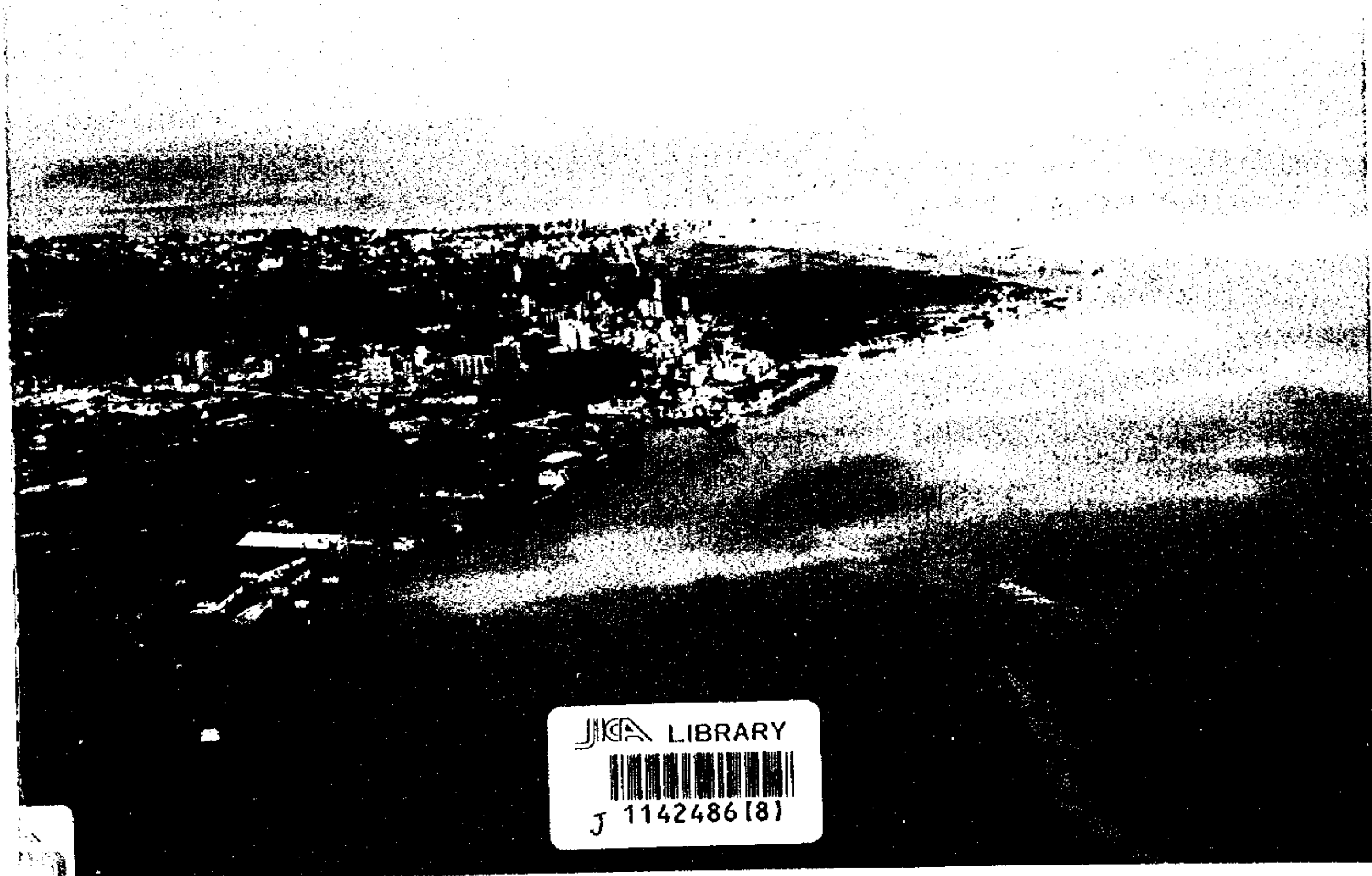
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)
MINISTRY OF TRANSPORT AND COMMUNICATIONS
THE REPUBLIC OF MOZAMBIQUE

社会開発調査部報告書

FINAL REPORT

THE STUDY FOR MAINTENANCE AND IMPROVEMENT PLAN OF ACCESS CHANNEL OF BEIRA PORT IN THE REPUBLIC OF MOZAMBIQUE

SUMMARY



MARCH 1998

TETRA CO., LTD.
OVERSEAS SHIPBUILDING COOPERATION CENTER

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SUMMARY

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CURRENCY EXCHANGE RATE

1 US Dollar = 11,300 Mozambican Meticals
= 116.84 Japanese Yen

(As of February, 1997)

PREFACE

In response to a request from the Government of the Republic of Mozambique, the Government of Japan decided to conduct a study for Maintenance and Improvement Plan of Access Channel of Beira Port in Mozambique and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent a study team to Mozambique four times between January 1997 and February 1998. The study team was headed by Dr. Shoji Sato and composed of members of Tetra Co., Ltd. and Overseas Shipbuilding Cooperation Center.

The team held discussions with the officials concerned of the Government of Mozambique and conducted field surveys at the study area. After the team returned to Japan, further studies were made and the present report was prepared.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of the Republic of Mozambique for their close cooperation extended to the team.

March, 1998

Kimio Fujita
President
Japan International Cooperation Agency

LETTER OF TRANSMITTAL

March, 1998

Mr. Kimio Fujita
President
Japan International Cooperation Agency

Dear Mr. Fujita

It is my great pleasure to submit herewith the Report for the Study for Maintenance and Improvement Plan of Access Channel of Beira Port in Mozambique.

The study team which consists of the Tetra Co., Ltd. and Overseas Shipbuilding Cooperation Center, headed by myself, conducted a survey in Mozambique from January 1997 to February 1998 as per the contract with the Japan International Cooperation Agency.

The findings of this survey were fully discussed with the officials of the Ministry of Transport and Communications and other authorities concerned to formulate the Siltation Analysis and Maintenance Dredging Plan of the Access Channel and to formulate and examine the feasibility of the introduction of a new dredger, and were then compiled into this report.

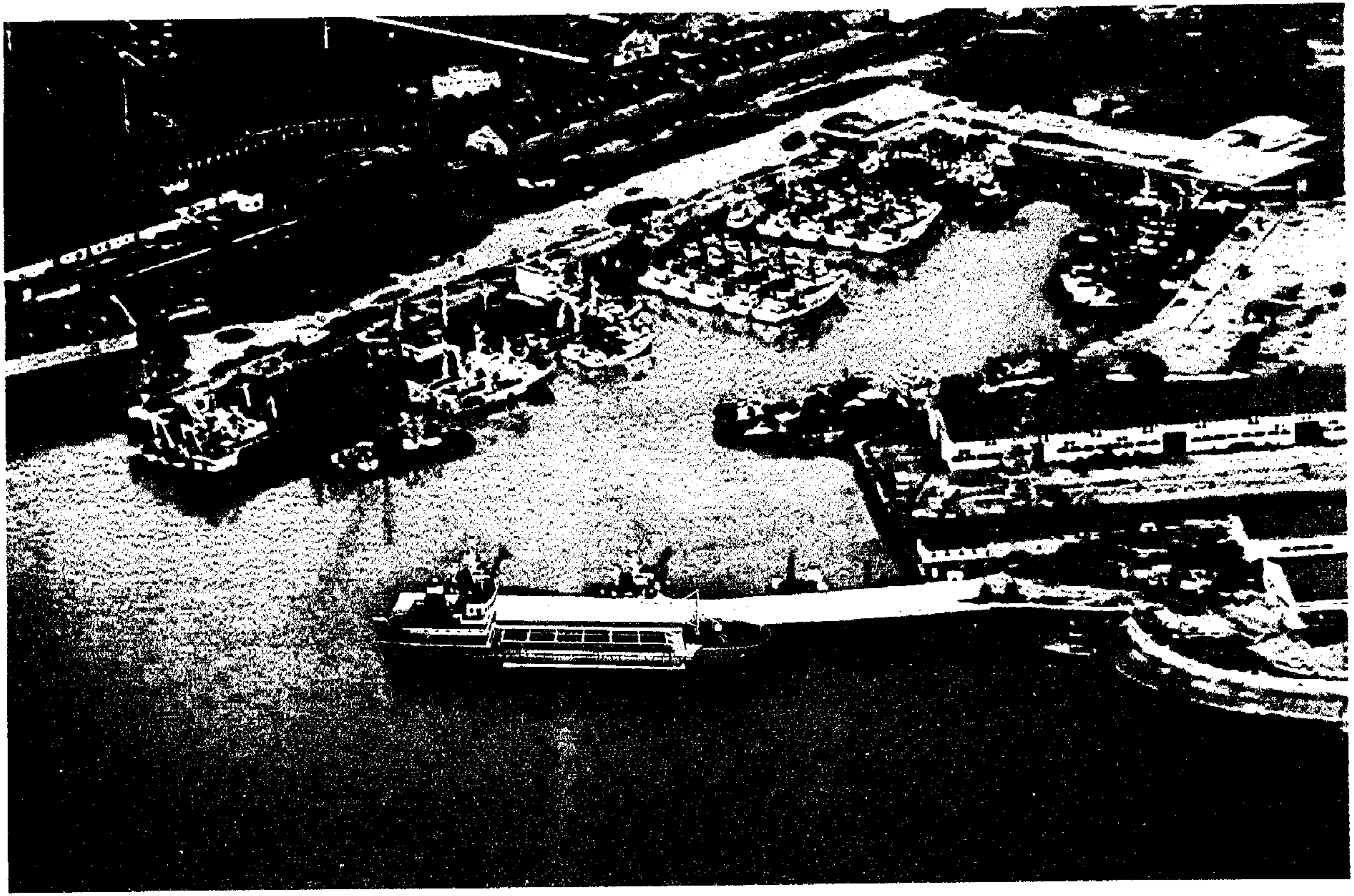
On behalf of the study team, I would like to express my deepest appreciation to the Government of Mozambique and other authorities concerned for their brilliant cooperation and assistance and for the heartfelt hospitality which they extended to the study team during the stay in Mozambique.

I am also greatly indebted to the Japan International Cooperation Agency, the Ministry of Foreign Affairs, the Ministry of Transport and the Embassy of Japan in Zimbabwe for giving us valuable suggestions and assistance during the preparation of this report.

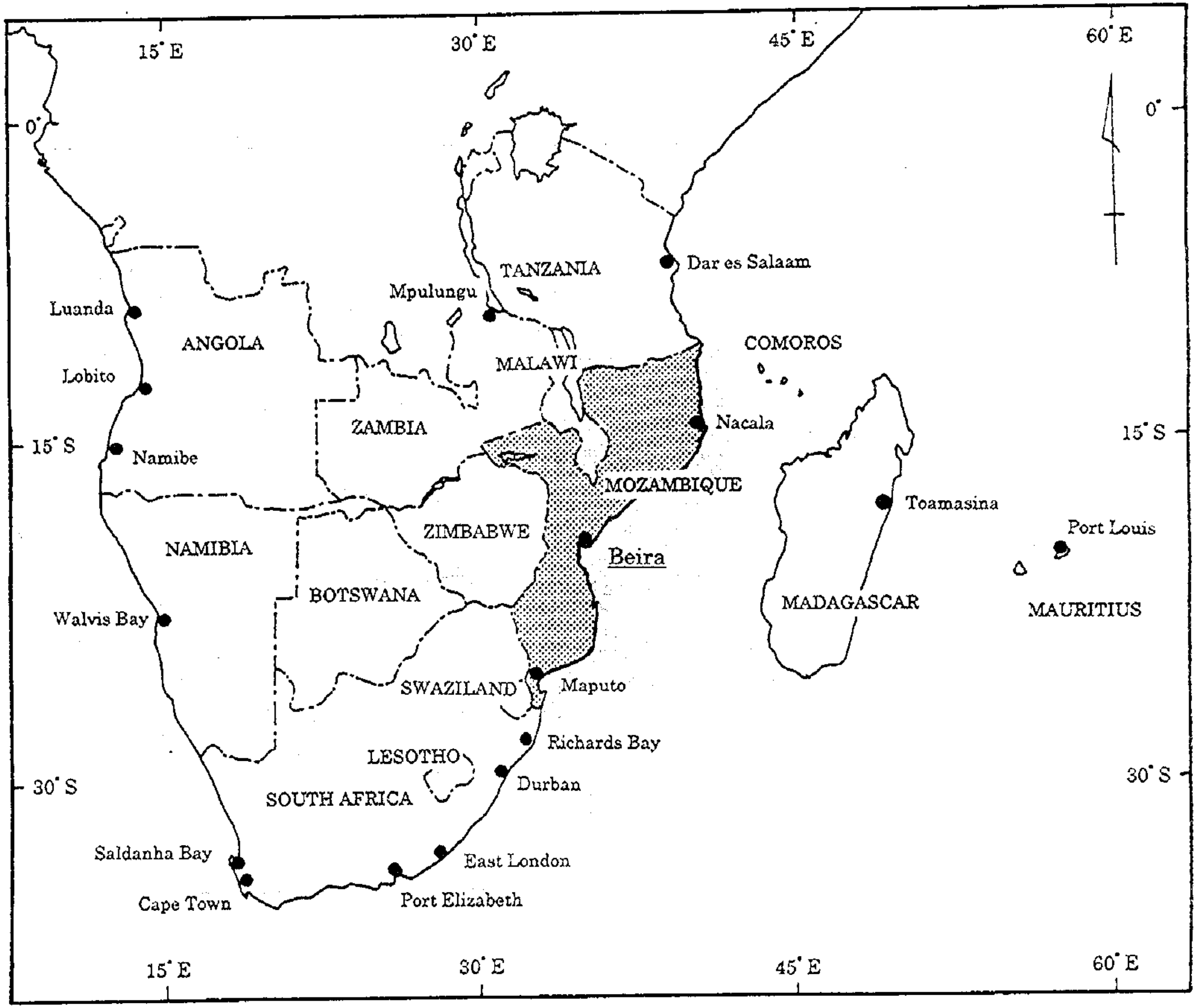
Respectfully,

Shoji Sato
Leader of the Study Team for
the Study for Maintenance and Improvement
Plan of Access Channel of Beira Port

