

Nominal capacity	3,500 tons/hour
Maximum capacity	4,200 tons/hour
Belt width	60"
Troughed idlers	35º

. Magnetic separator

Nominal capacity	3,500 tons/hour
Maximum capacity	4,200 tons/hour
Belt width	60"
Troughed idlers	35º

. *Truck of Lubrication*

For preventive maintenance of the terminal equipments it was foreseen the employment of one truck of lubrication

. *Workshop truck*

For the small maintenance of equipment that can not be transported to the workshop it was foreseen the employment of one workshop truck.

- *Unloading Terminal*

. *Unloader barges*

Nominal capacity by slewing......... 825 tons/hour
Maximum capacity by slewing .... 990 tons/hour
Type................................ rope trolley with travelling portal on rails

Portal gauge 8m
Outreach (until the center of the equipment)

. *Belt conveyors*

	Type 1	Type 2	Type 3
Nominal capacity............	1,659 tons/hour	2,600 tons/hour	4,900 tons/h
Maximum capacity............	1,980 tons/hour	3,200 tons/hour	5,880 tons/h
Belt width..................	42"	60"	72"
Troughed idlers	35º	35º	35º
Maximum speed...............	4 m/s	4 m/s	4 m/s

. *Stacker*

Nominal capacity............ 4,900 tons/hour
Maximum capacity............ 5,880 tons/hour
Type........................ telescopic outreach, articulated travelling portal on rails

Belt width.................. 72"
Gauge 8m
Maximum boom outreach....... 44m

. *Reclaimer*

Nominal capacity............	2,600 tons/hour
Maximum capacity............	3,200 tons/hour
Type........................	Bucket wheel at slewing and articuled boom,with self motor travelling portal on rails
Belt width	60"
Portal gauge	8m
Outreach....................	38m

. *Ship loader*

Nominal capacity.............	2,600 tons/hour
Maximum capacity	3,200 tons/hour
Type.........................	Travelling portal, articulatel telescopic outreach with telescopic chute
Belt width	60"
Portal gauge	12m

. *Wheel loader*

Capacity.....................	4.5 m^3
Type.........................	on wheel

. *Belt weigher*

Nominal capacity.............	4,900 tons/hour
Maximum capacity.............	5,880 tons/hour
Belt width	72"
Troughed idler	35º

. *Magnetic separator*

Nominal capacity.............	4,900 tons/hour
Maximum capacity.............	5,880 tons/hour
Belt width	72"
Troughed idler	35º

. Tractor

Blade width........................ 3m
Type.............................. on tracks

. Truck crane

To make general services of maintenance it was foreseen truck crane on tire with telescopic and slewing boom

. Truck of lubrication

For preventive maintenance of the terminal equipment it was foreseen the employment of one truck of lubrication.

. Workshop truck

For small maintenance of the equipments that can not be transported to the workshop it was foreseen the employment of one workshop truck.

7.2.7 *Investment and Transportation costs*

• Investment Costs

The investment costs were estimated in U.S. dollar , referred to July/82, for each of the terminal and transportation modes described before, discriminated by the following items:

- Civil Works - includes berthing quays,access bridges,reclamation and earth movement in the land area,railway and road access,foundations of the equipment ,civil works of the electrical installations,buildings and auxiliary installations, water, drawing, fire fighting,sewage and urbanization of the whole area. The dredging of the access channel and the turning basin,due to its significance in the case of the port of Beira was presented separately.

- Handling equipment - Includes all the equipment for handling the coal, even its electrical components. An allowance varying according to the location on the terminal between 20 and 25% of the value of each equipment was allowed for transportation and assembly costs at site.

- Electrical Installation

  - There was applied a percentage varying between 10 to 20% of the value of the equipment including transportation and assembly costs, according to the existence or not of electrical installations in the area. The high tension transmission lines were quoted separately for the terminals at Nhancapirire, Tete, Nacala and Chinde.

- Mobilization - There was made an allowance of around 5% of the civil works.

- Miscellaneous - An allowance of 15% of all items was included for engineering design and site supervision.

In the case of the shipping transport in the Cahora Bassa reservoir and in the Zambeze River the barges and pusher tugs were estimated and considered an allowance of 15%, the construction and improvements of the Zambeze River waterway were assumed as civil works , loading was put apart and navigation aids included as equipment .

Transportation Costs/ton of Coal

The annual operational and maintenance costs were estimated. The investment costs were annualized considering the depreciation rates and the real interest rate of 10% per year discouting inflation. The costs were estimated for three levels of 3 millions, 6 millions and 10 millions tons per year at the sea terminals and for the transportation in the Zambeze River and for 3 million and 6 million tons per year on the terminals and the transportation in the Cahora Bassa reservoir.

In the operational and maintenance costs were included:

- personnel costs plus social charges for the pusher tugs,barges and for each terminal.

- materials for consumption including the food for the tripulation of the tug boats.

- fuel, lubricants and electricity.

- insurance (only for the tugs and barges)

- tugs costs at the sea terminals.

- Maintenance of the civil works (1,5% to 3% of investment in the channel, except for the civil works in the river channel), equipments (7 to 8% except for barges were 3% was applied and the pusher boats with 10%), electrical installations(3%) and dredging (varying according to the local) as for the investments was added for miscellaneous costs.

In the case of dredging and tug assistance in the Beira terminal it was necessary to allocate part of the costs to other freight. For 3 million tons, 50% was allocated to coal, for 6 million 60% and for 10 million 75% considering the growing participation of the coal in the total freight traffic in the port. In the case of the dredging, 50% of the cost to deepen and maintain the channel for the ships up to 30.000 TDW was allocated to other freight considering the present limitation of 20.000 TDW to 22.000 TDW also trampers the ships for different cargoes.

The investment in the shipyard for assembly and repair at Nhacapirire was not included in the costs per ton to avoid double counting, for its costs were included in the construction and maintenance of the tugs and barges which will operate on the Cahora Bassa reservoir.

The lifetime of each item was estimated considering that in Mozambique all the installations and equipment are kept running for very long time. The following values were used:

Civil Works - 40 years

Equipment and electrical installation - 20 years

Tug boats and barges - 15 years

Dredging and protection works were not depreciated allowing necessary higher rates for maintenence. Certain movable equipment like front-end-loader and tractors have a much shorter life time varying between 5 to 10 years, but these values are small in relation to the other equipment and will not affect the results. Table 7.12 and respective Appendix II shows cost estimations.

[redacted]BLE[redacted]2 -[redacted]AL [redacted]LIN[redacted]D W[redacted]WAY[redacted]ANS[redacted]ATIO[redacted]OST[redacted]SU[redacted]

1 - MUCANHA-NHANCAPIRIRE ALTERNATIVES: TRANSPORTATION AND HANDLING COST FOR 1 x 10^6 TONS/YEAR; 3 x 10^6 TONS/YEAR; 6 x 10^6 TONS/YEAR.

	DIRECT COSTS US$ 1,000			INDIRECT COSTS US$ 1,000			TOTAL COSTS US$ 1,000			COSTS PER TON US$ 1.00		
	1st PHASE	2st PHASE	3st PHASE	1st PHASE	2st PHASE	3st PHASE	1st PHASE	2st PHASE	3st PHASE	1st PHASE	2st PHASE	3st PHASE
LOADING TERMINAL AT MUCANHA	1,117.6	1,653.0	2,204.1	673.0	673.0	844.3	1,790.6	2,326.0	3,048.4	1.79	0.78	0.51
LAKE TRANSPORTATION	1,005.2	2,925.6	3,885.8	595.0	1,635.0	2,155.0	1,600.2	4,560.6	6,040.8	1.60	1.52	1.01
UNLOADING TERMINAL AT NHANCAPIRIRE	1,782.8	2,388.9	3,746.6	1,052.6	1,052.6	1,486.9	2,835.4	3,441.5	5,233.5	2.84	1.15	0.87
TOTAL COST	3,905,6	6,967.5	9,836.5	2,320.6	3,360.6	4,486.2	6,226.2	10,328.1	14,322.7	6.23	3.45	2.39

2 - TETE-CHINDE ALTERNATIVES: TRANSPORTATION AND HANDLING COST FOR 1 x 10^6 TONS/YEAR; 3 x 10^6 TONS/YEAR; 6 x 10^6 TONS/YEAR.

LOADING TERMINAL AT TETE	2,091.0	3,307.2	4,122.0	439.4	585.9	700.9	2,530.4	3,893.1	4,822.9	0.84	0.65	0.49
RIVER TRANSPORTATION	7,193.7	12,551.0	20,051.1	4,677.5	7,510.9	11,477.5	11,871.2	20,061.9	31,528.6	3,96	3.34	3.15
UNLOADING TERMINAL AT CHINDE	12,729.5	17,492.7	23,516.6	7,680.4	8,837.3	11,945.0	20,409.9	26,330.0	35,461.6	6.80	4.39	3.54
TOTAL COST	22,014.2	33,350.9	47,689.7	12,797.3	16,934.1	24,123.4	34,811.5	50,285.0	71,813.1	11.60	8.38	7.18

3 - SEA TERMINAL: CHINDE ALTERNATIVE (TRAIN ARRIVAL) HANDLING COST FOR 1 x 10^6 TONS/YEAR; 3 x 10^6 TONS/YEAR; 6 x 10^6 TONS/YEAR.

LOADING AT CHINDE	11,590.7	15,399.9	22,666.7	7,595.9	8,696.6	11,748.0	19,186.6	24,096.5	34,414.7	6.40	4.02	3.45

4 - SEA TERMINAL: NACALA ALTERNATIVE - HANDLING COST FOR 1 x 10^6 TONS/YEAR; 3 x 10^6 TONS/YEAR; 6 x 10^6 TONS/YEAR.

LOADING AT NACALA	4,186.8	6,564.2	9,709.9	2,256.9	3,009.4	4,251.4	6,443.7	9,573.6	13,961.3	2.15	1.60	1.40

5 - SEA TERMINAL: BEIRA ALTERNATIVE (STUARY) - HANDLING COST FOR 1 x 10^6 TONS/YEAR; 3 x 10^6 TONS/YEAR; 6 x 10^6 TONS/YEAR.

LOADING AT BEIRA	4,128.5	6,470.2	9,718.2	3,542.9	4,937.3	6,992.6	7,671.4	11,408.1	16,710.8	2.56	1.90	1.67

8 - ECONOMICAL EVALUATION OF TRANSPORT ALTERNATIVES

8. ECONOMICAL EVALUATION OF TRANSPORT ALTERNATIVES

Aiming at selecting the most economical transport alternative for the coal outflow from the future Mucanha/Vuzi mines to a sea terminal at Mozambique Coast, the considered alternatives were compared in terms of the operational and total transport costs per ton.

It was simulated several coal production levels taking into account the coal to be produced in the Mucanha/Vuzi and Moatize mines. For the sake of comparison of the costs per ton, it was also accepted the hypothesis of transporting only the coal produced in Moatize mines at a level of 1.5×10^6 tons/year and 2.0×10^6 tons/year.

For the present study, the economical evaluation of alternative coal outflow from Mucanha/Vuzi and Moatize mines were developed only in terms of costs (considering capital investments and operational costs per ton transported), because:

- The regional impact of transport improvements in developing economies is extremely high and with peculiar characteristics for each case. At present time it would not be possible to carry out a study on impact evaluation due to its high costs and timing required.

- Besides the regional impacts, the improvement in transportation systems would benefit also the Mozambique economy by increasing foreign currency revenue with the increase in transportation services rendered to the neighboring countries. For the same reason as before - cost and time - it would not be possible for an evaluation of the multiplying effects of the increasing foreign currency revenue on Mozambique economy since it would require a long survey on the investment programs and opportunities and production effects as well.

8.1 Investment Costs

Although it has been staggered in time the coal outflow from Mucanha/Vuzi and Moatize mines, for the sake of comparing it with the forecasted traffic of other non coal products and transport capacity analysis, the investments were shown up in an independent manner and totalized for the production levels in each year.

For a stepwise analysis of investments it shall be considered as increment for each additional production level, the difference between the correspondent yearly investment and the preceding one.

Table 8.1 shows total investment costs in terminals for each alternative being the full details explained in item 7.2.

Table 8.2 shows estimated investment costs in navigation, which means tug boats, barges, dredging and protection services, signalling and buoys, being the full details also presented in item 7.2.

Table 8.3 shows total investments in wagons and locos for Mucanha/Vuzi and Moatize separately for each alternative. Full details on calculations are in the railway operational studies.

An aggregated view of investments by alternatives is shown in Table 8.4 based on studies from Chapter 7. This Table shows total investment costs and allocated costs on coal transportation. The accepted criteria for sharing investment costs between coal and other non coal traffic were:

- Railway investments in new connections, rehabilitation, upgrading and terminals were prorated between coal and general freight proportionally to the gross tonnages transported for each, showed in the railway operation item.
- For railway signalling and telecommunications, investment costs were prorated proportionally to trains x km/day required for the coal transported from Mucanha/Vuzi and Moatize mines and general freight as it can be seen in Table 8.5.

