SUMMARY OF STUDY RESULTS

PART I OUTLINE OF THE STUDY

CHAPTER 1. THE BACKGROUND OF THIS STUDY

There are four major ports or port complexes in Nigeria, nearly 70 percent of their combined traffic is borne by Lagos Port, due to the concentration of trade and industry in western Nigeria and particularly the Lagos area. Consequently, it is urgently necessary to expand the cargo-handling capacities of Lagos Port in order to alleviate the present congestion of the port and to cope with future increases in volume.

The New Ocean Terminal proposed at about 50km east of Lagos Port (referred to hereafter as "NOT-Lagos") is designed to fulfill these requirements.

Meanwhile, there have been suggestions that other sites for the New Ocean Terminal, particularly in the eastern states, be considered.

CHAPTER 2. OBJECTIVES OF THE STUDY

The study comprises the following two parts, with the aim of assessing the eastern coast as a site for port development.

Part 1: New Ocean Terminal

To study the possibilities of developing a New Ocean Terminal on the eastern coast with the same scale and function as NOT-Lagos.

But, the development of NOT could be very difficult due to the topographical conditions of the eastern coast. Therefore,

Part 2: Local Ports

To prepare sketches for possible port planning to meet future regional development along the eastern coast, and to evaluate these plans with respect to variously selected conditions.

CHAPTER 3. STUDY AREA

The study area has been designated by the Nigerian Ports Authority (NPA) as the vicinity of Opobo, Ibeno, and Jamestown in the eastern coast's Cross River State.

CHAPTER 4. FIELD INVESTIGATION

During the course of this study, following two study groups were dispatched to Nigeria.

(1) Natural conditions Survey Group
(2) Port planning group

PART II CONDITIONS OF THE SITE

CHAPTER 1. NATURAL CONDITIONS

(1) Geography

The topography of Nigeria is characterized by the River Niger and its largest tributary, the Benue. These two rivers flow through the country in a Y shape. Plains spread along the Niger and the Benue. A vast delta is formed at the river mouth of the Niger.

(2) Climate and vegetation

The climate and the vegetation show distinctive characteristics between the north and the south. From south to north, they change from tropical rain forests to savannahs.

(3) Winds

During the dry season, strong northeasterly winds prevail through most of Nigeria. In contrast, during the wet season, strong southwesterly winds sweep the entire country.

(4) Precipitation

The rainfall decreases both in duration and amount from the coast toward the interior. The coastal areas receive over 4,000 mm, spread over 8 – 10 months, the extreme north less than 250 mm, spread over 3 to 4 months.

(5) Waves

Waves arriving at the Nigerian coasts are swell, generated in the wind area caused by a depression in the Atlantic Ocean far offshore. Wave steepness is only about 0.005. As for the direction of deepwater waves, SW accounts for about half, and more than 80% of all waves are within the range of from S to W. The most common wave period is 12 seconds.

(6) Currents

The maximum current velocity in the mouth of the Kwa Ibo River is 0.8 ~ 1.3 m/s at flood tide, and 0.8 ~ 1.7 m/s at ebb tide. The current velocity in the offshore area is 0.05 ~ 0.35 m/s and its direction is east /west.

(7) Tide

Tidal elevations at the proposed port sites have been established as follows:

H.W.L.	+2.10 m
L.W.L.	+0.20 m

(8) Sediments

Sediments on the beaches facing Guinea Bay are composed of very uniform fine sand. Sediments off the Kwa Ibo Estuary are composed of silt and fine sand.

CHAPTER 2. SOCIO-ECONOMIC CONDITIONS OF THE EASTERN STATES

2-1. Socio-economic Conditions in the Eastern States

The eastern states are comprised of ten states; six states in the south and four states in the north (Fig. 2-1).

(1) Area and Population

The eastern states cover a total area of 489,711 km^2, or 53.0% of the Federation's total. The National Population Bureau has estimated this region's population to be about 27.4 million as of the 1963 census, and about 41.6 million in 1980, representing respectively (by estimation) 49.2% and 49.1% of the Federation's total population.

(2) Resources

1) Agricultural resources

Major food crops in the eastern states are yam, cassava, maize, and gunia corn. Yam and cassava, which are root crops, are produced mainly in the south. Maize is also produced in the south, while gunia corn is produced mainly in the north. In addition the eastern states also grow such root crops as oil palm, rubber, and ground nuts. Fruits are grown generally everywhere but livestock is raised mainly in the north.

2) Forest resources

The eastern states of Bendel and Cross River have large forest reserves, many of which are major production centers for industrial wood including high grade woods such as mahogany and obeche.

3) Fishing resources

In the eastern states, many types of fish such as shad, promfret, grouper, sole and catfish are caught. However, fishing is conducted mainly by individuals and families; industrial fishery is rare.

4) Mineral resources

Mineral deposits are concentrated in the eastern states. Petroleum, the mainstay of the Nigerian economy is found mainly in the Niger Delta area. There are some oil fields in the coastal part of Cross River State where the prospective site of NOT-east is situated. In addition to petroleum and its associated product, natural gas, the main mineral deposits in the eastern states are of coal, iron ore, tin, columbite, lead and zinc, and limestone.

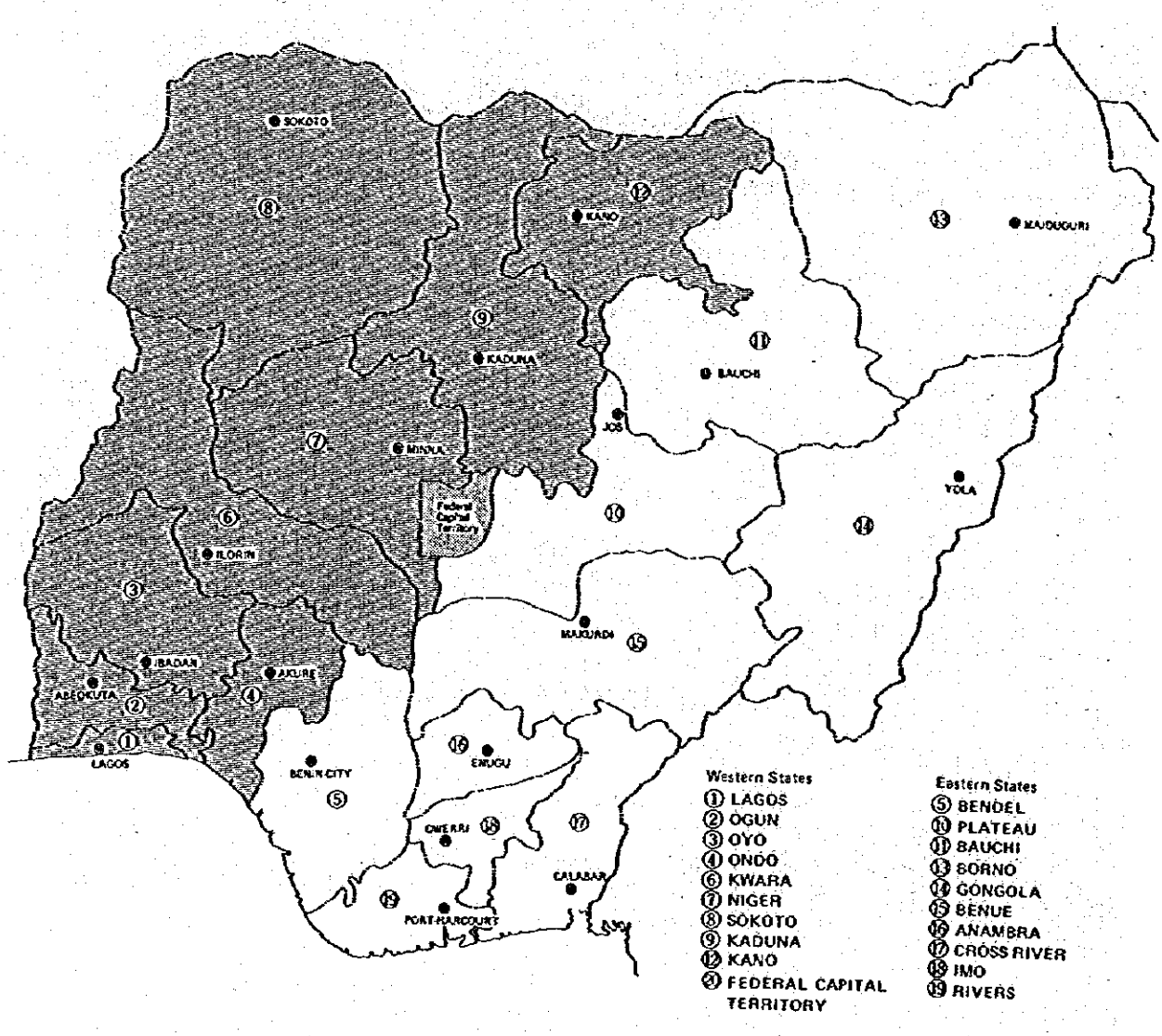


Fig. 2-1 Eastern and Western States

(3) Industry

The 1975–76 composition of the Nigerian GDP was 28.1% for the primary sector, 35.7% for the secondary sector and 36.2% for the tertiary sector. In recent years, the secondary (not only mining supported by petroleum but also building, construction, and manufacturing) and the tertiary sector (mainly wholesale and retail business) saw remarkable development.

In view of Nigeria's rapid population growth and the influx of foreign currencies due to foodstuff exports, the development of agriculture is vital not only as a means of maintaining favorable employment levels, but also, with an eye toward eventual self-sufficiency in foodstuffs. In the mining sector, meanwhile, new mineral resources are being explored in anticipation of the exhaustion of the nation's petroleum. At the same time, the government is promoting industrialization to support the nation's large population and improve the people's general welfare.
welfare.

The eastern states are, as a whole, an excellent agricultural zone with higher productivity than the western states, representing 60.2% of Nigeria's crop production and 2.74 tons of the average yield per hectare in 1978–79, which far exceeds the Federation's average of 1.58 tons.

On the other hand, the eastern states are far behind the western states in industrialization. The number of factories employing 10 or more workers was 516 in 1975. The number of workers was 66,986, the gross output was about ₦296 million, and the value added was about ₦154 million. The shares of the eastern states in the entire Federation were 40.5%, 27.8%, 11.3%, and 12.9%, respectively. These shares are fairly smaller than that of the population. In addition, manufacturing industries in the eastern states are on a smaller scale and with a lower productivity as a whole; resource-based industries are predominant and the accumulation of basic material industries (chemicals, iron and steel) and machine industry requiring advanced technology is smaller than in the western states.

Based on the above circumstances, priority should be given to promoting the industrial development of the eastern states, so that the nation can achieve balanced development.

2-2. Present Situation of and Development Plan for Transportation Facilities

(1) Roads

The road network in Nigeria is composed of federal trunk roads, state trunk roads, and other local roads.

When NOT-east is constructed, route F103 which connects Warri, Opobo, Eket, and Oron will become major route of commodity transportation.

(2) Railways

The rail network in Nigeria is composed of two north-south trunk lines connecting Lagos and Port Harcourt Port with inland areas. The cargo transportation capacity is at a very low level in many sections because of poor operation, insufficient line capacity, scarcity of skilled labor, and antiquated facilities.

There is a construction plan for new railway lines of standard gauge (1,435mm),with the aim of improving the cargo transportation capacity.

(3) Ports

1) Present situation of port facilities

Lagos Port (Apapa and Tin Can Island) is the biggest commercial port in Nigeria.

The old Apapa Quays (excluding the Third Wharf Extension) have a total quay length of 2,459m, and a handling capacity of up to twenty loading and discharging vessels at once. Water depth at the main berths is 8.23m. The Third Wharf extension has a total quay length of 1,600m of which 1,000m is used exclusively for containers and is well-equipped with modern cargo handling equipment. The maximum draught alongside is 11.5m.

Tin Can Island Port has a 2,500m wharf with ten berths.

Beside these, Kivikivi Jetty and Ikorodu Lighter Terminal serve as discharging depo for cargo off-loaded in mid-stream onto farges.

Port Harcourt Port, lies on the bend of Bonny River, is the second commercial port in Nigeria. The main quay is about 1,360m long, capable of berthing light main line vessels. The maximum draught at H.W.S. tides for vessels entering the port is 7.62m.

Delta port complex consists of ports of Warri, Koko, and Burutu. Warri Port includes an old port with a total quay length of 876m and a newly developed modern port commissioned for operation on 1979 which offers five additional general cargo berths, one RO-RO container berth, and two finger jetties, giving a total quay berth of 1,600m maximum draft alongside the new port is 11.5m. Koko port has a total quay length of 137m, maximum draft is 7.32m.

Calabar Port lies on the midstream of Cross River.

This port now comprises the old Calabar port and the new port which is 860m long, capable of providing modern berthing facilities for four to six vessels.

2) Cargo handling capacity

Table 2-1 shows the cargo throughput of 1979/80. The volume of general cargo was 8.38 million tons; container cargo 1.14 million tons; and other cargo 7.15 million tons. Total cargo volume was 16.68 million tons.

Nigerias petroleum oil terminal and jetties for oil tankers handled 105.2 million tons of crude oil and 2.0 million tons of refined petroleum oil in 1979/80.

(4) Inland Waterways

The main inland waterways in the eastern states consist of the two large rivers Niger and Benue, the Cross River, and the creeks in the Niger Delta. The Niger is to be used for the transportation of goods related to the Ajaokuta Steel Mill, and the dredging and the improvement of Niger port facilities are thus being energetically under taken in order to ensure year-round navigability throughout the dry and rainy seasons.

As for the River Benue, dredging and the improvement of facilities of river ports are proposed.

The inland waterways situated in the vicinity of the proposed site of NOT-east are the Cross, Calabar, Imo, and Kwa Ibo rivers. The most frequently used of these is the Cross River. There are ferries in Imo River and the Calabar also has some ferries. The Kwa Ibo River is used quite frequently as an access route to the crude oil tank farm of a petroleum company in Ibeno.

The improvement of navigational conditions of the River Niger can be expected not only to support the Ajaokuta steel project but also to contribute to the industrial development of the bordering eastern states of Benue, Anambra, Imo, and Rivers. No drastic improvement of

Table 2-1 Cargo Throughput Handled at All Ports: 1979/80

(Unit: ton)

Ports	General Cargo			Container			Others			Throughput			Share (%)
	Inward	Outward	Total	Inward	Outward	Total	Inward	Outward	Total	Inward	Outward	Total	
Lagos	3,546,244	265,241	3,811,485	902,961	35,510	938,471	5,033,308	188,218	5,221,526	9,482,513	488,969	9,971,482	69.6
Tin Can Island Port	1,548,934	15,707	1,564,641	66,846	791	67,637	–	–	–	1,615,780	16,498	1,632,278	
Port Harcourt	1,597,652	78,175	1,675,827	124,286	2,441	126,727	379,493	39,454	418,947	2,101,431	120,070	2,221,501	13.3
Warri	860,193	25,170	885,363	8,522	335	8,857	258,444	888,227	1,146,671	1,127,159	913,732	2,040,891	15.7
Koko	59,112	422	59,534	129	–	129	43,859	–	43,859	103,100	422	103,522	
Burutu	–	1,003	1,003	–	–	–	–	–	–	–	1,003	1,003	
Sapele	259,792	36,769	296,561	–	–	–	163,668	5,947	169,615	423,460	42,716	466,176	
Calabar	58,012	28,319	86,331	899	141	1,030	109,535	44,684	154,219	168,436	73,144	241,580	1.4
Total	7,929,939	450,806	8,380,745	1,103,633	39,218	1,142,851	5,988,307	1,166,530	7,154,837	15,021,879	1,656,554	16,678,433	100.0

navigational conditions is planned for smaller Cross, Calabar, Imo, and Kwa Ibo rivers, but if sea ports are constructed at their estuaries in the future, the extensive use of these rivers as inland waterways can be expected in connection with port-oriented industies.

(5) Pipelines

In Nigeria, pipelines used to be used mainly for transporting. Crude oil between the oil fields and export stock-yards. However, pipelines between oil fields and refineries or between refineries and stock points are now being rapidly constructed.

The building of a pipeline network that will extend to many major cities in Nigeria is being planned, so that in the futuer most petroleum products will be transported through pipelines rather than by lorries or railway.

PART III NEW OCEAN TERMINAL

CHAPTER 1. SCALE AND FUNCTIONS

(1) Fundamentals of NOT-east

The scale and functions of the New Ocean Terminal proposed for the eastern coast of Nigeria are assumed to be identical to those of NOT-Lagos. NOT-east will thus perform the commercial port and industrial port.

(2) Development of Commercial Port

Projected commercial cargo volume handled at NOT is shown in Table 3-1 and projected number and size of berthing facilities of commercial port for the year 2000 are shown in Table 3-2.

Table 3-1 Commercial Cargo Traffic and Berthing Facilities at the New Ocean Terminal in the Year 2000

Port	Cargo Traffic and Dimensions of Berthing Facilities	General Cargo			Grain	Petroleum Oil	Total
		Break Bulk	Containerized	Subtotal			
New Ocean Terminal	Cargo Traffic (thousands of tons)	6,606	13,414	20,020	1,042	5,400	26,462
	Number of Berths	33	27	60	1	3	64
	Total Length of Berths (m)	6,105	8,100	14,205	300	555	15,060

Table 3-2 Number and Size of Berthing Facilities for Commercial Cargoes at the New Ocean Terminal in the Year 2000

Cargo Traffic, Dimension of Vessels and Berths	General Cargo Berths		Grain Berth	Petroleum Oil Berths	Small Craft Berths	Total
	Break Bulk	Containerized				
Cargo Traffic (1,000 ton/yr.)	6,606	13,414	1,042	5,400	–	26,462
Maximum Size of Vessels (DWT)	15,000	50,000G.T.	60,000	15,000	280G.T.	–
Structural Depth of Berths (m)	-10	-12(-13*)	-14	-10	-3.5	–
Length of Each Berth (m)	185	300	300	185	–	–
Total Number of Berths	33	27	1	3	–	64
Total Length of Berths (m)	6,105	8,100	300	555	1,100	16,160
Total Width of Wharf (m)	200	400	300	–	25	–

Note: * At present, a depth of 12 m is sufficient for most modern container ships, but to meet future increase in ship size, an allowance of 1 m is taken into consideration for design purposes.

(3) Development of Industrial Port

The types and scales of industries in the year 2000 will be identical to those of NOT-Lagos. The development scales of these industries are shown in Table 3-3, and the number and size of berthing facilities of industrial port in the year 2000 are shown in Table 3-4.

(4) Development of New City

In connection with the New Ocean Terminal Project, it is necessary to construct a new city with a population of 200,000, including employees of NOT-east and their dependents, the land space necessary for the new city and its urban facilities are all compatible to those of the city for NOT-Lagos.