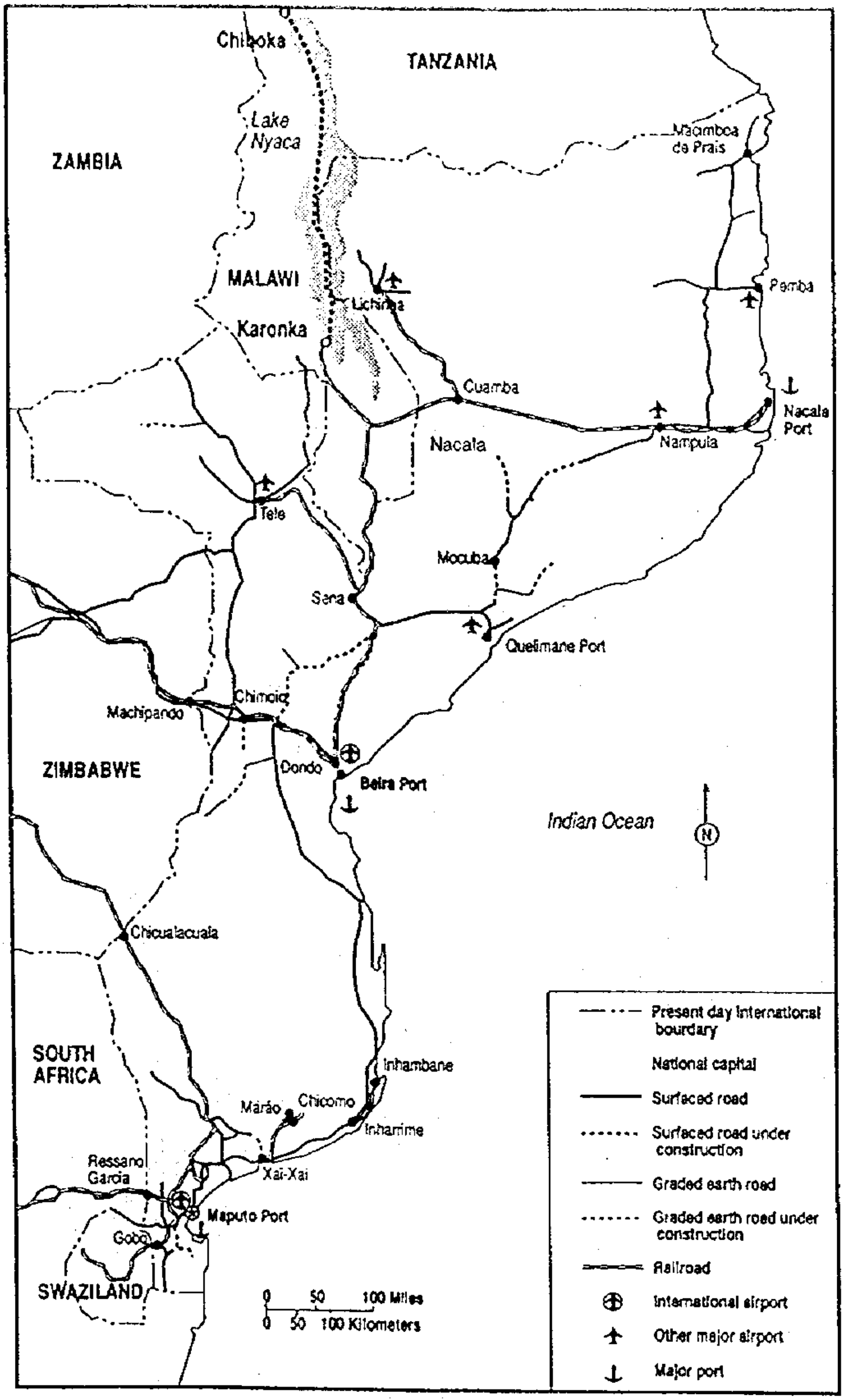
Beira Port and Access Channel



New Dredger and Berthing Jetty

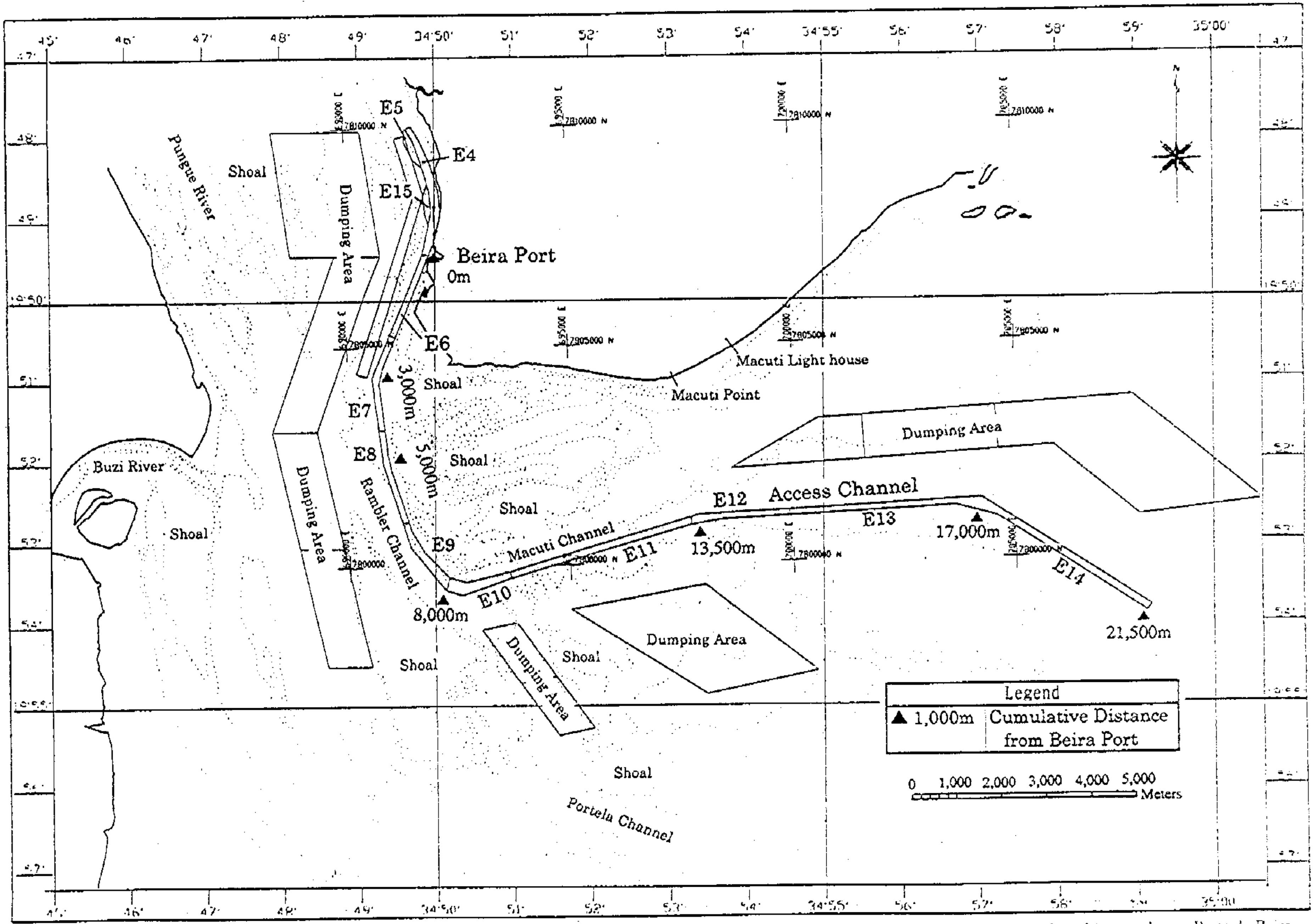


Location of Beira



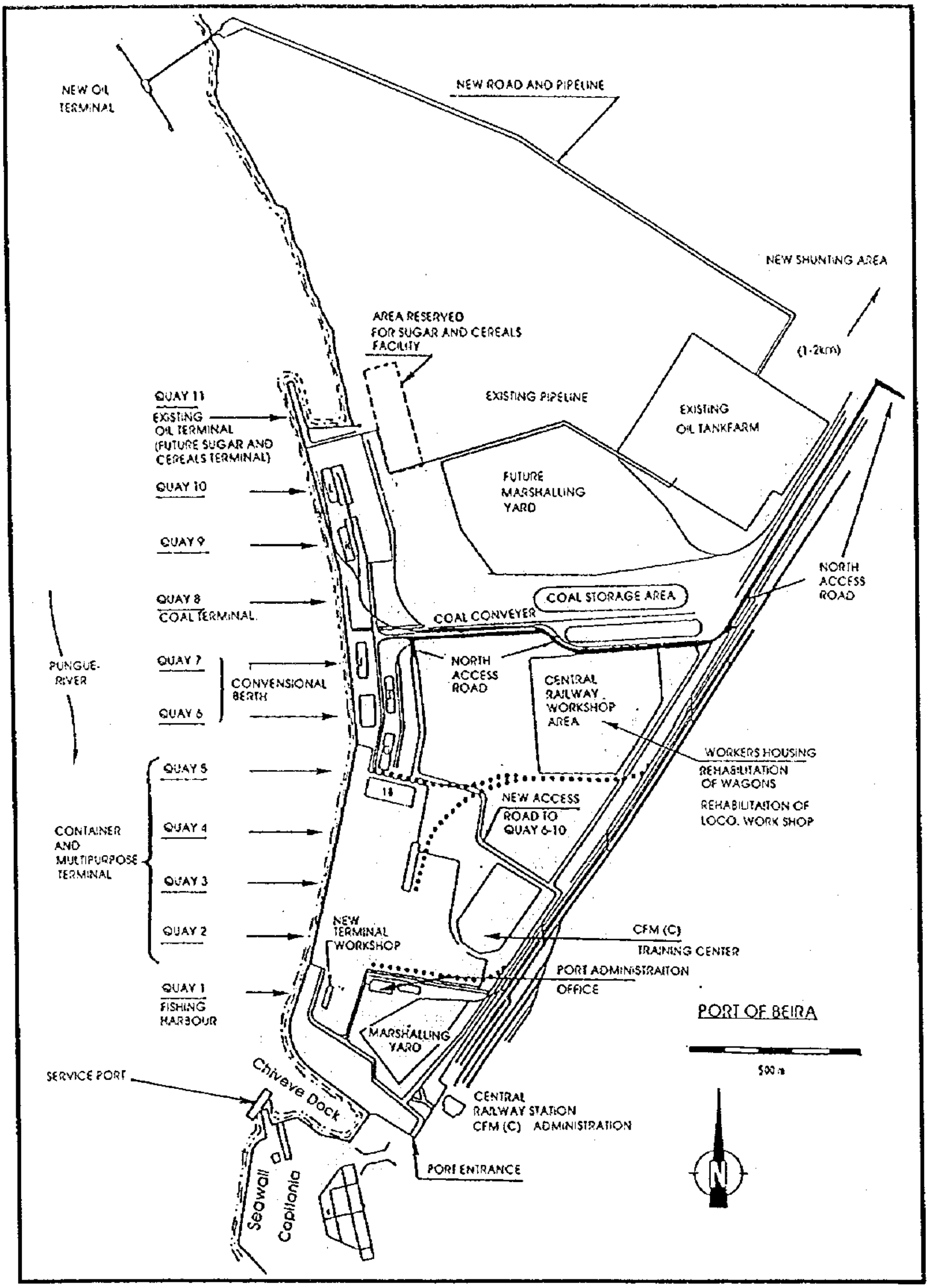
(Source: the Ministry of Transport and Communications)

. Transportation Network in Mozambique



Source : Map of Approaches to Porto da Beira No.1003

Location of Beira Port and the Access Channel



Facility Layout of Beira Port

ABBREVIATIONS

AM	Air Malawi
AZ	Air Zimbabwe
BCA	Beira Corridor Authority
BPTS	Beira Port Transport System
B/S	Balance Sheet
CA	Board of Management, CFM
CDL	Chart Datum Level
CFC	Conversion Factor for Consumption
CFL	Conversion Factor for Labor
CFM	Mozambique Ports and Railways
CFM-C	Mozambique Ports and Railways-Center
CFM-N	Mozambique Ports and Railways-North
CFM-S	Mozambique Ports and Railways-South
CFM-Z	Mozambique Ports and Railways-Zambezia
CIF	Cost, Insurance and Freight
DAC	Development Assistance Committee, OECD
DGPS	Global Positioning System in Differential Mode
DWT	Dead Weight Tonnage
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate and Return
EMODRAGA	Mozambique Dredging Company
FIRR	Financial Internal Rate of Return
FOB	Free on Board
GCT	General Cargo Terminal
GDP	Gross Domestic Product
GOJ	Government of Japan
GOM	Government of the Mozambique
GPS	Global Positioning System
HAT	Highest Astronomical Tide
IEE	Initial Environmental Examination
INAHINA	National Institute of Hydrography and Navigation
LAM	Mozambique Airline
LAT	Lowest Astronomical Tide
Loa	Length Overall
Lpp	Length between Perpendiculars
MCT	Multipurpose and Container Terminal
MHWN	Mean High Water Neap Tide
MHWS	Mean High Water Spring Tide
MLWN	Mean Low Water Neap Tide
MLWS	Mean Low Water Spring Tide
MSC	Mediterranean Shipping Company
MSL	Mean Sea Level
MT	Mozambique Meticals
MTC	Ministry of Transport and Communications
m-ton	Metric Ton
ODA	Official Development Assisstance

OECD	Organization for Economic Cooperation and Development
P/L	Profit and Loss
POL	Petroleum, Oil and Lubricant
RSA	Republic of South Africa
SADC	Southern Africa Development Community
SATCC	Southern Africa Transport and Communication Commission
SCF	Standard Conversion Factor
TEU	Twenty Footer Equipment Unit
UK	United Kingdom
US$	United States Dollar
USA	United States of America
UTM	Universal Traverse Mercator
ZA	Zambia Airline
Z$	Zimbabwe Dollar

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ABSTRACT

ABSTRACT

1 Background

Beira Port located in the central Mozambique, Maputo Port in the south and Nacala Port in the north are the major ports in Mozambique, each functioning as a gateway for national and international routes of transport connecting Mozambique and inland countries of Southern Africa. The Beira Corridor has been developed as the most efficient route to Zimbabwe, where the improvement of infrastructures such as railways, roads and pipelines is being carried out.

Beira Port has developed according to the "10-year Development Plan of Beira Corridor". At present, there exist 10 berths of container and general cargo terminal of 1,690 m in total length and an oil berth. However, Beira Port is situated at the river mouth of the Pungue River, and sedimentation in the Access Channel and the basin is the most serious problem in port management.

All maintenance dredging works in Mozambique is executed by EMODRAGA. However, EMODRAGA conducts dredging works in other ports besides Beira Port using only an obsolescent trailer suction dredger and other small vessels, so that it is impossible to dredge the big amount of sedimentation generated every year in Beira Port.

Under these circumstances, in response to the request of the Government of Mozambique, in February 1996, the Government of Japan dispatched a preliminary study mission to Mozambique under the grant aid scheme. Although the need and urgency of offering a dredger were acknowledged, it was judged necessary to study the sedimentation phenomena and to make the plan of improvement of the Access Channel based on a long range view. Therefore, the Government of Mozambique requested the Government of Japan for a cooperation in planning maintenance and improvement of the Access Channel to Beira Port.

2 Present Situation of Beira Port

The Access Channel to Beira Port is crossing an extensive shoal area. After "Access Channel Study" in 1982 and "Master Plan Study for the Port of Beira" in 1984, a capital dredging work was carried out for 19 months from March 1989. The channel was deepened to 8.0 m below CDL, taking the 30,000 DWT tanker and cargo ship as the design ship size. Thereafter, effective maintenance dredging work has not been executed, so that some part of the Channel become shallower than 5 m in depth. At present, most of the large sized ships entering

Beira Port have to wait until the tide level reaches the necessary water depth for sailing through the Channel.

In the last 5 years, the cargo volume including oil products handled at Beira Port was around 2.6 million metric tons a year with a steady increase, of which about 80 % were transit cargoes to and from the inland countries. In 1996, the maximum dead weight tonnage of calling ships to Beira Port was 30,611 tons of a oil tanker and the number of ocean going ships' call was 322.

3 Natural Condition

Beira belongs to the tropical zone which is characterized by the wet season from November to April and the dry season from May to October. The occurrence frequency of strong wind more than 10 m/sec is very small and it is mainly caused by cyclones in the wet season. The sea condition around the Access Channel is also very calm throughout the year, except the times of cyclones mainly attacking in the wet season. The tide in Beira is of typical semi-diurnal and its range is very large. Mean High Water and Mean Low Water at Spring Tide are respectively +6.5 and +0.9 m above CDL.

During the periods from January to April in the wet season and from July to September in the dry season in 1997, oceanographic survey was conducted in order to obtain characteristics of sea conditions. From this survey, the following characteristics have been obtained:

(a) In the wave observation at the point of 13 m deep near the entrance of the Access Channel from the 9th of February to the 9th of April, the maximum significant wave was 4.2 m in height and 10.7 sec in period. It is seemed to be the largest wave during the last ten years. Frequency of occurrence for waves more than 2 m in significant wave height was 3.9 %,
(b) Most of strong currents flow along the Access Channel and the observed maximum velocity was 2.5 m/s in the wet season,
(c) The turbidity is higher in the wet season than in the dry season and its observed maximum value was nearly 2,000 mg/l,
(d) Regarding the seabed material along the Access Channel, sand is predominant, while silt mainly exists in the north-south part of the Access Channel and in the vicinity of the channel entrance.

Along the Macuti Coast, sand transport toward the Pungue River is predominant. Some portion of the sand suspended up by waves and tidal currents on the Macuti Shoal can not reach to the north-south sections of the Channel at the time of strong ebb currents, forming sand banks toward the bending corner of the Channel and entering the Channel. Sediments discharged from the estuary of the Pungue River mostly seem to deposit in the wide area of the river mouth and in the south of the Channel.

4 Siltation Analysis of the Access Channel

Through analysis of sounding maps, the characteristics on sedimentation of the Access Channel have been obtained as follows:

(a) The annual sedimentation volume is greatly influenced by the fluctuation of river flow of the Pungue River and cyclones attacking Beira,
(b) The most severe sedimentation occurs in the vicinity of the bending corner of the Channel,
(c) In the vicinity of the channel entrance, a tendency of scouring in the wet season and deposition in the dry season is clearly observed.

From the calculation of sedimentation volume using sounding maps and the numerical simulation taking into consideration the above characteristics of sedimentation, the average annual maintenance dredging volume of the Access Channel has been estimated as follows:

(a) For 8M Channel, the average volume is estimated at 2,500,000 m^3,
(b) The average volume is estimated at 3,483,000 m^3 for 9M Channel, 1,700,000 m^3 for 7M Channel, 726,000 m^3 for 6M Channel, and 522,000 m^3 for 5M Channel,

Moreover, the actual maintenance volume for each year seems to vary up to more or less 50 % of the above values owing to the fluctuation of river and sea conditions.

5 Design of the Access Channel

The future demand forecast on cargo traffic at Beira Port has been estimated by adding the cargo tonnage, which is expected to shift to Harare-Beira route from Harare-Maputo after the improvement of the Access Channel, to the forecast of cargo volume by SATCC. The yearly cargo demand of Beira Port has been estimated as 3,274,400 tons in 2002, 3,737,650 tons in 2007 and 5,100,095 tons in 2017. Based on these forecast cargo volumes, the number of total calling ships is estimated to be 557 in 2002, 681 in 2007 and 959 in 2025.

The channel traffic simulation based on the above estimated number of calling ship has made clear that the waiting time of ships is significantly very high for 5M and 6M Channels, but it is within the permissible limit for 8M Channel. The design water depth for 8M Access Channel has been determined to be -8.0 m below CDL in E6+E7+E8, -8.5 m in E9+E10+E11 and -8.7 m in E11+E12+E14, taking in consideration the each waves condition. The design width has taken the same width as in the capital dredging in 1990.

6 Maintenance Dredging Works in the Access Channel

The trailing suction hopper dredger with hopper capacity of 2,000 m^3 is considered to be an optimal option for the purpose of maintaining 8M Access Channel with dredging volume of 2.5 million m^3 from the simulation of maintenance dredging plan. Taking 8 weeks for maintenance and repair etc., the total annual workable time becomes 4,224 hours and the annual required working time becomes 3,921 hours. Their working time ratio is 0.93, so that the proposed hopper capacity is appropriate.

The new dredger with a hopper of 2,000 m^3 has to work 6 days a week for the first 5 years to clear the backlog up and from 2005 onward will work 5 days a week to maintain the depth of 8M Access Channel.

The dredging fleet formation of two dredgers with each hopper capacity of 1,000 m^3 can also be considered in place of a dredger of 2000 m^3. But, it is not recommended due to higher capital and running cost, though it has such advantages as the possibility of phased purchase/introduction and higher operation efficiency at the low tide by the low draft.