TABLE 8.1 - TOTAL INVESTMENT COSTS IN TERMINALS

in US$ 1,000 JUL.82

TERMINALS	M/V - $1x10^6$ tons	M/V - $3x10^6$ tons	M/V $6x10^6$ tons
	MO - $2x10^6$ tons	MO - $3x10^6$ tons	MO $4x10^6$ tons
	TOTAL- $3x10^6$ tons	TOTAL- $6x10^6$ tons	TOTAL-$10x10^6$ tons
1. RAILWAY	5,999	7,726	11,695
. Civil Works	5,939	7,606	11,575
. Equipment	60	120	120
2. MUCANHA (LAKE)	16,460	16,460	20,969
. Civil Works	4,590	4,590	6,750
. Equipment	8,170	8,170	10,519
. Dredging	3,700	3,700	3,700
3. NHANCAPIRIRE (LAKE)	24,525	24,525	36,053
. Civil Works	8,280	8,280	10,700
. Equipment	14,545	14,545	23,653
. Dredging	1,700	1,700	1,700
4. TETE (RIVER)	26,067	43,624	55,192
. Civil Works	11,350	15,310	18,710
. Equipment	14,717	28,314	36,482
5. CHINDE OFF SHORE	290,620	331,294	454,023
. Civil Works	171,510	175,960	196,410
. Equipment	119,110	155,334	257,613
6. BEIRA	146,216	186,716	247,959
. Civil Works	27,850	30,550	45,350
. Equipment	31,866	47,166	68,109
. Dredging	42,500	65,000	90,500
. Signalling and Buoys	44,000	44,000	44,000
7. NACALA	59,022	75,422	107,812
. Civil Works	32,400	35,100	50,200
. Equipment	26,622	40,322	57,612

M/V = Mucanha/Vuzi

MO = Moatize

TABLE 8.2

ESTIMATED INVESTMENT COSTS IN NAVIGATION

(US$ 1,000 JULY 1982)

MUCANHA/VUZI → MOATIZE → TOTAL →	1×10^6t 2×10^6t 3×10^6t	3×10^6t 3×10^6t 6×10^6t	6×10^6t 4×10^6t 10×10^6t
1. CAHORA BASSA LAKE			
MUCANHA-NHANCAPIRIRE	9,300	24,900	32,700
o TUGS	3,000	9,000	12,000
o BARGES	4,800	14,400	19,200
o DREDGING AND PROTECTION	–	–	–
o SIGNALLING AND BUOYS	1,500	1,500	1,500
2. ZAMBEZE RIVER			
TETE – CHINDE	101,100	143,600	203,100
o TUGS	15,000	27,500	45,000
o BARGES	36,000	66,000	108,000
o DREDGING AND PROTECTION	47,100	47,100	47,100
o SIGNALLING AND BUOYS	3,000	3,000	3,000

TABLE 8.3 - TOTAL INVESTIMENTS IN LOCOS AND WAGONS FOR THE COAL TRANSPORTATION FROM MUCANHA/VUZI AND MOATIZE MINES

in US$ 10^3 jul.82

ROUTES	1988			1990			1995			2000			2010		
	M/V 0.5×10^6 tons	MO 1.5×10^6 tons	TOTAL 2.0×10^6 tons	M/V 1.0×10^6 tons	MO 2.0×10^6 tons	TOTAL 3.0×10^6 tons	M/V 3.0×10^6 tons	MO 3.0×10^6 tons	TOTAL 6.0×10^6 tons	M/V 6.0×10^6 tons	MO 4.0×10^6 tons	TOTAL 10.0×10^6 tons	M/V 6.0×10^6 tons	MO 4.0×10^6 tons	TOTAL 10.0×10^6 tons
1. ROUTE 1-BEIRA															
1.1. ALTERNATIVE 1.1: THROUGH NORTHERN AND CFM-CENTER															
. Wagons	3,920	8,848	12,768	7,840	11,760	19,600	23,520	17,640	41,160	47,040	23,520	70,560	47,040	23,520	70,560
. Locos	4,290	8,580	12,870	8,580	11,440	20,020	25,740	17,160	42,900	51,480	22,880	74,360	51,480	22,880	74,360
1.1. ALTERNATIVE 1.2: THROUGH SOUTHERN AND CFM-CENTER															
. Wagons	3,416	8,848	12,264	6,776	11,760	18,536	20,328	17,640	37,968	40,656	23,520	64,176	40,656	23,520	64,176
. Locos	4,290	8,580	12,870	7,150	11,440	18,590	21,450	17,160	38,610	42,900	22,880	65,780	42,900	22,880	65,780
2. ROUTE 2-NACALA															
2.1. ALTERNATIVE 2.1: THROUGH SOUTHERN AND MALAWI															
. Wagons	6,384	17,808	24,192	12,768	23,744	36,512	38,304	35,616	73,920	76,608	47,488	124,096	76,608	47,488	124,096
. Locos	10,010	28,600	38,610	20,020	37,180	57,200	60,060	55,770	115,830	120,120	74,360	194,480	120,120	74,360	194,480
2.2. ALTERNATIVE 2.2: THROUGH SOUTHERN AND ZAMBEZIA															
. Wagons	5,040	13,720	18,760	10,024	18,256	28,280	32,072	27,384	57,456	60,144	36,512	96,656	60,144	36,512	96,656
. Loco	7,150	15,730	22,880	11,440	20,020	31,460	31,460	30,030	61,490	61,490	40,040	101,530	61,490	40,040	101,530
2.3. ALTERNATIVE 2.3: THROUGH NORTHERN AND MALAWI															
. Wagons	6,888	17,808	24,696	13,776	23,744	37,520	41,328	35,616	76,944	82,656	47,488	130,144	82,656	47,488	130,144
. Locos	11,440	28,600	40,040	22,880	37,180	60,060	34,320	55,770	90,090	68,640	74,360	143,000	68,640	74,360	143,000
2.4. ALTERNATIVE 2.4. THROUGH NORTHERN AND ZAMBEZIA															
. Wagons	5,544	13,720	19,264	11,088	18,256	29,344	33,264	27,384	60,648	66,528	36,512	103,040	66,528	36,512	103,040
. Locos	7,150	15,730	22,880	12,870	20,020	32,890	35,750	30,030	65,780	70,070	40,040	110,110	70,070	40,040	110,110
3. ROUTE 3-ZAMBEZE RIVER															
3.1. ALTERNATIVE 3.1: THROUGH SOUTHERN															
. Wagons	896	1,344	2,240	1,736	1,792	3,528	5,208	2,688	7,896	10,416	3,584	14,000	10,416	3,584	14,000
. Locos	1,430	2,860	4,290	2,860	2,860	5,720	8,580	4,290	12,870	17,160	5,720	22,880	17,160	5,720	22,880
3.2. ALTERNATIVE 3.2: THROUGH NORTHERN															
. Wagons	2,016	1,344	3,360	4,032	1,792	5,824	12,096	2,688	14,784	24,192	3,584	27,776	24,192	3,584	27,776
. Locos	2,860	2,860	5,720	4,290	2,860	7,150	12,870	4,290	17,160	25,740	5,720	31,460	25,740	57,200	31,460

M/V = Mucanha/Vuzi

MO = Moatize

(Cont.)

TABLE 8.4

ESTIMATED INVESTMENT COSTS FOR EACH ALTERNATIVE (MISCELLANEOUS EXCLUDED)

(IN US$ 10^3 OF JULY 1982)

COAL PRODUCTION	TOTAL COSTS				COSTS ALLOCATED TO THE COAL			
MUCANHA/VUZI	–	1×10^6t	3×10^6t	6×10^6t	–	1×10^6t	3×10^6t	6×10^6t
MOATIZE	2×10^6t	2×10^6t	3×10^6t	4×10^6t	2.0×10^6t	2×10^6t	3×10^6t	4×10^6t
TOTAL	2×10^6t	3×10^6t	6×10^6t	10×10^6t	2.0×10^6t	3×10^6t	6×10^6t	10×10^6t
a) ROUTE 1 – BEIRA								
a.1 – ALTERNATIVE 1.1-NORTHERN								
• RAILWAY INVESTMENTS	129,271	403,361	403,361	424,665	74,794	234,490	286,114	328,258
•• NEW CONNECTIONS (1)	9,911	278,522	278,522	278,664	5,692	161,543	197,750	217,358
•• REHABILITATION AND UPGRADING (2)	97,819	97,819	97,819	118,921	56,178	56,735	69,451	92,758
•• SIGNALLING	13,643	14,453	14,453	14,513	8,186	8,672	10,117	9,723
•• TELECOMMUNICATIONS	7,898	12,567	12,567	12,567	4,738	7,540	8,796	8,419
• ROLLING STOCK	23,200	39,620	84,060	144,920	23,200	39,620	84,060	144,920
•• LOCOS	11,400	20,020	42,900	74,360	11,440	20,020	42,900	74,360
•• WAGONS	11,760	19,600	41,160	70,560	11,760	19,600	41,160	70,560
• TERMINALS	146,216	151,432	193,434	258,128	146,216	151,432	193,434	258,128
•• MUCANHA (Rail)	–	5,216	6,718	10,169	–	5,216	6,718	10,169
•• BEIRA (Ocean)	146,216	146,216	186,716	247,959	146,216	146,216	186,716	247,959
TOTAL ALT.1.1	298,687	594,413	680,855	827,713	244,210	425,542	563,608	731,306
a.2 – ALTERNATIVE 1.2-SOUTHERN								
• RAILWAY INVESTMENTS	129,271	260,779	260,779	282,083	74,794	150,770	183,343	215,020
•• NEW CONNECTIONS (1)	9,911	138,936	138,936	139,078	5,692	80,582	97,255	107,090
•• REHABILITATION AND UPGRADING (2)	97,819	97,819	97,819	118,921	56,178	56,735	68,473	92,758
•• SIGNALLING	13,643	14,052	14,052	14,112	8,186	7,869	9,133	8,890
•• TELECOMMUNICATIONS	7,898	9,972	9,972	9,972	4,738	5,584	6,482	6,282
• ROLLING STOCK	23,200	37,126	76,578	129,956	23,200	37,126	76,578	129,956
•• LOCOS	11,440	18,590	38,610	65,780	11,440	18,590	38,610	65,780
•• WAGONS	11,760	18,536	37,968	64,176	11,760	18,536	37,968	64,176
• TERMINALS	146,216	192,417	234,419	315,150	146,216	192,420	234,429	315,150
•• MUCANHA (Lacustrine)	–	16,460	16,460	20,969	–	16,460	16,460	20,969
•• NHANCAPIRIRE (Lacustrine)	–	24,525	24,525	36,053	–	24,525	24,525	36,053
•• NHANCAPIRIRE (Railway)	–	5,216	6,718	10,169	–	5,219	6,718	10,169
•• BEIRA (Ocean)	146,216	146,216	186,716	247,959	146,216	146,216	186,716	247,959
• LAKE NAVIGATION	–	9,300	24,900	32,700	–	9,300	24,900	32,700
•• BARGES	–	4,800	14,400	19,200	–	4,800	14,400	19,200
•• TUGS	–	3,000	9,000	12,000	–	3,000	9,000	12,000
•• DEMARCATION	–	1,500	1,500	1,500	–	1,500	1,500	1,500
•• DREDGING AND CHANNEL PROTECTION	–	–	–	–	–	–	–	–
TOTAL ALT.1.2	298,687	499,622	596,676	759,889	243,348	390,396	519,240	692,826

(Cont.)

(1) MOATIZE-CATEME VARIANT INCLUDED (32 Km)

(2) CATEME-CAMBULATSISSE SECTION INCLUDED (16 Km).

(Cont.)

TABLE 8.4

ESTIMATED INVESTMENT COSTS FOR EACH ALTERNATIVE (MISCELANEOUS EXCLUDED)

(IN US$ 10^3 OF JULY 1982)

COAL PRODUCTION	TOTAL COSTS				COSTS ALLOCATED TO THE COAL			
MUCANHA/VUZI	-	1×10^6t	3×10^6t	6×10^6t	-	1×10^6t	3×10^6t	6×10^6t
MOATIZE	2×10^6t	2×10^6t	3×10^6t	4×10^6t	2×10^6t	2×10^6t	3×10^6t	4×10^6t
TOTAL	2×10^6t	3×10^6t	6×10^6t	10×10^6t	2×10^6t	3×10^6t	6×10^6t	10×10^6t
b) ROUTE 2 - NACALA								
b.1 - ALTERNATIVE 2.1-SOUTHERN AND MALAWI								
• RAILWAY INVESTMENTS	254,686	386,195	386,195	407,233	192,792	308,228	327,719	357,805
•• NEW CONNECTIONS (1)	100,158	229,184	229,184	233,135	75,798	183,347	194,806	205,158
•• REHABILITATION AND UPGRADING	138,839	138,839	138,839	155,473	105,071	111,071	118,013	136,816
•• SIGNALLING	2,270	2,679	2,679	3,132	1,725	2,036	2,196	2,662
•• TELECOMMUNICATIONS	13,419	15,493	15,493	15,493	10,198	11,774	12,704	13,169
• ROLLING STOCK	60,924	93,712	189,750	318,576	60,924	93,712	189,750	318,576
•• LOCOS	37,180	57,200	115,830	194,480	37,180	57,200	115,830	194,480
•• WAGONS	23,744	36,512	73,920	124,096	23,744	36,512	73,920	124,096
• TERMINALS	59,022	105,223	123,125	175,003	59,022	105,223	123,125	175,003
•• MUCANHA (Lacustrine)	-	16,460	16,460	20,969	-	16,460	16,460	20,969
•• NHANCAPIRIRE (Lacustrine)	-	24,525	24,525	36,053	-	24,525	24,525	36,053
•• NHANCAPIRIRE (Railway)	-	5,216	6,718	10,169	-	5,216	6,718	10,169
•• NACALA (Ocean)	59,022	59,022	75,422	107,812	59,022	59,022	75,422	107,812
• LAKE NAVIGATION	-	52,500	95,000	154,500	-	52,500	95,000	154,500
•• BARGES	-	36,000	66,000	108,000	-	36,000	66,000	108,000
•• TUGS	-	15,000	27,500	45,000	-	15,000	27,500	45,000
•• DEMARCATION	-	1,500	1,500	1,500	-	1,500	1,500	1,500
•• DREDGING AND CHANNEL PROTECTION	-	-	-	-	-	-	-	-
TOTAL ALT.2.1	374,632	638,413	795,078	1,056,838	312,738	559,663	735,594	1,005,884
b.2 - ALTERNATIVE 2.2-SOUTHERN AND ZAMBEZIA								
• RAILWAY INVESTMENTS	629,416	760,926	760,926	767,509	507,414	638,782	683,055	712,792
•• NEW CONNECTIONS (1)	545,290	674,315	674,315	677,729	439,383	566,425	606,883	630,288
•• REHABILITATION AND UPGRADING	66,871	66,871	66,871	69,978	53,883	56,171	60,184	65,079
•• SIGNALLING	2,408	2,818	2,818	2,880	1,974	2,310	2,282	2,534
•• TELECOMMUNICATIONS	14,847	16,922	16,922	16,922	12,174	13,876	13,706	14,891
• ROLLING STOCK	38,276	59,740	118,946	198,196	38,276	59,740	118,946	198,186
•• LOCOS	20,020	31,460	61,490	101,530	20,020	31,460	61,490	101,530
•• WAGONS	18,256	28,280	57,456	96,656	18,256	28,280	57,456	96,656
• TERMINALS	59,022	105,223	123,125	175,003	59,022	105,223	123,125	175,003
•• MUCANHA (Lacustrine)	-	16,460	16,460	20,969	-	16,460	16,460	20,969
•• NHANCAPIRIRE (Lacustrine)	-	24,525	24,525	36,053	-	24,525	24,525	36,053
•• NHANCAPIRIRE (Railway)	-	5,216	6,718	10,169	-	5,216	6,718	10,169
•• NACALA (Ocean)	59,022	59,022	75,422	107,812	59,022	59,022	75,422	107,812
• LAKE NAVIGATION	-	9,300	24,900	32,700	-	9,300	24,900	32,700
•• BARGES	-	4,800	14,400	19,200	-	4,800	14,400	19,200
•• TUGS	-	3,000	9,000	12,000	-	3,000	9,000	12,000
•• DEMARCATION	-	1,500	1,500	1,500	-	1,500	1,500	1,500
•• DREDGING AND CHANNEL PROTECTION	-	-	-	-	-	-	-	-
TOTAL ALT.2.2	726,714	935,189	1,027,897	1,173,408	604,712	807,829	943,308	1,108,512

(Cont.)

(Cont.)

