II-1-4. Sediments

Sediments on the beaches facing Guinea Bay are composed of very uniform fine sand. Median diameter d_{50} and sieve analysis coefficient S_0 $(=\sqrt{d_{75}/d_{25}})$ are approximately 0.21 mm and 1.06 according to the sieve analysis test performed by the natural conditions survey group.

Fig. II-1-7 shows the types of bottom sediments off the Kwa Ibo Estuary reported by HRS.[1)] Sediments are composed mostly of sand near the beach, but further offshore, they become muddy. In our recent survey on bottom materials, the median diameter d_{50} in the same area is 0.039 mm and 0.086 mm. According to the Mobil Kwa Ibo Oil Terminal, the bottom sediments near the offshore platform (water depth about -20 m) are mud. Therefore, it is clean that bottom materials at proposed port site are composed of silt and fine sand.

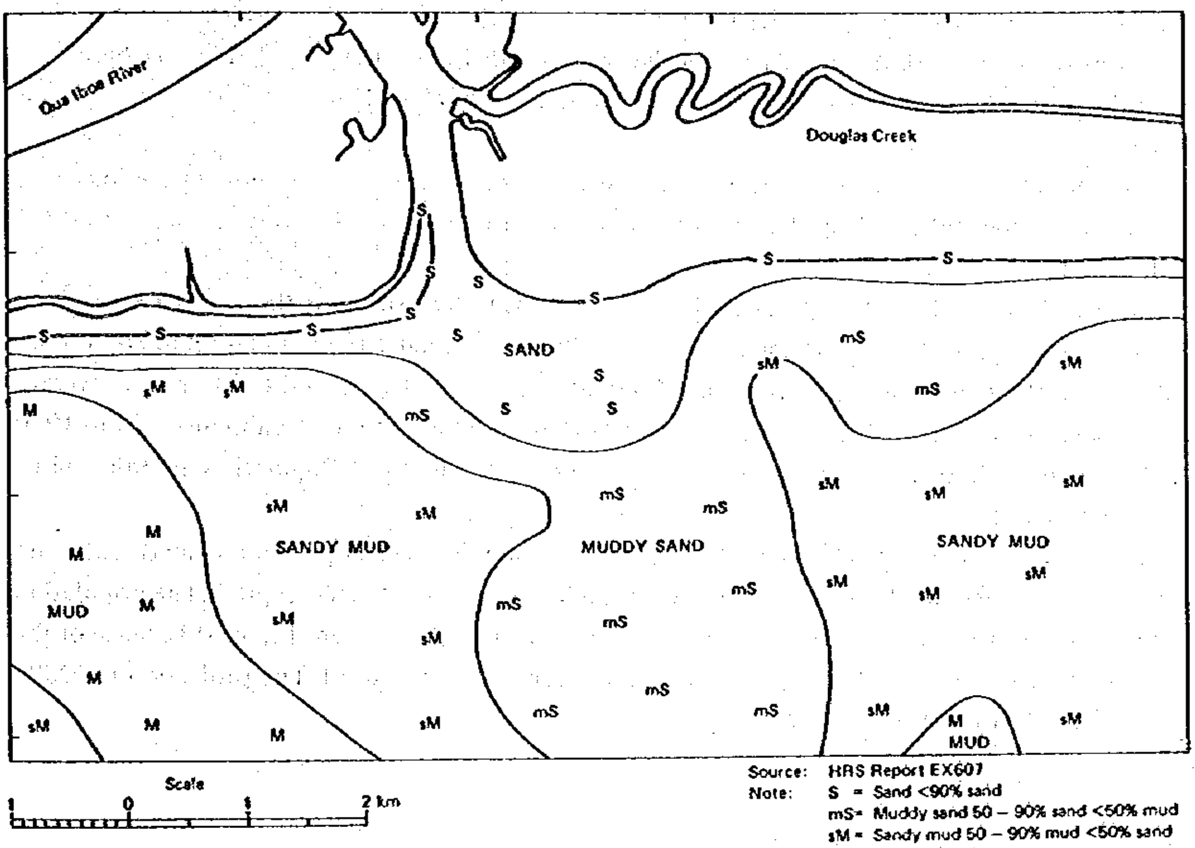


Fig. II-1-7 General Classification of Sediment Types (after HRS Report EX607)

CHAPTER 2. SOCIO-ECONOMIC CONDITIONS OF THE EASTERN STATES

II-2.1. Socio-economic Conditions in the Eastern States

(1) Area and Population

The eastern states comprise the ten states shown in Fig. II-2-1. This division is identical to the division set up in the Phase I Report on NOT-Lagos, in which the other nine states were designated as western states.

The eastern states cover a total area of 489,711 km^2, or 53.0% of the Federation's total. Many of the inland states in the northern part are large. Borno State is the largest with 116,400 km^2; Gongola the second largest with 91,390 km^2; and Bauchi the third largest with 64,605 km^2. Cross River State, where the proposed sites for NOT-east are situated has an area of 27,237 km^2, the seventh largest of the eastern states.

As of the year 1980, the population of the eastern states was estimated at about 41.6 million, or 49.1% of the Federation's total (about 84.7 million), somewhat smaller than the percentage of its area.

The population of the south eastern states is large for their area. Imo is most populous with about 5.6 million, followed by Anambra with about 5.4 million, and Cross River with about 5.3 million (Table II-2-1).

Nigeria has the largest population of all the Africa countries and the growth rate of its population is very high. The National Population Bureau estimates the population at about 84.7 million, in 1980 showing an increase of about 50% over 1963 (55.7 million) and an average annual growth rate of 2.50%. The Bureau projects that the rate of population increase from 1980 to 2000 will be 2.56%, slightly more than the rate for 1963 to 1980. Population in 2000 will be 140,446,000 (Table II-2-1, II-2-2).

According to the projections of National Population Bureau. Population growth rates are almost identical for most states, except in cases such as Lagos, the federal capital. The population ratio of eastern to western states should therefore shift somewhat toward the west because of the great increase in Lagos, but is expected to remain generally unchanged. The projection for 2000 is 48.8%/51.2% (Table II-2-1, II-2-2).

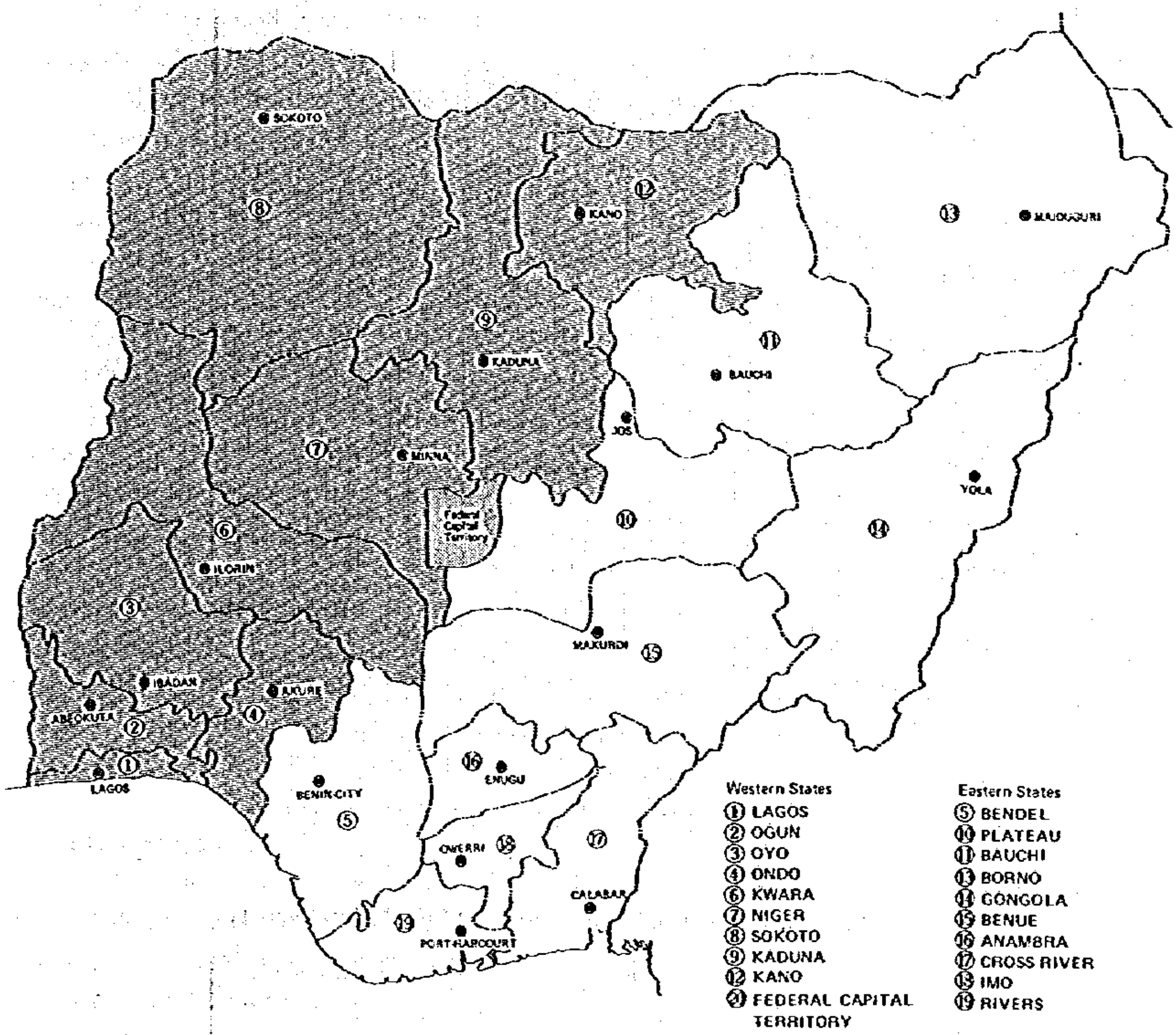


Fig. II-2-1 Eastern and Western States

Table II-2-1 Area and Population

	Area		Population					
			1963		1980		2000	
	km^2	%	in thousands	%	in thousands	%	in thousands	%
Western States								
Lagos	3,345	0.4	1,444	2.6	2,476	2.9	4,830	3.4
Ogun	16,762	1.8	1,551	2.8	2,353	2.8	3,879	2.8
Ondo	20,959	2.3	2,730	4.9	4,140	4.9	6,827	4.9
Oyo	37,705	4.1	5,209	9.4	7,901	9.3	13,027	9.3
Kwara	66,869	7.2	1,714	3.1	2,601	3.1	4,288	3.1
Niger	65,037	7.0	1,194	2.1	1,812	2.1	2,987	2.1
Sokoto	102,535	11.1	4,539	8.2	6,885	8.1	11,351	8.1
Kaduna	70,245	7.6	4,098	7.4	6,217	7.3	10,249	7.3
Kano	43,285	4.7	5,775	10.4	8,760	10.3	14,442	10.3
Subtotal	434,057	47.0	28,254	50.8	43,145	50.9	71,880	51.2
Eastern States								
Bendel	35,500	3.8	2,461	4.4	3,733	4.4	6,135	4.4
Rivers	21,850	2.4	1,720	3.1	2,609	3.1	4,301	3.1
Imo	11,850	1.3	3,673	6.6	5,571	6.6	9,185	6.5
Anamba	17,675	1.9	3,597	6.5	5,456	6.4	8,995	6.4
Cross River	27,237	2.9	3,478	6.2	5,276	6.2	8,699	6.2
Benue	45,174	4.9	2,427	4.4	3,681	4.3	6,070	4.3
Plateau	58,030	6.3	2,027	3.6	3,074	3.6	5,088	3.6
Gongola	91,390	9.9	2,605	4.7	3,952	4.7	6,516	4.6
Bauchi	64,605	7.0	2,431	4.4	3,688	4.4	6,080	4.3
Borno	116,400	12.6	2,997	5.4	4,547	5.4	7,497	5.3
Subtotal	489,711	53.0	27,416	49.2	41,587	49.1	68,566	48.8
Federation Total	923,768	100.0	55,670	100.0	84,732	100.0	140,446	100.0

Sources: Area: Nigerian Year Book, The Daily Times
Population: Official Census, 1963
1980 and 2000: Mid-Year Population Projections by State, National Population Bureau, 1978
Note: The subtotal of the western states' area includes the Federal Capital Territory.

Table II-2-2 Growth Rate of Population and Population Density

	Yearly gorwth rate (%)		Population density (prsons/km^2)		
	1963 – 1980	1980 – 2000	1963	1980	2000
Western States					
Lagos	3.22	3.40	432	740	1,444
ogun	2.48	2.53	93	140	231
Ondo	2.48	2.53	130	198	326
Oyo	2.48	2.53	138	210	345
Kwara	2.48	2.53	26	39	64
Niger	2.48	2.53	18	28	46
Sokoto	2.48	2.53	44	67	111
Kaduna	2.48	2.53	58	89	146
Kano	2.48	2.53	133	202	334
Subtotal	2.52	2.59	64	98	163
Eastern States					
Bendel	2.48	2.52	69	105	173
Rivers	2.48	2.53	79	119	197
Imo	2.48	2.53	310	470	775
Anambra	2.48	2.53	204	309	509
Cross River	2.48	2.53	128	194	319
Benue	2.48	2.53	54	81	134
Plateau	2.48	2.55	35	53	88
Gongola	2.48	2.53	29	43	71
Bauchi	2.48	2.53	38	57	94
Borno	2.48	2.53	26	39	64
Subtotal	2.48	2.53	56	85	140
Federation Total	2.50	2.56	60	92	152

(2) Resources

1) Agricultural resources

Nigeria has abundant agricultural resources thanks to its vast area and favorable climate. (Figs. II-2-2 and II-2-3)

Major food crops in the eastern states are yam, cocoyam, cassava, millet, gunia corn and maize, with lesser crops of rice, wheat, and soybeans. The eastern states produce all these food crops. Yam and cassava, which are root crops, are mainly produced in the south. Maize is also produced in the south, while gunia corn is produced mainly in the north.

Tree crops consist mainly of groundnuts, cocoa, oil palms, cotton, and rubber, important export items which comprise Nigeria's cash crops. The eastern states have production centers of oil palms in Rivers State and Cross River State; rubber in Bendel State and Cross River State; and groundnuts in Borno State and Bauchi State.

Bananas, melons, oranges, and other fruits are grown in the eastern states. Livestock is raised mainly in the north; little other than goats can be kept in the south because of the presence of the tse-tse fly.

2) Forest resources

About 96,000 km², or nearly 10% of Nigeria, is said to be permanent forest estates (forest reserves) where more than 600 types of trees grow. Thirty of these, about 5% of the total, are supplied for industrial use and include many types of high grade woods and hardwoods, such as mahogany and obeche. The eastern states of Bendel and Cross River have large forest reserves, many of which are major production centers for industrial wood.

3) Fishing resources

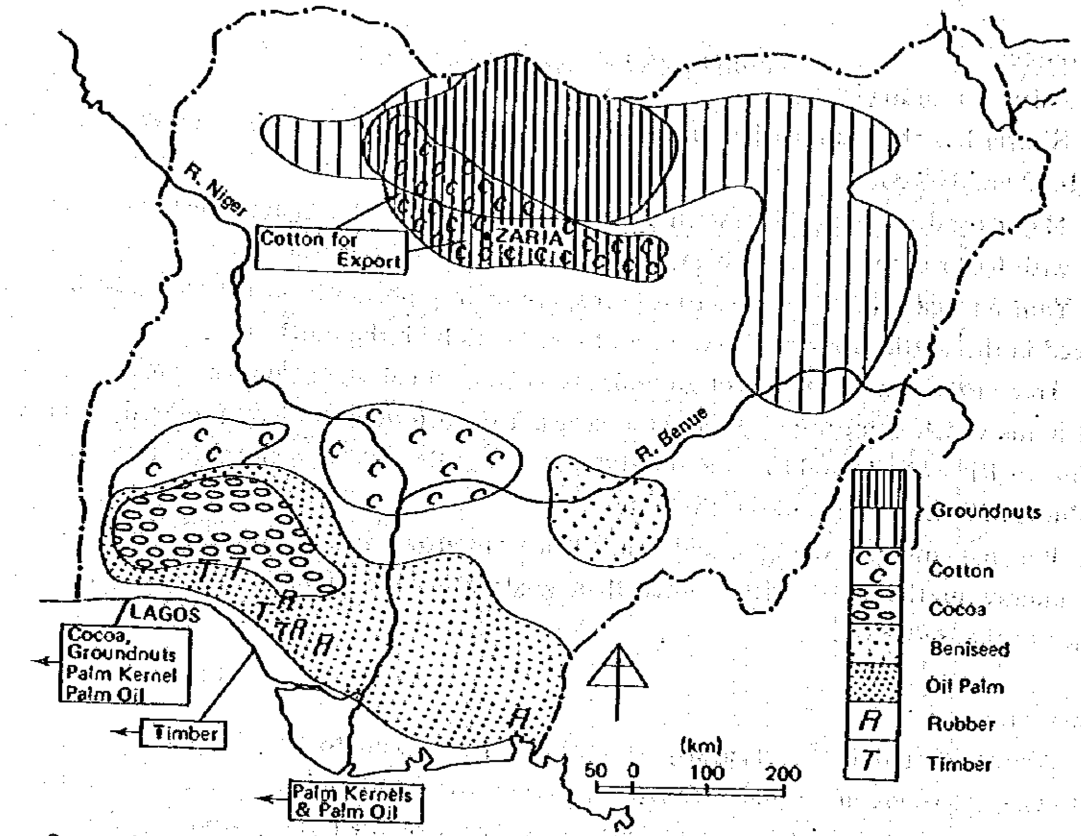
The fishing resources of Nigeria lie in her seas, lakes, swamps, lagoons, and rivers. More than half of the domestic production is from coastal and blackish waters, followed by catches from rivers, ponds, and lakes. Fishing is practised mainly in an artisanal form; industrial fishery is a rarity. Edible ocean fish including promfret, scad, great trevally, groupers, shad, rabbit fish, mackerel, and sharks can be taken in the coastal waters, while croakers and soles school further out to sea. Shrimp also exist in abundance, and the catfish is representative of the Nigerian fresh-water fish.

In the eastern coastal states, shad is the most common sea-water fish. Promfret, groupers, scad, mackerel, and sharks are also common. The catfish is the most common fresh-water fish.

4) Mineral resources

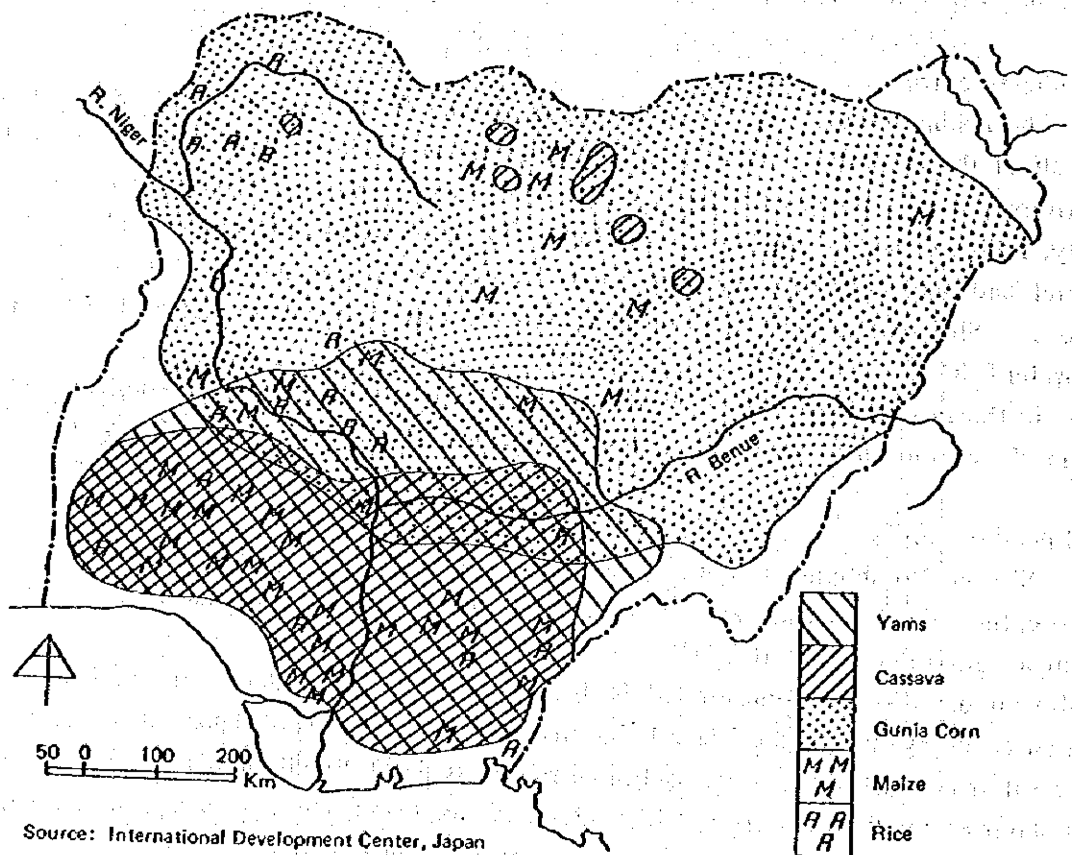
Nigeria also abounds in mineral resources, most importantly petroleum, natural gas, coal, iron ore, tin, columbite, lead, zinc, and limestone. Gold, copper, tungsten, molybdenum, and bauxite are also mined. (Fig. II-2-4)

Mineral deposits are concentrated in the eastern states. Petroleum, the mainstay of the Nigerian economy, lies in the Niger Delta area. This petroleum is of light and superior quality with a sulfur content of 0.2%. Its confirmed reserve is about 20 billion barrels; its production in 1979 about 859 million barrels, of which 93.4% was exported. This export represented 93.8% of the nation's total export value. There are some oil fields in the coastal part of Cross-River State



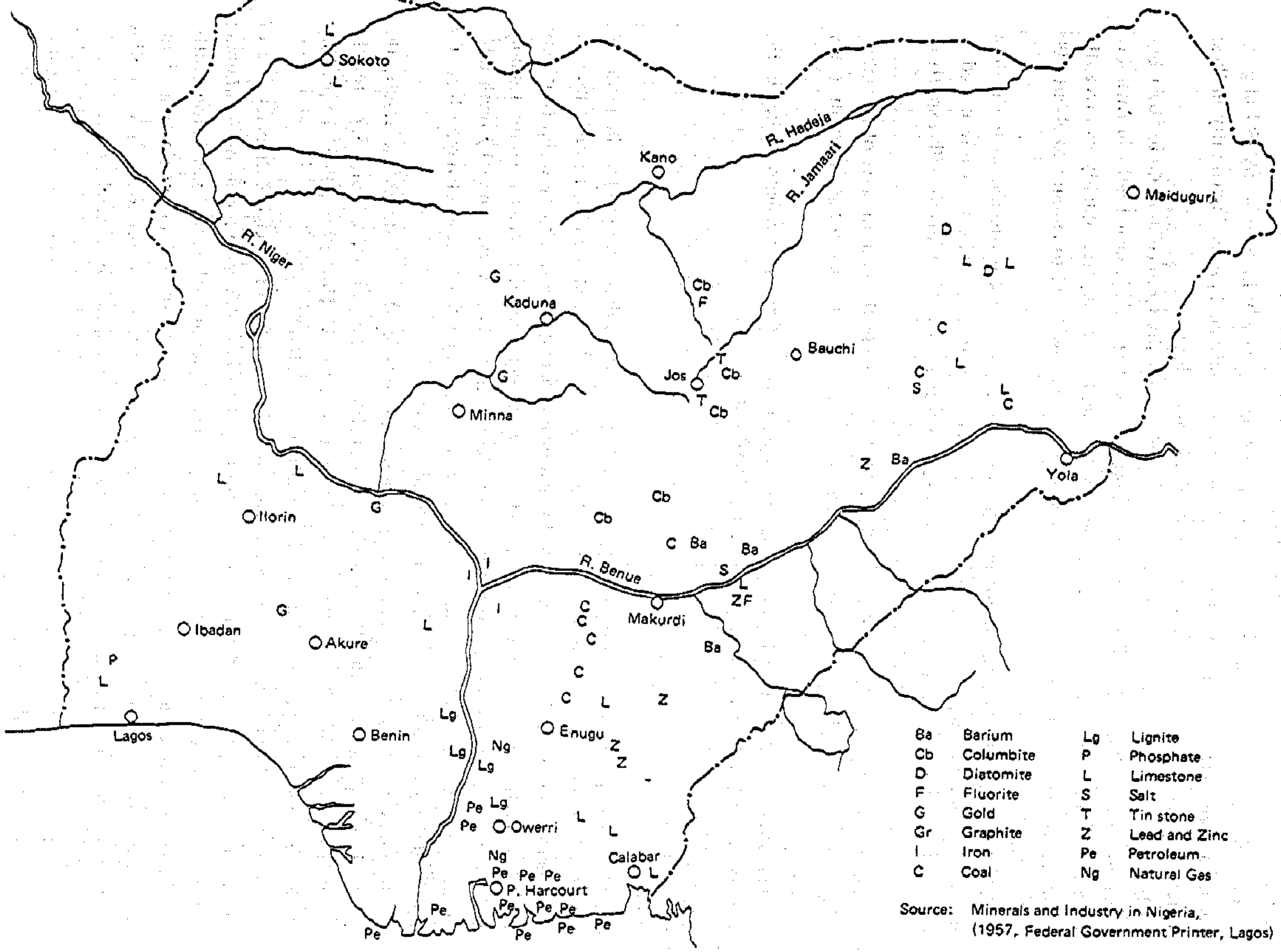
Source: International Development Center, Japan

Fig. II-2-2 Map of Places Producing Staple Agricultural Products (1)



Source: International Development Center, Japan

Fig. II-2-3 Map of Places Producing Staple Agricultural Products (2)



Source: Minerals and Industry in Nigeria, (1957, Federal Government Printer, Lagos)

Fig. II-2-4 Mineral Map of Nigeria

where the proposed sites for NOT-east are situated, and a new deposit is said to have recently been discovered. Natural gas, an associated product of crude oil is also abundant.

Coal deposits lie mainly in the central eastern region specifically in the vinicity of Enugu in Anambra State and Okabba in Benue State. Nigeria is the only coal-producing country in West Africa with an estimated total reserve of about 224.8 million tons.

Iron ore found in Nigeria in the past was mainly of low quality (iron content 40 to 50%), but deposits of about 76.5 million tons were confirmed to exist at Agbaja near Enugu in Anambra State and at the confluence of the Niger and the Benue. Coal of superior quality was recently discovered at Itakpe in the western state of Kwara with deposits said to amount to about 400 million tons.

Tin and columbite are the major metallic minerals exported from Nigeria. In the eastern states tin is mined mainly in Plateau and Bauchi States, while columbite is mainly mined in Bauchi State. Nigeria is one of the world's largest exporters of these minerals with exports of 5,300 tons of tin and 1,600 tons of columbite in 1974.

The main deposits of lead and zinc exist in Abakaliki area in the eastern state of Anambra. 1,606 tons of lead and 2,236 tons of zinc were mined in 1964, although these are not in steady production.

Limestone is widely distributed throughout Nigeria. One of the larger deposits lies in the vicinity of Calabar close to the proposed sites of NOT-east.

(3) Industry

The primary sector represented 55.4% of the Nigerian gross domestic product in 1965–66 (1962–63 factor cost base), thus classifying Nigeria as an agricultural country. Later, as revenue from petroleum export became central to the national economy, the secondary sector (not only mining but also building, construction, and manufacturing) and the tertiary sector (mainly wholesale and retail businesses) saw remarkable development. The average annual growth rates between the years 1965–66 and 1975–76 were 15.1% and 9.7%, respectively, which far exceeded the overall 6.8% growth rate for industry as a whole.

In the primary sector, meanwhile, agricultural production decreased. As the result, 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 (Table II-2-3). Notwithstanding, the primary sector continues to employ more than half the nation's work force.

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 industry, 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 its general welfare.

Since GDP data are not available by state, we analyzed the industrial characteristics of the eastern states with reference mainly, to agriculture and manufacturing industry, using other data. The outline is as follows:

Table II-2-3 Gross Domestic Product at 1962–63 Factor Cost

	A: 1965–66		B: 1970–71		C: 1975–76		Average Annual Growth Rate		
	N million	%	N million	%	N million	%	B/A	C/B	C/A
1. Primary Sector	1,742.2	55.4	1,887.7	44.7	1,712.2	28.1	1.6	-1.9	-0.2
Agriculture & Livestock	1,524.2	48.4	1,580.8	37.5	1,343.5	22.0	0.7	-3.2	-1.3
Forestry & Logging	143.4	4.6	129.2	3.1	180.4	3.0	-2.1	6.9	2.3
Fishing	74.6	2.4	177.7	4.2	188.3	3.1	19.0	1.2	9.7
2. Secondary Sector	533.0	16.9	1,040.1	24.7	2,178.7	35.7	14.3	15.9	15.1
Mining & Quarrying	149.8	4.8	501.5	11.9	866.4	14.2	27.3	11.6	19.2
Building & Construction	162.2	5.2	221.0	5.2	688.0	11.3	6.4	25.5	15.5
Manufacturing & Craft	221.0	7.0	317.6	7.5	624.3	10.2	7.5	14.5	10.9
3. Tertiary Sector	871.6	27.7	1,291.2	30.6	2,209.6	36.2	8.2	11.3	9.7
Electricity & Water Supply	18.2	0.6	24.0	0.6	57.1	0.9	5.7	18.9	12.1
Wholesale & Retail Trades	418.4	13.3	512.9	12.2	745.8	12.2	4.2	7.8	6.0
Transport & Communication	146.2	4.6	137.9	3.3	318.3	5.2	-1.2	18.2	8.1
General Government	96.8	3.1	327.6	7.8	555.7	9.1	27.6	11.1	19.1
Education	97.0	3.1	133.1	3.2	233.8	3.8	6.5	11.9	9.2
Health	22.6	0.7	39.5	0.9	77.2	1.3	11.8	14.3	13.1
Other Services	72.4	2.3	116.2	2.8	221.7	3.6	9.9	13.8	11.8
Total	3,146.8	100.0	4,219.0	100.0	6,100.5	100.0	6.0	7.7	6.8

Source: Federal Office of Statistics, Lagos.