7 Environmental Assessment

In the environmental examination, there was not found any injurious substances complying to the level of international standards in the quality of water and sediments. Also, it is concluded that the dredging of the Access Channel is not expected to generate any significant damaging impact on the environment.

8 Economic and Financial Analysis

The Project has been evaluated by means of cost-benefit analysis, comparing the case of achievement of the Project (With case) with the present case of non-achievement of the Project (Without case). In "Without case", the channel water depth is maintained at 5.0 m equal to that in 1997 by dredging 521,991 m^3 a year under outside contract. In "With case", one new dredger is introduced to dredge

2,500,000 m^3 a year under operation by EMODRAGA in order to maintain the channel water depth at 8.0 m.

In the economic analysis, the EIRR of this Project has been calculated to be 24.38 % at the shadow price, which is much higher than the estimated opportunity cost of capital (12 %). Moreover, the EIRR of 8M channel is better than other cases of 5M, 6M, 7M and 9M Channels, and is the best even taking into consideration the risk analysis of the fluctuation of investment cost and project life.

In the financial analysis, the operation costs of maintenance dredging work are assumed to be paid by the Port Department of CFM-C, which consists of the fixed expenses equivalent to the fixed cost of EMODRAGA and the variable expenditure in proportion to the dredged volume by US$ 0.54/m^3. Under this assumption, the FIRR becomes 2.28 %, which is the same level as the interest rate of foreign loans. But, at the end of project life of 25 years, this project is able to gain current assets of US$ 29 million which will enable to recover the initial investment of US$ 27 million, and EMODRAGA also can use the new funds of US$ 5 million. Therefore, this Project is considered efficiently to be feasible in spite of the low level of FIRR.

9 Implementation Plan

For the construction of the new dredger, approximately 20 months are required after contracting. And further 3 months will be necessary for mobilization to Beira Port and for delivery. Moreover, it is important to make an arrangement on survey boats, navigation aids, management and operation system and training of crews.

10 Recommendation

As the countermeasure for the maintenance and improvement of the Access Channel to Beira Port, it is recommended urgently to introduce the above mentioned dredger with hopper capacity of 2,000 m^3 and to recover and maintain the Access Channel to -8 m below CDL by using the new dredger.

Recruitment and training of new crews and shift of existing experienced crews shall be arranged and implemented well before the introduction of the new dredger. The training program of crews of the dredger and engineers in charge of dredging plan and oceanographic survey should be appropriately arranged and conducted before introducing the new dredger.

Moreover, the extensive hydraulic surveys in the Access Channel including its surrounding area shall be executed in the wet and dry seasons every year, in order to make clear the seasonal and yearly change of sedimentation phenomena in the Access Channel and to contribute for establishing a appropriate plan of dredging works.

The location of dumping areas is an important factor controlling the efficiency of dredging operation. Therefore, sounding surveys of the dumping areas shall be conducted as often as possible in order to establish the appropriate dredging and dumping plan.

The dredging works are executed under the contract between CFM and EMODRAGA. The contract forms after the introduction of the new dredger should be studied carefully by them and prepared in advance in order to secure the sound finance of EMODRAGA.

INTRODUCTION

INTRODUCTION

This report is the result of "The Study for Maintenance and Improvement Plan of Access Channel of Beira Port in the Republic of Mozambique" which was conducted from December 1996 to March 1998.

1 Background of the Study

Beira Port located in central Mozambique, Maputo Port in the south and Nacala Port in the north are the major ports in Mozambique, each functioning as a gateway for national and international routes of transport connecting Mozambique and inland countries of Southern Africa. The Beira Corridor is the most efficient route to Zimbabwe, where improvements of infrastructure such as railways, roads and pipelines are being carried out.

Beira Port is situated at the river mouth of the Pungue River and has 10 berths with a total berth length of 1,632 m and water depth of 10.0 - 12.0 m and a new oil terminal with water depth of 13.5 m. Cargo volume currently handled at the port was about 2.6 million metric tons in the year 1996, of which domestic cargo amounts to only 360,000 metric tons with most of the remainder in transit of Zimbabwe.

In Beira Port, siltation of the Access Channel is presenting the most serious problem in port management. The water depth of the Access Channel is 5.0 m below CDL at some portion, as a result that large vessels must enter and leave the port during high tide. In order to secure the safety of vessels calling at the port, it is necessary to dredge and maintain the Access Channel.

All maintenance dredging work in Mozambique has been conducted by EMODRAGA, utilizing one obsolescent trailing suction hopper dredger and other small dredging vessels. The existing dredging equipment owned by EMODRAGA, however, does not have enough capacity to properly dredge the huge amount of silted material in many ports in Mozambique; thus Beira, Maputo and Quelimane Ports are suffering serious siltation problems.

Under these circumstances, the Government of Mozambique requested the Government of Japan for a grant aid for a dredger. In February 1996, a preliminary study mission was dispatched to Mozambique under the grant aid scheme. Although the need and urgency of offering a dredger were acknowledged, it was deemed necessary to study the siltation phenomena before formulating countermeasures against siltation based on a long range view. In March 1996, the country requested again the Government of Japan for cooperation in planning, maintenance and improvement of the Access Channel at Beira Port.

2 Study Objective

In accordance with the conditions described above and in response to a request from the Government of the Republic of Mozambique, the objectives of the study are listed as follows.

1) To formulate a maintenance and improvement plan of the Access Channel and Basin in order to maintain the port functions at Beira Port.
2) To transfer the related technology to Mozambique counterpart through the survey studies.

3 Scope of the Study

To achieve the objectives mentioned above, the study shall cover the following items.

1) Investigation on the present conditions of the port, the Access Channel and dredging activities
2) Preparation of effective countermeasures against the shoaling problem in the port
3) Formulation of maintenance and improvement plan of the Access Channel and basin

4 Study Execution

The study was conducted as follows.

1) Presentation of Inception Report, the first field survey and presentation of the Progress Report; January - March 1997.
2) The second field survey on natural conditions; April - May 1997.
3) Presentation of the Interim Report and the third field survey; July - September 1997.
4) Presentation of the Draft Final Report and the forth field survey; January - February 1998.

The final report is produced on the basis of the comments on the Draft Final Report provided by the Government of the Republic of Mozambique.

CHAPTER 1

OUTLINE OF MOZAMBIQUE AND NEIGHBORING COUNTRIES

Chapter 1 Outline of Mozambique and Neighboring Countries

1.1 General

Mozambique is an agricultural country with fertile land located on the east coast of Southern Africa. Though nuts, sugar and raw cotton are known as the traditional exporting crops, currently prawns are becoming the major export. While the major trading partners are European countries, the trading volume with South Africa has recently been increasing. Since 1977, diplomatic relations between Mozambique and Japan have been established. The major export commodities to Japan are prawns and the imported goods from Japan are machines and spare parts.

1.2 Geography and Climate

1.2.1 Geographical Features

The total area of Mozambique is about 802,000 km^2. The northern part shares the borders with Tanzania, Malawi and Zambia. To the west, it borders Zimbabwe, South Africa and Swaziland. The eastern side is facing Mozambique Channel, separating the country from Madagascar Island.

The coastal line is 2,800 km long with an abundance of bays and inlets. The plains and hilly area cover 60 % of the land of the country. Also high lands of 500 m to 1,000 m in altitude constitute 30 % and the mountainous regions cover only 10% of the country. The western and northern territories are in high lands. Five large rivers, including the Zambezi River, run through the country to the Indian Ocean. A part of Lake Malawi and Lake Cabora Bassa are located in the northern territory of the country.

1.2.2 Climatic Conditions

The climate of Mozambique is tropical savanna. The country can be divided into four climatic regions; the tropical monsoon climate in the northern area, the tropical coastal climate in the central area, the subtropical climate in the southern area and the tropical savanna climate in the inland area. Generally, each area has the dry and wet seasons in the year.

1.3 Socioeconomic Situation

The population of Mozambique was 17.4 million in 1995 and the average rate of population growth from 1991 to 1995 was 4.9 % per annum. The total population in 1996 was 18.0 million and the active population aged between 15 and 64 years old was 75.8 %. And the population in 2000 is estimated at 20.0 million. The population of Zimbabwe, Malawi and Zambia was 11.5 million, 10.0 million and 9.4 million, respectively in 1995. The average growth rate of population in Zimbabwe, Malawi and Zambia from 1991 to 1995 was 3.0 %, 3.9 % and 3.5 % per annum, respectively.

In Mozambique, the average growth rate of Gross Domestic Product (GDP) was 6.24 % for 5 years, in which GDP in 1993 was 1.37 billion US$, then GDP per capita was 90 US$. In Zimbabwe, the average GDP growth rate was 0.5 % for 5 years and GDP in 1993 was 4.99 billion US$, 520 US$ GDP per capita. The GDP of Zimbabwe is 3.64 times as much as Mozambique's. The average GDP growth rates in Malawi and Zambia were 1.56 % and 0.6 % for 5 years, respectively. The GDP in 1993 was 1.81 billion US$, 200 US$ GDP per capita and 1.37 billion US$, 380 US$ GDP per capita, respectively.

Exports from Mozambique accounted for 170 million US$ in 1995. Its principal commodities were prawns (81.3 million US$), cotton (18.9 million US$), fruit (14.0 million US$) and wood (9.4 million US$) in 1995. The main destinations of exports from Mozambique in 1995 were Spain (16.1 %), South Africa (13.3 %), USA (11.6 %) and Portugal (11.2 %).

Imports to Mozambique accounted for 784 million US$ in 1995. The main imports were farm products (131.7 million US$), vehicle (131.0 million US$), machine (159.5 million US$) and coal (95.9 million US$) in 1995. The main origins of imports to Mozambique in 1995 were South Africa (44.2 %), Zimbabwe (6.7 %), Saudi Arabia (5.9 %) and Portugal (4.4 %).

Table 1.3-1 Real Gross Domestic Product Growth Rate of Mozambique and Neighboring Countries

(unit : %)

	1991	1992	1993	1994	1995	note-1	note-2
Mozambique	4.9	-0.8	19.3	4.8	3.0	90	1.37
Zimbabwe	3.2	-5.8	0.9	7.4	-3.2	520	4.99
Malawi	7.8	-7.9	10.8	-12.4	9.5	200	1.81
Zambia	-0.2	-5.2	9.7	-5.1	3.8	380	1.37

Note-1 : Per Capita GDP (US$) in 1993, Note-2 : GDP(billion US$) in 1993
Source : The Economist Intelligence Unit, Country Report, 4th quarter in 1996

1.4 Transport Sector

1.4.1 Sea Transport Sector

The ports of Beira, Maputo and Nacala are the principal ports in Mozambique, which are included in the maritime ports' system under the Southern African Development Community (SADC) now comprising 16 regional ports of Tanzania, Mozambique, Mauritius, South Africa, Namibia, Angola and Zambia.

The 15 regional ports of Southern Africa except the inland port handled a total cargo of 155.74 million tons in 1995, an overall increase of 9.1% over the 1994. The total traffic handled in the ports of South Africa accounted for 89.5 % in 1995. The share of Mozambican ports of Beira, Maputo and Nacala in the total traffic handled accounted for 3.3 % i.e. 5.554 million tons.

As regards the handling of international transit traffic of the coastal countries, the ports of Beira, Maputo, Dar es Salaam and Durban are the principal transit ports for imports and exports from/to the landlocked countries. The total transit traffic from the landlocked countries was 5.88 million tons in 1995. Beira Port accounted for 34.0 % of the total transit traffic in SADC countries and 79.2 % of the total traffic handled at Beira Port is a transit traffic to the hinterland.

1.4.2 Railway Transport

The hinterland of Beira includes the central provinces of Mozambique, Southern Malawi and Northern and Northeastern Zimbabwe. Zambia is also the hinterland of Beira. Central and Northern Malawi are users of both Nacala and Beira corridors. From the view of the railway distance, Beira Port has an advantage to serve Harare (Zimbabwe), Lusaka (Zambia), Blantyre (Malawi) and their adjacent area.

1.4.3 Road Transport

The total extension of the road network is 32,000 km, however, 76 % of which is unpaved. The extension of asphalt pavement roads and gravel pavement roads are 5,497 km and 2,020 km, respectively. The road network of the Beira Corridor, linking the hinterland landlocked countries, is listed as Beira -Mutare - Harare - Lusaka Road and Beira - Chimoio - Tete - Malawi / Zambia Roads.

1.4.4 Air Transport

The following are the principal airports in Mozambique, with regular flights between Maputo and local airports. Two international airports, namely Maputo and Beira are networked to other international airports.

International Airports:	Maputo, Beira
Domestic Airports:	Nampula, Pemba, Quelimane, Tete and Lichinga

1.5 Industrial Activities

Mozambique, which has a long coast line facing the Indian Ocean, play an important role as the gateway to the neighboring inland countries. Therefore, the transportation sector of the country has been generating much of the foreign currency for a long time. The transport sector at factor cost had a share of 15.5 % of GDP in 1995. The origins and component of real GDP in Mozambique and neighboring countries are shown in Table 1.5-1.

Agricultural production in Mozambique contributed 27.2 % to the GDP in 1995. The output of sugar beet is also growing where 465,800 tons of sugar beet in 1996 represented a significant increase from 313,200 tons in 1995 and 234,000 tons in 1994. Also, 65,000 tons of cashew nuts in 1996 showed a major increase from 33,400 tons in 1995 and 29,400 tons in 1994.

Fishery occupies an important place in the national economy. Prawns accounted for 40.5 % of all exports in 1995. The total fish catch of 24,170 tons in 1994 consists of 6,600 tons of prawn, 14,000 tons of fish meat, 350 tons of crab and 300 tons of lobster.

The manufacturing sector contribution to the GDP at factor cost represents 22.9 % in Zimbabwe, 13.9 % in Malawi, 25.2 % in Zambia, whereas it contributes 26.3 % in Mozambique. Among the factors of the GDP in Mozambique, the rate of construction figure resulting from high public investment (60.5 % of GDP on components) takes up 11.2 %.

The GDP rate of the mining sector at factor cost was 7.2 % in Zimbabwe and 6.1 % in Zambia. The main mining production in Zimbabwe in 1994/95 consists of asbestos (51,800 tons), chrome ore (196,200 tons) and gold (229,000 fine oz). The principal mining production in Zambia in 1994/95 consisted of copper (350,476 tons), cobalt (2,485 tons), lead (2,002 tons) and zinc (3,446 tons).

Table 1.5-1 Origins and Components of Real Gross Domestic Product in Mozambique and Neighboring Countries

(unit : % of total)

Origins of Gross Domestic Product national name / year	Mozambique 1995	Zimbabwe 1994	Malawi 1994	Zambia 1994
Agriculture & forestry	27.2	13.6	31.3	18.0
Mining & quarrying		7.2		6.1
Manufacturing	26.3	22.9	13.9	25.2
Transport & communications	15.5	6.1	17.4	4.0
Distribution,hotels & restaurants		10.7	7.3	11.7
Public administration		9.6	15.6	21.3
Other	31.0	29.9	14.5	13.7
GDP at factor cost	100.0	100.0	100.0	100.0

Components of Gross Domestic Product national name / year	Mozambique 1995	Zimbabwe 1994	Malawi 1994	Zambia 1994
Private consumption	63.3	51.5	22.7	66.3
Public consumption	12.1	27.2	66.8	22.5
Gross fixed capital formation	60.5	22.4	11	10.2
Change in stocks		6.1	2.1	-1.4
Exports of goods & services	24.0	32.6	-2.7	23.4
Imports of goods & services	-59.9	-34.9		-19.3
Statistical discrepancy		-4.9		-1.7
GDP at market prices	100.0	100.0	100.0	100.0

Source : Bank of Mozambique, Statistical Bulletin, June 1997

Table 1.5-2 Railway Distance to Main City and Share of Transit Traffic of SADC Port

(unit : km, 1,000 tons)

Country / Port (Main City)	Mozambique	Zimbabwe (Harare)	Malawi (Bulantyre)	Zambia (Lusaka)	Others	Total
Beira		(600km)	(649km)	(1,050km)		
Transit volume	518	1,737	180	51	1	2,488
Maputo		(1,270km)		(2,020km)		
Transit volume	819	761			681	2,261
Nacala			(807km)	(1,705km)		
Transit volume	138		277			415
Dar es Salaam		(3,465km)	(1,800km)	(2,045km)		
Transit volume			11	1,083	3,142	4,236
Durban		(2,065km)	(3,658km)	(2,751km)		
Transit volume	29	307	105	12	26,050	26,503
Others' Port						
Transit volume	78	5	15		84,973	85,071
Total	1,519	2,810	588	1,148	114,847	121,590

Source : SATCC, Annual Report, 1996-1997

Table 1.5-3 Population of Hinterland of Beira Port

(unit : million persons)

Port	Mozambique	Zimbabwe	Malawi	Zambia	Tanzania	Total
Beira	5.70	8.37	5.29	0.52		19.88
Maputo	10.20	3.11				13.31
Nacala	1.52		4.71			6.23
Dar es Salaam				8.85	29.70	38.55
Total	17.42	11.48	10.00	9.37	29.70	77.97

Note : Population of each port is estimated by share of transit volume in Table 1.5.6-1

In Mozambique, Gencor of South Africa is about to commit itself to a 500 million US$ investment in tantalite mining. Other mining projects are interested in, or are already engaged in, such as mining for bentonite, tantalite, graphite, diamonds, titanium and mineral sands.

