6.2.3 Alternative II

1) Berth Location

Beyond the limit of area earmarked for the future port expansion by N.P.A., two prospective berth space can be found inside the port; those are immediately inside the southern and northern breakwaters. When allocating required area of 20 ha for ore terminal inside the southern breakwater, the waterfront of revetment interferes with the existing approach channel, forcing the breakwater to be relocated. This is considered quite difficult under the present port operation. On the other hand, the allocation to north-breakwater area does not bring about any difficulty in view of navigation and area requirement. For this reason, the latter plan has been taken as Alternative II.

2) Berth Construction

Unlike Alternative I, Alternative II requires the construction of a new berth and reclamation of back-up yard. The major facilities of this berth is listed below.

land reclamation	: 750 m x 250 m = 19 ha
revetment	: 1,250 m
iron ore berth	: 1 berth
dredging	: 8,270,000 m^3

3) Berth Layout

There are two types of shiploader, conventional type and slewing type. A conventional shiploader runs on the continuous platform back and forth to cover the all hatches of ore carriers, while slewing shiploader is supported by a linear track and a turn table. On this turn table, the shiploader rotates inself to

allocate the loading conveyor to a suitable hatch position of vessels. Since the slewing-type shiploader is more economical and efficient than the conventional one, the shiploader for Alt. II plan adopts this slewing type. Major facility such as turn table, linear track, breasting dolphins and mooring dolphins are aligned as shown in Fig. 6.9, taking into full consideration hatch coverage and ship position in breasting and mooring.

4) Land Reclamation

In order to allocate the terminal facilities discussed in 4.1, the area of 250 m x 750 m is necessary. Assuming that the elevation of reclamation at 4 m above the sea datum, the required volume of land-fill is estimated around 1.5 million m^3. The material for landfill is available from sand deposit adjacent to the southern breakwater and partly from the basin in front of a new berth to be dredged for a new turning basin. Sand deposit outside the southern breakwater is estimated about 1.5 million m^3 or more.

5) Revetment

The water depth along the proposed revet line is around 1,250 m on an average. As the structural type, rip-rap and sheet pile revetment can be considered. Mainly because of economization, rip-rap revetment is adopted. Rip-rap rock can be shiped from the quarry site south of Mamba point.

6) Breasting/Mooring Dolphins and Shiploading Pier

The breasting and mooring dolphins are designed with vertical piled foundation and batter piled foundation respectively on the basis of the same concept applied

in 5.5.4. The shiploader pier, which consists of a turn table and a linear track, is designed with a combination of vertical and batter piles. The major dimensions of the above facilities are as follows:

Table 6.4 Main Features of Dolphins and Shiploading Pier/Alt. II

	Main Breasting Dolphin	Mooring Dolphin	Shiploader Pier
Diameter of Piles	ø 1217.2	ø 711	ø 711
Number of Piles	6	16	134
Attendant Appurtenance	Fender	Borrard	

7) Dredging

If the design criteria of dredging established in 4.3.3 and 4.3.4 is applied to Alt. II plan, the estimated quantity of dredging is 4.6 million m^3 inside the port and 3.7 million m^3 outside the port, totaling 8.3 million m^3.

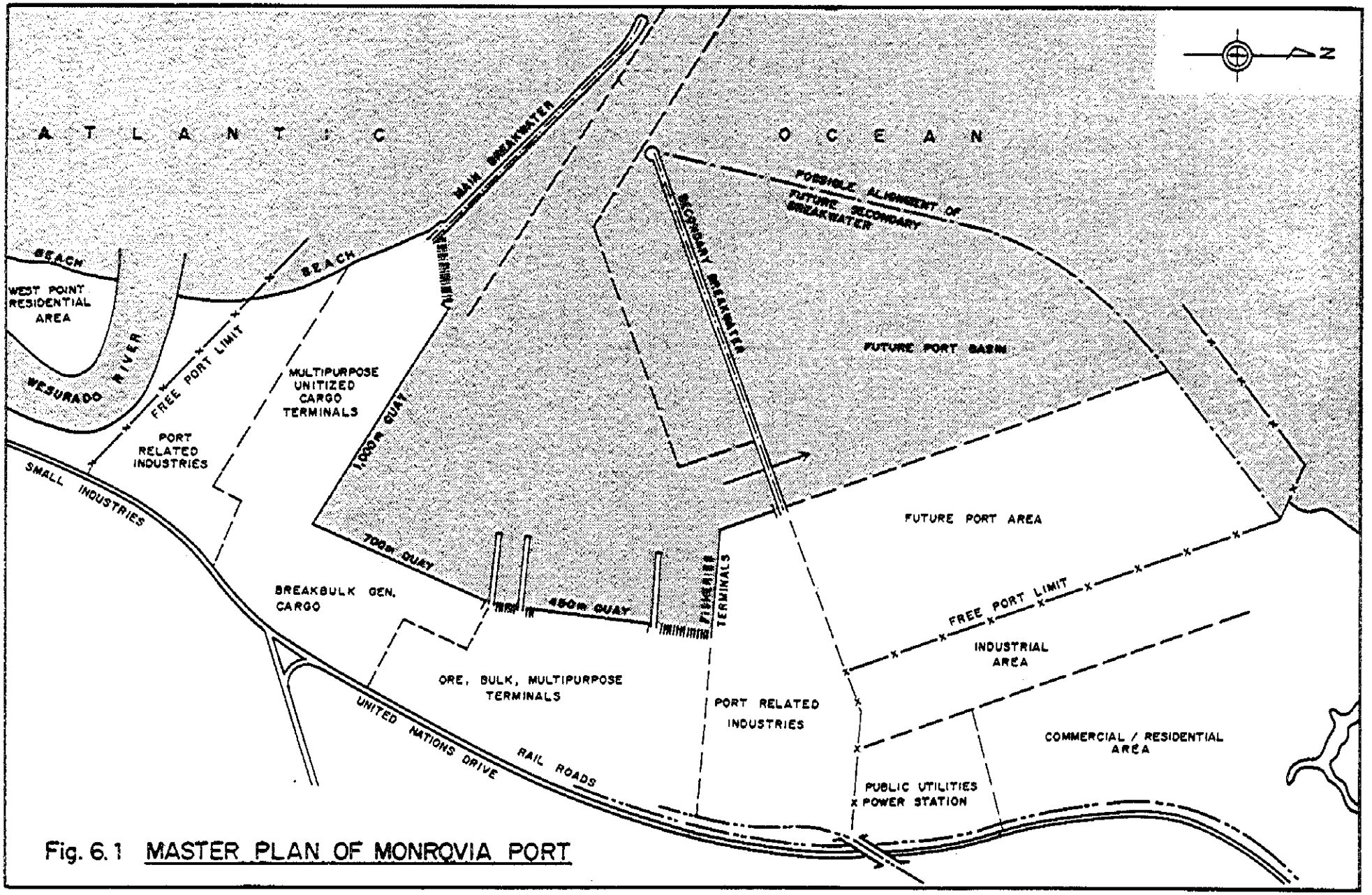


Fig. 6.1 MASTER PLAN OF MONROVIA PORT

Fig. 6 2 DREDGING PLAN / MONROVIA SITE / ALT. II

-19 -18 -17 -16 -15 -14 -13 -12 -11 -10 -9 -8

Approach Channel

-14.7

North Break water

Anchorage Area

-14.1

Turn

South Break water

REMARKS

- 19.5 M

- 18.5M

+ 4.0M

-19 -18 -17 -16 -15 -14 -13 -12 -11 -10 -9 -8 -7

SCALE 1 : 10,000

100 0 500

FREE PORT OF MONROVIA

Cape Mesurado

MONROVIA

SPRIGGS PAYNE

Congo Town

FIGURE 6.2

Fig. 6 2 DREDGING PLAN / MONROVIA SITE / ALT. II

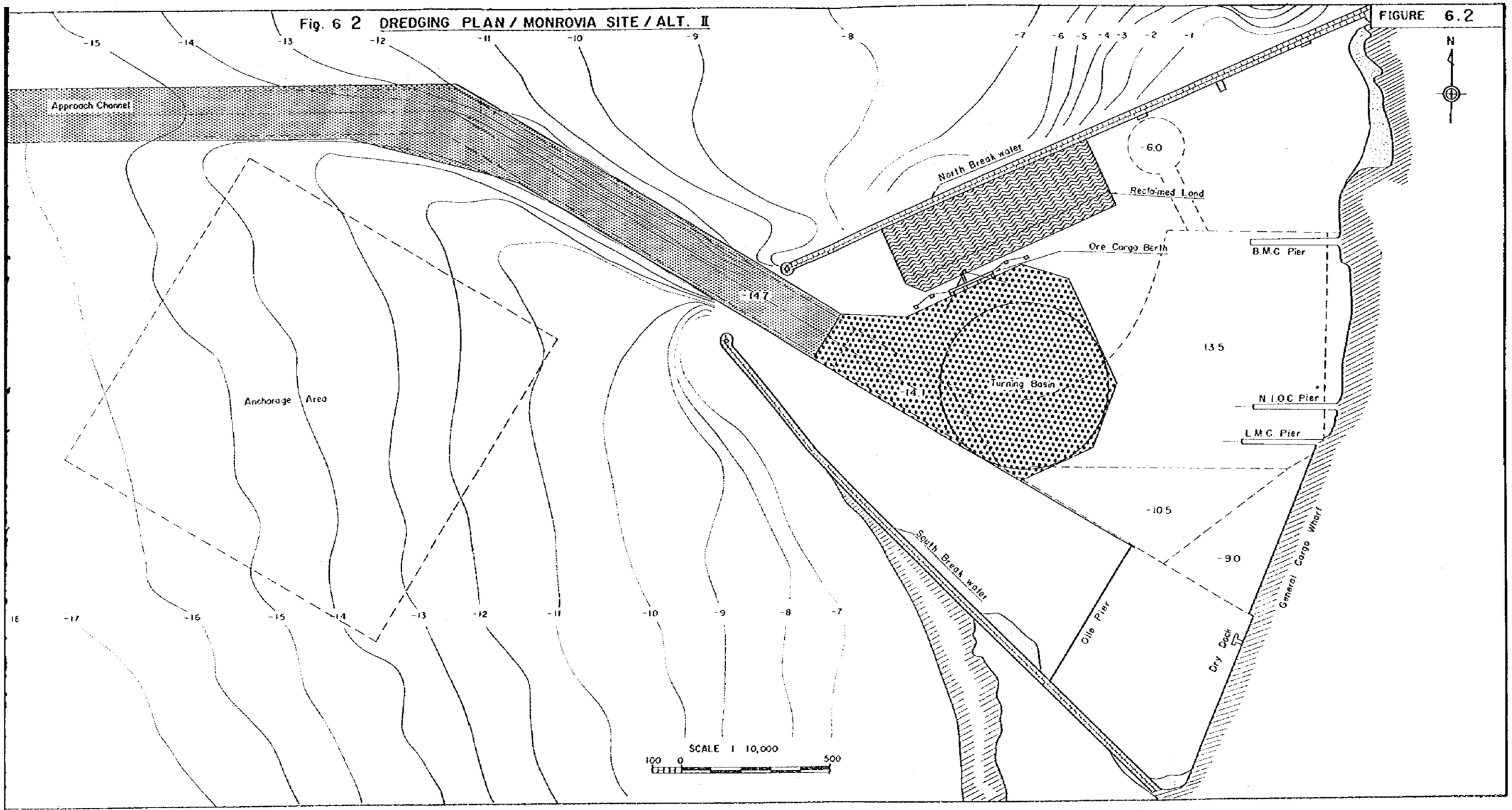
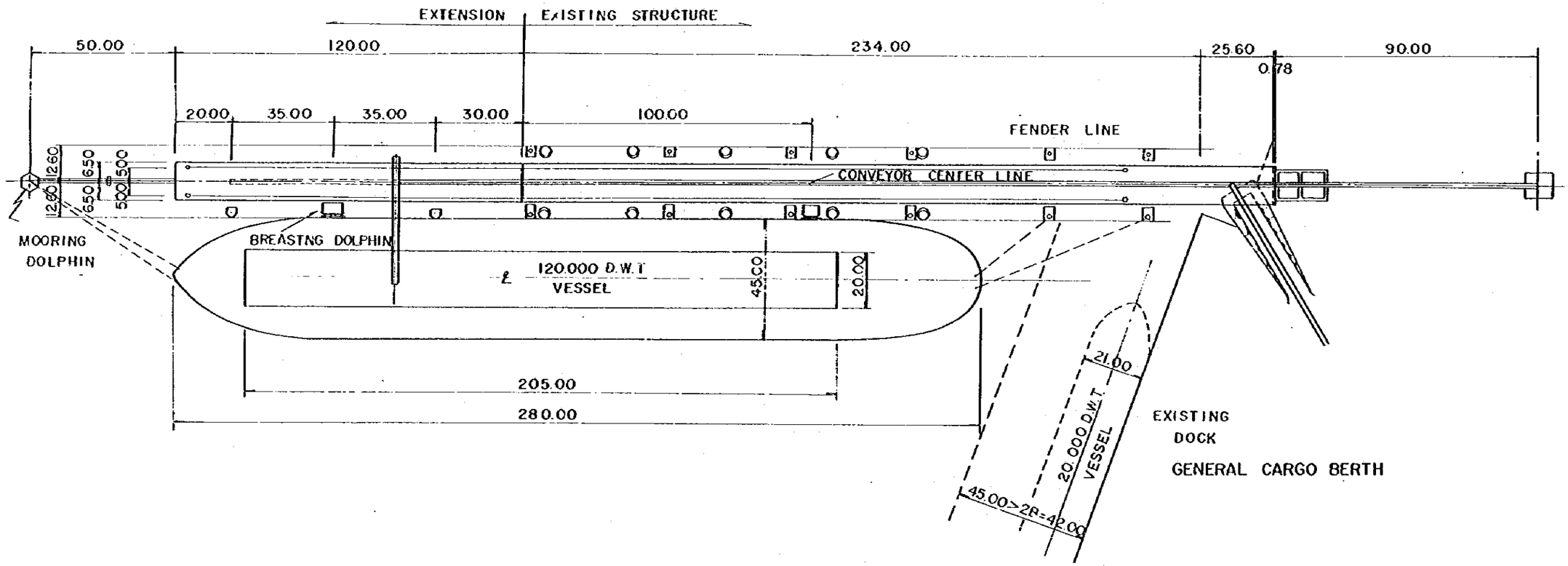