1) Agriculture

a. Crops

In 1978–79, the area planted for crops other than oil palms and rubber was 3,302,000 ha with a production of 9,053,000 tons in the eastern states, representing 34.7% and 60.2%, respectively, of the Federation's total. The staple crops were yam (4,958,000 tons, 54.8%), cassava (1,237,000 tons, 13.7%) and gunia corn (1,205,000 tons, 13.3%). These three crops alone account for 81.8% of the output of all crops. Production is large relative to the size of the planted area, indicating that productivity is good. The average yield per hectare in the eastern states is 2.74 tons, which far exceeds the Federation's average of 1.58 tons. (Table II-2-4)

b. Livestock

The count of livestock kept in the Federation in 1978–79 was 94,692,000 head. Of this total, the eastern states accounted for 45,941,000 or 48.5%. In the shares of the eastern states for the entire Federation by type of livestock, pigs were the highest with 75.2%, followed by poultry with 54.2%. The ratios of goat and sheep were relatively small at 37.8% and 38.4%, respectively. As mentioned already, livestock is raised mainly in the northern part of the eastern states (Table II-2-5).

The area and the population of the eastern states are 53.0% and 49.1%, respectively, of the Federation's total (1980) (see Table II-2-1). Whereas the planted area for crops amounts to only 34.7%, crop production is 60.2% and the livestock count is 48.5%. There are, in addition, production centers of oil palms in the eastern states. It can therefore be concluded from the comparison of agriculture-related indicators with the population ratios that the eastern states are, as a whole, an excellent agricultural zone with a higher productivity than the western states.

Table II-2-4 Crop Estimates 1978–79

	A: Federation Total				B: Eastern States				Average Yield per Hectare		Share (B/A:%)	
	Area Planted		Production		Area Planted		Production					
	'000 ha	%	'000 tons	%	'000 ha	%	'000 tons	%	Federation	Eastern States	Area Planted	Production
Cassava	181	1.9	1,621	10.8	121	3.7	1,237	13.7	8.96	10.22	66.9	76.3
Yam	470	4.9	5,866	39.0	367	11.1	4,958	54.8	12.48	13.51	78.1	84.5
Cocoyam	37	0.4	182	1.2	31	0.9	157	1.7	4.92	5.06	83.8	86.3
Millet	2,377	25.0	2,386	15.9	712	21.6	538	5.9	1.00	0.76	30.0	22.5
Gunia Corn	3,008	31.6	2,409	16.0	1,036	31.4	1,205	13.3	0.80	1.16	34.4	50.0
Maize	631	6.6	659	4.4	346	10.5	335	3.7	1.04	0.97	54.8	50.8
Beans	1,472	15.5	498	3.3	265	8.0	101	1.1	0.34	0.38	18.0	20.3
Soybeans	20	0.2	11	0.1	6	0.2	3	0.0	0.55	0.50	30.0	27.3
Ground Nut	810	8.5	801	5.3	204	6.2	198	2.2	0.99	0.97	25.2	24.7
Cotton	201	2.1	211	1.4	25	0.8	37	0.4	1.05	1.48	12.4	17.5
Rice	152	1.6	280	1.9	75	2.3	201	2.2	1.84	2.68	49.3	71.8
Melon	131	1.4	106	0.7	99	3.0	66	0.7	0.81	0.67	75.6	62.3
Beniseed	16	0.2	18	0.1	15	0.5	17	0.2	1.13	1.13	93.8	94.4
Total	9,506	100.0	15,048	100.0	3,302	100.0	9,053	100.0	1.58	2.74	34.7	60.2

Source: Provisional Report on Crop Estimates 1978/79, Federal Office of Statistics, Lagos.

Table II-2-5 Livestock Estimates: 1978/79

(Number kept)

	A: Federation		B: Eastern States		Share (B/A: %)
	'000	%	'000	%	
Poultry	60,460	63.8	32,799	71.4	54.2
Goats	22,538	23.8	8,519	18.5	37.8
Sheep	7,780	8.2	2,988	6.5	38.4
Catteles	2,473	2.6	1,033	2.2	41.8
Pigs	613	0.6	461	1.0	75.2
Donkeys	687	0.7	141	0.3	20.5
Total	94,692	100.0	45,941	100.0	48.5

Source: Livestock Estimates 1978/79, Federal Office of Statistics, Lagos.

2) Manufacturing industry

The Nigerian manufacturing industry in 1975 comprised 1,290 factories, each employing 10 or more workers. The number of workers in the employ of these factories was 244,243; the gross output about ₦2.61 billion; and the value added about ₦1.19 billion. The per-factory number of workers was 189 and the per-factory gross output was about ₦2 million; the per-worker gross output was ₦10,691 and the rate of value added was 45.4%. (Table II-2-6)

Nigeria's manufacturing industry can be outlined as follows:

a. Manufacturing industries based on the domestic resources of Nigeria and catering to the basic needs of food, clothing, and housing are predominant. These include food processing, textiles and apparel, wood products and furniture, ceramic, stone and clay products, and others. These industries represent 63.0% of the number of factories, 63.0% of the number of workers, 50.6% of the gross output, and 52.0% of the value added.

b. In addition to the above, there are other industries which utilize domestic resources. They produce leather and leather products, pulp, petroleum and coal products, rubber products, etc.

c. Chemical products represent fully 8.4% of the total gross output. The major products are final products such as drugs, medicines, and soap, but basic chemical industry products are mostly imported.

d. The production of primary iron and steel, and nonferrous metals represents only 1.0% of the total gross output. Steel and other iron materials are therefore mostly imported.

e. The machine industry represents 9.2% of the total gross output but this industry produces mainly electrical machines and equipment for the daily use of the people.

The above characteristics of the Nigerian manufacturing industry indicate that industrialization is still in the initial stage and that industry lacks structural inter relations among industries, in other words, the inner circulation and roundabout of industrial production. However, Nigeria is active in industrialization and has since 1975 embarked on automobile assembly plants, oil refineries, iron and steel plants, and other projects – some of which have already been completed – so the present industrial structure has been improved from the level of 1975.

Broken down by state, the conditions of the manufacturing industry in 1975 were as shown in Table II-2-7. In this table, the total of values for states somewhat differs from the Federation's total due to statistical reasons.

The number of factories in the eastern states is 516. The number of workers is 66,986, the gross output is about ₦296 million, and the value added is about ₦154 million. The shares of the eastern states in the entire Federation are 40.5% in the number of factories, 27.8% in the number of workers, 11.3% in the gross output, and 12.9% in the value added.

As can be seen from the above, Nigeria's manufacturing industry extends only slightly into the east, being concentrated in the western states. The population ratio between the eastern and western states is nearly equal at 49 : 51, but the ratio of workers in manufacturing industry is approximately 28 : 72. The eastern states are thus far behind the western states in industrialization. This is in contrast to the fact that the eastern states, as described already, constitute an excellent agricultural zone with a relatively high productivity. But in Nigeria, manufacturing industries, notably large industrial plants, are highly concentrated in Lagos State, which represents 25.7% of the Federation total's number of factories, 43.6% of the number of industrial workers, 65.6% of its gross output, and 87.1% of its value added. The gap, therefore, in industrial accumulation between the western states minus Lagos State, and the eastern states is not so pronounced as it might seem. It must nonetheless be said that manufacturing industries in the eastern states are on a smaller scale as a whole and that their productivity is low. (Table II-2-7)

Among the eastern states, Anambra and Bendel excel in the number of factories. Cross River and Bendel excel in the number of workers. Bendel is second only to Anambra in gross output while Anambra takes first and Bendel second in value added. These three states are central to the manufacturing industries of the eastern states and are all in the south. By contrast, the industrial accumulation in the northern states of Gongola, Bauchi, and Borno is very low.

According to the regional distribution of factories in the Industrial Directory 1980, the manufacturing industries in the eastern states are characterized as follows: (Table II-2-8)

a. The greater part of industry in the eastern states centers on vegetable oils and fats, grain mill products, sawmills, wooden furniture and fixtures, rubber products (crepe rubber), petroleum refining, and other industries using the resources of these states (oil palms, rice, wood, rubber, and petroleum).
b. Chemical product plants are relatively few. There are only two plants producing basic industrial chemicals, and none producing fertilizers, pesticides, or other chemical products.
c. The eastern states have only two plants in the iron and steel basic industries, compared with seven for the western states.
d. Machine industry factories are also few. There is only one radio and television plant, and six automobile building and assembly plants; there is no plant producing electrical appliances or motorcycles.

The above characteristics, by industry, of the manufacturing industries in the eastern states represent intensively the characteristics of the Federation itself which have already been described. Resource-based industries are predominant and the accumulation of basic material industries (chemicals; iron and steel) and machine industry is smaller than in the Western states, demonstrating that the industries in the eastern states consist mainly of traditional local industries and that in these states, modern industries requiring more advanced technologies are particularly underdeveloped, compared with the western states.

In as much as the eastern states are far behind the western states in industrialization, the industrial development of the eastern states should be promoted with priority, so that the nation can achieve balanced development.

Table II-2-6 Survey of Results by Manufacturing Industry: 1975

	Factory		Employee		Gross Output		Value Added		Per Establishment		Gross Output Per Employee (₦)	Rate of Value Added (%)
	Number	%	persons	%	₦ '000	%	₦ '000	%	Employees (person)	Gross Output (₦ '000)		
Food Processing	294	22.8	56,961	23.3	683,274	26.2	328,914	27.7	194	11,995	11,995	48.1
Textiles & Apparel	132	10.2	60,673	24.8	458,719	17.6	197,046	16.6	460	3,475	7,561	43.0
Leather & Leather Products	41	3.2	6,231	2.6	69,329	2.7	40,455	3.4	152	1,691	11,126	58.4
Wood Products & Furniture	276	21.4	21,517	8.8	92,264	3.5	44,077	3.7	78	334	4,288	47.8
Pulp & Paper Products	25	1.9	5,114	2.1	82,183	3.1	29,781	2.5	205	3,287	16,070	36.2
Printing & Publishing	98	7.6	12,396	5.1	69,207	2.7	41,574	3.5	126	706	5,583	60.1
Chemical Products	41	3.2	9,801	4.0	219,311	8.4	120,894	10.2	239	5,349	22,376	55.1
Petroleum & Coal Products	15	1.2	3,054	1.3	151,617	5.8	69,109	5.8	204	10,108	49,645	45.6
Rubber & Plastic Products	66	5.1	16,513	6.8	121,617	4.7	59,329	5.0	250	1,843	7,365	48.8
Ceramic, Stone & Clay Products	111	8.6	15,854	6.5	86,878	3.3	46,986	4.0	143	783	5,480	54.1
Primary Iron & Steel; Non-ferrous Metal	6	0.5	720	0.3	29,007	1.1	24,293	2.0	120	4,835	40,288	83.7
Fabricated Metal Products	119	9.2	27,334	11.2	289,258	11.1	102,601	8.7	230	2,431	10,582	35.5
Machinery	43	3.3	7,810	3.2	240,560	9.2	75,070	6.3	182	5,594	30,802	31.2
Others	23	1.8	1,265	0.5	17,868	0.7	5,294	0.4	55	777	14,125	29.6
Total	1,290	100.0	244,243	100.0	2,611,092	100.0	1,185,423	100.0	189	2,024	10,691	45.4

Source: Economic Indicators Vol. 13, Federal Office of Statistics, Lagos.
Note : This table is the summary of "the 1975 Survey of Manufacturing Establishment employing more than ten persons".

Table II-2-7 Manufacturing Industry by State: 1975

	Factory		Employee		Gross Output		Value Added		Per Establishment		Gross Output per Employee (₦)	Rate of Value Added (%)
	Number	%	Persons	%	₦ '000	%	₦ '000	%	Employees (persons)	Gross Output (₦ '000)		
The Western States												
Lagos	328	25.7	105,086	43.6	1,713,896	65.6	779,466	65.5	320	5,225	16,309	45.5
Ogun	53	4.2	1,890	0.8	6,909	0.3	3,820	0.3	36	130	3,656	55.3
Ondo	50	3.9	3,690	1.5	13,632	0.5	8,741	0.7	74	273	3,694	64.1
Oyo	100	7.8	7,474	3.1	40,755	1.6	26,240	2.2	75	408	5,453	64.4
Kwara	28	2.2	7,590	3.2	88,794	3.4	68,356	5.7	271	3,171	11,699	77.0
Niger	16	1.3	343	0.1	1,066	0.0	711	0.1	21	67	3,108	66.7
Sokoto	36	2.8	4,056	1.7	18,213	0.7	8,458	0.7	113	506	4,490	46.4
Kaduna	59	4.6	24,765	10.3	276,982	10.6	87,457	7.3	420	4,695	11,184	31.6
Kano	89	7.0	19,057	7.9	155,130	5.9	53,339	4.5	214	1,743	8,140	34.4
Subtotal	759	59.5	173,951	72.2	2,315,377	88.7	1,036,588	87.1	229	3,051	13,311	44.8
The Eastern States												
Bendel	108	8.5	16,888	7.0	80,419	3.1	35,092	2.9	156	745	4,762	43.6
Rivers	37	2.9	7,629	3.2	41,485	1.6	14,555	1.2	206	1,121	5,438	35.1
Imo	76	6.0	4,364	1.8	28,399	1.1	17,233	1.4	57	374	6,508	60.7
Anambra	131	10.3	7,766	3.2	66,732	2.6	36,174	3.0	59	509	8,593	54.2
Cross River	66	5.2	23,521	9.8	23,740	0.9	13,966	1.2	356	360	1,009	58.8
Benue	26	2.0	795	0.3	3,214	0.1	2,161	0.2	31	124	4,043	67.2
Plateau	42	3.3	4,241	1.8	40,310	1.5	29,249	2.5	101	960	9,505	72.6
Gongola	12	0.9	786	0.3	1,346	0.1	963	0.1	66	112	1,712	71.5
Bauchi	8	0.6	465	0.2	6,696	0.3	3,103	0.3	58	837	14,400	46.3
Borno	10	0.8	531	0.2	3,672	0.1	1,260	0.1	53	367	6,915	34.3
Subtotazl	516	40.5	66,986	27.8	296,013	11.3	153,756	12.9	130	574	4,419	51.9
Federation Total	1,275	100.0	240,937	100.0	2,611,390	100.0	1,190,344	100.0	189	2,048	10,838	45.6

Source: Economic Indicators Vol. 13, Federal Office of Statistics, Lagos.

Table II-2-8 Distribution of Manufacturing Industry: 1980

Industry Type	Share of the Eastern States				
	75 ~ 100%	50 ~ 74%	25 ~ 49%	1 ~ 24%	Nothing
Food Processing (510/759)	• Fish Crustaces & Similar Foods (Canning, preserving, processing (3/3) • Vegetable Oils & Fats (81/109) • Grain Mill Products (44/53) • Distillery & Blending of Spirits (3/4)	• Bakery Products (344/462) • Beer & Stout • Brewing (5/8)	• Meat Products (12/31) • Dairy Products (7/10) • Animal Feed (3/10) • Soft Drinks & Carbonated Water (4/13)	• Fruits & Vegetable (canning, preserving and processing) (1/9) • Sugar Factories & Refineries (1/6) • Miscellaneous Food Preparations (1/15) • Tobacco Products (1/6)	• Cocoa, Chocolate & Sugar Confectionery (0/20)
Textile & Apparel (313/462)	• Apparel(212/234)	• Textiles (89/157)	• Carpet & Rugs (2/5)	• Finished Textile Good (5/31) • Knitting Mills (4/29) • Cordage, Rope & Turine (1/6)	
Leather & Leather Products (35/96)		• Footwear Leather (29/45)		• Tannery & Leather Finishing (4/31) • Leather Products & Luggage (2/19)	• Fur Dressing & Dyeing Industries (0/1)
Wood Products & Furnitures (228/327)	• Other Wood Products (9/11) • Wooden Furnitures & Fixture (134/169)	• Sawmills (85/147)			
Pulp & Paper Products (2/29)			• Pulp, paper & paper boad (2/6)		• Paper Containers & Boxes (0/12) • Others (0/11)
Printing & Publishing (81/180)			• Printing & Publishing (81/180)		
Chemical Products (35/127)			• Soap & Other(20/45) Toilet Preparation • Paints, Varnishes & Lacquers (4/14) • Drugs & Medicine (9/33)	• Basic Industrial Chemicals (2/12)	• Fertilizer & Pesticide (0/5) • Other Chemical Products (0/18)
Petroleum & Coal Products (2/7)		• Petroleum Refineries (2/3)			• Other Petroleum & Coal Products (0/4)
Rubber & Plastic Products (40/123)	• Other Rubber Products (28/33)		• Tire & Tubes (1/4) • Tire Retreading (5/14)	• Plastic Products (6/72)	
Ceramic Stone & Clay Products (64/135)		• Pottery China & Earthware (7/11)	• Cement (5/11) • Blocks, Bricks, Tiles & Other Products (50/104)	• Glass & Glass Products (2/9)	
Primary Iron & Steel Nonferrous Metal (4/13)		• Nonferrous Metal Basic Industries (2/4)		• Iron & Steel Basic Industries (2/9)	
Metal Products (192/383)		• Structural & Fabricated Products (170/315)	• Cutlery, Hand Tools & General Hardware (7/25) • Metal Furniture (15/43)		
Machinery (27/108)		• Agricultural Machinery & Equipment (3/5) • Shipbuilding & Repair (8/15) • Bicycle Assembly (2/4)	• Other Machines & Equipment (2/8) • Electrical and Industrial Machinery & Apparatus (2/6)	• Radio T.V. and Communication Equipment & Apparatus (1/17) • Other Electrical Apparatus & Supplies (1/10) Automobile Building & Assembly (8/21)	• Special Industrial Machinery & Equipment (0/9) • Electrical Appliances & House Ware (0/9) • Motorcycle Assembly (0/2) • Precision Machinery (0/2)
Others (3/22)				• Other Manufacturing Industries (3/18)	• Jewellery & Related Articles (0/4)

Note: exampe (2/6)
2 shows number of factories in the eastern states.
6 shows number of factories in Nigeria.

Source: Industrial Directory, 8th edition 1980, Federal Ministry of Industries, Lagos.

II-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. The federal trunk roads and the state trunk roads are constructed and maintained by the Federal Government and the State Governments, respectively. The present total length of the federal trunk roads is 27,000 km; the local trunk roads 41,000 km.

When NOT-east is constructed, route F103 which connects Warri, Opobo, Eket, and Oron will become major route of commodity transportation. Improvement of the road approaching route F103 is considered to be one of related projects of NOT-east. A part of route F103 has already been improved, but it is 2-lane road and its traffic capacity is insufficient. After the opening of NOT-east, widening opprations will be necessary. The cost of this widening is not included in the project cost of NOT-east.

(2) Railways

1) Present conditions

The rail network in Nigeria is composed of two north-south trunk lines connecting Lagos and Port Harcourt Port with inland areas (Fig. II-2-6). The total length is 3,505km and all the lines consist of single track, 3' -6" gauge (1,067 mm). The average cargo transportation volume over the last several years is 2.5 million tons/year. 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.

2) Construction plan for new railway lines

There is a construction plan for new railway lines of standard gauge (1,435mm) to connect Warri and Calabar Port, as well as Lagos and Port Harcourt Port with the interior. The routes of the new lines are different from the routes of the existing lines and will be newly developed. Positions of the route are as yet uncertain due to political reasons. Fig.II-2-7 shows the latest plan.

Center posts on the line connecting Port Harcourt with Makurdi or Ajaokuta have already been put up and construction could commence at the end of 1981 or the beginning of 1982. It would require three years to complete works.

Warri-Akore-Kabba-Ajaokuta Line is the second priority line after the above-mentioned Port Harcourt Line. The aim of constructing this line is the transportation of from Kabba to Ajaokuta. Transportation capacity of the new line will be 10 - 12 million tons/year.

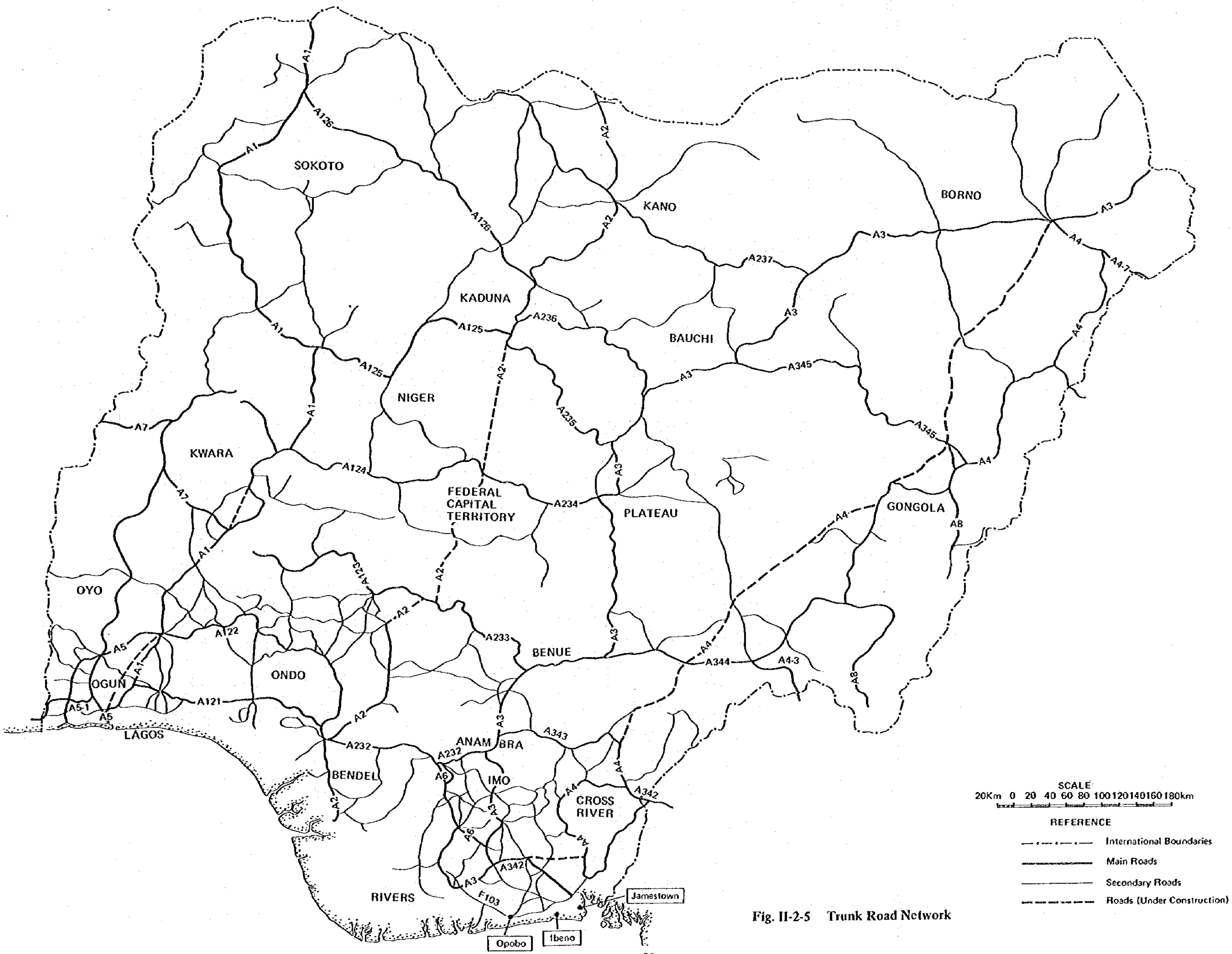


Fig. II-2-5 Trunk Road Network

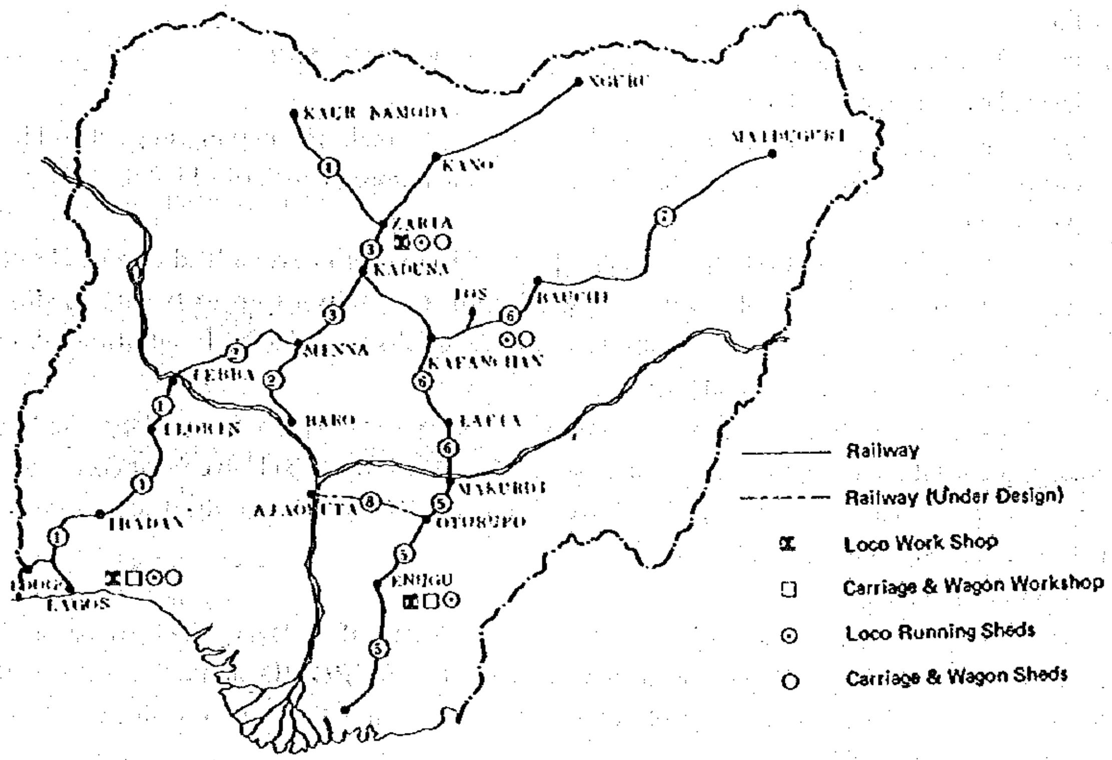


Fig. II-2-6 Railway Network

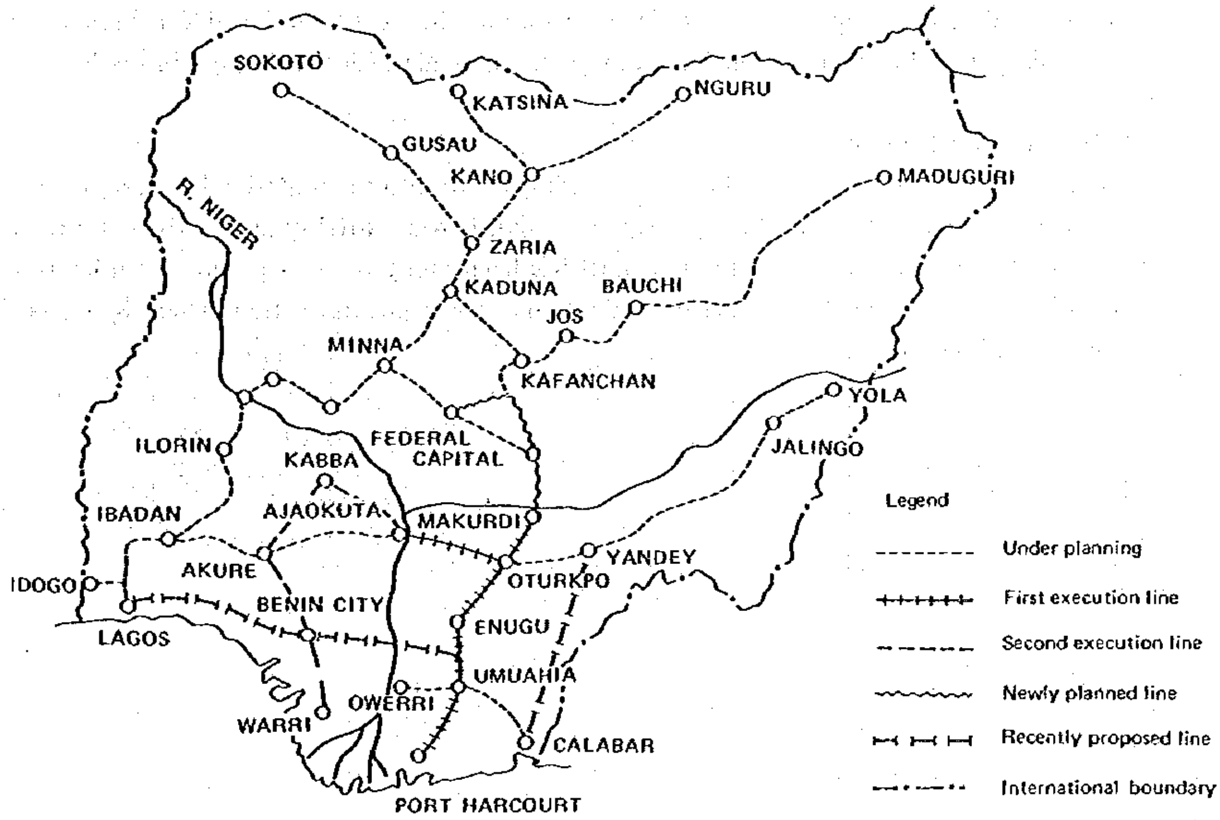


Fig. II-2-7 New Standard Gauge Line

(3) Ports

1) Present situation of port facilities[1]

a. Lagos Port (Apapa and Tin Can Island)

These two ports are served by a common entrance channel. The maximum permissible draft is 10.7 m. Recently, the channel has been dredged to a maximum depth of -11.0 m.