TABLE 8.4

ESTIMATED INVESTMENT COSTS FOR EACH ALTERNATIVE (MISCELANCEOUS EXCLUDED)

(IN US$ 10^3 OF JULY 1982)

COAL PRODUCTION	TOTAL COSTS				COSTS ALLOCATED TO THE COAL			
MUCANHA/VUZI	-	1×10^6t	3×10^6t	6×10^6t	-	1×10^6t	3×10^6t	6×10^6t
MOATIZE	2×10^6t	2×10^6t	3×10^6t	4×10^6t	2×10^6t	2×10^6t	3×10^6t	4×10^6t
	2×10^6t	3×10^6t	6×10^6t	10×10^6t	2×10^6t	3×10^6t	6×10^6t	10×10^6t
b.3 - ALTERNATIVE 2.3-NORTHERN AND MALAWI								
• RAILWAY INVESTMENTS	254,686	528,780	528,780	549,446	192,792	417,523	445,227	451,409
•• NEW CONNECTIONS (1)	100,158	368,770	368,770	372,721	75,798	291,328	313,454	305,631
•• REHABILITATION AND UPGRADING	138,839	138,840	138,840	155,102	105,071	109,683	118,014	127,183
•• SIGNALLING	2,270	3,080	3,080	3,534	1,725	2,402	2,002	3,039
•• TELECOMUNICATIONS	13,419	18,090	18,090	18,089	10,198	14,110	11,757	15,556
• ROLLING STOCK	60,924	97,580	167,034	273,144	60,924	97,580	167,034	273,144
•• LOCOS	37,180	60,060	90,090	143,000	37,180	60,060	90,090	143,000
•• WAGONS	23,744	37,520	76,944	130,144	23,744	37,520	76,944	130,144
• TERMINALS	59,022	64,238	82,140	117,981	59,022	64,238	82,140	117,981
•• MUCANHA (Rail)	-	5,216	6,718	10,169	-	5,216	6,718	10,169
•• NACALA (Ocean)	59,022	59,022	75,422	107,812	59,022	59,022	75,422	107,812
TOTAL ALT.2.3	374,632	690,598	777,954	940,571	315,635	577,341	694,401	842,534
b.4 - ALTERNATIVE 2-4-NORTHERN AND ZAMBEZIA								
• RAILWAY INVESTMENTS	629,416	903,508	903,508	910,092	507,414	749,455	798,574	835,231
•• NEW CONNECTIONS (1)	545,290	813,902	813,902	817,316	439,383	675,539	723,600	751,930
•• REHABILITATION AND UPGRADING	66,871	66,871	66,871	69,979	53,883	55,502	59,515	64,380
•• SIGNALLING	2,408	3,218	3,218	3,280	1,974	2,606	2,188	2,722
•• TELECOMUNICATIONS	14,847	19,517	19,517	19,517	12,174	15,808	13,271	16,199
• ROLLING STOCK	38,276	62,234	126,428	213,150	38,276	62,234	126,428	213,150
•• LOCOS	20,020	32,890	65,780	110,110	20,020	32,890	65,780	110,110
•• WAGONS	18,256	29,344	60,648	103,040	18,256	29,344	60,648	103,040
• TERMINALS	59,022	64,238	82,140	117,981	59,022	64,238	82,140	117,981
•• MUCANHA (Rail)	-	5,216	6,718	10,169	-	5,216	6,718	10,169
•• NACALA (Ocean)	59,022	59,022	75,422	107,812	59,022	59,022	75,422	107,812
TOTAL ALT.2.4	726,714	1,029,980	1,112,076	1,241,223	604,712	875,927	1,007,142	1,166,362

(Cont.)

TABLE 8.4

ESTIMATED INVESTMENT COSTS FOR EACH ALTERNATIVE (MISCELLANEOUS EXCLUDED)

(IN US$ 10^3 OF JULY 1982)

COAL PRODUCTION	TOTAL COSTS				COSTS ALLOCATED TO THE COAL			
MUCANHA/VUZI	–	1 x 10^6t	3 x 10^6t	6 x 10^6t	–	1 x 10^6t	3 x 10^6t	6 x 10^6t
MOATIZE	2 x 10^6t	2 x 10^6t	3 x 10^6t	4 x 10^6t	2 x 10^6t	2 x 10^6t	3 x 10^6t	4 x 10^6t
TOTAL	2 x 10^6t	3 x 10^6t	6 x 10^6t	10 x 10^6t	2 x 10^6t	3 x 10^6t	6 x 10^6t	10 x 10^6t
c) ROUTE 3-ZAMBEZE RIVER								
c.1-ALTERNATIVE 3.1-ACESS SOUTH								
• RAILWAY INVESTMENTS	20,169	130,913	130,913	131,042	16,767	98,304	111,347	117,865
•• NEW CONNECTIONS (1)	19,667	128,521	128,521	128,650	16,366	96,391	109,243	115,785
•• REHABILITATION AND UPGRADING (2)	–	–	–	–	–	–	–	–
•• SIGNALLING	104	305	305	305	83	244	268	265
•• TELECOMUNICATIONS	398	2,087	2,087	2,087	318	1,669	1,836	1,815
• ROLLING STOCK	4,652	9,248	20,766	36,880	4,652	9,248	20,766	36,880
•• LOCOS	2,860	5,720	12,870	22,880	2,860	5,720	12,870	22,880
•• WAGONS	1,792	3,528	7,896	14,000	1,792	3,528	7,896	14,000
• TERMINALS LACUSTRINE	–	46,201	47,703	67,191	–	46,201	47,703	67,191
•• MUCANHA (Lacustrine)	–	16,460	16,460	20,969	–	16,460	16,460	20,969
•• NHANCAPIRIRE (Lacustrine)	–	24,525	24,525	36,053	–	24,525	24,525	36,053
•• NHANCAPIRIRE (Railway)	–	5,216	6,718	10,169	–	5,216	6,718	10,169
• LAKE NAVIGATION	–	9,300	24,900	32,700	–	9,300	24,900	32,700
•• BARGES	–	4,800	14,400	19,200	–	4,800	14,400	19,200
•• TUGS	–	3,000	7,000	12,000	–	3,000	9,000	12,000
•• DEMARCATION	–	1,500	1,500	1,500	–	1,500	1,500	1,500
• TERMINALS RIVER	321,903	321,903	381,636	519,384	321,903	321,903	381,636	519,384
•• TETE (River)	26,067	26,067	43,624	55,192	26,067	26,067	43,624	55,192
•• TETE (Railway)	5,216	5,216	6,718	10,169	5,216	5,216	6,718	10,169
•• CHINDE (Sea/River)	290,620	290,620	331,294	454,023	290,620	290,620	331,294	454,023
• RIVER NAVIGATION	89,200	101,100	143,600	203,100	89,200	101,100	143,600	203,100
•• BARGES	27,600	36,000	66,000	108,000	27,600	36,000	66,000	108,000
•• TUGS	11,500	15,000	27,500	45,000	11,500	15,000	27,500	45,000
•• DREDGING	47,100	47,100	47,100	47,100	47,100	47,100	47,100	47,100
•• DEMARCATION	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000
TOTAL ALT.3.1	435,924	609,365	749,518	990,297	432,522	586,056	729,952	977,120
c.2-ALTERNATIVE 3.2-ACCESS NORTH								
• RAILWAY INVESTMENTS	20,169	310,632	310,632	311,235	16,734	223,793	267,213	282,808
•• NEW CONNECTIONS (1)	19,667	298,189	298,189	298,460	16,363	214,696	256,443	271,598
•• REHABILITATION AND UPGRADING	–	5,537	5,537	5,860	–	3,987	4,762	5,332
•• SIGNALLING	104	1,041	1,041	1,050	77	770	906	893
•• TELECOMUNICATIONS	398	5,865	5,865	5,865	294	4,340	5 102	4,985
• ROLLING STOCK	4,652	12,974	31,944	59,236	4,652	12,974	31,944	59,236
•• LOCOS	2,860	7,150	17,160	31,460	2,860	7,150	17,160	31,460
•• WAGONS	1,792	5,824	14,784	27,776	1,792	5,824	14,784	27,776
• TERMINALS	321,903	327,119	388,354	529,553	327,119	327,119	388,354	529,553
•• MUCANHA (Railway)	–	5,216	6,718	10,169	5,216	5,216	6,718	10,169
•• TETE (Railway)	5,216	5,216	6,718	10,169	5,216	5,216	6,718	10,169
•• TETE (River)	26,067	26,067	43,624	55,192	26,067	26,067	43,624	55,192
•• CHINDE (Off Shore)	290,620	290,620	331,294	454,023	290,620	290,620	331,294	454,023
• RIVER NAVIGATION	89,200	101,100	143,600	203,100	89,200	101,100	143,600	203,100
•• BARGES	27,600	36,000	66,000	108,000	27,600	36,000	66,000	108,000
•• TUGS	11,500	15,000	27,500	45,000	11,500	15,000	27,500	45,000
•• DREDGING	47,100	47,100	47,100	47,100	47,100	47,100	47,100	47,100
•• DEMARCATION	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000
TOTAL ALT. 3.1	435,924	751,825	874,530	1,102,124	437,705	664,986	831,111	1,074,697

TABLE 8.5 - TRAIN.KM/DAY IN CONSIDERED ALTERNATIVES

in 1000 train.km/day

ALTERNATIVES/LINKS	LENGTH (KM)	1988 TRAIN/KM/DAY MV	1988 M	1988 CG	1988 % COAL	1990 TRAIN/KM/DAY MV	1990 M	1990 CG	1990 % COAL	1995 TRAIN/KM/DAY MV	1995 M	1995 CG	1995 % COAL	2000 TRAIN/KM/DAY MV	2000 M	2000 CG	2000 % COAL	2010 TRAIN/KM/DAY MV	2010 M	2010 CG	2010 % COAL
ROUTE 1 - BEIRA																					
-ALTERNATIVE 1.1:NORTH	915	0.94	1.90	2.02	58	1.89	2.47	2.96	60	3.89	2.06	2.58	70	4.44	1.99	3.11	67	4.44	1.99	4.07	61
.Mucanha-Cambulatsisse	340	0.37	-	-	100	0.75	-	0.31	71	2.21	-	0.38	85	2.21	-	0.44	83	2.21	-	1.67	57
.Moatize-Cambulatsisse	58	-	0.19	0.13	59	-	0.25	0.14	64	-	0.38	0.17	69	-	0.50	0.20	71	-	0.50	0.30	63
.Cambulatsisse-Beira	517	0.57	1.71	1.89	55	1.14	2.22	2.51	57	1.68	1.68	2.03	62	2.23	1.49	2.47	60	2.23	1.49	2.10	64
-ALTERNATIVE 1.2:SOUTH	726	0.80	1.90	1.89	59	1.60	2.47	3.22	56	2.85	1.87	2.54	65	3.46	1.63	2.95	63	3.46	1.63	3.17	61
.Nhancapirire-Moatize	151	0.17	-	-	100	0.33	-	0.52	39	0.98	-	0.17	85	0.98	-	0.20	83	0.98	-	0.29	77
.Moatize-Beira	575	0.63	1.90	1.89	57	1.27	2.47	2.70	58	1.87	1.87	2.37	61	2.48	1.63	2.75	60	2.48	1.63	2.88	59
2) ROUTE 2 - NACALA																					
2.1-ALTERNATIVE 2.1:SOUTH-MALAWI	1128	1.92	4.79	1.24	84	2.74	2.24	1.58	76	4.73	3.22	1.75	82	8.02	4.34	2.09	85	8.02	4.34	2.47	[illegible]
.Nhancapirire-Moatize	151	0.26	-	-	100	0.50	-	0.19	72	1.51	-	0.24	86	1.51	-	0.29	83	1.51	-	0.23	[illegible]
.Moatize-Malawi-Nacala	977	1.66	4.79	1.24	83	2.24	2.24	1.39	76	3.22	3.22	1.51	81	6.51	4.34	1.80	86	6.51	4.34	2.24	[illegible]
2.2-ALTERNATIVE-2.2:SOUTH-ZAMBEZIA	1232	1.36	3.57	1.06	82	3.84	3.51	1.61	82	4.49	3.51	1.96	81	7.98	4.67	1.61	88	7.98	4.67	2.36	[illegible]
.Nhancapirire-Moatize	151	0.17	-	-	100	0.33	-	0.17	66	0.98	-	0.20	83	0.98	-	0.24	80	0.98	-	0.35	74
.Moatize-Zambezia-Nacala	1081	0.19	3.57	1.06	81	3.51	3.51	1.44	83	3.51	3.51	1.76	80	7.00	4.67	1.37	89	7.00	4.67	2.01	[illegible]
2.3-ALTERNATIVE-2.3:NORTH-MALAWI	1317	2.14	4.78	0.47	94	3.42	2.68	1.75	78	6.29	4.88	2.20	65	9.52	4.47	2.27	86	9.52	4.47	2.67	[illegible]
.Mucanha-Cambulatsisse	340	0.58	-	-	100	1.12	-	0.44	72	1.70	-	0.54	76	3.40	-	0.34	91	3.40	-	0.34	[illegible]
.Moatize-Cambulatsisse	58	-	0.28	0.19	60	-	0.38	0.21	64	-	0.29	0.26	53	-	0.39	0.31	56	-	0.39	0.31	[illegible]
.Cambulat.-Malawi-Nacala	919	1.56	4.50	0.28	96	2.30	2.30	1.10	81	4.59	4.59	1.40	86	6.12	4.08	1.62	86	6.12	4.08	2.02	[illegible]
2.4-ALTERNATIVE-2.4:NORTH-ZAMBEZIA	1429	1.49	3.57	1.07	82	3.00	4.65	1.75	81	8.54	3.69	2.12	68	8.85	4.65	2.78	83	8.85	4.65	3.82	[illegible]
.Mucanha-Cambulatsisse	340	0.37	-	-	100	0.75	-	0.37	67	2.21	-	0.44	83	2.21	-	0.54	80	2.21	-	0.78	[illegible]
.Moatize-Cambulatsisse	58	-	0.19	0.16	54	-	0.25	0.17	59	-	0.37	0.20	65	-	0.25	0.26	49	-	0.25	0.37	[illegible]
.Cambulatsisse-Zambezia-Nacala	1023	1.12	3.38	0.91	83	2.25	4.40	1.21	85	3.32	3.32	1.48	82	6.64	4.40	1.78	86	6.64	4.40	2.67	[illegible]
3) ROUTE 3 - ZAMBEZE RIVER																					
3.1-ALTERNATIVE-3.1-SOUTH ACCESS	152	0.14	0.10	-	100	0.30	0.14	0.11	80	0.87	0.20	0.14	88	0.87	0.28	0.16	87	0.87	0.28	0.23	[illegible]
.Nhancapirire-Tete	123	0.14	-	-	100	0.30	-	0.11	73	0.87	-	0.14	86	0.87	-	0.16	84	0.87	-	0.23	[illegible]
.Moatize-Tete	29	-	0.10	-	100	-	0.14	-	100	-	0.20	-	100	-	0.28	-	100	-	0.28	-	[illegible]
3.2-ALTERNATIVE-3.2-NORTH ACCESS	427	0.82	0.10	-	100	1.64	0.14	0.62	74	4.82	0.20	0.74	87	4.82	0.28	0.88	85	4.82	0.28	1.30	[illegible]
.Mucanha-Moatize	398	0.41	-	-	100	0.82	-	0.31	72	2.41	-	0.37	87	2.41	-	0.44	84	2.41	-	0.65	[illegible]
.Moatize-Tete	29	0.41	0.10	-	100	0.82	0.14	0.31	76	2.41	0.20	0.37	87	2.41	0.28	0.44	86	2.41	0.28	0.65	[illegible]

= Train/day with origin in Moatize

V = Train/day with origin in Mucanha/Vuzi

MG = Train/day of general freight

Table 8.4 shows only the calculated costs not computing miscellaneous which are generally considered as 15% for engineering services and between 5% to 10% for equipment estimations at a pre-feasibility study.