FIGURE 6.3

Fig. 6.3 PLAN AND SIDE VIEW OF PROPOSED LOADING PIER FOR MONROVIA SITE / ALT. I



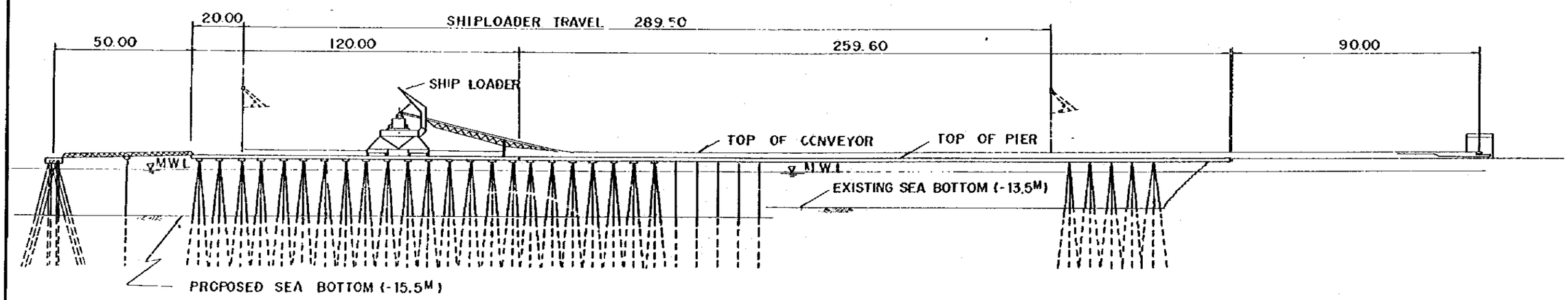


Fig. 6.4 TYPICAL SECTION OF DOLPHINS FOR MONROVIA SITE

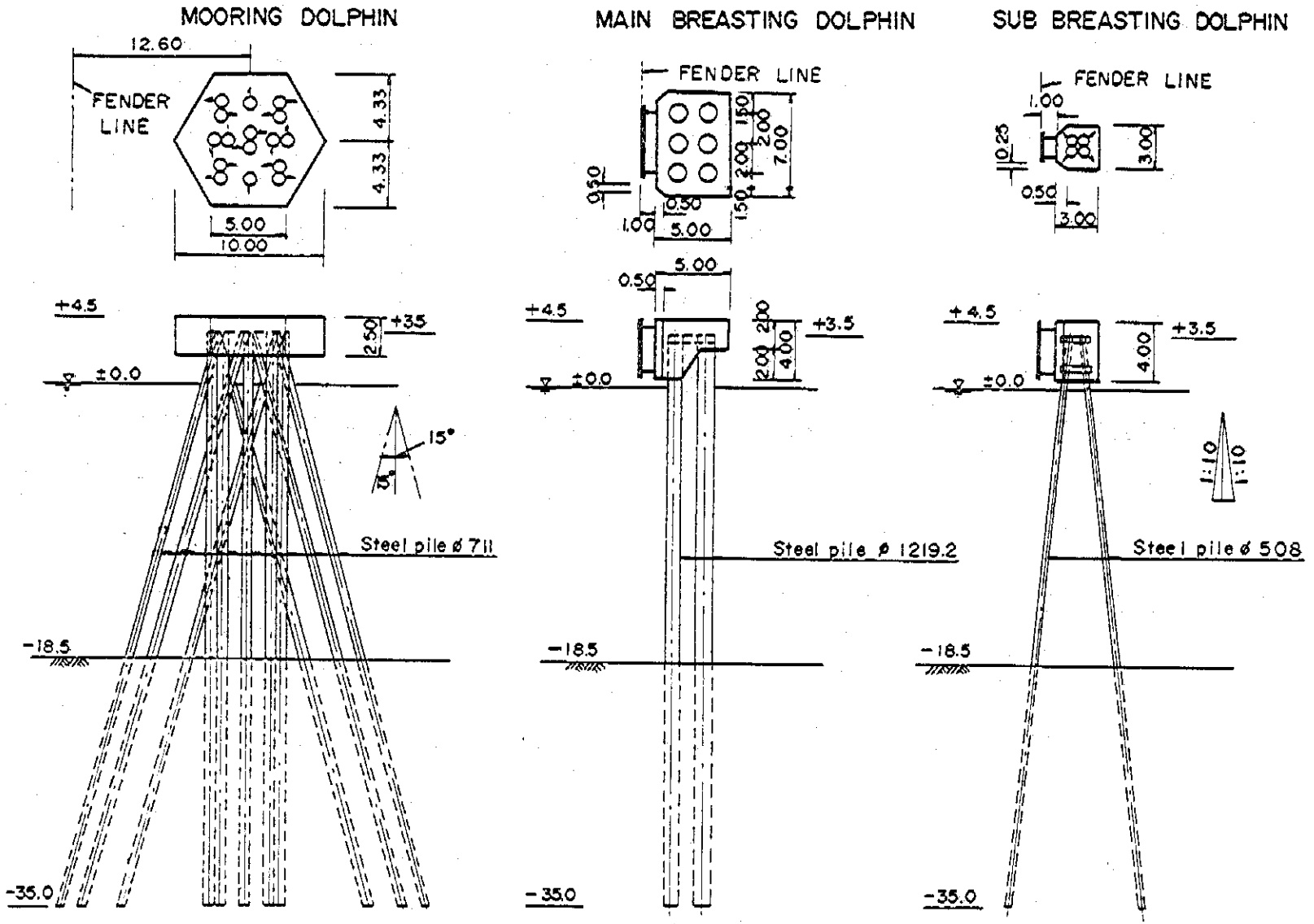


Fig. 6.5 PROPOSED LOADING PIER / ALT. I / MONROVIA SITE

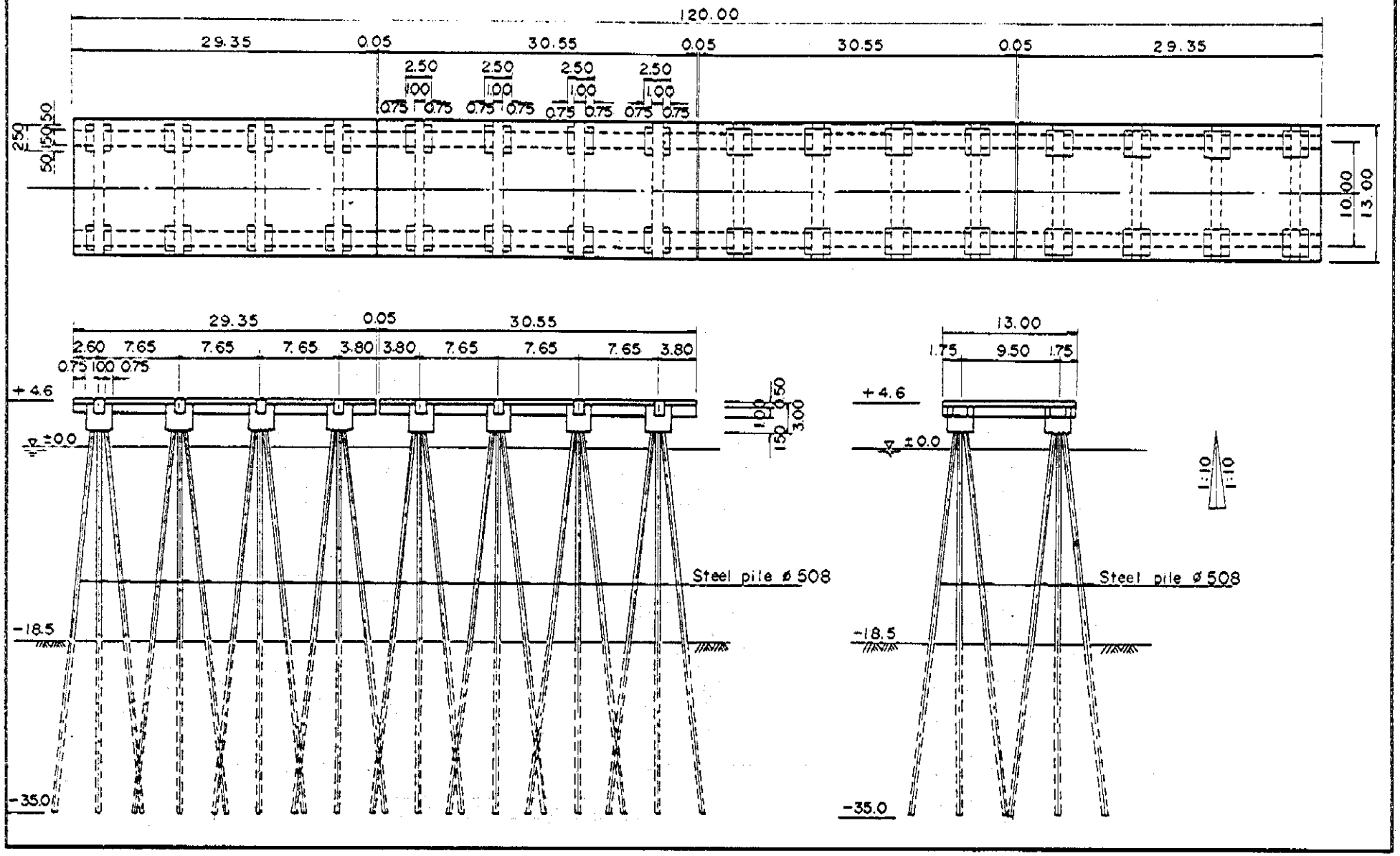


Fig. 6.6 DREDGING PLAN / MONROVIA SITE / ALT. I

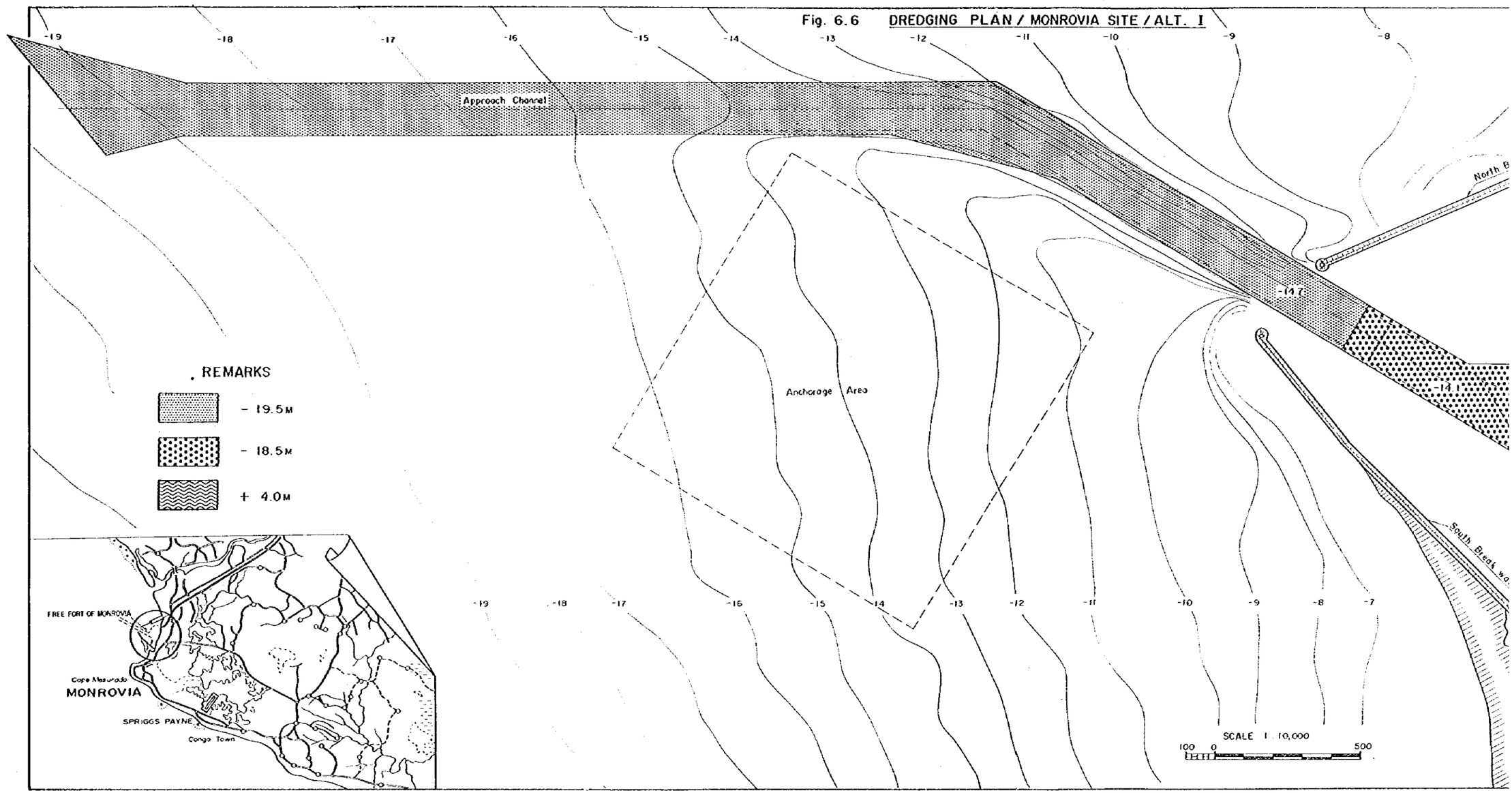