Inland countries, Zimbabwe, Malawi and Zambia, need foreign seaports as their trade gate. Taking into account the distance (time) and the cost of cargo transportation, Beira Port is the most natural outlet for Zimbabwe, Malawi and Zambia. Distances by railway to main cities are shown in Table 1.5-2. Beira Port has handled the most cargo volume (2,488,200 tons) and has recorded the most transit share (1,969,500 tons, 79.2 %) in Mozambique. The population of hinterland of Beira Port in 1995 was estimated at 19.88 million as shown in Table 1.5-3 which is 1.5 times higher than that of Maputo Port.

1.6 Development Plan

1.6.1 National Development Plan

Regarding the government program of the present National Development Plan, it was stated in May 1995 that the main objective of economic development in Mozambique was the eradication of poverty and, in order to achieve this objective, the Government established the target between 6 and 7 % of GDP growth rate between 1995-1997 and this figure would increase to 8 and 9 % until the end of 20th century. According to the component of Public Investment Plan in 1995-1998, the share of public investment on Transport and Communications (32.5 %) is the highest of all, more than the share on Health (21.6 %) or Education (12.6 %).

1.6.2 Regional Development Plan

In order to achieve the economic growth of over 10 % per annum in Sofala Province towards the 21st century, the following strategic vision on the Regional Development Plan should be established.

(1) Increase in the use of Beira Port by Zimbabwe and other countries

(2) More Investment by commercial investors

1) Influx of the investments and new investors to Beira and other place along the coast,
2) Investments in sugar industry concluded (Tica, Buzi, Sena),
3) Faster rate of investment, with the creation of more saw mills and the completion of projects,

4) Investment in refrigeration for the fishing industry,
5) Rapid success in geological and feasibility studies permit some production of minerals.

(3) The main existing industries (cement, asbestos, mills, textiles, etc.) are 100 % operational,

(4) Rehabilitation of infrastructure, etc.

Instances of influx of investments and new investors to Beira except investment in sugar industry, saw mills and refrigeration for the fishing industry are as follows :

(1) Beira iron project (2.5 million tons in 2001, investment of US$ 600 million)
Investors: JCI of mining house in Republic of South Africa,

(2) Temane and Buzi gas-field development (investment of US$ 127 million)
Investors = Arco, a leading US energy producer, and South Africa's Sasol,

(3) US$ 300 million rehabilitation of the Moatize to Beira railway line, as the plan to revive Moatize coal mines by the National Coal Company,

(4) The pulp project facility with a plan to produce 500,000 tons per annum and the project to build a warehouse for vegetable at Beira Port.

Therefore, the demand of cargo volume of Beira Port is forecast to increase significantly in the future.

1.6.3 Development Plan for Beira Corridor

The 10-year Development Plan named Beira Port Transport System (BPTS) by Southern Africa Transport and Communications Commission (SATCC) was prepared as a guideline to develop the Beira Corridor. The plan covers all transport and telecommunication links in the hinterland of Beira Port comprising a series of port, railway, road and infrastructure projects as well as technical assistance.

The Beira Corridor Authority was established in 1985 to carry out the planning, implementation and supervision of the BPTS programs and terminated its activities in June 1996. At the termination of the 10-year development program at a total cost of more than 400 million US$, the Beira Corridor had been reestablished and modernized to serve the central region of Mozambique as well as Zimbabwe and other landlocked countries.

1.6.4 Development Plan for Beira Port

According to the final progress report of the Beira Corridor Authority, the major port projects under the BPTS projects carried out during 1987-1996 are as follows.

Principal BPTS Projects during 1987 - 1996

- Channel dredging
- Navigation aids
- Multipurpose and Container Handling Terminal
- Reconstruction of Berths 2 to 5
- New Oil Terminal
- Equipment for container handling
- Tug and pilot boat for Beira Port
- Deep-sea pilot boat / modification of tug boats

Recently, the projects of a sugar and cereal facility and a wooden chip facility are under way at the north end of the port area.

CHAPTER 2

PRESENT SITUATION OF BEIRA AND OTHER PORTS

Chapter 2 Present Situation of Beira and Other Ports

2.1 Port Facilities

2.1.1 General

The history of Beira Port dated back to 1887 when a military post was founded at the estuary of the Pungue River. The first section of the existing wharf was built immediately after the First World War, and the major extensions took place after 1930 with the construction of Quay 2 to 5. In 1953, the existing coal terminal was constructed. Furthermore, the port was expanded upstream and terminated with the construction of Quay 11 to serve Ro-Ro vessels and oil tankers in 1981.

The 10-year development plan of the Beira Transport System was prepared with the assistance of SATCC. Under the control of the Beira Corridor Authority, infrastructure rehabilitation and re-equipment of the port as well as technical assistance and training were carried out. The renovation of Quays 2 to 5 into a multipurpose and container terminal and the construction of a new oil terminal at Quay 12 were the principal projects installed according to the development program.

2.1.2 Wharf

Accommodation of oceangoing ships is provided by a continuous quay with 10 berths of 1,632 m in total length and a new oil terminal with 260 m in length located one km upstream of the old oil quay at Quay 11 as shown in Table 2.1.2-1. The Multipurpose and Container Terminal of 645.90 m in total length at Quays 2 to 5 was constructed during 1987 - 1992. The New Oil Terminal has been in operation since 1994. The southern end of the port contains Quay 1 of fishing harbor and Chiveve Dock for the service boats. A dry dock is also located in the south side of the same area.

2.1.3 On-land Facilities and Cargo Handling Equipment

On-land facilities and cargo handling equipment of the main terminals are listed as follows.

(1) Multipurpose and Container Terminal

- Container yard	200,000 m^2
- Gantry crane	2 units (40 tons handling capacity)
- Rail transfer crane	1 unit (40 tons handling capacity)

- Warehouse 11,000 m²
- Handling equipment Forklifts, trailers, etc.

(2) General Cargo Terminal
- Covered warehouses 15,000 m²
- Transit sheds 10,000 m²
- Agent's warehouses 60,000 m²
- Handling equipment Electric cranes, mobile cranes, forklifts

(3) New Oil Terminal (Quay 12)
- Tanker size Unloading of 500 to 50,000 DWT tanker; Loading of 500 to 2,500 DWT tanker
- Pipeline system 12" (fuel), 16" (diesel), 16" (jet oil), 16" (petrol)
- Tank farm Tank farm 2.3 km inland

Table 2.1.2-1 Main Characteristic of Terminals of Beira Port

Terminal Wharf	Function	Length	Design Depth	Year in Use
Container Terminal		645.90 m		
Quay 2	Multipurpose and Container	161.50 m	12.0 m	1992
Quay 3	Multipurpose and Container	161.50 m	12.0 m	1992
Quay 4	Multipurpose and Container	161.45 m	12.0 m	1992
Quay 5	Multipurpose and Container	161.45 m	12.0 m	1992
General Cargo Terminal		858.00 m		
Quay 6	General Cargo	170.00 m	10.0 m	1964
Quay 7	General Cargo	165.50 m	10.0 m	1975
Quay 8	Coal/Ore	187.90 m	10.0 m	1953
Quay 9	General Cargo	167.30 m	10.0 m	1967
Quay 10	General Cargo and Ro-Ro	167.30 m	10.0 m	1967
Oil Terminal		388.55 m		
Quay 11	Liquid Bulk and Ro-Ro	128.55 m	10.0 m	1981
Quay 12	Liquid Bulk	260 m	13.5 m	1994
	Total Length	1,892.45 m		
Others				
Chiveve Dock	Service Boat Use	448.00 m	4.5 m	
Quay 1	Fishing Harbor	183.00 m	6.0 m	

Source: Beira Port Transport System, 10-year Development Plan, SATCC, 1986

2.1.4 The Access Channel and Turning Basin

At the capital dredging during 1989 and 1990, the Access Channel and the turning basin of Beira Port shown in Figure 2.1.4-1 were constructed as follows. The slope of the channel was designed at 1 : 10.

Table 2.1.4-1 Dimensions of the Access Channel and Turning Basin

Section	Construction Depth(m)	Construction Width(m)
Turning Basins		
E5	5.5	200.
E15	7.5	145.
Channels		
E4	8.00	200
E6	8.00	135
E7	8.00	135
E8	8.00	135
E9	8.80	135 - 250
E10	9.20	250 -155
E11	8.70	155
E12	8.80	140
E13	8.50	140
E14	8.70	160

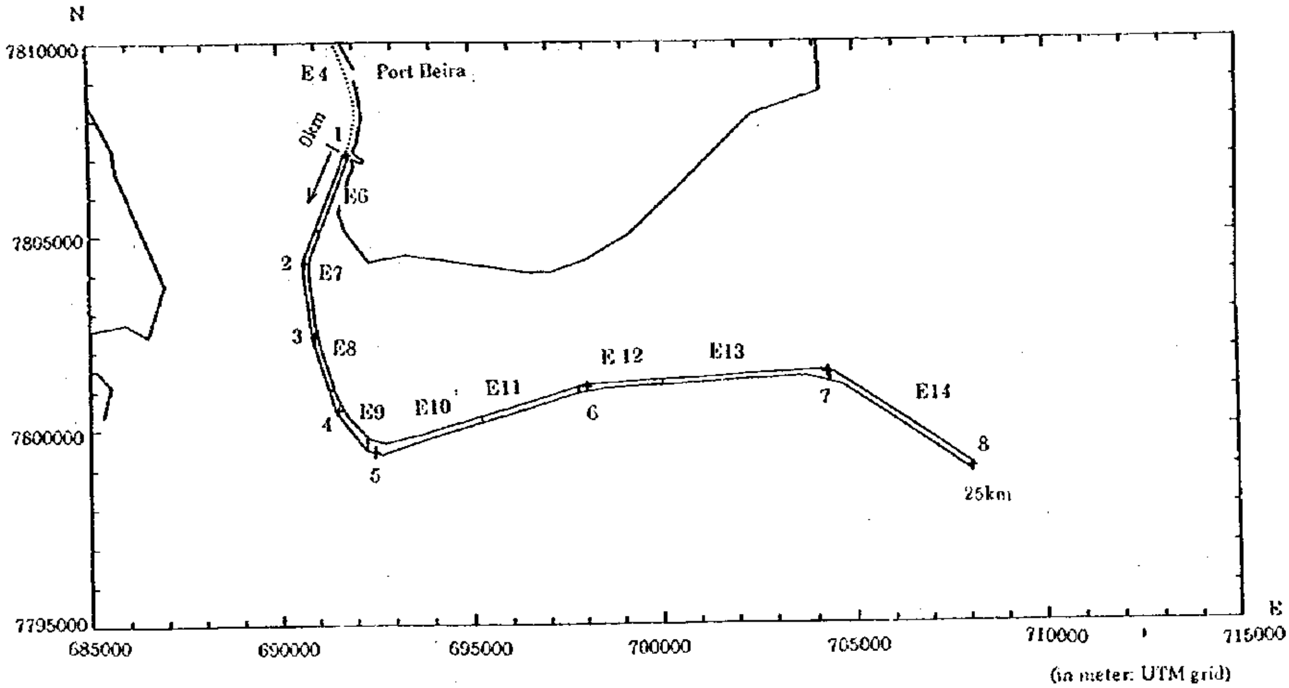


Figure 2.1.4-1 Location of Sections in the Access Channel

2.1.5 Navigation Aids

Beira Port is located along the left bank of the estuary of the Pungue River and connected with the open sea through the Macuti Channel. The total length of the Access Channel is about 28 km; E4 is about 3 km and E6 to E14 is about 25 km as shown in Figure 2.1.4-1. Anchorage facilities for deep sea vessels are located near the entrance of the Access Channel and another anchorage for shallow draft vessels is located near the port entrance of Section E7. Navigation aids have been installed under the BPTS project for safe maneuvering through the long approach channel to Beira Port. Most of the buoys are subject to be moved from their original position according to the current bathymetry and the depth of the Access Channel by INAHINA.

2.1.6 Dredging Fleet and Maintenance Facility

(1) Dredging Fleet

EMODRAGA is conducting dredging services with following fleet.

1) Trailing Suction Hopper Dredger

"Rovuma"	Hull	77.75 m x 13.4 m x 5.95 m – 5.4 m
	Propulsion Engine	1,125 ps x 2
	Dredge pump engine	950 ps x 1
	Hopper Capacity	1,538 m^3
	Dredging Depth	24.0 m
	Complement	28 persons (1-Shift)
	Gross Ton	1,745.83 t

2) Grab Dredger

"Lurio"	Pontoon	24 m x 12 m x 2 m, Bucket 1.5 m^3

3) Backhoe Dredger

"Tembe"	Pontoon	35.6 m x 11.4 m x 2.75 m, Bucket 2.0 m^3

4) Other Associated Working Vessels

a) Split Hopper Barge

"BD-I", "BD-II"	650 m^3 hopper capacity type
"BD-III", "BD-IV"	150 m^3 hopper capacity type

b) Tug Boat

"Chire"	340 ps x 2 engines
"Rambe"	275 ps x 1 engine,
"Saskia"	240 ps x 1 engine

c) Survey Boat

"Tiky"	9.9 m length type

d) General Service Boat

"Chali"	11.58 m length type

(2) Maintenance Facility

1) BEIRANAVE

In Chiveve area of Beira Port, there is a ship repair yard "BEIRANAVE", with a useful dry dock for the maintenance of the new dredger.

From the results of the survey, BEIRANAVE is the most suitable maintenance yard for the new dredger.

2) Other Facilities in Beira

In Beira, EMODRAGA has a warehouse for storing materials, spare parts, consumables, etc. and machining quarter for small parts production and repair.

And also CFM-C has jetty, machine shop, warehouse in Beira, which will support the new dredger as maintenance facilities.

2.1.7 Service Boats

Following service boats such as tug boat, pilot boat and line boat, are prepared to secure the navigation and berthing works of calling vessels. These service boats are moored in Chiveve Dock on the south side of the Fishing Harbor.

- Tug Boat	30 ton bollard pull harbor tug,	2 boats
- Pilot Boat	12.5 m in length,	2 boats
- Deep-sea Pilot Boat	13.5 m in length,	1 boat
- Work and Line Boat	9.1 m in length,	2 boats

2.2 Port Activities

2.2.1 Sea Transport Sector

Currently, the main overseas shipping lines which have vessels calling at Beira Port are listed as CMB-Transport, Doal Conventional, MSC Mediterranean Shipping, Messina, Maersk, NYK and Unicorn. The shipping route of ocean liners is through East African ports such as Mombasa, Dares Salaam and Maputo to the adjacent international hub ports of Cape Town and Durban or to Jedda and Jebel Ali in Middle East. A new service connecting East Africa to the international network connecting Beira Port to Colombo and Jebel Ali is put into operation to ease the congestion of the hub ports in South Africa. Regular feeder ships generally visit Beira Port from Durban through Maputo Port.

2.2.2 Ships' Call

(1) Number of Ships' Call

Table 2.2.2-1 shows the number of ships' calls to Beira Port for the period from 1986 to 1996. The average number of ships' calls in the last 5 years is approximately 400 per year. Recently, the total number of calling ships has been decreasing. However, the number of ocean going vessels' call is steadily increasing.

Table 2.2.2-1 Number of Ships' Calls at Beira Port

Year	Ocean Going	Cabotage	Passenger,etc	Total
1986	177	---	---	274
1987	238	110	44	392
1988	272	102	72	446
1989	270	149	86	505
1990	266	116	84	466
1991	260	116	104	480
1992	297	89	35	421
1993	365	83	22	470
1994	341	56	26	423
1995	311	38	18	367
1996	322	37	12	371

Source: Final Progress Report, Beira Corridor Authority

(2) Sizes of Calling Ships

The maximum and average of Dead Weight Tonnage (DWT) and Length Overall (Loa) of calling ships in 1996 are shown in Table 2.2.2-2. Tankers recorded the largest DWT ship of 30,611 tons in the total calling ships. Regarding Loa of calling ships, 206.1 m of a container carriers was the longest.

Table 2.2.2-2 Maximum and Average Ship Size by Ship Type

Year: 1996

	Tanker	Bulk Carrier	Container Carrier	General C. Carrier	Others
DWT max. (ton)	30,611	26,040	24,472	19,370	5,084
DWT ave. (ton)	19,106	12,362	8,429	7,703	863
Loa max. (m)	189.0	194.8	206.1	197.9	109.2
Loa ave. (m)	166.0	151.3	138.0	123.2	63.7

DWT of calling ships are tabulated in Table 2.2.2-3. Among calling ships of more than 16,000 DWT, tankers take up 85 %, which suggests that the size of tankers is the predominant factors to design the dimensions of the Access Channel. Loa of the bigger ships concentrate in the range from 160 to 180 m and most of them are less than 200 m.

(3) Arrival Draft of Calling Ships

Arrival draft of calling ships are tabulated in Table 2.2.2-4. In spite of the shallow water depth of the Access Channel, drafts deeper than 10.5 m were recorded in 1996. It is presumed that these deeper draft ships passed through the critical points of the Access Channel during the higher tide level of the spring tide. 70 % of the total calling ships entered the Port with a draft less than 8.0 m and ships of the draft more than 10.0 m shared 2 % of the total number of calling ships.

(4) Waiting Time of Calling Ships

Most of the large sized ships entering Beira Port have to wait until the tide level reaches the necessary water depth for sailing through the Channel. Other cases of ship waiting are caused by prohibition of night sailing and other factors such as berth arrangement and preparation.