An evaluation of total costs of investments required for increasing capacity of the existing railway system and to promote its connection to future Mucanha/Vuzi mines complemented by terminals gives a rough idea of the amount of capital investment required in each alternative and transport level.

A summary of total aggregated investment costs and the costs assigned to coal appears in Table 8.6. It can be noticed that for both total costs of coal and general freight transport services and the costs assigned to coal for establishing the freight tariffs the alternative which demands smaller amounts of investment is the alternative 1.2 - Southern through Cahora Bassa lake navigation and CFM-Central System to the port of Beira, followed on second by alternative 1.1 - Northern through Cambulatsisse and CFM-Central System to the port of Beira.

It is considered also an estimate of investments required if only Moatize coal outflow was transported at the 1.5×10^6 tons and 2.0×10^6 tons level without therefore investments in connecting existing railway system to the Mucanha/Vuzi mines. This hypothesis will therefore be best evaluated when analysis for selecting the most adequate alternative is carried on when costs per transported ton will be evaluated.

8.2 *Selecting the most economical alternative*

For selecting the most economical alternative it has been considered the operating and investment costs for railway, terminals and/or navigation in each alternative. The operational costs in each transport mode are displayed in details on Chapter 7.

Table 8.6 exhibits in aggregated form the operational costs by alternative.

TABLE 8.6 - SUMMARY OF AGGREGATED TOTAL INVESTIMENT COSTS ALLOCATED TO COAL FOR EACH ALTERNATIVE

US$ 10^3 of Jul.82

M/VUZI	MOATIZE ONLY		MOATIZE ONLY		1×10^6 tons		3×10^6 tons		6×10^6 tons	
MOATIZE	1.5×10^6 tons		2×10^6 tons		2×10^6 tons		3×10^6 tons		4×10^6 tons	
TOTAL	1.5×10^6 tons		2×10^6 tons		3×10^6 tons		6×10^6 tons		10×10^6 tons	
	TOTAL	COAL	TOTAL	COAL	TOTAL	COAL	TOTAL	COAL	TOTAL	COAL
ROUTE 1 - BEIRA										
. ALTERNATIVE 1.1 - NORTH										
- Railway investiments	129,271	74,794	129,271	74,794	403,361	234,490	403,361	286,114	424,665	328,258
- Rolling stock	17,428	17,428	23,200	23,200	39,620	39,620	84,060	84,060	144,920	144,920
- Terminals	146,216	146,216	146,216	146,216	151,432	151,432	193,434	193,434	258,128	258,128
- Miscellaneous (10%)	29,291	23,843	29,868	24,421	59,441	42,554	68,085	56,360	82,771	73,130
TOTAL ALTERNATIVE 1.1	322,206	262,281	328,555	268,631	653,854	468,096	748,940	619,968	910,484	80[illegible],436
. ALTERNATIVE 1.2 - SOUTH										
- Railway investments	129,271	73,932	129,271	73,932	260,779	150,770	260,779	183,343	282,083	215,020
- Rolling stock	17,428	17,428	23,200	23,200	37,126	37,126	76,578	76,578	129,956	129,956
- Terminals	146,216	146,216	146,216	146,216	192,417	192,417	234,419	234,419	315,150	315,150
- Investiment in the navigation way	-	-	-	-	1,500	1,500	1,500	1,500	1,500	1,500
- Tugs and Barges	-	-	-	-	7,800	7,800	23,400	23,400	31,200	31,200
- Miscellaneous (10%)	29,291	23,757	29,868	24,334	49,962	38,961	59,667	51,924	75,989	69,262
TOTAL ALVERNATIVE 1.2	322,106	261,333	328,555	267,682	549,584	428,574	656,343	571,164	835,878	762,103
ROUTE 2 - NACALA										
. ALTERNATIVE 2.1 - SOUTH AND MALAWI										
- Railway investments	254,686	192,792	254,686	192,792	386,195	308,228	386,195	327,719	407,233	357,805
- Rolling stock	46,408	46,408	60,924	93,712	93,712	93,712	189,750	189,750	318,576	318,576
- Terminls	59,022	59,022	59,022	59,022	105,223	105,223	123,125	123,125	175,003	175,003
- Investiment in the navigation way	-	-	-	-	1,500	1,500	1,500	1,500	1,500	1,500
- Tugs and Barges	-	-	-	-	51,000	51,000	93,500	93,500	153,000	153,000
- Miscellaneous (10%)	36,011	29,822	37,463	34,552	63,763	55,966	79,407	73,559	105,531	100,588
TOTAL ALTERNATIVE 2.1	396,127	328,044	412,095	380,078	701,393	615,629	873,477	809,153	1160,843	1106,472
ALTERNATIVE 2.2 - SOUTH AND ZAMBEZIA										
- Railway investments	629,416	507,414	629,416	507,414	760,926	638,782	760,926	683,055	767,509	712,792
- Rolling stock	29,450	29,450	38,276	38,276	59,740	59,740	118,946	118,946	198,196	198,196
- Terminals	59,022	59,022	59,022	59,022	105,223	105,223	123,125	123,125	175,003	175,003
- Investiment in the navigation way	-	-	-	-	1,500	1,500	1,500	1,500	1,500	1,500
- Tugs and Barges	-	-	-	-	7,800	7,800	23,400	23,400	31,200	31,200
- Miscellaneous (10%)	71,788	59,588	72,671	60,471	93,518	81,304	102,789	95,002	117,340	111,869
TOTAL ALTERNATIVE 2.2	789,676	655,474	799,385	665,183	1028,707	894,349	1130,686	1045,028	1290,748	1230,560
ALTERNATIVE 2.3 - NORTH AND MALAWY										
- Railway investments	254,686	195,689	254,686	195,689	528,780	417,523	528,780	445,227	549,446	451,409
- Rolling stock	46,408	46,408	60,924	60,924	97,580	97,580	167,034	167,034	273,144	273,144
- Terminals	59,022	59,022	59,022	59,022	64,238	64,238	82,140	82,140	117,981	117,981
- Miscellaneous (10%)	36,011	30,111	37,463	31,563	69,059	57,934	77,795	69,440	94,057	84,253
TOTAL ALTERNATIVE 2.3	396,127	331,230	412,095	347,198	759,657	637,275	855,749	763,841	1034,628	926,787
ALTERNATIVE 2.4 - NORTH AND ZAMBEZIA										
- Railway investments	629,416	510,016	629,416	510,016	903,508	749,455	903,508	798,574	910,092	835,231
- Rolling stock	29,450	29,450	38,276	38,276	62,234	62,234	126,428	126,428	213,150	213,150
- Terminals	59,022	59,022	59,022	59,022	64,238	64,238	82,140	82,140	117,981	117,981
- Miscellaneous (10%)	71,788	59,848	72,671	60,731	102,998	87,592	111,207	100,714	124,122	116,636
TOTAL ALTERNATIVE 2.4	789,676	658,336	799,385	668,045	1132,978	963,519	1223,283	1107,856	1365,345	1282,998
[illegible]TE 3 - ZAMBEZE RIVER										
. ALTERNATIVE 3.1 - SOUTH ACCESS										
- Railway investments	20,169	16,767	20,169	16,767	130,913	98,304	130,913	111,347	131,042	117,865
- Rolling stock	4,204	4,204	4,652	4,652	9,248	9,248	20,766	20,766	36,880	36,880
- Lake terminals	-	-	-	-	46,201	46,201	47,703	47,703	67,191	67,191
- Lake navigation	-	-	-	-	1,500	1,500	1,500	1,500	1,500	1,500
- Lake Tugs and Barges	-	-	-	-	7,800	7,800	23,400	23,400	31,200	31,200
- River Terminals	321,903	321,903	321,903	321,903	321,903	321,903	381,636	381,636	519,384	519,384
- River Navigation	50,100	50,100	50,100	50,100	50,100	50,100	50,100	50,100	50,100	50,100
- River Tugs and Barges	29,325	29,325	39,100	39,100	51,000	51,000	93,500	93,500	153,000	153,000
- Miscellaneous (10%)	42,570	42,229	43,592	43,252	61,866	58,605	74,951	72,995	99,029	97,712
TOTAL ALTERNATIVE 3.1	468,271	464,528	479,516	475,774	680,531	644,661	824,469	802,947	1089,326	1074,832
. ALTERNATIVE 3.2 - NORTH ACCESS										
- Railway investments	20,169	16,734	20,169	16,734	310,632	223,793	310,632	267,213	311,235	282,808
- Rolling stock	4,204	4,204	4,652	4,652	12,974	12,974	31,944	31,944	59,236	59,236
- Lake Terminals	327,119	327,119	327,119	327,119	327,119	327,119	388,354	388,354	529,553	529,553
- River navigation	50,100	50,100	50,100	50,100	50,100	50,100	50,100	50,100	50,100	50,100
- River Tugs and Barges	29,325	29,325	39,100	39,100	51,000	51,000	93,500	93,500	153,000	153,000
- Miscellaneous (10%)	43,091	42,748	44,114	43,770	75,182	66,498	87,453	83,111	110,312	107,469
TOTAL ALTERNATIVE 3.2	474,008	470,230	485,254	481,475	827,007	731,484	961,983	914,222	1213,436	1182,166

It can be seen that:

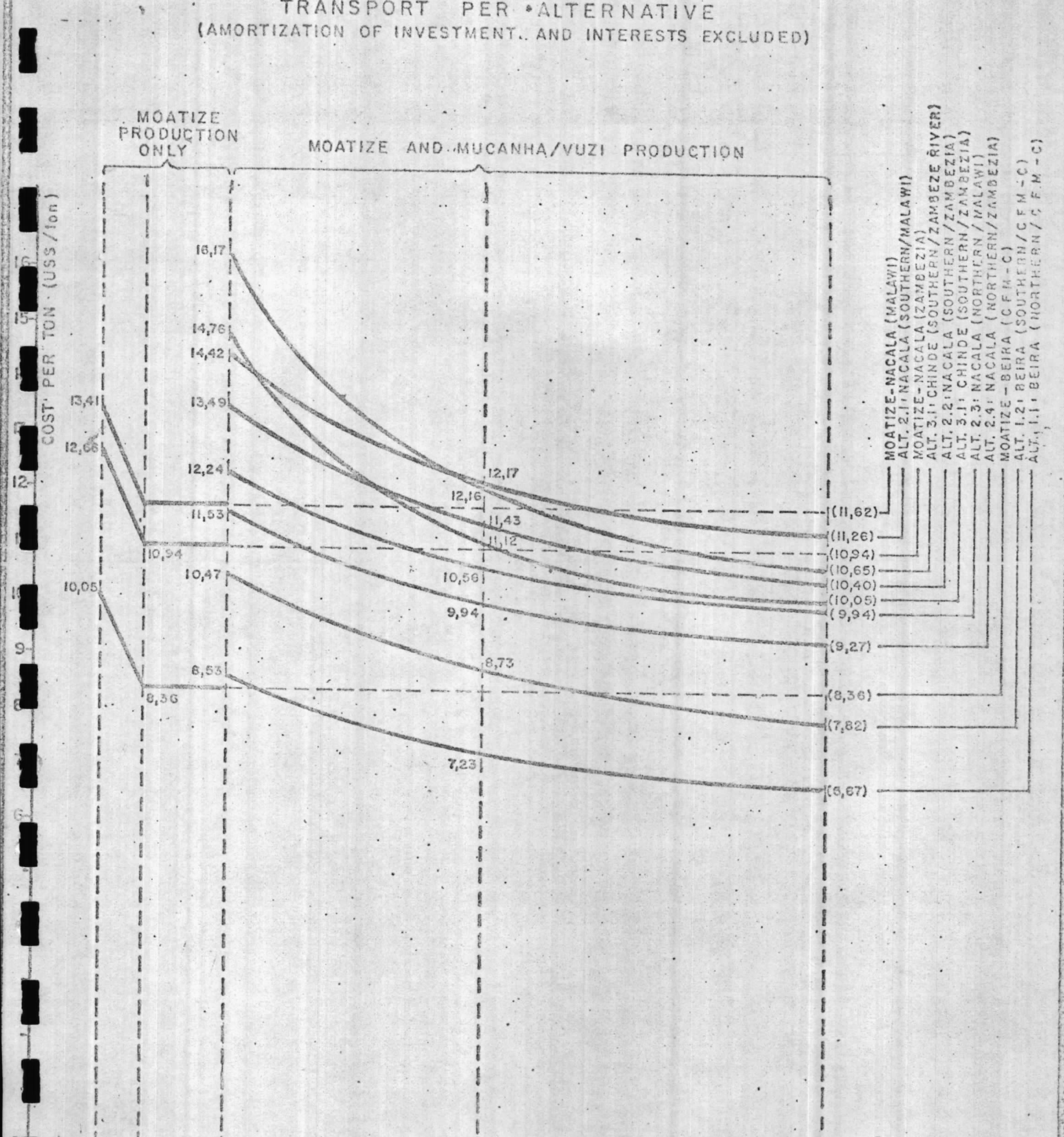
- The alternative which shows smaller operational costs per transported ton of coal is alternative 1.1 - Northern which stablish direct connection from railway coal terminal at Mucanha, through Cambulatsisse up to the port of Beira (Fig. 8.1).

- For only 1.0×10^6 tons of coal produced in Mucanha/Vuzi and considering an additional 2.0×10^6 tons produced in Moatize, it would rather be transported the Moatize coal only, as costs are concerned, for any production level equal or superior to 2×10^6 tons. At the production level of 1.5×10^6 tons produced in Moatize, operational costs only for the Moatize coal transported is higher than for both the 1.0×10^6 tons from Mucanha/Vuzi and 2.0×10^6 tons from Moatize. In what transportation costs are concerned the minimum coal production which permit adequate costs to the price structure of international coal market is close to 3×10^6 tons for Mucanha/Vuzi and 3×10^6 tons from Moatize coal, declining substantially with increase in production.
- Even considering amortization of capital plus interests of financing included in the coal transportation costs, alternative 1.1 - Northern shows inferior costs to alternative 1.2 - Southern.

For estimations of capital investment amortization, it was considered:

- that only 70% of the costs assigned to coal would be effected through international loans. The remaining 30% would be covered by Mozambique's domestic resources.

- For the sensibility analysis, it was assumed that the averaged rate of loans interests would be of Ø%, 5%, 10% and 15% per year. These rates would be the resulting averaged values for a basket of financial arrangements composed by suppliers credit, loans from international funds and donations. As the Ø% interest rate is obviously too low and the 15% rate is too high,



STUDY OF OUTFLOW ALTERNATIVES

Graphical Representation of Total Operating Costs for the Coal they both define the lower and upper limits acceptable. The averaged interest rate will be, for sure, between 5% and 10% per year.

- The assumed average time for the loans was 20 years based on OPEC Fund conditions.

- The amortization formula applied was:

$$Aa = S.P. \frac{i\,(1 + i)^n}{(1 + i)^n - 1}$$

being:

Aa = value of the annual amortization

S = percent participation of foreign currency loans in total investment assigned to coal (assumed 70%)

P = value of investments assigned to coal

i = assumed interests.