Fig. 6.6 DREDGING PLAN / MONROVIA SITE / ALT. I

FIGURE 6.6

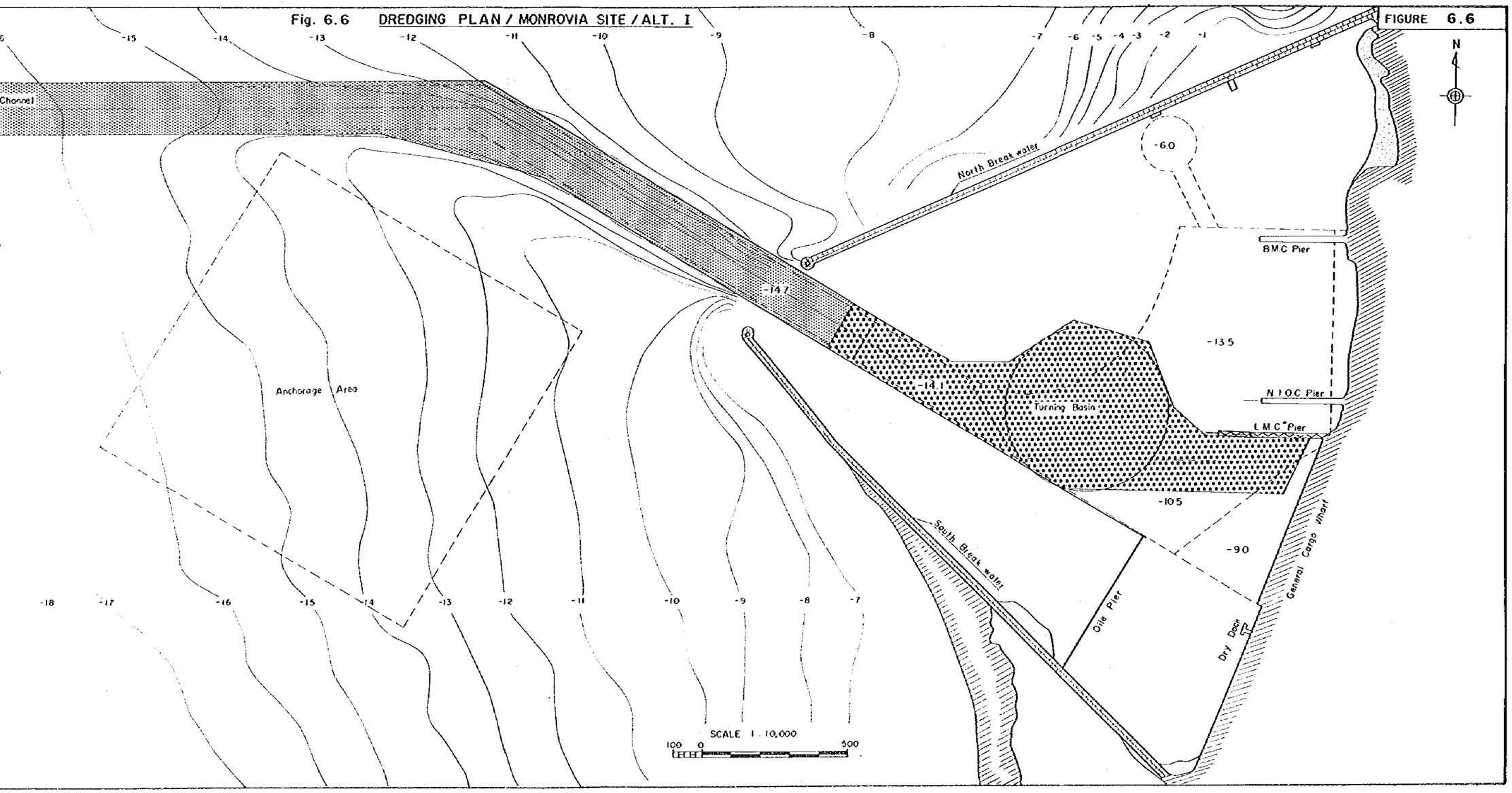


Fig. 6.7 RECLAIMED LAND ARRANGEMENT FOR MONROVIA SITE

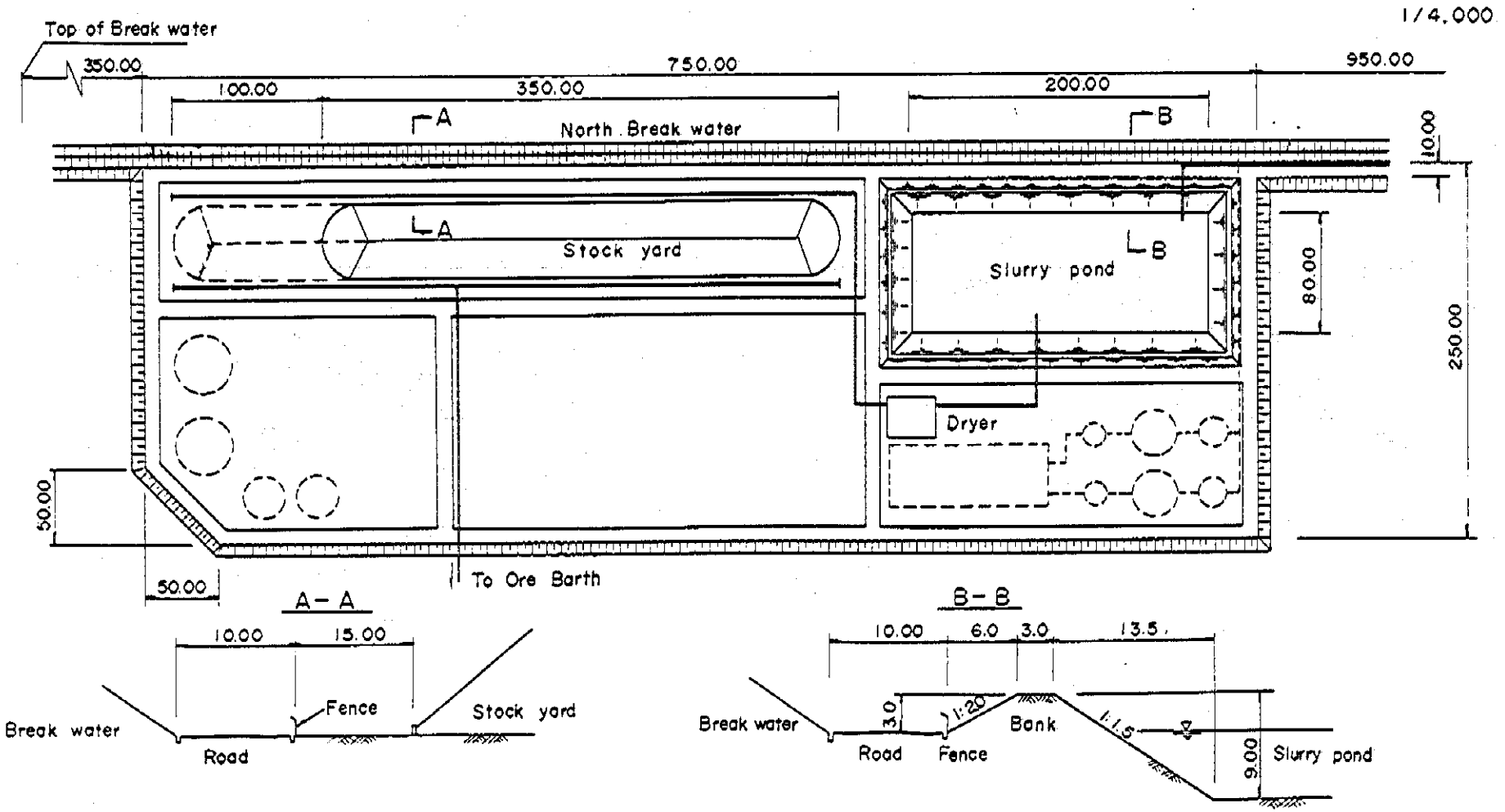


Fig. 6.8 TYPICAL SECTION OF SEAWALL & BREAKWATER FOR MONROVIA SITE

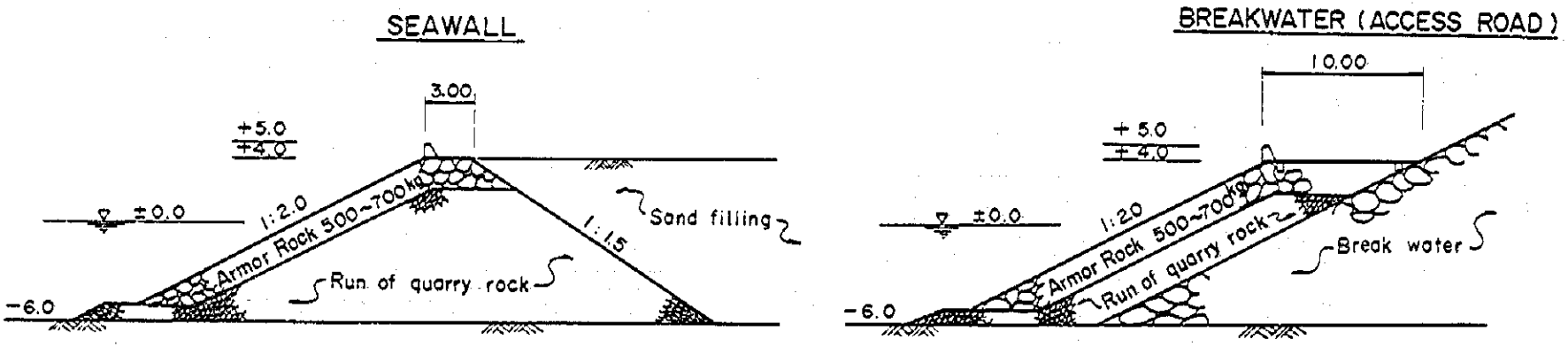


Fig. 6.9 PROPOSED LOADING BERTH FOR MONROVIA SITE (ALT. II) & ROBERTSPORT SITE (ALT. I & II)