CHAPTER 2. LOCATION OF THE NEW OCEAN TERMINAL

The study area may be divided into the following three parts, according to topographical and other conditions:

1) Right bank of the Imo River
2) Area from the left bank of the Imo River to the right bank of the Cross River
3) Jamestown vicinity (area from the Mbo River to the Tom Shot Bank)

Table 3-3 Development Scales of Industries in the New Ocean Terminal

Type of Industries	Production Scale	Plant Area ($1,000\ m^2$)	Employment (person)
Iron and Steel	Crude Steel 6 million tons/year	7,000	10,000[1]
Petroleum Refining	400,000 barrels/day	3,000	1,200
Petrochemicals	ethylene basis 400,000 tons/year	2,100	2,350
Chemical Fertilizer	500,000 tons/year	150	200
Automobile Assembly	200,000 vehicles/year (two shifts)	1,200	5,000
Shipbuilding and Repair	200,000 DWT dock	450	1,000
Flour Mill and Food Processing	500,000 tons/year	150 (80)	1,800 (200)
Edible Oil	250,000 tons/year	50	200
Power Station	1 million KW	400	250
Subtotal		14,500	22,000
Other Related Industries		3,800	8,000
Public Space including Roads and Railways, etc.		5,500	
Total		23,800	30,000

Notes: 1) Including the employees of related industries.
2) Figures in parenthesis under "Flour Mill and Food Processing" indicate values for Flour Mills in the category. Figures immediately above are comprehensive for the category.

Table 3-4 Number and Size of Berthing Facilities for Industrial Cargoes at the New Ocean Terminal in the Year 2000

Cargo Traffic, Dimension of Vessels and Berthing Facilities	Iron and Steel Berths				Petroleum Oil Berths		Petrochemical Berths		Ship-building & Repair Berths	Grain Berths	Total
	Iron Ore	Coal	Lime-stone	Iron & Steel Products	Crude Oil	Refined Oil Products	Crude Salt	Petro-Chemical Products	Steel & Equip-ment	Grain	
Cargo Traffic (1,000 ton/yr.)	8,430	3,330	1,140	1,620	18,850	7,160	150	965	*	750	42,395
Maximum Size of Vessels (DWT)	150,000	120,000	50,000	15,000	100,000	50,000	15,000	15,000	15,000	60,000	–
Structural Depth of Berths (m)	-18	-17	-13	-10	-16	-13	-10	-10	-10	-14	–
Length of Each Berth (m)	350	310	270	185	400	270	185	185	185	300	–
Total Number of Berths	2	1	1	9	2	1	1	5	3	1	26
Total Length of Berths (m)	700	310	270	1,665	800	270	185	925	555	300	5,980

Note: * The ship building berths are planned mainly for repairs and outfits, but may be occasionally used to unload materials for ship repairs etc.

The characteristics of each of these areas are outlined below:

1) Right bank of the Imo River

In this area, two large creeks run parallel to the coastline spanning about 10 km from the coastline inland. These creeks divide the area into three blocks.

2) Area from the left bank of the Imo River to the right bank of the Cross River

This area has a somewhat arched but uniform sandy beach. To the rear is a large tract of rather flat tropical rain forest. The area is divided into two blocks, east and west, by the Kwa Ibo River, which flows through the approximate center.

3) Vicinity of Jamestown (the area from the Mbo River to the Tom Shot Bank)

This area occupies the right bank of the Cross River. The bay around Tom Shot Bank is a very shallow area with extremely developed sand bars.

If NOT were constructed on the right bank of the Imo River, the breakwater would block the river flow, therefore, the shipping channel could suffer serious siltation. It should accordingly be clear that the right bank of the Imo River is unsuitable site for NOT.

It NOT were constructed in the area from the Mbo River to the Tom Shot Bank, the terminal itself could be plagued with sedimentation because the bay around Tom Shot Bank is a very shallow area with many sand banks. It should thus be clear that this area too is unsuitable.

From the left bank of the Imo River to the right bank of the Cross River, the conditions affecting the construction of NOT are almost identical at all points. The vicinity of Ibeno, the estuary of the Kwa Ibo River, is the most favorable of the sites for the initial planning of NOT, because the river and creeks can be used as a channel.

NOT-east is therefore planned for the Ibeno site and the changes expected for the NOTs located in the other points of the study area will be studied.

CHAPTER 3. LAYOUT OF THE NEW OCEAN TERMINAL

(1) Principles for the Formulation of the Master Plan

The basic layout of facilities for NOT-Ibeno is modeled after NOT-Lagos with consideration to the natural conditions of the site as follows:

1) An artificially excavated port is the selected type for NOT-Ibeno.
2) Three intra-harbor channels with one harbor entrance are to be excavated toward the land area.
3) The Kwa Ibo River is to be diverted and its original channel made into harbor channels.
4) To reduce the amount of excavation work as much as possible, facilities requiring the same water depths are to be grouped together.
5) Facilities are to be located in such a way that the development of commerical and industrial port facilities may proceed under state planning.
6) Space for future expansion is to be provided.

(2) Scale and Layout of Breakwaters

If the water depth at the tip of the main breakwater is set as approximately equal to the water depth of the shipping channel, it would be −18m and the total length of the breakwater quite great because of the gentle slope of sea bed. Part of the approach channel should therefore be maintained by regular dredging.

Based on the above, the scale and the layout of the breakwater have been determined as follows:

Construction costs for the breakwater are calculated initially for various layouts shown in Fig. 3−1. Then, total maintenance dredging costs over 10, 20, and 30 years are calculated, using the expected siltation volume. The discount rate for the calculation of maintenance dredging cost was set as 5%.

Fig. 3−2 shows the water depth at the tip of the breakwater on the abscissa with both the construction cost of the breakwater and the maintenance dredging cost on the ordinate. In this figure, the water depth at the point of intersection of the construction cost curve and the maintenance dredging cost curve shows the condition where sum of the both costs is at its minimum. The calculated water depths are − 11.6 m for 10 years, −13.0 m for 20 years, and −13.6 m for 30 years dredging, respectively. Based on the above calculation, the water depth at the tip of the west breakwater has been set at − 13 m.

(3) Diversion of River Course and Construction of Training Jetty

The course of the Kwa Ibo River is to be diverted toward the coastline from Okorutip, and a training jetty of 1,800 m length is to be constructed on the right bank of the new estuary. The water depth at its tip is − 5.0 m. The original channel is converted as a part of shipping channels.

(4) Layout of Channels and Turning Basins

The width of the entrance channel and the inner harbor channels are planned as two-way channels.

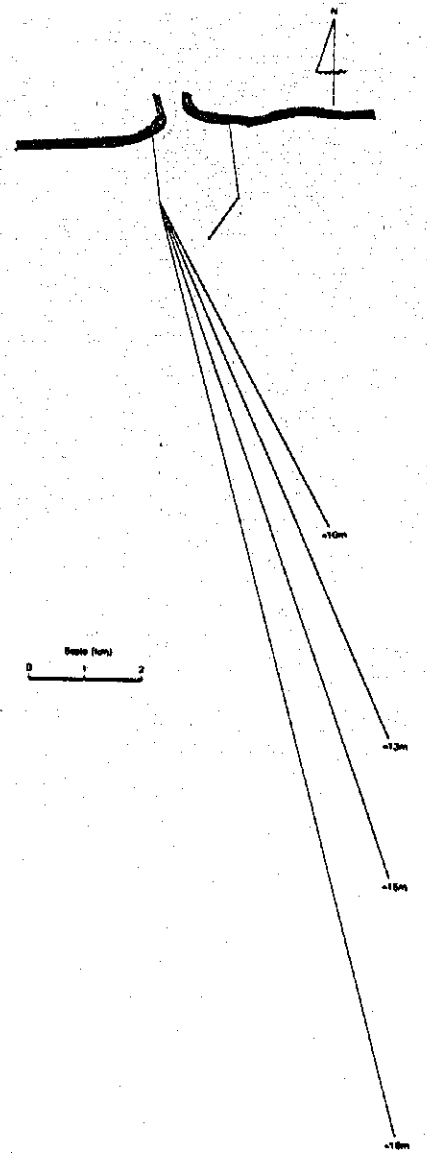


Fig. 3-1 Various Layouts of the Breakwaters

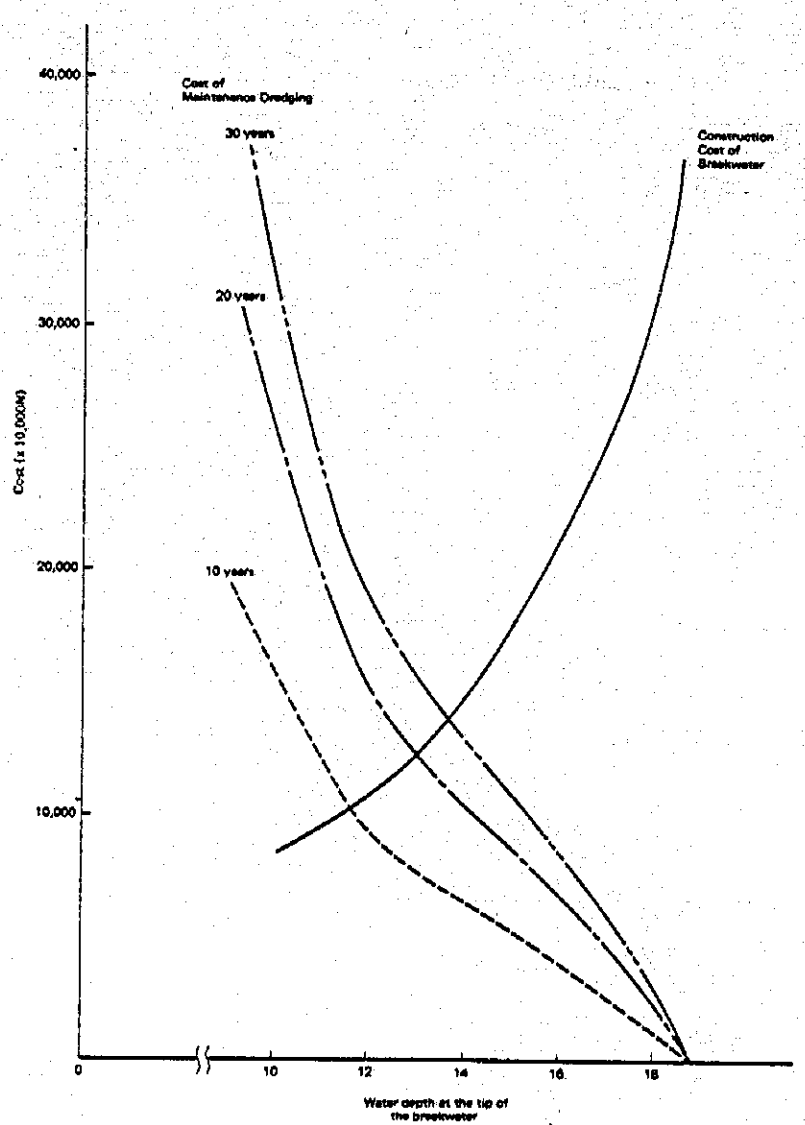


Fig. 3-2 Costs of Maintenance Dredging and Breakwater Construction

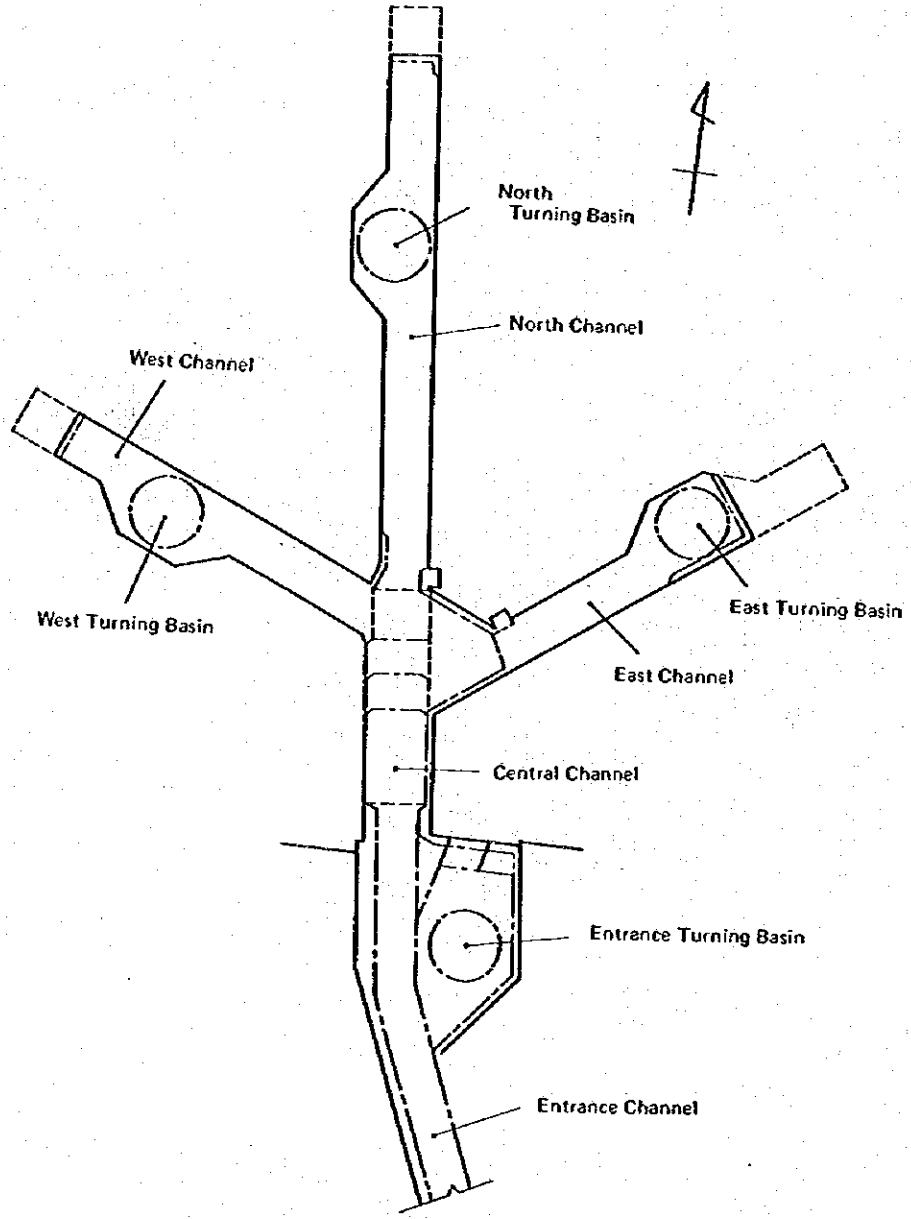


Fig. 3-3 Names of Channels and Turning Basins

Table 3-5 Scale of the Channels

	Entrance Channel	Central Channel	West Channel	North Channel	East Channel
Width (m)	350	600	400	400	400
Water Depth (m)	Inside Breakwater 18 Outside Breakwater 19	13 – 18	10	12 (Future 13)	10
Length (m)	21,900	1,800	3,100	4,700	3,100

(5) Layout of Commercial Port Facilities

The layout of commercial port facilities (container whaves, breakbulk cargo wharves, grain wharves, petroleum oil wharves, and small craft basins) was determined in accordance with the following principles;

1) For efficient wharf use, mooring facilities should be of a marginal type.
2) To minimize channel dredging in the harbor, deep water facilities should be located near the harbor entrance, relatively shallow water facilities in the recesses of the channels. Facilities with the same water depth should be grouped in the same channel.
3) However, aside from considerations of water depth, facilities must be placed strategically to allow maximum efficiency in their use – i.e. facilities to be used in the initial stages of construction should be grouped together.
4) Small craft basins should be located in the center of the harbor and in the industrial port section.
5) The petroleum wharves are to be located outside the excavated channel, taking the safety of the harbour into consideration.
6) Land for port-related business the area of this land is about 240ha is situated to the rear of the public wharves.

(6) Layout of Industrial Port Facilities

Industry location is proposed with attention to the following points.

1) Industries requiring mass transportation of materials or products and depending heavily on ship transportation should be located along watersides.
2) Industries using and discharging large quantities of sea water shold be located at places facing the open sea and favorable to the use and drainage of water.
3) Interrelated industries should be located adjacently.
4) Industries using large quantities of fuel and likely to cause soot or dust shold be located with consideration to wind and other factors, to avoid causing nuisance to the urban district.
5) Industries requiring port facilities with great water depth shold be located near the harbour entrance.

The port facilities and layout of industives which are arranged in accordance with the above-mentioned principles are shown in Fig. 3–4.

(7) Scale and Layout of Urban Facilities

The proposed number of employees under the NOT plan totals 50,000. The population of the new city in the year 2000 is estimated as 200,000 based on this figure.

The total area of development is 2,900 ha. Fig. 3–5 shows the layout of the new city.

The total construction cost of the new city is estimated about ₦1.5 billion. Table 3–6 shows the contents of the cost.