Apapa Port:

The old Apapa Quays (excluding the Third Wharf Extension) cover a land area of about 100 ha with a total quay length of 2,459 m, and a handling capacity of up to twenty loading and discharging vessels at once. Water depth at the main berths is -8.23 m. In addition, about 35 mooring buoy pool anchorages and jetties are available.

The Third Wharf Extension, located south of the existing Apapa Quay along the Badagry Creek, has a total quay length of 1,600 m of which 1,000 m is used exclusively for containers and is well-equipped with modern cargo handling equipment. The maximum draft alongside is 11.5 m. The port is served by rail and road.

Tin Can Island Port:

Tin Can Island Port is situated at west of Apapa, North of Badagry Creek. It consists of a 2,500 m wharf with ten berths (seven for general cargo, two for RO-RO, and one for dry bulk). It covers an area of 73 ha and is capable of handling between 10 and 15 vessels at a time. The maximum draft alongside is 11.5 m.

Kirikiri Jetty:

This is a lighter terminal which serves as a discharging depot for cargo off-loaded in mid-stream onto barges. Both "phase one" and "phase two" of the terminal provide 780 m total quay length with covered/open storage areas. One of the phases was designed for discharging bagged cement while the other was allocated to private companies, for the purpose of discharging general cargo.

Ikorodu Lighter Terminal:

This terminal was also constructed as an off-loading depot into the hinterland for cargo being off-loaded in mid-stream and overside discharge of cargo. It has a total quay length of 1,140 m with a -4.5 m water depth. The Ikorodu channel has been dredged to -4 m and seven lighting pillars are being installed in the channel to facilitate day and night navigation. There is an auxiliary stroage of about 100 ha.

1) Handbook of the Nigerian Ports Authority, 1980.

Table II-2-9 Berthing Facilities: Apapa Quay

Berth Identity/Number	Length (m)	Maximum Draft (m)
OLD APAPA QUAYS:		
1	157	8.23
2	146	8.23
3 ~ 5, 7, 8, 10 ~ 13	152	8.23
6	183	8.23
7A and 10A	122	8.23
14	220	8.23
THIRD APAPA WHARF EXTENSION:		
15 ~ 18	250	13.50
19 and 20	250	13.50
OTHER BERTHS:		
Fish Wharf	115	5.48
Bulk Oil Plant (B.O.P.) (Lever Brothers Wharf)	152	7.92
Petroleum Wharf Apapa (P.W.A.) for Ocean Going Tankers	177	7.62
Petroleum Wharf Apapa (Inner) (P.W.A.) for Coaster Tankers	76	4.88
New Oil Jetty (N.O.J.)	177	7.62
Ijora Wharf	122	5.79
MARINE BUOY NO.:		
1	182	7.93
2	182	7.62
3	167	7.32
4	228	7.32
5	152	7.62
6	182	7.01
7	152	5.79
8	122	5.28
9	106	5.48
10 and 11	91	4.87
Bruce Buoy 1 ~ 4	182	8.23
Pool Anchorage 2	182	8.23
Pool Anchorage 3 and 4	137	7.93
Commodore Buoy No. 1	288	8.23
Commodore Buoys No. 2 and 3	215	8.23

Table II-2-10 Berthing Facilities: Tin Can Island Port

Berth Identity/Number	Maximum Length (m)	Maximum Draft (m)
1, 1A and 2	180	10.0
3	185	10.0
4 and 4A	180	10.0
5	165	10.0
6, 7 and 7A	200	10.0
8	195	10.0
9	120	9.0
9A	155	9.0
10	165	9.0

b. Rivers Port Complex

Port Harcourt Port lies on the bend of the Bonny River and serves, by virtue of its connection with the mainlines system of the Nigerian Railway Corporation, the hinterland embracing the Rivers, Imo, and Anambra States, and some northern States. The port is also the shipping point for coal mined from the Udi coal fields near Enugu.

The main quay, which covers an area of about 47 ha, is about 1,360 m long, capable of berthing eight main line vessels. The maximum draft at H.W.S. tides for vessels entering Port Harcourt Port is 7.62 m; though Bonny channel 11.73 m; and Okrika 9.14 m Chart Datum.

Table II-2-11 Berthing Facilities: Port Harcourt Port

Berth Identity/Number		Length (m)	Maximum Draft (m)
1 ~ 3		158.00	7.92
4		110.00	7.92
5		128.00	7.92
6 and 7		134.00	7.92
8		137.00	7.62
9		143.00	7.62
10 and 11		137.00	6.71
12		107.00	6.00
Lighter Berth		8.00	1.83
Tanker Buoys		183.00	6.71
Dockyard Creek:			
Mooring Buoy	1	189.00	7.00
	2	205.00	7.00
	3	160.00	7.00
	4	239.50	7.00
	5	181.00	7.00

c. Delta ports complex

The ports of Warri, Koko, and Burutu are operated by the Authority for the handling of cargo. The approaches to all Delta ports are restricted by the water depth at Escravos Bar which is at present -6 m. The depth of the channel must be dredged to at least -10 m so that vessels drawing deeper drafts can be berthed and the newly constructed modern port facilities at the Warri port can be exploited fully. To this effect, the channel from Warri to Burutu has already been dredged up to -10 m, with the exception of areas where oil or gas pipelines cross the channel. The pipelines are to be re-located by the various oil companies by the end of 1980. The remaining part of the channel up to the Escravos will also be dredged and completed by mid-1981.

Warri Port: Warri is some 68 nautical miles from the Escravos Bar. The port includes an old port with a total quay lenght of 876 m and a newly developed modern port commissioned for operation on 16th June, 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 11.5 m.

Table II-2-12 Berthing Facilities: Warri Port

Berth Identity/Number	Length (m)	Maximum Draft (m)
OLD PORT		
Main Berths 1 ~ 4	490 (total)	6.5
Canal Berths 1 ~ 3	340 (total)	6.5
Customs Jetty 1	46	4.0
6 Mooring Buoy Berths	122 ~ 137	
NEW PORT:		
6 Main Berths – 250 Meters Each	1500 (total)	11.5 MSLW
1 Roll-on/Roll-off	100	11.5
1 Service Berth		11.5

Koko Port: This port lies on the Benin River, 48 nautical miles from the Escravos lighthouse. The wharf is 137 m long with 7.32 m of water alongside. Adequate cargo-handling equipment and sufficient space for storage are also available.

Table II-2-13 Berthing Facilities: Koko Port

Berth Identity/Number	Length (m)	Maximum Draft (m)
1	137	7.32

Table II-2-14 Berthing Facilities: Burutu Port

Berth Identity/Number	Length (m)	Maximum Draft (m)
Main Berth	229	(N/A)
Small Berth	91	(N/A)

d. Calabar Port:

This port is about 40 nautical miles from the Fairway Buoy and 5 nautical miles from the main entrance channel of the Cross River. The maximum recommended draft for vessels using this main line river port is 7 m Chart Datum.

This port now comprises the old Calabar port and the new port which is 860 m long, capable of providing modern berthing facilities for four to six vessels and has been commissioned for operation since 19th June, 1979.

Table II-2-15 Berthing Facilities: Calabar Port

Berth Identity/Number	Length (m)	Maximum Draft (m)
OLD PORT		
Jackson wharf	150	7.00
Millerio wharf	150	7.00
Buoy Berths	—	7.00
NEW PORT		
1 ~ 3 (Esuk Utan)	286.6	7.00

2) Cargo throughput

Table II-2-16 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.

Table II-2-16 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

Nigeria's petroleum oil terminal and jetties include both on-shore and off-shore terminal facilities for oil tankers. These facilities handled 105.2 million tons of crude petroleum oil and 2.0 million tons of refined petroleum oil in 1979/80.

Table II-2-17 Cargo Throughput Handled at Oil Terminals

(1,000 tons)

Oil Terminal/Port	Crude Petroleum Oil	Refined Petroleum Oil		
		Discharged	Loaded	Total
Rivers Port Complex				
Bonny terminal				
on-shore	7,966			
off-shore	19,623			
Okrika Jetty		465	716	1,180
Brass terminal	13,883			
Delta Port Complex				
Escravos terminal	17,637			
Forcados terminal	32,404			
Pennington terminal	2,405			
Warri		11	807	818
Calabar Port				
Kwa Ibo terminal	11,349			
Total	105,267	476	1,523	1,999

Source: NPA Diary 1981

The existing Apapa Petroleum Jetty is close to port installations and thus exposes the port to hazards which could arise from the outbreak of fire. Consequently, a new petroleum jetty at Atlas Cove was planned to provide berthing facilities for oil tankers. The jetty was completed in July of 1981.

(4) Inland Waterways

Nigeria has many inland waterways such as rivers, creeks, lagoons, etc. 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 Calabar River, the Imo River and others are also used.

At one time the rivers Niger and Benue were extensively used for the transport of agricultural products intended for export from the northern states but their importance has declined in recent years because of the improvement of roads. The Niger, however, has been given an entirely new role, and is to be used for the transportation of goods related to the Ajaokuta Steel Mill in the western state of Kwara. 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, mainly between Lokoja and Onne port. This effort will make the river available for barge transportation of 2,000 to 6,000 tons, by securing a water depth of -1.5 to -2.0 meters. An annual transportation amount of 200,000 tons is expected as a result of this improvement.

As for the River Benue, dredging and the improvement of facilities of such river ports as

Makurdi, Ibi, Lau, and Yola are proposed and the necessary survey are to be conducted in 1982.

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 at Oron, Itigidi, Oferekpe, Ikot Okpara, Afunatam, and other points. The Calabar also has some ferries, including one used exclusively for the transportation of limestone. The Imo River has a ferry at Ikot Abashi (Opobo) and a base for an artisanal marine fisheries project. Speed boats are operated between Ikot Abashi and Port Harcourt; time taken for this transport is 2 to 3 hours. 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 quantities of goods transported by these inland waterways are small; goods transported include limestone, fish, wood, palm oil and kernels, etc.

The improvement of navigational conditions of the River Niger marks the advent of a new era of inland waterways transportation, and can be expected not only to support the Ajaokuta steel mill project but also to contribute to the industrial development of the bordering eastern states of Benue, Anambra, Imo, and Rivers. No drastic improvement of 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 industries.

(5) Pipelines

Pipelines are the most suitable form of transportation for liquids and gas. There are vast petroleum pipeline networks in the U.S.A., Europe, and the U.S.S.R. In Nigeria, pipelines used to be used mainly for transporting crude oil between the oil fields and export stockyards. However, pielines between oil fields and refineries or between refineries and stock points are now being rapidly constructed.

Major pipeline routes lie between the interior and the Port Harcourt and Warri refineries. There is also the Warri – Benin City – Ikorodu – Lagos – Ikorodu – Ibadan – Ilorin route for petroleum products, and the Warri – Kaduna route for crude oil and petroleum products. Further, the Port Harcourt – Enugu – Makurdi route for petroleum products is currently being constructed.

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

Agent deal of petroleum products will also be transported via NOT and produced in NOT. Therefore, it is likely that construction of a new petroleum products pipeline between NOT and the interior (or NOT and existing pipelines) will have to be examined in the future.

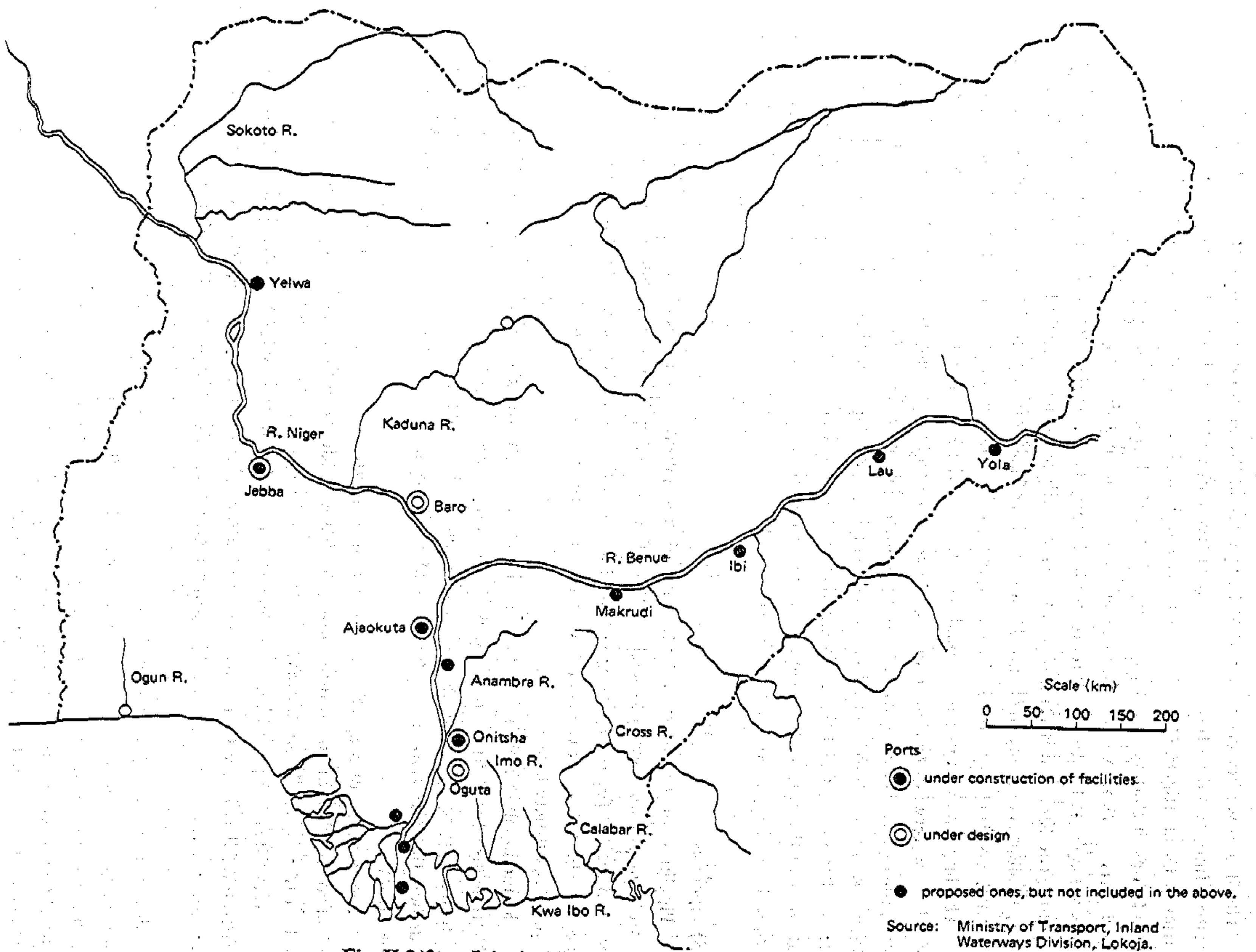


Fig. II-2-8 Principal Inland Waterways and River Ports

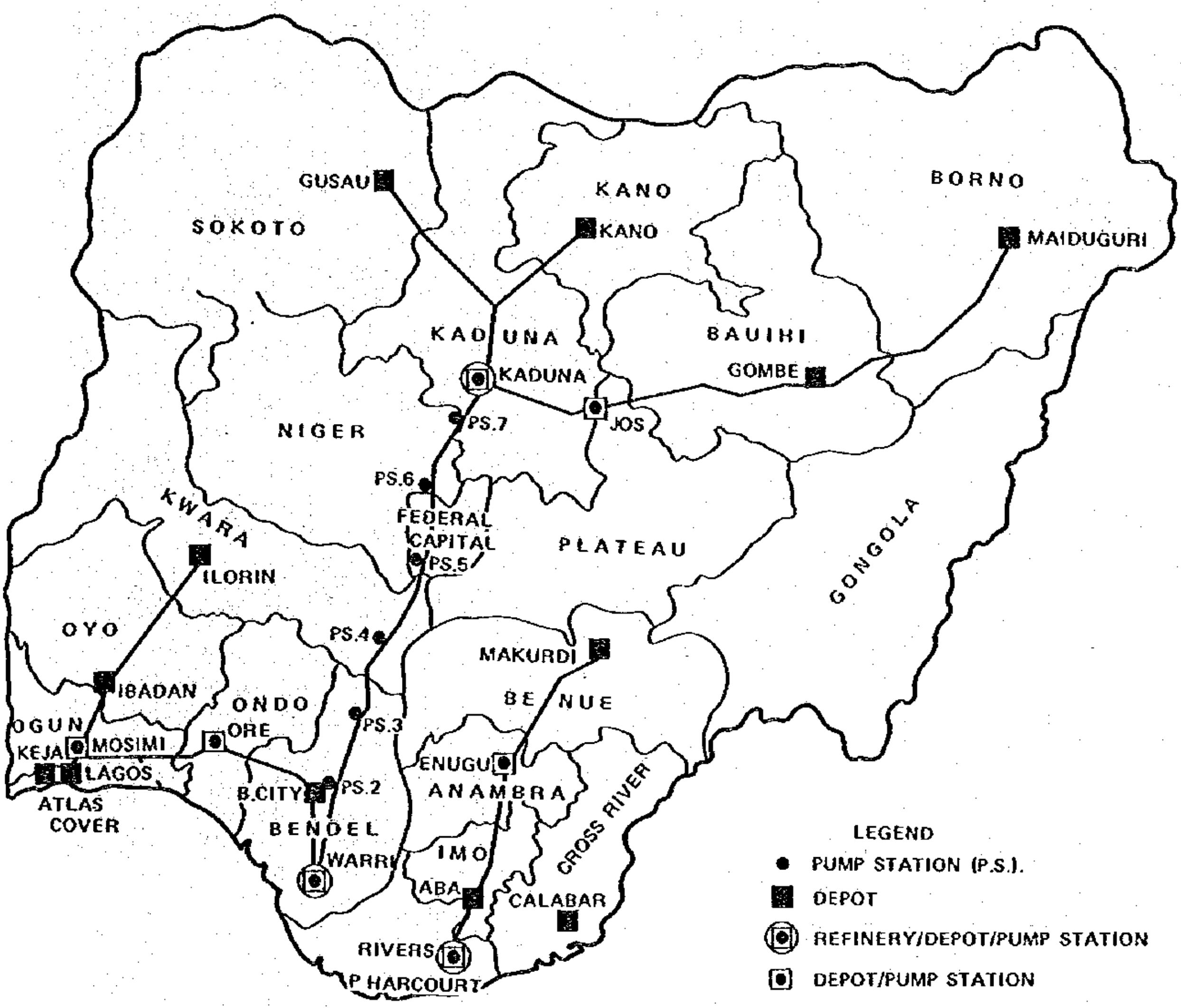


Fig. II-2-9 Pipeline Network

PART III NEW OCEAN TERMINAL

CHAPTER 1. SCALE AND FUNCTIONS

III-1-1. 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 following two functions:

(1) Commercial Port

NOT-east will function as a commercial port, helping to alleviate the congestion of Lagos Port and to deal with future increases in traffic.

(2) Industrial Port

As a port develops, the conditions of the surrounding area favoring the growth of industries improve rapidly. An industrial port development project will thus follow the development of the commercial port, to best profit these conditions.

III-1-2. Development of Commercial Port

NOT-Lagos is expected to handle about 26 million tons of commercial cargo traffic in the year 2000, as shown in Table III-1-1. Cargo throughput, number of berths, and types of facilities at NOT-east will be identical to those of NOT-Lagos. Projected number and size of berthing facilities of commercial port for the year 2000 are shown in Table III-1-2.

Table III-1-1 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	Petro-leum Oil	Total
		Break Bulk	Contain-erized	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 III-1-2 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.

III-1-3. Development of Industrial Port

The types and scales of industries in the year 2000 will be identical to those of NOT-Lagos. The types of industries to be located are:

(1) Iron and steel, petroleum refining, petrochemicals and shipbuilding

These industries are dependent upon the availability of extensive land area and a long, deep waterfront for cargo handling.

(2) Chemical Fertilizers

The oil refinery provides fuel oil for other industries and naphtha for petrochemicals and chemical fertilizers, forming an industrial complex linked by pipeline.

(3) Automobile Assembly

To promote the consolidation of Nigeria's industrial foundation and the nurturing of her industrial structure, material or intermediate product industries requiring high-level technology, such as iron and steel, petrochemicals, and advanced engineering industries such as automobile assembly should be encouraged.

(4) Flour Mills, Food Processing, and Edible Oil Manufacturing

These industries meet consumer demand and require waterfront for incoming raw materials.

The development scales of these industries are shown in Table III-1-3.

Number and size of berthing facilities of industrial port in the year 2000 are shown in Table III-1-4.

Table III-1-3 Development Scales of Industries in the New Ocean Terminal

Type of Industries	Production Scale	Plant Area (1,000 m²)	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 III-1-4 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.

III-1-4. Development of a 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. This scale is the same as that of the new city for NOT-Lagos.

The land space necessary for the new city and its urban facilities are all compartable to those of the city for NOT-Lagos, but the layout is slightly different due to topographical considerations.

CHAPTER 2. LOCATION OF THE NEW OCEAN TERMINAL

III-2-1. Topographical Conditions of Study Area and Particulars of Land Use

(1) General Conditions of the Coastline

The general conditions of the coastline from Opobo to Jamestown are as shown in the sketch in Fig. III-2-1, which is based mainly on the results of helicopter observation corrected in accordance with the results of the aerial photographic survey and the geological study.

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)

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.

a. Block on the seashore side: Development of sand dunes on the coastline. At the estuary of the Imo River, sand banks stretch offshore from the banks of the river. At their limits, sand bars branch off the estuary intercepting the river.
   In this block, as a whole, the ground is somewhat elevated. Shell-BP's pump station is located near the center of the block.
b. Central block: The ground is generally low. The coast is lined with delta palms; the interior with mangroves.
c. Inland block: Old Opobo Town occupies the southeastern corner.
   Sand supply to the eroded waterline is presently being effected by pump dredger.

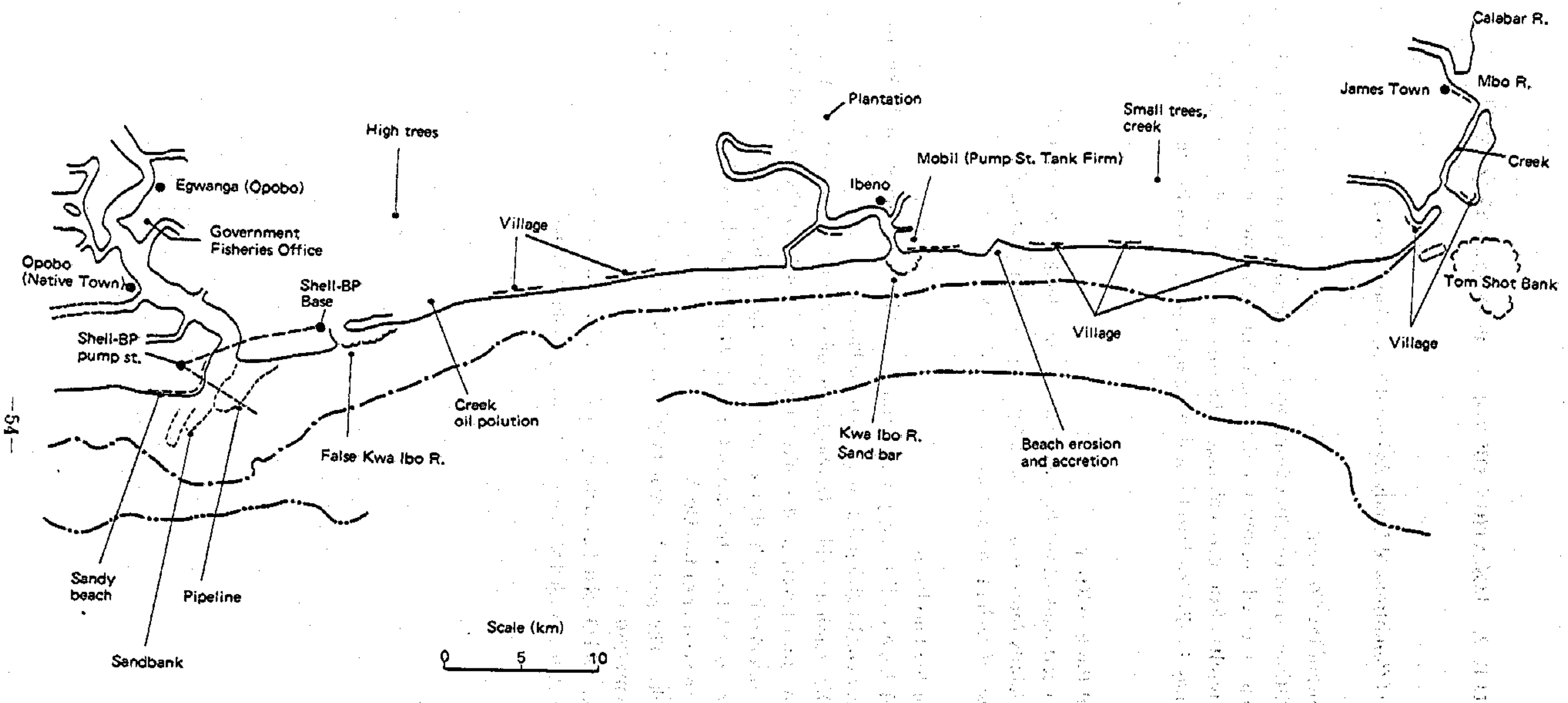


Fig. III-2-1 General Conditions between Opobo and Jamestown

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.

The topographical conditions of the two blocks are somewhat different.

a. Western block: There are few creeks, except for some small creeks running parallel in one section immediately behind the coastline. The ground seems to be higher than the ground in the eastern block. Vegetation to the rear includes many tall trees.
b. Eastern block: Many creeks run almost parallel to the coastline. According to hydrographic charts, the hinterland is almost completely inundated during the rainy season.

Sea conditions (sea bed slope, wave characteristics, littoral drift etc.) are fairly constant throughout this area.

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. The land area is divided by creeks into numerous blocks, most of which are marsh land with mangroves and delta palms. According to the hydrographic chart, there are many banks and bars at the Cross River estuary, indicating that the sediment transport of the river is considerable.

(2) General Conditions of Opobo, Ibeno and Jamestown

Sketches of these three sections of the study area are shown in Figs. III-2-2 ~ III-2-4.