Table 2.2.2-5 shows the number of tide waiting ships and the average waiting time of arriving ships whose draft is deeper than 5.0 m. In 1988, before capital dredging of the Access Channel, 70.2 % of the total arriving ships had to wait at the average tide waiting time of 9.2 hours. Immediately after the completion of the capital dredging in 1991, the number of tide waiting ship shows a rapid decrease, reflecting the improvement of the accessibility of the Channel. Recently the waiting time of calling ships has worsened and the number of tide waiting ships counted for 28 in 1991 and 202 in 1996, because no significant maintenance dredging was carried out after the capital dredging. It shows that the channel siltation is a very serious problem for ship operation and navigation as well as sailing costs.

Table 2.2.2-3 Dead Weight Tonnage of Calling Ships by Ship Type

Year: 1996

DWT (ton)	Tanker	Bulk Carrier	Container Carrier	G. Cargo Carrier	Others	Total
DWT≧32,000	-	-	-	-	-	-
32,000>DWT≧30,000	1	-	-	-	-	1
30,000>DWT≧28,000	-	-	-	-	-	-
28,000>DWT≧26,000	-	1	-	-	-	1
26,000>DWT≧24,000	5	-	1	-	-	6
24,000>DWT≧22,000	25	3	1	-	-	29
22,000>DWT≧20,000	-	5	5	-	-	10
20,000>DWT≧18,000	12	3	3	2	-	20
18,000>DWT≧16,000	10	8	4	2	-	24
16,000>DWT≧14,000	-	10	3	7	-	20
14,000>DWT≧12,000	1	6	16	2	-	25
12,000>DWT≧10,000	-	9	14	3	-	26
10,000>DWT≧8,000	2	9	12	2	-	25
8,000>DWT≧6,000	-	1	54	1	-	56
6,000>DWT≧4,000	3	3	7	7	1	21
4,000>DWT≧2,000	3	1	30	3	-	37
2,000>DWT	-	9	2	12	40	63
Total	62	68	152	41	41	364

Table 2.2.2-4 Arrival Draft of Calling Ships by Ship Type

Year: 1996

Arrival Draft (m)	Tanker	Container	Dry Cargo	Others	Total
11.0>Draft≧10.5	6	-	1	-	7
10.5>Draft≧10.0	6	-	3	-	9
10.0>Draft≧9.5	9	-	19	-	25
9.5>Draft≧9.0	8	11	17	-	36
9.0>Draft≧8.5	11	12	7	-	30
8.5>Draft≧8.0	4	15	8	-	27
8.0>Draft≧7.5	8	27	9	-	44
7.5>Draft≧7.0	8	49	6	-	63
7.0>Draft≧6.5	-	17	8	1	26
6.5>Draft≧6.0	-	8	4	-	12
6.0>Draft≧5.5	-	5	7	2	14
5.5>Draft≧5.0	1	2	3	12	18
5.0>Draft≧4.5	1	-	8	5	14
4.5>Draft≧4.0	-	2	4	7	13
4.0>Draft≧3.5	-	4	2	8	14
3.5>Draft≧3.0	-	-	2	3	5
3.0>Draft≧2.5	-	-	2	3	5
2.5>Draft≧2.0	-	-	2	-	2
Total	62	152	112	41	364

Table 2.2.2-5 Average Tide Waiting Time of Arrival Ships

Year	No. of Arrival Ships (1)	No. of Tide Waiting Ships (2)	% (2)/(1)	Average Tide Waiting Time (hr)
1988	265	186	70.2	9.2
1991	243	28	11.5	6.2
1994	305	91	29.8	8.2
1996	289	202	69.9	15.0

Capital Dredging: from 1989 to 1991

(5) Cargo Handling Time of Calling Ships

Cargo handling time is calculated based on the records of arrival and departure time of calling ships by CFM-C. Tankers take 21 hours to discharge oil products on average. Bulk carriers need much more time and the current average handling time reaches 159 hours (6.6 days).

2.2.3 Cargo Handled

Statistics of cargo handled at Beira Port during the period from 1986 to 1996 are summarized in Table 2.2.3-1. Since the implementation of the BPTS projects such as the construction of the new container terminal have become effective, the cargo handling capacity has been improved significantly and the cargo traffics rose sharply from 1.704 million tons in 1991 to 2.638 million tons in 1993. In the last 5 years, the trend of the total tonnage including oil products has shown a steady increase with slight fluctuation to the level of 2.5 million tons. In particular, the transit import and export traffics, excluding drought relief, show a sharp increase after the completion of the BPTS projects.

The main commodities exported from Zimbabwe are tobacco, cotton, coffee, maize and granite as well as coal. Regarding import products, fertilizers and food products such as maize, rice and soya as well as oil products are predominant. Commodity types from and to Malawi are almost the same as those from Zimbabwe.

2.2.4 Cargo Handling Operations

(1) Container Terminal

Containers are loaded and unloaded by gantry cranes and are moved to the container yard by a tugmaster or chassis. For transferring containers to railway

Table 2.2.3-1 Statistics of Cargo Handled at Beira Port

Cargo in 1,000 metric ton

Year	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
A. Transit											
* Export	101.0	237.0	241.5	274.0	350.3	252.1	209.3	411.6	576.3	365.3	595.0
* Imports excl. POL	52.0	81.0	106.6	181.9	192.9	140.6	786.5	746.9	473.8	598.9	645.9
(Drought Relief incl.)							(670.0)	(370.0)		(102.7)	(20.2)
Total excl. POL	153.0	318.0	348.1	455.9	543.2	392.7	995.8	1,158.5	1,050.1	964.2	1,240.9
* POL Imports	585.0	695.0	734.7	837.0	896.0	904.5	945.3	990.3	1,070.9	1,005.3	1,005.2
TOTAL	738.0	1,013.0	1,082.8	1,292.9	1,439.2	1,297.2	1,941.1	2,148.8	2,121.0	1,969.5	2,246.2
B. Mozambique International Trade											
* Export	22.0	18.0	29.4	23.5	21.3	41.9	19.0	25.0	24.7	64.3	57.8
* Imports excl. POL	84.0	131.0	177.8	189.0	155.8	158.3	284.3	284.1	162.2	279.5	162.0
Total excl. POL	107.0	147.0	207.2	212.5	177.1	200.2	303.3	309.1	186.9	343.8	219.9
POL Imports	52.0	63.0	64.6	88.5	54.9	79.4	66.6	86.1	103.7	121.6	84.4
Total	159.0	211.0	271.8	301.0	232.0	279.6	369.9	395.2	290.6	465.4	304.2
C. Mozambique National Trade											
Cabotage	117.0	138.0	161.9	161.1	157.6	127.3	81.3	93.5	53.1	53.3	52.9
A + B + C											
Total	1,014.0	1,362.0	1,516.5	1,755.0	1,828.8	1,704.1	2,392.3	2,637.5	2,464.7	2,488.2	2,603.3
TOTAL, excl. POL	377.0	604.0	717.2	829.5	877.9	720.2	1,380.4	1,561.1	1,290.1	1,361.3	1,513.7

* Average weight per TEU calculated at 10 tons.

*Cabotage: Coastal traffic

Source: Final Progress Report, Beira Corridor Authority wagons, the railed transfer crane located at the railway terminal yard is used. In the container yard and the container freight warehouse, containers are handled by forklifts of adequate lifting capacity.

(2) General Cargo Terminal

Electric cranes alongside the quay or mobile cranes are utilized for loading and unloading cargoes. Bulk cargoes transported alongside the quays by railway wagons are directly loaded onto ships by shore-side cranes.

(3) Oil Terminal

Petroleum products such as fuel, diesel, jet oil and petrol are discharged from a tanker berthing at Quay 12 or Quay 11 and transferred to the tank farm through pipelines.

2.2.5 Operation and Management

Both CFM and EMODRAGA are public companies under MTC. The administrative function of transportation on the ports and railways of Beira Port is under CFM-C, one of the four executive departments under the Board of Management, CFM. Organization Chart of CFM-C is shown in Figure 2.2.5-1.

In spite of an increase in expenses during 1992-1996, owing to port operational revenue of CFM defrayed by most of the foreign currency, marginal profit has always been plus and the financial management of CFM can be easily established against inflation. The operational loss in 1994 was caused by the rehabilitation after the Civil War whose costs amounted to US$ 2.5 billion. The fixed cost increased after 1993 and the administration in the finance of every sector became profitable after 1995. As a result, the rate of marginal profit rose to 67.7 % in the Port Section of CFM-C, Beira Port.

Organization chart of EMODRAGA is shown in Figure 2.2.5-1. The total personnel of EMODRAGA is 213 employees consisting of 109 persons in head office in Beira and 104 persons in branch office in Maputo. According to profit and loss of EMODRAGA during 1992-1996, income from the CFM Agreement has grown from 2.2 billion Meticals (64.7 %) in 1992 to 24.4 billion Meticals (92.8 %) in 1996. Total expenses in 1996 were 73.8 % of the total revenue, among which wages and salaries were 9.8 %, fuel and oil were 22 %, repairs were 5% and material and spare parts were 9 % of the total revenue.

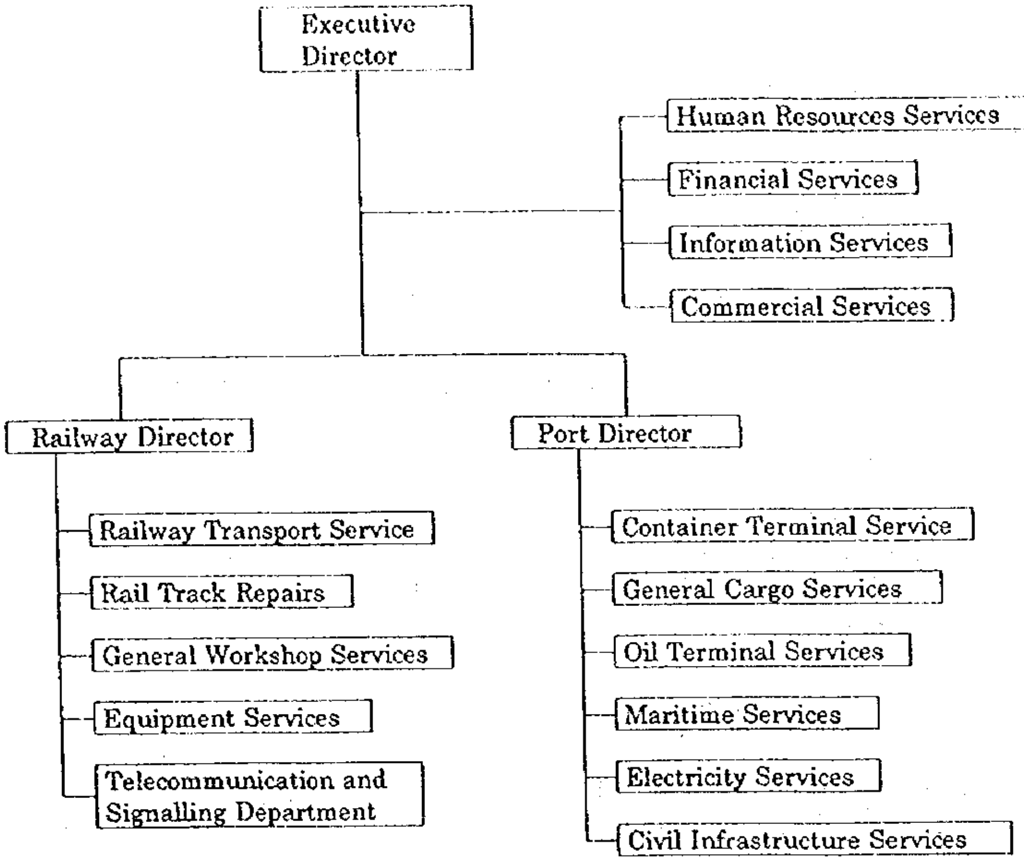


Figure 2.2.5-1 Organization Chart of CFM-C

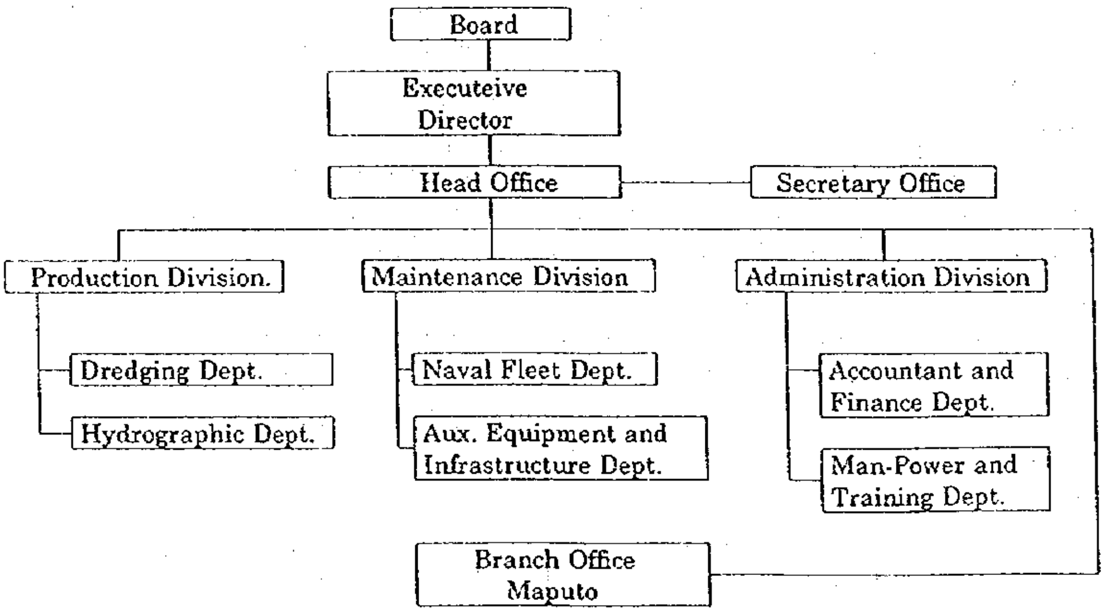


Figure 2.2.5-2 Organization Chart of EMODRAGA

Table 2.2.5-1 The Change of P/L (Operational Revenue, Expense, Profit) in CFM, CFM-C and Port Section of CFM-C

(unit : billion meticals)	1992			1993			1994			1995			1996		
	ALL-CFM	CFM-C	PORT	ALL-CFM	CFM-C	PORT	ALL-CFM	CFM-C	PORT	ALL-CFM	CFM-C	PORT	ALL-CFM	CFM-C	PORT
(Cargo Volume of Beira Port: 1000 tons)			2,392.3			2,637.5			2,613.8			2,488.2			2,603.3
(A) Operational Revenue	213.9	110.8	76.7	295.4	161.9	94.3	467.4	220.9	110.0	950.7	293.8	205.9	1195.2	455.6	282.0
6.2 Salaries, Wages	41.0	15.3	6.1	71.1	30.4	12.2	109.9	42.6	17.0	161.8	75.0	30.0	173.5	80.4	32.2
6.8 Other expenses	63.9	28.7	8.1	125.6	60.6	18.1	221.1	88.2	19.5	309.6	127.2	25.9	355.2	148.1	58.8
(B) Total Direct Cost	104.9	44.0	14.2	196.7	91.0	30.3	331	130.8	36.5	471.4	202.2	55.9	528.7	228.5	91.0
(A-B) Marginal Profit	109.0	66.9	62.5	98.7	71.0	64.0	136.4	90.1	73.5	479.3	91.6	150.0	666.5	227.1	191.0
(C) Depreciation Expense	14.2	2.9	2.2	102.4	63.5	49.9	200.5	100.6	79.7	414.4	100.6	70.0	438.6	100.6	70.0
(D=A-B-C) Operational Profit	94.8	63.9	60.3	-3.7	7.5	14.1	-64.1	-10.5	-6.2	64.9	-9.0	80.0	227.9	126.5	121.0
E) Financial Revenue	5.7	2.7	2.1	34.2	8.2	6.4	10.5	4.1	3.2	53.9	34.5	24.0	61.8	34.5	24.0
F) Financial Expense	1.1	0.3	0.2	12.6	3.3	2.6	6.15	3.7	2.9	21.6	2.0	1.4	112.3	2.0	1.4
(G=D+E-F) Continuing Profit	99.4	66.3	62.2	17.9	12.4	17.9	-59.8	-10.1	-5.9	97.2	23.6	0.0	177.4	159.0	143.6
Exchange Rate (Metical for US$)	2,432.4			3,722.70			5,918.10			10,785.0			11,230.0		
The Number of Regular Emploee				18,159			18,738	6,914		18,500	5,435	2,170	18,000	5,580	1,977
The Number of Total Emploee				23,700			31,348	11,759		28,500	11,650	4,651	27,000	11,423	4,047

Note : PORT= Port Section of CFM-C

Table 2.2.5-2 The Change of P/L (Operational Revenue, Expense, Profit) in EMODRAGA

(unit : billion meticals) Year	1992	(Ratio)	1993	(Ratio)	1994	(Ratio)	1995	(Ratio)	1996	(Ratio)
Income from CFM Agreement	2.2	64.7%	4.4	89.8%	8.0	89.9%	15.2	93.8%	24.4	92.8%
Other Revenues	1.2	35.3%	0.5	10.2%	0.9	10.1%	1.0	6.2%	1.9	7.2%
(A) Total Revenues of EMODRAGA	3.4	100.0%	4.9	100.0%	8.9	100.0%	16.2	100.0%	26.3	100.0%
(B) Total Expenses of EMODRAGA	3.1	91.2%	6.5	132.7%	10.6	119.1%	18.3	113.0%	19.4	73.8%
(A)-(B) Revenues-Expenses	0.3	8.8%	-1.6	-32.7%	-1.7	-19.1%	-2.1	-13.0%	6.9	26.2%

2.2.6 Problems and Constraints

The current situation and problems at Beira Port are outlined below.