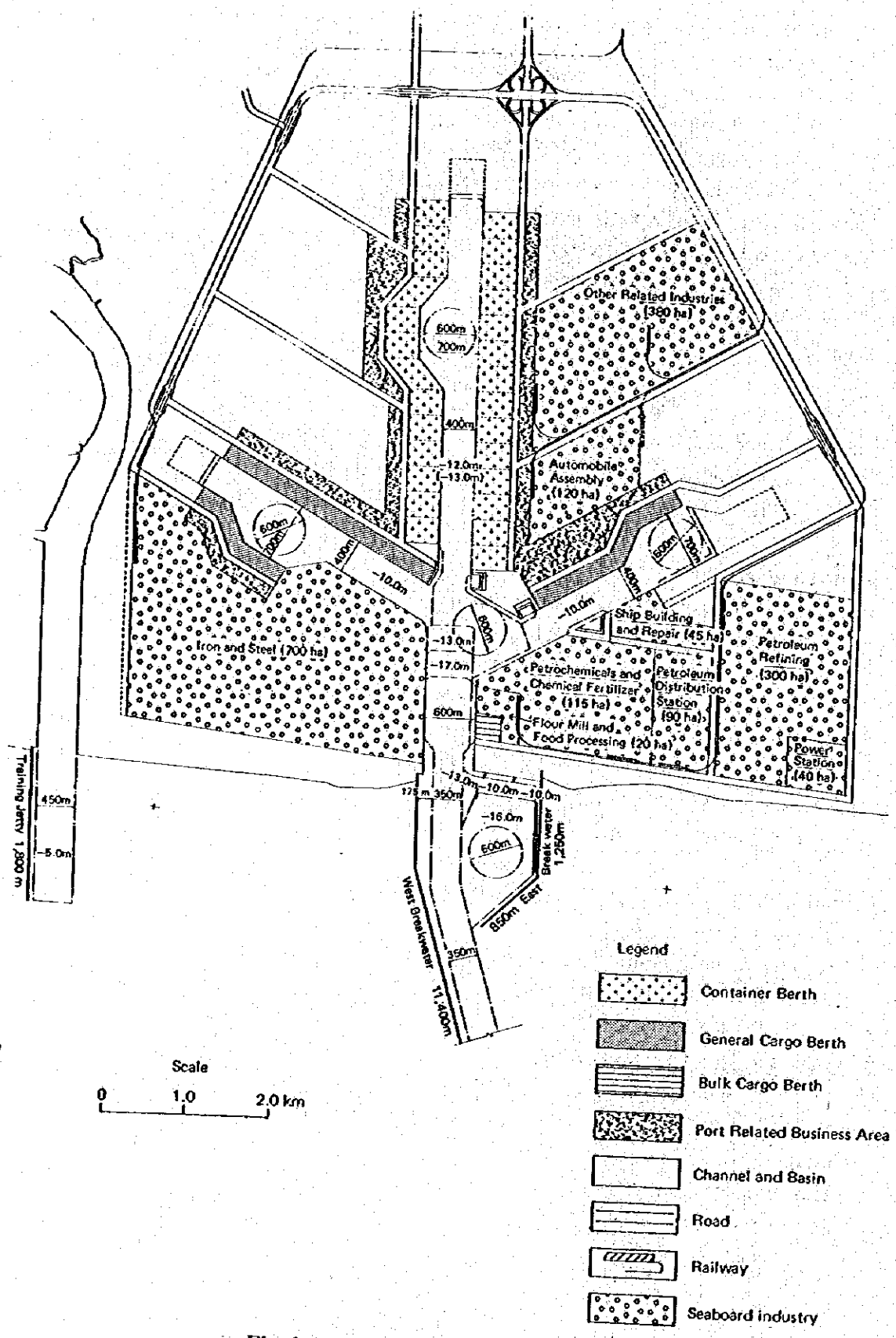


Fig. 3-4 Layout of Port Facilities and Industries

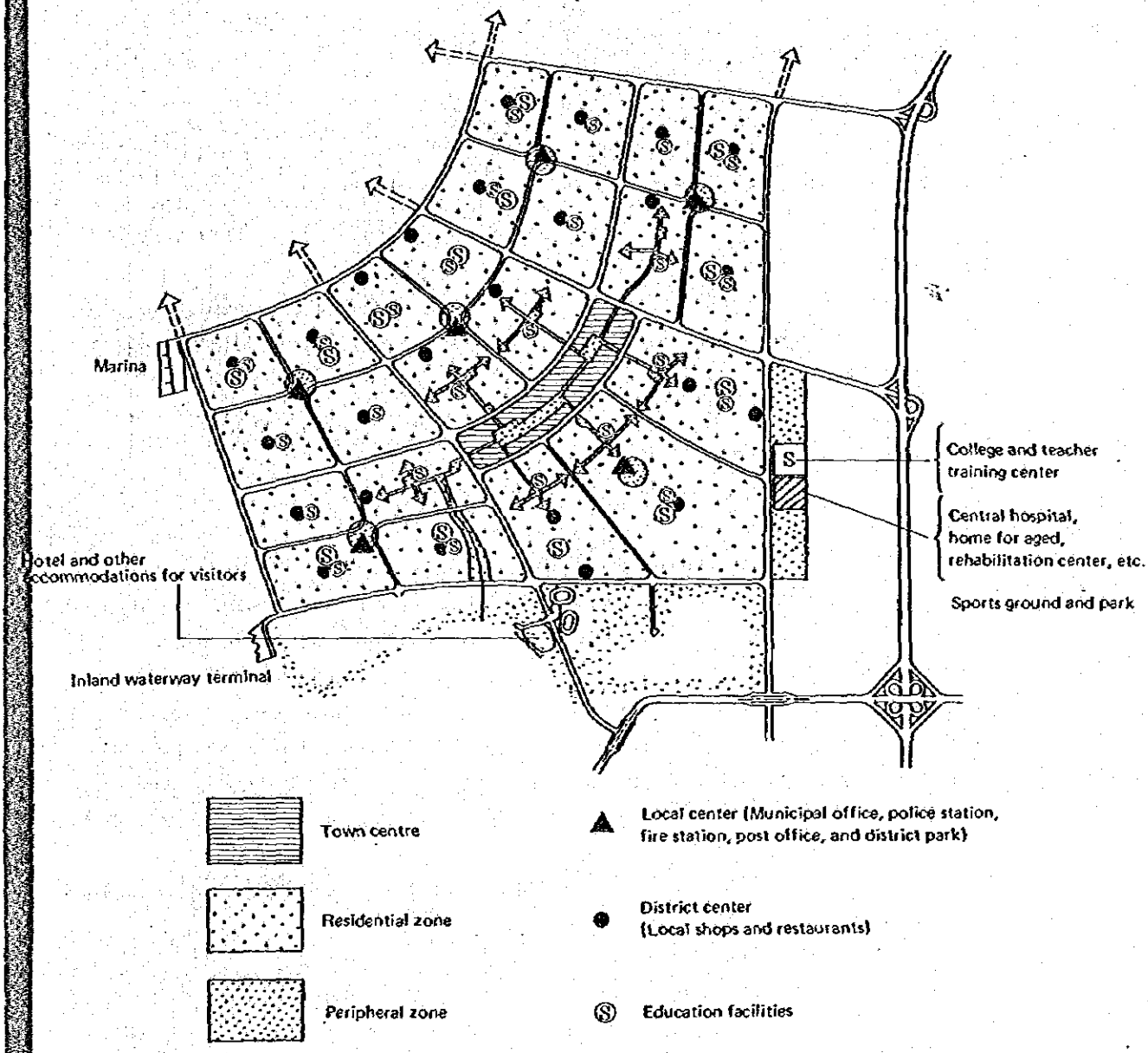


Fig. 3-5 New City: Conceptual Plan

Table 3-6 Construction Cost of the New City

Unit: million ₦, 1981 current price

Type of Work	Construction Cost (mean value)	
Public Sector		
Infrastructures	425 – 625	(525)
Open Space & Recreational Facilities	10 – 20	(15)
Architectures for Public Services	120 – 160	(140)
Subtotal	555 – 805	(680)
Private Sector		
Housing	460 – 660	(560)
Architecture for Commerce & Business	260 – 380	(320)
Subtotal	720 – 1,040	(880)
New City Total	1,275 – 1,845	(1,560)

Notes:
1. The design standard is the same as a standard of a future target for the Third National Development Plan and of Lagos State Government.
2. Unit costs are set according to construction costs in Nigeria and the budget as presented in "Recurrent and Capital Estimates of the Government of the Federal Republic of Nigeria 1978--79". Both of these sources are supplemented by recent experiences in various countries.
3. Infrastructures include deforestation, roads, water and electric energy supply, sewerage and storm water drainage, but exclude costs of cut/fill operations because of uncertainty regarding topographical conditions.
4. Open space, etc. includes parks, open space, a golf field, a recreational port, and an inland waterway terminal.
5. Architecture for public services includes facilities for administration, education, healthy and social welfare.
6. Housing includes telephone connections.

(8) Transport Facilities

The road network related to the NOT project is composed generally of port roads, urban roads and main access roads.

The port road system must handle not only the transportation of port-related cargo, but also the commuter transportation of port workers and related business transportation in support of port activities. The urban roads will be composed of the arterial road and approach road. A main access road will tie in NOT with the federal road to the rear.

A port railway is proposed for the industrial section only. It will be connected at Umuahia to the new standard-gauge line now being planned.

The total construction cost is given in Table 3–7.

(9) Master Plan

The master plan of Not-east in the year of 2000 is shown in Fig. 3–6.

Table 3-7 Construction Cost for Transportation Facilities

	Quantity	Construction Cost (million ₦)
Road		
Port Road		151.3
Ring Road		68.3
6-lane	9.4 km	27.3
4-lane	8.9 km	20.5
Clover I.C.	1 unit	6.9
Diamond I.C.	4 unit	13.6
Beam Road		83.0
4-lane	36.1 km	83.0
Urban Road		93.9
4-lane urban road	35.7 km	82.1
4-lane aproach road	5.1 km	11.8
Main Access Road		25.2
6-lane	5.5 km	16.0
Trumpet I.C.	2 unit	9.2
Subtotal		270.4
Railway		
Port Railway		35.3
Embankment	26.6	31.9
Yard	1 unit	3.4
Main Access Railway		182.6
Embankment	145.0 km	174.0
Junction	1 unit	1.7
Bridge	3,000 m^2	6.9
Subtotal		217.9
Total		488.3

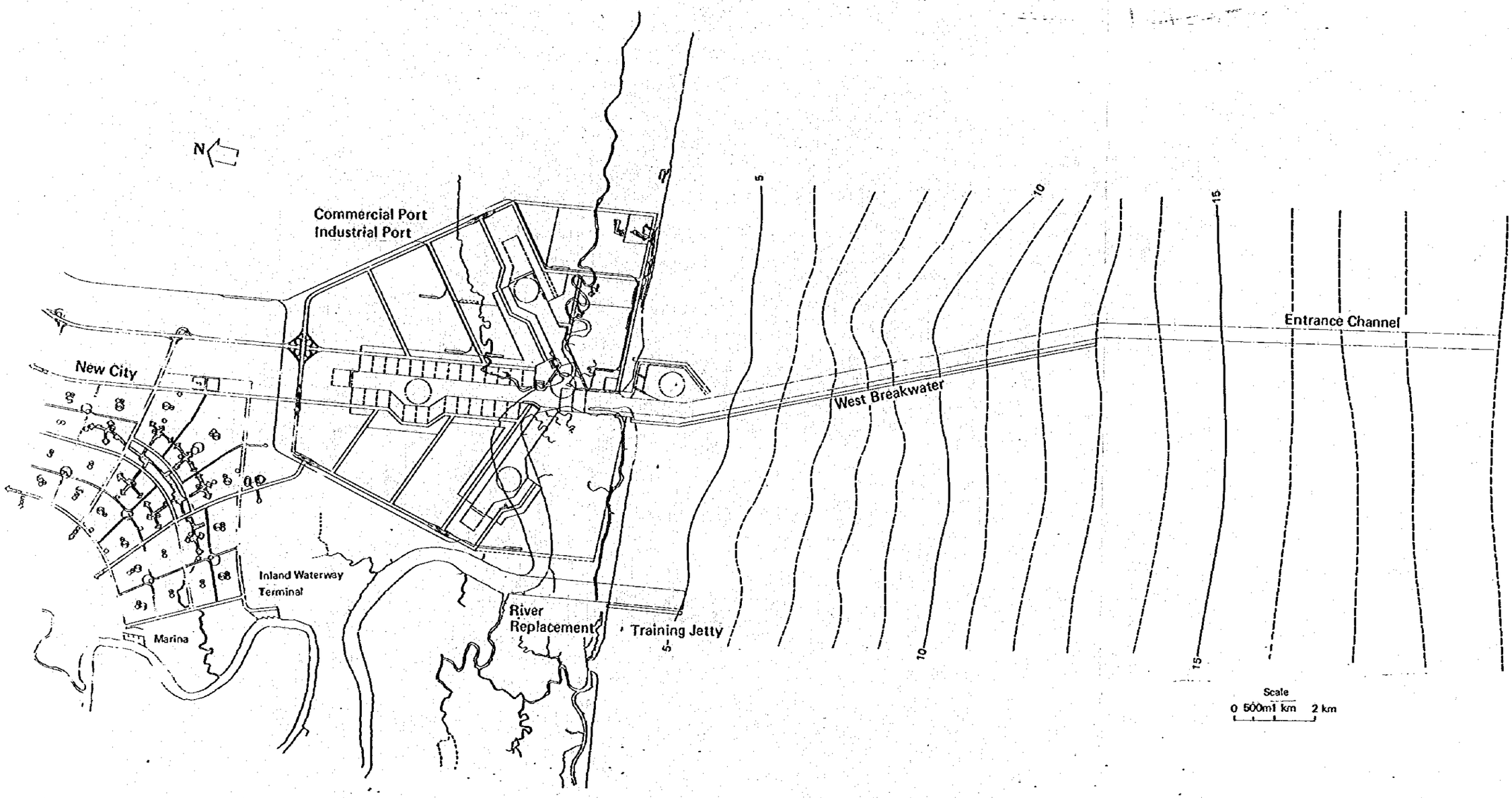


Fig. 3-6 Master Plan of the New Ocean Terminal in the Year 2000

CHAPTER 4. PRELIMINARY DESIGN OF MAJOR PORT FACILITIES

The major port facilities consist of breakwaters and berth facilities for a commercial port and an industrial port. In order to facilitate the comparison of construction costs between NOT-east and NOT-Lagos, the preliminary designing of the major port facilities of NOT-east has been carried out, using the same structural types as applied for NOT-Lagos.

The structural dimensions, however, have been revised to cater to the local design conditions of NOT-east, especially marine conditions (tide and waves) and soil conditions. The major revisions to the original structure of NOT-Lagos can be summarized below.

Table 3-8 Key points of the designing in NOT-east

Local natural conditions	Revision	Facilities
1) Tidal elevation of H.W.L. at NOT-east is about 1.0m higher than at NOT – Lagos	• The elevation of wharf at NOT-east has been lifted up to +4.0m	Berth
2) Design wave height at NOT-east is lower than at NOT-Lagos.	• Dimensions of breakwater have been reduced.	Breakwater
3) Soil conditions at Jamestown and Opobo, NOT-east are inferior to those at NOT-Lagos.	• Width of platform has been widened. • Revetment for pier has been designed in the form of sheet pile. • Pile penetration of Ibeno and Jamestown has been increased by 10m.	Berth
4) Quarry rock is very scarce in NOT-east.	• Rock material required for armor-stone has been replaced by concrete block.	Breakwater

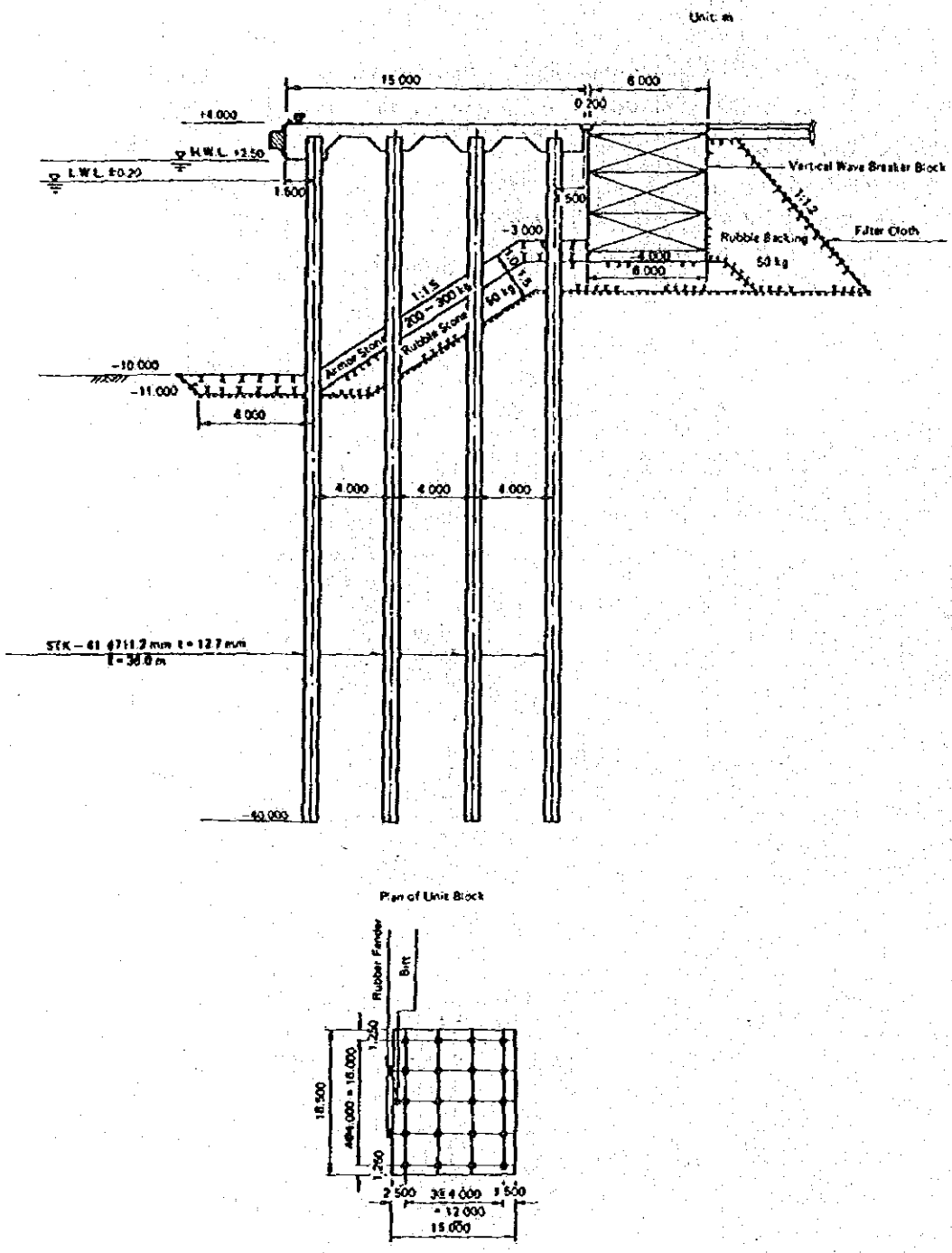


Fig. 3-7 Typical Section of General Cargo Wharf (Ibeno)

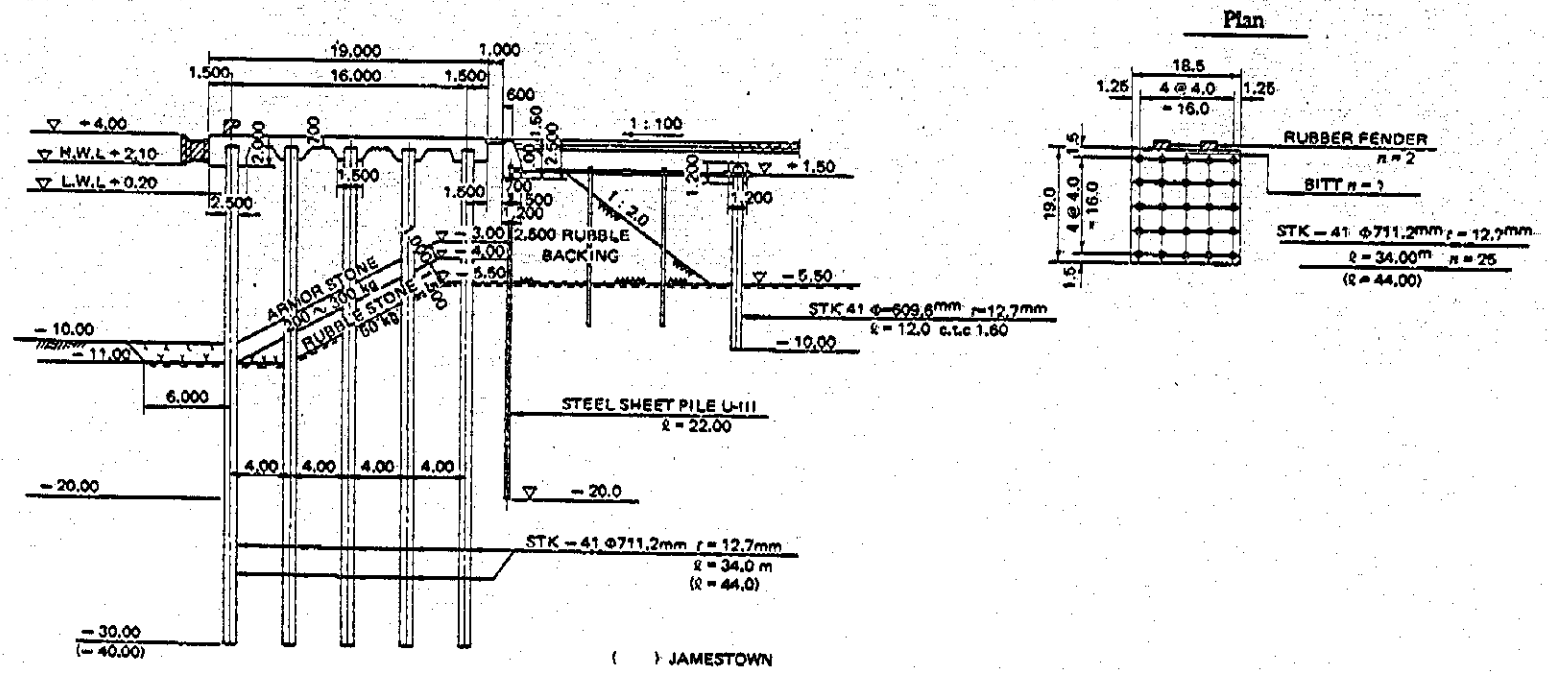


Fig. 3-8 Typical Section of General Cargo Wharf
(Jamestown, Opobo)