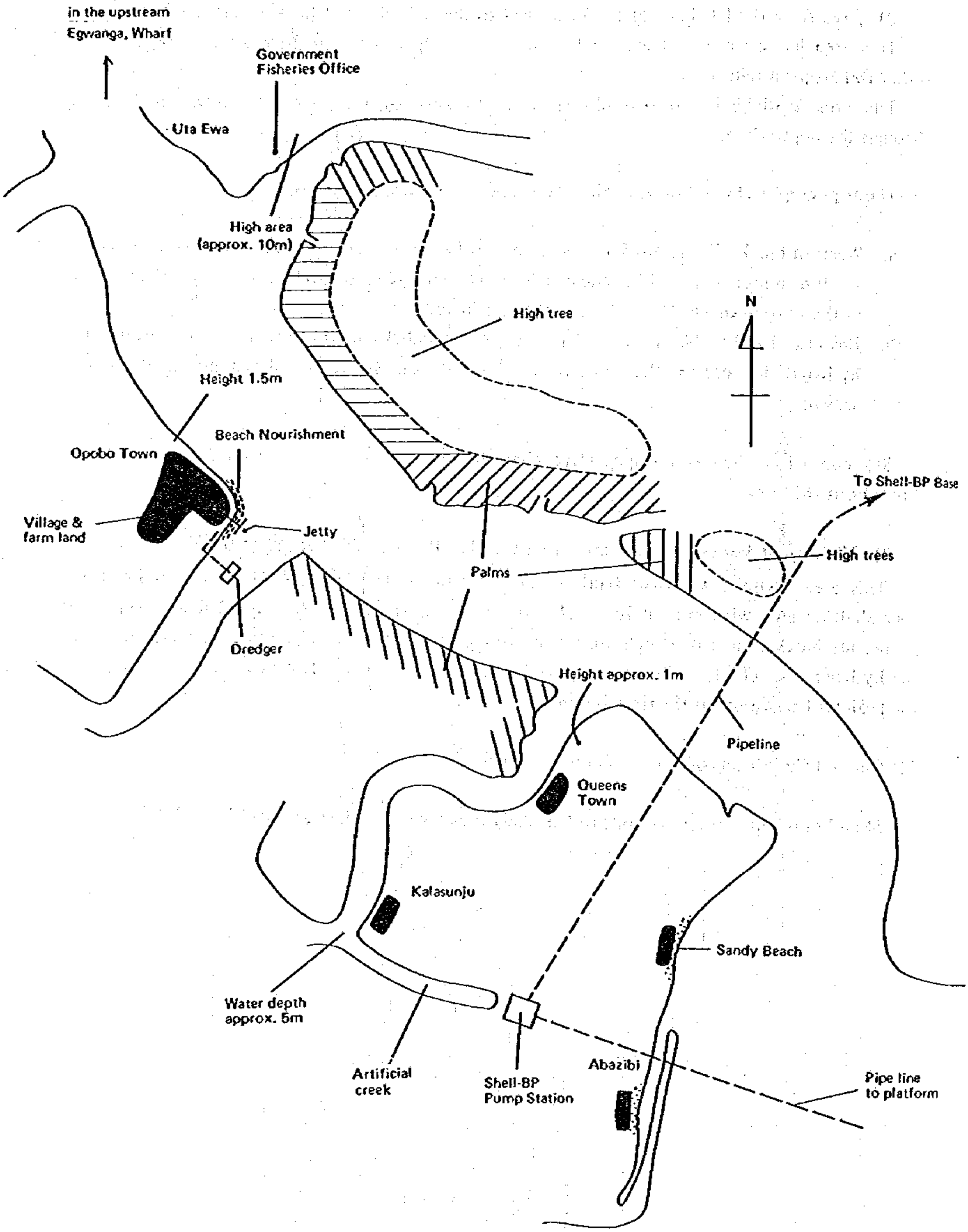


Fig. III-2-2 Opobo Site

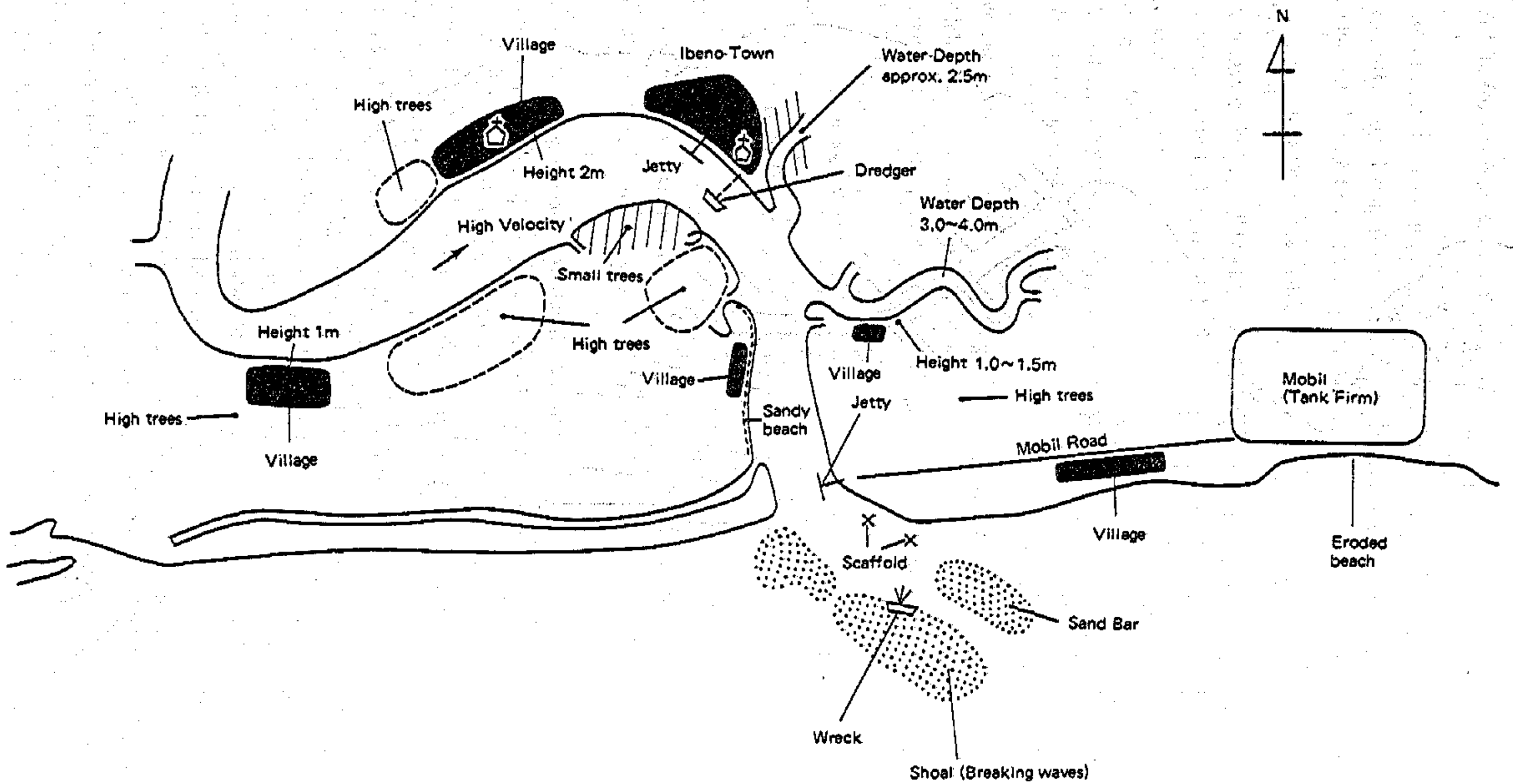


Fig. III-2-3 Ibeno Site

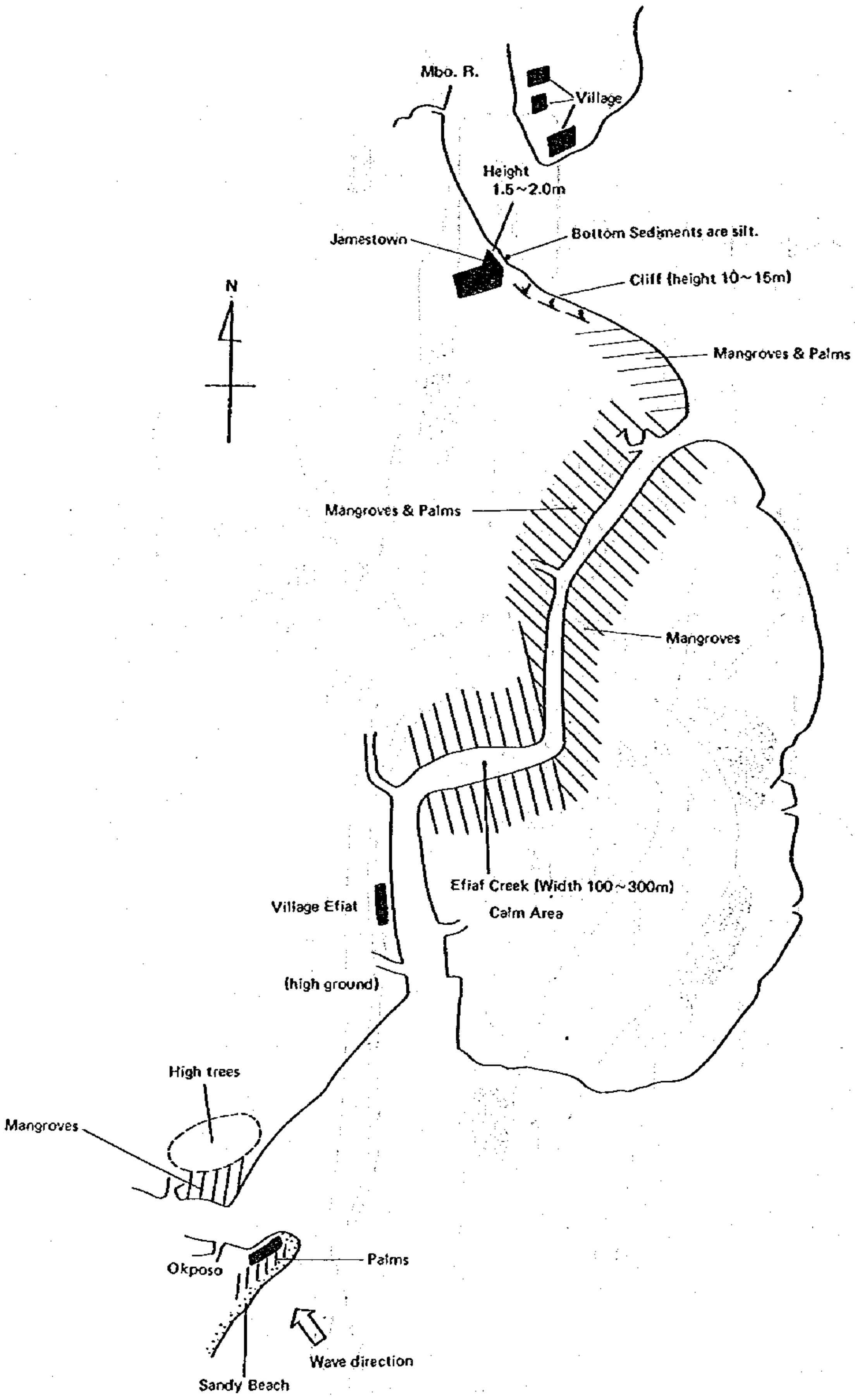


Fig. III-2-4 Jamestown Site

III-2-2. A Site for the New Ocean Terminal

(1) Essential Conditions for Proposed Sites for NOT

The essential conditions for a site where a large-scale commercial or industrial port like NOT can be constructed may be summarized as follows:

1) Location

A commercial port should be constructed near the origins or destinations of its traffic. An industrial port should be located near large concentrations of consumers.

2) Geography

A vast tract of land is required for NOT. This holds true not only for an industrial port but also for a commercial port.

3) Water depth

Although a channel can be dredged, an entrance channel having sufficient water depth and accessibility without dredging is likely to be a governing factor in choosing sites for large-scale ports.

4) Sea conditions

Calm sea conditions are required for the site.

5) Soil condition

For siting heavy industries such as iron and steel, oil refining and petrochemicals, ground with sufficient bearing capacity is essential.

(2) A Site for the New Ocean Terminal

As mentioned in II-1-3, the prevailing wave direction is SW. If NOT were constructed on the right bank of the Imo River, the breakwater would block the river flow (Fig. III-2-5). Therefore, the shipping channel could suffer serious siltation, as the water flowing out of the Imo River enters the channel. It should accordingly be clear even before any financial considerations 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. The required total length of the breakwater would be much longer than that of other areas. 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.

Based on the prototype, dredging volume, length of the breakwater, and other factors can easily be calculated. 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.

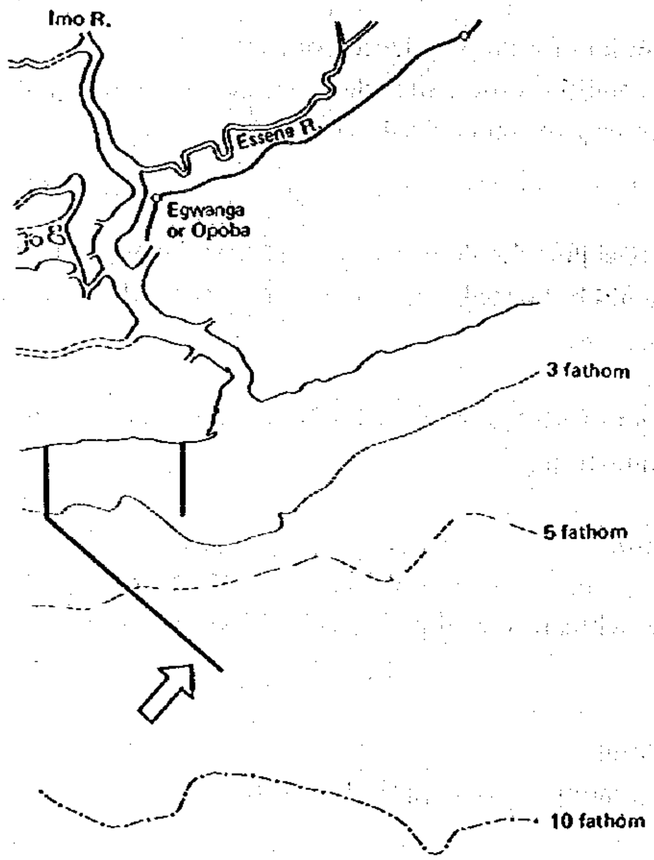


Fig. III-2-5 Layout of the Breakwaters Assumed on the Right Bank of the Imo River

CHAPTER 3. LAYOUT OF THE NEW OCEAN TERMINAL

III-3-1. 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) Configuration of Port

An artificially excavated port is the selected type for NOT-Ibeno.

(2) Channels

Three intra-harbor channels with one harbor entrance are to be excavated toward the land area.

(3) Diversion of the Kwa Ibo River

The Kwa Ibo River is to be diverted and its original channel made into harbor channels.

(4) Concentration of Similar Facilities

To reduce the amount of excavation work as much as possible, facilities requiring the same water depths are to be grouped together.

(5) Phased Development

Facilities are to be located in such a way that the development of commercial and industrial port facilities may proceed under state planning.

(6) Space for Future Expansion

Space for future expansion is to be provided.

(7) Port Roads

Port roads joining the trunk road F103 at Eket are proposed.

(8) Port Railway

Port railway of standard gauge is to be laid connecting the industrial port to the main line at Umuahia.

(9) New City

Urban facilities are to be erected northwest of the port area, in consideration of the predominant wind direction.

III-3-2. Scale and Layout of Breakwaters

The functions of the breakwaters are to block the predominant waves from the south west assuring sufficient calm within the harbor, and to shelter the entrance channel reducing estimated siltation volume.

Table III-4-1 shows wave directions in points shallower than −20m. These waves are south-west in direction with 12 second periods in the offshore area.

Direction of the breakwater and water depht at the tip of the breakwater must be determined in designing the breakwater. With regard to the orientation of the breakwater,

(1) Sufficient calm must be maintained within the harbor.

(2) If the orientation of the west breakwater approaches being parallel to the shoreline, it will block incident waves to excess. In such a case, there would be a clear difference between the wave height of the sheltered area and that of the unsheltered area, causing a slope in mean water level. Longshore currents would thus flow to the port area (from east to west). Eventually, significant changes in beach configuration to the east of NOT-east would be produced by the longshore sand drift from east to west. The orientation of the west breakwater must therefore be to some extent perpendicular to the shoreline to avoid such beach erosion.

(3) The shipping channel should be located in the deeper area to cut dredging volume.

(4) If the orientation of the west breakwater approaches perpendicularity to the shoreline, incident waves will approach the breakwater from the oblique course. In this case, wave force against the breakwater can be more easily reduced than in the case of wave approach from the normal direction. The width of the breakwater can thus be reduced.

The following considerations are made concerning water depth at the tip of the breakwater.

(1) The approach channel should be sheltered in order to prevent siltation.

(2) Safe navigation of a maximum size vessel of 17 m draft should be assured.

(3) The length of the breakwater should safely exceed ship stopping distance (five ship lengths).

Water depth at the tip of the main breakwater is approximately equal to the water depth of the shipping channels in case of the major Japanese ports. If this were applied to NOT-east, the water depth at the tip of the breakwater would be−18 m and the total length of the breakwater quite great. 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. III-3-2 with water depths at the tip of the breakwater −10m, −13m, −15m, and −18m. Then, total maintenance dredging costs over 10, 20, and 30 years are calculated, using the siltation rates shown in Table III-6-1. The discount rate for the calculation of maintenance dredging cost was set as 5%, as per the mean of the recent official rates in Nigeria.

Fig. III-3-3 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

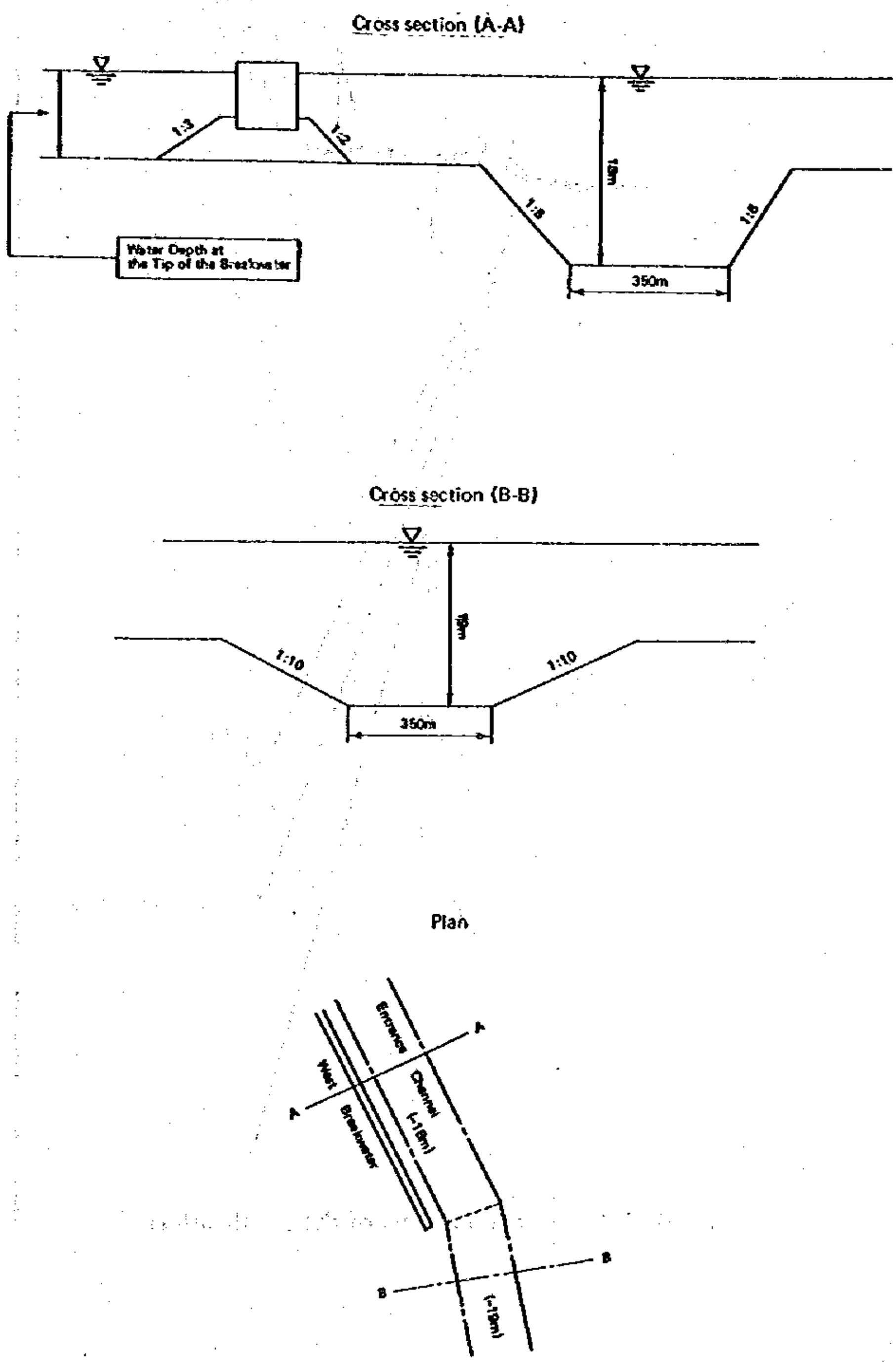


Fig. III-3-1 Water Depth at the Tip of the Breakwater

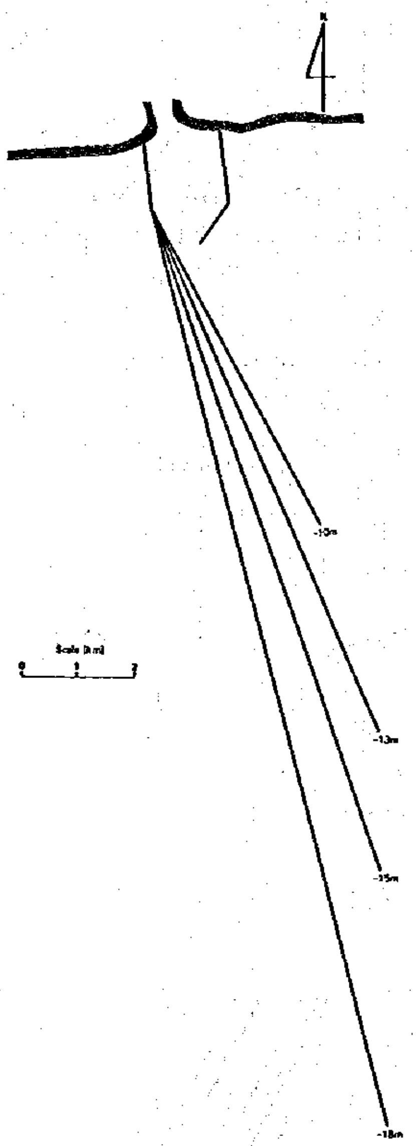


Fig. III-3-2 Various Layouts of the Breakwaters

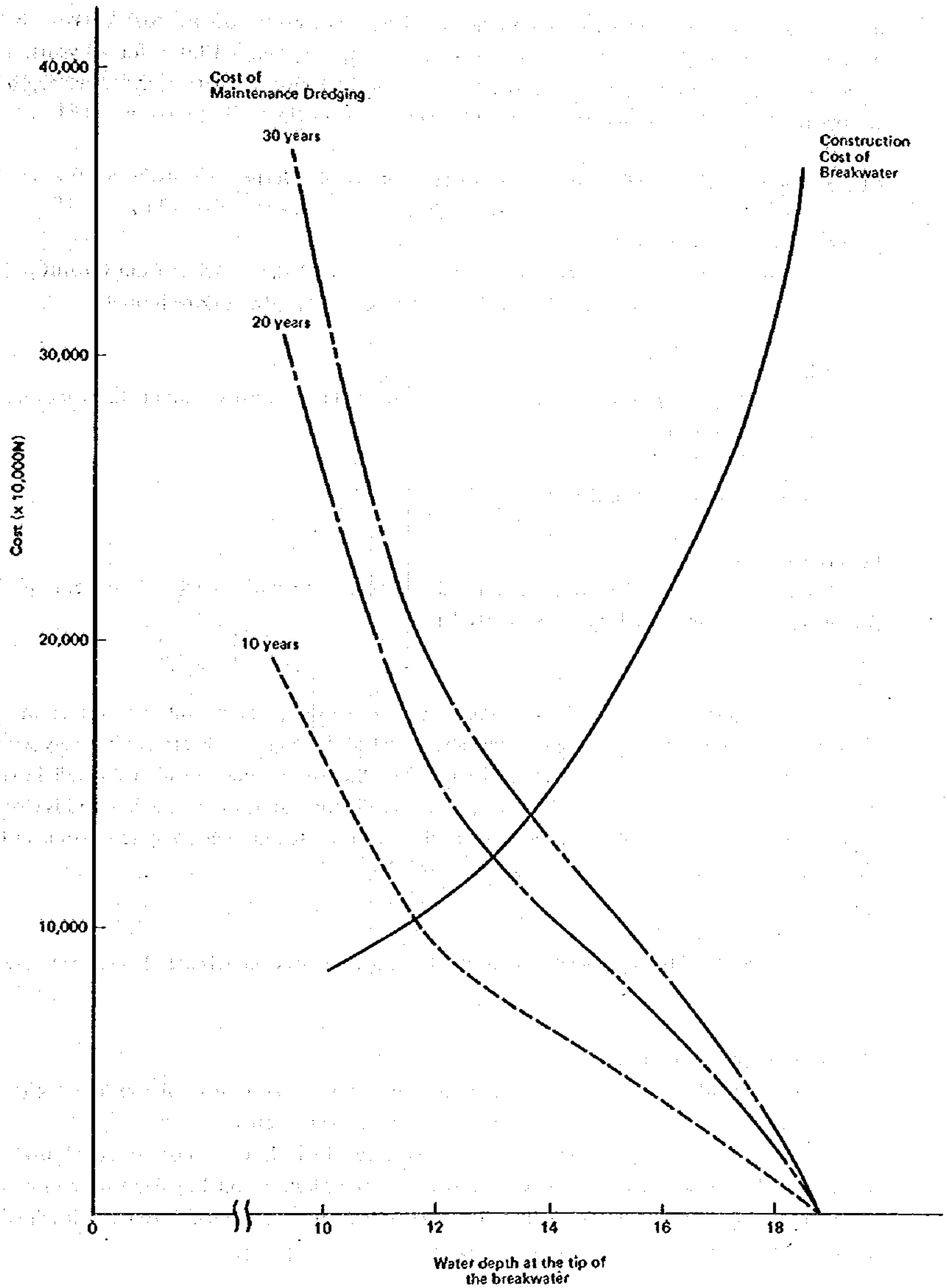


Fig. III-3-3 Costs of Maintenance Dredging and Breakwater Construction maintenance dredging cost curve shows the condition where sum of the both costs is at its minimum. The calculated water depths are −11.6 m for 10 years, −13.0 m for 20 years, and −13.6 m for 30 years dredging, respectively. Based on the above calculation, the water depth at the tip of the west breakwater has been set at −13 m.

III-3-3. Diversion of River Course and Construction of Training Jetty

(1) Diversion of River Course

The course of the Kwa Ibo River is to be diverted toward the coastline from Okorutip. No allowances are made for the protection of the slope's face and a natural slope is used.

(2) Training Jetty

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.

III-3-4. Layout of Channels and Turning Basins

(1) Principles

The following principles were established in accordance with the basic concept of the formulation of the master plan covered in III-3-1.

1) Configuration

The entrance channel is located taking account of the predominant wave direction and aiming for a minimization of dredging work. The sea bed slope in the eastern coast is very gentle (about 1/1,400), and, up to the water depth of −10 m, the contour lines are almost parallel to the coastline. The −20m contour line however, moves in slightly toward the coastline and is closest to shore at a point, SSE of Ibeno. The channel will be constructed in such a way as to connect the tip of the breakwater with this point, as in Fig. III-3-13.

2) Width of the channels

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

3) Water depths of channels

An under-keel clearance of 1 m is provided for the section of the entrance channel outside the breakwater to accommodate ship oscillation due to waves.

Because of the great length of the entrance channel, it is not proposed that the breakwater be relied upon to prevent the shoaling of the whole channel by deposition of marine sediments. The necessary water depth at the part of the entrance channel is to be maintained by year-round dredging.

(2) Scale and Layout of the Channels

1) Names of the channels

The names of the channels are as shown in Fig. III-3-4.

2) Scale of the channels

The scale of the channels is as shown in Table III-3-1.

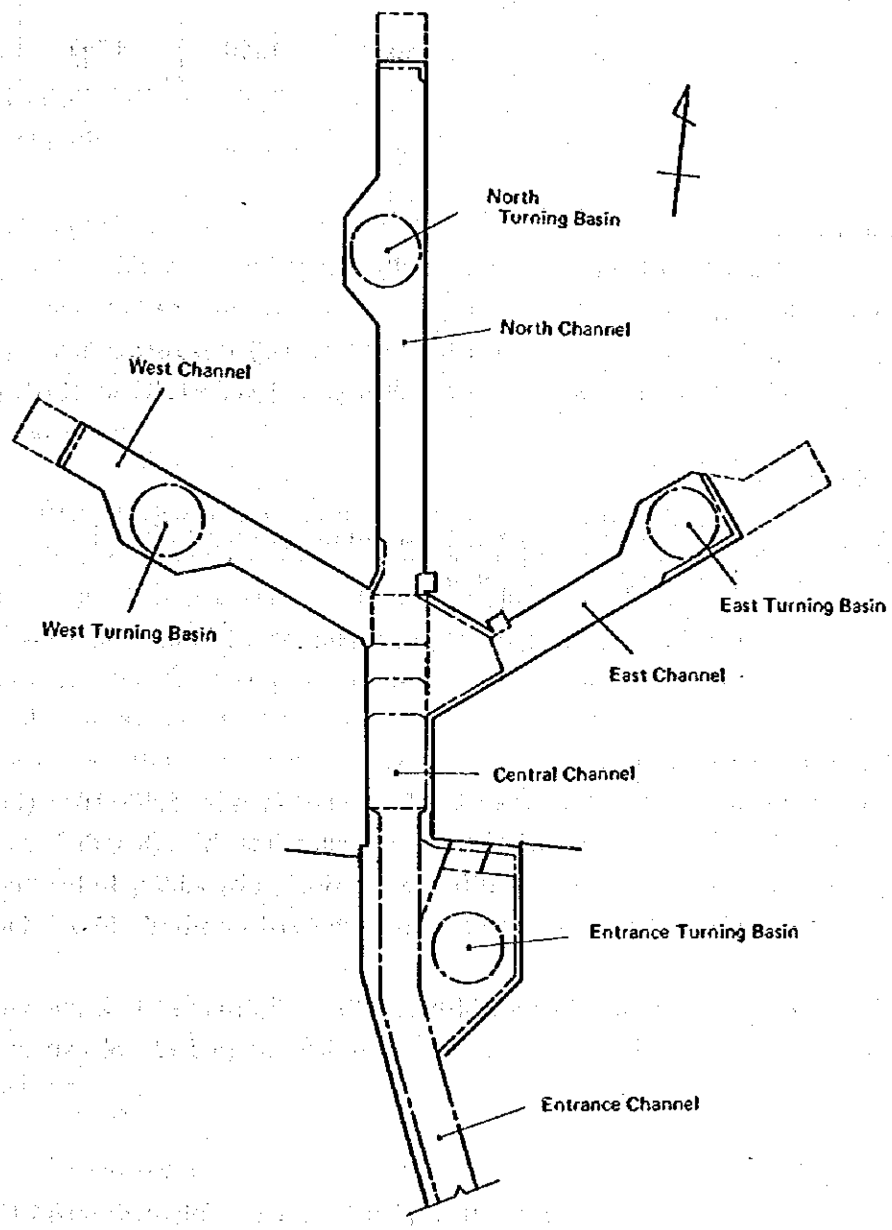


Fig. III-3-4 Names of Channels and Turning Basins

Table III-3-1 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

a. Width

Entrance channel:

A two-way channel for light traffic is generally planned to be as wide as the length of the largest ship passing through.

The largest ship expected to enter NOT is a 150,000 DWT class ore-carrier (overall length 300 ~ 320 m), so the width of the entrance channel is projected as 350 m.