It can be observed on Table 8.7 that variation in interests do not alter relative position of alternative 1.1 and 1.2. This happens because differences in investment values in favor of alternative 1.2 is covered by difference of operating costs in favor of alternative 1.1.

This final result contests in a certain extent the former results presented to Mozambique officials and OPEC FUND in the preliminary report which indicated Alternative 1.2 - Southern, across Cahora Bassa lake as the most economical alternative in terms of investment and operating costs.

It must be realized that in a pre-feasibility study it is considered acceptable for an error up to 20%. Notwithstanding all efforts aiming at minimizing error basis, it is almost impossible to evaluate in a precision base which would be the error percent without a more detailed project to support estimations.

TABLE 8.7

COST PER TON OF TRANSPORTED COAL (IN US$ 10^3 OF JULY OF 1982)

A) ROUTE 1 - BEIRA

ITEMS OF COSTS	MUC./VUZI	MOATIZE ONLY		1.0×10^6t	3×10^6t	6×10^6t
	MOATIZE	1.5×10^6t.	2.0×10^6t.	2.0×10^6t	3×10^6t	4×10^6t
	TOTAL	1.5×10^6t.	2.0×10^6t.	3.0×10^6t	6×10^6t	10×10^6t.
.1) ALTERNATIVE 1.1-NORTH/CFM-C						
• RAILWAY TERMINAL AT MUCANHA		-	-	1,790	2,326	3,048
• RAILWAY OPERATIONAL COSTS		6,032	7,524	13,812	25,696	41,074
• COAL TERMINAL AT BEIRA		7,671	7,671	7,671	11,408	16,710
• MISCELLANEOUS (10%)		1,370	1,519	2,327	3,943	6,083
ANNUAL OPERATIONAL COSTS	US$ 10^3	15,073	16,714	25,600	43,373	66,915
OPERATIONAL COSTS/TON	US$/TON	10.05	8.36	8.53	7.23	6.69
TOTAL INVESTIMENTS	US$ 10^3	262,281	268,631	468,096	619,968	804,436
70% OF THE INVESTMENTS÷20 YEARS	i = Ø %	9,180	9,402	16,383	21,698	28,155
TOTAL ANNUAL COSTS	i = Ø %	24,253	26,116	41,983	65,071	95,070
TOTAL COSTS/TONS.	i = Ø %	16.17	13.06	13.99	10.84	9.51
AMORTIZATION OF THE CAPITAL PLUS INTERESTS (10^3)	i = 5 %	14,732	15,089	26,293	34,823	45,185
	i = 10 %	21,565	22,087	38,488	50,975	66,142
	i = 15 %	29,332	30,042	52,349	69,333	89,962
TOTAL ANNUAL COSTS (US$ 10^3)	i = 5 %	29,805	31,803	51,893	78,196	112,100
	i = 10 %	36,638	38,801	64,088	94,348	133,057
	i = 15 %	44,405	46,756	77,949	112,706	156,877
TOTAL COSTS/TON (US$/TON.)	i = 5 %	19.87	15.90	17.30	13.03	11.21
	i = 10 %	24.42	19.40	21.36	15.72	13.31
	i = 15 %	29.60	23.38	25.98	18.78	15.69
.2) ALTERNATIVE 1.2-SOUTH/CFM-C						
• LAKE TERMINAL AT MUCANHA		-	-	1,790	2,326	3,048
• LAKE NAVIGATION		-	-	1,600	4,560	6,040
• LAKE TERMINAL AT NHANCAPIRIRE		-	-	2,835	3,441	5,233
• RAILWAY TERMINAL AT NHANCAPIRIRE		-	-	1,790	2,326	3,048
• RAILWAY OPERATIONAL COSTS		6,032	7,524	12,875	23,554	37,011
• COAL TERMINAL AT BEIRA		7,671	7,671	7,671	11,408	16,710
• MISCELLANEOUS (10%)		1,370	1,519	2,856	4,761	7,109
ANNUAL OPERATIONAL COSTS	US$ 10^3	15,073	16,714	31,417	52,376	78,199
OPERATIONAL COSTS/TON	US$/TONS.	10.05	8.36	10.47	8.73	7.82
TOTAL INVESTIMENTS	US$ 10^3	262,281	268,631	428,574	571,164	762,108
70% OF THE INVESTMENTS÷20 YEARS	i = Ø %	9,180	9,402	15,000	19,990	26,673
TOTAL ANNUAL COSTS	i = Ø %	24,253	26,116	46,417	72,313	104,872
TOTAL COSTS/TONS.	i = Ø %	16.17	13.06	15.47	12.06	10.49
AMORTIZATION OF THE CAPITAL PLUS INTERESTS (US$ 10^3)	i = 5 %	14,732	15,089	24,073	32,082	42,807
	i = 10 %	21,565	22,087	35,238	46,962	62,662
	i = 15 %	29,332	30,042	47,929	63,875	85,229
TOTAL ANNUAL COSTS (US$ 10^3)	i = 5 %	29,805	31,803	55,490	84,458	121,006
	i = 10 %	36,638	38,801	66,655	99,338	140,861
	i = 15 %	44,405	46,756	79,346	116,251	163,428
TOTAL COSTS/TONS (US$/TONS.)	i = 5 %	19.87	15.90	18.50	14.08	12.10
	i = 10 %	24.42	19.40	22.22	16.56	14.09
	i = 15 %	29.60	23.38	26.46	19.37	16.34

TABLE 8.7

COST PER TON OF TRANSPORTED COAL

[illegible]) ROUTE 2 - NACALA (IN US$ 10^3 OF JULY OF 1982)

ITEMS OF COSTS	MUC./VUZI	MOATIZE ONLY		$1.0x10^6t$	3×10^6t	6×10^6t
	MOATIZE	$1.5x10^6t$	2×10^6t	$2.0x10^6t$	3×10^6t	4×10^6t
	TOTAL	$1.5x10^6t$	2×10^6t	$3.0x10^6t$	6×10^6t	10×10^6t
[illegible].1) ALTERNATIVE 2.1: SOUTH/MALAWI						
• LAKE TERMINAL AT MUCANHA		-	-	1,790	2,326	3,048
• LAKE NAVIGATION		-	-	1,600	4,560	6,040
• LAKE TERMINAL AT NHANCAPIRIRE		-	-	2,835	3,441	5,233
• RAILWAY TERMINAL AT NHANCAPIRIRE		-	-	1,790	2,326	3,048
• RAILWAY OPERATIONAL COSTS		11,851	14,684	24,860	44,184	71,067
• COAL TERMINAL AT NACALA		6,443	6,443	6,443	9,573	13,961
• MISCELLANEOUS (10%)		1,829	2,113	3,352	6,641	10,240
[illegible]NNUAL OPERATIONAL COSTS	US$ 10^3	20,123	23,240	43,250	73,051	112,637
OPERATIONAL COSTS/TONS	US$/TONS	13.41	11.62	14.42	12.17	11.26
[illegible]OTAL INVESTMENTS	US$ 10^3	328,044	380,078	615,629	809,153	1,106,472
[illegible]0% OF THE INVESTMENTS÷20 YEARS	i = Ø %	11,481	13,302	21,547	28,320	38,726
TOTAL ANNUAL COSTS	i = Ø %	31,604	36,542	64,797	101,371	151,363
[illegible]OTAL COSTS/TONS.	i = Ø %	21.07	18.27	21.60	16.89	15.14
AMORTIZATION OF THE CAPITAL-PLUS INTERESTS (US$ 10^3)	i = 5 %	18,426	21,348	34,579	45,450	62,150
	i =10 %	26,972	31,250	50,618	66,530	90,976
	i =15 %	36,686	42,505	68,847	90,490	123,740
TOTAL ANNUAL COSTS (US$ 10^3)	i = 5 %	38,549	44,588	77,829	118,501	174,787
	i =10 %	47,095	54,490	93,868	139,581	203,613
	i =15 %	56,809	65,746	112,097	163,541	236,377
TOTAL COSTS/TONS (US$/TONS.)	i = 5 %	25.70	22.29	25.94	19.75	17.48
	i =10 %	31.40	27.24	30.29	23.26	20.36
	i =15 %	37.87	32.87	37.37	27.26	23.64
[illegible].2) ALTERNATIVE 2.2: SOUTH/ZAMBEZIA						
• LAKE TERMINAL AT MUCANHA		-	-	1,790	2,326	3,048
• LAKE NAVIGATION		-	-	1,600	4,560	6,040
• LAKE TERMINAL AT NHANCAPIRIRE		-	-	2,835	3,441	5,233
• RAILWAY TERMINAL AT NHANCAPIRIRE		-	-	1,790	2,326	3,048
• RAILWAY OPERATIONAL COSTS		10,821	13,458	22,327	40,122	63,215
• COAL TERMINAL AT NACALA		6,443	6,443	6,443	9,573	13,961
• MISCELLANEOUS (10%)		1,726	1,990	3,678	6,236	9,454
[illegible]NNUAL OPERATIONAL COSTS	US$ 10^3	18,990	21,891	40,463	68,583	103,999
OPERATIONAL COSTS/TONS	US$/TONS	12.66	10.94	13.49	11.43	10.40
TOTAL INVESTIMENTS	US$ 10^3	655,474	665,183	894,349	1,045,028	1,230,560
[illegible]0% OF THE INVESTMENTS÷20 YEARS	i = Ø %	22,941	23,281	31,302	36,575	43,069
TOTAL ANNUAL COSTS	i = Ø %	41,931	45,172	71,765	105,158	147,068
TOTAL COSTS/TONS.	i = Ø %	27.95	22.59	23.92	17.53	14.71
[illegible]MORTIZATION OF THE CAPITAL PLUS INTERESTS (US$ 10^3)	i = 5 %	36,818	37,363	50,235	58,699	98,743
	i = 10 %	53,894	54,692	73,535	85,924	144,541
	i = 15 %	73,304	74,389	100,018	116,869	196,596
TOTAL ANNUAL COSTS (US$ 10^3)	i = 5 %	55,806	59,254	90,698	127,282	202,742
	i = 10 %	72,884	76,583	113,998	154,507	248,540
	i = 15 %	92,294	96,280	140,481	185,452	300,595
TOTAL COSTS/TONS (US$/TONS.)	i = 5 %	37.20	29.63	30.23	21.21	20.27
	i = 10 %	48.59	38.29	38.00	25.75	24.85
	i = 15 %	61.53	48.14	46.83	30.91	30.06

TABLE 8.7

COST PER TON OF TRANSPORTED COAL (IN US$ 10^3 OF JULY OF 1982)

B) ROUTE 2 - NACALA

ITEMS OF COSTS						
	MUC./VUZI	MOATIZE ONLY		1.0×10^6 t	3×10^6 t	6×10^6 t
	MOATIZE	1.5×10^6 t	2×10^6 t	2.0×10^6 t	3×10^6 t	4×10^6 t
	TOTAL	1.5×10^6 t	2×10^6 t	3.0×10^6 t	6×10^6 t	10×10^6 t
b.3) ALTERNATIVE 2.3:NORTH/MALAWI						
• RAILWAY TERMINAL AT MUCANHA		-	-	1,790	2,326	3,048
• RAILWAY OPERATIONAL COSTS		11,851	14,684	25,156	45,717	73,366
• COAL TERMINAL AT NACALA		6,443	6,443	6,443	9,573	13,961
• MISCELLANEOUS (10%)		1,829	2,113	3,339	5,762	9,037
ANNUAL OPERATIONAL COSTS	US$ 10^3	20,123	23,240	36,728	63,378	99,412
OPERATIONAL COSTS/TONS	US$/TONS	13.41	11.62	12.24	10.56	9.94
TOTAL INVESTIMENTS	US$ 10^3	328,044	380,078	637,275	763,841	926,787
70% OF THE INVESTMENTS÷20 YEARS	i = Ø %	11,481	13,302	22,304	26,734	32,437
TOTAL ANNUAL COSTS	i = Ø %	31,604	36,542	59,032	90,112	131,849
TOTAL COSTS/TONS	i = Ø %	20.07	18.27	19.68	15.02	13.18
AMORTIZATION OF THE CAPITAL PLUS INTERESTS (10^3)	i = 5 %	18,426	21,348	35,796	42,905	52,057
	i = 10 %	26,972	31,250	52,398	62,804	76,202
	i = 15 %	36,686	42,505	71,268	85,423	103,645
TOTAL ANNUAL COSTS (US$ 10^3)	i = 5 %	38,549	44,588	75,524	106,283	151,469
	i = 10 %	47,095	54,490	89,126	126,182	175,614
	i = 15 %	56,809	65,745	107,996	148,801	203,057
TOTAL COSTS/TONS (US$/TONS.)	i = 5 %	25.70	22.29	24.17	17.71	15.15
	i = 10 %	31.40	27.24	29.71	21.03	17.56
	i = 15 %	37.87	30.87	36.00	24.80	20.31
b.4) ALTERNATIVE 2.4:NORTH/ZAMBEZIA						
• RAILWAY TERMINAL AT MUCANHA		-	-	1,790	2,326	3,048
• RAILWAY OPERATIONAL COSTS		10,821	13,458	23,205	42,338	67,255
• COAL TERMINAL AT NACALA		6,443	6,443	6,443	9,573	13,961
• MISCELLANEOUS(10%)		1,726	1,990	3,144	5,424	8,426
ANNUAL OPERATIONAL COSTS	US$ 10^3	18,990	21,891	34,582	59,661	92,690
OPERATIONAL COSTS/TONS	US$/TONS	12.66	10.94	11.53	9.94	9.27
TOTAL INVESTMENTS	US$ 10^3	655,474	665,183	963,519	1,107 856	1 282 998
70% OF THE INVESTMENTS÷20 YEARS	i = Ø %	22 941	23 281	33 723	38 774	44 904
TOTAL ANNUAL COSTS	i = Ø %	41 931	45 172	68 305	98 435	137 594
TOTAL COSTS/TONS.	i = Ø %	27,95	22,59	22,77	16,41	13,76
AMORTIZATION OF THE CAPITAL PLUS INTERESTS (US$ 10^3)	i = 5 %	36,818	37,363	54,121	62,228	72,066
	i = 10 %	53,894	54,692	79,222	91,090	105,490
	i = 15 %	73,304	74,389	107,753	123,895	143,481
TOTAL ANNUAL COSTS (US$ 10^3)	i = 5 %	55,808	59,254	88,703	121,889	164,756
	i = 10 %	72,884	76,583	113,804	150,751	198,180
	i = 15 %	92,294	96,280	142,335	183,660	236,171
TOTAL COSTS/TONS (US$/TONS)	i = 5 %	37.20	29.63	29.57	20.31	16.48
	i = 10 %	48.59	38.29	37.93	25.14	19.82
	i = 15 %	61.53	48.14	47.44	30.61	23.62

TABLE 8.7

COST PER TON OF TRANSPORTED COAL

C) ROUTE 3-ZAMBEZE-RIVER (IN US$ 10^3 OF JULY OF 1982)