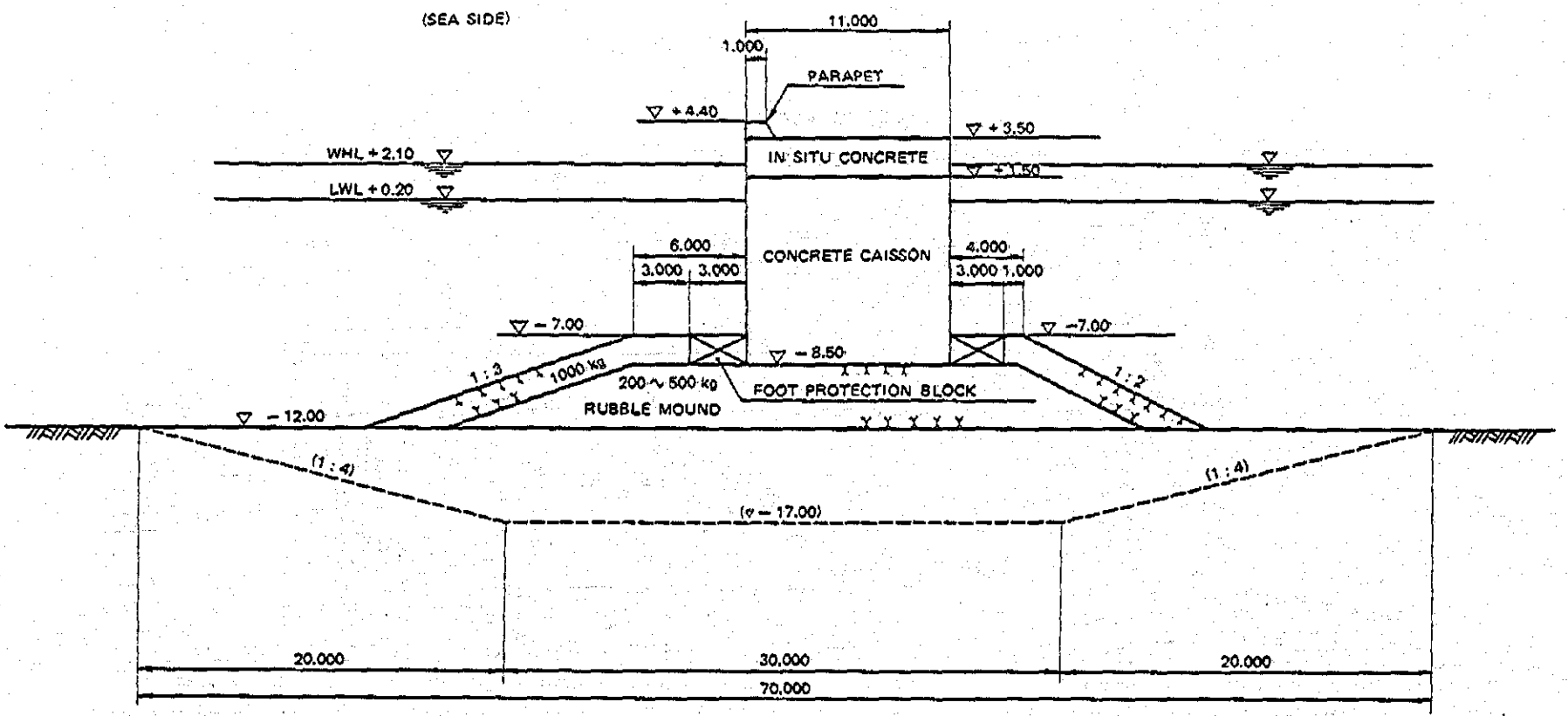


Fig. 3-9 Cross Section of Breakwater (-12 m)

CHAPTER 5. ROUGH ESTIMATES OF CONSTRUCTION COSTS

(1) Method and Scheme of Construction

Transportation of materials and equipment, construction of breakwater, dredging and reclamation, and construction of mooring facilities were studied as method and scheme of construction.

1) Transportation plan

Riprap and crushed stones will be transported from Old Netin. Cement will be transported from the Calabar factory or imported through Port Harcourt Port or Calabar factory or imported through Port Harcourt Port or Calabar Port. Steel, other standardized products, construction machines, and equipment will be imported via Port Harcourt Port and Calabor Port.

The large quantities of imported materials and equipment which are to be transported to Port Harcourt by oceangoing vessels will be transhipped to the Opobo area and transported on land to the site.

2) Breakwaters

Table 3–9 shows the approximate quantities of stone, caisson, and concrete for the construction of breakwaters at Ibeno.

Table 3-9 Quantity of Materials for Breakwaters

	Type	Length	Materials	Quantity
West Breakwater	Rubble Mound Breakwater	3,100 m	Stone	378,000 m^3
	Composite Breakwater	8,300 m	Stone	847,000 m^3
			Caisson	830
			Concrete	363,000 m^3
East Breakwater	Rubble Mound Breakwater	2,100 m	Stone	176,000 m^3
Training Jetty	Rubble Mound Breakwater	1,800 m	Stone	218,000 m^3

3) Dredging and reclamation

A cutter suction dredger of 4,000 p.s. will be used for dredging the Kwa Ibo River new estuary, central channel, east channel, north channel, and west channel.

The aproach channel will be dredged by a hopper suction dredger.

Table 3–10 shows the approximate volume of dredging.

Table 3-10 Approximate Volume of Dredging (Ibeno)

Unit: Million m^3

West channel	14.8
North channel	38.5
East channel	21.9
Central channel	30.5
Entrance channel	48.5
Entrance turning basin	8.6
River dredging	8.4
Total	171.2

(2) Comparison of Rough Construction Cost Estimates

Principal conditions of the cost estimates are as follows:

1) Exchange rate: ₦1=¥400
2) Unit prices are based on the investigation done in 1981.

Table 3-11 shows estimates of construction cost of port facilities at Ibeno.

Table 3-11 Construction Cost of Port Facilities

Unit: Million ₦

Item	EAST		LAGOS	
	Quantity	Cost	Quantity	Cost
(1) Commercial Port				
1. Preliminary and Temporary Work	Road 21 km	34.5	Road 63 km	43.8
2. Breakwaters and Shore Protection Facilities	16,300 m	189.0	7,150 m	118.8
3. Mooring Facilities and Related Facilities				
a. General Cargo Berth	33 Berth	290.2	33 Berth	257.5
b. Container Berth	27 B.	769.0	27 B.	668.7
c. Bulk Cargo & Petroleum Berths	5 B.	89.5	5 B.	84.6
4. Dredging and Reclamation	140×10^6 m³	308.0	86×10^6 m³	168.1
5. Administration Office and Related Buildings		8.1		8.1
6. Utilities		47.7		47.7
7. Navigation Aids		3.9		3.9
8. Port Service Boats		8.6		8.6
9. Power Station	400 MW	86.7	400 MW	86.7
Subtotal		1835.2		1496.5
(2) Industrial Port				
1. Preliminary and Temporary Work		8.1		11.7
2. Mooring Facilities				
a. Iron and Steel Berth	13 Berth	105.5	13 Berth	83.3
b. Oil Berth	3 B.	6.9	3 B.	5.6
c. Chemicals Berth	6 B.	26.8	6 B.	22.6
d. Shipbuilding Berth	3 B.	13.4	3 B.	11.3
e. Bulk Cargo Berth	1 B.	13.7	1 B.	11.6
3. Dredging and Reclamation	31×10^6 m³	68.6	19×10^6 m³	34.7
Subtotal		243.0		180.8
Total		2078.2		1677.3

Table 3-12 shows comparison of construction costs in three sites (Opobo, Ibeno, Jamestown).

Table 3-12 Comparison of Construction Costs

	Ibeno	Opobo	Jamestown
Temporary Work	₦ 43 M	Same as Ibeno	Length of access road must be doubled
Breakwaters	₦ 173 M	Same as Ibeno	Same as Ibeno
Mooring Facilities	₦ 1,315 M pile length 43 m width of wharf 15 ~ 22 m	3% up 33 m 19 ~ 26.5 m	7% up 43 m 19 ~ 26.5 m
Dredging	₦ 377 M	20% up	30% up
Total Cost	₦ 2,078.2 M	₦ 2,200 ~ 2,300 M	₦ 2,300 ~ 2,400 M

Maintenance dredging cost needed for NOT-east is not included in table 3-11. The yearly cost of maintenance dredging is 11.6 million ₦.

Although displacement with sand for the sea bottom at the proposed site of the composite breakwaters may be necessary, its ₦19.8 million cost is not included in Table 3-11.

CHAPTER 6. ENGINEERING EFFECTS

(1) Siltation of the Entrance channel

The main breakwater shelters only part of the entrance channel and channel water depth is to be maintained by regular maintenance dredging in the unsheltered section.

Likely siltation volume in the unsheltered section was calculated using the method proposed by Harrison and Owen.

The annual siltation height is shown in Table 3–13. The annual siltation volume can be obtained by multiplying siltation height by channel area.

Table 3-13 Calculation of Siltation

h (m) (M.W.L.)	U (m/s)	U_{*0}(m/s)	U_{*0}/U_{*e}	$S\rho_b/cw$	Thickness of deposited mud (m/year)
10	0.14	0.0093	0.62	0.43	4.3
12	0.16	0.011	0.73	0.35	3.5
14	0.19	0.013	0.87	0.28	2.8
16	0.22	0.015	1.0	0.23	2.3
18	0.246	0.0164	1.09	0.11	1.1

(2) Beach Erosion

On the West African Coast facing the Bight of Biafra, littoral drift is carried from west to east because swell from the southwest direction prevails throughout the year. When a breakwater is constructed, accretion will therefore occur on the west side (updrift side of the sediment transport) while erosion will occur on the east side (downdrift side).

Likely shoreline changes around NOT-east were calculated using a beach mathematical model. The results are as follows:

1) On the beach to the west of the training jetty, the shoreline gradually accretes.
2) On the beach between the training jetty and the west breakwater, the plan shape of the shoreline will be concave toward the sea. There is accretion to the immediate west of the west breakwater and erosion on the east side of the new estuary created by the short-cut. The erosion of the latter can be controlled by building groins and seawalls.
3) On the beach to the east of the east breakwater, little change occurs in the present plan shape of the shoreline. Though there will be slight erosion, shore protection facility is not necessary there because it is away from the NOT site and only sparsely inhabited.

(3) Calmness of the Harbor

Diffraction coefficient inside the harbor is less than 0.05 for the predominant deep water waves of wave direction SW and this indicates sufficient calmness.

(4) Seiche

Observation of long period waves should be conducted before the construction stage of port facilities, and necessary countermeasures should be taken if long period waves prove to exist.

CHAPTER 7. EFFECTS OF THE DEVELOPMENT

7-1. The Comparison of Transportation Cost

(1) Scope of Comparison

1) Cargo types and traffic volume

Cargo types are commercial and industrial cargoes for inland transportation as projected in the Report on the New Ocean Terminal, Lagos (Phase II). The total volume of cargo included in the comparison is 26,507,000 tons, composed of 18,912,000 tons for commercial cargo and 7,595,000 tons for industrial cargo. These are derived by subtracting the following cargo volumes from 26,462,000 tons of the commercial cargo total and 18,435,000 tons of the industrial cargo total in the Phase II Report.

a. Cargo volume for the manufacturing industries of NOT

Commercial cargo: 3,852,000 tons (imported fuel oil, motor vehicle parts, etc.)

Industrial cargo: 3,056,000 tons (fuel oil, naphtha for fertilizer, steel for shipbuilding and repair)

b. Total volume of petroleum products for general use

Commercial cargo: 3,698,000 tons (imported fuel oil)

Industrial cargo: 7,784,000 tons

It is assumed that petroleum products will be delivered via the national pipeline network to be constructed throughout Nigeria. Since, however, the pipeline freight rates are not yet available and the flexibility of pipeline transportation should preclude a major difference in transportation cost regardless of the site chosen for NOT, the petroleum products are excluded from comparison.

2) Transport section

The calculation of inland transportation cost is limited to the transportation between NOT (Lagos or east) and each CEA (Centers of Economic Activity). The CEAs are as proposed in the existing reports (MIT Reports) and are composed of 23 areas throughout the country.

3) Inland distribution of cargo

The transport volume of cargo is, in principle, allocated to all CEAs, using the distribution ratios by port cargo type. However, the distribution of local market-oriented industries is limited to a certain part of the Federation in consideration of their location tendency and the relation between their production scale and market conditions.

4) Cargo volume by transport mode

It is assumed that cargo transportation will consist of three modes: truck, inland waterway and rail. Prefered transport modes have been determined in consideration of transport distance, freight rates (cost), infrastructure conditions between NOT and each CEA, the preference for transport mode attributable to cargo type, and the economical and stabilized goods transportation.

a. Lagos site

① Truck: o100% for cargo transportation, for CEAs within about 600 km road transport of NOT-Lagos

o50% for cargo transportation, road transport distance of over 600 km.

② Rail: o50% for cargo transportation, road transport distance of over 600 km.

③ Inland waterway: oInland waterways is not used because there is no easy access from the Lagos site to a major trunk channel of the Niger River.

b. East site

① Truck: o100% for cargo transportation, for CEAs within about 600 km road transport of NOT-east.

o50% for cargo transportation, road transport distance of over 600 km.

o50% for cargo transportation, road transport distance of over 600 km in the case of CEA which can make use of inland waterways.

o25% for cargo transportation, road transport distance within about 600 km in the case of CEA which can make use of inland waterways.

oExport cargoes are transported by truck because 100% of exports are assumed to be transported by inland waterways.

② Rail: o50% for cargo transportation, for CEAs within about 600 km road transport of NOT-east.

o25% for cargo transportation, road transport distance of over 600 km in the case of CEA which can make use of inland waterways.

o0% for exports because all export cargoes are assumed to be transported by inland waterways.

③ Inland waterway: o50% for cargo transportation, road transport distance from a river port to CEA within about 100 km.

o100% for export cargo transportation.

oThe cargoes which are not fit for inland waterways transport (commercial cargo: container, industrial cargo: motor vehicle, flour and bran) will be transported exclusively by truck or partly by rail.

Table 3-14 shows cargo volume calculated by the above transport mode ratios. In the case of the Lagos site, the ratio of truck transportation is high because the distribution volume in the western states is large, particularly for the southern states surrounding Lagos and Ibadan. In the case of the East site, the ratio of rail transportation is high because the long-distance transportation volume is larger than in the case of the Lagos site.

5) Freight rates

Transportation cost is, in principle, calculated by current freight rates (1981).

Table 3-14 Cargo Volume by Transport Mode in 2000

('000 tons)

Destination or Origin	Transport Mode	Lagos site				East site			
		Commercial Cargo		Industrial Cargo	Total	Commercial Cargo		Industrial Cargo	Total
		Imports	Exports			Imports	Exports		
West	Truck	9691	1234	4962	15886	5785	760	2727	9271
		(88.6)	(93.7)	(90.5)	(89.5)	(52.9)	(57.7)	(51.9)	(52.9)
	Inland waterway	0	0	0	0	155	93	218	466
		(0.0)	(0.0)	(0.0)	(0.0)	(1.4)	(7.1)	(4.2)	(2.7)
	Rail	1253	83	522	1858	5004	465	2305	7773
		(11.4)	(6.3)	(9.5)	(10.5)	(45.7)	(35.3)	(43.9)	(44.4)
	Subtotal	10943	1317	5484	17744	10943	1317	5250	17510
		(100.0)	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)
East	Truck	4661	457	1582	6699	4880	308	1532	6719
		(77.4)	(72.5)	(75.0)	(76.5)	(81.0)	(48.8)	(65.3)	(74.7)
	Inland waterway	0	0	0	0	495	253	580	1327
		(0.0)	(0.0)	(0.0)	(0.0)	(8.2)	(40.2)	(24.7)	(14.8)
	Rail	1362	174	529	2064	648	70	233	950
		(22.6)	(27.5)	(25.0)	(23.5)	(10.8)	(11.0)	(9.9)	(10.6)
	Subtotal	6022	630	2111	8763	6022	630	2345	8997
		(100.0)	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)
Total	Truck	14351	1691	6544	22586	10664	1067	4260	15991
		(84.6)	(86.8)	(86.2)	(85.2)	(62.9)	(54.8)	(56.1)	(60.3)
	Inland waterway	0	0	0	0	649	346	798	1793
		(0.0)	(0.0)	(0.0)	(0.0)	(3.8)	(17.8)	(10.5)	(6.8)
	Rail	2614	257	1051	3921	5652	534	2537	8723
		(15.4)	(13.2)	(13.8)	(14.8)	(33.3)	(27.4)	(33.4)	(32.9)
	Subtotal	16965	1947	7595	26507	16965	1947	7595	26507
		(100.0)	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)

(2) Comparison of Transportation Costs

Table 3-15 shows total cargo transportation costs for both the Lagos and East sites. The annual transportation cost is about ₦187 million (17.2%) higher and the average per-ton freight rate is ₦7.1 higher for the East site than for the Lagos site.

The most significant contributing factor in the higher transportation costs of the East site is the great volume of long-distance shipping demanded by the concentration of Nigeria's economic activity in the western states. According to the result of transportation cost calculation, the cost difference between the Lagos and East sites cannot be bridged reconciled, even with the extensive use of comparatively economical transport modes such as rail and inland waterway in the case of the East site. The higher transportation cost will probably be offset, mainly by rises in commodity prices or decreases in value added. But it constitutes at any rate a loss from the standpoint of the national economy.

7-2. Contrast of Development Benefits by Site of the New Ocean Terminal

The characters and the degrees of the development benefits of the New Ocean Terminal differ in accordance with the socio-economic conditions of each site. Table 3-16 contrasts the development benefits for each NOT site.