1 / 200

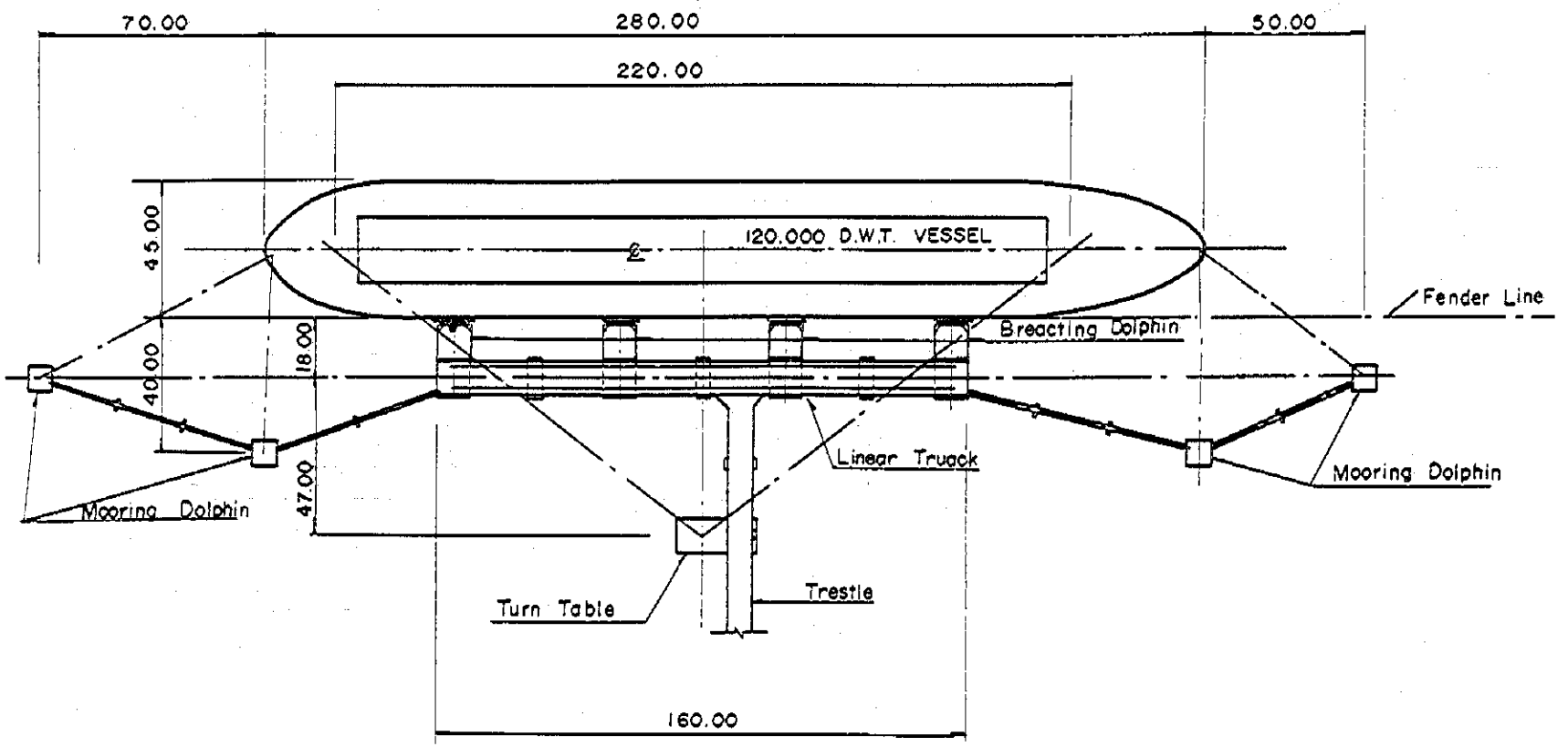


Fig. 6.10 TYPICAL SECTION OF DOLPHINS FOR ROBERTSPORT SITE 1/400

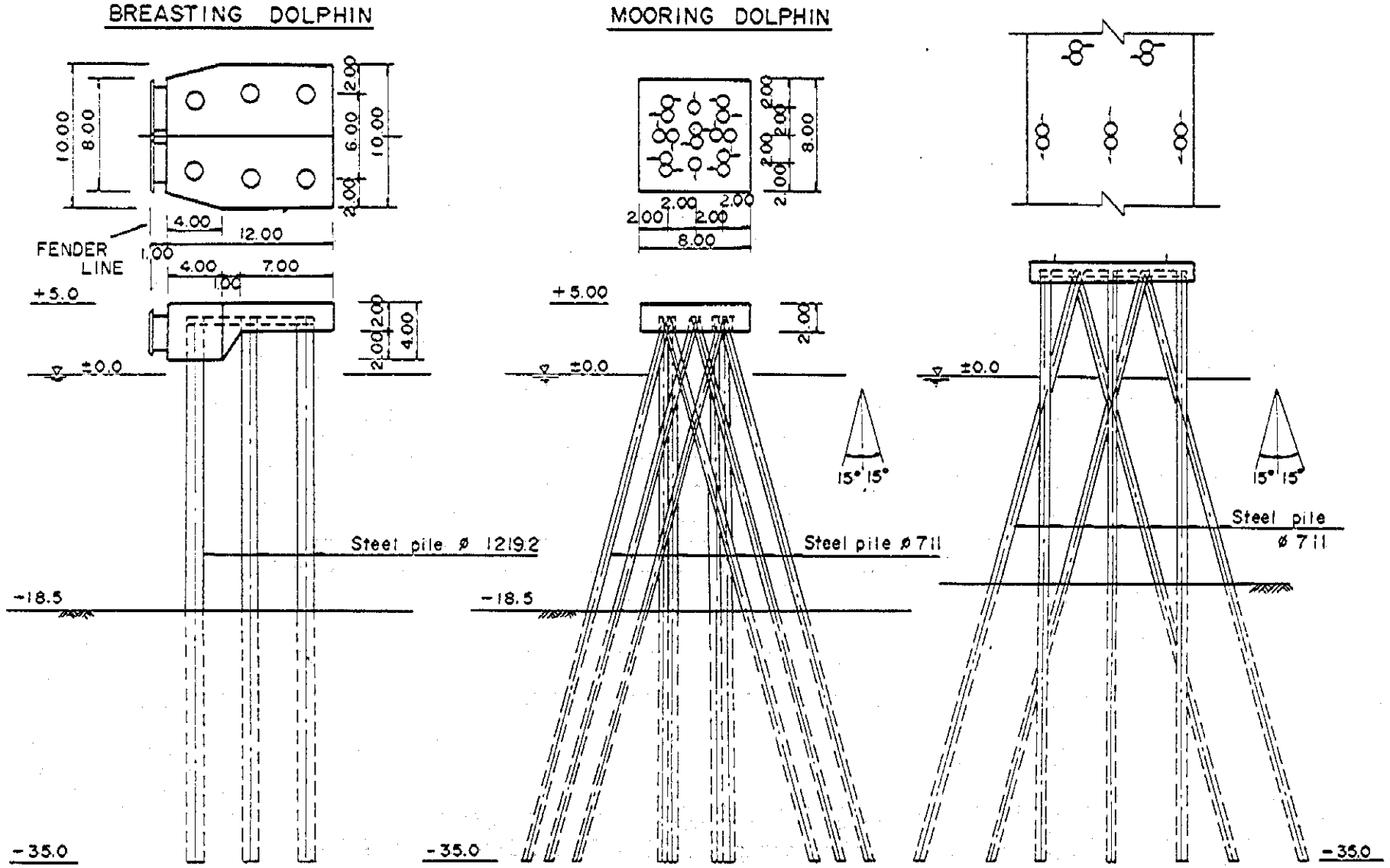
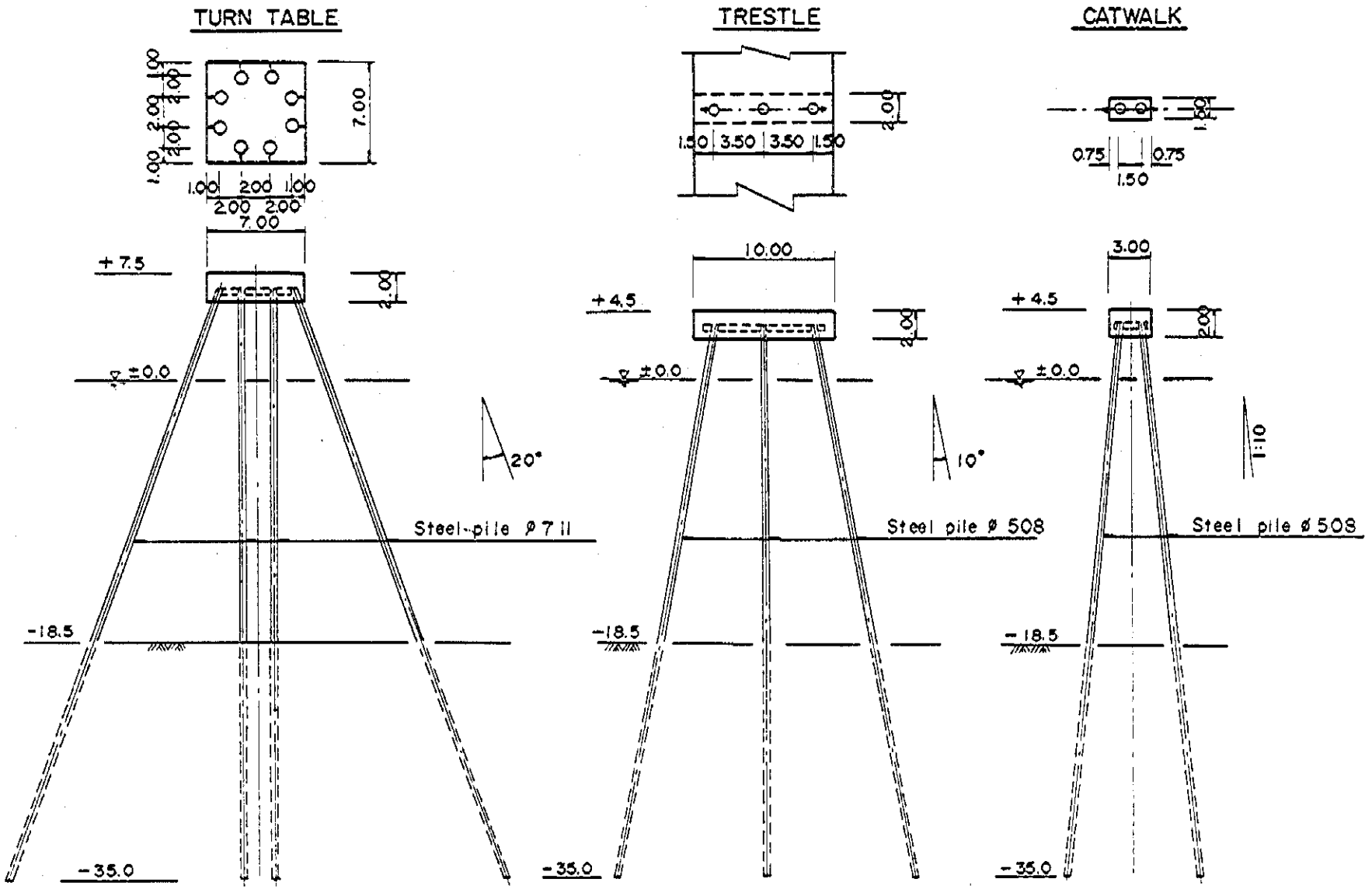


Fig. 6.11 TYPICAL SECTION OF TURN TABLE, TRESTLE AND CATWALK



CHAPTER VII

ALTERNATIVE STUDY FOR ROBERTSPORT SITE

CHAPTER VII

ALTERNATIVE STUDY FOR ROBERTSPORT SITE

7.1 BACKGROUND OF PORT DEVELOPMENT

Robersport is located approximately 80 km away from Monrovia and 15 km east of the national border to Sierra Leone. The town of Robersport, the capital of Grand Cape Mount County, has a population of about 21,000, one tenth of those in Monrovia. Most of the people appears to earn their living by fishery and small scale farming. Unlike other counties, lower Grand Cape Mount County has not benefited from national project, remains undeveloped, resulting in high unemployment rate. Though holding a good potential forest area behind, lumber/log production have not been developed up to now due to poor accessibility and no existance of associated port for shipping like Harper and Greenville. Besides lumber product, the exploitation of Bie Mountain, located between Bomi Hill and Mano Mine, is expected to start in near future. These projects give employment opportunities to the local people and helps leveling up the living standard of this region in the long run. At the back of Robertsport town, lies a large lagoon called "Lake Piso" where fishery is conducted for local supply only. This lake, blessed with extremely beautiful scenery, has great potential for the development of tourism, so that marine-oriented-tourism is worth studying in the frame of town planning on county basis. The rubber plantation, east of the Piso Lake, is operated

by Goodrich Co, and small villages are dotted around there.

The Mano River Union was established in 1973 between Sierra Leone and Liberia to promote the development of Mano River region. The future activities of this union covers a variety of projects, like hydro power and irrigation development of Mano River and construction of trunk road between Monrovia and Freetown.

To cater for implementation of these projects, establishing a new port, small or large, is one of essential, so that the port study related to Wologisi project is required to proceed keeping this background in mind.

7.2 NATURAL CONDITION

7.2.1 Topography

The study area extends over approximately 80 km from Robertsport town site to east edge of Lake Piso. Robertsport town is located east of the outlet of Lake Piso and Cape Mount lies behind the town. Into this Lake Piso flow the creeks named Maa Creek, Mofe Creek and Mafa River. The Lake Piso is, generally shallow, especially in the outlet facing the Atlantic Ocean, around 1 to 2 m deep even in H.W., giving difficulty for coastal vessels to enter for anchoring or berthing. In this lake, there lies Masating Island, the biggest island of Liberia.

In the Cape Mount, steep rock hills are extending out to the shoreline, so that only narrow strip of sand beach lies between these hills and the sea.

The Cape Mount is composed of seven rocky points formed mainly of hard rock suitable for qurry materials and between these small points, arch-shaped sand beachs

are extending with an average width of 50 - 70 m.

Small creeks break into these beaches during wet season, but almost dry during dry season.

The shoreline east of Cape Mount is stretching monotonously almost 35 km up to Lofa River with a narrow strip of sand beach, behind which beach plain is stretching about 1.5 km up to the Lake Piso. This beach plain is covered with low dense trees and partly covered with small ponds and lakes such as Lake Jaa and Lake Jakunu.

The road up to Monrovia runs near the Lake Piso and the access from this road to the shoreline is limited to one narrow road leading to a fishing camp. This road is available only by four-wheel-drive jeep. Additionally from Lafia, a foot path runs to shoreline.

North west of the outlet of Lake Piso, a large sand bank is stretching in the north-west direction, behind which swampy area is extending along the shoreline to the Mano River.

7.2.2 Climate

Generally speaking, in Liberia the nearer the coastal area, the higher the precipitation rate gets. The average annual rainfall in Robertsport of about 4,000 mm, mainly, centers on four months from June to September, accounting for three fourth of total rainfall. Even during the dry season between October and May, there are occasional showers. Average temperature is around 27°C and the hotest months are April and May.

7.2.3 Wind

It seems that there is no major difference in wind

condition between in Monrovia and in Robertsport. Since there is no reliable wind data at Robertsport, overall characteristics of winds along the Liberian coast is cited from the A.M. Glenn and Associates' report entitled "Meteorological-Oceanographic Factors Affecting Design and Operation of Proposed Port Facilities on the Liberian Coast: Vicinity of Fisherman's Lake".
A brief seasonal summary of the normal wind conditions is as follows:
December - February: Wind directions are approximately equally distributed around the compass. Both "Harmattan" winds (N.NE), and Guinea Monsoon winds (SE, S, SW, and W) occur in this season.
Wind speeds exceed 14 mph 1% of the time in December. This is the calmest season.

March - May: Guinea Monsoon winds predominate. SE, S, SW and W winds occur 68% of the time in May. Wind speeds exceed 14 mph 7% of the time in May.

June - August: Guinea Monsoon winds strongly predominate. SE, S, SW and W winds occur 99% of the time in August. Wind speed exceed 14 mph 35% of the time in August. This is the windiest season.

September - November: Guinea Monsoon winds predominate. SE, S, SW and W winds occur 76% of the time in October. Wind sppeds exceed 14 mph 8% of the time in October.

The prevailing winds which will affect the design and operation of the berthing installations are contained in the Southest to West range of the compass occuring approximately 74% of the year. The yearly occurance of the prevailing winds in the SE, to SW, quadrant is approximately 60% and in the S to W quadrant, approximately 64%. The following tabulates the wind intensities and their annual occurence around the compass.