Central channel:

Width = width of two-way channel + width of mooring basin x 2

= 350 m + 50 m x 2 = 450m

To allow very large ships turning space, however, an extra 150 m of width is added yielding a total width of 600 m.

West, north and east channels:

The maximum size of ships for the east and west channels is 15,000 DWT (length approximately 165 m); that of the north channel 50,000 DWT container ships (length 240 ~ 250 m).

For the north channel, the figure of 400 m was arrived at by adding to the maximum ship length, 100 m for the width of mooring basin in front of berths on both side, and an allowance of 50 m.

By the same consideration, while a width of 300 ~ 350 m is sufficient for the east and west channels, 400 m is used for these channels in anticipation of future expansion of their functions.

b. Water depth

For all channels, sufficient water depth is planned for the full-load draft of ships of the maximum size.

For the entrance channel, an under-keel clearance of 1 m is allowed on the outside of the breakwater to accommodate ship oscillation due to waves.

For the north channel, the plan provides for future increase in depth to –13 m, if necessary.

(3) Basins

1) Waiting basin

No waiting basin to be used for anchorage or mooring is proposed inside NOT.

2) Operating basin

Mooring and unmooring space: Space with a width of 50 m is provided in front of all mooring facilities.

3) Turning basin

A turning area with a diameter of 600 m is provided for each channel and near the harbor entrance. (This diameter is twice the presumed 300 m maximum ship length).

II-3-5. Layout of Commercial Port Facilities

(1) General Layout of Commercial Port Facilities

The layout of commercial port facilities (container wharves, breakbulk cargo wharves, grain wharves, petroleum oil wharves, and small crafts 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 volume 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 crafts basins should be located in the center of the harbor and in the industrial port section.

(2) Scale and Layout of Commercial Port Facilities

1) Scale of commercial port facilities

A unit scale of commercial port facilities similar to that of NOT-Lagos is proposed in Table III-3-2.

2) Layout of wharf facilities

Wharf facility layouts similar to those of NOT-Lagos are planned as per Fig. III-3-4 ~ III-3-6.

Table III-3-2 Unit Scale of Commercial Port Facilities

	Container Wharf	Break Bulk Cargo Wharf	Grain Wharf	Petroleum Oil Wharf	Samll Crafts Basin
Projected Ship Size					
Ship size (DWT)	50,000	15,000	60,000	15,000	280 GT
Full-load draft (m)	11	9.5	12.0 ~ 13.0	9.5	
Over-all length (m)	240 ~ 250	165	200 ~ 250	165	
Width (m)		22	30 ~ 35	–	
Mooring wharves					
Length (m)	300	185	300	185	–
Depth (m)	-12.0(13.0)	-10.0	-14.0	-10.0	-3.5
Depth of terminal	400	200	300		
Remarks	Container crane: 2 units Freight station: 6,000 m^2	Apron width: 20 m	Pneumatic unloader: 400 ton/hours x 2 units Silo: 100,000 tons	Dolphine type	

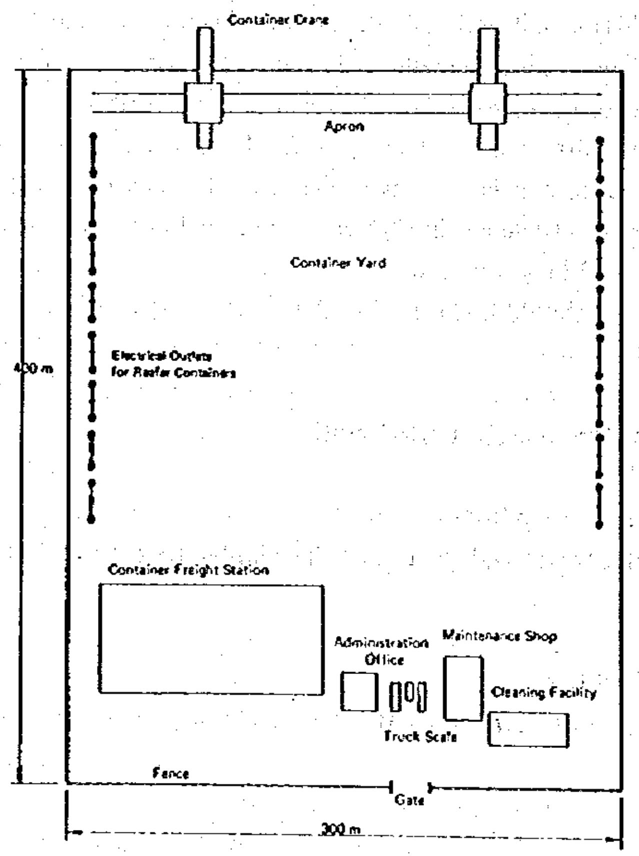


Fig. III-3-5 Layout of Container Terminal Facilities

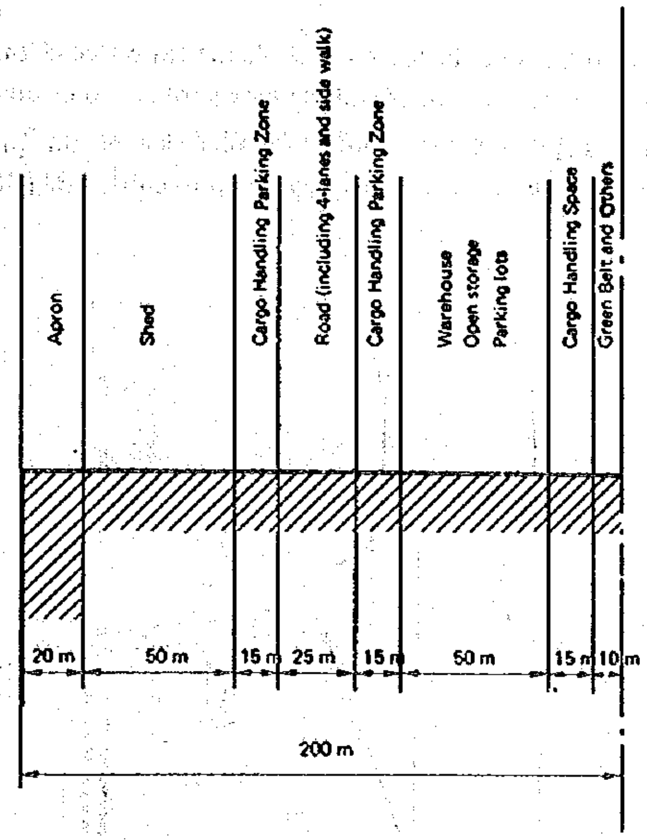


Fig. III-3-6 Cross Section of Break Bulk Cargo Terminal Facilities

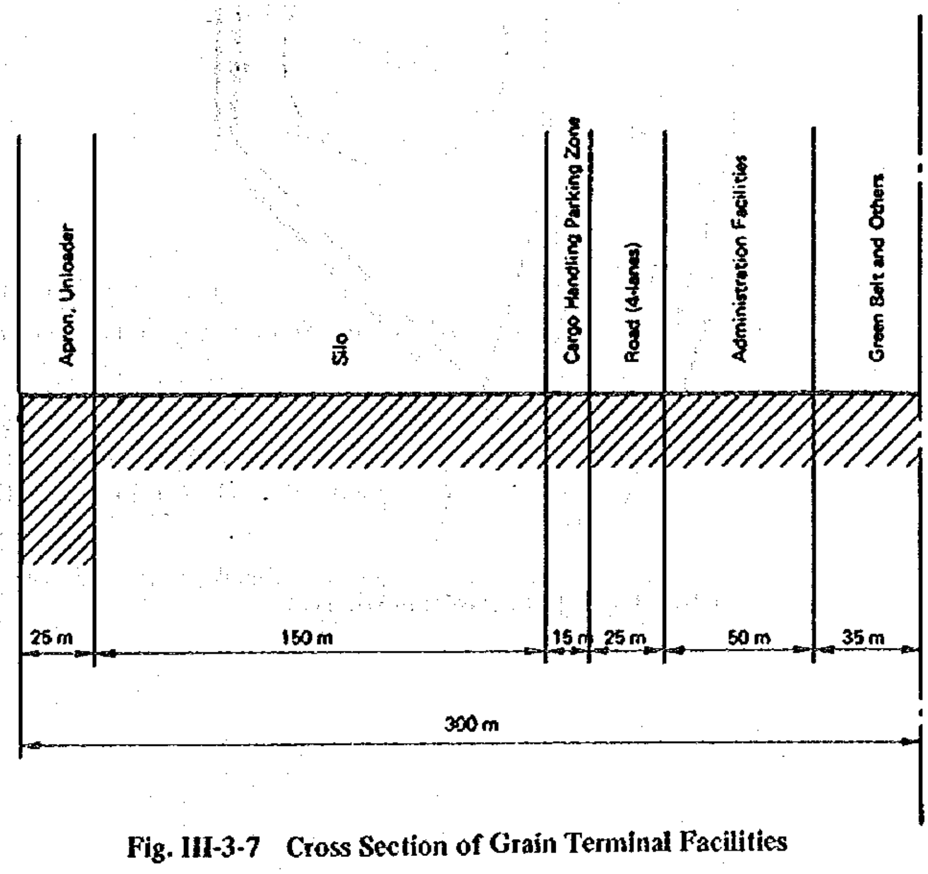


Fig. III-3-7 Cross Section of Grain Terminal Facilities

3) Petroleum wharf

The petroleum wharves are to be located outside the excavated channel, taking the safety of the harbour into consideration. The wharf and the tank yard are connected by pipelines.

A berth of water depth –10m is planned for one side of the private jetty. For the remaining two berths, a jetty is proposed. Ships may tie up to either side (Fig. III-3-8).

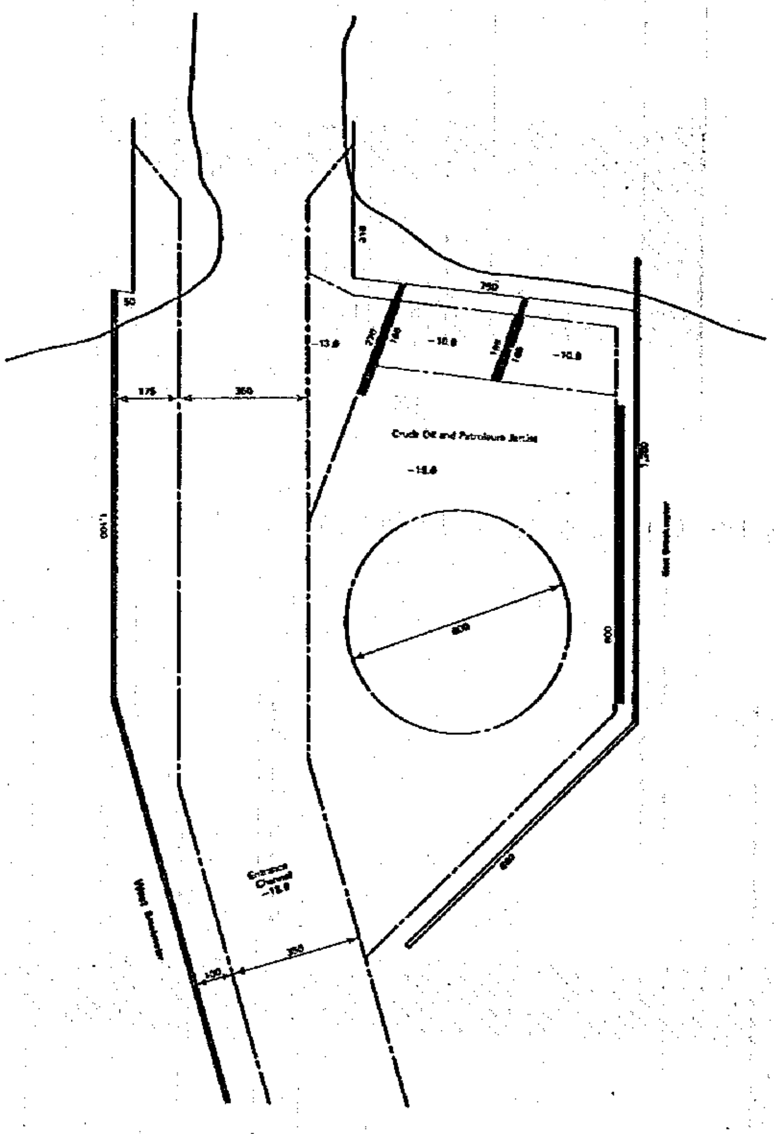


Fig. III-3-8 Layout of Petroleum Wharves

4) Small crafts basin

The small crafts basin must be as calm as possible, and should thus be positioned near the center of the harbour.

The number of vessels to use the small crafts basins and the scale of the basins are similar to those of NOT-Lagos (Fig. III-3-9).

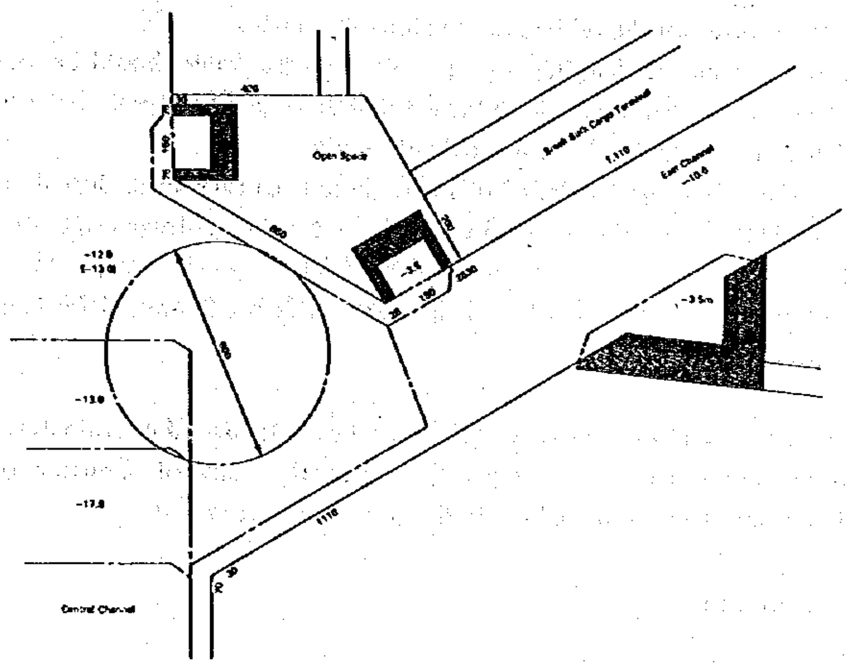


Fig. III-3-9 Layout of Small Crafts Basins

5) Port related business areas

As at NOT-Lagos, land for port-related business is situated to the rear of the public wharves.

The width of this area is to be 150 m at minimum, projected with consideration toward the road system and other conditions of land use in the vicinity.

The area of this land is about 240 ha, approximately equal to the 225 ha plot at NOT-Lagos.

The public service facilities will be located mainly behind the small crafts basin.

III-3-6. Layout of Industrial Port Facilities

(1) Overall Approach to Industry Location

Industry location is proposed with attention to the following points, which had also been taken into consideration in the planning of NOT-Lagos:

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 should 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 should 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 should be located near the harbor entrance.

In addition to the points above, efforts must be made toward coordinating the timing of port construction, industrial estate preparation, and the start of industry operation and consideration taken toward overall land use in the New Ocean Terminal.

(2) Specific Location of Industries

1) Iron and steel

This industry will be located on the west side of the central channel due not only to the applicability of points 1), 2), 4), and 5) in (1), but also because a lot as large as 700 ha is available there with a bearing capacity presumed relatively satisfactory.

2) Oil refining

The oil refinery will be located in the area containing the existing tank farm.

3) Petrochemical and chemical fertilizer

These industries will be located on the east side of the central channel adjacent to the oil refinery in consideration of point 3) in (1).

4) Flour milling, food processing and oil manufacture (vegetable oils and fats)

These industries will be located on the east side of the central channel in consideration of point 5) in (1). They will be located adjacent to the public grain terminal, in the event that not all cargo can be handled at the private wharf.

5) Shipbuilding and repair

This industry will be located along the east channel in consideration of point 1) in (1).

6) Automobile and related industries

Located behind the public wharves on the east side of the north wharf inasmuch as they do not necessarily require a private waterfront.

(3) Layout of Port Facilities for Each Industry

Necessary port facilities listed in Table III-1-4 are planned in accordance with the above-mentioned locations of each industry as follows:

1) The iron ore and coal berths of the ironworks will be located contiguous to the west bank of the central channel. The iron and steel products berths will be located along the west channel.
2) Petroleum oil berths will be located, in order of water depth, on the harbor side of the east breakwater. The berths and the oil refinery will be connected by pipelines.
3) Petrochemical products berths will be located on the south bank of the east channel.
4) The grain wharf will be located on the east side of the central channel.

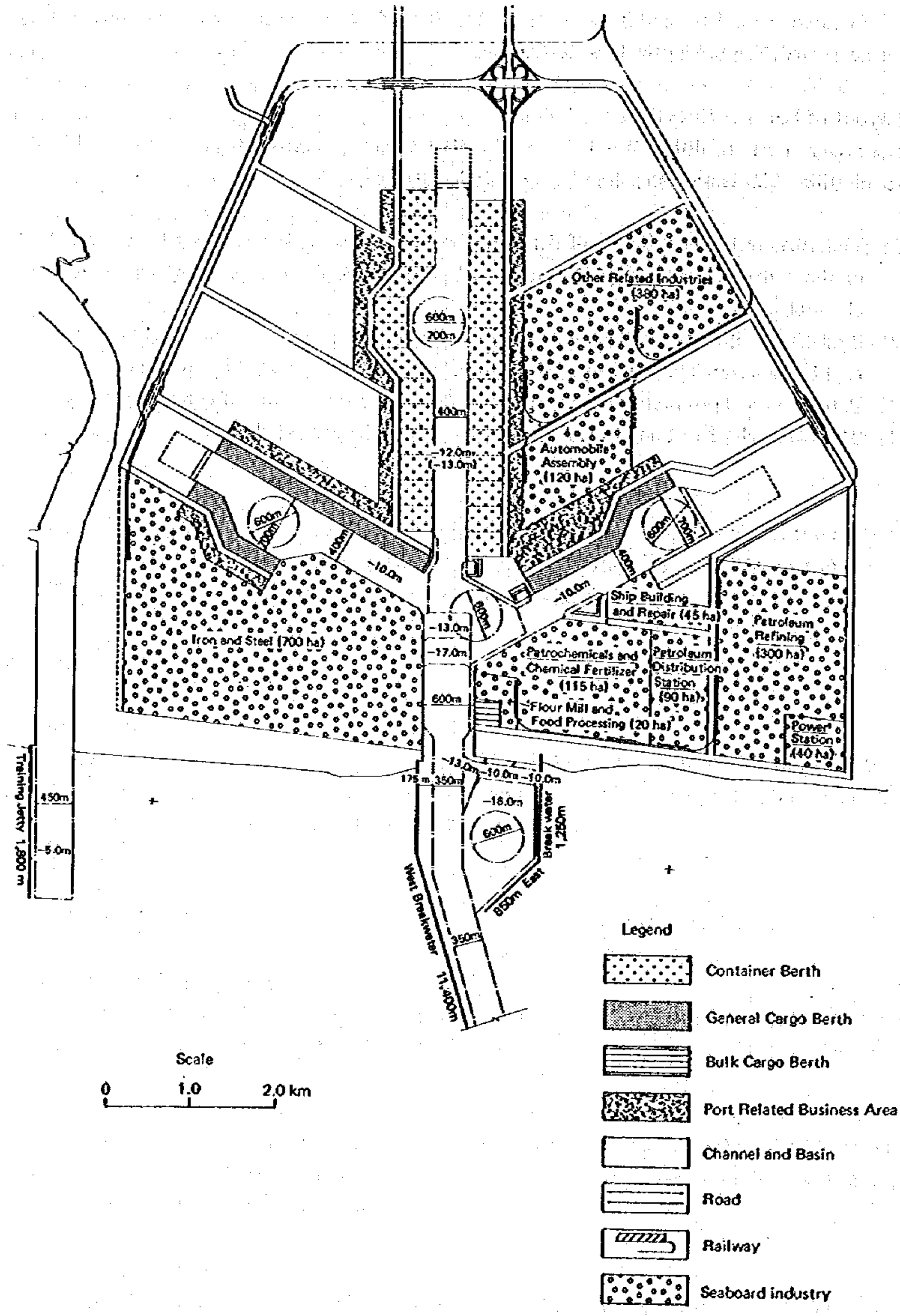


Fig. III-3-10 Layout of Port Facilities and Industries

III-3-7. Scale and Layout of Urban Facilities

(1) Basic Concept

The scale and layout of urban facilities are similar to those of NOT-Lagos.

Construction cost is not entirely similar to that of NOT-Lagos due to different topographical conditions. On the other hand, construction cost figures for NOT-Lagos do not include whatever is spent on ground leveling prior to construction, because the local topographical conditions are not clearly known. Therefore, the effect of topography on leveling cannot be taken into consideration.

In the case of NOT-east, there is no lagoon in the rear, so a marina and an inland waterway terminal will be constructed on the left bank of the Kwa Ibo River.

(2) Scale of the New City

The proposed number of employees under the NOT plan totals 50,000: 20,000 for the commercial port and 30,000 for manufacturing industries. The population of the new city in the year 2000 is estimated based on this figure and assuming a ratio of employees to total population of about 40/60.

Table III-3-3 Population Scale of the New City (Year 2000)

	Proposed Value (people)	Remarks
Population	200,000	
Employees		
Agriculture, Mining & Quarrying	0 (0%)	
Manufacturing and Processing	30,000 (36%)	
Construction and Building	8,000 (10%)	
Distribution/Electricity, Gas and Water	17,000 (20%)	
Transport and Communications	20,000 (24%)	
Services	8,000 (10%)	
Total	83,000 (100%)	
Number of households	40,000	5 people/household

It is proposed that housing sectors of medium density be developed composed mainly of independent houses and 2 ~ 4 story apartment houses. Population density for the district is projected at 70 people/ha.

The total area of development and the land use of the urban area are shown in Table III-3-4. The total area is 2,900 ha: the housing sector's net residential density is 140 people/ha; its gross residential density about 100 people/ha.

Table III-3-4 Planned Land Use for the New City (Year 2000)

Land Use	Area (ha)
Residential Area	1,450 (50%)
Commerce and Office	120 (4%)
Public Facilities	170 (6%)
Roads	580 (20%)
Open Space	580 (20%)
Total	2,900 (100%)

(3) Layout of Urban Facilities

The new city is composed of the following three zones as shown in Fig. III-3-10:

1) Town center
2) Residential zone
3) Peripheral zone

Shops, amusement facilities, and public facilities catering to the convenience and amenities of city life are to be concentrated in the town center.

The residential zone is to be divided into 26 blocks, each with a population of about 7,000 ~ 9,000, an area of about 70 ~ 90 ha, and about 1,600 houses. The residential zone is a community unit with no through traffic. It also constitutes a primary school section.

The peripheral zone is planned as a recreational area – a "green belt" serving as a buffer between NOT and the area for the lodging of NOT's visitors.

(4) Location of the New City

There seem to be no topographical restrictions on the location of the new city, as a large tract of flat land extends to the rear of the NOT site, but considering the dominant wind direction (southwest), it is desirable for the new city to be located to the northwest of NOT.

The new city will therefore be located between NOT and the existing town of Eket, which is about 15km north-northwest of NOT.

In this location, the new city will satisfy the following requirements demanded by NOT-Lagos:

1) The new city must be located within 10 km from the center of NOT to minimize commuting distance.
2) There must be sufficient space for future extension to the north and west.
3) There must be space for recreational facilities.

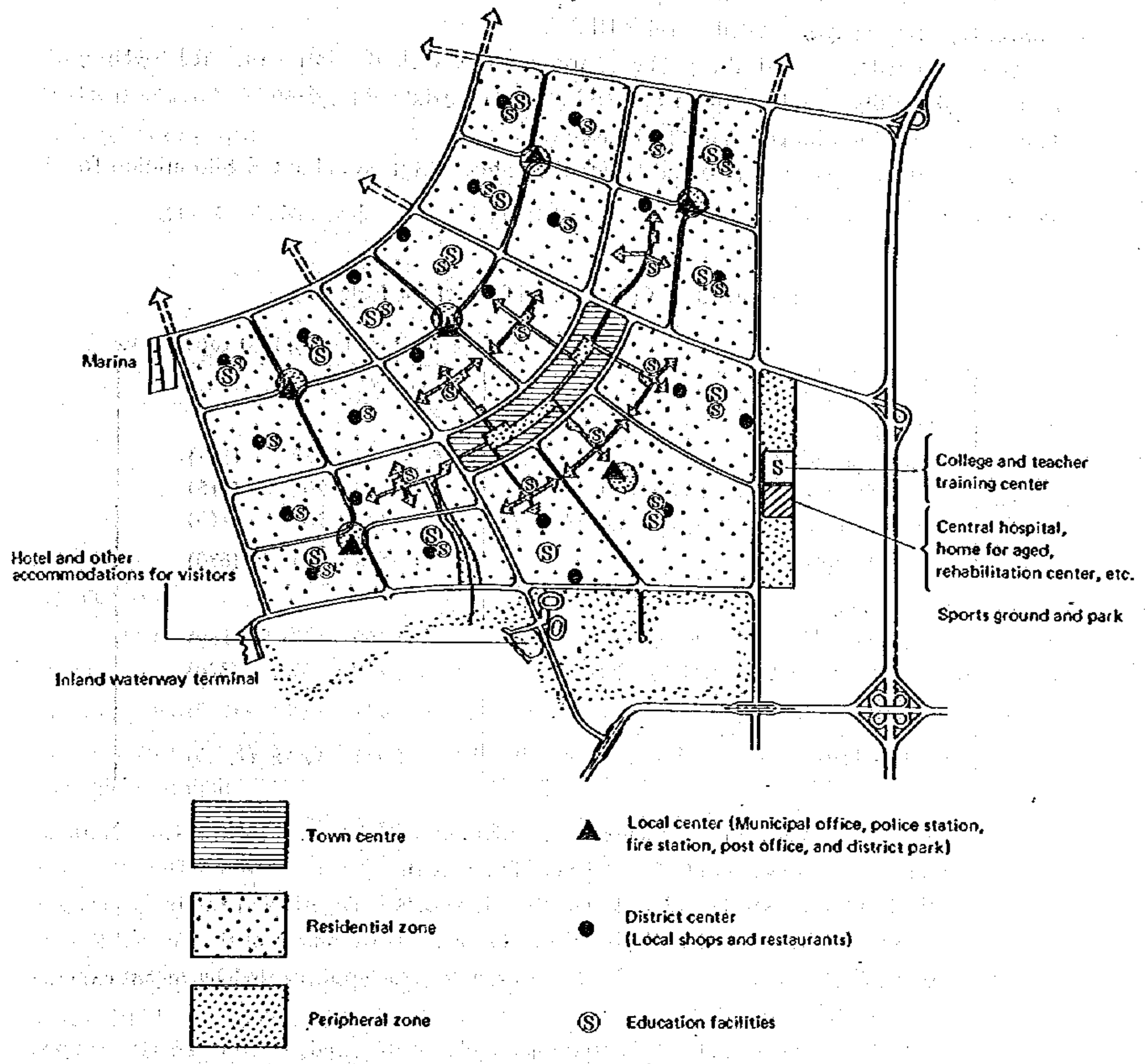


Fig. III-3-11 New City: Conceptual Plan

(5) Construction Cost of the New City

The total construction cost of the new city is estimated at approximately ₦ 1,500 million.

To indicate funds required in the public and private sectors respectively, construction cost by project type is roughly estimated in Table III-3-5.

It is assumed here that the public sector constructs all the infrastructures, open space, recreational facilities, and buildings for public services, while the private sector constructs all housing and buildings for commerce and business.

Total costs are about ₦ 680 million for the public sector and about ₦ 880 million for the private sector.

Table III-3-5 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.

III-3-8. Transport Facilities

(1) Road Network

1) Composition

The road network related to the NOT project is composed generally of the following three types of roads:

- NOT Roads Network
  - Port Road
    - Ring Road
    - Beam Road
  - Urban Road
    - Arterial Road
    - Approach Road
  - Main Access Road

2) Port 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. Therefore, a network of sufficiently spacious port roads will be constructed over the entire NOT complex, covering the rear of the wharves, the interior, and the vicinity of the industrial base.

The port road network for the commercial port wharves will be composed of the beam roads running immediately behind and parallel to the wharves and the ring road that connects these beam roads. This network receives traffic originating from the wharves and the land for port-related work.

Port roads for connection to the industrial base will be laid on the boundaries between industrial blocks, connected to the ring road.

All beam roads will be four lanes wide, while the ring road will have four to six lanes, depending on traffic volume estimates.

A width of 75m is allowed for all road sites regardless of proposed lane count so that roads may be widened in the future as required.