ITEMS OF COSTS						
	MUC./VUZI	MOATIZE ONLY		1.0×10^6t	3×10^6t	6×10^6t
	MOATIZE	1.5×10^6t	2.0×10^6t	2.0×10^6t	3×10^6t	4×10^6t
	TOTAL	1.5×10^6t	2.0×10^6t	3.0×10^6t	6×10^6t	10×10^6t
c.1 ALTERNATIVE 3.1: SOUTH/ZAMBEZE RIVER						
• LAKE TERMINAL AT MUCANHA		–	–	1,790	2,326	3,048
• LAKE NAVIGATION		–	–	1,600	4,560	6,040
• LAKE TERMINAL AT NHANCAPIRIRE		–	–	2,835	3,441	5,233
• LAKE TERMINAL AT NHANCAPIRIRE		–	–	1,790	2,326	3,048
• RAILWAY OPERATIONAL COSTS		409	486	1,562	3,372	5,875
• RIVER TERMINAL AT TETE		2,530	2,530	2,530	3,893	4,823
• NAVIGATION ON THE ZAMBEZE RIVER		5,935	7,914	11,871	20,062	31,522
• COAL OFF SHORE TERMINAL AT CHINDE		20,409	20,409	20,409	26,330	37,261
• MISCELLANEOUS(10%)		2,928	3,134	4,439	6,631	9,685
ANNUAL OPERATIONAL COSTS	US$ 10^3	32,211	34,473	48,826	72,941	106,535
OPERATIONAL COSTS/TONS	US$/TONS	21.47	17.24	16.27	12.16	10.65
TOTAL INVESTMENTS	US$ 10^3	464,528	475,774	664,661	802,947	1,074,832
70% OF THE INVESTMENTS÷20 YEARS	i = Ø %	16,258	16,652	22,563	28,103	37,619
TOTAL ANNUAL COSTS	i = Ø %	48,469	51,125	71,389	101,044	144,154
TOTAL COSTS/TONS.	i = Ø %	32.31	25.56	23.80	16,840	14.41
AMORTIZATION OF THE CAPITAL PLUS INTERESTS (US$ 10^3)	i = 5 %	26,092	26,724	36,210	45,101	60,373
	i = 10 %	38,194	39,119	53,005	66,020	88,374
	i = 15 %	51,950	53,207	72,094	89,796	120,202
TOTAL ANNUAL COSTS (US$ 10^3)	i = 5 %	58,303	61,197	85,036	118,042	166,908
	i = 10 %	70,405	73,592	101,831	138,961	194,909
	i = 15 %	84,161	87,680	120,920	162,737	226,737
TOTAL COSTS/TONS (US$/TONS)	i = 5 %	38.87	30.60	28.34	19.67	16.69
	i = 10 %	46.94	36.80	33.94	23.16	19.49
	i = 15 %	56.11	43.84	40.31	27.12	22.67
c.2 ALTERNATIVE 3.2-NORTH/ZAMBEZE RIVER						
• RAILWAY TERMINAL AT MUCANHA		–	–	1,790	2,326	3,048
• RAILWAY OPERATIONAL COSTS		409	486	3,648	8,316	14,725
• RIVER TERMINAL AT TETE		2,530	2,530	2,530	3,893	4,823
• ZAMBEZE RIVER NAVIGATION		5,935	7,914	11,871	20,062	31,522
• COAL OFF SHORE TERMINAL AT CHINDE		20,409	20,409	20,409	26,330	37,261
• MISCELLANEOUS(10%)		2,928	3,134	4,024	6,092	9,138
ANNUAL OPERATIONAL COSTS	US$ 10^3	32,211	34,473	44,272	67,019	100,517
OPERATIONAL COSTS/TONS	US$/TONS	21.47	17.24	14.76	11.17	10.05
TOTAL INVESTMENTS	US$ 10^3	464,528	475,774	731,484	914,222	1,182,166
70% OF THE INVESTMENTS÷20 YEARS	i = Ø %	16,258	16,652	25,601	31,997	41,375
TOTAL ANNUAL COSTS	i = Ø %	48,469	51,125	69,873	99,016	141,892
TOTAL COSTS/TONS.	i = Ø %	32.31	25.56	23.29	16.50	14.19
AMORTIZATION OF THE CAPITAL PLUS INTERESTS (US$ 10^3)	i = 5 %	26,092	26,724	41,087	51,352	66,402
	i = 10 %	38,189	39,119	60,144	75,169	97,200
	i = 15 %	51,950	53,207	81,804	102,240	132,205
TOTAL ANNUAL COSTS (US$ 10^3)	i = 5 %	58,303	61,197	85,359	118,371	166,919
	i = 10 %	70,405	73,592	104,416	142,188	197,717
	i = 15 %	84,161	87,680	126,076	169,259	232,722
TOTAL COSTS/TONS (US$/TONS.)	i = 5 %	38.87	30.60	28.45	19.73	16.69
	i = 10%	46.94	36.80	34.81	23.70	19.77
	i = 15%	56.11	43.84	42.03	28.21	23.27

Since it was agreed from the sensitivity analysis that the advantages in favor of alternative 1.1 - Northern and CFM - Central System which the greatest annual amortization costs of investment relatively to the alternative 1.2 - Southern and CFM-Central System were overcome by the smaller operating cost of alternative 1.1, even if considered the interest variation from Ø% to 15%, a cost variation sensitivity analysis was carried out to evaluate for what level of cost reduction in alternative 1.2 would it be equal to alternative 1.1.

The revising investment and operating costs in lake terminals of Mucanha and Nhancapirire and in lake navigation were based upon the following criteria:

- *Investment Revision*

  - Mucanha terminal - not revised
  - Lake Transport

As an example, at the 3×10^6 tons/year for Mucanha/Vuzi was cut off one convoy to the value of US$ 7,800,000.00 to reduce idle capacity.

Initial fleet = 3 tug boats and 12 barges with an utilization index of 28.8% of used capacity at a 3.0×10^6 tons of coal level.

Revised fleet = 2 tug boats and 8 barges with an utilization index of 43.2% of used capacity.

  - Nhancapirire terminal - not revised.
  - Total reduction in investments.

Reduction in US$ 571,164,000.00 to US$ 563,364,000.00 - which means a reduction in investments in the order of 1.37% which was the same for the other production levels.

⊙ *Operating Costs Revision*

⊙⊙ *Mucanha Terminal Cost Revision*

- *Direct Costs*

To exemplify, it is shown operating cost reductions for a 3.0×10^6 tons production level in Mucanha/Vuzi and 3.0×10^6 tons for Moatize.

Consumption Material: reduction from US$ 100,000,000.00 to US$ 70,000.00.

Operational labor force: not revised.

Fuel and lubricants: reduction from US$ 100,000.00 to US$ 70,000.00.

Electrical energy: reduction from US$ 542,000.00 to US$ 217,000.00, due to not using all the equipments simultaneously during the working hours of the terminal. It was assumed a consumption in 40% of the installed capacity.

- *Maintenance*

Port civil works: reduction from US$ 84,600,00 to US$ 28,200.00. Adopted the 1% index on the investments.

Other civil works: not revised.

Equipment: reduction from US$ 594,000.00 to US$ 171,300.00.Adopted the 3% index on investments in equipments.

Electrical installations: reduction from US$ 22,000,00 to US$ 11,400.00. Adopted the 2% index on investments in electrical installations.

- *Indirect Costs*

Administration labor force: not revised.

Depreciation: not revised.

- *Summary of Mucanha Terminal Cost Revision*

Total reduction on annual operating cost estimates from US$ 2,326,000.00 to US$ 1,451,100.00.

oo *Lake Navigation Cost Revision*

As before, example is shown for a 3×10^6 tons coal production for Mucanha/Vuzi and 3×10^6 tons for Moatize.

- *Direct Costs*

- Operational labor force.

Specialized: reduction from US$ 84,000.00 to US$ 56,000.00.

Not specialized: reduction from US$ 36,000.00 to US$ 24,000.00.

Operational labor force reduction is due to reduction in one convoy.

Consumption Materials: reduction from US$ 90,000.00 to US$ 60,000.00 due to reduction in one convoy.

Fuel: not revised.

Insurance: reduction from US$ 468,000.00 to US$ 312,000.00, due to reduction in one convoy.

- *Maintenance*

Tug Boats - reduction from US$ 900,000.00 to US$ 240,000.00 due to reduction of one convoy and considering 4% on the acquisition price.

Barges - reduction from US$ 432,000.00 to US$ 192,000.00 due to reduction in one convoy and considering 2% on the acquisition price.

Signalling and buoys: not revised.

- *Indirect Costs*

Depreciation: assumed 20 years economical life for tugs and barges.

Tug Boats: reduction from US$ 600,000.00 to US$ 300,000.00 due to reduction in one convoy.

Barges: reduction from US$ 960,000.00 to US$ 480,000.00 due to reduction in one convoy.

Signalling and buoys: not revised.

- *Summary of lake navigation*

Total reduction on annual operating cost from US$ 4,560,000.00 to US$ 2,654,600.00.

oo *Nhancapirire Terminal*

As before example is shown for a 3×10^6 tons of coal production in Mucanha/Vuzi and 3×10^6 tons in Moatize.

- *Direct Costs*

Operational labor force: not revised.

Consumption materials: reduction from US$ 100,000.00 to US$ 70,000.00.

Fuel and lubricants:
- Fixed: reduction from US$ 150,000.00 to US$ 100,000.00.
- Wheel loader: not revised.

Electrical energy: reduction from US$ 472,500.00 to US$ 189,000.00 due not using all equipment simultaneously during terminal working hours. It was assumed a consumption value in a 40% of installed capacity.

- *Maintenance*

Port civil works: reduction from US$ 91,800.00 to US$ 30,600.00. - It was assumed an index of 1% on investment value.

Other civil works: not revised.

Equipment: reduction from US$ 1,016,000.00 to US$ 293,300.00. Assumed a 3% index on the acquisiton cost.

Electrical installations: reduction from US$ 57,300.00 to US$ 29,400.00. Assumed an index of 2% on the installations costs.

- *Indirect Costs*

Administration labor force: not revised.
Depreciation: not revised.

- Summary of Nhancapirire Terminal

  Reduction in the annual operating costs from US$ 3,441,500.00 to US$ 2,265,600.00.

- Summary of total operating costs at Nhancapirire Terminal

Reduction of total annual operating costs, from US$ 10,328,100.00 to US$ 6,371,300.00.

Table 8.8 display earlier operating costs and revised costs for the Mucanha terminal.

Table 8.9 and 8.10 shows the same as before for lake navigation and Nhancapirire terminal.

Finally Table 8.11 shows costs per ton of transported coal.

In Table 8.11 it can be seen that notwithstanding the annual cost reduction of 6%, which was considered acceptable within the limits of operation safety in alternative 1.2 - Shouthern, the cost per ton is only equal to alternative 1.1 - Northern in case of interest rates over a 10% yearly which is considered too high.

TABLE 8.8 – MUCANHA TERMINAL – OPERATING COSTS REDUCTIONS

US$ 10^3 JUL.82

COST ITEMS	EARLIER			RECTIFIED		
	$1x10^6$tons	$3x10^6$tons	$6x10^6$tons	$1x10^6$tons	$3x10^6$tons	$6x10^6$tons
1.1– Direct Costs						
a) Operational labor						
– Qualified	126.0	126.0	201.6	126.0	126.0	201.6
– Non Qualified	57.6	57.6	93.6	57.6	57.6	93.6
b) Consumption materials	50.0	100.0	150.0	35.0	70.0	105.0
c) Fuel and lubricants	50.0	100.0	150.0	35.0	70.0	105.0
d) Electrical energy	180.6	542.0	643.0	72.2	217.0	257.2
e) Maintenance						
– port civil works	84.6	84.6	142.2	28.2	28.2	47.4
– other civil works	26.6	26.6	30.2	26.6	26.6	30.2
– equipment	520.0	594.0	764.8	171.3	171.3	220.6
– electrical instalations	22.2	22.2	28.7	11.4	11.4	14.7
Sub-Total 1	1,117.6	1,653.0	2,204.1	563.3	778.1	1,075.3
1.2– Indirect Costs						
a) Administration labor						
– administrator	27.2	27.2	27.2	27.2	27.2	27.2
– non qualified	16.0	16.0	16.0	16.0	16.0	16.0
– qualified	14.0	14.0	14.0	14.0	14.0	14.0
b) Depreciation						
– civil works	207.3	207.3	261.3	207.3	207.3	261.3
– equipment	408.5	408.5	525.8	408.5	408.5	525.8
Sub-total 2	673.0	673.0	844.3	673.0	673.0	844.3
TOTAL	1,790.6	2,326.0	3,048.4	1,236.3	1,451.1	1,919.6
COST/TON	1.79	0.78	0.51	1.24	0.48	0.32

TABLE 8.9 - LAKE NAVIGATION - OPERATING COSTS REDUCTION

US$ 10³ JUL.82

COST ITEMS	EARLIER			RECTIFIED		
	$1x10^6$ tons	$3x10^6$ tons	$6x10^6$ tons	$1x10^6$ tons	$3x10^6$ tons	$6x10^6$ tons
1.1- Direct Costs						
a) Operational labor						
- qualified	28.0	84.0	112.0	28.0	56.0	112.0
- non qualified	12.0	36.0	48.0	12.0	24.0	48.0
b) Consumption materials	30.0	90.0	120.0	30.0	60.0	120.0
c) Fuel and lubricants	290.2	870.6	1,160.8	290.2	870.6	1,160.8
d) Insurance						
- tug boats	60.0	180.0	240.0	60.0	120.0	240.0
- barges	96.0	288.0	384.0	96.0	192.0	384.0
e) Maintenance						
- tug boats	300.0	900.0	1,200.0	120.0	240.0	480.0
- barges	144.0	432.0	576.0	96.0	192.0	384.0
- signalling and buoys	45.0	45.0	45.0	45.0	45.0	45.0
Sub-Total 1	1,005.2	2,925.6	3,885.8	777.2	1,799.6	2,973.8
1.2- Indirect Costs						
a) Depreciation						
- tug boats	200.0	600.0	800.0	150.0	300.0	600.0
- barges	320.0	960.0	1,280.0	240.0	480.0	960.0
- signalling and buoys	75.0	75.0	75.0	75.0	75.0	75.0
Sub-Total 2	595.0	1,635.0	2,155.0	465.0	855.0	1,635.0
TOTAL	1,600.2	4,560.6	6,040.8	1,242.2	2,654.6	4,608.8
Cost/Ton	1.60	1.52	1.01	1.24	0.88	0.77