Table 7.1 Frequency of Wind by Velocity

Wind Velocity (MPH)	Frequency (%)
0 - 4	17.4
5 - 9	53.7
10 - 14	16.3
Sub Total	87.4
15 - 19	7.0
20 - 24	3.2
25 - 29	1.6
30	0.8
Total	100.0

The above figures show that the winds do not exceed 14 mph in 87.4% of the total annual time.

Under the wind speeds in excess of 14 knots, 120,000 DWT class vessels have much difficulty of maneuvering inside the port area, even with tug assistance due to slow ship speed of 4 - 5 knots. Reflecting little occurence of dangerous winds, when determing berth alignment and channel orientation, it can be said that wave directions shall be paid more attention than wind directions in Robersport area.

7.2.4 Wave

Since there is no wave record near Robertsport, overall information obtained from the U.S. National Weather Data Center is used for assessing the wave condition of this area. The prevailing wave direction and frequencies are coincidental with the wind directions described in the preceding paragraph. The seasonal wave height-direction regime at the subject location is as follows:

December - February: Significant wave height exceeds 4 feet

10% of the time in December. This is the calmest season.

March - May: Significant wave height exceeds 4 feet 23% of the time in May.

June - August: Significant wave height exceeds 4 feet 37% of the time in August. This is the roughest season.

September - November: Significant wave height exceeds 4 feet 22% of the time in October.

The annual occurence of wave intensities from all directions is as follows:

Table 7.2 Frequency of Wave by Height

Significant Wave Height (Feet)	Frequency (%)
0 - 2	35.6
2 - 4	41.6
4 - 6	11.9
Sub Total	89.1
6 - 8	6.9
8 - 10	2.7
10 - 15	0.9
15	0.4
Total	100.0

It is the Consultant's opinion that the sea climate summarized above may be little conservative, judging from the offshore swells observed during the last investigation period. The offshore waves, as approaching the Cape Mount, are refracted through about 30 degree, and decays to less than half in wave height in the sheltered sea ground west of the Cape Mount.

At this sheltered area, it would be possible to construct a port without breakwater, but a port along the coast

east of the Cape Mount requires breakwater to withstand the swells.

7.2.5 Tide

Since there is no tidal data in Robertsport, a tidal gauge was installed near the outlet of Lake Piso, and observations were continued all through the investigation period from mid-November to mid-December, 1978. The maximum tidal range observed is 60 cm. According to the information from the National Hydrographic Authority, the figure of Zo (the average elevation of sea surface above sea datum) is 50 cm. Therefore H.W.L. is expected to be 1.0 m (0.5 x 2). There is no large difference from the figure in Morovia port where a maximum tidal range is 1.10 m.

7.2.6 Current

The intensity of currents in the vicinity of the Cape Mount is not strong. Constant currents flow in the direction of South-east with a speed less than 0.2 knots. The maximum current speed is expected around 0.4 knots. Due to limitted term of observation, it may not be concluded, though, it is considered that currents are not a fatal factor for planning port structure and ship maneuvering in Robertsport area.

7.2.7 Subsoil

Due to no offshore subsoil information near Robertsport, the preliminary designing on this area is carried out, refering to a sole data of soil boring which was conducted by the American Consultant on the shore about 10 km east of the Cape Mount. The data shows the existence of sandy soil partly inserted with silt down to -35 m from the ground.

Since the Cape Mount, mainly composed of hard rock, is projecting to the shoreline, the supposed bed rock layer is expected to be lying in the practical depth for piling.

7.3 PRINCIPAL FEATURES OF SELECTED ALTERNATIVES

7.3.1 Background

Since there are no port facilities in Robertsport, the site sellection is not restricted as occured in Monrovia port site. Two alternatives can be taken up as follows;

Alternative I : New port construction at the south coast of the Cape Mount

Alternative II: New port construction at the west coast of the Cape Mount

In the area south of the Cape Mount, the isobatic water-depth contours runs almost parallel to the shoreline and no natural breakwater like the Cape Mount exists.

The west of Cape Mount area where Robertsport town is situated, is skirted by steep sided hills of the Cape Mount and has no wide coastal plain except for the vicinity of the outlet of Lke Piso where wide sand beach is extending gradually toward onshore. As to water depth, the area immediately off the Cape Mount is the deepest and the outlet of Lake Piso is shallowest. As to degree of shelterness, offshore waves diminish down to 1/3 in height just before the Robertsport town.

7.3.2 Alternative I

1) Requirement for Port Construction

The major requirement for Alt. I is composed of the following components.

Landfill	:	35,000 m^3
Breakwater	:	1,400 m

Revetment	:	530 m
Dredging	:	17,780,000 m^3
Iron ore berth	:	1 Berth
General cargo berth	:	1 Berth
Small boat basin	:	1
Navigation facility	:	7,500 m^2

2) Landfill

Unlike Monrovia/Alt. II, the proposed cargo berth site is located on the shoreline, requiring no big landreclamation. The marginal-type wharf for cargo berth requires some landfill at the rear of apron area. This fill material can be supplied by dredged material.

3) Breakwater

The proposed berth site is exposed to open sea, and easily affected by the prevailing swells and waves. Under this sea climate, the breakwaters shall be located to permit the ships to turn and berth smoothly and safely.

On account of construction constraint, the tip of breakwater is located in the water depth shallower than 19 - 20 m below sea datum. The eastern breakwater is located to cope with the prevailing waves from SSE direction, while the western breakwater plays a role of sand trap against littoral drift. The sheltered area is approximately 800 ha which gives enough space for 120,000 DWT class vessel to make turn with tug assistance.

4) Revetment

The entire stretch of revetment is 530 m. Structurally, this revetment is formed of L-shape concrete wall to works as both a wharf of small boats and a retaining wall for pier.

5) Dredging

Some part of turning basin protected by breakwater is located in the water depth shallower than -13.5 m, requiring dredging. Total amount of dredging is estimated at 17.8×10^6 m^3. The good material to be dredged is used for landfill, and the remaining is cast outside the breakwater.

6) Ore Loading Pier

It is desirable that ore loading pier is located to make full use of natural water depth here in Robertsport. However, the whole area of turning basin can not be protected by breakwater due to constraint of expansion of the existing breakwater. In consequence of economical cost comparison, ore loading pier with turning basin is located in the water-depth of average -13 m. Structually, this pier is designed as separate-dolphin-type.

7) Other Facilities

The general cargo (marginal_type wharf) is designed as relieving plat form, connected with back-up area onshore. The small boat basin is located at the foot of the eastern breakwater to secure sufficient calmness.

7.3.3 Alternative II

1) Requirement for Port Construction

The major requirement is the same as the previous plan (Alt. I) except for breakwater. No breakwater is required for this alternative, since the site is well sheltered by the Cape Mount.

2) Landfill (Land cut) and Dredging

The stockyard complex area is landfilled by the suitable material cut from the shoreside of the Cape Mount hill. The rocks quarried in the work of landcut is used for rip-rap of revetment. All structure is located in the natural water depth, so that no dredging is required in this plan.

3) Ore Loading Pier and Cargo Pier

The ore loading pier (dophin type) is located in the water depth of -19 m. The orientation of pier is about 30^{o} against the prevailing waves. The cargo pier is located at the rear of breakwater, parallel to the trestle line, structually this pier is designed as a relieving platform type.

4) Other Facilities

The trestle has two-lane traffic roads and one conveyor on top. Small boat basin is located inside the small rockfill jetty.