Table 3-15 Inland Transportation Cost for All Cargoes

Type of Cargo	Transport Mode	A: Lagos site			B: East site			Cost Balance (B – A) (N '000)
		(a) Cargo Volume (tons)	(b) Cost (N '000)	b/a (N)	(a) Cargo Volume (tons)	(b) Cost (N '000)	b/a (N)	
Commercial cargo (Imports)	Truck	14351000	571902	39.9	10664000	572035	53.6	133
		(84.6)	(79.8)		(62.9)	(65.9)		
	Inland waterway	0	0	0.0	649000	8589	13.2	8589
		(0.0)	(0.0)		(3.8)	(1.0)		
	Rail	2614000	144430	55.3	5652000	287417	50.9	142987
		(15.4)	(20.2)		(33.3)	(33.1)		
	Subtotal	16965000	716332	42.2	16965000	868041	51.2	151709
		(100.0)	(100.0)		(100.0)	(100.0)		
Commercial cargo (Exports)	Truck	1690500	64900	38.4	1067000	58625	54.9	-6275
		(86.8)	(84.2)		(54.8)	(68.3)		
	Inland waterway	0	0	0.0	346000	4461	12.9	4461
		(0.0)	(0.0)		(17.8)	(5.2)		
	Rail	256500	12178	47.5	534000	22725	42.6	10547
		(13.2)	(15.8)		(27.4)	(26.5)		
	Subtotal	1947000	77078	39.6	1947000	85811	44.1	8733
		(100.0)	(100.0)		(100.0)	(100.0)		
Industrial Cargo	Truck	6544250	257859	39.4	4259525	223414	52.5	-34445
		(86.2)	(87.9)		(56.1)	(69.8)		
	Inland waterway	0	0	0.0	797950	8874	11.1	8874
		(0.0)	(0.0)		(10.5)	(2.8)		
	Rail	1050750	35545	33.8	2537375	87617	34.5	52072
		(13.8)	(12.1)		(33.4)	(27.4)		
	Subtotal	7595000	293404	38.6	7595000	319905	42.1	26501
		(100.0)	(100.0)		(100.0)	(100.0)		
Total	Truck	22585750	894661	39.6	15990525	854074	53.4	-40587
		(85.2)	(82.3)		(60.3)	(67.1)		
	Inland waterway	0	0	0.0	1793100	21924	12.2	21924
		(0.0)	(0.0)		(6.8)	(1.7)		
	Rail	3921250	192153	49.0	8723375	397759	45.6	205606
		(14.8)	(17.7)		(32.9)	(31.2)		
	Subtotal	26507000	1086814	41.0	26507000	1273757	48.1	186943
		(100.0)	(100.0)		(100.0)	(100.0)		

Table 3-16 Contrast of Development Benefits by NOT Site

Item	Development Benefits	
	NOT-east	NOT-Lagos
1. Improvement of physical distribution function		
(1) Increase of cargo traffic capacity	O	O
(2) Assurance of stabilized transportation of goods and diversification of distribution channels	O	O
(3) Reduction of distribution losses	O	O
(4) Improvement of physical distribution function incorporating that of the existing port	Δ	O
(5) Saving of number of days of container transportation	X	O
(6) Transportation cost of commercial and industrial cargoes	X	O
(7) New socio-economic investments for public services, etc. to support the NOT functions	X	O
2. Accumulation and improvement of urban function		
(1) Accumulation of planned and rational urban function	O	O
(2) Re-development of the vicinities of the existing port	Δ	O
(3) Impact on the regional economy and society	O	Δ
3. Creation of industrial development bases and improvement of industrial structure		
(1) Creation of industrial development bases and improvement of industrial structure	O	O
(2) Industrial development efficiency of the NOT development	Δ	O
(3) Correction of socio-economic imbanace and balanced development of the country	O	X
4. Encouragement of regional development		
(1) Increase of employment opportunity	O	O
(2) Increase of land value	O	O
(3) Assurance of a qualified labor force	X	O
(4) Improvement of welfare of local inhabitants	Δ	O
5. Development of coastal shipping and related physical distribution industries	O	Δ
6. Construction investment		
(1) Construction investment	O	O
(2) Construction cost of NOT	X	O
7. Development of inland waterways and related distribution industries	O	X
8. National security	O	X

Note: O : Development benefits
Δ : Comparatively smaller development benefits
X : Disadvantageous to the NOT development

PART IV LOCAL PORT

CHAPTER 1. SCOPE OF WORK

The purpose of the study of Part IV is to sketch the planning of the local ports, which are considered to be feasible from the viewpoints of natural and socio-economic conditions in each of the three eastern sites (Opobo, Ibeno, and Jamestown).

CHAPTER 2. FUNCTIONS AND FORM OF LOCAL PORTS

2-1. Functions of Local Ports

Local ports in the eastern coast can possibly have both industrial and commercial port functions.

The necessity of developing a commercial port will depend upon the predicted volume of the public and manufacturers' cargoes.

The feasibility of developing an industrial port is dependant upon the possible locations of port-related and port-oriented industries. Locations for these industries are affected by the water depth of the ports and the size of berthing ships.

2-2. Form of Local Ports

The outline of the local ports are as follows:

1) Typical ships using berths are 2,000 DWT class barges and 100 G/T class fishing boats. As the draft of these ships is less than 3 m, dredging for provision and maintenance of the shipping channels is not needed.
2) Port facilities for the above mentioned ships are to be planned alongside the rivers at Opobo, Ibeno, and Jamestown. A sea berth is also to be planned for larger ships at Ibeno.
3) Inland waterways transportation is to be utilized.

CHAPTER 3. DEVELOPMENT OF COMMERCIAL PORT

3-1. Basic Policy of Revised Forecast of Cargo Traffic Through the Commercial Port

(1) Target Year

In view of the nature of this project, the target year for the revised forecast is 2000.

(2) Economic Frame

Table 4-1 Economic Frame

	Period	Economic frame
I	1975–1979	Past actual economic results
II	1979–1985	Economic program in Outline of the 4th National Development Plan
III	1985–2000	Future economic trends in Nigeria and various forecasts on world economy

(3) Method of Forecast

A macroscopic method of forecasting is used, as general cargo movement in Nigeria is in close correlation with the gross domestic product (excluding the mining sector).

3-2. Forecast of General Cargo Traffic

(1) Forecast Formula

The following forecast formula set in the Phase II Report is used as the model formula:

$Yi = 0.83Xi - 1577.31$

$r = 0.924$, Yi; 1,000 tons, Xi; million nairas.

(2) Forecast of General Cargo Traffic Through the Commercial Port

1) Assumed economic growth rate for the forecast

The economic growth rate for this forecast is assumed as in Table 4-2.

Table 4-2 Growth Rate of Gross Domestic Product (GDP)

(Unit: %)

	Period	Growth rate of GDP	Growth rate of GDP (excluding the mining sector)
I	1975–1979	9.6	9.8
II	1979–1985	7.2	8.6
III	1985–2000	4.5	5.0
–	1975–2000	6.0	6.6

(43)

The growth rate for Phase I is the actual growth rate for 1970–1976; the growth rate for Phase II is the growth rate proposed in Outline of the 4th National Development Plan. The growth rate for Phase III was set at 4.5%, based on various forecasts recently released on world economy, with consideration toward trends in the growth rates of OPEC and semi-developed countries with which Nigeria is affiliated, and the structural problems peculiar to the Nigerian economy.

2) Results of general cargo traffic forecast

The results of the forecast on cargo traffic in 2000 A.D. based on the established growth rates are shown in Table 4-3.

Table 4-3 Results of Forecast of Traffic Volume of General Cargo

Year	Traffic Volume of General Cargo (1,000 tons)	Increase Rate over 1975 Traffic Volume	Average Annual Growth Rate (%)
1975	6,110	100	7.6%
2000	38,200	625	

3-3. General Cargo Handling Capacity at Nigerian Ports

Cargo handling capacity at the Nigerian ports in the year 2000 was determined as follows:

1) Cargo handling capacities of New Ocean Terminal, Federal Ocean Terminal, Warri Port, and Calabar Port were calculated assuming complete execution of the present port development plans at these ports.

2) Cargo handling capacity of other ports is assumed to remain at 1979 levels.

Table 4-4 shows the total cargo handling capacity of all ports. The total general cargo handling capacity (38.3 million tons) is almost equal to projected general cargo volume in the year 2000 (38.2 million tons).

Table 4-4 Estimated Cargo Handling Capacity at all Ports in 2000

(Unit: 1,000 tons)

	General	Container	Subtotal	Others	Total
Lagos	4,580	3,400	7,980	4,000	11,980
Port Harcourt	1,700	150	1,850	420	2,270
Warri	1,930	20	1,950	1,200	3,150
Federal Ocean Terminal	900	1,300	2,200	1,500	3,700
Koko	60	–	60	50	110
Burutu	10	–	10	–	10
Sapele	700	300	1,000	170	1,170
Calabar	1,400	1,800	3,200	200	3,400
Subtotal	11,280	6,970	18,250	7,540	25,790
New Ocean Terminal	6,610	13,410	20,020	6,440	26,460
Grand Total	17,890	20,380	38,270	13,980	52,250

Notes: 1. Figures for Lagos Port and New Ocean Terminal are based on the Phase II Report.
2. Figures for Warri Port are based on the NPA's estimate. Division of cargo (General and Container) were made assuming configuration of current percentages.
3. Figures for Federal Ocean Terminal are based on the MIT report. As for the division between "general" and "container", allocation was made by the ratio of berth number and on the assumption that the per-berth handling capacity for container and RO-RO berths is double that of general cargo berth. As to other cargoes of FOT, 1.5 million tons of coal was taken into account.
4. Figures for Calabar Port are based on the results of the hearing done at NPA-Calabar. As to the division of cargo, the figure for "others" is after the example of the Federal Ocean Terminal (FOT).
5. Figures for the other ports have been calculated at 1979 levels.

CHAPTER 4. DEVELOPMENT OF INDUSTRIAL PORTS

4-1. Step to the Study

The examination of the scale of the industrial ports proceeds according to the following steps.

1) Selection of port-oriented industries
2) Assumption of production scale of industries
3) Forecasting the volume of water-bone cargoes
4) Allocation of industries

4-2. Selection of Industries

From the viewpoints of the achievement of the industrial sector's policy goals in the above-mentioned Fourth National Development Plan and the effective exploitation of the port's hinterland, it is appropriate that the port-oriented industries located at the eastern coast site be among the following six categories.

1) Resource-Based Industries
2) Agriculturally Oriented Industries
3) Local Market Oriented Industries
4) Import Substituting Industries.
5) Export Industries.
6) Industries improving the industrial structure of the hinterland.

The followings are port oriented industries that belong to any of the above-mentioned six categories and are eligible for inclusion in the Local Port, in view of the location conditions (e.g. resource availability and product demand) of the hinterland and the economic feasibility of plant construction:

Food processing	: Palm oil processing, seafood processing, flour milling, and animal feed processing.
Wood products	: Wood processing.
Chemical products	: Chemical fertilizers and salt manufacture.
Petroleum products	: Petroleum refining.
Ceramic stone and clay products	: Concrete products.
Iron and steel	: Steel shearing and slitting (steel processing).
Metal products	: Structural metal products.
Machinery	: Boat building and repair, shipbuilding and repair.

The correspondence between these industries and the aforementioned six categories is shown in Table 4-5.

Table 4-5 Selection of Industries

	View-point of Selection (category of industry)					
	Resource-based industry	Agriculturally oriented industry	Local market-oriented	Import-substituting	Export	Improving industrial structure of hinterland
Palm oil processing	◎	○	○		◎	
Seafood processing	◎	○	○	◎	○	
Flour milling			◎	○		
Animal feed processing		◎	◎			
Wood processing	◎	○	○		◎	
Chemical fertilizers	◎	◎	○	◎	○	○
Salt manufacture	◎		○	○	○	
Petroleum refining	◎		○		○	○
Concrete products			◎			
Steel shearing and slitting			◎			
Structural metal products			◎			
Boat building and repair		◎	○			
Shipbuilding and repair				○	○	◎

Note: ◎ Primary viewpoint
○ Secondary viewpoint

4-3. Scale of Industrial Ports

1) Production scale of industries

The production scale of the industries to be located in the Local Port was examined according to the following considerations.

a. The main factors in assuming production scales are products demand, resource volume supplied, and economically feasible scales of plants.

b. Here we have assumed production scales for plants based mainly on economically feasible ones.

Table 4-6 shows the production scales of industries to be located.

Table 4-6 Production Scale of Industries to be Located

	Production Scale (ton/year)	Required Raw Materials and Materials (ton/year)
Palm oil processing	Refined oil 100,000	Crude palm oil 110,000
Sea food processing	Processed sea food 50,000	Fresh fish 52,500
Flour milling	Flour and bran 500,000	Wheat 500,000
Animal feeds	200,000	Maize, milo, bran, etc. 200,000
Wood processing	Lumber, plywood, veneer, etc. 250,000	Logs 312,500
Chemical fertilizers	250,000	LNG (or naphtha) 100,000
Salt manufacture	100,000	Seawater 4,000,000
Petroleum refining	100,000 B.P.S.D 4,475,000	Crude oil 4,712,500
Concrete products	100,000	Cement 95,000
Steel shearing and slitting	100,000	Steel 105,000
Structural metal products	50,000	Steel 52,500
Boat building and repair	Fishing and other boats 1,000	Wood or plastic 1,050
Shipbuilding and repair	30,000	Steel 20,000
Total	6,206,000	10,261,050

2) Volume of water-borne cargo

Volumes of water-borne cargo are estimated by individual industry, taking into account the supply conditions of raw materials and resources, the market conditions of products, the transport characteristics of raw materials and products, and the transport conditions of the local port site (Table 4-7).

Table 4-7 Volume of Water-borne Cargoes of Industrial Port

	Raw Materials		Products	
	Volume of Water-borne Cargoes	Water-borne Cargo Ratio	Volume of Water-borne Cargoes	Water-borne Cargo Ratio
Palm oil processing		0%	50,000t	50%
Sea food processing	52,500t	100%	10,000t	20%
Flour milling	500,000t	100%		0%
Animal feed processing	120,000t	60%		0%
Wood processing	156,250t	50%	125,000t	50%
Chemical fertilizers		0%	50,000t	20%
Salt manufacture		0%	20,000t	20%
Petroleum refining	2,356,250t	50%	2,257,000t	50%
Concrete products	47,500t	50%	50,000t	50%
Steel shearing and slitting	84,000t	80%	20,000t	20%
Structural metal products	42,000t	80%	10,000t	20%
Boat building and repair	525t	50%	1,000t	100%
Shipbuilding and repair	16,000t	80%	30,000t	100%
Total	3,375,025t	32.9%	2,641,000t	42.6%

Note) Water-borne cargo ratio = volume of water-borne cargoes/volume of raw materials or production x 100

4-4. Allocation of Industries for the Three Sites

Table 4-8 shows area of plant sites and the number of employees proportional to the production scale of industries.

The industries were allocated by site according to the port conditions of the three sites (Opobo, Ibeno and Jamestown) and the socio-economic conditions (including recourses) of the hinterland (Table 4-8).

Table 4-8 Plant Area, Number of Employees and Location of Industries

	Production Scale (ton/year)	Plant Area (1,000 m²)	Number of Employees	Location		
				Opobo	Ibeno	Jamestown
Palm oil processing	Refined oil 100,000	50	300	O		
Seafood processing	Processed sea food 50,000	80	2,200	O		O
Flour milling	Flour and bran 500,000	60	200		O	
Animal feeds	200,000	60	200		O	
Wood processing	Boards, plywood, veneer, etc. 250,000	200	1,500			O
Chemical fertilizers	250,000	80	100		O	
Salt manufacture	100,000	400	200		O	
Petroleum refining	4,475,000	1,000	500		O	
Concrete products	100,000	40	150	O	O	O
Steel shearing and slitting	100,000	30	100			O
Structural metal products	50,000	120	1,200		O	O
Boat building and repair	Fishing and other boats 1,000	20	150	O		
Shipbuilding and repair	30,000	80	500		O	
Total	6,206,000	2,220	7,300			

CHAPTER 5. LAYOUT OF PORT FACILITIES AND INDUSTRIAL COMPLEX

5-1. Volume of Cargo Handled at Ports

The cargo handling capacity of the ports in the year 2000 is enough for the estimated general cargo volume. Therefore, of the port facilities required at the local ports, capacity of mooring facilities is determined by the volume of cargo generated from industries located in the hinterland of the ports. Table 4-9 shows the volume of cargo handled at the ports, classified by site, industry, and incoming/outgoing.

5-2. Layout of Port Facilities

Figs. 4-1 ~ 4-3 show the plans of port facilities and the industrial complexes in the Opobo, Ibeno, and Jamestown sites. The characteristic points at each site are as follows:

(1) Opobo Site

The wharf is to be called at by barges for inland waterways and fishing boats. Handled cargoes are palm oil, seafood, and cement.

(2) Ibeno Site

For flour milling and animal feed processing, raw materials are imported using bulk carriers of 35,000 DWT class. So, a sea berth is planned at a water depth of -13m. Crude oil and petroleum products are handled at the existing Qwa Ibo Oil Terminal sea berth. Other cargoes (chemical fertilizers, salt, steel, and cement) are transported using barges.

(3) Jamestown Site

Logs are brought in using rivers. Cargoes handled at the wharf is seafood, wood products, steel, and cement.

Table 4-9 Volume of Cargo Handled at Ports

(Unit: '000 tons)

	Opobo							Ibeno							Jamestown						
	Foreign Trade			Domestic Trade			Total	Foreign Trade			Domestic Trade			Total	Foreign Trade			Domestic Trade			Total
	Ex.	Im.	Total	Ex.	Im.	Total		Ex.	Im.	Total	Ex.	Im.	Total		Ex.	Im.	Total	Ex.	Im.	Total	
Palm oil	50		50				50														
Seafood processing	10		10		525	525	625								10		10		525	525	625
Flour milling									500	500				500							
Animal feed processing									120	120				120							
Wood processing															125		125		1565	1563	2813
Chemical fertilizers								50		50				50							
Salt manufacture								20		20				20							
Petroleum refining								2275	2356	4631				4631							
Concrete products					47.5	47.5	47.5					47.5	47.6	47.5					47.5	47.5	47.5
Steel shearing and slitting																		20	84	104	104
Structural metal products											10	42	52	52				10	42	52	52
Boat building and repair					0.5	0.5	0.5														
Shipbuilding and repair											<30>	16	16	16							
	60		60		1005	1005	1605	2345	2976	5321	10	1055	1155	54365	135		135	30	3323	4623	5973
General Cargo	60		60		53	53	113	70		70	10	58	68	138	135		135	30	1785	2085	3435
Dry bulk cargo					47.5	47.5	47.5		620	620		47.5	47.5	6675					1565 47.5	1563 47.5	1563 47.5
Liquid bulk cargo								2275	2356	4631				4631							

Note: < > means weight of ships.
It is not included in cargo.