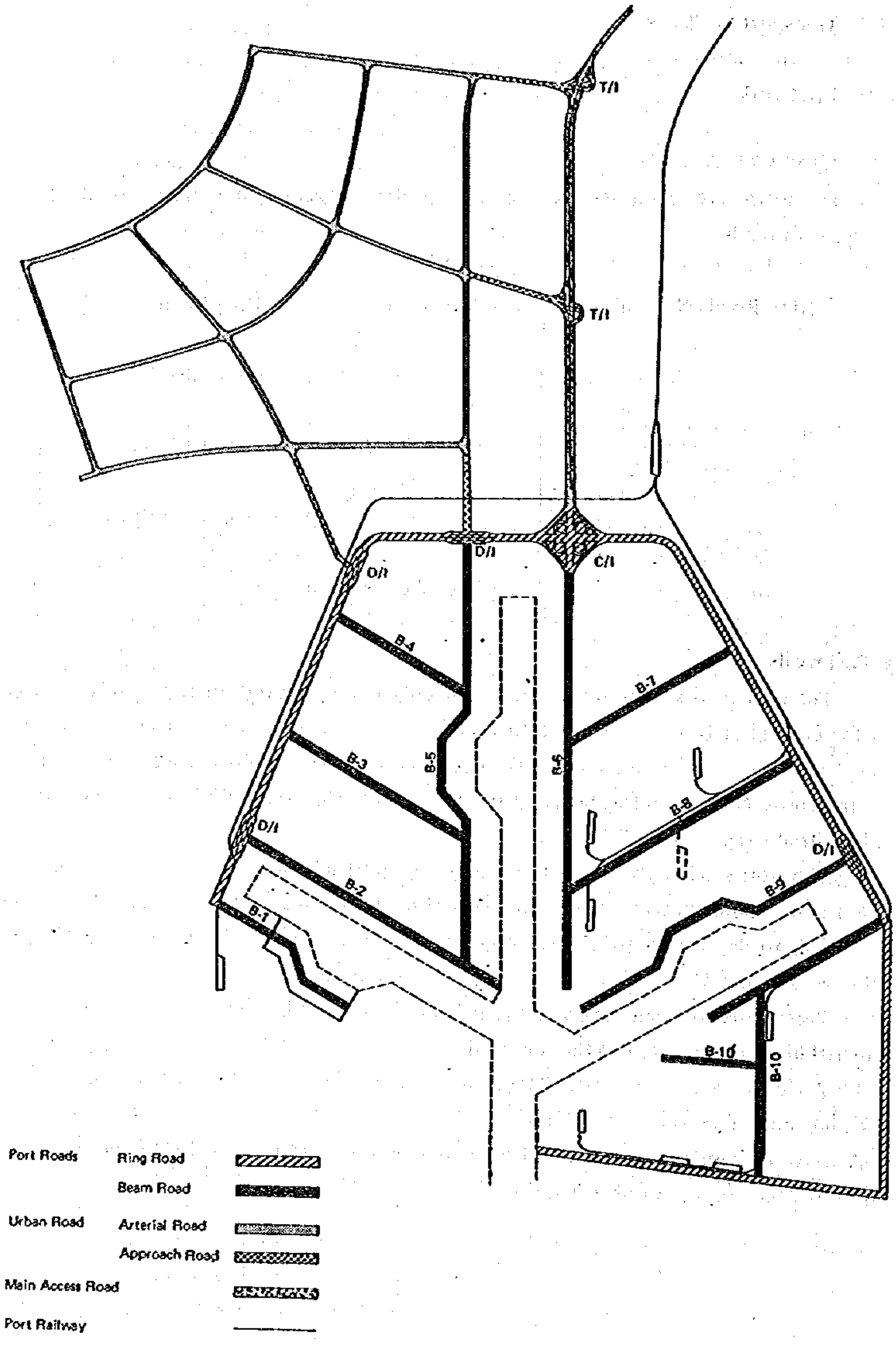


Fig. III-3-12 Transportation Network

3) Urban roads

The basic layout of the new city is precisely the same as that for NOT-Lagos. The layout of urban roads is accordingly similar. Since 50,000 individuals or 60 percent of the workforce of the new city will be employed at NOT, the first task in planning the transport network is to provide commuter transportation for these workers. For this purpose, four arterials will be connected to the main access road and the ring road. Within the city itself, each of them will serve about four housing sections (400 ha) and be arranged at intervals of 1.5 – 2km.

4) Main access road

A main access road will tie in NOT with the federal road to the rear.

This main access road will be an extension of beam port road B-6 to run from its intersection with the ring road to F103 in the eastern part of Eket.

The main access road will be a 6-lane highway, about 5.5 km long, with a roadbed width of 75m to allow for future widening as required.

(2) Railway

1) Port railway and marshalling yard

A port railway is proposed for the industrial section only.

Sidings for the plants will be provided by the respective industries.

Commercial port cargo transported by rail will be routed via the marshalling yard, to be constructed at the junction between the port railway and the access railway.

All industrial lines and sidings for the respective industrial plants will be single-tracked.

The length of plant sorting lines is in accordance with the effective train length of 400m.

The total proposed length of the port railway is 26.6 km: 9.4 km for the west line and 17.2 km for the east line.

One sorting line of 400 m will be provided for the west line; seven sorting lines of 2,800 m (total length) for the east line.

2) Main line plan

The port railway will be connected at Umuahia to the new standard-gauge line now being planned. The length of this main line is about 145.0 km.

(3) Construction Cost of Transportation Facilities

The construction costs of transportation facilities are estimated using unit prices as shown in Table III-3-6. These unit prices were determined by updating to 1981 those used in the Phase II Report.

The total construction cost, calculated using unit prices shown in Table III-3-6, is given in Table III-3-7.

Table III-3-6 Construction Unit Cost for Transportation Facilities

Facilities	Unit Cost
Road	
6-lane Road	2.9 million ₦/km
4-lane Road	2.3 million ₦/km
Interchange: Clover Type	6.9 million ₦/Unit
Trumpet Type	4.6 million ₦/Unit
Diamond Type	3.4 million ₦/Unit
Railway	
Standard Gauge Single Track (Including signalling, telecommunication, & small structures)	1.2 million ₦/km
Bridge	2,295 ₦/m²
Yard (Excluding main trail)	3.4 million ₦/Unit
Junction (Excluding main trail)	1.7 million ₦/Unit

Table III-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 m²	6.9
Subtotal		217.9
Total		488.3

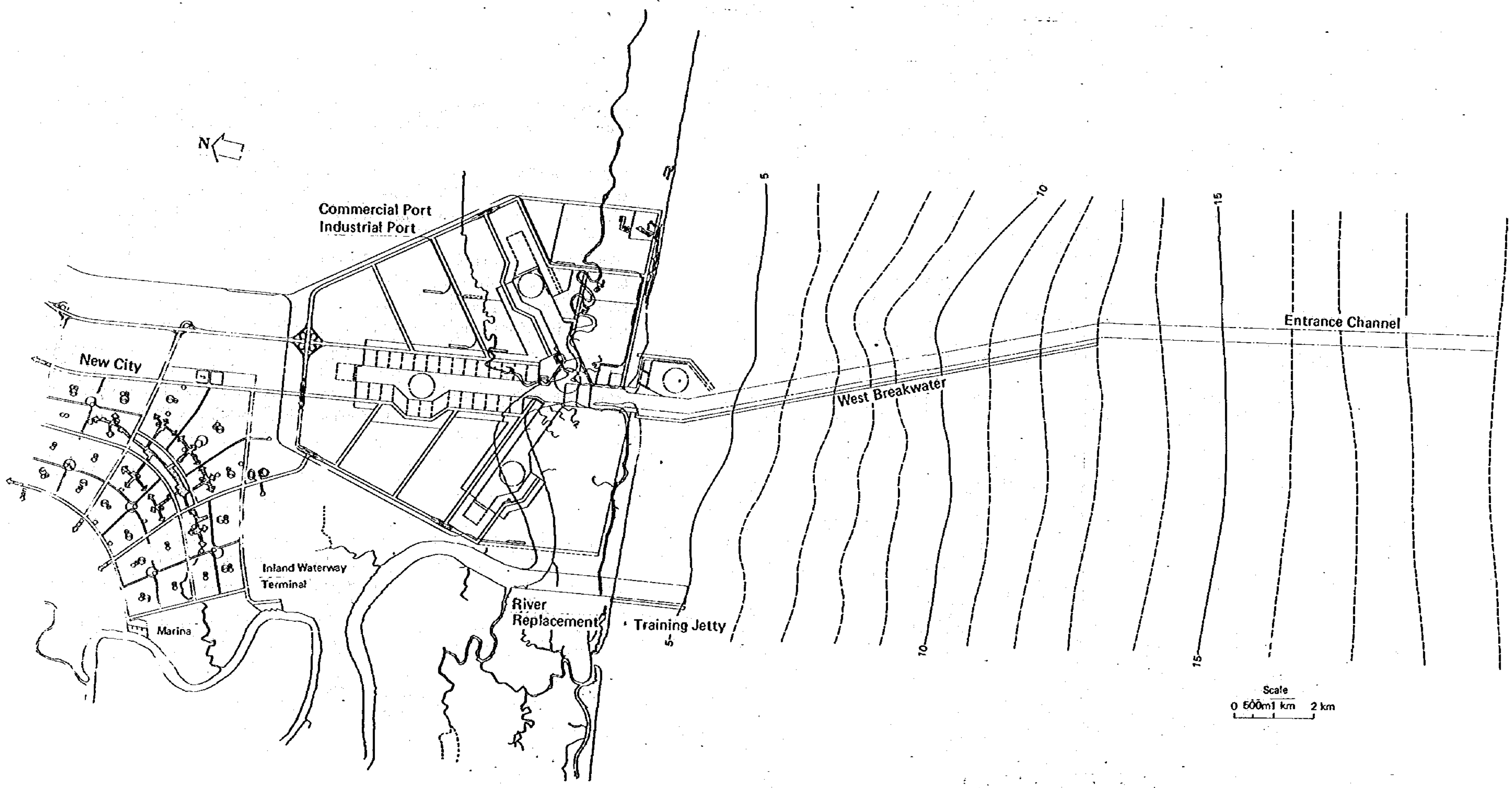


Fig. III-3-13 Master Plan of the New Ocean Terminal in the Year 2000

CHAPTER 4. PRELIMINARY DESIGN OF MAJOR PORT FACILITIES

III-4-1. Remarks on the Preliminary Designing

Breakwaters and berth facilities suited to commercial and industrial ports were designed for NOT-Lagos; the same facilities, in principle, are planned for NOT-east. Berth allocations in the form of artificially excavated ports are proposed.

This preliminary port study aims at approximating construction costs for NOT-east. The definitive details of each structure shall be revised or redesigned in the stages of detailed designing. In order to facilitate cost comparison of both port sites, the structure of port facilities for NOT-east has been designed after NOT-Lagos.

NOT-Lagos is located in an area with good soil foundation. According to the test borings for NOT-east, the Ibeno site has good soil foundation, while the other two sites (Opobo and Jamestown) are inferior to NOT-Lagos. Under these conditions, proposed port facilities at the Ibeno site could be modeled after the same structural type recommended for NOT-Lagos, but those at Opobo and Jamestown would require some modifications.

The NOT-east breakwater would be placed in seas gentler than those at NOT-Lagos. So, the same structural type of NOT-Lagos has been adopted for NOT-east, but each dimension of breakwater has been revised considering the wave condition of NOT-east.

III-4-2. Natural Conditions Surrounding Designing

(1) Tide

Although sufficient tidal observations have not yet been carried out at the proposed port sites, tidal elevations at the sites (Opobo, Ibeno and Jamestown) have been tentatively established using tidal data from neighboring ports such as Calabar and Opobo.

Existing tidal data (Spring Tide)

Opobo	H.W.L.	+1.95 m
	L.W.L.	+0.12 m
Calabar	H.W.L.	+2.29 m
	L.W.L.	+0.27 m

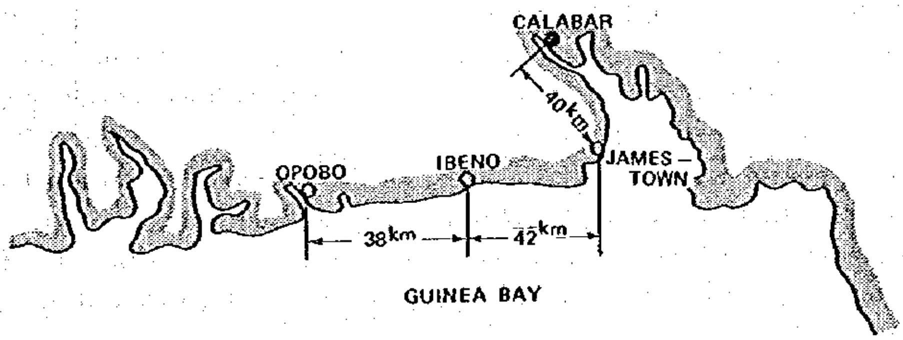


Fig. III-4-1 Location of Studied Sites and Ports

While the proposed port site at the Opobo area is located quite near an established tidal station, the other two sites are located about 40km away from such established tidal stations.

As is well known, the tidal elevations of a given area are governed by such factors as its position on the globe (latitude and longitude) and surrounding geographical features. Since the proposed port sites are located within as little as 40km of established tidal stations, and because surrounding geographical features are not complicated, the average figures already established for those existing tidal elevations have been adopted as tentative tidal elevations for NOT-east.

Tidal elevation is one of the major factors in determining the elevations of wharves, piers and breakwaters.

It is considered that a difference of 10 cm to 20 cm in tidal elevation is trivial at the preliminary designing stage, so the following average figure has been used for all proposed port sites (Jamestown, Ibeno, and Opobo).

Tidal elevations at the proposed port sites

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

(2) Earthquake

Inasmuch as there has been to date no significant seismic disturbance in Nigeria, seismic force has been in general disregarded in the designing of port facilities and other major structures.

Nevertheless, as eastern Nigeria borders on the United Republic of Cameroun where there is some volcanic activity, it is not inconceivable that this region could be affected by seismic disturbance in the future. In similarly situated Guinea, structures of major importance such as long-spanned bridges are designed in expectation of only a low degree of seismic force (kh = 0.05).

In the preliminary designing of NOT-east it may therefore be advisable that some allowances are made for possible seismic disturbance. However, seismic disturbances of kh 0.05 are so slight that the design of most port facilities need not be influenced by this factor. It is the consultant's belief that in the stage of this report, no special seismic considerations are necessary, and that proper attention to safety factor constitutes sufficient precaution.

(3) Soil Conditions

As described in the soil report for the NOT project on the eastern coast, two sets of test borings have been carried out at each proposed port site. The locations of test bores and the boring logs are shown in Figs. III-4-2 and III-4-3.

The geological composition of the coastal area between Opobo and Jamestown is based on alluvial deposits from the River Niger. Generally, the upper layer is sandy soil, with silty clay or silty sand underlying this upper layer.

Proportionate to the vast area required for the proposed port construction, the number of borings is relatively small, and it may therefore be difficult to draw accurate conclusions about soil conditions based only on that limited data. Anyhow, as the first step to analyse the soil condition at the port sites, overall soil conditions have been studied in view of foundation engineering.

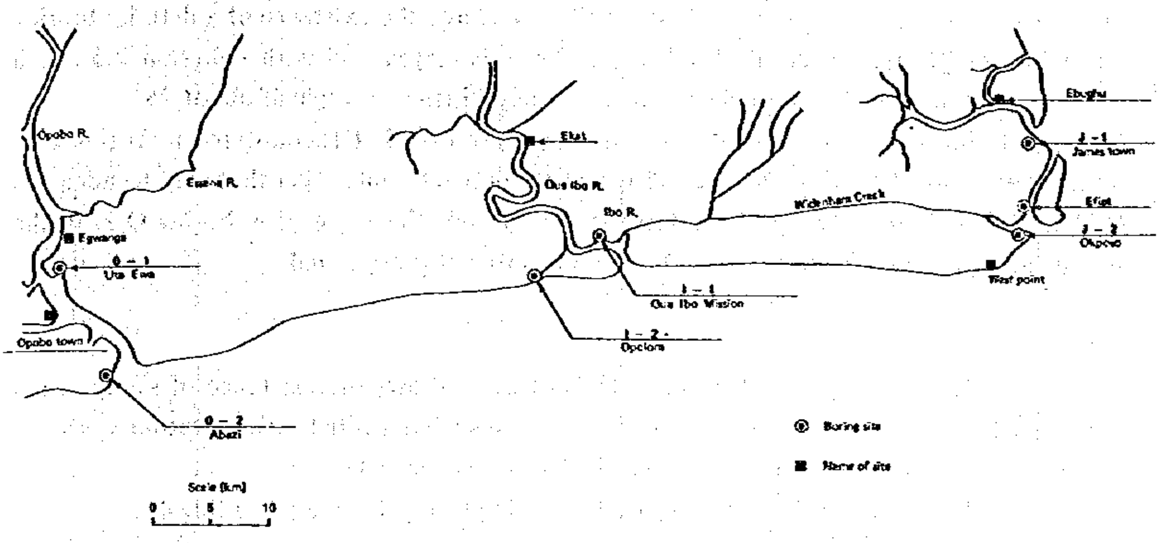


Fig. III-4-2 Locations of Test Boring Sites

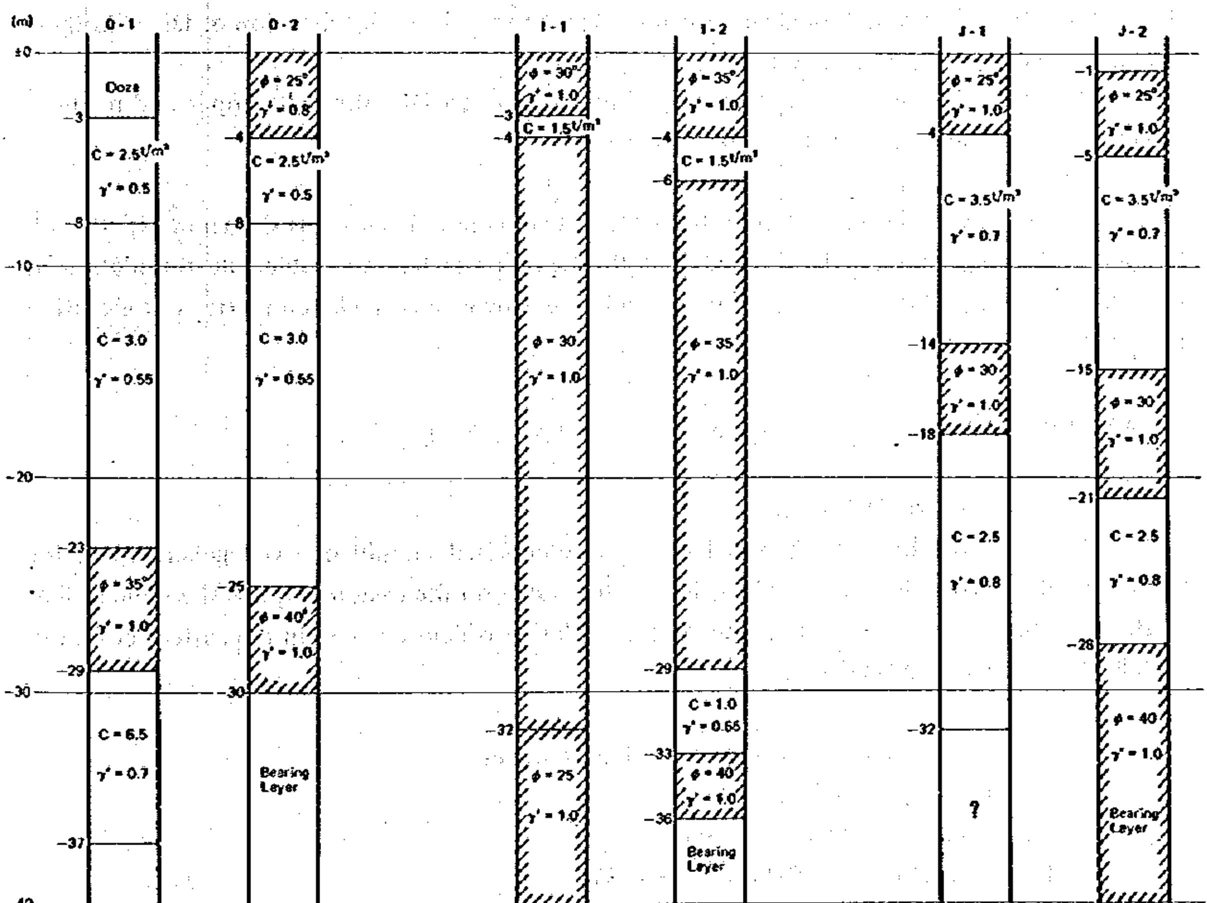


Fig. III-4-3 Boring Logs

1) Opobo

Boring O-2, taken near the proposed site at Opobo, shows the existence of a definite bearing layer suitable for piled foundation. The medium layer is clayey soil with cohesion 2.5 ~ 3.0 t/m^2. The upper layer consists of sandy soil with an internal friction angle of about 25°.

Boring O-1, however, shows no specific bearing layer like that encountered in boring O-2. However, at elevation DL-26 ~ -28m, there is a very compact sandy layer that may be adequate for light load foundation. The medium layer is clayey soil, the same as in boring O-2. In the surface layer (upper layer), unlike boring O-2, muddy soft soil is deposited.

2) Ibeno

Boring I-1, where the prototype of NOT is located, shows the existence of sandy soil in the upper, medium, and lower layers as well. However, no such definite bearing stratum as seen in boring I-2 can be found. At elevation DL-38m, the N-valve is about 18.

Boring I-2 shows the existence of a specific bearing layer, N-value exceeding 45.

3) Jamestown

Boring J-1 shows the following soil pattern: an upper layer of sandy soil; a medium layer consisting of 10m of thick clay and 5m of thick sand; a lower layer of clayey soil, cohesion less than 2.5 ~ 3.0 t/m^2. No definite bearing stratum can be found. At the elevation of DL-35m there is a layer of stiff clay, average N-value 15.

Boring J-2 indicates a sandy bearing layer at elevation DL-30m. The upper and medium layers have the same characteristics as in Boring J-1.

As mentioned before, soil conditions for designing have been set as shown in Fig. III-4-4. Comparing bearing strata, it is assumed that the Opobo site has a reliable pile foundation at elevation DL-30m, while the sites at Ibeno and Jamestown have such foundations at elevation DL-40m.

(4) Wave Condition

1) Estimates of design offshore waves

Waves approaching the Nigerian coast are comprised mainly of swell generated in the wind area of the Atlantic Ocean. The origin of the waves on the eastern coast is the same as that of those on the western coast. The dimensions of design offshore waves in the eastern coast can thus be described as in NOT-Lagos:

- Significant wave height of design offshore waves (recurrence period 50 years): 6.0 m
- Significant wave period: 12 sec
- Direction of design offshore waves: SW

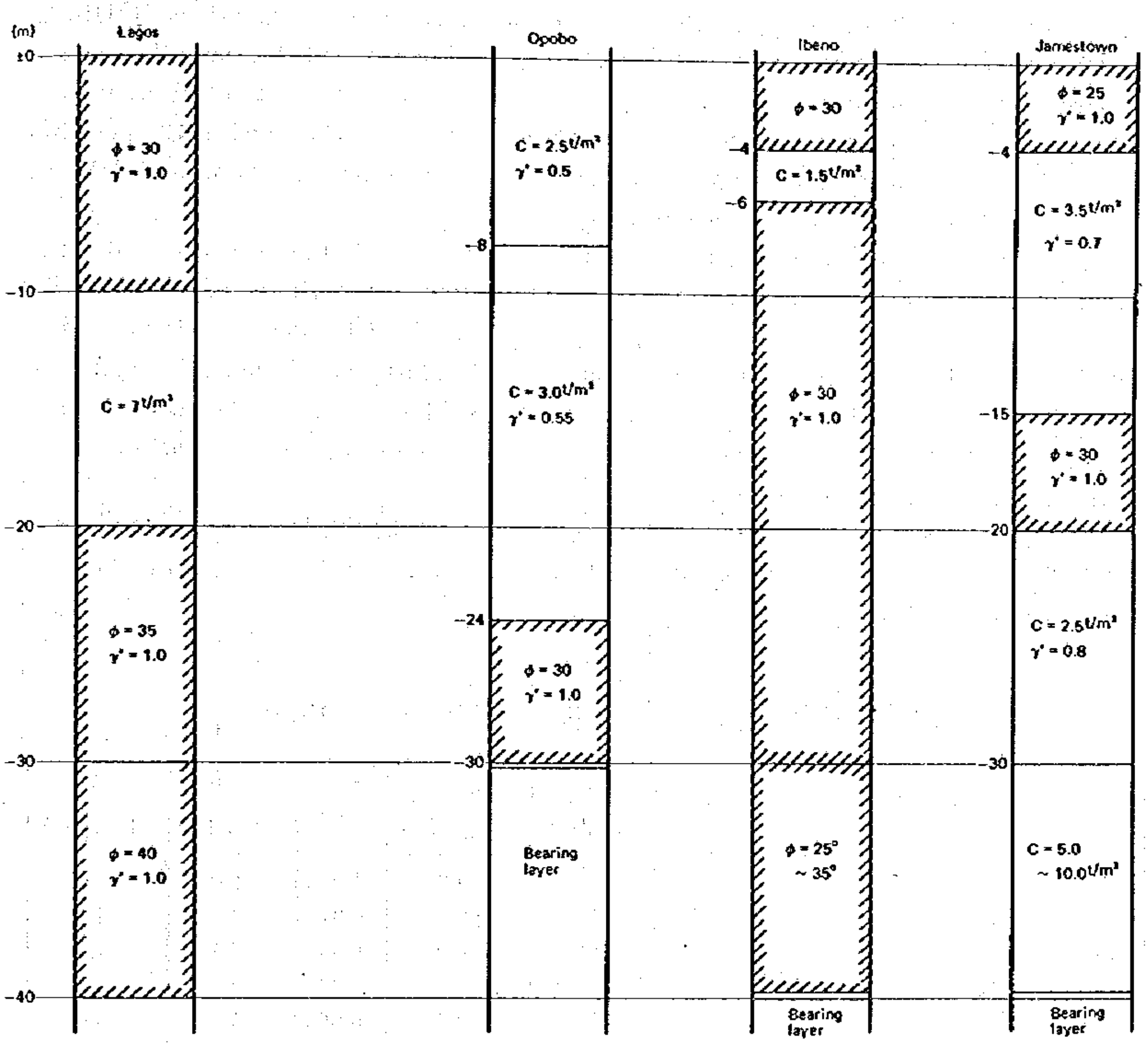


Fig. III-4-4 Soil Condition for Designing

2) Calculation of design wave heights at respective water depths

The average gradient of the bottom slope in the eastern coast is approximately 1/1400. The transformation of irregular waves due to breaking is calculated using the method developed by Goda.[1] This calculation method is based on the concept that wave height distribution of irregular waves in deep sea is in accordance with the Rayleigh distribution, and that components of waves begin breaking at corresponding breaking water depths – that is, small waves break near the shore; larger waves break further offshore.

The bottom slope of the eastern coast is flat, so wave height in this area is lowered due to bottom friction, as well as shoaling, breaking, and refraction. Although the effect of bottom friction on breaking waves is not sufficiently understood at this point, the method proposed by Bretschneider and Reid[2] has been adopted. Strictly speaking, this method can not be applied for breaking waves, but has been chosen tentatively as second best. Field observations of waves at various water depths must be carried out during the feasibility study to derive actual figures for the effect of bottom friction at each site.

Table III-4-1 shows design wave heights at different sea depths. Decreasing rate of wave heights K_f at 5.5 m deep is 0.50, so the height of waves affected by friction is half of that of waves when friction is absent.

Table III-4-1 Design Wave Height at Different Sea Depths

h (m)	h/Lo	Kr	α	Ho'(m)	Without Friction		K_f	With Friction	
					$H_{1/3}$(m)	H_{max} (m)		$H_{1/3}$(m)	H_{max}(m)
18	0.080	0.86	22°	5.2	5.0	9.0	1.0	5.0	9.0
16	0.071	0.85	20°	5.1	5.0	8.9	0.91	4.6	8.1
14	0.062	0.84	18°	5.0	5.0	8.9	0.83	4.2	7.4
12	0.053	0.83	17°	5.0	5.2	8.5	0.74	3.8	6.3
10	0.044	0.83	15°	5.0	5.2	7.5	0.66	3.4	5.0
8	0.036	0.82	13°	4.9	4.7	6.3	0.59	2.8	3.7
6	0.027	0.82	11°	4.9	3.8	4.9	0.52	2.0	2.5
4	0.018	0.81	8°	4.9	2.8	3.6	0.45	1.3	1.6

h = Sea depth
Lo = Wave length in deep sea
Kr = Refraction coefficient
α = Predominant wave angle from south
Ho' = Equivalent deep sea wave height
$H_{1/3}$ = Significant wave height
K_f = Friction coefficient

1) Y. Goda; Irregular wave deformation in the surf zone, Coastal Eng. in Japan, JSCE, Vol. 18, 1975.

2) Bretschneider, C.L. and R.O. Reid; Modification of wave height due to bottom friction, percolation and refraction, B.E.B. Tech. Memo. No.45, 1954.

(5) Design Criteria of Berths

The design criteria of each berth of NOT have been established as shown in Tables III-4-2 and III-4-3. The contents of design criteria are the same as those for NOT-Lagos with the exception of platform elevations. Considering the tidal elevation at NOT-east of 1.0m higher than that at NOT-Lagos, all the platform elevations have been raised 1.0m.

Table III-4-2 Design Criteria of Commercial Port Berths

	General Cargo Berth	Container Berth	Bulk Cargo Berth	Petroleum Berth	Small Crafts Berth
Design Conditions					
Crown height (m)	+4.0	+4.0	+4.0	+5.0	+3.0
Surcharge (t/m²)	2.0	1.0	2.0	–	0.5
Design depth (m)	-10	-13	-14	-10	-3.5
Design length (m)	185	300	300	185	–
Size of vessels (D.W.T)	15,000	50,000 G.T	60,000	15,000	280G.T
Berthing speed of vessels (m/sec)	0.15	0.15	0.15	0.15	–
Cargo Handling Facilities					
Type	mobile crane	container crane	penumatic unloader	loading arms	–
Capacity (t/hr)	–	–	400	1,000	–
Lifting load (t)	maximum lifting load 20	net lifting load 30.5	–	–	–

Table III-4-3 Design Criteria of Industrial Port Berths

	Ore Berth			Oil Berth
	Iron ore	Coal	Limestone	
Design Conditions				
Crown height (m)	+4.0	+4.0	+4.0	+5.0
Surcharge (t/m²)	2.0	1.0	2.0	–
Design depth (m)	-18.0	-17.0	-13.0	-16.0
Design length (m)	350	310	270	400
Size of vessels (D.W.T.)	150,000	120,000	50,000	100,000
Berthing speed of vessels (m/sec)	0.12	0.12	0.15	0.12
Machine/equipment	unloader	unloader	unloader	unloading arm
Type				
Capacity (t/h)				
Lifting load (t)				

III-4-3. Preliminary Designing of Berth

(1) Commercial Port

The approach to preliminary design for NOT-east follows that established for NOT-Lagos.