FIGURE 7.1

Fig. 7.1 PROPOSED PORT FOR ROBERTSPORT SITE / ALT. I

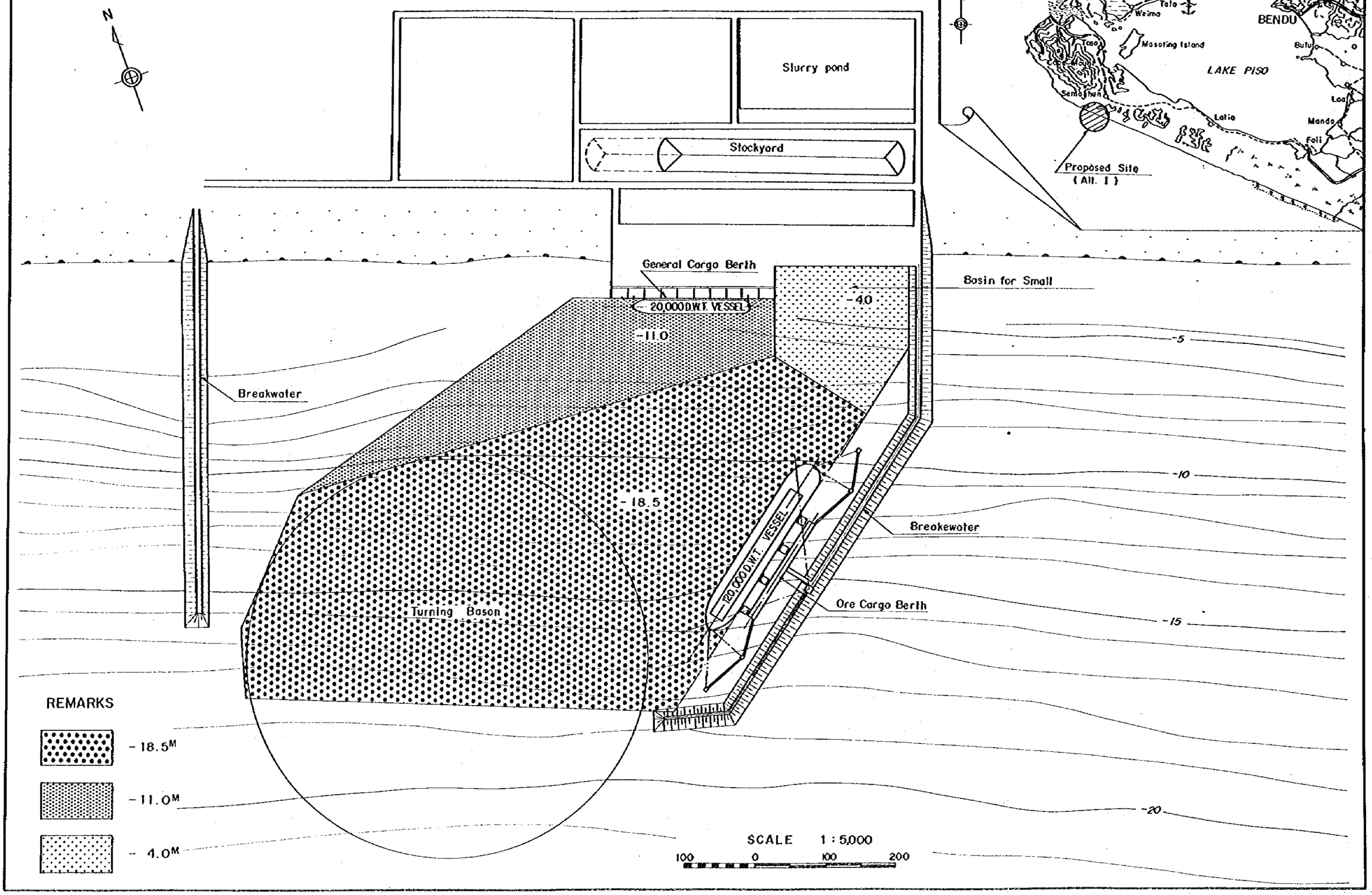


Fig. 7.2 (1) TYPICAL SECTION OF BREAKWATER FOR ROBERTSPORT SITE / ALT. I

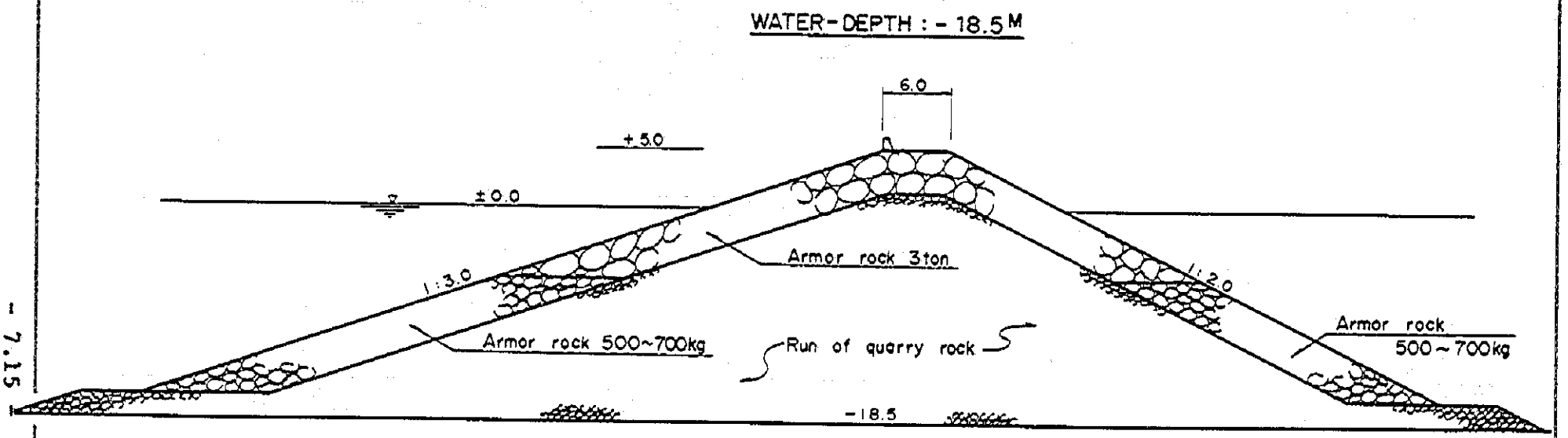


Fig. 7.2 (2) TYPICAL SECTION OF BREAKWATER FOR ROBERTSPORT SITE / ALT. I

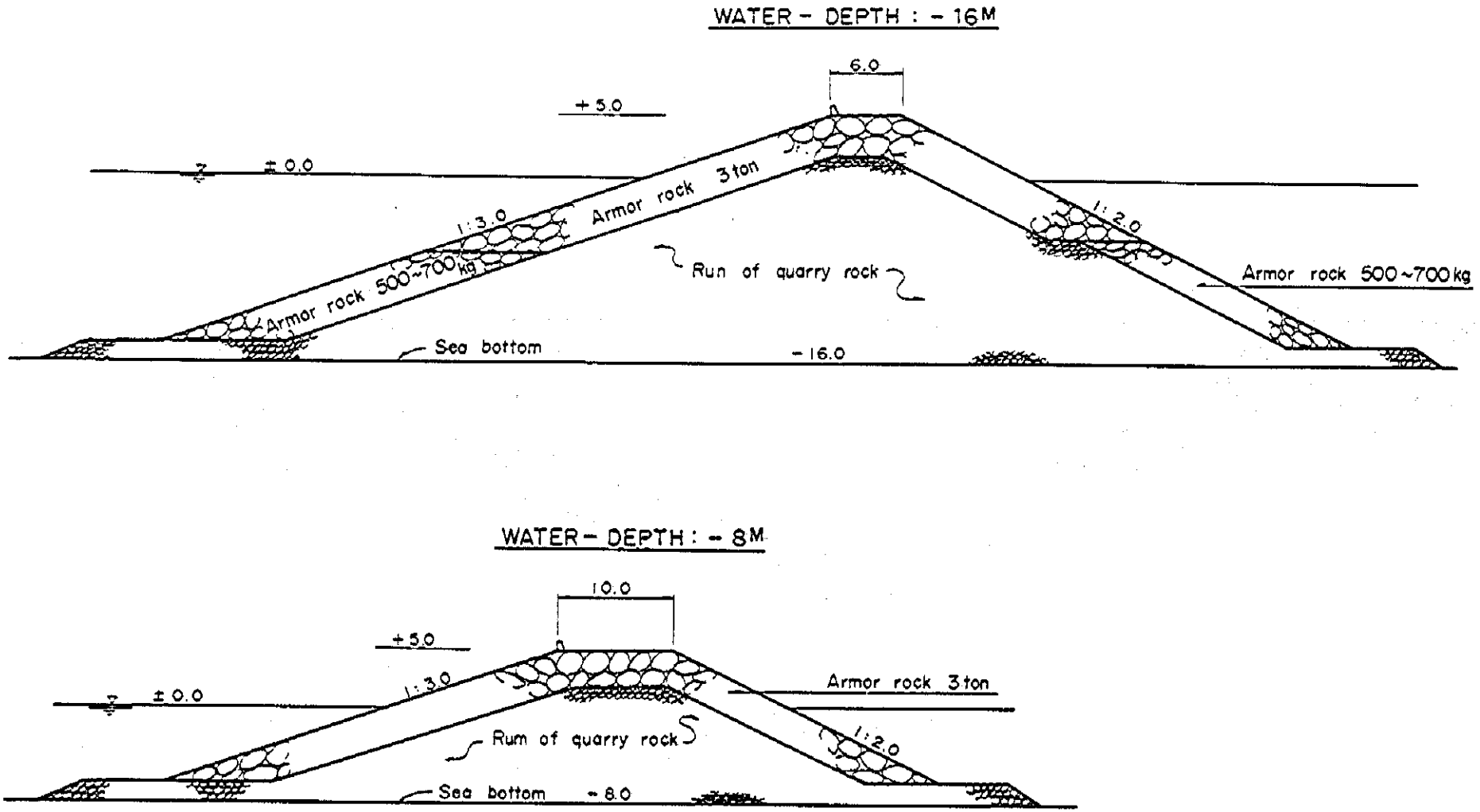


Fig. 7.3 TYPICAL SECTION OF PLATFORM-TYPE WHARF/ROBERTSPORT SITE / ALT. I & II

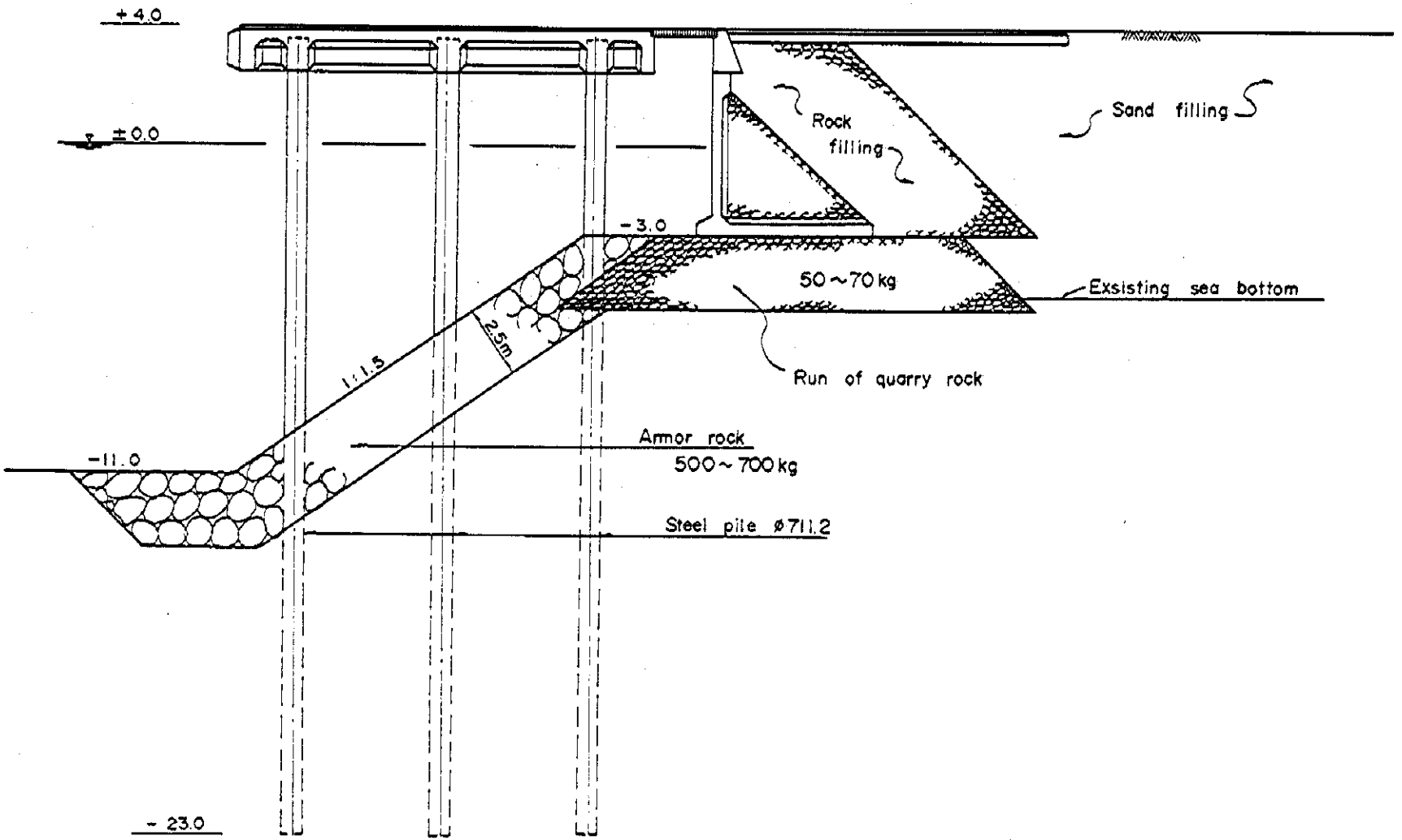


FIGURE 7.4

Fig. 7.4 PROPOSED PORT FOR ROBERTSPORT SITE / ALT. II

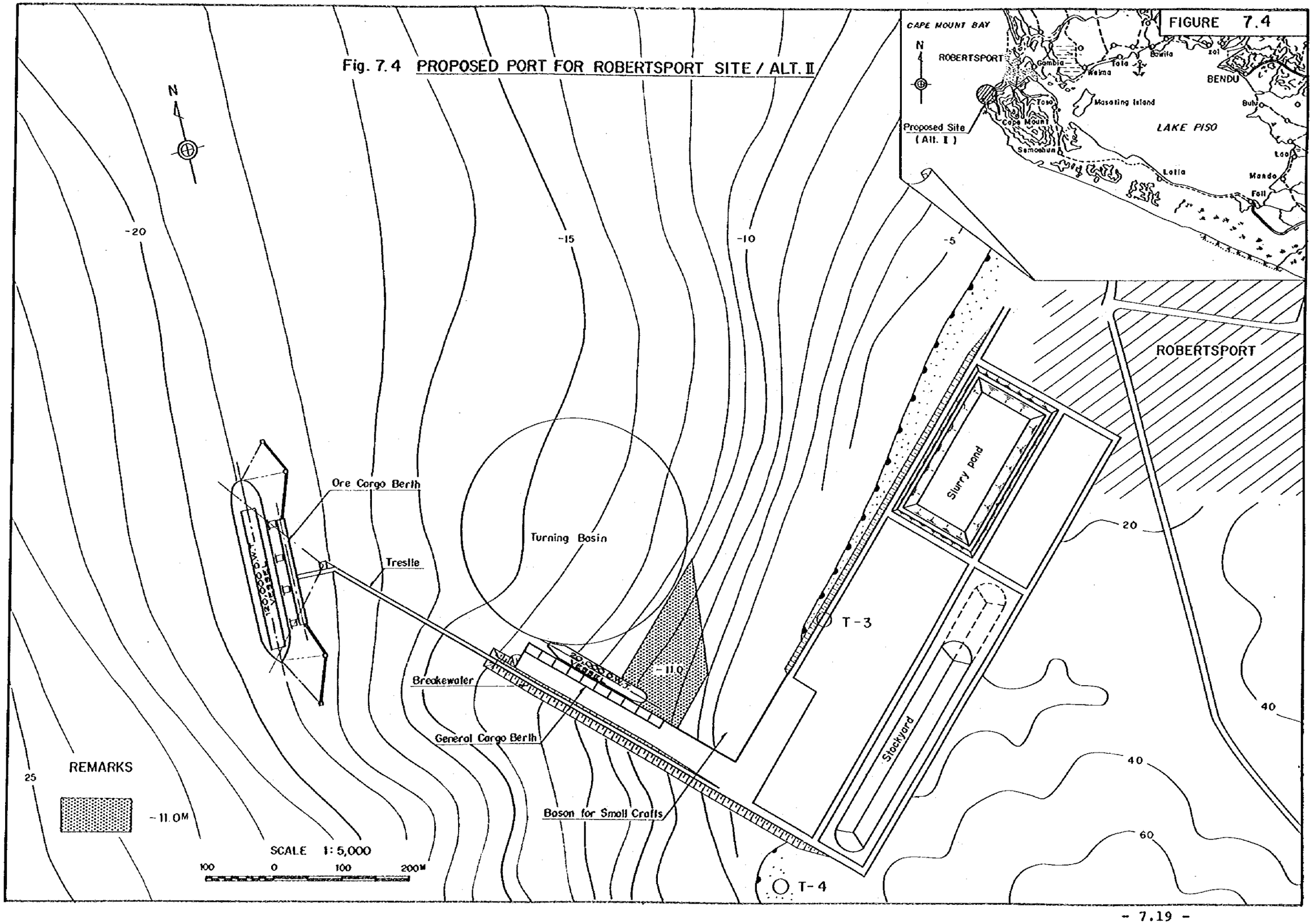
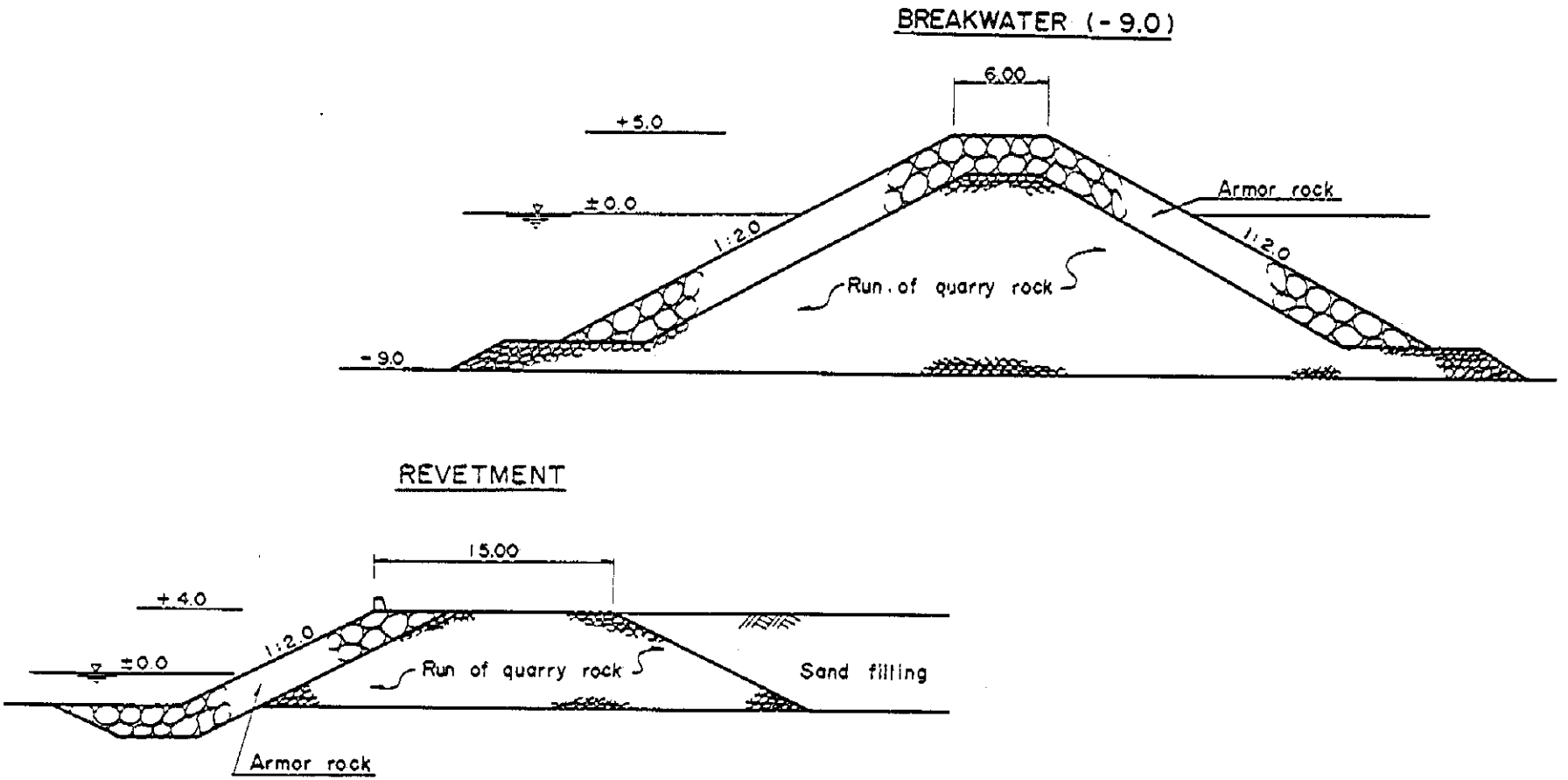