(1) Port Activities

Beira Port has been playing an important role in sea transportation not only for Mozambique but also for such land locked countries as Zimbabwe, Malawi, Zambia, etc. The cargo handling capacity of the port is estimated at around 5 million freight tons with the existing port facilities as compared with 4 million freight tons handled in 1996. The onshore port facilities and road/railway connection are in a comparatively good condition. To cope with an increasing traffic demand, improvement and repair of cargo handling equipment and railway facilities are being planned.

(2) Siltation in the Access Channel

The major bottleneck of Beira Port has long been recognized as its shallow approach channel which is under serious siltation all the time. The existing Access Channel to Beira Port was deepened to -8.0 m below CDL from the previous depth of -6.0 m below CDL under the contract PA-1 during the period from March 1989 to August 1990. Since then, no substantial maintenance dredging works have been carried out.

(3) Present Condition of Channel Navigation

The existing channel has been silted to the depth of 4.8 m below CDL and the maximum draft of ship calling the port is limited to 10.3 m at present. This draft limitation leads to an eventual uneconomical arrangement of ship operators to use either a smaller ship with full cargoes or a large ship with part cargoes for shallower draft. According to interviews with major shipping agents in Beira, most of large ships have to wait for the high tide or are scheduled to arrive just before high tide to avoid otherwise unnecessary waiting time.

Night navigation is prohibited for ships larger than Loa 150 m and thus all the large ships have to navigate at daytime high tide on entering and leaving the port resulting in long waiting time.

With a very large tidal range of more than 6 m, the port narrowly receive ships without any major maintenance dredging work. However, if the channel is further silted, most of the shipping companies operating large vessels will divert them to the other ports through consideration of transport economy and safety.

(4) Dredging Fleet

The existing dredging fleet of EMODRAGA are obsolescent and far below the capacity required to maintain the channel to the original design depth. Only one grab dredger is available in Beira Port. The trailing suction hopper dredger "Rovuma" mainly working in Maputo is difficult to mobilize to Beira due to her deteriorated condition and insufficient dredging capacity to be shared with the other ports. Necessity of maintenance dredging work has long been recognized but neither the contract dredging work nor the purchase of a dredger has been undertaken due to financial constraints.

(5) Future Prospects

After the recent stabilization of social security coupled with the restructuring of CFM, Beira Port is recovering the past prosperous economic activities with sharply increasing port cargoes in recent years. Cargoes to/from the landlocked countries show remarkable increase and various facilities to handle them are planned in the port area. According to the cargo forecast conducted by SATCC, the volume of port cargo is expected to increase from 2.5 million ton in 1995 to 4.9 million ton in 2017. Thus, the existing silted channel has become an increasingly destructive constraint for a sound growth of Beira Port.

(6) Marine Accidents

Though navigation in the existing channel is somewhat tricky especially in periods of strong tidal current and inclement weather, no major marine accidents have been recorded except for one grounding accident in 1996.

2.3 Dredging Activities

2.3.1 Present Organization

In 1980, EMODRAGA was established as an independent dredging service organization which was controlled directly by the Ministry of Transport and Communications.

In May 1989, the Government of Mozambique transferred the ownership and management responsibilities of the port and railway division to CFM. CFM was organized with 4 regional Executive Directorates, CFM-S, CFM-C, CFM-Z and CFM-N.

Executive Directorate of CFM-C is in charge of the administration of Beira Port. The outline of the activities of each division of EMODRAGA is as follows;

- Production Division: (35 members)	Planning and control of dredging works
- Maintenance Division: (40 members)	Repair and maintenance of dredging fleet
- Administration Division: (23 members)	All matters related to accounting and administrative works
- Branch Office in Maputo: (104 members)	Dredging Department Naval Fleet Department Accounting and Finance Department

2.3.2 Expenses and Assets of EMODRAGA

The revenue and expenses of EMODRAGA in 1996 were as follows;

(1) Income from CFM Agreement is US$ 2,175,988 (93 % of total revenue). Other remaining revenues are from rent and hire of building and equipment.

(2) Total expenditure is US$ 1,726,314 (73 % of total revenue).

The overall fixed assets and those of the Beira region were US$ 1,326,442 and US$ 705,709, respectively by the end of 1996. Fixed assets in Beira was 53.2 % of total assets of EMODRAGA.

2.3.3 Past Dredging Works

The past dredging works executed at Beira Port are summarized in Tables 2.3.3-1 and 2.3.3-2.

The following table shows that the channel was dredged at an average annual rate of 0.33 million m^3 by the trailing suction hopper dredger "Rovuma" for the period from 1983 to 1988 and the quay front areas and the fishery port at 0.8 million m^3 by the backhoe dredger "Sofala" for 8 years from 1983 to 1990.

Table 2.3.3-1 Soil Volume Dredged at Beira Port

(measured hopper volume in m^3)

	Rovuma	Site	Herz	Site	Sofala	Site	Lurio	Total
1983	564,563				22,400			586,963
	242,769	B10			22,400	Chiveve		
	83,205	Q1-10						
	11,865	Q6-10						
	226,724	B9-11						
1984					98,700			98,700
					98,700	Chiveve		
1985	1,229,170				42,800			1,858,933
	1,187,270	B9-11			42,800	Chiveve		
	41,900	B3-6						
1986	444,500				24,060			468,560
	340,560	B9-10			24,060	Chiveve		
	103,940	EEStock						
1987	240,925				99,130			340,355
	5,439	Renab			84,330	Chiveve		
	7,7953	B1-3			5,600	Q8-9		
	7,707	B3-5a			9,200	Q5-6		
	61,622	B6-8						
	88,204	B9-13						
1988	73,520		5,685		127,350			206,555
					120,900	Chiveve		
					650	Q9		
	73,520	B5a-8	5,685	B5a-8	1,300	Q5-6		
1989	34,152				117,575			151,727
	34,152	B1/3			53,525	Chiveve		
					28,250	Q11		
					8,675	Q9		
					9,100	Q5-6		
					18,025	Praya N		
1990					144,170			144,170
					108,795	Chiveve		
					3,250	Q11		
					3,250	Q8		
					7,250	Q6-7		
					6,700	Q2-5		
					14,375	B5/8		
					240	B1/3/5		
Total	2,022,267		5,685		676,185			3,268,700

Source; EMODRAGA Dredging Report, "BNo, QNo" denote Buoy and Quay No.

(refer Figure 2.1.1-1 for Quay No and Figure 2.1.5-1 for Buoy No)

Extensive capital dredging work was carried out in Beira Port by Breenjenbout - Boskalis and EMODRAGA for 19 months from March, 1989. The work was carried out to deepen the Access Channel of 33 km to the depth of CDL -8 m including the turning basin and the dredging production was approximately 10.0 million m³.

Table 2.3.3-2 Soil Volume Dredged at Beira Port after Capital Dredging in 1989-90

(measured hopper volume in m³)

	E1	E2	E5	E7	E8	E9	E10	E11	Total	Quay
1990	650	0							650	
1991	90,317	424,238	27,350			125,866			667,771	5,230
1992	8,850	58,154	450		49,899				117,353	
1993	608,166	17,257		126,766	<......	327,885	.....	--->	1,080,074	16,900
1994	14,200	0							14,200	0
1995	35,230	2,100							37,330	26,351
1996	37,080	250							37,330	21,170
Total	794,493	501,999	27,800	126,766	49,889	453,751			1,954,708	
%	40.6	25.7	1.4	6.5	2.6	23.2			100.0	

Source: EMODRAGA Dredging Report, "E" denotes section of the channel see Figure 4.2.2-1.

Other records such as work time, main features of operated dredgers and other supporting vessels are shown in Table 2.3.3-3.

The annual siltation rate has been estimated in the order of 3.5 million to 6.0 million m³ in the previous study. The past figures of maintenance dredging are far below the estimated volume of soil silted in the channel causing serious shoaling of the channel. As shown in the above table, the maintenance dredging in the period after the capital dredging concentrated in 1991 and 1993 and in the area in front of the berths accounting for about 65 % suggesting higher necessity in the inner section of the Channel.

Table 2.3.3-3 Past Records of Dredging Works at Beira Port

Contract	P.A.1 (Capital Dredging Works)	
Client	B.C.A.-MTC	
Contractor	Breenjenbout - Boskalis/EMODRAGA	
Supervisor Eng.	DHV-Holland	
Duration of works	March/1989 to September/1990 (19 months)	
Dredging Area	Access channel, turning basins - from Beira Port to 34km of shore access channel.	
Dumping areas used	D2, D3, D4	
Dredging profile	Length: 33,408 m Breadth min.: 135 m Depth: -8 m (CD) Slopes: 1:10	
Dredging production	10,000,000 m^3	
Weekly production	120,000 m^3	
Characteristics of dredged materials	Silt, fine sand, coarse sand, clay and hard clay	
Work Time		
Working hours per day	24 hrs/day	
Working days per week	7 days/week	
Working weeks per year	45 weeks/year	
Dredging cycle time	From 1.5 to 6.5 hrs	
Dredgers	No. 1	No. 2
Ship's name	Cornelis Zanen	Johanna Jacoba
Builder	IHC	IHC
Built year	1982	1977
Principal dimenstions	128x23x10.0m	104x17.50x6.95
Hopper capacity	8,000m^3	3,250 m^3
Ship's speed fully loaded	15.5 knts	12.8 knts
Main propulsion engine	6,900 HPx2	2,350 HPx2
Dredge pump engine	3,100 HPx2	1,960 HPx2
Type of drag head	California/IHC- Silt	California/IHC- Silt
Total Installed power	15,025 HP	
Other equipment involved		
Cornelis Zanen	13 months	
T.S.H.D.-"Johanna Jacoba"	8 months	
Tug boat "Sea Eagle II" (Plow)	4 months	
Tug boat "Bison-1"	3 months	
Survey boat "Margo"	21 months	
General Service Launch "Drakensteyn"	13 months	
General Service Launch "Hendrikje"	9 months	
Backhoe dredger "Sofala"	2 months	
Survey boat "Tiky II"	6 months	
Tug boat "Chire"	2 months	

2.4 Present Condition of Other Ports

Mozambique has three major international sea ports servicing the Southern African region and many regional ports located along the coastline.

- International Ports: Maputo, Beira, Nacala
- Regional Ports: Mocimboa de Prais, Pemba, Angoche, Pebane, Quelimane, Chinde, Inahambane, Xai Xai

2.4.1 Maputo Port

Maputo Port provides a variety of services for all type of cargo as the gateway of the Maputo Corridor connecting South Africa, Zimbabwe, Swaziland, Botswana, Zambia and Zaire with railway and road connection. At the south end of the port, a dry dock is situated for ship repairing. The approach to the port comprises the Northern Channel which is dredged to be 100 m wide, offering a minimum depth 8 m to 10 m during high tide.

2.4.2 Nacala Port

Nacala Port provides the gateway for domestic traffic as well as the Nacala Corridor connecting to Malawi by railway and road. The railway line linking Nacala Port to Cuamba has an extension of 533 km where a total rehabilitation and a spot rehabilitation of 77 km are continuously being carried out. This is one of the best natural deep water harbors in Africa with no siltation problem.

CHAPTER 3

NATURAL CONDITION

Chapter 3 Natural Condition

3.1 Topographic Condition

The port city of Beira is located in Sofala Province, central Mozambique. Beira Port is located on the left bank of the Pungue River and the Macuti Beach at the southern part of the city, facing the Mozambique Channel.

3.2 Meteorological Condition

The City of Beira is situated at latitude 19°48' S and longitude 34°50' E, within the tropical zone which is characterized by the wet season from November to April and a dry season from May to October. The meteorological conditions in Beira are described below.

3.2.1 Temperature

Temperature varies between 20℃ and 29℃. The mean annual temperature is 24.5℃.

3.2.2 Relative Humidity

The mean annual relative humidity is 72.1 %. The difference between the wet season and the dry season is small.

3.2.3 Rainfall

The mean annual rainfall is approximately 1,400 mm and the monthly variation is also high. For example, it varies from 11.6 mm in September to 254.6 mm in January. According to the monthly rainfall records in the last decade, the monthly rainfall of less than 50 mm occurred in some months during the dry season every year and the monthly rainfall of more than 400 mm occurred in 1988, 1990, 1991 and 1996.

Comparing the rainfall in Beira between the first three months of 1997 and the last decade, the rainfall in February 1997 was extremely heavy.

3.2.4 Winds

According to the statistics of the last 25 years, the frequency of occurrence of moderate wind less than 5 m/s ranges between 70 % and 79 % from April to July, between 60 % and 69 % in March and August, between 50 % and 59 % from

September to February and within 44 % in October. The frequency of wind more than 10 m/s is very low, being less than 1 % from February to August and 1 % to 2 % from September to January and within 2.4 % in October. The most predominant direction of wind is from ENE to SE.

3.2.5 Cyclones

According to the statistics in the last thirty years from the National Institute of Meteorology, there have been 23 cyclones which strongly affected Mozambique. Cyclones are generated in the South-Western Indian Ocean from November to April, and affect Beira, particularly, in February and March.

Table 3.2.5-1 List of Major Cyclones

Year	Cyclone Name			Year	Cyclone Name		
1956/4-1957/3				1977/4-1978/3			
1957/4-1958/3				1978/4-1979/3	Angele		
1958/4-1959/3				1979/4-1980/3			
1959/4-1960/3				1980/4-1981/3	Edwige		
1960/4-1961/3				1981/4-1982/3			
1961/4-1962/3	Daisy	Kate	Gina	1982/4-1983/3	Benedite	Elinah	
1962/4-1963/3				1983/4-1984/3			
1963/4-1964/3	Christine			1984/4-1985/3			
1964/4-1965/3				1985/4-1986/3	Berobia		
1965/4-1966/3	Germaine			1986/4-1987/3			
1966/4-1967/3	Daphne	Irma		1987/4-1988/3	Hely	Filao	
1967/4-1968/3	Flossie			1988/4-1989/3			
1968/4-1969/3				1989/4-1990/3			
1969/4-1970/3				1990/4-1991/3			
1970/4-1971/3	Delphine			1991/4-1992/3			
1971/4-1972/3				1992/4-1993/3			
1972/4-1973/3	Dorothee			1993/4-1994/3	Nadia		
1973/4-1974/3				1994/4-1995/3			
1974/4-1975/3	Honorine	Elsa		1995/4-1996/3	Bonita		
1975/4-1976/3				1996/4-1997/3	Lisette		
1976/4-1977/3	Emilie						

3.3 Sea Condition

3.3.1 General

In addition to the collection and analysis of the existing data and the information related to the sea conditions, the following surveys have been carried out in Beira Port, the Access Channel, dumping areas and offshore area.

3.3.2 Bathymetric Survey

In order to clarify the oceanographic phenomenon and siltation mechanism of the Access Channel and its surroundings, the bathymetric survey was carried out at coastal and offshore areas around Beira Port in the wet and dry seasons.

According to the bathymetric chart shown in Figure 3.3.2-1, some major shoal areas can be observed alongside the Access Channel. The bending corner area of the Access Channel such as Sections E9 and E10 is considered as a critical area for safe navigation due to heavy siltation. Soft silty sediment was recognized predominantly at the estuary of the Pungue River.

On the other hand, according to these survey maps, the water depth in February, during the wet season, was deeper by 2 to 0.5 m than in July of the dry season in most of the survey area.

3.3.3 Bank Configuration Survey

The configuration and distribution of banks and shoals existing around the estuary of the Pungue River were observed by aircraft and boat. The banks along the Access Channel from Beira Port to Macuti Light House were observed frequently at spring low tide.

3.3.4 Tide Observation Survey

The tidal level at Beira Port derived from the Admiralty Tide Table is indicated in Figure 3.3.4-1. It is typical semi-diurnal tide in the vicinity of Beira. The actual tidal level data were collected from the tide observation station of CFM-C in Beira Port and tide observation during our bathymetric surveys were carried out.