In designing the berth, the relieving platform type, the platform type, the sheet pile type, the gravity type and the dolphin type can be considered. In this study, for the convenience of cost comparison of both port sites (west and east), the same structures such as the steel-pipe relieving platform, the steel-pipe dolphin and the steel-sheet pile wharf have been studied. However, in each structure mentioned above, minor revisions have been made to allow for design requirements.

Inasmuch as the soil conditions of NOT-east are inferior to those of NOT-Lagos, the following basic design points have been studied and revised in preliminary designing.

1) Pile penetration

At NOT-Lagos the bearing strata for piled foundation are located at elevation DL-30m.

On the other hand, as shown in Fig. III-4-3 at NOT-east the bearing strata fluctuate considerably. Examining the engineering logs of the two sets of boring each taken at the proposed port sites (Opobo, Ibeno and Jamestown), the seaside borings at each site indicate definite bearing strata, while shoreside ones show no definite layer suitable for piled foundation.

As the port layout covers both seaside and shoreside areas, for safety's sake the deeper of the two has been chosen in determining bearing layer elevations figures (see Table III-4-4).

Table III-4-4 Bearing Layer Elevations

NOT (east)	NOT (Lagos)
Opobo DL-30 m Ibeno DL-40 m Jamestown DL-40 m	Lagos DL-30 m

2) Horizontal Reactions of Piles

As water depths for the berths range from 10 m to 18 m, and soil conditions at these elevations are generally poor (except for the Ibeno site), the horizontal reactions of the piles have been newly calculated for the Jamestown and Opobo sites.

Table III-4-5 Soil Characteristics of Each Site

Opobo	$C = 3.0\ t/m^2$ $\bar{N} = 5$	clay
Ibeno	$\phi = 30°$ $\bar{N} = 10 \sim 20$	sand
Jamestown	$C = 3.5\ t/m^2$ $\bar{N} = 10$	clay
Lagos	$\bar{N} = 20$	clay

Calculations indicate that the pile dimension applied at NOT-Lagos will meet design requirements for NOT-east.

3) Sheet pile wharf

At NOT-Lagos, the small crafts basin wharves were designed with steel sheet piled structure. As mentioned above, the soil condition at Opobo and Jamestown area is very poor, and required dimensions for sheet pile have been studied. The result of these calculations is that U-III type sheet pile has been adopted.

4) Slope of riprap under relieving platform

The slope stability of the riprap under the relieving platforms has been checked at the Opobo and Jamestown sites. Calculations show that a slope gradient of 1:1.5 is too steep, and that at least i = 2.0 is required.

Consequent to this wider riprap work, the platform must be widened as well. Resulting platform widths are shown in Table III-4-6.

Table III-4-6 Width of Platform

Site / Water Depth	Opobo, Jamestown	Ibeno	Remarks
-10 m	19.0 m	15.0 m	General cargo wharf
-12 m	24.5 m	21.0 m	Container wharf
-14 m	26.5 m	22.0 m	Bulk cargo wharf

(3) Industrial Port

The basic types of port facilities are comparable to those of the commercial port. The platform elevation of the Ibeno site has been set 1.0m higher than that of NOT-Lagos. At the Jamestown and Opobo sites, pile penetration, slope of riprap, and platform width have been modified.

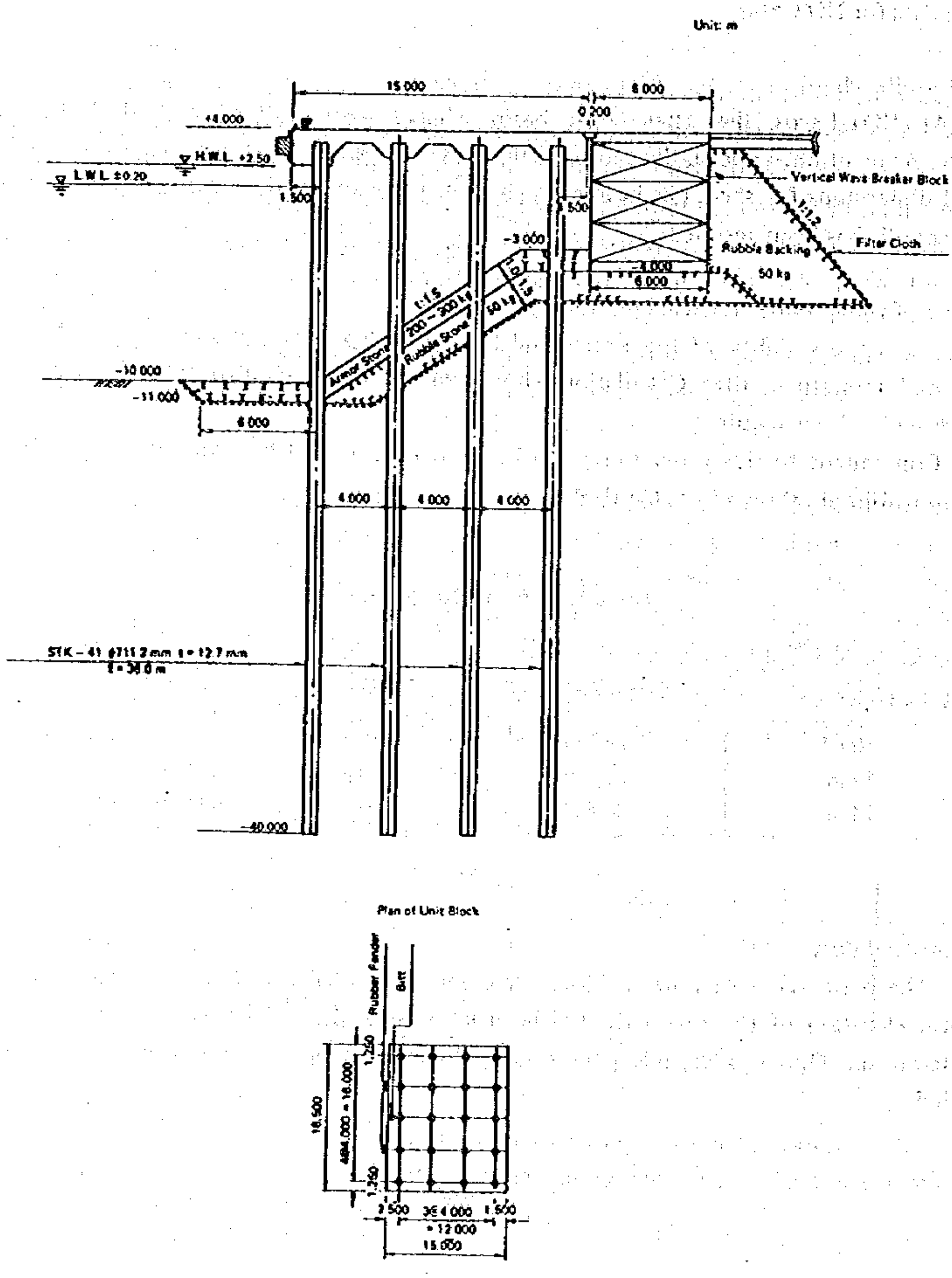


Fig. III-4-5 Typical Section of General Cargo Wharf (Ibeno)

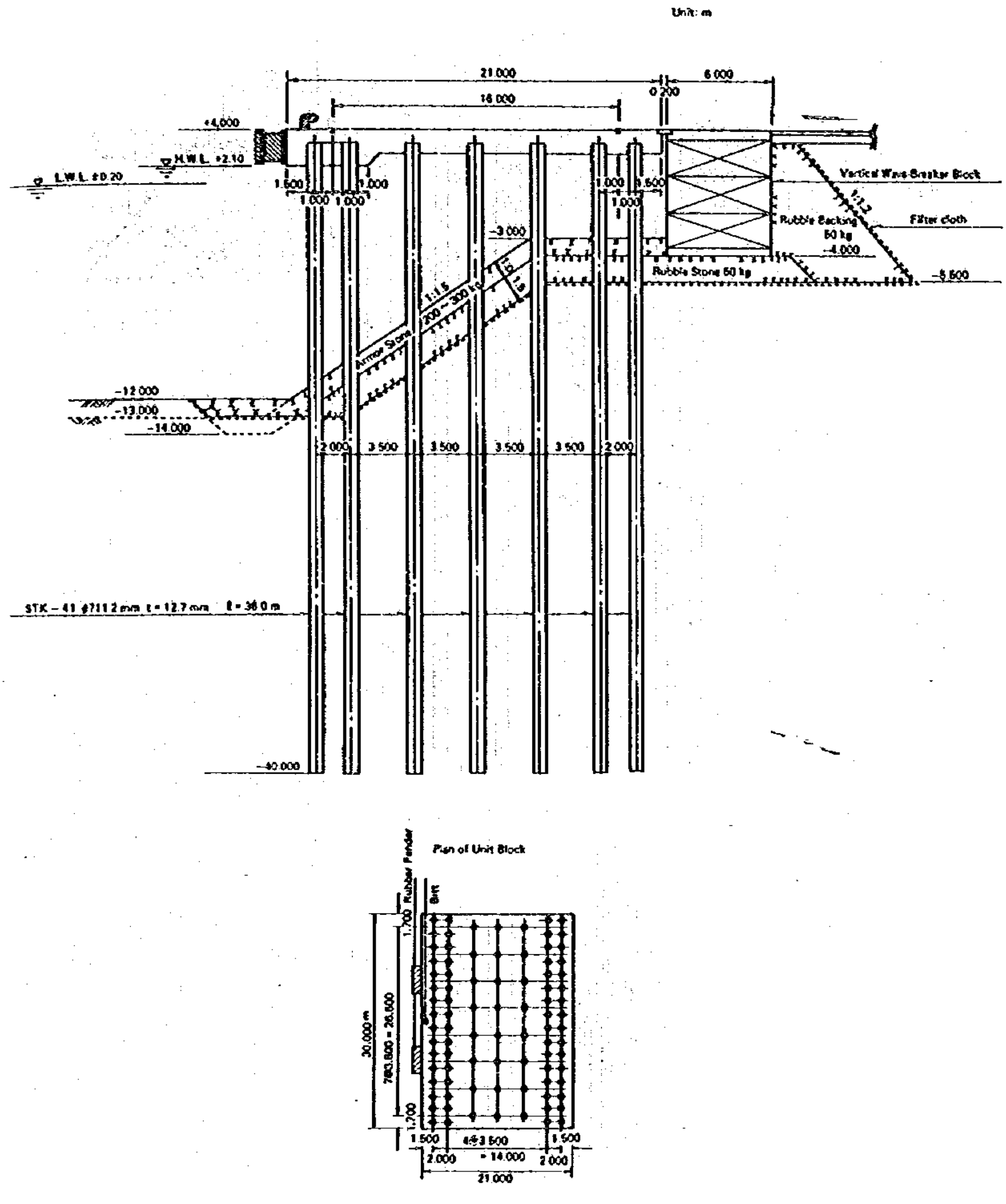
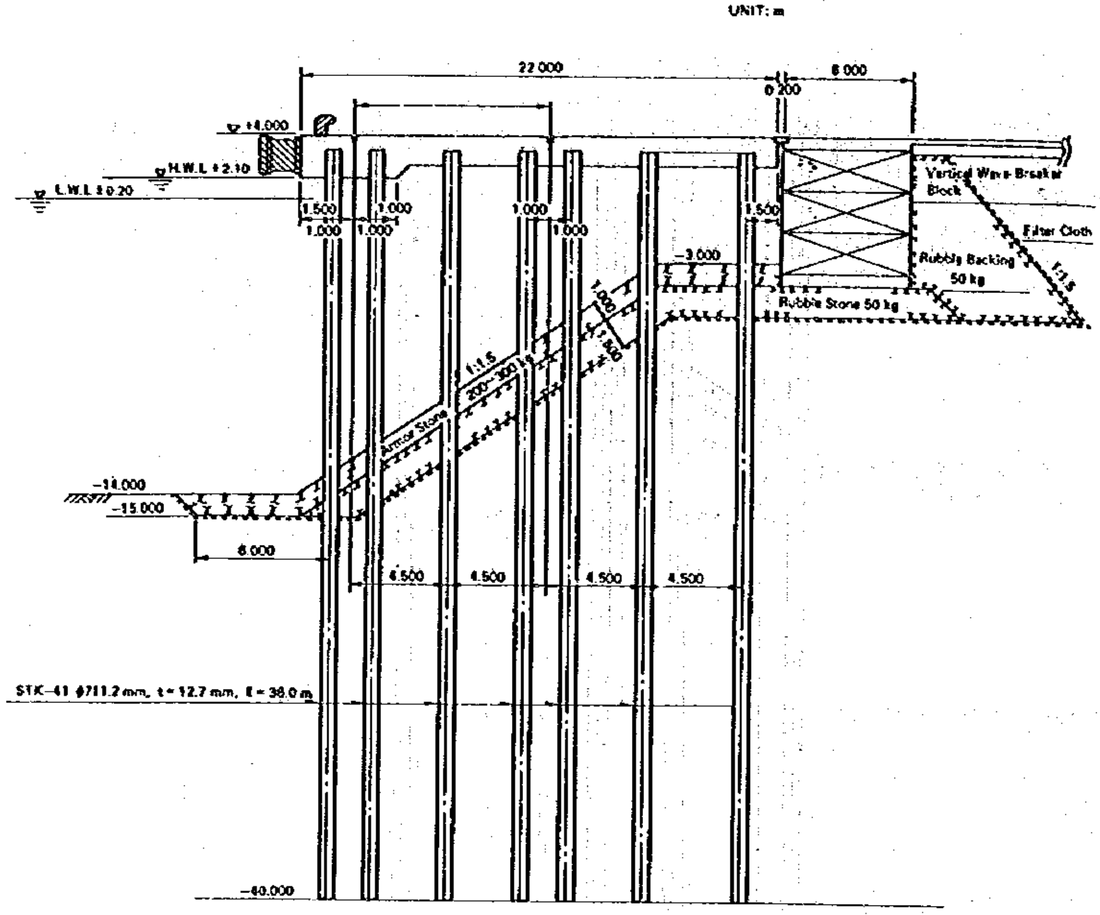


Fig. III-4-6 Typical Section of Container Wharf
(Ibeno)



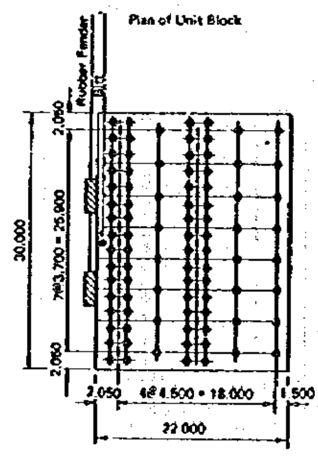


Fig. III-4-7 Typical Section of Bulk Cargo Wharf (Ibeno)

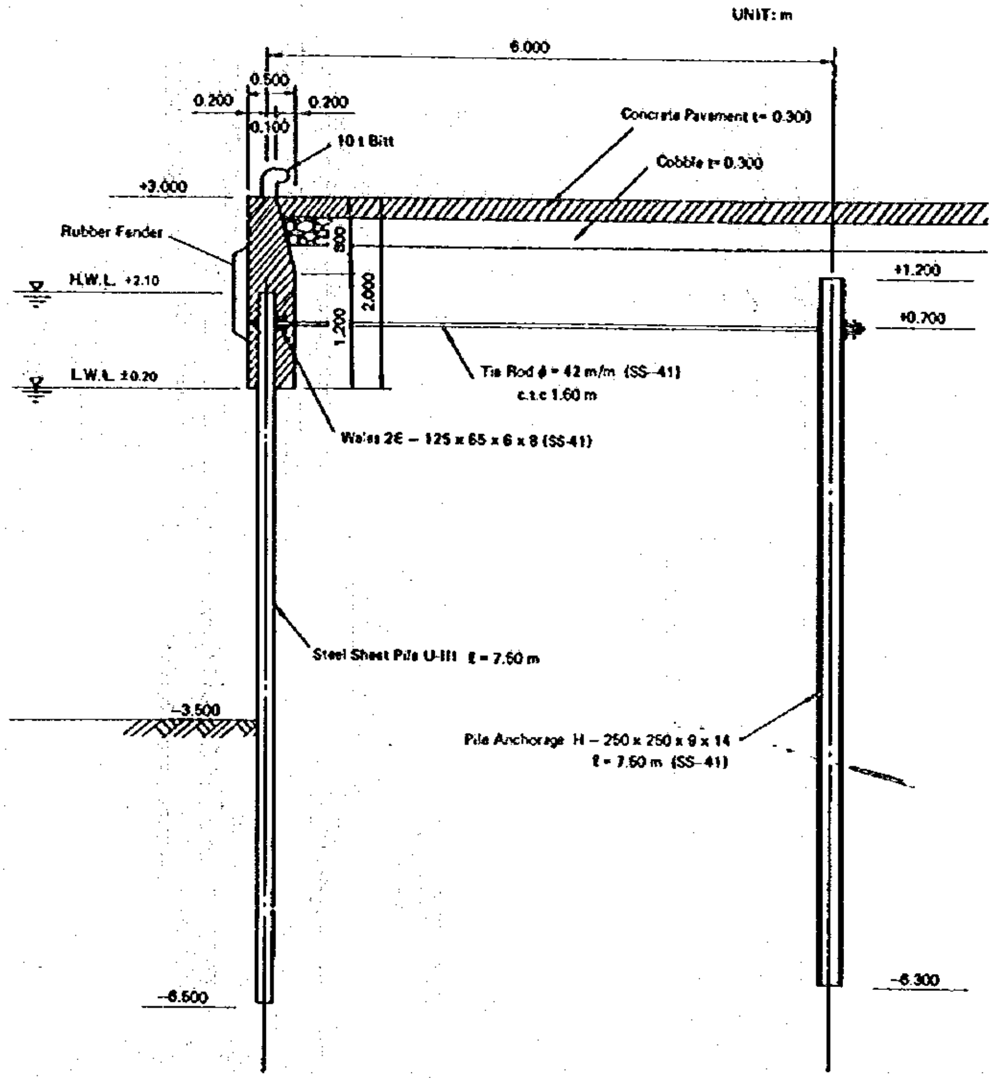


Fig. III-4-8 Typical Section of Small Crafts Wharf (Ibeno)

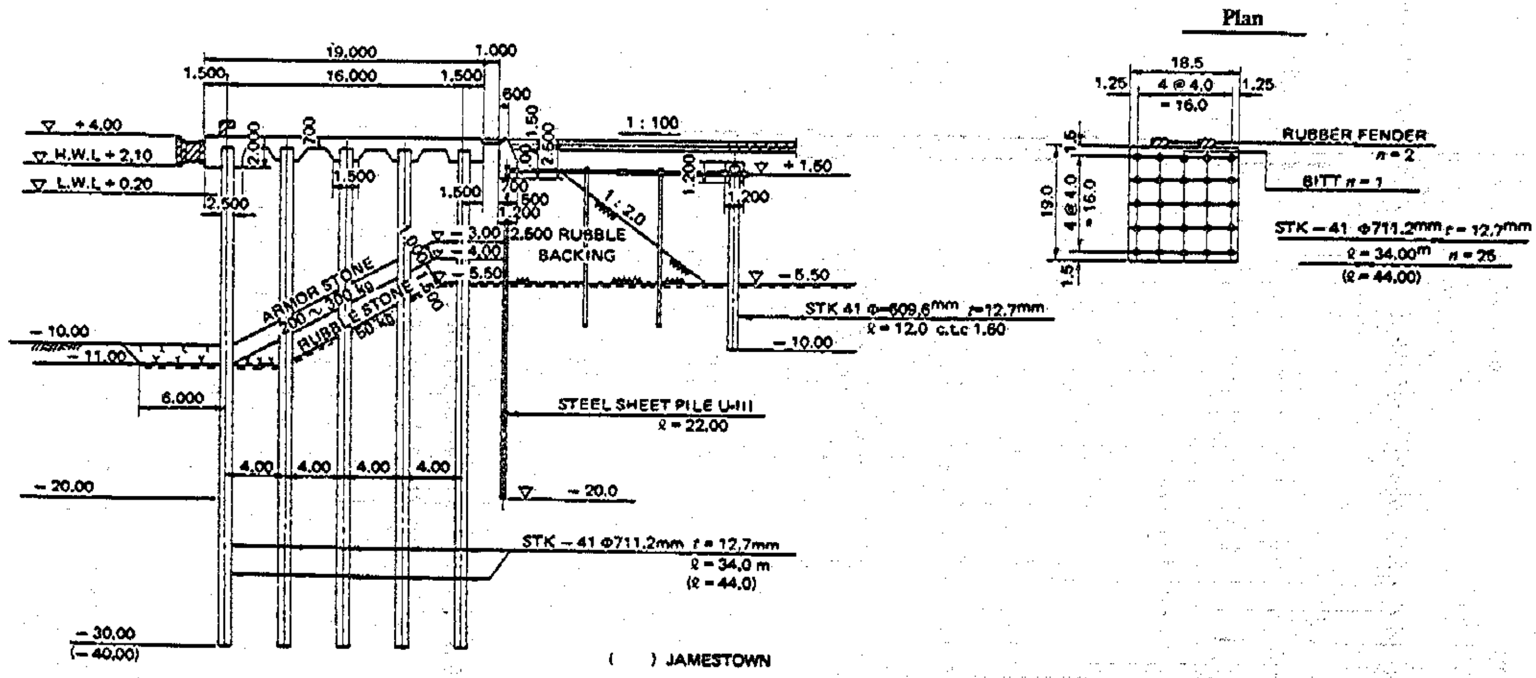


Fig. III-4-9 Typical Section of General Cargo Wharf
(Jamestown, Opobo)

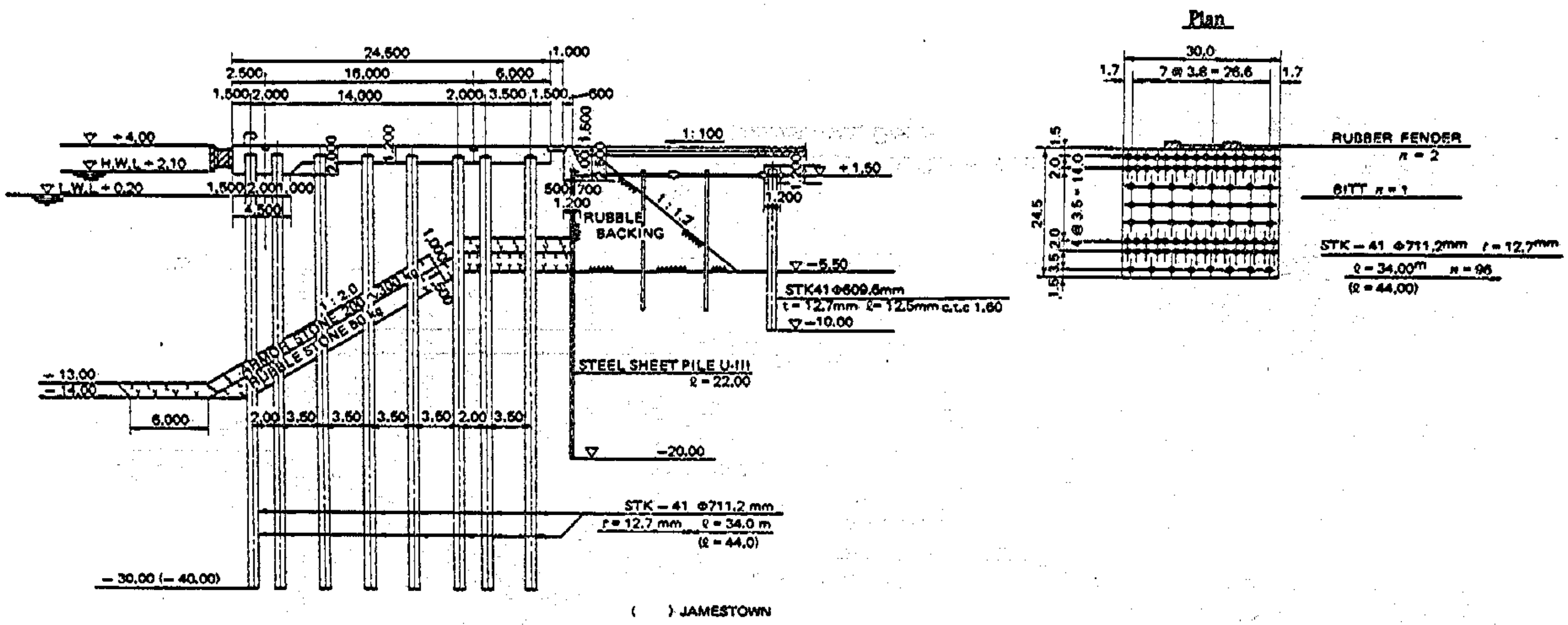


Fig. III-4-10 Typical Section of Container Wharf (Jamestown, Opobo)

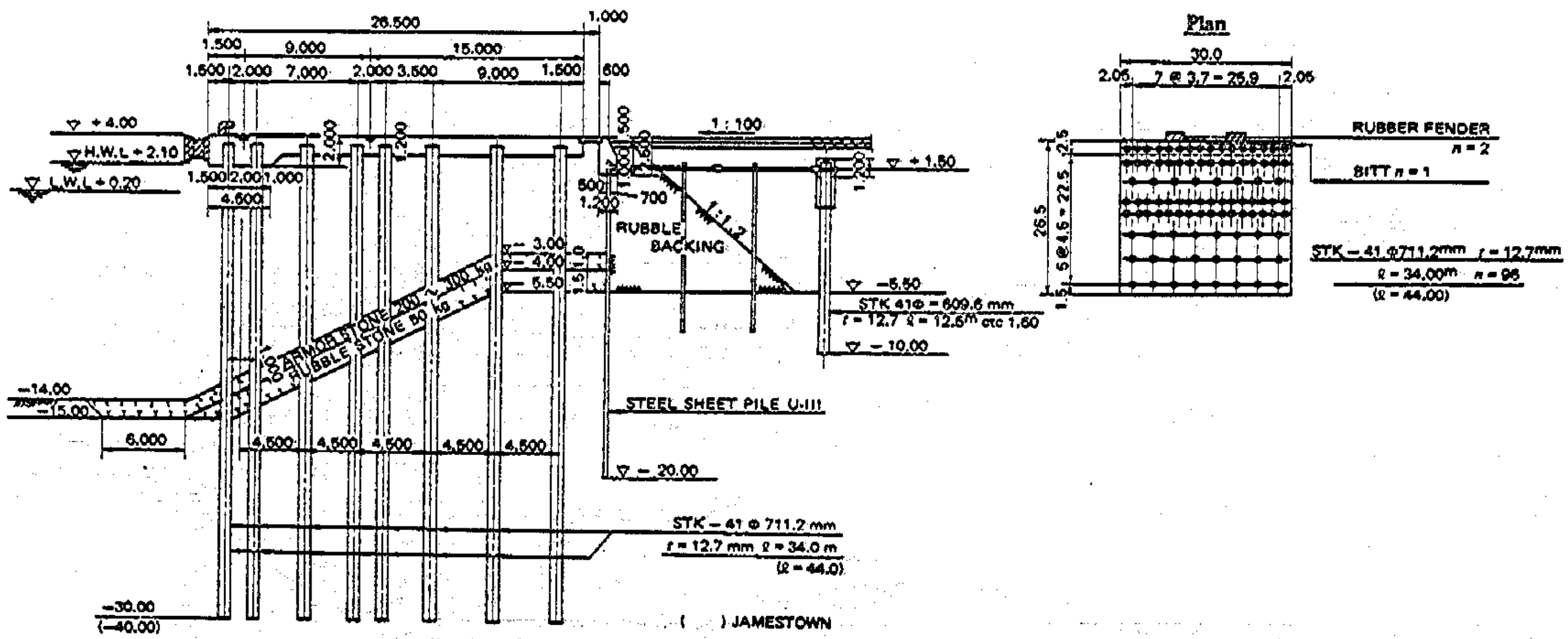


Fig-III-4-11 Typical Section of Bulk Cargo Wharf
(Jamestown, Opobo)