Fig. 7.5 TYPICAL SECTION OF REVETMENT FOR ROBERTSPORT SITE / ALT. II



CHAPTER VIII

COMPARISON OF ALTERNATIVES

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COMPARISON OF ALTERNATIVES

8.1 CONSTRUCTION COSTS

8.1.1 Mobilization of Construction Material and Equipment

In Liberia, most of construction materials except for steel products are available though limited in quantity.

In Monrovia site, coarse aggregate for concrete is available from the quarry plant in the suberban area and rip-rap material of 100 kg to 1,000 kg size can be quarried from Mamba point west of the existing Monrovia port. In Robertsport site, both coarse aggregate and rip-rap material can be quarried from the Cape Mount. Fine aggregate will be available for both sites from the adjacent beaches.

The steel products shall be imported from abroad, e.g. Japan or Europe. The offshore construction equipment such as dredgers and pile-driving-barges shall be mobolized from the nearest port such as Lagos or some major ports in Europe. Onshore construction machineries and plants are likely to be hired from local contractors. As Robertsport site is not provided with off-loading facilities, imported materials shall be unloaded in Monrovia port and reloaded onto trucks for road transportation. At present, the road between Monrovia and Robertsport is of well conditioned laterite pavement, allowing transportation of heavy materials. Considering the road

condition during wet season, however, steel pipes and other heavy elements are better to be barged and off-loaded at the construction jetty which also serves for repairing equipment. This construction pier shall be located in the sheltered area adjacent to the construction site.

8.1.2 Preliminary Estimation of Construction Costs

Construction costs for each alternative plan were estimated preliminary at the price of end-1978 and compared as shown in Table 8.1.

Table 8.1 Comparison of Construction Costs

(million US$)

Work Item	Monrovia Site		Robertsport Site	
	Alt-I	Alt-II	Alt-I	Alt-II
Direct Construction Cost				
Dredging	17.8	19.0	4.9	0.1
Land reclamation	-	2.2	-	-
Land-fill	-	-	0.2	-
Land-fill & cut	-	-	-	7.0
Revetment	-	5.5	1.3	3.1
Breakwater	-	-	20.8	6.9
Berth extension	1.5	-	-	-
New ore berth	-	3.1	3.1	3.9
New cargo berth	-	-	1.4	1.4
Construction pier	-	-	1.5	1.5
Access road	-	2.3	-	-
Sub-total	19.3	32.1	33.2	23.9
Engineering and Administration /1	2.9	4.8	5.0	3.6
Physical Contingency /2	2.2	3.7	3.8	2.8
Total	24.4	40.6	42.0	30.3

/1 15% of direct construction costs

/2 10% of direct construction costs plus engineering & administration

8.2 ANNUAL PORT COST

Annual port costs for each alternative were estimated under the following conditions:

1) Annual port cost is composed of amortization of capital costs and recurrent costs for maintenance and repair.

2) For estimating amortization cost, interest rate and amortization period are tentatively assumed to be 10% and 20 years respectively.

3) Port construction cost are distributed annually as follows:

Table 8.2 Cost Distribution

(Unit: million US$)

	1st year	2nd year	3rd year	4th year	Total
Monrovia/Alt I	12.2	12.2	-	-	24.4
Monrovia/Alt II	13.4	13.6	13.6	-	40.6
Robertsport/Alt I	10.5	10.5	10.5	10.5	42.0
Robertsport/Alt II	10.1	10.1	10.1	-	30.3

4) Annual maintenance and repair costs are estimated at 1% of capital costs for dredging, berth and revetment.

The culculated annual port costs for each alternative are given below.

Table 8.3 Annual Port Cost

(Million US$)

Alternatives	Amortization	Maintenance & Repair	Total
Monrovia/Alt. I	3.01	0.24	3.25
Monrovia/Alt. II	5.24	0.41	5.65
Robertsport/Alt. I	5.73	0.42	6.15
Robertsport/Alt. II	3.99	0.30	4.29

8.3 COMPARATIVE REMARKS

As shown in the preceding sections, Alternative-I at Monrovia Port site is least expensive plan in terms of construction costs and annual port costs. For further comparison, unit port charges were calculated, dividing annual port costs by annual ore throughput, as follows:

Table 8.4 Unit Port Charge

(US$/ton)

Alternative	1st Stage (4 million tons/year)	2nd Stage (7 million tons/year)
Monrovia/Alt. I	0.81	0.46
Monrovia/Alt. II	1.41	0.81
Robertsport/Alt. I	1.54	0.88
Robertsport/Alt. II	1.07	0.61

It is also shown that Alternative-I at Monrovia Port site is most advantageous financially from the viewpoint of port users.

On the other hand, Robertsport Alternatives become advantageous in case the larger size of ore carrier, e.g. 200,000 to 250,000 DWT class, are operated in the future. Robertsport plan is able to be developed to accommodate larger carriers up to 250,000 DWT class without excessive investment, while Monrovia plan requires additional investment costs for a considerable dredging works to accommodate large size carriers. In addition, the proposed general cargo berth at Robertsport site have a handling capacity of 200,000 to 400,000 tons per year which provide the excess capacity for general cargoes other than the cargoes of 100,000 ton/year related to the Wologisi Mining Project.

Furthermore, the port development at Robertsport will give significant impacts on the regional development of the hinterland, including Mano river basin area. For example, a great contribution will be expected to enable the easy exportation of timber products in the upper Grand Cape and Lower Lofa Counties. A road to be prepared for the construction of the proposed carrier pipeline of iron ore is envisaged to encourage the forest exploitation and serve the easier transportation of timber products. If the proposed cargo port is established in Robertsport, log export of a minimum of 100,000 ton/year is expected. Besides, rubber products from hinterland of Robertsport will be enabled to be exported directly from a new port instead of shipping through Monrovia Port, the sole international port presently available. The port development at Robertsport is also substantial requirement to the comprehensive development of the Mano River Basin located along the border with Siera Leone.

As a conclusion, Alternative-I at Monrovia site is the most realistic and financially advantageous plan from a viewpoint of efficiency for the Wologisi Mining Project itself. From a viewpoint of impacts to the regional development,

however, Alternatives at Robertsport are worthy of considering for the further studies in a comprehensive approach. A draft scope of the studies for comprehensive port development of Robertsport is given in Appendix G.

APPENDIXES

APPENDIXES

APPENDIX A	PRELIMINARY CALCULATION OF FLEET DISTRIBUTION & VESSELS TIME IN PORT
APPENDIX B	SOIL DATA OBTAINED/MONROVIA & ROBERTSPORT SITES
APPENDIX C	RESULTS OF HYDROGRAPHIC SURVEY/SOUNDING
APPENDIX D	RESULTS OF CURRENT OBSERVATION
APPENDIX E	RESULTS OF SEABED/SEAWATER SAMPLING
APPENDIX F	RESULTS OF THE INVESTIGATION OF SEABED FEATURES
APPENDIX G	SCOPE OF THE STUDY FOR THE PORT DEVELOPMENT OF ROBERTSPORT

EXPECTED FLEET DISTRIBUTION

Vessel Size DWT	Average Vessel Size DWT	Percentage (%)	Throughput			
			4 Mill. TPY/Stage I		7 Mill. TPY/Stage II	
			Tonnage Mill. T.	No. of Vessels/Year	Tonnage Mill. T.	No. of Vessels/Year
90 - 120,000	105,000	60	2.4	23	4.2	41
70 - 90,000	80,000	30	1.2	15	2.1	27
Less than 70,000	50,000	10	0.4	8	0.7	14
Total			4.0	46	7.0	82

YEARLY TOTAL SERVICE TIME

(Hours)

Vessel Class DWT	4 Mill. TPY/Stage I			7 Mill. TPY/Stage II		
	No. of Vessels/Yr.	Service Time/Vessel	Total Time/Yr.	No. of Vessels/Yr.	Service Time/Vessel	Total Time/Yr.
105,000	23	36.0	828	41	36.0	1,476
80,000	15	30.2	453	27	30.2	816
50,000	8	23.5	188	14	23.5	329
Total	46		1,469	82		2,621

VESSEL SERVICE TIME - MONROVIA PORT

ITEMS (HRS)	VESSEL SIZE (1000 DWT)								
	50	80	105						
1. Initial Time	1.0	1.0	1.0						
2. Shift Changes & Breaks	0.5	1.0	1.5						
3. Trimming & Draft Checking	0.6	0.8	0.8						
4. Hatch Shifting	2.4	2.6	2.8						
5. Ballast Pumping	0.5	-	-						
6. Net Loading Time	8.4	13.4	17.5						
7. Unscheduled Down Time	2.1	3.4	4.4						
8. Cleaning between Products	-	-	-						
9. Tidal or Channel Restrictions	4.0	4.0	4.0						
10. Berthing In & Out	4.0	4.0	4.0						
11. TOTAL TIME	23.5	30.2	36.0						
12. Effective Loading Rate (Average) TPH DWT/(1-8)	3,225	3,600	3,750						
13. Efficiency % (# 12/Nom Rate)	40	45	47						

Design Shiploading Rate: 6,850 TPH Nominal: 6,000 TPH

VESSELS TOTAL TIME IN PORT

Item	Throughput	
	4 Mill. TPY/Stage I	7 Mill. TPY/Stage II
Total Service Time/Yr. (Hrs.)	1,469	2,621
Berth Occupancy (%)	17	30
Total Waiting Time/Yr. (Hrs.)	250	790
Average Waiting Time/Vessel (Hrs.)	5.4	9.6
Average Total Time in Port Per Vessel Class (Hrs.)		
- 105,000 DWT	41.4	45.6
- 80,000 DWT	35.6	39.8
- 50,000 DWT	28.9	33.1

FIELD CORE LOG

Page : APPENDIX B-1

Enclosure :

Order No : 369 7635

Boring No: B 1

Position : Channel : 7603.9 E

Channel : 9626.9 N

Waterdepth : 14.15 m **Date :** 4.4.78 **Time :** 11.45 a.m.

Reference mudline / Waterdepth to MLW Spt : 13.90 m + boring depth

Scale (m)	Reference from mudline (m)	Sample from - to (m)	description of sample	SPT N blows	U.C.S (kp/cm²)
0.00					
	0.00				
		0.00 - 0.90	very soft to semiliquid black organic mud, some coarse sand		0
	0.90				0
1.0		0.90 - 1.00	coarse yellowish sand, very loose		
		1.00 - 1.45		1	
2.0					
3.0					
		3.54 - 4.54	very loose compacted yellowish sand, mostly coarse/ medium sand, some fine gravel		
4.0					
		4.58 - 5.03	ditto	2	
5.0	5.10				
			rock, unweathered greyish, blackish (hornblende, quartz, glimmer)		
	6.15				
		End of boring			

FIELD CORE LOG

Page : APPENDIX B-2

Enclosure :

Order No : 369 7635

Boring No: B 2

Position : Channel : : 7605.3 E

Channel : : 9513.8 N

Waterdepth : 15.70 m **Date :** 24.3.78 **Time :** 9.00 a.m.