TABLE 8.10 - NHANCAPIRIRE TERMINAL - OPERATING COST REDUCTION

US$ 10^3 JUL.82

COST ITEMS	EARLIER			RECTIFIED		
	$1x10^6$tons	$3x10^6$tons	$6x10^6$tons	$1x10^6$tons	$3x10^6$tons	$6x10^6$tons
1.1- Direct Costs						
a) Operational labor						
- Qualified	277.2	277.2	327.6	277.2	277.2	327.6
- Non Qualified	79.2	79.2	115.2	79.2	79.2	115.2
b) Consumption materials	50.0	100.0	150.0	35.0	70.0	105.0
c) Fuel and lubricants						
- fixed consumption	80.0	150.0	200.0	50.0	100.0	150.0
- wheel loader	22.0	66.0	132.0	22.0	66.0	132.0
d) Electrical energy	157.5	472.5	945.0	63.0	189.0	372.0
e) Maintenance						
- port civil works	91.8	91.8	156.6	30.6	30.6	52.2
- other civil works	78.3	78.3	82.2	78.3	78.3	82.2
- equipment	889.5	1,016.6	1,560.3	293.3	293.3	484.3
- electrical installations	57.3	57.3	77.7	29.4	29.4	42.2
Sub-total 1	1,787.8	2,388.9	3,746.6	958.0	1,213.0	1,868.7
1.2- Indirect Costs						
a) Administration labor						
- administrator	27.2	27.2	27.2	27.2	27.2	27.2
- non qualified	24.0	24.0	24.0	24.0	24.0	24.0
- qualified	21.0	21.0	21.0	21.0	21.0	21.0
b) Depreciation						
- civil works	249.5	249.5	310.0	249.5	249.5	310.0
- equipment	730.9	730.9	1,104.7	730.9	730.9	1,104.7
Sub-total 2	1,052.6	1,052.6	1,486.9	1,052.6	1,052.6	1,486.9
TOTAL	2,835.4	3,441.5	5,233.5	2,010.6	2,265.6	3,355.6
COST/TON	2.84	1.15	0.87	2.01	0.76	0.56

TABLE 8.11 - RECTIFIED COSTS PER TON OF TRANSPORTED COAL

US$ 10³ JUL.82

COST ITEMS	ALTERNATIVE 1.2-SOUTHERN			ALTERNATIVE 1.1-NORTHERN		
	3×10^6 tons	6×10^6 tons	10×10^6 tons	3×10^6 tons	6×10^6 tons	10×10^6 tons
Lake Terminal at Mucanha	1,236	1,451	1,919	-	-	-
Lake Navigation	1,242	2,654	4,608	-	-	-
Lake Terminal at Nhancapirire	2,010	2,265	3,355	-	-	-
Railway Terminal at Nhancapirire	1,790	2,326	3,048	-	-	-
Railway Operational costs	12,840	23,506	37,025	-	-	-
Beira Terminal	7,671	11,408	16,710	-	-	-
Miscellaneous (10%)	2,678	4,361	6,666	-	-	-
Annual Operational Costs	29,467	47,971	73,331	25,566	43,330	66,812
Operational Costs per ton	9.82	8.00	7.33	8.52	7.22	6.68
Total Investments	422,721	563,364	751,700	468,096	619,960	804,436
70% of the investiment ÷ 20 years (i = 0%)	14,795	19,717	26,309	16,383	21,698	28,155
Annual Total Costs (i = 0%)	44,262	67,688	99,640	41,949	65,028	94,967
Total Costs per ton (i = 0%)	14.75	11.28	9.96	13.98	10.83	9.49
Amortization of the principal plus interests (i = 5%)	23,744	31,627	42,222	26,293	34,823	45,185
(i =10%)	34,756	46,297	61,806	38,488	50,975	66,142
(i =15%)	47,274	62,978	84,064	52,349	69,333	89,962
Annual Total Costs (i = 5%)	53,211	79,598	115,553	51,859	78,153	111,997
(i =10%)	64,223	94,268	135,137	64,054	94,305	132,954
(i =15%)	76,741	110,949	157,395	77,915	112,663	156,774
Total Costs per Ton (i = 5%)	17.73	13.27	11.55	17.29	13.03	11.20
(i =10%)	21.40	15.71	13.51	21.35	15.72	13.30
(i =15%)	25.58	18.49	15.73	25.97	18.78	15.68

Figure 8.2 to 8.5 shows the graphic representation of investments and costs per ton of coal transported in each production level from both Mucanha/Vuzi and Moatize mines in a Ø%, 5%, 10% and 15% interest rate for capital amortization respectively.

Figure 8.6 shows the graphic representation of investments and costs per ton of coal transported in each production level from both Mucanha/Vuzi and Moatize mines for only the Alternative 1.1 - Northern and rectified Alternative 1.2 - Southern for the whole set of Ø%, 5%, 10% and 15% interest rate.