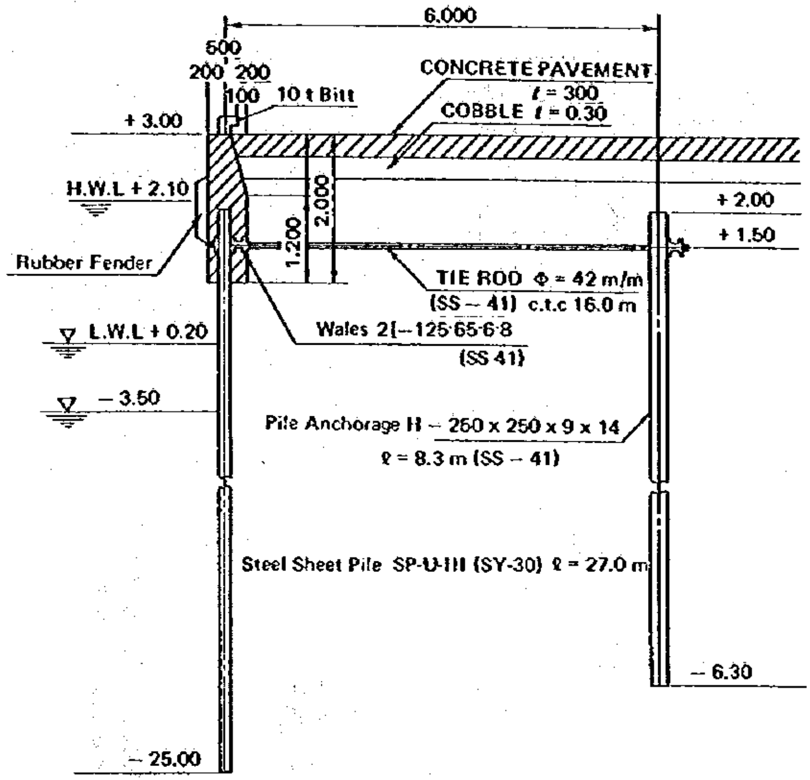


Fig. III-4-12 Typical Section of Small Crafts Wharf (Jamestown, Opobo)

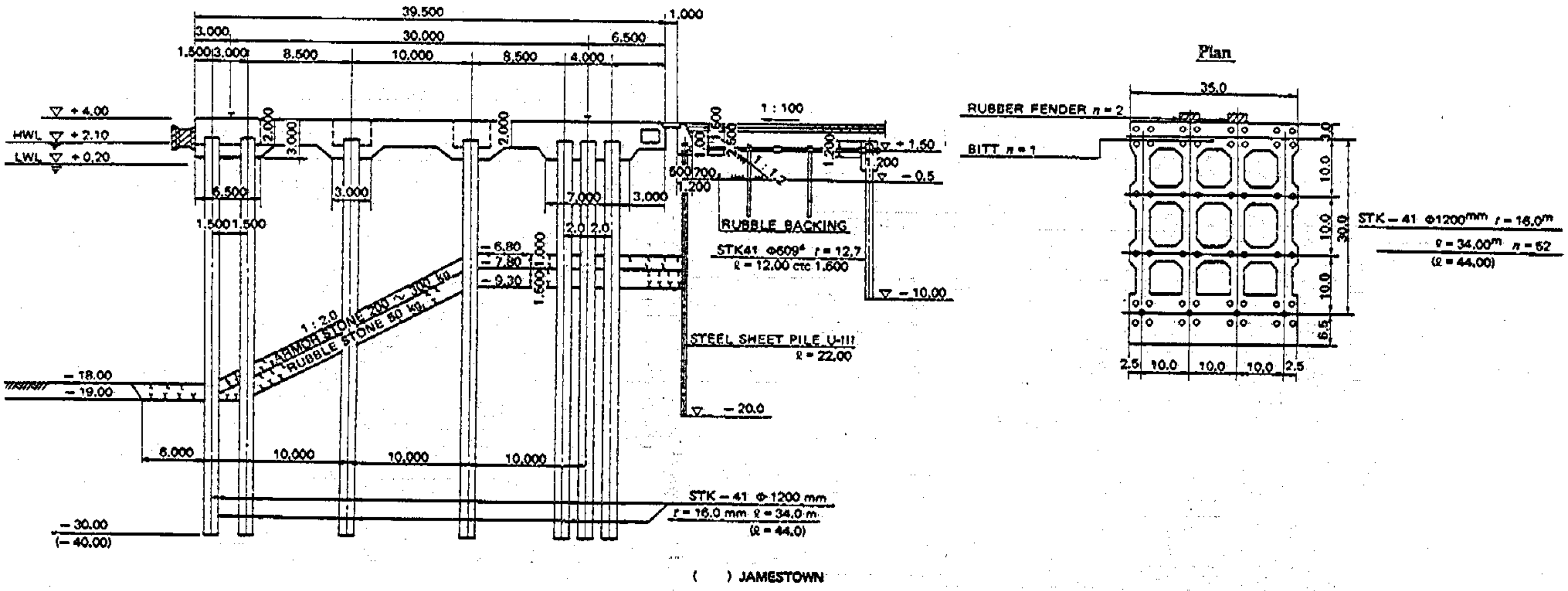


Fig. III-4-13 Typical Section of Iron Ore Wharf (Jamestown, Opobo)

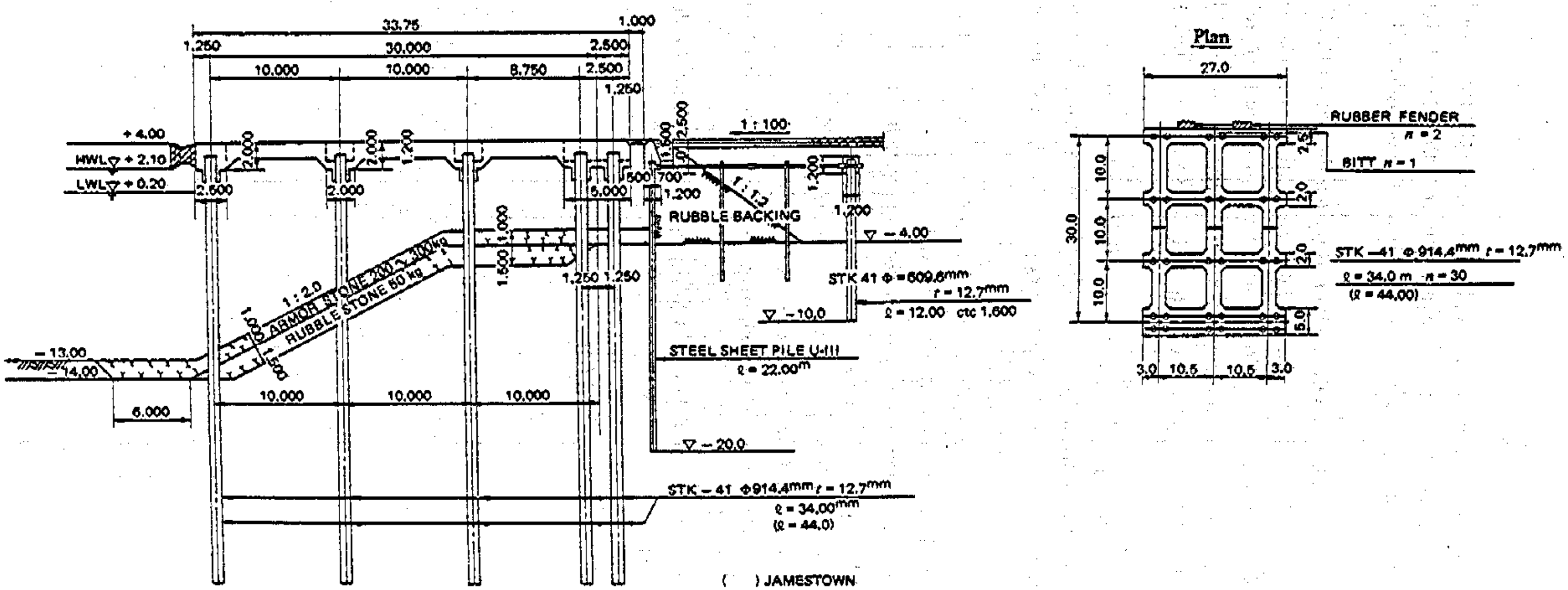


Fig. III-4-14 Typical Section of Limestone Wharf
(Jamestown, Opobo)

III-4-4. Designing of Breakwater

As seen in Table III-4-1, design waves for each water depth were set in the figure of $H_{1/3}$ and H_{max}. It may be noted that wave heights at NOT-east are slightly lower than those at NOT-Lagos. This is attributed to the fact that the considerably smoother seabed has a damping effect on the waves.

The waves come to the breakwater with the certain angles not perpendicular to the line of the breakwater. This angle is not exactly right angle, but on the safe side all the designing sections of the breakwater have been determined on the assumption that the waves come perpendicular to the line of breakwater. Caisson and rubble mound are the structure types considered. Required sections at the corresponding water depths were calculated and are shown in Figs. III–4-15, III-4-16.

In comparing the unit costs of both types, it was assumed that for water depths exceeding DL-5.5m, the caisson type is more economical than the rubble mound type. Accordingly at depths shallower than DL-5.5m the rubble mound type was applied, while at depths exceeding D.L.-5.5m, it was preferable to apply the caisson type.

In the designing of the breakwater, the widths of the structures were determined in accordance with stability analysis (sliding, overturning, and bearing).

The elevations of the structures were determined by the following procedure:

(1) The bottom elevation of in-situ coping-concrete was set at DL + 1.50m considering tidal elevation, top elevation of breakwater, and weight of capping concrete.
(2) The elevation of the rubble mound was set in round numbers of 0.5m unit according to the formula $EL = L.W.L.-(1.5 \times H_{1/3} + 3.0)$.
(3) The elevation of the breakwater was set at D.L. + 3.50m; that of the parapet calculated as follows: $EL = H.W.L. + 0.6 H_{1/3}$.

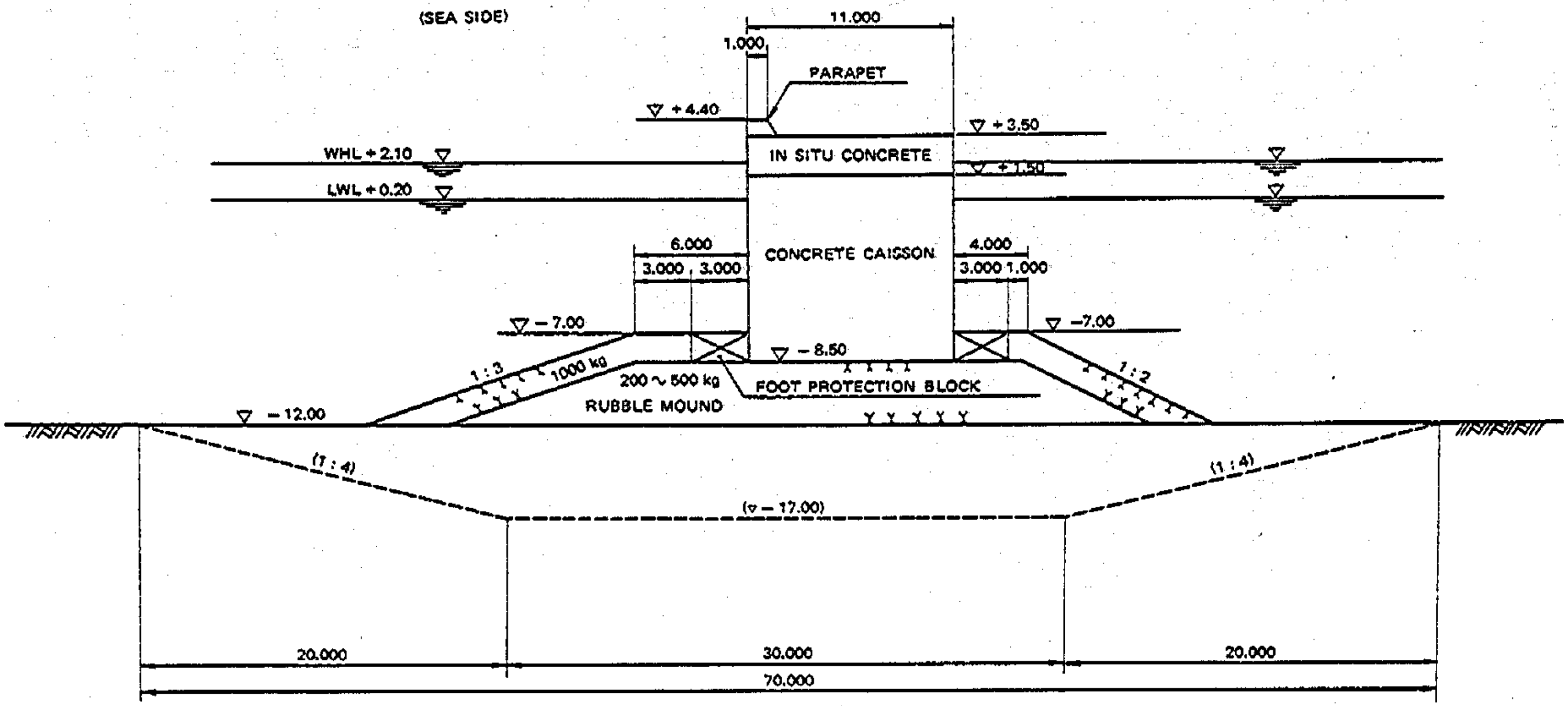


Fig. III-4-15 Cross Section of Breakwater (−12 m)

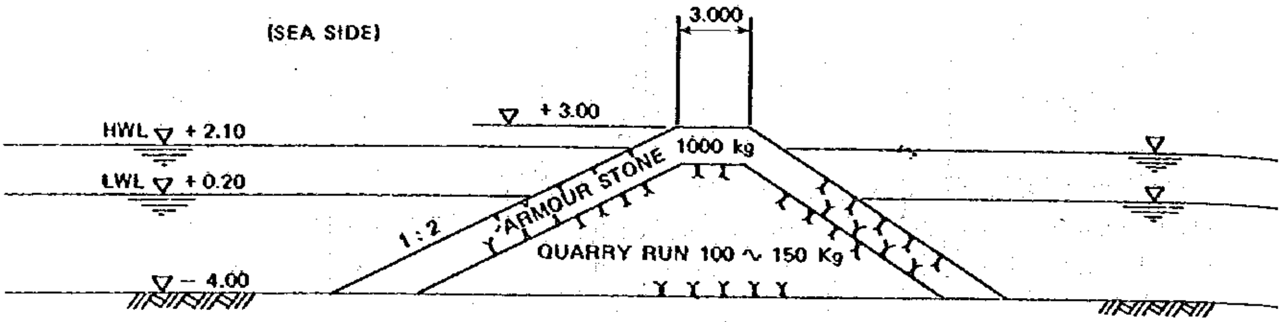


Fig. III-4-16 Cross Section of Breakwater (–4m)

CHAPTER 5. ROUGH ESTIMATES OF CONSTRUCTION COSTS

III-5-1. Method and Scheme of Construction

(1) Scheme of Temporary Works

1) Temporary access roads

The origins of construction materials and equipment are as follows:
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 Port. Steel, other standardized products, construction machines, and equipment will be imported via Port Harcourt Port and Calabar Port.

The nearby town of Eket is linked by entirely paved roads with ports Port Harcourt and Calabar, and these roads will serve as haul roads following minor repair and maintenance. One 20km stretch near Eket where the road surface is unsatisfactory must be repaved.

The large quantities of imported materials and equipment which are to be transported to Port Harcourt by oceangoing vessels will be transhipped to barges at the mooring buoys in the Bonny River and pulled to the Opobo area by tugboat, via the Strongface Creek.

A temporary jetty built near the existing Opobo jetty for unloading construction material and relatively short haul distance between Eket and Opobo would cut both transportation costs and time on land.

10 of the 16 km of existing road between Eket and the project site will be widened to four lanes and paved. The remaining 6 km section will be paved following the removal of mangrove and palm trees and the completion of embanking operations.

Four interconnected roads will be provided for the site itself: one for the camp and the office, one for the construction yard, one for the caisson manufacturing yard, and one shunt to the temporary jetty.

In the reclaimed area, these roads will be constructed on the banks to be provided for dredging work.

2) Temporary wharves

One temporary wharf each will be constructed at Opobo in the Imo River, Ibeno in the Kwa Ibo River, and inside the western breakwater. The purpose of the temporary wharf at Opobo is to unload imported materials and equipment brought from Port Harcourt. The temporary wharf at Ibeno will be used for the embarkation and debarkation of personnel and the loading and unloading of materials and equipment until the completion of the third temporary wharf on the western breakwater.

The temporary wharf on the western breakwater will be used not only as a facility for the loading and unloading of personnel, materials, and equipment during construction, but also as a shelter for workships.

3) Construction yards

Yards will be included within the site for a construction office, warehouses and a repair shop, for mixing of concrete products, and for storage of steel pipe piles.

Worker housing will be erected separate from such plant yards.

(2) Breakwaters

1) Quantity of materials

Table III-5-1 shows the approximate quantities of materials necessary for the construction of breakwaters at Ibeno.

Table III-5-1 Quantity of Materials for Breakwaters

	Type	Length	Materials	Quantity
West Breakwater	Rubble Mound Breakwater	3,100 m	Stone	378,000 m³
	Composite Breakwater	8,300 m	Stone Caisson Concrete	847,000 m³ 830 363,000 m³
East Breakwater	Rubble Mound Breakwater	2,100 m	Stone	176,000 m³
Training Jetty	Rubble Mound Breakwater	1,800 m	Stone	218,000 m³

2) Rubble mound breakwater

Rubble mound breakwaters will be constructed, stage by stage, from the shoreline out.

Rubble delivered by dump truck is deposited directly from the truck, but stones for the tread are dumped on the embankment. Once dumped, the stones are arranged roughly by a clamshell or a backhoe so as to form the designated cross section. Lastly, divers grade the stones.

3) Composite breakwater

Stones from a quarry will be delivered by large dump truck and loaded on to grab-stone barges (self-propelled type) of 500 m^3 level at the temporary jetty. Stones are deposited into place at a designated position by grab bucket.

Caissons are manufactured in a yard provided at the project site. After completion, the caissons will be launched by dredging the area in front of them with a cutter suction pump dredger.

(3) Dredging and Reclamation

1) Dredging

Dredging for relocating the estuary of the Kwa Ibo River is the first operation to be performed. A cutter suction dredger of 4,000 p.s. will be used for this work; the dredged material will be used for banking behind the east side iron and steel industrial yard, and for reclamation in the Opolon and Okurutip areas on the west side. After the new estuary is completed, dredging work will be carried out from upstream down.

Pump dredgers will be brought in through the new estuary and dredging will be started in the following order: central channel; east channel; north channel; west channel. On the sea side, meanwhile, dredging using an 8,000 p.s. cutter suction dredger will be started from a water depth of –5 m (about 5 km from the shore).

The entrance channel will be dredged by hopper suction dredger and the material from the dredging will be disposed offshore at a depth of more than –30 m, to avoid siltation.

2) Reclamation

Banks will be prepared, using material removed in the initial stages of dredging. A spillway will be provided for each dumping area of 4 ~ 5 km^2 and drainage will be effected, taking advantage of the existing creek.

+5.0 m will be used as the final reclamation height, but reclamation will be carried to a height of +5.5 ~ +6.0 m, in anticipation of subsidence.

Of the total volume of dredging, 15 % represents clay or silty clay. Since these are unsuitable as reclaiming materials; they will be disposed of outside the proposed industrial and housing areas.

3) Approximate volume of dredging

Table III-5-2 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

(4) Mooring Facilities

All mooring wharves other than small crafts basins will have foundations of steel pipe piles.

Their construction will follow the order of dredging mentioned above: central channel; east channel; north channel; west channel.

Riprap work for the foundations of the earth-retaining concrete blocks will be preceded by the driving of those piles whose driving would later be made difficult by the presence of riprap. Pile driving on the front side will be carried out after the installation of concrete blocks and filling with back-fill stones. Riprap work for the slope and the placing of cover stones will be performed after the completion of pile driving. Since the pier is about 20 m wide, riprap will be deposited by grab-bucket sand carrier from the front and by clamshell from the rear.

The small crafts basins and temporary wharves will be assembled by land machines prior to dredging, as they are of steel sheet pile construction.

III-5-2. Comparison of Rough Construction Cost Estimates

(1) Conditions of the Cost Estimates

1) Exchange rate: ₦ 1 = ¥400

2) Unit prices are based on table 1-1, Appendix 1.

3) The operational costs of workships were consolidated in Table 1-2, Appendix 1, using unit prices based on our investigation. This table serves as the basis of this estimation.

4) As for Commercial Port Facilities 5. Administration Office and Related Buildings; 6, Utilities; 7, Navigation Aids; and 9, Power Station; it has been assumed that construction costs in local and foreign currencies rose by 20% and 25%, respectively.

5) It is assumed that stones and crushed rock materials for concrete and road construction materials will be transported to NOT-east from Old Netin (north of Calabar); from Abeokuta to NOT-Lagos.

6) It is assumed that beach sand or dredged sand at the site will be used as fine aggregate for the concrete.

(2) Rough Estimate of Construction Cost of Port Facilities

Tables III-5-3 ~ III-5-5 show construction costs of commercial port, construction costs of industrial port, and total construction cost of both commercial and industrial ports.

Table III-5-3 Construction Cost of Commercial Port

Unit: Million ₦

Item	East		Lagos	
	Quantity	Cost	Quantity	Cost
1. Preliminary and Temporary Work	Road 21 KM	34.5	Road 63 KM	43.8
2. Breakwaters and Shore Protection Facilities				
1. Breakwaters	13,500 M	171.5	5,150 M	108.8
2. Shore protection facilities	1,000 M	5.4	2,000 M	10.0
3. Training jetty	1,800 M	12.1	–	–
3. Mooring Facilities and Related Facilities				
1. General cargo berth	33 Berth	290.2	33 B	257.5
2. Container berth	27 B	769.0	27 B	668.7
3. Bulk cargo berth	1 B	37.9	1 B	35.5
4. Petroleum berth	3 B	47.3	3 B	46.0
5. Small crafts berth	1,100 M	4.3	1,100 M	3.1
4. Dredging and Reclamation	$140 \times 10^6 M^3$	308.0	$86 \times 10^6 M^3$	168.1
5. Administration Office and Related Buildings	SUM	8.1	SUM	8.1
6. Utilities				
1. Water supply	SUM	16.1	SUM	16.1
2. Sewage and drainage	"	11.4	"	11.4
3. Electricity supply	"	8.7	"	8.7
4. Road and green belt for port service area	"	8.6	"	8.6
5. Communications system	"	2.9	"	2.9
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
Total		1,835.2		1,496.5

Table III-5-4 Construction Cost of Industrial Port

Unit: Million N

Item	East		Lagos	
	Quantity	Cost	Quantity	Cost
1. Preliminary and Temporary Work	SUM	8.1	SUM	11.7
2. Mooring Facilities				
1. Iron and Steel Berth				
a. Iron ore berth	2 Berth	38.1	2 B	30.1
b. Coal berth	1 B	16.9	1 B	12.8
c. Limestone berth	1 B	10.3	1 B	6.6
d. Steel products berth	9 B	40.2	9 B	33.8
2. Oil Berth				
a. Crude oil berth	2 B	4.9	2 B	4.0
b. Refined oil berth	1 B	2.0	1 B	1.6
3. Chemicals Berth				
a. Chemical materials	1 B	4.5	1 B	3.8
b. Chemicals	5 B	22.3	5 B	18.8
4. Shipbuilding Berth	3 B	13.4	3 B	11.3
5. Bulk Cargo Berth	1 B	13.7	1 B	11.6
3. Dredging & Reclamation	$31 \times 10^6 M^3$	68.6	$19 \times 10^6 M^3$	34.7
Total		243.0		180.8

Table III-5-5 Total Construction Cost of Ports

Unit: Million N

Facilities	East	Lagos
Commercial Port	1,835.2	1,496.5
Industrial Port	243.0	180.8
Total	2,078.2	1,677.3

(3) Comparison of Construction Costs in Three Eastern Areas.

Table III-5-6 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

(4) Cost for Maintenance Dredging

At the eastern coast, a 5,000 m^3 class hopper suction pump dredger will be necessary for maintenance dredging.

The yearly cost of maintenance dredging is ₦11.6 million.

(5) Additional Cost for Composite Breakwater

An engineering source from Mobil Company at Ibeno reports the existence of a mud layer approximately 4 ~ 5 m deep under the sea bottom at the proposed site of the composite breakwater.

Displacement with sand is the most efficient remedy for soft and weak foundations and although this may be necessary, its ₦19.8 million cost is not included in Table III-5-3.

CHAPTER 6. ENGINEERING EFFECTS

III-6-1. Siltation of the Entrance Channel

Because of the very gentle (about 1/1,400) sea-bottom slope on the eastern coast, only an exceedingly long breakwater could extend to a water depth of –18 m. It may therefore be advisable to construct a breakwater which shelters only part of the entrance channel, and to maintain channel depth by maintenance dredging in the unsheltered section.

According to Section II-1-4 "Sediments", the bottom sediments in the areas proposed for the channel are mud, and this mud will cause the siltation of the channel.

Predicted volume of siltation for channels not sheltered by the breakwater is calculated below.

Fig. II-1-6 in Section II-1-3 shows the current velocities off the Kwa Ibo River estuary reported by HRS. The current velocity in the east/west direction is about 0.30 m/s. In our observation, meanwhile, current velocity 2 m below the water surface is 0.20 ~ 0.30 m/s. From the above, we have assumed that the maximum current velocity at the water surface in the area proposed for the channel is 0.30 m/s. When the distribution of current velocities is logarithmic, the average current velocity, U, is 0.26 m/s. The friction velocity, U_{*o} is 0.017 m/s if U/U_{*o} is 15.0.

Siltation volume was calculated by the method proposed by Harrison & Owen[1]. This method can be applied to the case in which mud is transported by current, and assumes that siltation is caused because channel dredging prolongs deposition and shortens erosion time.

The formula for erosion volume from the bottom is as follows:

$$\dot{m}_e = M \left\{ (U_{*o}/U_{*e})^2 - 1 \right\}$$
$$= 0.29\,(1.07\,\tau_b - 1) \quad \cdots\cdots\cdots\cdots \text{ equation for salt water}$$

It is judged from experience that $c \cdot w = 0.064\ g/m^2/s$ is reasonable as the product of multiplication of concentration, c, and mud settling velocity, w.

Therefore, $M/c \cdot w$ is set at 4.53, and the curve intermediate between $M/c \cdot w = 1$ and 10 in Fig. III-6-1 is used to calculate the siltation volume. Since it is expected that channel dredging will cause siltation, it can be considered that the present situation is at the critical condition where the curve ($M/c \cdot w = 4.53$) crosses the axis of abscissas. Therefore, $U_{*o}/U_{*e} \fallingdotseq 1.15$ and, because $U_{*o} = 0.017$ m/s, $U_{*e} = 0.015$ m/s. Meanwhile, the critical bottom shear stress for the deposition of suspended mud, τ_d, is about 0.07 N/m^2. So, $U_{*d} = 0.0083$ m/s. In the case of friction velocity making sinusoidal variation with an amplitude of 0.017 m/s, deposition occurs when U_{*o} is 0~ 0.0083 m/s and erosion occurs when it is 0.015 ~ 0.017 m/s. Also, U_{*d}/U_{*e} is 0.55. Thus, siltation volume can be determined by the curve shown with a broken line in Fig. III-6-1.

1) Harrison, A.J.M. and M.W. Owen; Siltation of fine sediments in estuaries, Paper D1, Proc. of 14th Congress of International Association for Hydraulic Research, 1971.

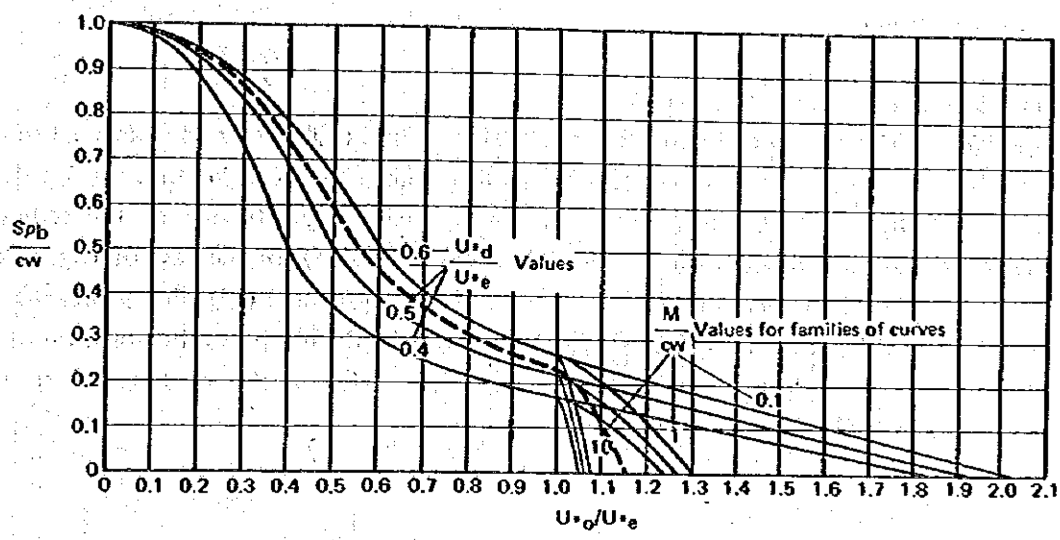


Fig. III-6-1 Siltation Function (after Harrison and Owen)

It is assumed that channel dredging does not affect current volume or current direction, and that only velocity changes. The annual siltation height can be given as in Table III-6-1 by means of Fig. III-6-1. The annual siltation volume can be obtained by multiplying siltation height by channel area.

Table III-6-1 Calculation of Siltation

h (m) (M.W.L.)	U (m/s)	U_{*o}(m/s)	U_{*o}/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

The water depth at the tip of the western breakwater is −13m according to Section III-3-2 "Scale and Layout of Breakwaters". In this case, the maintenance dredging volume of the entrance channel is approximately 5.29 million m^3/year. This dredging can be performed by a 5,000 m^3 class hopper suction pump dredger.

In the above calculation, siltation due to slumping of the channel slope is not considered. As to the side slope, 1:10 will be recommended, as at the muddy-bottomed Indonesian port of Banjarmasin, to prevent slumping as much as possible.

Finally, the above calculation about the siltation rate involves many assumptions. At the stage of the feasibility study, detailed studies – for example, measurement of siltation rates in test pits – must be executed to estimate siltation volume more precisely.