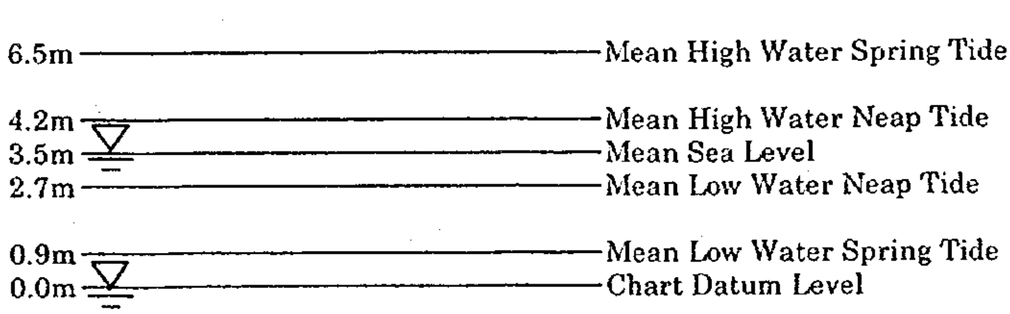


Figure 3.3.4-1 Tide Level Chart

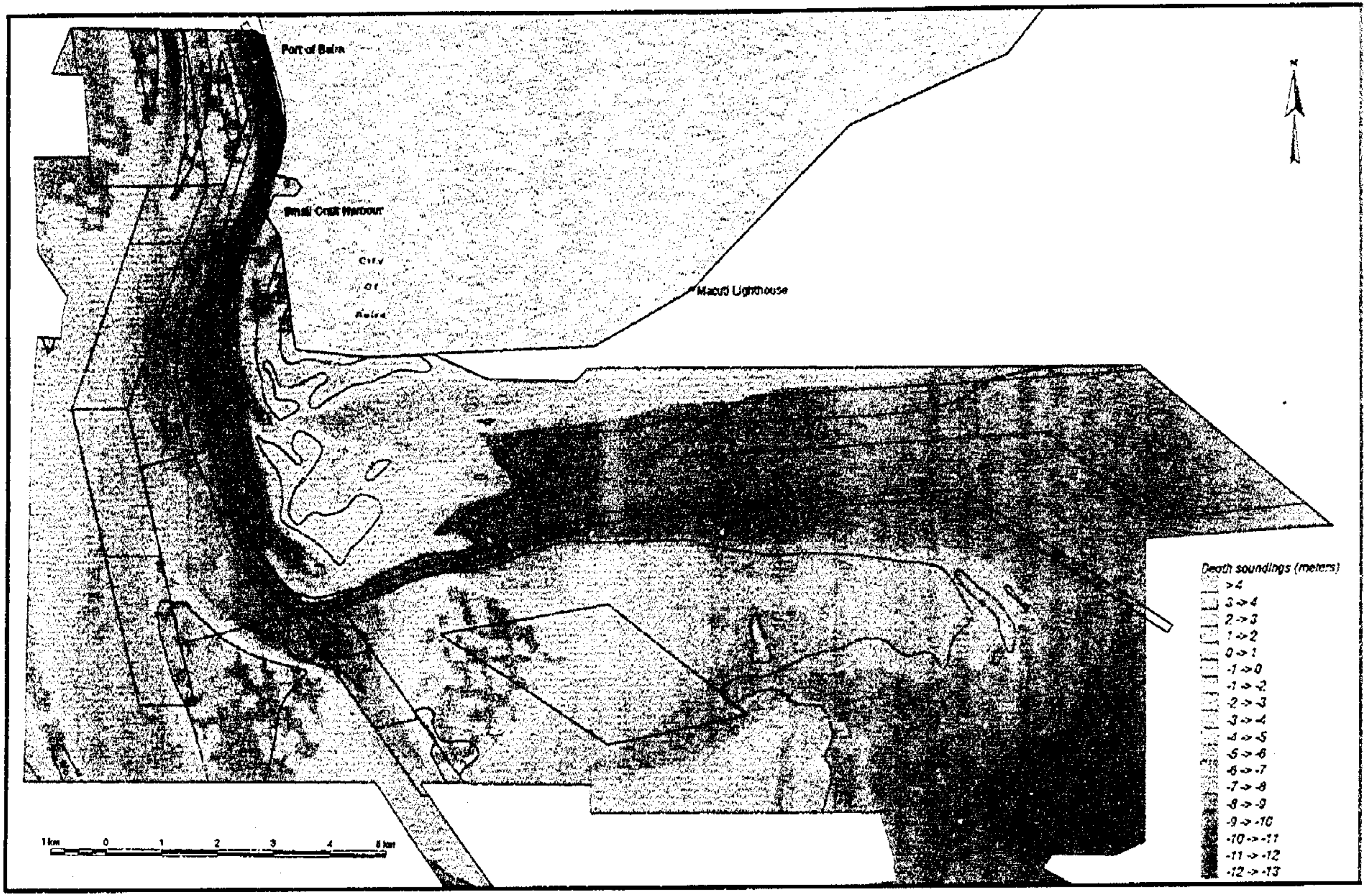


Figure 3.3.2-1 Bathymetric Chart in Dry Season

3.3.5 Wave Observation Survey

The wave observation survey was carried out to analyze the wave condition at the coast and offshore area in the vicinity of the Access Channel in the wet season. Wave buoy 1 was installed at 19° 55.04' S and 35° 1.57' E water depth 13 m and wave buoy 2 was at 19° 52.64' S and 34° 52.65' E water depth 5 m. The data of these buoys were transmitted by radio transfer system to the recorder set at the on-land base station.

Wave occurrence by direction is shown in Table 3.3.5-1. Wave occurrence by height and tide period is described in Tables 3.3.5-2 and 3.3.5-3.

The maximum significant wave height during the observation was 4.2 m with period of 10.7 seconds at Wave Buoy 1 which was generated by Cyclone "Lisette". At this time, the significant wave height at Buoy 2 was 2.2 m with period of 8.8 seconds.

Concerning the wave height at Buoy 1, the frequency of occurrence is 51.6 % for 0.5 to 1 m, 35.5 % for 1.0 to 1.5 m, 8.8 % for 1.5 to 2.0 m and 3.9 % for more than 2.0 m. The predominant wave direction is E and SE.

The occurrence rate of waves with 0.5 m to 1.0 m in height is 50.4 % and that of wave period less than 6 seconds is 44.8 % at Buoy 1. Also the occurrence rate of waves with 0.5 m to 1.0 m in height is 63.9 % and that of wave period less than 6 seconds is 79.2 % at Buoy 2.

During the period of wave observation, the south easterly waves were predominant. In only first two weeks of March, the easterly or the east-north-easterly waves were frequently observed while cyclone "Lisette" affected at Sofala Province.

3.3.6 Current Observation Survey

Siltation of the Access Channel and the basin is caused by the interaction between wave, current and sediment. Therefore, the study team carried out a current observation survey and float tracking survey at spring and neap tides in both the wet and dry seasons.

The results of the current observation in spring tide are illustrated in Figures 3.3.6-1 and 3.3.6-2. And the current speeds derived from the float tracking survey are described in Tables 3.3.6-1 and 3.3.6-2.

Table 3.3.5-1 Wave Occurrence by Direction in Wet Season at Buoy1

WAVE HEIGHT(m)	S	SE	E	NE	TOTAL
4.0-	0.0%	0.6%	0.0%	0.0%	0.6%
3.5-4.0	0.0%	0.0%	0.0%	0.0%	0.0%
3.0-3.5	0.0%	1.1%	0.0%	0.0%	1.1%
2.5-3.0	0.0%	0.9%	0.0%	0.0%	0.9%
2.0-2.5	0.3%	0.9%	0.1%	0.0%	1.3%
1.5-2.0	1.0%	7.1%	0.7%	0.0%	8.8%
1.0-1.5	0.6%	26.5%	7.7%	0.7%	35.5%
0.5-1.0	1.0%	31.5%	16.2%	2.8%	51.6%
0.0-0.5	0.0%	0.0%	0.3%	0.0%	0.3%
TOTAL	2.8%	68.5%	25.1%	3.6%	100.0%

Table 3.3.5-2 Wave Occurrence by Wave Period in Wet Season at Buoy1

WAVE PERIOD(s)/ WAVE HEIGHT(m)	-6.0	6.0-8.0	8.0-10.0	10.0-12.0	12.0-14.0	14.0-	TOTAL
4.0-	0.0%	0.0%	0.1%	0.1%	0.0%	0.0%	0.3%
3.5-4.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
3.0-3.5	0.0%	0.1%	0.3%	0.1%	0.0%	0.0%	0.6%
2.5-3.0	0.1%	0.1%	0.1%	0.0%	0.0%	0.0%	0.4%
2.0-2.5	0.3%	1.0%	0.0%	0.0%	0.0%	0.0%	1.3%
1.5-2.0	3.7%	4.1%	0.1%	0.6%	0.0%	0.0%	8.6%
1.0-1.5	22.4%	9.6%	5.1%	0.7%	0.6%	0.0%	38.4%
0.5-1.0	18.1%	9.3%	14.1%	6.7%	2.0%	0.1%	50.4%
0.0-0.5	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%
TOTAL	44.8%	24.3%	20.0%	8.3%	2.6%	0.1%	100.0%

Table 3.3.5-3 Wave Occurrence by Wave Period in Wet Season at Buoy2

WAVE PERIOD(s)/ WAVE HEIGHT(m)	-6.0	6.0-8.0	8.0-10.0	10.0-12.0	12.0-14.0	14.0-	TOTAL
4.0-	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
3.5-4.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
3.0-3.5	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2.5-3.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2.0-2.5	0.1%	0.0%	0.4%	0.0%	0.0%	0.0%	0.6%
1.5-2.0	0.9%	0.4%	0.1%	0.0%	0.0%	0.0%	1.5%
1.0-1.5	7.2%	1.0%	0.0%	0.6%	0.0%	0.0%	8.8%
0.5-1.0	50.7%	4.6%	4.9%	3.1%	0.4%	0.0%	63.9%
0.0-0.5	20.2%	1.3%	1.3%	1.8%	0.4%	0.0%	25.1%
TOTAL	79.2%	7.5%	6.9%	5.5%	0.9%	0.0%	100.0%

(1) Predominant Current during Spring Tide

Generally, current patterns during the spring tide correspond clearly to the difference of tide condition. On the subject of the current pattern, the middle and the bottom layer at each station have a similar phenomenon. Particularly from station No.7 to No.13, which are situated offshore, the tendency is conspicuous. The current velocity of each station has a clear tendency that velocity is getting stronger from bottom to surface. The strongest current was recorded on both flood and ebb tide at station No. 2, of which velocities are 2.50 m/sec, northerly current during flood tide and 2.30 m/sec of south-southeasterly current during ebb tide.

(2) Predominant Current during Neap Tide

In general, the current pattern during the neap tide does not correspond to the tide condition. The current directions at each station during both flood and ebb tides show a pattern which flows into or along the channel. The strongest current was recorded at station No.2 which is the northerly current with 1.45 m/sec during flood tide. Also at station No.5, the southerly current flows with 1.45 m/sec during ebb tide.

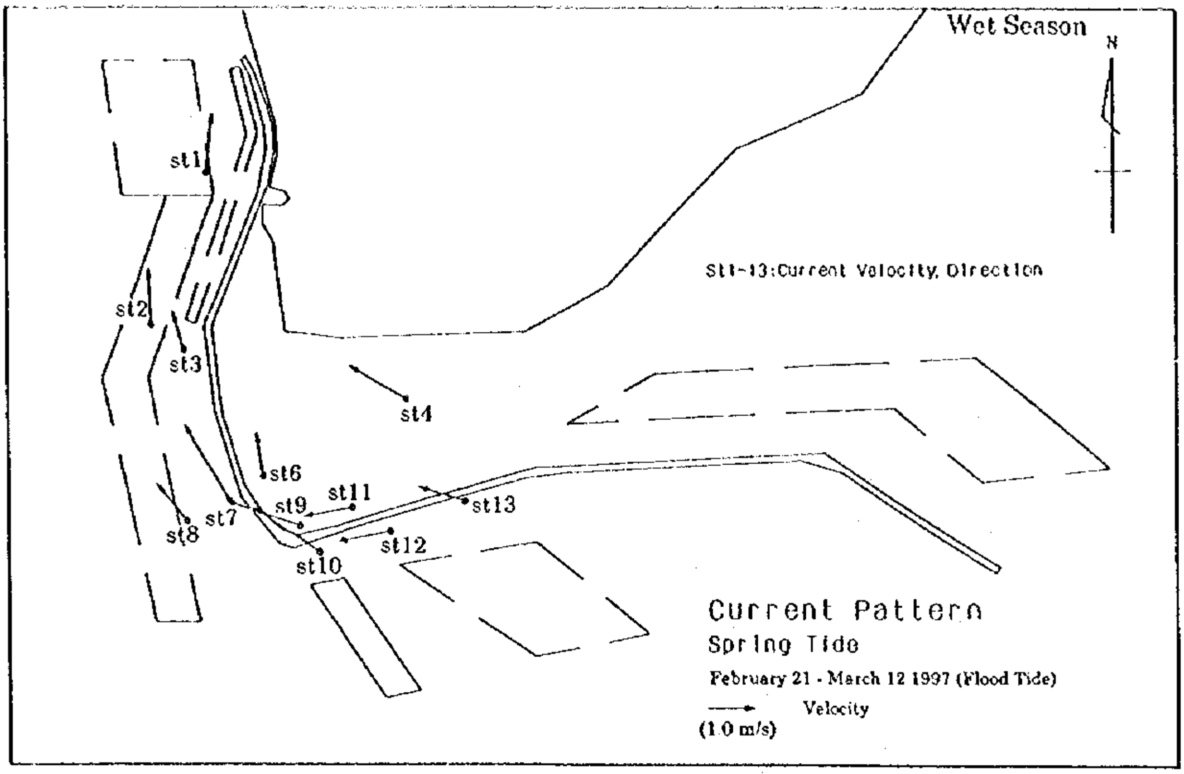
(3) Float Tracking during Spring Tide

At all survey stations, the current patterns show that the float drifts easterly from the ebb tide until the beginning of flood tide through the slack water. After that, the swift flood current carries the float to the mouth of the Pungue river. The strongest current at each station during flood and ebb tide is shown in the table below.

Table 3.3.6-1 Float Tracking Result during Spring Tide in Dry Season

Station	Velocity(F)*	Direction	Velocity(E)*	Direction
Stf 1	1.46m/sec	West	1.27m/sec	East
Stf 2	2.05m/sec	North	0.99m/sec	Northeast
Stf 3	1.85m/sec	North	1.41m/sec	Northeast

*(F)flood tide (E)ebb tide



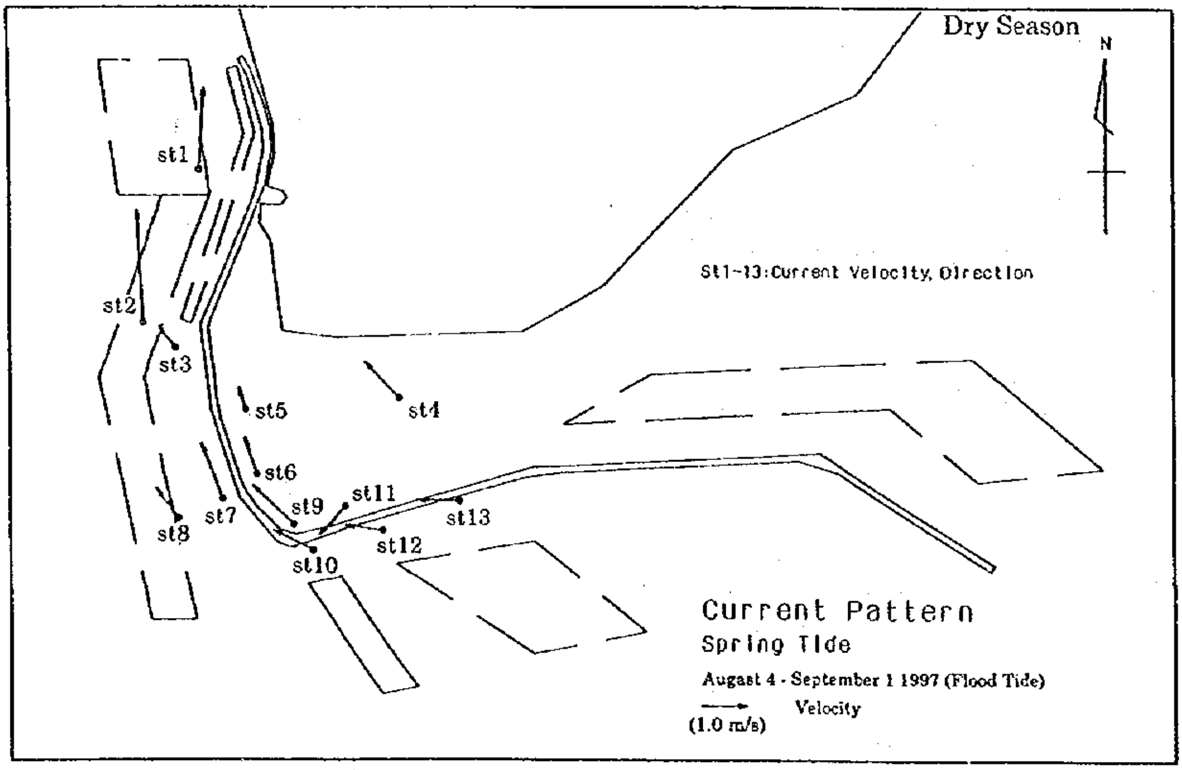
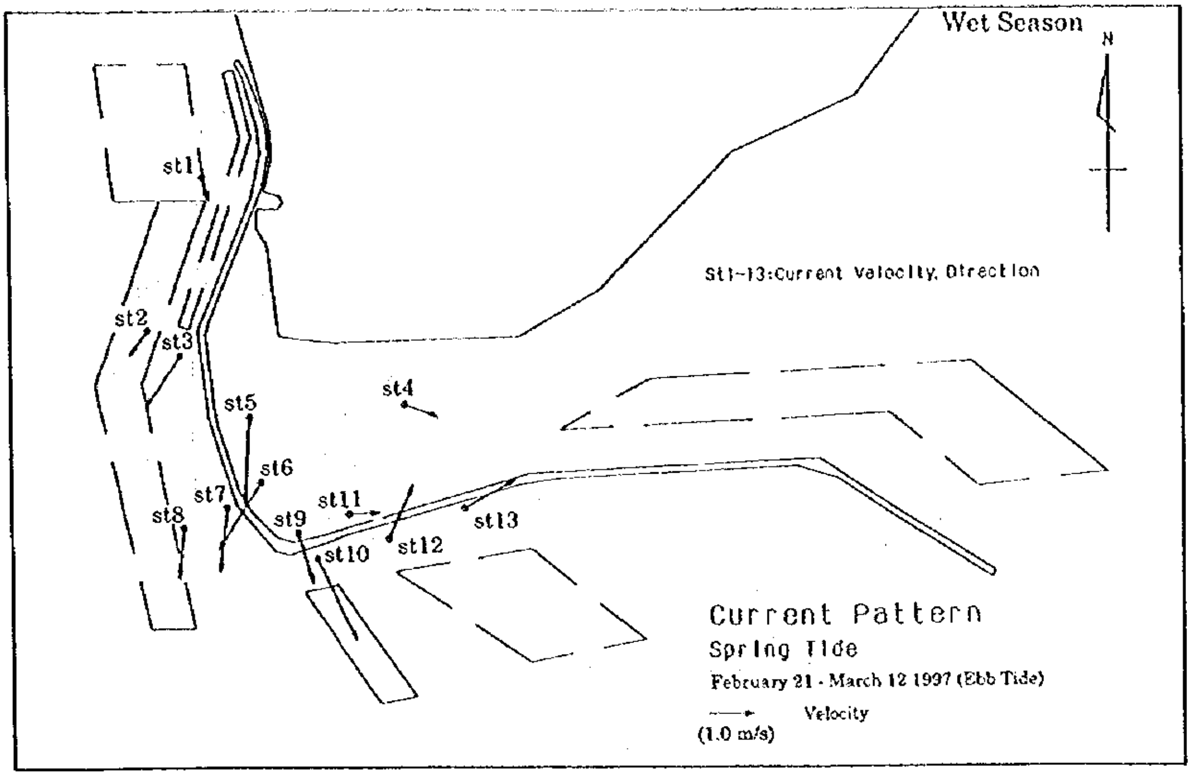