MT-GEIPOT

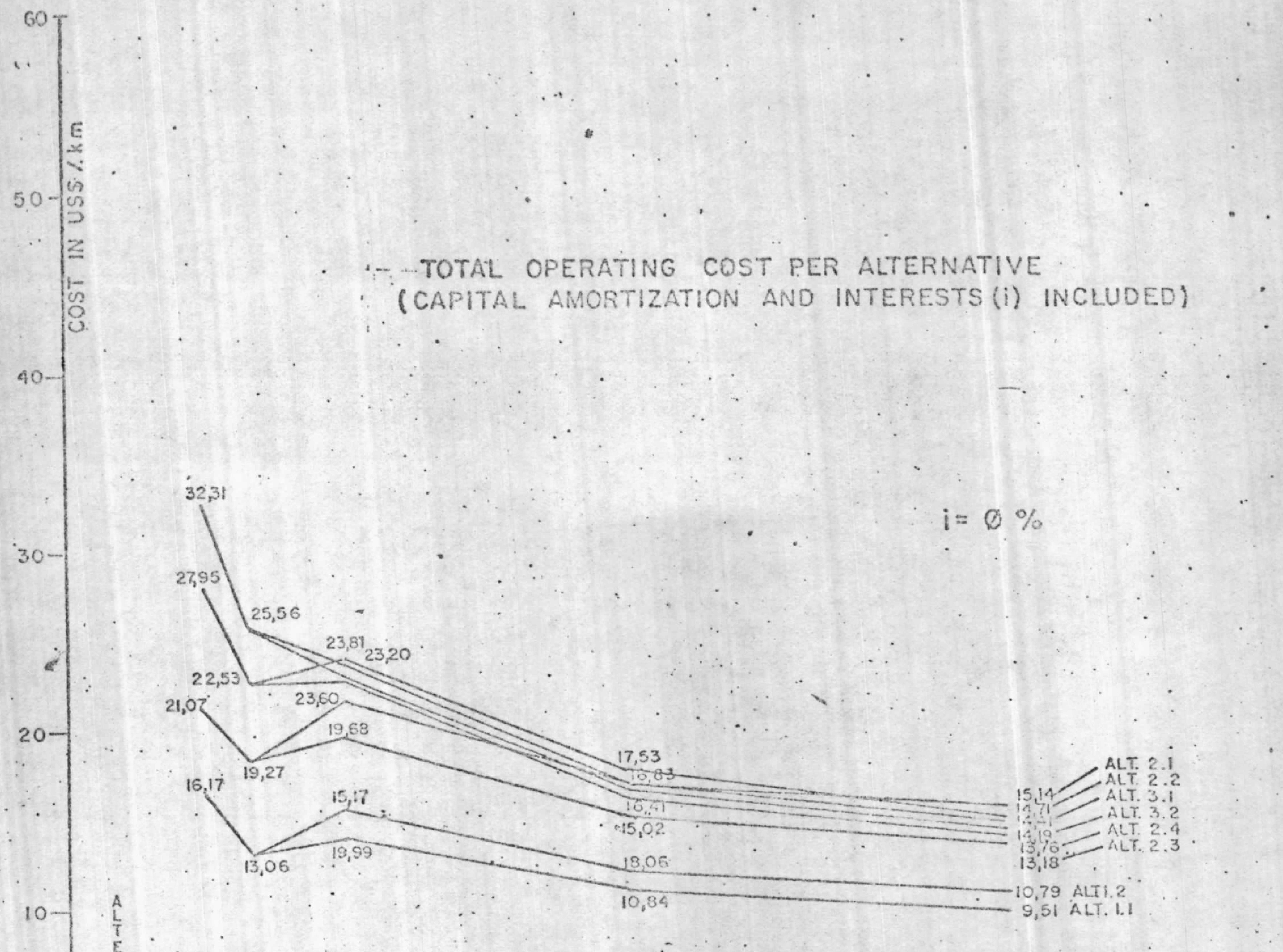


FIG. 8.2

STUDY OF OUTFLOW ALTERNATIVES

Graphical Representation of Alternatives Under Study

MT-GEIPOT

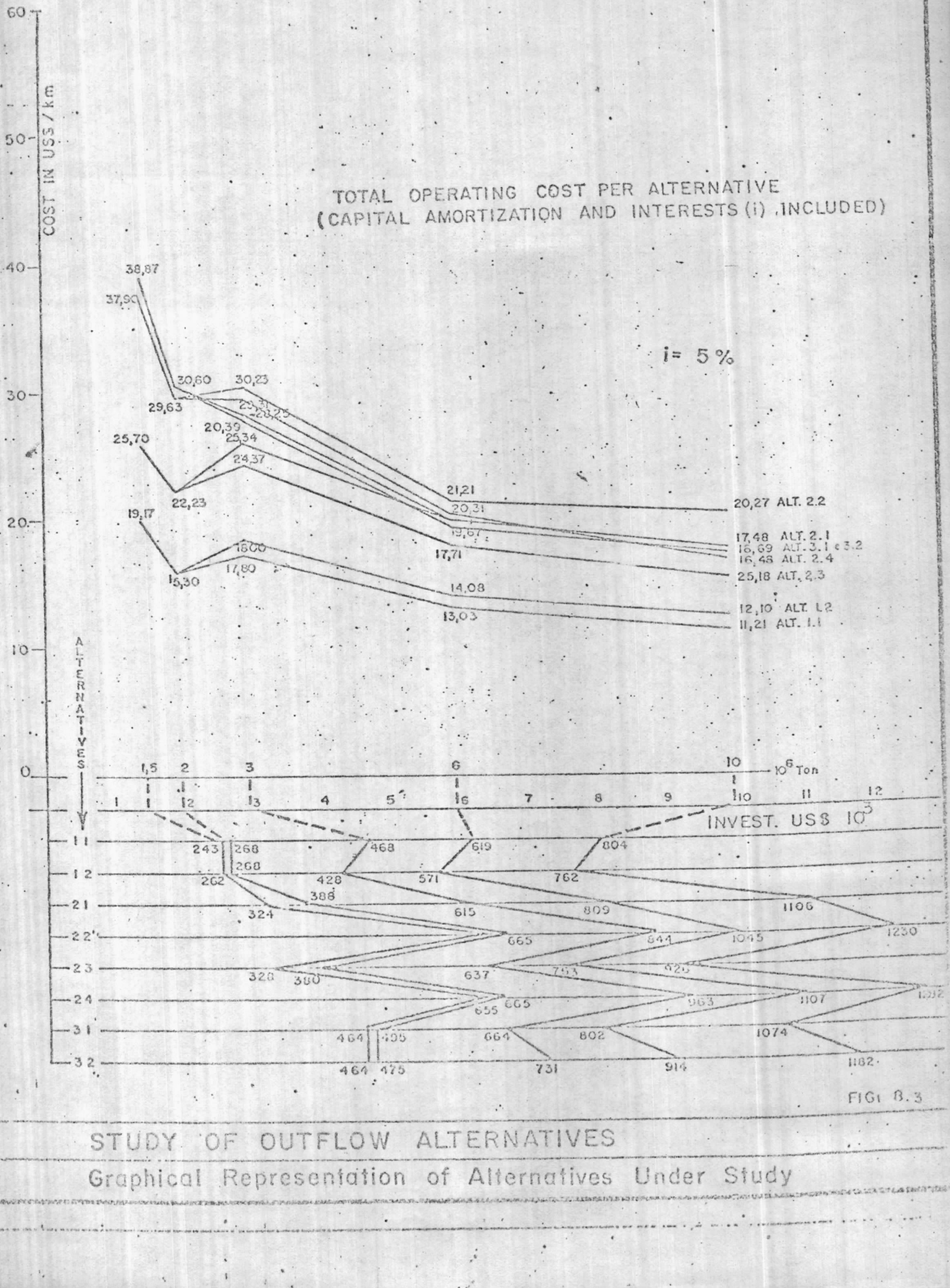


FIG. 8.3

STUDY OF OUTFLOW ALTERNATIVES

Graphical Representation of Alternatives Under Study

MT-GEIPOT

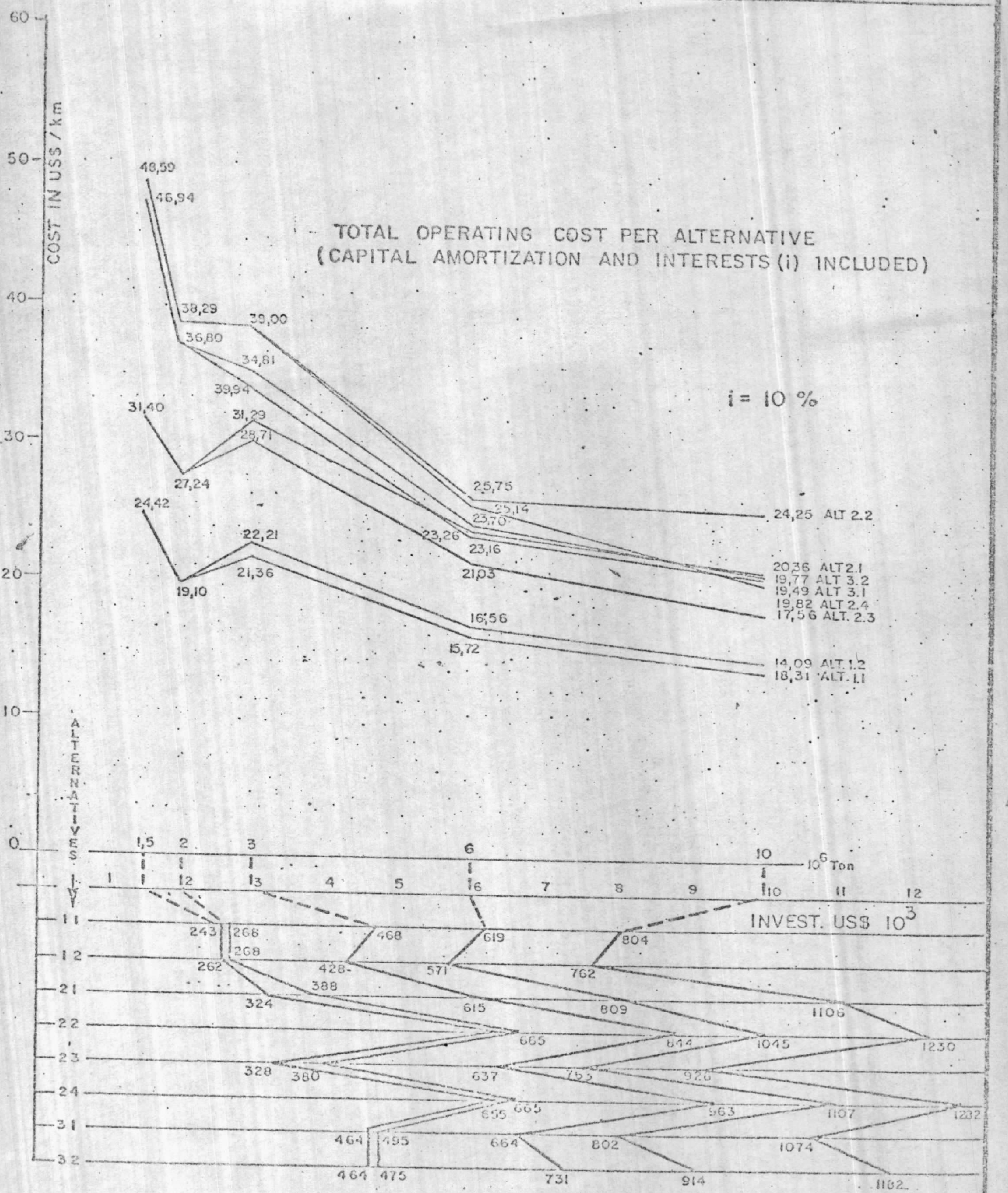


FIG. 8.4

STUDY OF OUTFLOW ALTERNATIVES

Graphical Representation of Alternatives Under Study

MT-GEIPOT

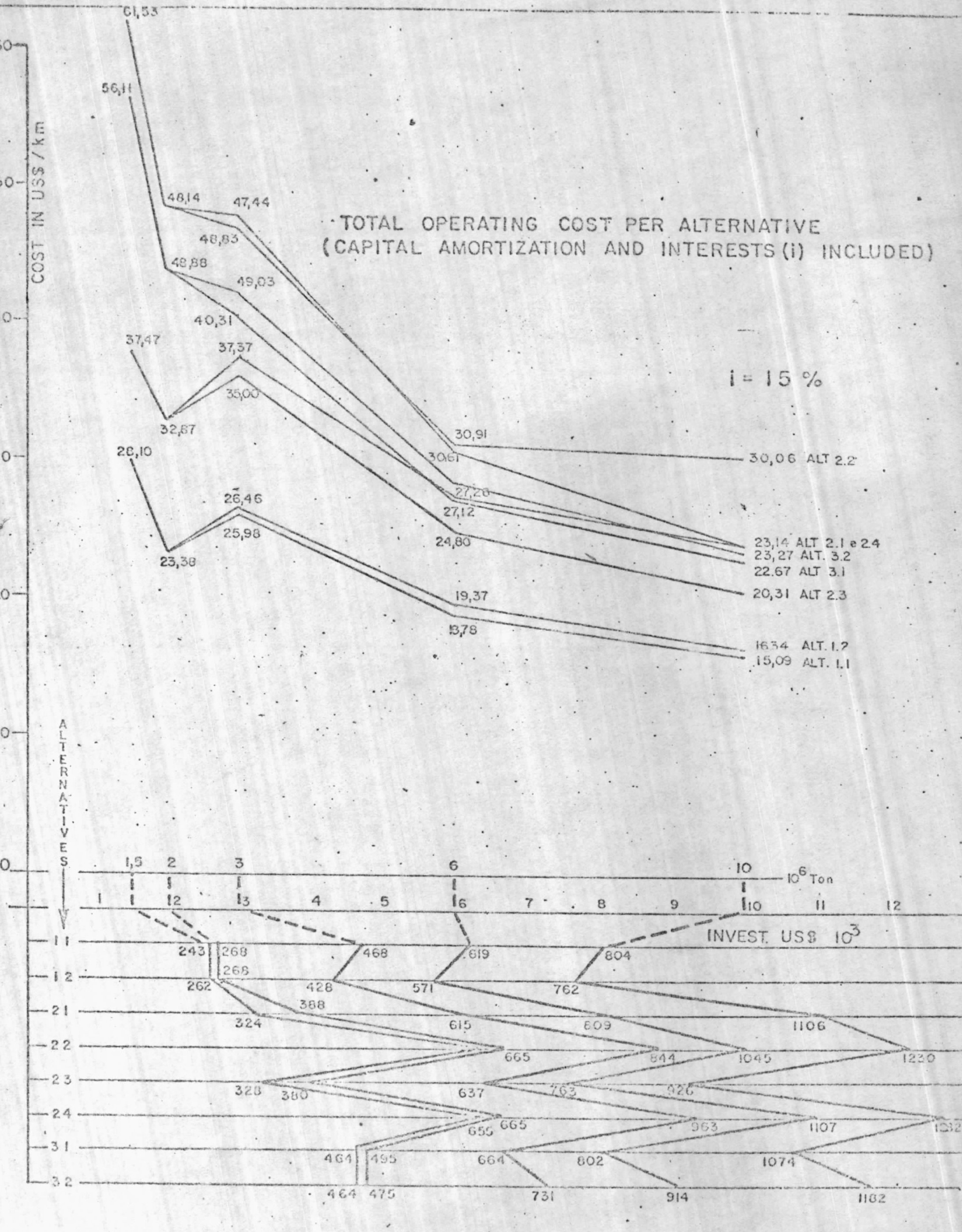


FIG 8.5

STUDY OF OUTFLOW ALTERNATIVES

Graphical Representation of Alternatives Under Study

MT-GEIPOT

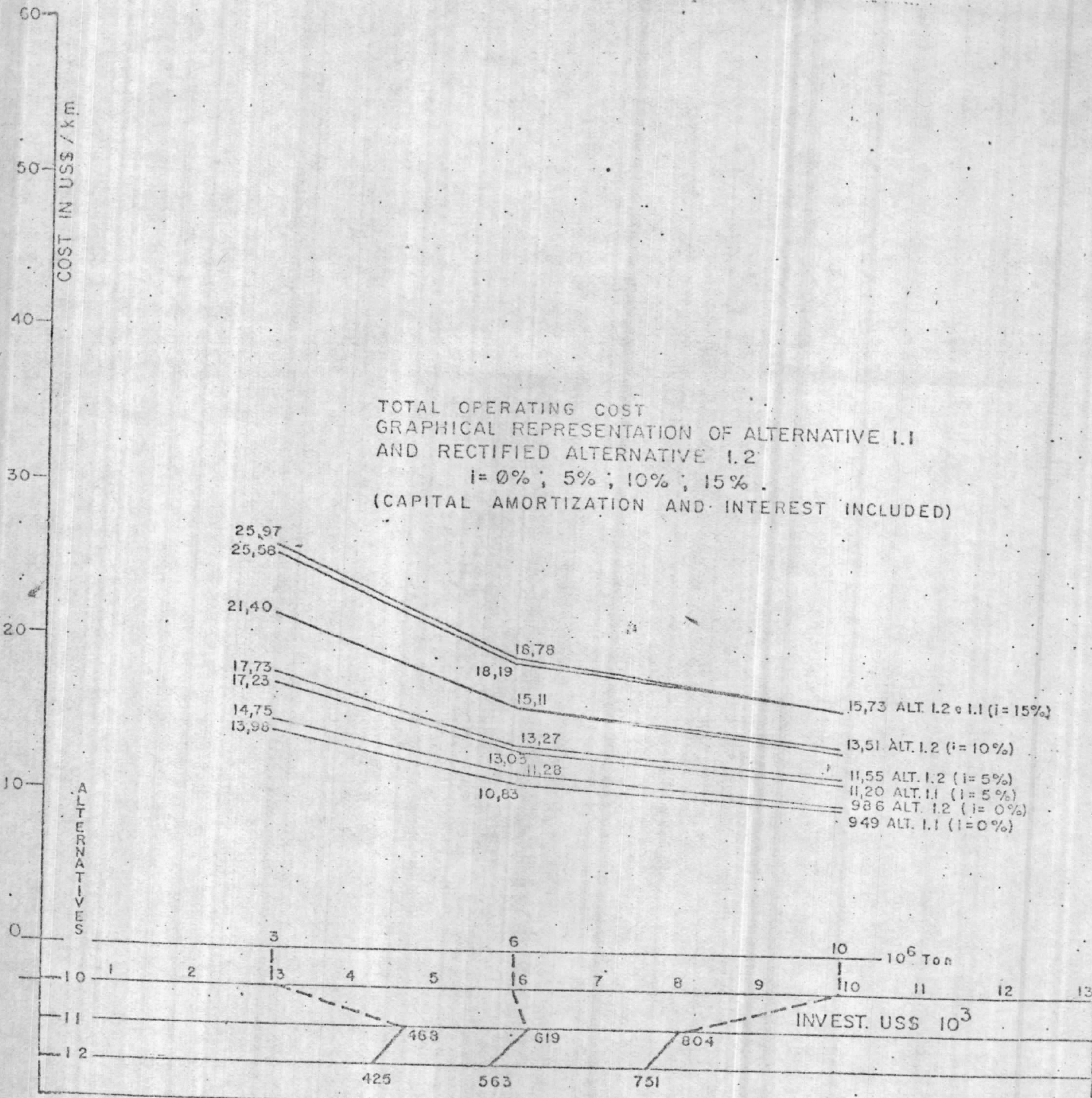


FIG. 8.6

STUDY OF OUTFLOW ALTERNATIVES

Graphical Represeniation of Alternatives Under Study

9 - CONCLUSIONS

9. CONCLUSIONS

It has been developed by GEIPOT an effort aiming at reducing to a minimum the error basis normally accepted in a pre-feasibility studies, to allow the conclusive indication of the most economical route and alternative for the coal transport outflow from the Mucanha/Vuzi mines.

Notwithstanding this effort two alternatives, both in Route 1 - Beira are very close in cost and within reduced limits of error more than acceptables.

Alternative 1.1 - Northern through Cambulatsisse and CFM - Central System is exclusively railway mode type and has the advantage of allowing Mozambique to develop a training effort in human resources in only one modal specialization, which is by its turn already traditional in the country, requiring only a quantitative and qualitative training to operate the new production levels besides its lower operating costs.

As a disadvantage it can be pointed out its greatest investment costs which would require an additional effort from Mozambique officers in obtaining the difference of financial resources in an restrained international money market.

Alternative 1.2 - Southern, across Cahora Bassa lake up to Nhancapirire and interconnection with the CFM - Central System in Moatize and going to Beira have by its turn the advantage of its smaller investment cost and the fact that it passes close to Sanangoê where coal occurrence is observed (not researched) and if proved it would benefit in the future by the proposed alternative 1.2 transportation system.

As a disadvantage presents greater operating cost and the need of diversified human resource training in several specializations as terminal, navigation and railroad operation.

Sensitivity analysis indicates that:

- Even assuming an interest rate variation in 0%, 5%, 10% and 15%, for the amortization of the capital invested based on foreign loans and credits, the difference in annual operating costs in favor of Alternative 1.1 - Northern and CFM-Central System up to Beira port easily overcomes the differences in annual amortization of capital and interests invested on the basis of foreign loans and credits in favor of alternative 1.2 - South across Cahora Bassa lake up to the port of Beira.

  It was assumed an amortization time for 20 years and with a rate of interest in a 5% to 10% interval would result from a combination of foreign loans, credit and donations.

- Based on possible reduction in 6% of the alternative 1.2-Southern cost without affecting safety in operations demonstrated that even in this case the cost per ton of coal transported from Mucanha/Vuzi and Moatize would only be equal to Alternative 1.1 - Southern in case of an interest rate over 10% a year.

It is evident that, at a pre-feasibility study level values in alternative 1.1 and 1.2 are close enough not allowing absolute certainty concerning the alternative chose. This gives Mozambique Government the freedom to choose either one or other alternative for political or qualitative reasons.

Based upon the results of the analysis GEIPOT indicates as the most economical, alternative 1.1 - Northern which comprises the construction of the railway terminal at Mucanha, the construction of the railway connection from Mucanha to Cambulatsisse (340 km long) the construction of the Moatize to Cateme variant (32 km long), the rehabilitation and upgrading of the railway section Cateme to Cambulatsisse (26 km long) and Cambulatsisse to the port of Beira (517 km long) and construction of the coal terminal at the port of Beira (Franquia point).

List of References

Documents and Studies

1 - HIDROTÉCNICA PORTUGUESA - Plano Prospectivo Indicativo da Navegabilidade do Rio Zambeze - TOMO 1 e 2 (DNA)

2 - SOGREAH ING. CONSULT - Projeto de Aproveitamento do Rio Zambeze para Navegação entre o Tete e o Mar(1981) - DNPCFM

3 - Henderson Busby Partnership Cooper & Lybrand Ass.Limited Bertlin and Partner Moçambique Coal Transportarion Study-Phase I-Prefeasibility Study (1981) - GSECHI

4 - Jones Baldemeier & Colto - Report on the Ocean Transportation of Moçambique Coal - GSECHI

5 - RDA - Veb Kombinat - Estudo sobre o Transporte de Carvão de Moçambique(Moatize à Beira) e o Transbordo de Carvão no Porto da Beira

6 - NEDECO-Inception Report Beira Port Study and Progress Report-1981-MPTS

7 - RDA-Veb Kombinat-Estudo sobre o Transporte de Carvão de Moatize à Beira e o Transbordo do Carvão no Porto de Beira/RPM(I e II)

8 - Hidrotécnica Portuguesa - Plano Diretor do Porto da Nacala-Plano de Desenvolvimento (Tomo 2,3 and Technical notes)-1977

9 - Bertlin and Partners Consulting Engineers Port of Beira - Pre-Feasibility Study of Channel Improviments - Vol. 3-1978-DNPCFM

10 - Soros Associates-Coal Handling Terminal Port of Nacala,Mozambique Engineering Report-1976

11 - Transkomplet - Estudo das Possibilidades de Criação de Condições para Navegação na Albufeira de Cahora Bassa - DNTF

12 - VIAK AB - Estudo Nacional de Transportes - 1978

13 - NEDECO - Inland Transportation and Transport Costs-1982

14 - Southern Africa Transport and Communications Commission-1981

15 - Port of Nacala (How to Save or Railage costs and get your goods there quicker

16 - Port of Lourenço Marques (idem, idem)

17 - Principais Portos de Moçambique-DNPCF

18 - Tabela de Marés do porto de Maputo-Capitania de Portos de Maputo

19 - ANFRENA-Agência Nacional de Portos e Navegação

20 - Salários Oficiais na RPM - engº Lemos de Brito

21 - Sondagens Geológicas - Nacala

22 - Perfil da Linha Norte - (km 0-km 534) - CFM-Norte

23 - Perfil da Linha Centro- CFM-Centro

24 - Perfil da Ligação Cambulatsise-Mucanha(escala 1:2500)

25 - Rede Ferroviária de Moçambique

26 - Rede Rodoviária da RPM

27 - Interligação das Linhas Ferroviárias de Tete-Malawi-Moçambique

28 - Cartas e Fotos Aéreas(1:50.000)

29 - Porto de Nhancapirire - Plano Geral

30 - Porto de Mucanha

31 - Variantes das Linhas Férreas

32 - Esquema de Ação do Sistema "Trisponter"

33 - Cartas Náuticas nºs 416, 417, 418 a 466

34 - Porto da Beira-
- Desenvolvimento Futuro do Porto-Jan. 80
- Plano Hidrográfico-Mai. 69

35 - Cartas (Escala 1:500.000) nºs 01, 10, 11, 18, 19, 23

36 - Cópias de Plantas, Quadros, Textos para complementação do estudo da BRIAN COLQUHOUN O'DONNE & PARTNERS

37 - Tabela de Marés - 1982 - Vol, II

38 - STATISTICS
Population, Production, flows, economical information

39 - Estudo das Cheias do Rio Zambeze - Rendel, Palmer & Tritton-1978/79

40 - King L.C. - South African Scenery. A Text book of geomorphology London - 1961 - 2ª edição - pag. 361

41 - Fernando Real - Geologia da Bacia do Rio Zambeze - Moçambique-Lisboa - 1966.