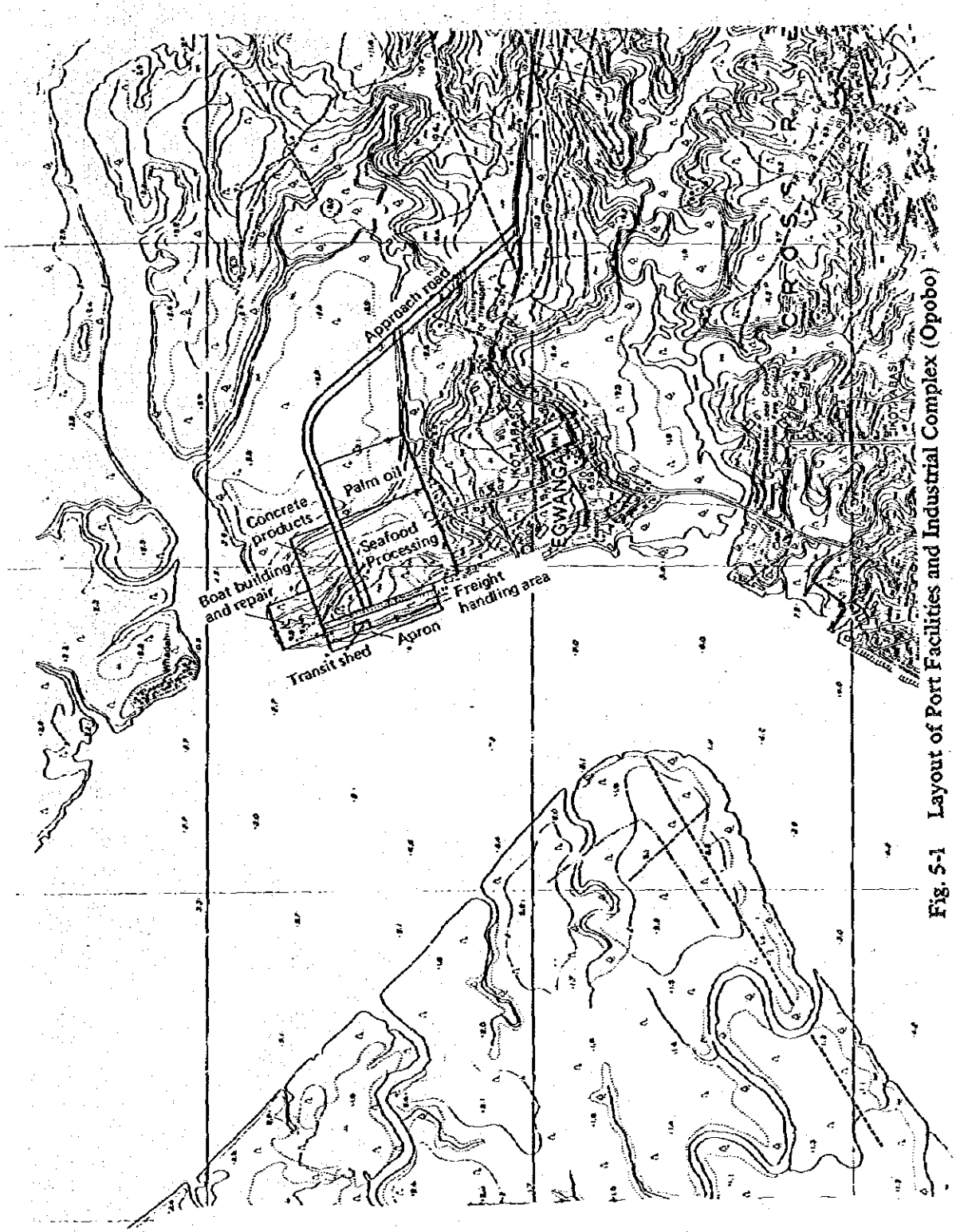


Fig. 5-1 Layout of Port Facilities and Industrial Complex (Opobo)

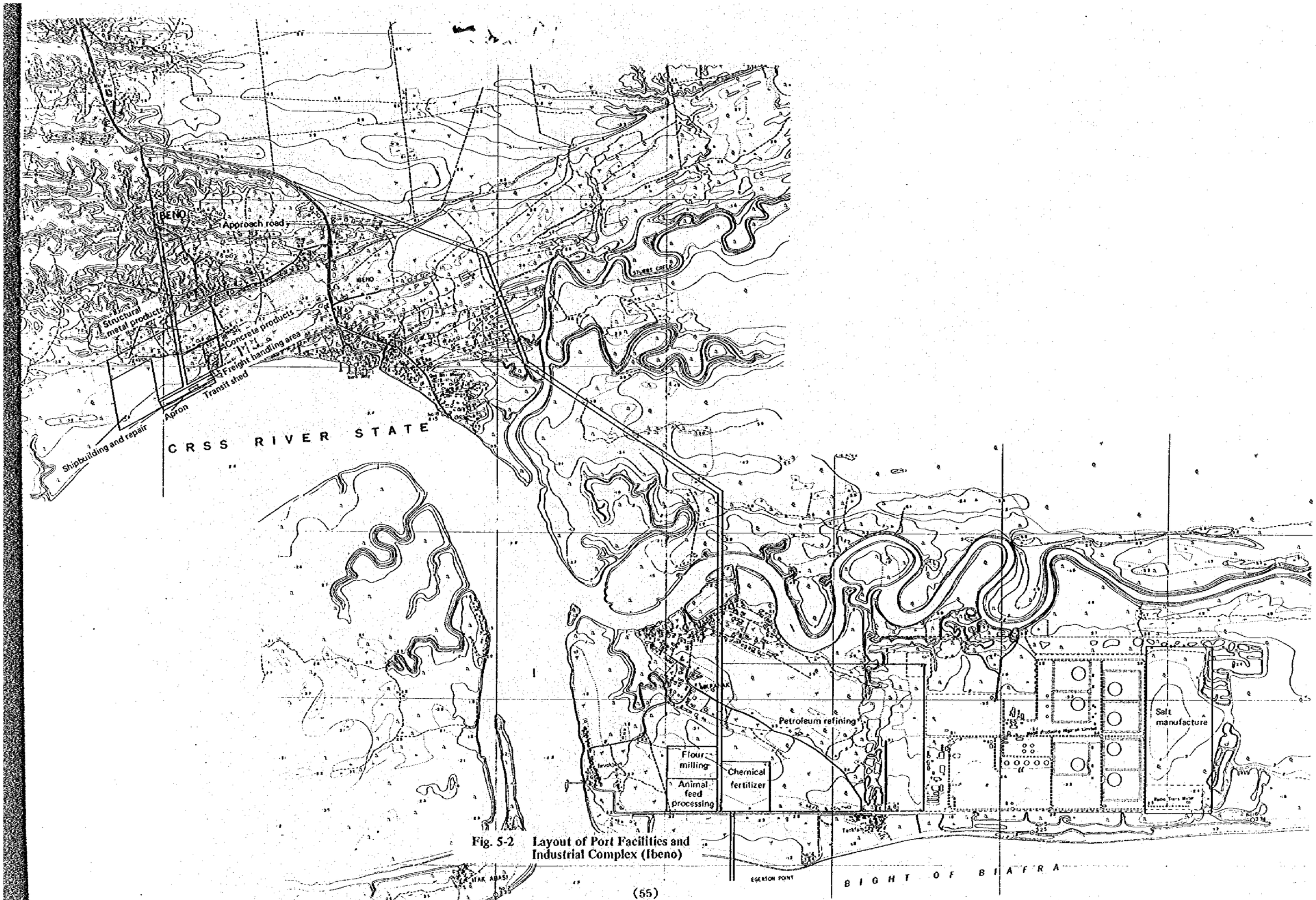


Fig. 5-2 Layout of Port Facilities and Industrial Complex (Ibeno)

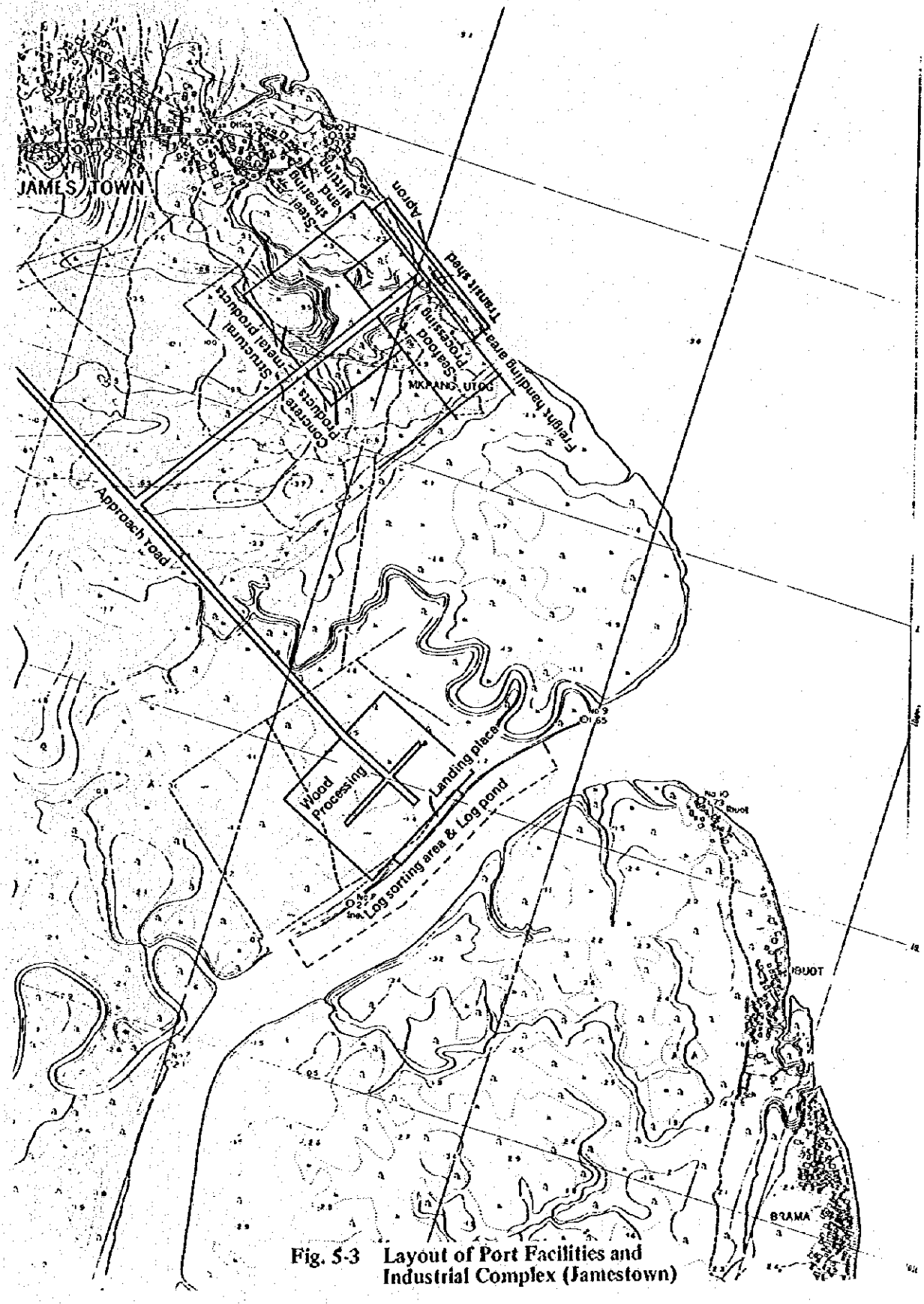


Fig. 5-3 Layout of Port Facilities and Industrial Complex (Jamestown)

CHAPTER 6. COMMENTS FROM THE TECHNICAL VIEWPOINTS

6-1. Natural Conditions

Ships calling at local ports are 2,000 DWT class barges of about 2 m draft. So, dredging for provisiion of shipping channels is not needed and the following points will be enough for maintenance of the channels.

(1) At Opobo site, the shipping channel through the sand bar at the Imo river mouth must be deep enough.
(2) At Ibeno site, the shipping channel must be deep enough on the sand bar off the Kwa Ibo river mouth.
(3) At Jamestown site, siltation should carefully be prevented in front of the wharf.

6-2. Designing and Construction

Mooring facilities planned for the three sites are −3 m deep wharves. L-shaped concrete block will be most suitable as the structural type of the wharves from the viewpoints of feasibility, construction, and durability.

At Ibeno site, a sea berth will be constructed at a site of −13 m deep, 10 km off the coast. The distance between the sea berth and Ibeno site will be connected using trestle.

At Jamestown site, the ground surface is composed of layers of silt and clay, the existing soil should be displaced with sand for the provision of the wharf foundation.

PART I OUTLINE OF THE STUDY

CHAPTER 1. THE BACKGROUND OF THIS STUDY

There are four major ports or port complexes located along Nigeria's approximately 750-kilometer coast: Lagos Port (Apapa and Tin Can Island); the Rivers Port Complex (Port Harcourt Port); the Delta Ports Complex (Warri Port, Koko Port, and Burutu Port); and Calabar Port. In 1979/80 about 17 million tons of cargo were handled at these four ports.

Although there are four major ports or port complexes, nearly 70 percent of their combined traffic is borne by Lagos Port, due to the concentration of trade and industry in western Nigeria and particularly the Lagos area. Consequently, it is urgently necessary to expand the cargo-handling capacities of Lagos Port in order to alleviate the present congestion of the port and to cope with future increases in volume.

The New Ocean Terminal proposed at about 50km east of Lagos Port (referred to hereafter as "NOT-Lagos") is designed to fulfill these requirements.

Meanwhile, there have been suggestions that other sites for the New Ocean Terminal, particularly in the eastern states, be considered.

CHAPTER 2. OBJECTIVES OF THE STUDY

Based on the above, the study comprises the following two parts, with the aim of assessing the eastern coast as a site for port development.

Part 1: New Ocean Terminal

To study the possibilities of developing a New Ocean Terminal on the eastern coast with the same scale and function as NOT-Lagos.

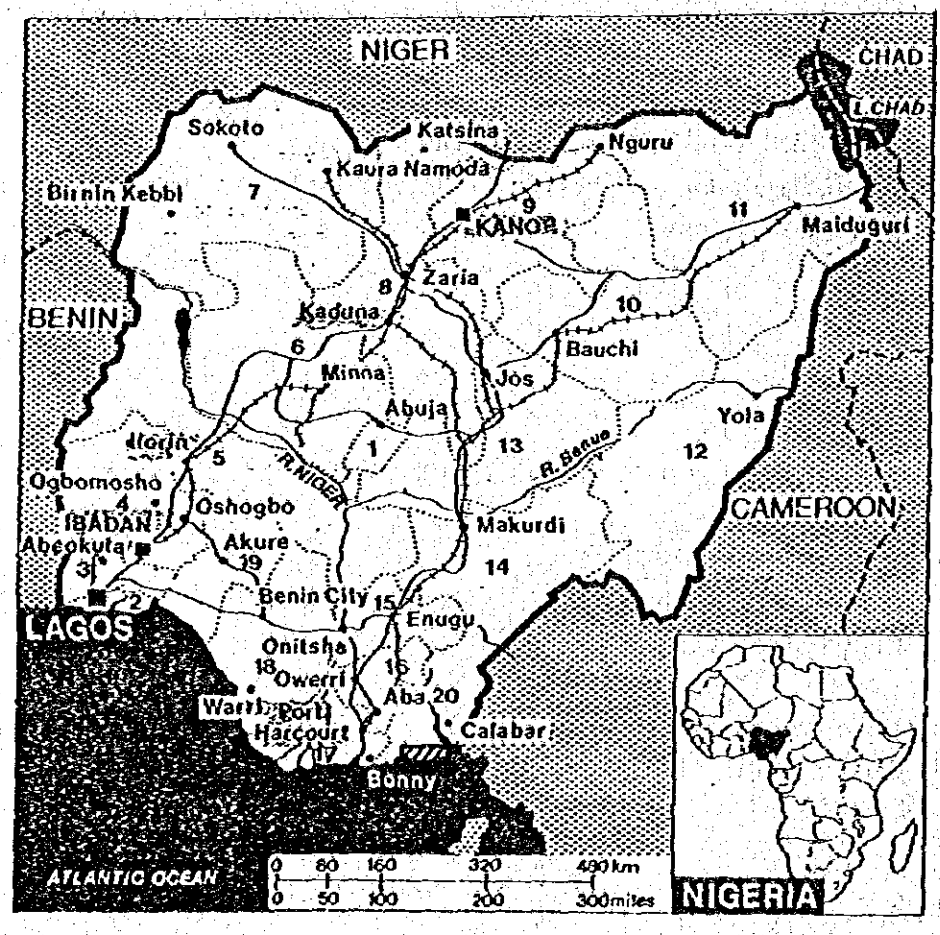
But, the development of NOT could be very difficult due to the topographical conditions of the eastern coast. Therefore,

Part 2: Local Ports

To prepare sketches for possible port planning to meet future regional development along the eastern coast, and to evaluate these plans with respect to variously selected conditions.

CHAPTER 3. STUDY AREA

The study area has been designated by the Nigerian Ports Authority (NPA) as the vicinity of Opobo, Ibeno, and Jamestown in the eastern coast's Cross River State.
Fig. I-3-1 shows the location of the study area.
A detailed map of the study area is shown in Fig. I-3-2.



1 Federal Capital Area
2 Lagos State
3 Ogun State
4 Oyo State
5 Kwara State
6 Niger State
7 Sokoto State
8 Kaduna State
9 Kano State
10 Bauchi State
11 Borno State
12 Gongola State
13 Plateau State
14 Benue State
15 Anambra State
16 Imo State
17 Rivers State
18 Bendel State
19 Ondo State
20 Cross River State

Study Area

Fig. I-3-1 Location of Study Area

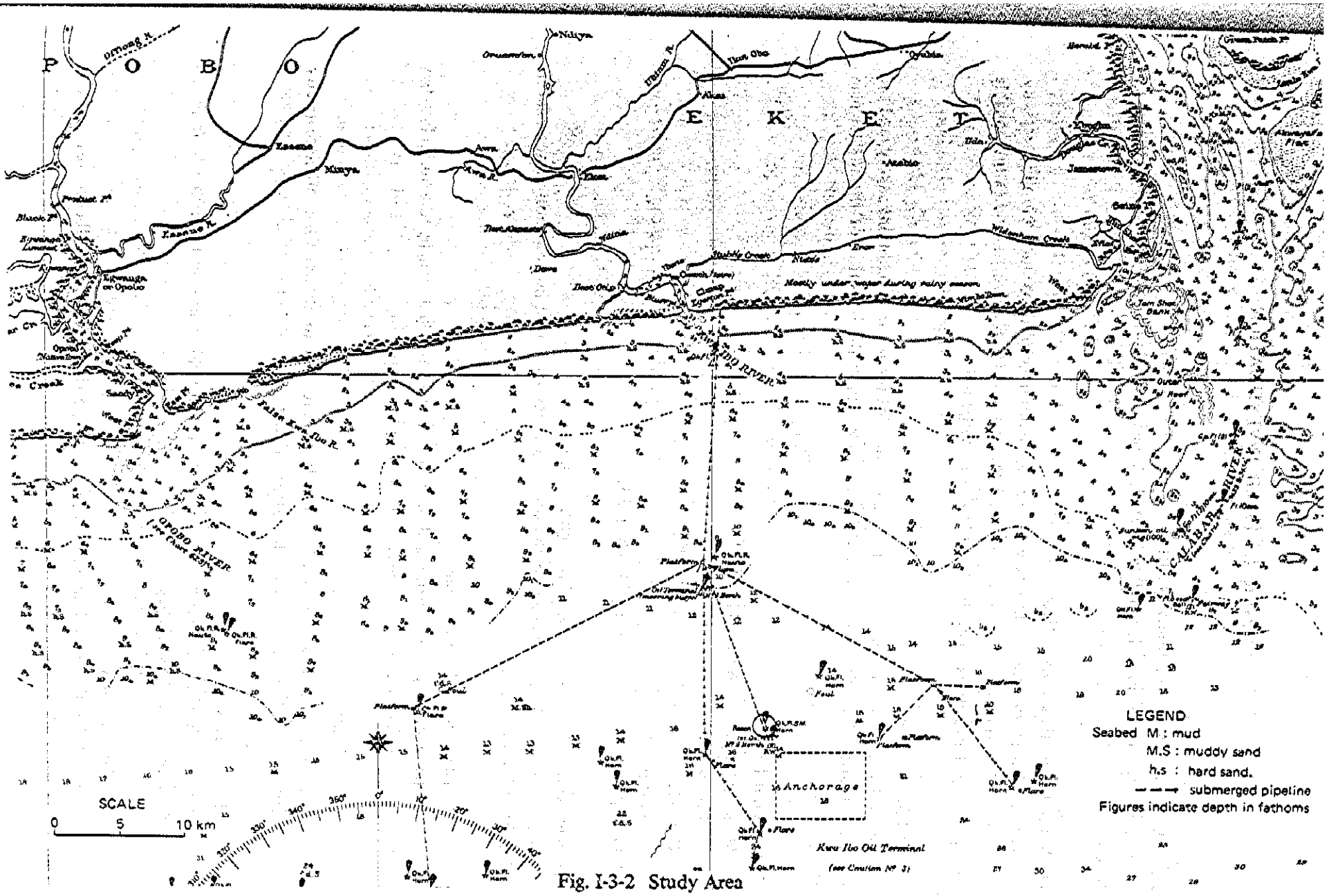


Fig. I-3-2 Study Area

CHAPTER 4. FIELD INVESTIGATION

I-4-1. Study Procedure and Study Teams

During the course of this study, two study groups as detailed below were dispatched to Nigeria.