Figure 3.3.6-1 Current Pattern of Flood Tide during Spring Tide



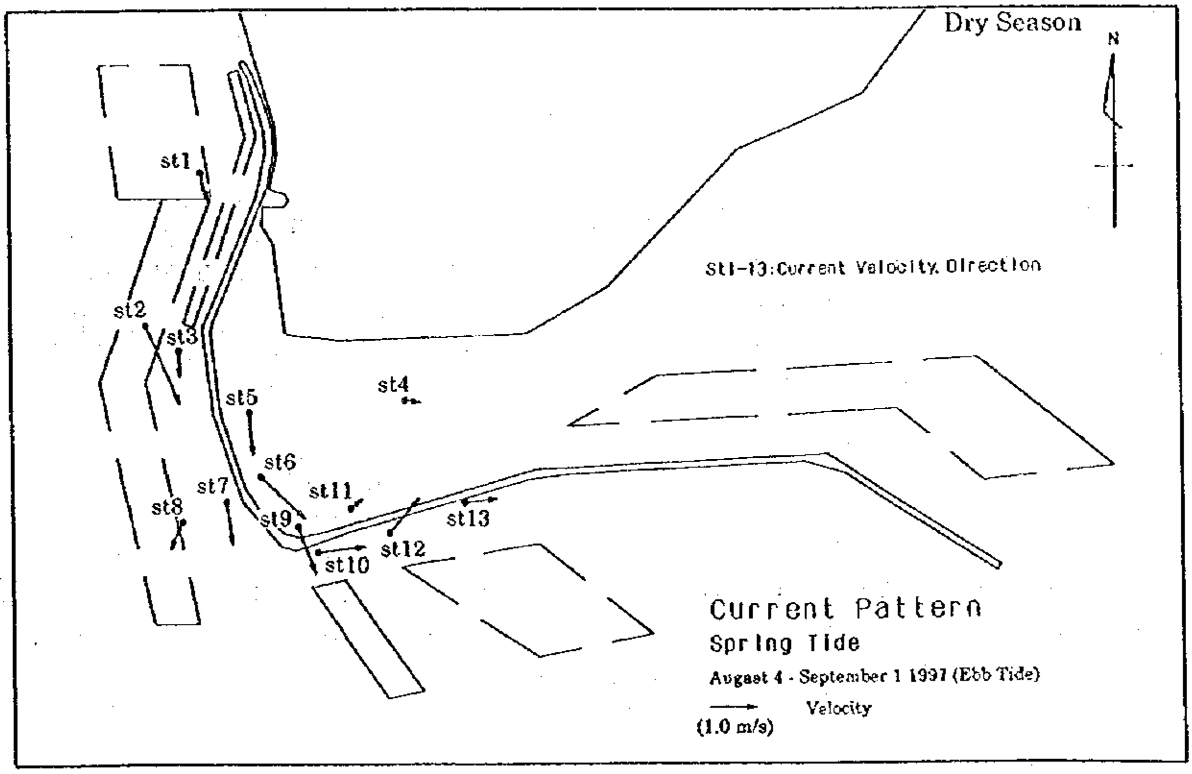


Figure 3.3.6-2 Current Pattern of Ebb Tide during Spring Tide

(4) Float Tracking during Neap Tide

There is clear contrast between weak current to the west during flood tide and strong current to the east during ebb tide. The strongest currents at each station at flood and ebb tides are shown in Table 3.3.6-2.

Table 3.3.6-2 Float Tracking Result during Neap Tide in Dry Season

Station	Velocity(F)*	Direction	Velocity(E)*	Direction
Stf 1	0.19m/sec	West	0.88m/sec	East
Stf 2	0.31m/sec	North-northwest	0.88m/sec	East
Stf 3	0.31m/sec	West	0.83m/sec	East-northeast

*(F)flood tide (E)ebb tide

3.3.7 Turbidity Observation Survey

Observation of turbidity measured by a turbidity meter was carried out at the same stations as the current observation in the wet and dry seasons. The turbidity measurement was carried out at the same layer and simultaneously with the current observation survey. Maximum turbidities are summarized in Table 3.3.7-1.

(1) Turbidity Measurements during Spring Tide

The turbidity is influenced by the tide condition at the most of stations. The turbidity during the spring tide is slightly smaller than the one during the ebb tide. Generally, higher turbidity was recorded during low tide. Regarding the vertical change, the turbidity becomes higher from the surface to the bottom. Also the maximum turbidity was recorded at the ebb tide period.

(2) Turbidity Measurements during Neap Tide

Comparing the value of the wet and dry seasons, there is no clear indication, but there is little deference between the wet season and the dry season. It is slightly higher in the wet season than in the dry season, due to heavy rain fall in the up stream of the Pungue river in the wet season.

Table 3.3.7-1 Maximum Turbidity in Wet and Dry Season

Observation Station	Turbidity on Spring Tide (ppm) Wet Season (maximum)	Dry Season (maximum)	Turbidity on Neap Tide (ppm) Wet Season (maximum)	Dry Season (maximum)
1	1,020	1,719	225	84
2	1,250	1,726	230	105
3	1,512	1,692	335	142
4	764	739	190	80
5	1,665	1,651	305	336
6	1,443	1,220	332	561
7	1,624	1,132	65	73
8	1,420	802	103	166
9	1,523	1,089	154	96
10	1,220	1,247	90	74
11	1,284	1,158	278	173
12	1,382	669	202	146
13	1,220	524	185	28

*Turbidity at Nos.1 and 2 during Spring Tide in the Dry Season was observed with Wave of 1.2 m high.

3.4 Bottom Sediment Condition

In order to analyze the bottom sediment conditions, seabed materials were sampled in quay front basin, the Access Channel and offshore area in the wet and dry seasons.

The results of analyses on all samples in the wet season are presented in Table 3.4-1. Concerning to the Access Channel, sand is predominant, but silt mainly exists at the south-east section in the port side of the bending corner of the channel and in the vicinity of Section E14 at the offshore. Coarse sand is recognized in the vicinity of the bending corner. As regards the offshore area, fine sand is predominantly existing. Silty material is observed more at the north side than at the south side of the Access Channel.

Table 3.4-1 Characteristics of Bottom Sediment in Wet Season

Sample No.	Gravel (%)	Sand (%)	Silt + Clay (%)	Texture Class	D(50) (mm)	Moist. Cont. (%)	Bulk Dens. (g/cm^3)	Dry Dens. (g/cm^3)	Void Ratio	S. G.	Component Minerals
C2	0	36	63	Sandy Silt	0.030	197.7	1.270	0.431	5.08		
C4	0	100	0	Sand	0.420	16.9	1.901	1.626	0.63		
C5	14	67	19	Gravelly Silty Sand	0.320	30.9	1.909	1.485	0.80	2.63	15%:chlorite-montmorillonite clay
C6	0	100	0	Sand	0.180	32.7	1.856	1.397	0.90		15%:illite clay
C7	4	96	0	Slightly Gravelly Sand	0.800	14.7	1.671	1.457	0.82		35%:shell and coral fragments.
C8	0	100	0	Sand	0.350	16.0	1.583	1.365	0.94		35%:quartz
C9	4	96	0	Slightly Gravelly Sand	0.600	13.0	1.622	1.435	0.73		<1%:ilmenite and almandine garnet
C10	2	98	0	Sand	0.770	12.3	1.637	1.458	0.81	2.65	96%:sand-sized quartz grains
C11	30	70	0	Gravelly Sand	1.490	9.8	1.686	1.536	0.73		3%:shell and rock fragments
C12	6	94	0	Slightly Gravelly Sand	0.790	10.9	1.585	1.429	0.85		<<1%:heavy minerals
C13	9	91	0	Slightly Gravelly Sand	0.750	13.4	1.719	1.516	0.75		
C14	1	99	0	Sand	1.000	5.5	1.531	1.451	0.83		
C15	6	94	0	Slightly Gravelly Sand	0.600	16.9	1.741	1.489	0.78		
C16	0	33	77	Sandy Silt	0.023	179.0	1.282	0.458	4.72	2.61	45%:chlorite-montmorillonite clay
C17	0	28	72	Sandy Silt	0.009	247.8	1.225	0.352	6.44		45%:illite clay
C18	0	100	0	Sand	0.150	24.9	1.450	1.161	1.28		10%:quartz and shell fragments
C19	0	44	56	Sandy Silt	0.040	86.2	1.512	0.812	2.22		with mica flakes
C20	0	100	0	Sand	0.460	1.6	1.285	1.265	1.09		<<1%:shiny black ilmenite
C21	2	98	0	Sand	0.600	89.0	1.385	1.373	0.93		
C22	0	16	84	Sandy Silt	0.004	145.7	1.197	0.487	4.38	2.63	60%:chlorite-montmorillonite
C23	0	100	0	Sand	0.220	31.4	1.871	1.424	1.86		30%:illite clay
B1	0	64	36	Silty Sand	0.109	69.9	1.595	0.939	1.79		5%:quartz, shell fragments and
B2	0	46	53	Sandy Silt	0.050	63.9	1.335	0.815	2.21		mica flakes
B4	1	99	0	Sand	0.420	20.2	1.667	1.387	0.91		<2%:ilmenite and almandine garnet
B6	11	89	0	Slightly Gravelly Sand	0.240	36.6	1.756	1.286	1.06		with lesser amounts of schorl
B8	0	100	0	Sand	0.300	18.6	1.670	1.408	0.88		tourmaline
B12	1	99	0	Sand	0.195	22.4	1.639	1.339	0.98		
B17	0	100	0	Sand	0.240	22.7	1.663	1.355	0.96		
B19	2	98	0	Sand	0.440	17.9	1.698	1.433	0.85		
B24	6	94	0	Slightly Gravelly Sand	0.890	18.4	1.629	1.376	0.93		Average 95%:sand-sized quartz
B31	6	94	0	Slightly Gravelly Sand	0.920	4.8	1.541	1.476	0.80	2.65	grains
B32	3	97	0	Slightly Gravelly Sand	0.670	12.0	1.641	1.465	0.81	2.65	Average 4%:shell and rock fragments
B33	7	93	0	Slightly Gravelly Sand	0.930	2.3	1.549	1.514	0.75	2.65	<<<1%:heavy minerals

3.5 Littoral Drift and Sedimentation

The Access Channel to Beira Port passes through the extensive shoal area in front of the Port. Sand drift of this area is supplied along the northern coast from the mouth of the Zambezi River and other rivers, from the Pungue and Buzi Rivers and from the mouth of rivers in the southern area. The first one is the most influential, especially on the formation of the Macuti Shoal, because the drainage area of the Zambezi River is extremely extensive in comparison with the other rivers.

Figure 3.5-1 shows an overview of littoral drift in the vicinity of the Access Channel, which is presumed from data described in previous sections and past sounding maps. Sediments discharged from the estuary of the Pungue River, in general, are fine sand and silt owing to its flat bottom slope except in heavy flood times. They mostly seems to deposit in the wide mouth area excluding the narrow part in front of the quays of Beira Port and in the south of the Access Channel.

Along the Macuti Beach located at the east of Beira Port, sand transport toward the Pungue River is predominant, since most of waves come from an easterly direction against the perpendicular to the coastal line and tidal currents also are prevailing in the direction toward the Pungue River on the Macuti Coast. And some part of them moves toward the Port along the left bank of the Pungue River and others deposit on the bottom of Sections from E6 to E8 of the Access Channel or flow in the Channel by strong tidal currents.

While sand suspended-up by waves on the Macuti Shoal is also transported obliquely seaward by offshore-word currents besides in parallel to the coastal line , the amount of which increases with wave height. They can not reach Sections from E6 to E8 at the time of strong currents at ebb tide along the Channel, forming sand banks toward the bending corner and entering into the Channel.

Some sand also enters into the Channel from the direction of the Pelican and Rambler Shoals by waves and tidal currents. Sand transported through the Channel until the entrance of Channel deposits widely in its vicinity, a part of which is moved by waves toward the coast. But, this sand transported to the Macuti Beach is supposed to be a little in volume as compared with the sand going out from the Beach.

The above mentioned characteristics of sand transport has been also confirmed by the results of chemical element analysis of sand.

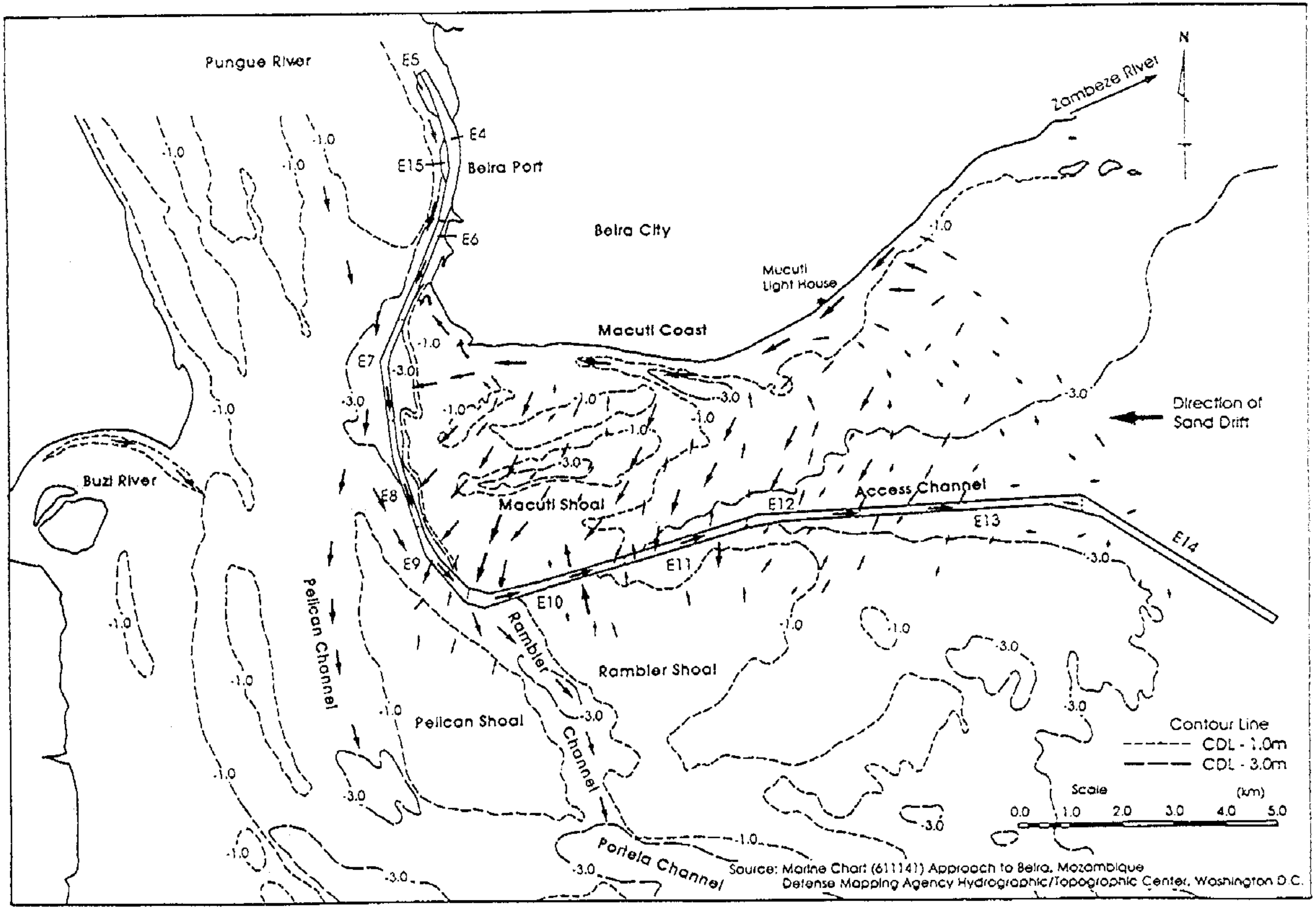


Figure 3.5-1 Overview of Littoral Drift in the Vicinity of Access Channel