(1) Natural Conditions Survey Group

The objectives of this group were to survey natural conditions and compile necessary background data for the master plan study of NOT-east and for preparing sketches for possible port planning. This group can be divided into three smaller units.

1) Port planning unit

The tasks of this unit were the overall management of the natural conditions survey, and the opening of discussion with Nigerian counterparts concerning the direction of the master plan study.

The personnel are as follow:

Masao Ohno, Executive Director, OCDI
Group leader
Hideo Kayahara, Deputy Director, OCDI
Port planning

This group stayed in Nigeria during March, 1981.

2) Surveying and oceanographical investigation unit

This unit carried out surveying of the sites and oceanographical investigation in accordance with the following outline:

a. Aerial photographic surveying

Aerial photographs of Ibeno and Jamestown were newly taken by the unit. For the Opobo area, existing pictures were purchased for mapping.

b. Echo sounding

Echo sounding was conducted in the Ibeno area up to about 20km offshore (water depth -20m) to check the accuracy of the existing charts.

c. Beach surveying

Shallow beaches inaccessible by survey boat, and land areas of 50 – 100m in from the shoreline were surveyed by leveling.

d. Tidal observation

Tidal observation was done using a pressure-type tidal gauge in the Ibeno area and tide poles at all three sites.

e. Observation of wave height, wave direction, and wave period
Visual observations were made in the Ibeno area.

f. Sampling of bottom sediments
For studying sedimentaiton and littoral drift, samples of bottom sediments were taken from rivers and beaches in the three areas.

The members of this unit are as follows:

Takehiko Hirano, Deputy Manager, Overseas Dept., KASCO
Leader of surveying and oceanographical investigation
Tomoyuki Hashimoto, KASCO
Kenji Sakai, KASCO
Yoshimichi Hayasaka, KASCO
Kenji Saiki, KASCO
Takaki Hirose, KASCO
Survey and oceanographical investigation
Hiroyuki Nagayoshi, KASCO
Coordination of survey and oceanographical investigation

This group stayed in Nigeria from February to May, 1981.

3) Geological investigation unit

This unit carried out borings to ascertain the geological conditions of the proposed sites for NOT-east in accordance with the following outline:

a. Boring and sampling
Boring and sampling were done at six locations; two locations in each of the three areas.

b. Laboratory test
Samples were brought to the laboratory and tested.

The personnel of this group are:

Yoshikazu Itoh, Senior Civil Engineer, PCI
Leader of geological investigation
Hirofumi Kawabata, Senior Soil Engineer, PCI
Geological investigation

This group stayed in Nigeria from March to June, 1981.

(2) Port Planning Group

The objectives of this group were to collect information and data through meetings with government officials and representatives of private companies, and to perform field observations of the proposed port development sites. Finally, the master plan was formulated in Japan, based on the data collected in Nigeria.

The master plan covers:

a. Port planning
b. Traffic forecast
c. Industrial development planning
d. Natural conditions
e. Structural design
f. Cost estimates

The personnel are as follow:

Masao Ohno, Executive Director, OCDI
Leader
Hideo Kayahara, OCDI
Co-Leader, port planning
Michio Nakagawa, OCDI
Traffic forecast and transport planning
Masahiro Yokogawa, OCDI
Contruction and cost estimates
Yorihiro Mano, OCDI
Industrial development planning and transport planning
Kiyokuni Okubo, OCDI
Structural design
Hiroaki Ozasa, OCDI
Natural conditions
Hozumi Katsuta, JICA
Coordination

This group stayed in Nigeria during June and July 1981.

Aside from the port planning group mentioned above, a team for the draft final report was formed as follows and dispatched to Nigeria during October and November 1981.

Masao Ohno, Executive Director, OCDI
Leader
Hideo Kayahara, Deputy Director, OCDI
Co-Leader
Hiroaki Ozasa, Hydraulic Engineer, OCDI
Masahiro Yokogawa, Civil Engineer, OCDI

A team for the final report was also formed as follows:

Masao Ohno, Executive Director, OCDI
Leader
Hideo Kayahara, Deputy Director, OCDI
Co-Leader
Michio Nakagawa, Economist, OCDI

I-4-2. Investigation Area

The areas where topographical survey (aerial photographic surveying), echo sounding, and geological investigations were carried out are shown in Fig. I-4-1. As geographical and geological investigations were limited to the vicinities of Opobo, Ibeno, and Jamestown, further site observations and hinterland observations were carried out on a wider scale by the port planning team and NPA officers by automobile, boat and helicopter.

I-4-3. Timetable

The overall timetable of the study is shown in Table I-4-1. The investigation of natural conditions was completed, and the port planning study carryed out based on the results. The final results of this study will be forwarded to the Nigerian Government by mid-February, 1982.

I-4-4. Organizations Visited by the Groups

The authorities and organizations visited by the groups are listed below:

Central Planning Office
Ministry of Transport
Nigerian Ports Authority
  Head Office, Lagos
  Port Harcourt Branch Office, Port Harcourt
  Calabar Branch Office, Calabar
Federal Office of Statistics
Meteorological Department, Federal Ministry of Civil Aviation
Nigerian Railway Corporation
Nigerian Institute for Oceanography and Marine Research, Federal Ministry of Science and Technology
Ministry of Economical Planning, Cross River State
Palm Produce Board
Trans Amadi Industrial Layout
Pamil Industries Ltd.
Mobil Ibeno Terminal
Crushed Rock Industries (Nigeria) Ltd.
JETRO Nigeria Office

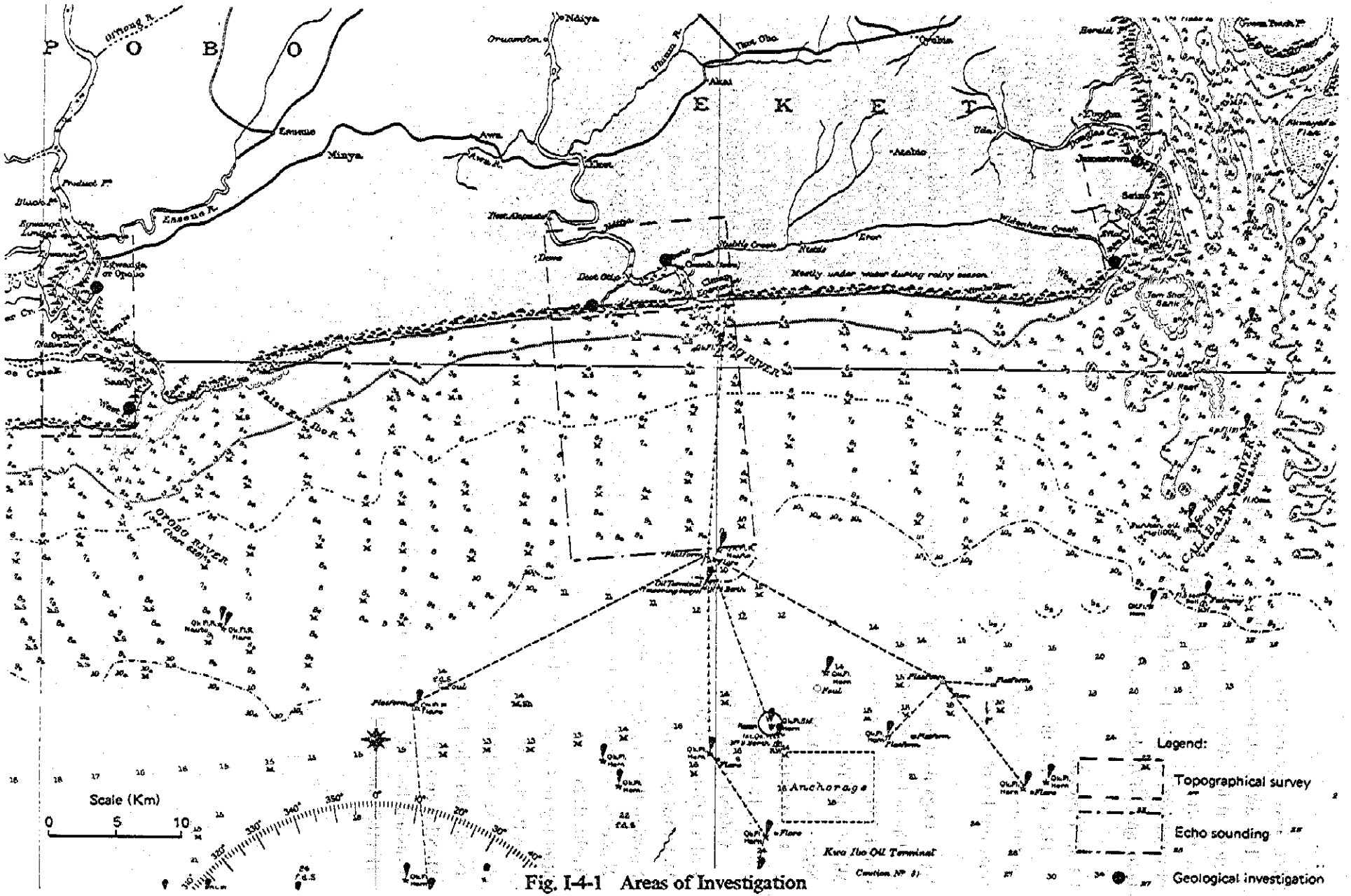
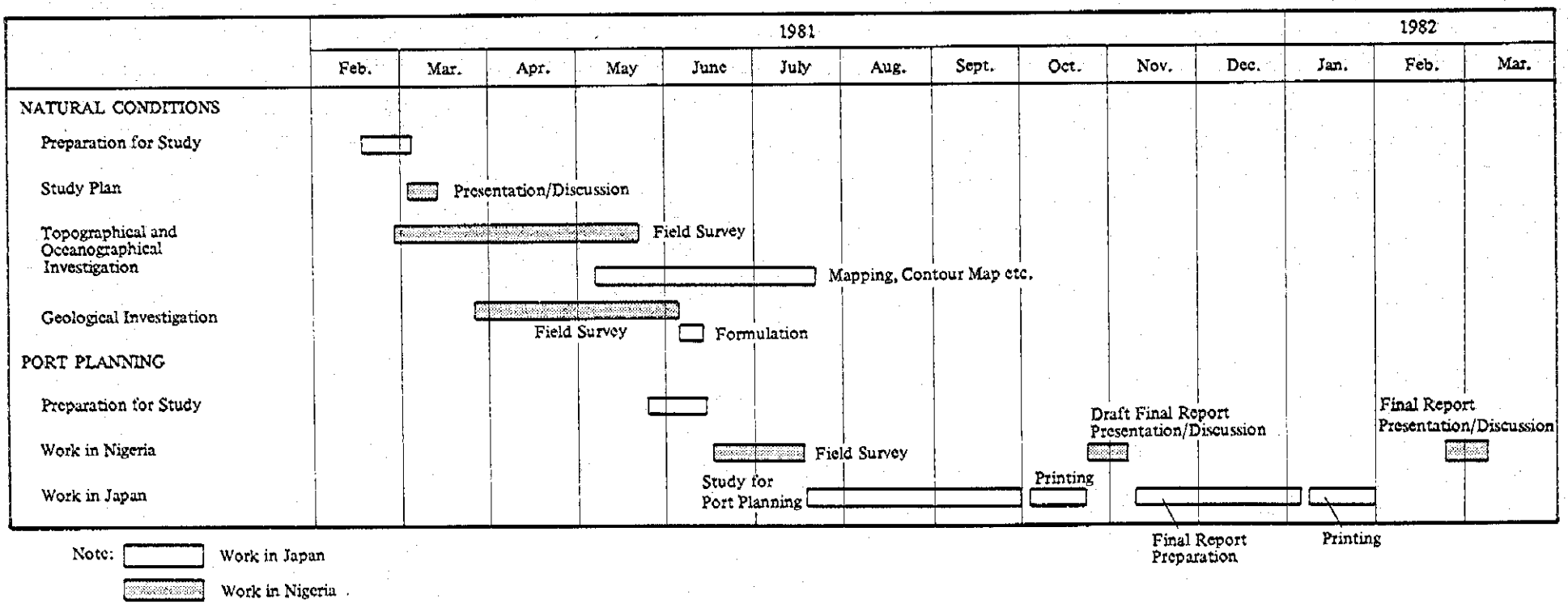


Fig. I-4-1 Areas of Investigation

Table I-4-1. Overall Timetable of the Study



PART II CONDITIONS OF THE SITE

CHAPTER 1. NATURAL CONDITIONS

II-1-1. Geography

The name Nigeria stems from the River Niger. This river has a length of 4,169 km and is the third largest in Africa. The topography of Nigeria is characterized by the River Niger and its largest tributary, the Benue. These two rivers flow through the country in a Y shape. The country has no high mountain and its plains spread along the Niger and the Benue and the rest consists mostly of plateau. And a vast delta is formed at the river mouth of the Niger (Fig. II-1-1).

The climate and the vegetation show distinctive characteristics between the north and the south but there are no great differences between the east and the west. From south to north, mangrove swamp forests, deltaic swamp forests, tropical rain forests, Guinea savannahs, Sudan savannahs and wooded tropical steppes extend in the east-west direction (Fig. II-1-2).

II-1-2. Climate

(1) General

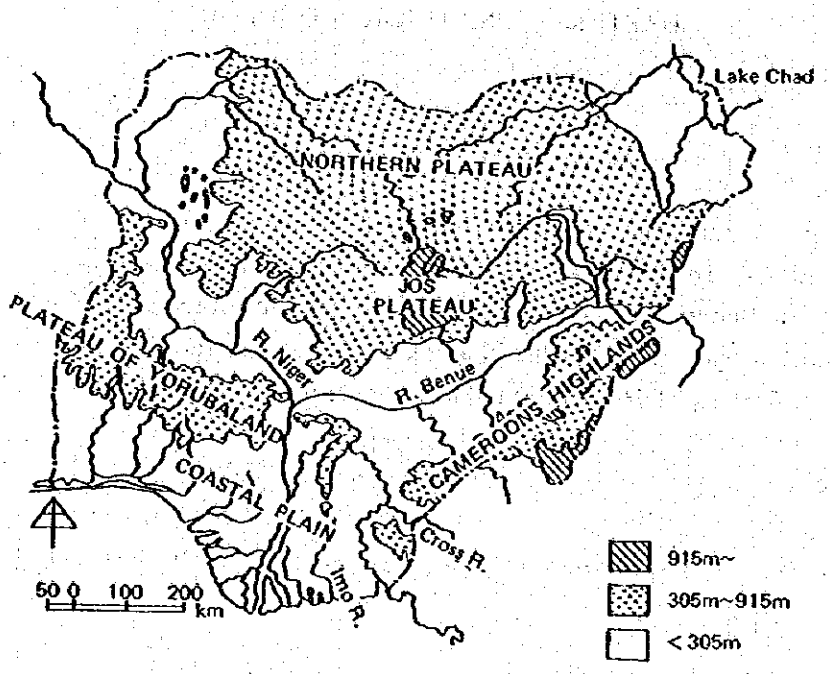
Nigeria is situated near the tropical low-pressure belt called as the Doldrum Belt. During the dry season (November–April) the belt lies approximately on the Nigerian coast and somewhat further to the south. It shifts northerly toward the wet season (May–October), reaching the vicinity of the Sahara Desert, its northern limit, at the end of June.

Monsoon winds prevail constantly, buffeting the low-pressure belt from both north and south. Accordingly, during the dry season, when the low-pressure belt lies near the Nigerian coast, strong northeasterly winds prevail in the area north of the coastal line, and through most of Nigeria. As the center of the low-pressure belt lies in the coastal area, however, the winds become weaker in the area near the shore, where land and sea breeze prevail daily. Also during the dry season, powdery sand of the Sahara Desert, carried in on the northeasterly winds, veils the entire horizon of Nigeria, and the skies appear overcast for weeks on end. This phenomenon is known as the harmattan.

In contrast, during the wet season, when the low-pressure belt lies to the north, strong southwesterly winds sweep the entire country. Fig. II-1-3 shows wind directions and relative positions of the low-pressure belt during the dry and wet seasons respectively.

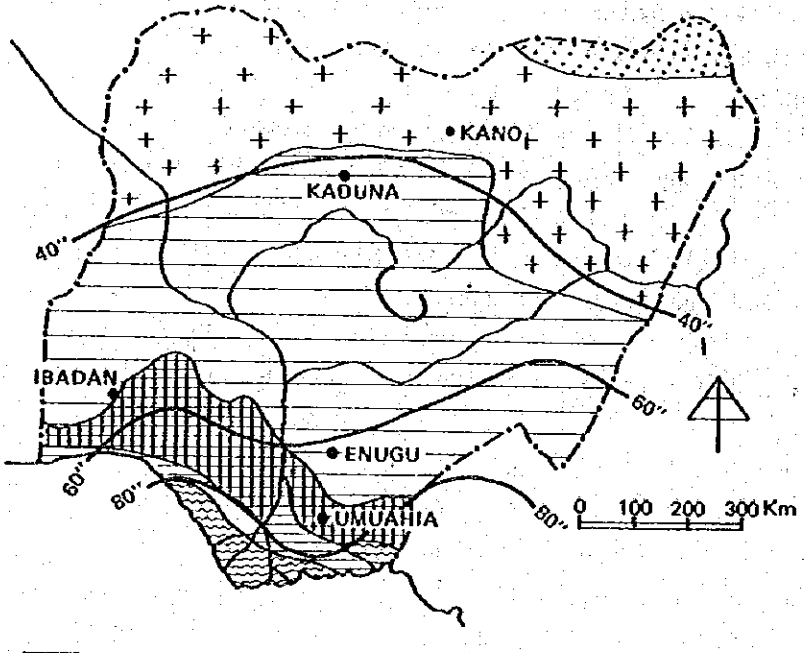
Thunderstorms occur throughout the year in Nigeria, being most frequent and violent at the beginning and the end of the wet season. They move westward at speeds of 10-13m/s accompanied by gusts and dying down rapidly. They are frequent in the coastal area, particularly on the southeast coast. Wind speed can go as high as 30m/s in squally thunderstorm.

Details of the thunderstorms such as their scales, central air pressures, and routes are not known due to insufficient observation data. However, judging from the facts that the only damages due to thunderstorms are caused by lowland flooding due to heavy rain, and that homes near the coast are not damaged by wind waves generated by tunderstorms, it may be assumed that waves generated by thunderstorms are not high enough to be taken into consideration in the New Ocean Terminal plan.



Source: International Development Center, Japan

Fig. II-1-1 General Topographical Map of Nigeria



Source: International Development Center, Japan.

Fig. II-1-2 Map of Vegetation and Precipitation in Nigeria

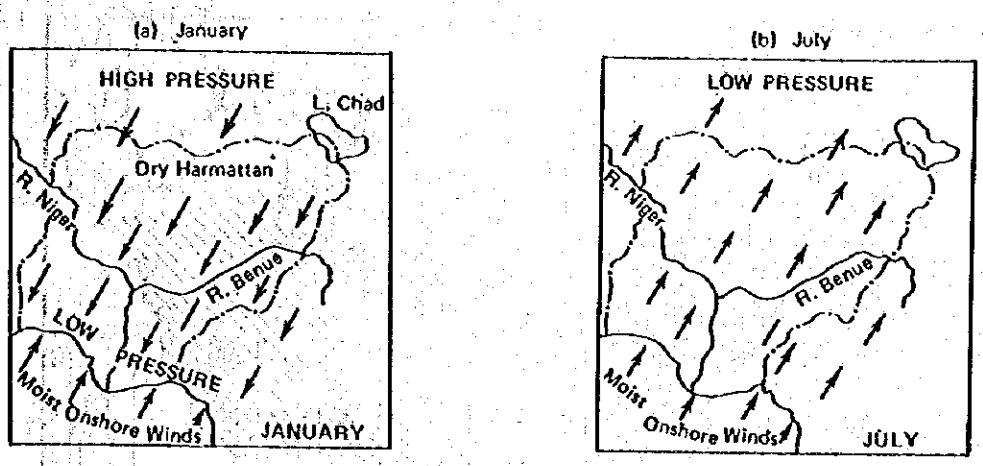


Fig. II-1-3 Pressure and Winds in January and July

(2) Precipitation

Basically, the following characteristics can be observed in Nigeria's rainfall pattern.

1) The rainfall decreases both in duration and amount from the coast toward the interior except where altitudinal effects create isolated regions of higher rainfall, e.g. the Jos Plateau. The coastal areas receive over 4,000 mm, spread over 8-10 months, the extreme north less than 250 mm, spread over 3 to 4 months.

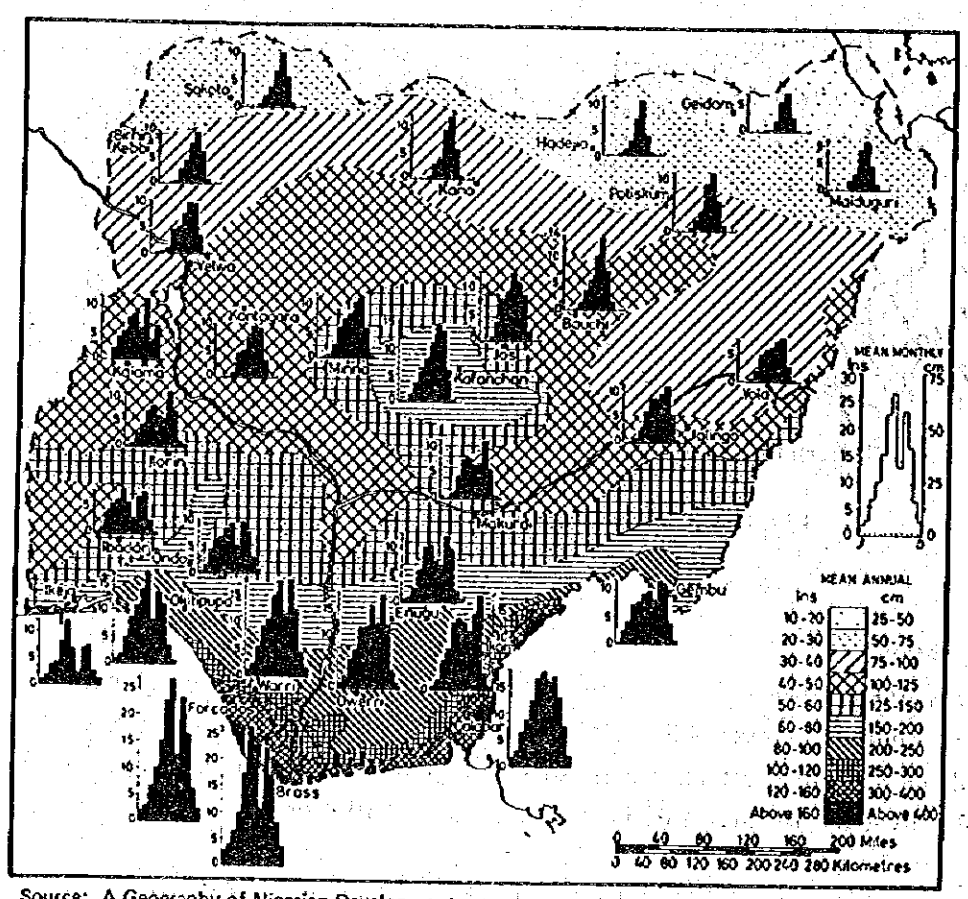
2) The incidence of rainfall can be linked to one or more of the following four factors:

a. Coastal effects occurring in a strip about 30 km in width where the oceanic regime is strong.

b. Monsoonal effects which are generally widespread and are generated by stratiform clouds.

c. Local thunderstorms which are generally sporadic and are widely experienced inland during the main rainy season.

d. Disturbance lines, i.e. belts of intense thunderstorms moving westward and depositing heavy rains of short duration.



Source: A Geography of Nigerian Development

Fig. II-1-4 Mean Annual Rainfall

(3) Winds

Fig. II-1-5 shows the monthly frequency distribution of winds by direction as observed by the Ikeja Observatory, situated north of Greater Lagos about 30 km in from the coast. As will be discernible from this graph, southwesterly winds are predominant in the rainy season (May through September), whereas in the dry season (October through April) considerable northerly winds blow as well.

Table II-1-1 shows the monthly maximum wind velocities measured at Port Harcourt in 1976-1981 and the wind directions recorded at the time of measurement. Wind velocities of higher than 20 m/s were recorded on several occasions. The highest recorded wind velocity is 25.7 m/s. Southwesterly winds appear relatively infrequently, indicating that the highest winds are caused by thunderstorms. Table II-1-2 shows yearly highest wind gusts, speeds in m/s for Port Harcourt and Calabar from 1953 to 1977. These wind gusts were caused by thunderstorms. The highest wind speed is 30 m/s, recorded in Calabar.

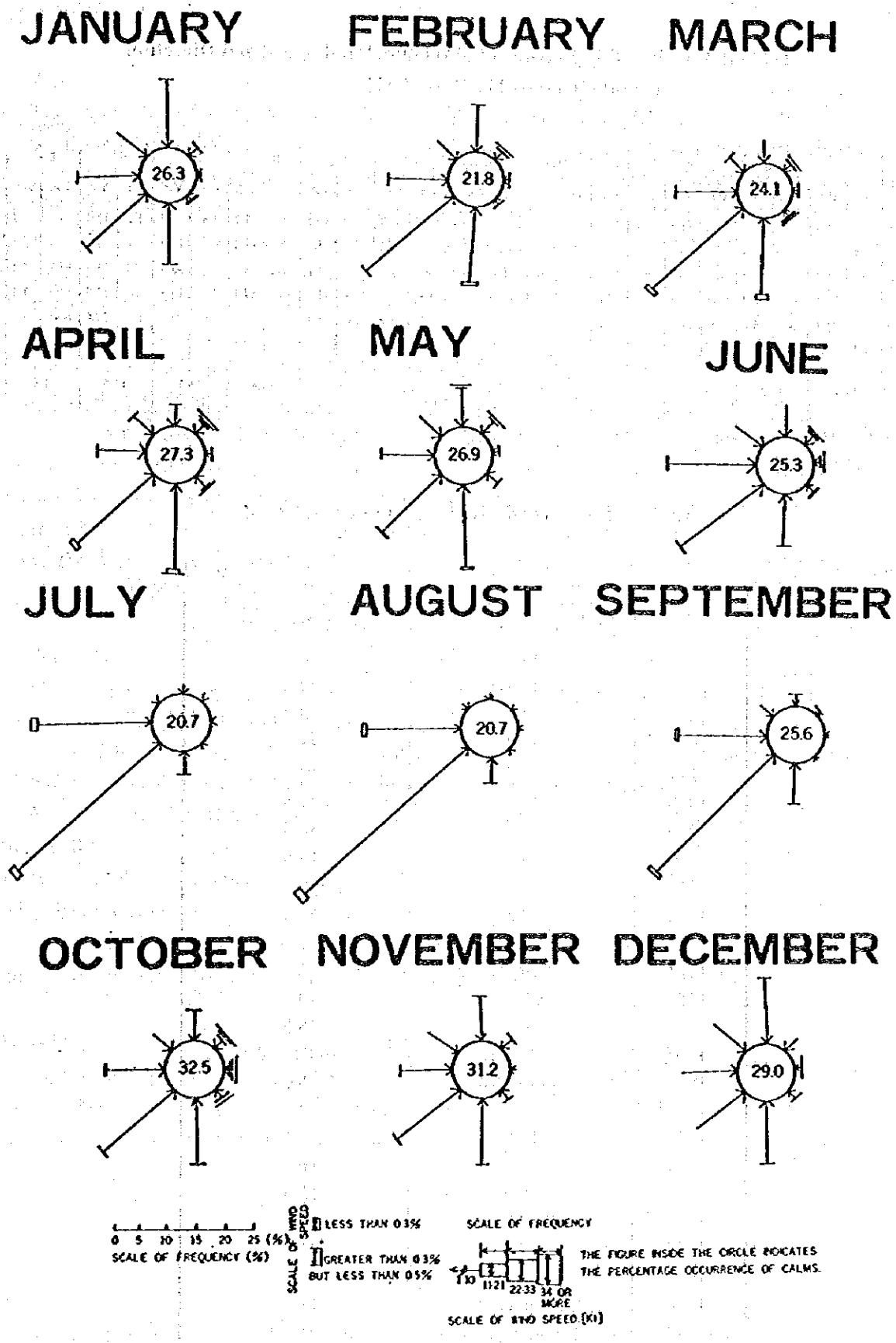


Fig. II-1-5 Wind Roses, Ikeja

Table II-1-1. Monthly Records of Maximum Wind Speed and Direction at Port Harcourt (1976 – 1981)

(Unit: m/s)

Year	Jan.		Feb.		March		April		May		June		July		Aug.		Sept.		Oct.		Nov.		Dec.	
	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.
1976	N	10.3	NE	23.7	ENE	25.7	NNE	25.2	–	–	NNE	15.4	WSW	10.3	WSW	10.3	SSW	9.2	SW	9.2	SE	13.4	N	7.7
1977	SSW	8.2	N	21.6	–	–	E	26.7	E	18.5	WSW	9.2	W	9.2	W	8.7	E	18.0	WSW	13.4	SW	7.2	S	9.2
1978	S	12.3	S	9.2	E	16.5	E	21.1	E	17.5	SW	14.4	W	9.2	WSW	9.2	N	18.0	NNE	12.9	ESE	19.5	SSW	15.4
1979	SSE	10.3	NNE	23.7	NNE	24.7	NE	18.0	ESE	16.5	SSW	7.7	SW	8.2	SSW	7.2	NE	17.5	SE	13.9	N	18.0	NNE	8.2
1980	E	23.7	S	18.0	SSE	24.7	NE	20.6	SSE	19.5	–	–	W	9.2	SW	8.2	SW	9.2	N	23.1	NE	20.6	NNE	7.7
1981	NNE	7.7	N	7.7																				
Max. Speed Mean	12.1		17.3		22.9		22.3		18.0		11.7		9.2		8.7		14.4		14.5		15.7		9.6	

Source: Department of Meteorological Service, Port Harcourt.

Table II-1-2. Yearly Highest Wind Gusts Speeds

(m/s)

Year	Highest Wind Speed (Calabar)	Highest Wind Speed (Port Harcourt)
1953	12	20.5
1954	18.5	12
1955	15	18.5
1956	16.5	15
1957	12.5	12
1958	16	17.5
1959	26	18.5
1960	14	17.5
1961	17	18.5
1962	14.5	17.5
1963	25	17
1964	19	23
1965	30	19
1966	20	18.5
1967	No Record	No Record
1968	No Record	No Record
1969	20	17.5
1970	12.5	17.5
1971	20	16
1972	16.5	18.5
1973	22.5	20
1974	17.5	25
1975	20	28.5
1976	No Record	26
1977	No Record	26

Source: Meteorological Department.

II-1-3. Sea Conditions

(1) Waves

The characteristics of waves on the Nigerian coast are outlined below, based on wave observations conducted at a point lat. 5°23'N; long. 5°00'E (water depth about -50 m) off Forcados and at Igando, proposed site of the NOT-Lagos. The waves arriving at the Nigerian coast are swell, generated in the wind area caused by a depression in the Atlantic Ocean far offshore. Prior to breaking on the Nigerian coast, they undergo angular spreading, frequency spreading, or energy reduction. Wave steepness is only about 0.005. As for the direction of deepwater waves, SW accounts for about half, and more than 80% of all waves are within the range of from S to W. The most common wave period is 12 seconds.

Since waves breaking on the Nigerian coast have the above-mentioned characteristics, it was predicted that the same characteristics would be seen in waves arriving at the eastern coast of Nigeria. This was supported by the results of the observation conducted by the natural conditions survey group on the eastern coast. Due, however, to a very gentle bottom slope of about 1/1,400, the wave on the eastern coast are damped by bottom friction and are therefore believed to be lesser in height than the waves in the western coast. This must be taken into consideration when fixing the design wave height for breakwaters. The effect of bottom friction was calculated using Bretschneider & Reid's theory (See III-4-2).

(2) Currents

The investigated area has three rivers: the Imo River, the Kwa Ibo River, and the Cross River. The average discharge of tidal and fresh water of the Imo River is 6,990 m^3/s, with a far smaller discharge of fresh water, at 230 m^3/s. Our recent observation of currents conducted at the Kwa Ibo River clearly shows that the flow in the river mouth is affected by the tide.

According to the HRS Report[1] the maximum current velocity in the mouth of the Kwa Ibo River is 0.8~1.3 m/s at flood tide, and 0.8~1.7 m/s at ebb tide (See Fig. II-1-6). The observation of our natural conditions survey group indicated maximum velocities of 0.80 m/s at flood tide and 1.30 m/s at ebb tide.

According to the HRS Report[1] the current velocity in the offshore area is 0.05 ~0.35 m/s and its direction is east/west. Velocity observed by our group was 0.10 ~ 0.30 m/s.

(3) Tide

According to the British Chart 1860, the tide levels at Opobo and Calabar are as shown in Table II-1-3. The spring-tide tidal range at Opobo is 1.83 m while that at Calabar is 2.02 m. These tidal ranges are larger than the tidal range of 1.0 m at the NOT-Lagos site.

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1) Qua Iboe River, Nigeria, Hydraulic model investigation of navigation channel stability, HRS Report EX 607, 1972.

Table II-1-3. Tide Levels on the Eastern Coast

(Unit: m)

Place	Height above datum of soundings			
	High Water		Low Water	
	Mean Sp.	Mean Nps.	Mean Sp.	Mean Nps.
Opobo R. Entrance	1.95	1.46	0.12	0.70
Calabar R. Tom Short Point	2.29	1.83	0.27	0.76

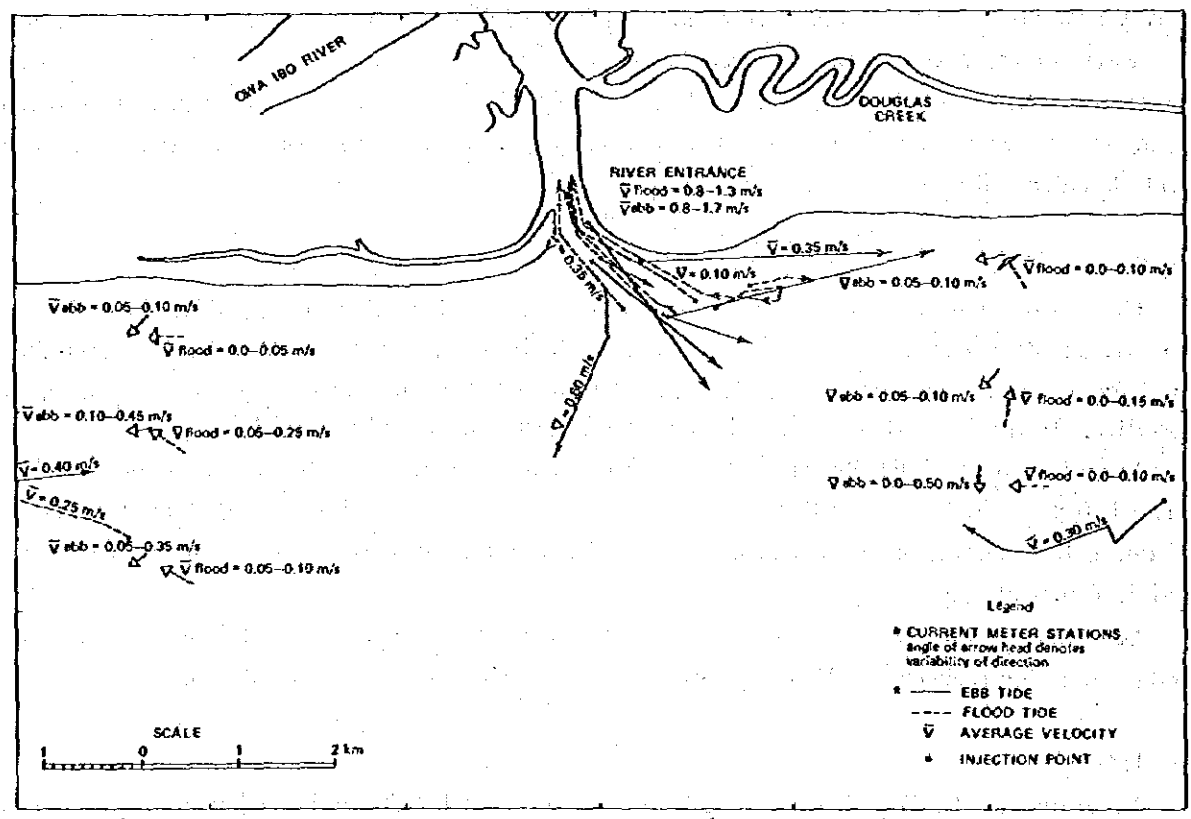

Fig. II-1-6 Current velocities and directions in the vicinity of the Qwa Ibo River (after HRS Report EX607)