Reference mudline / Waterdepth to MLW Spt : 14.50 m + boring depth

Scale	Reference from mudline	Sample from - to	description of sample	SPT N	U.C.S
(m)	(m)	(m)		blows	(kp/cm²)
0.00					
	0.00				
	0.36	0.00 - 0.36	very soft to liquid brownish/greyish clay, silt and sand	0	0 0
1.0		0.36 - 0.83	brown/brownish coarse sand and some fine gravel, some medium sand in loose to medium compaction		
		1.50 - 2.04		4	
2.0		2.02 - 2.32	ditto		
3.0					
4.0		4.15 - 4.45	ditto	6	
	4.80				
5.0		5.50 - 6.00	sticky brownish/blackish medium to coarse sand and some silt		0.75
6.0		6.00 - 6.30	black fine to medium sand, glimmer micae rutile in medium dense compaction	23	
		6.30 - 6.60	ditto		
7.0		7.32 - 8.12	top of highly weathered rock but some coarse sand and fine gravel graphitlike micae, shining	28	

FIELD CORE LOG

Page: APPENDIX B-3

Enclosure :

Order No : 369 7635

Boring No : B 2 **Date :**

Scale (m)	Reference from mudline (m)	Sample from - to (m)	description of sample	SPT N blows	U.C.S (kp/cm²)
8.0		7.88 - 8.68	weathered rock	36	
	8.68				
9.0			end of boring		

FIELD CORE LOG

Page : APPENDIX B-4

Enclosure :

Order No : 369 7635

Boring No: B 3

Position : Channel : : 6990.3 E

Channel : : 9380.9 N

Waterdepth : 7.13 m Date : 27.3.78 Time : 9.20 a.m.

Reference mudline / Waterdepth to MLW Spt : 6.20 m + boring depth

Scale (m)	Reference from mudline (m)	Sample from - to (m)	description of sample	SPT N blows	U.C.S (kp/cm²)
0.00					
	0.00				
		0.00 - 0.24	black semiliquid organic mud and clay	0	0
	0.24	0.24 - 1.00	yellowish/blackish fine to medium sand in loose to medium compaction		
1.0	1.00				
	1.38	1.00 - 1.38	coarse greyish sand and fine gravel in loose compaction		
2.0		1.38 - 2.00	greyish medium to coarse sand	6	
3.0		3.38 - 3.53	greyish, blackish fine to medium sand, loose compaction	6	
	3.53				
		3.53 - 3.68	stiff blackish clay		1.30
4.0					
		4.99 - 5.07	ditto		1.20
5.0	5.07				
		5.07 - 5.99	yellowish fine to coarse sand in loose to medium compaction		
6.0	6.20				
	6.50		stiff greyish/blackish clay		
7.0		7.20 - 7.65	yellowish loose compacted fine to medium sand	4	

FIELD CORE LOG

Page : APPENDIX B-5

Enclosure :

Order No : 369 7635

Boring No : B 3 **Date :**

Scale (m)	Reference from mudline (m)	Sample from - to (m)	description of sample	SPT N blows	U.C.S (kp/cm²)
8.0		8.20 - 8.70	ditto		
9.0	9.50				
		9.73 - 10.43	yellowish medium to coarse snad with some fine gravels and pebbles in medium compaction	15	
10.0		10.50 - 10.85	ditto		
11.0		11.44 - 12.14	ditto		
12.0					
13.0					
		13.92 - 14.82	ditto	18	
14.0					
15.0		15.10 - 16.10	ditto		
16.0					

FIELD CORE LOG

Page : APPENDIX B-6

Enclosure :

Order No : 369 7635

Boring No : B 3

Date :

Scale (m)	Reference from mudline (m)	Sample from - to (m)	description of sample	SPT N blows	U.C.S (kp/cm²)
17.0					
		17.80 - 18.20	ditto		
18.0	18.20				
		End of boring			
19.0					
20.0					

FIELD CORE LOG

Page: APPENDIX B-7

Enclosure :

Order No : 369 7635

Boring No: B 4

Position : **Channel** : : 7451 E

Channel : : 8486 N

Waterdepth : 12.03 m **Date** : 30.3.78 **Time** : 8.25 a.m.

Reference mudline / Waterdepth to MLW Spt : 10.0 m + boring depth

Scale (m)	Reference from mudline (m)	Sample from - to (m)	description of sample	SPT N blows	U.C.S (kp/cm²)
0.00					
	0.00				
	0.60	0.00 - 0.60	soft, very soft, semiliquid black clay and mud	0	0 0
	1.00	0.60 - 1.00	blackish coarse sand, very loose		
1.0		1.00 - 1.40	medium stiff darkbrown/ black silt/clay with organic matter		0.75
2.0		2.10 - 3.45	ditto	6	0.75
3.0	3.45				
			interrupted and abandoned		
4.0					
5.0					

FIELD CORE LOG

Enclosure :

Order No : 369 7635

Boring No: B 5

Position : Channel : : 7561 E

Channel : : 8428 N

Waterdepth : 9.40 m **Date :** 31.3.78 **Time :** 9.35 h a.m.

Reference mudline / Waterdepth to MLW Spt : 8.60 m + boring depth

Scale	Reference from mudline	Sample from - to	description of sample	SPT N	U.C.S
(m)	(m)	(m)		blows	(kp/cm²)
0.00					
	0.00				
		0.00 - 1.00	very soft/liquid black organic clay and mud	0	0
1.0	1.30				
		2.02 - 3.02	stiff/hard dark brown/black clay with some organic decay and timber		0.75
2.0					1.25
3.0					
4.0		4.20 - 4.90	stiff dark brown/black clay		1.25
	4.90				
5.0		4.90 - 4.95	yellowish light cohesive sand, fine medium and coarse.		
		5.04 - 5.49	ditto, very loose compaction	2	
6.0	6.00				
		6.90 - 7.90	yellowish medium to coarse sand with fine gravel, loose to medium compaction		
7.0					

FIELD CORE LOG

Page: APPENDIX B-9

Enclosure :

Order No : 369 7635

Boring No : B 5 **Date :**

Scale (m)	Reference from mudline (m)	Sample from - to (m)	description of sample	SPT N blows	U.C.S (kp/cm²)
8.0					
		8.50 - 8.80	ditto		
9.0					
		9.50 - 9.80	ditto	12	
10.0					
		10.50 - 10.80	ditto		
11.0		11.35 - 11.65	ditto	18	
	11.65				
12.0		11.65 - 12.35	fair yellowish fine gravel in good compaction, some pebbles	12	
		12.49 - 12.80	ditto		
13.0	13.15				
		13.15 - 13.40	coarse sand and fine gravel with clay, balls i.d. 1 cm and silt	6	
14.0		14.00 - 15.00	ditto		
15.0	15.49				
16.0					

FIELD CORE LOG

Enclosure :

Order No : 369 7635

Boring No : B 5 **Date :**

Scale (m)	Reference from mudline (m)	Sample from - to (m)	description of sample	SPT N blows	U.C.S (kp/cm²)
17.0		17.10 - 18.10	clear uniform coarse sand and fine gravel in medium/ dense compaction	23	
18.0	18.10				
19.0			End of boring		
20.0					

FIELD CORE LOG

Page : APPENDIX B-11

Enclosure :

Order No : 369 7635

Boring No : B 6

Position : Channel : : 7659.9 E

Channel : : 8367.4 N

Waterdepth : 7.49 m Date : 2.4.78 Time : 8.30 h a.m.

Reference mudline / Waterdepth to MLW Spt : 7.50 m + boring depth

Scale (m)	Reference from mudline (m)	Sample from - to (m)	description of sample	SPT N blows	U.C.S (kp/cm²)
0.00					
	0.00				
1.0		1.00 - 2.00	very soft semiliquid black organic mud and clay, some sand particles	0	0
2.0	2.61				0
3.0	3.38	2.88 - 3.38	very loose blackish medium sand		0.3 0.3
4.0	4.50	3.38 - 3.88	dark brown to black clay, stiff/hard with organic decay and timber		1.3 1.3
5.0		4.90 - 5.90	brownish-greyish fine to medium sand in loose to medium compaction, some silt		0.6
6.0	6.00				
7.0		6.18 - 7.18	yellowish fine to coarse snad with some fine gravel, slightly cohesive, medium compaction		0.80 1.00

FIELD CORE LOG

Page : APPENDIX B-12

Enclosure :

Order No : 362 7635

Boring No : B 6 **Date :**

Scale (m)	Reference from mudline (m)	Sample from - to (m)	description of sample	SPT N blows	U.C.S (kp/cm²)
8.0					
		8.53 - 9.53	yellowish medium to coarse sand, some pebbles, loose to medium compaction	15	
9.0					
10.0		10.04 - 11.04	ditto, medium (to dense) compaction	(28)	
11.0					
12.0		(12.08 - 13.08)	ditto, medium compaction	8	
13.0					
14.0		14.39 - 14.63	ditto, medium compaction		
	14.63				
		14.63 - 15.39	coarse to medium sand with cohesive sticky loam and silt	8	0.8
15.0					
16.0					1.00

FIELD CORE LOG

Page : APPENDIX B-13

Enclosure :

Order No : 369 7635

Boring No : B 6 **Date :**

Scale (m)	Reference from mudline (m)	Sample from - to (m)	description of sample	SPT N blows	U.C.S (kp/cm²)
17.0		16.20 - 18.20	ditto, some white clay parts less 3 percent	4	
18.0	18.20				
19.0			End of boring		
20.0					

FIELD CORE LOG

Enclosure :

Order No : 369 7635

Boring No: B 7

Position : **Channel** : : 7666.0 E

Channel : : 8018.6 N

Waterdepth : 1.79 m **Date** : 7.4.78 **Time** : 8.40 h a.m.

Reference mudline / Waterdepth to MLW Spt : 1.80 m + boring depth

Scale (m)	Reference from mudline (m)	Sample from - to (m)	description of sample	SPT N blows	U.C.S (kp/cm²)
0.00					
	0.00	0.00 - 0.30	brownish/black medium sand of very loose compaction	0	
		0.30 - 1.00	brownish - ditto		
1.0					
2.0		2.56 - 3.16	brownish - ditto	2	
3.0					
4.0	4.20				
		4.91 - 5.44	brownish/blackish medium to coarse sand of loose compaction, rutile?	5	
5.0					
6.0		6.33 - 7.33	ditto rutile particles		
7.0	7.80				

FIELD CORE LOG

Enclosure :

Order No : 369 7635

Boring No : B 7

Date :

Scale (m)	Reference from mudline (m)	Sample from - to (m)	description of sample	SPT N blows	U.C.S (kp/cm²)
8.0					
		8.24 - 9.04	brownish/blackish, (very) soft silt with coarse sand		
9.0		9.67 - 10.67	soft to stiff clay and silt, black		0.6
10.0		10.67 - 10.85	stiff greyish/black clay and silt, some organic matter		1.25
	10.85				
11.0		10.85 - 11.67	greyish fine to medium sand with 2 intermediate clay layers of 0.5 cm thickness		
12.0		11.59 - 12.59	greyish fine to medium sand with organic debris of 1 cm i.d., thin organic strate, loose compaction, rutile	7	
13.0					
14.0		14.20 - 14.40	ditto		
	14.40				
15.0		14.40 - 15.20	brownish fine to medium sand, some fine gravel	8	0.70
16.0		16.23 - 17.03	ditto, but light grey, some organic intercalations		

FIELD CORE LOG

Page: APPENDIX B-16

Enclosure :

Order No : 369 7635

Boring No : B 7 **Date :**

Scale (m)	Reference from mudline (m)	Sample from - to (m)	description of sample	SPT N blows	U.C.S (kp/cm²)
17.0	17.03				
		17.03 - 17.23	dark brown fine sand of loose compaction	3	
18.0		18.42 - 19.42	dark brown fine to medium sand, some fine to medium gravel, medium dense	12	
19.0					
20.0	20.10				
		20.28 - 21.28	Light fine to coarse sand loose compacted	4	
21.0					
22.0		22.35 - 23.35	ditto	6	
23.0					
24.0		24.16 - 25.16	ditto		
25.0	25.16				
			End of boring		

FIELD CORE LOG

Enclosure :

Order No : 369 7635

Boring No: B 8

Position : Channel : : 7779 E

Channel : : 8292 N

Waterdepth : 7.20 m Date : 10.4.78 Time : 9.25 h a.m.

Reference mudline / Waterdepth to MLW Spt : 7.20 m + boring depth

Scale (m)	Reference from mudline (m)	Sample from - to (m)	description of sample	SPT N blows	U.C.S (kp/cm²)
0.00					
	0.00				
	0.40	0.00 - 0.40	blackish soft mud and clay and coarse sand	0	0
		0.40 - 1.10	black stiff/hard clay		0.90
1.0					
2.0		2.10 - 3.37	ditto		1.00
3.0		3.71 - 4.31	hard black clay		1.50
4.0	4.31				
		4.31 - 4.71	blackish cohesive sand, loose compaction		
5.0		5.35 - 6.00	ditto		
6.0		6.40 - 7.40	slightly silty fine to coarse sand with some fine gravel in loose compaction, yellowish greenish	3	
7.0					
	7.90				

FIELD CORE LOG

Enclosure :

Order No : 369 7635

Boring No : B 8 **Date :**

Scale (m)	Reference from mudline (m)	Sample from - to (m)	description of sample	SPT N blows	U.C.S (kp/cm²)
8.0		8.31 - 9.31	medium dense/medium coarse sand with some fine gravels, some very hard conglomerated particles, all yellowish brownish, no cohesion		0.6
9.0		9.78 - 10.78	loose medium/coarse sand brownish/yellowish, some fine gravels	3	
10.0	10.80				
11.0	11.80	10.97 - 11.70	(very) hard red-yellow clay with some sand		3.25
12.0		11.94 - 12.94	brownish medium uniform sand with some reddish clay particles	8	
13.0	13.42				
	13.72	13.42 - 13.72	yellowish hard clay		2.28
14.0		13.72 - 14.07	uniform sand, coarse with some fine gravels		
15.0					
16.0		16.04 - 17.04	yellowish fine gravel, loose compaction (fine parts missing)		

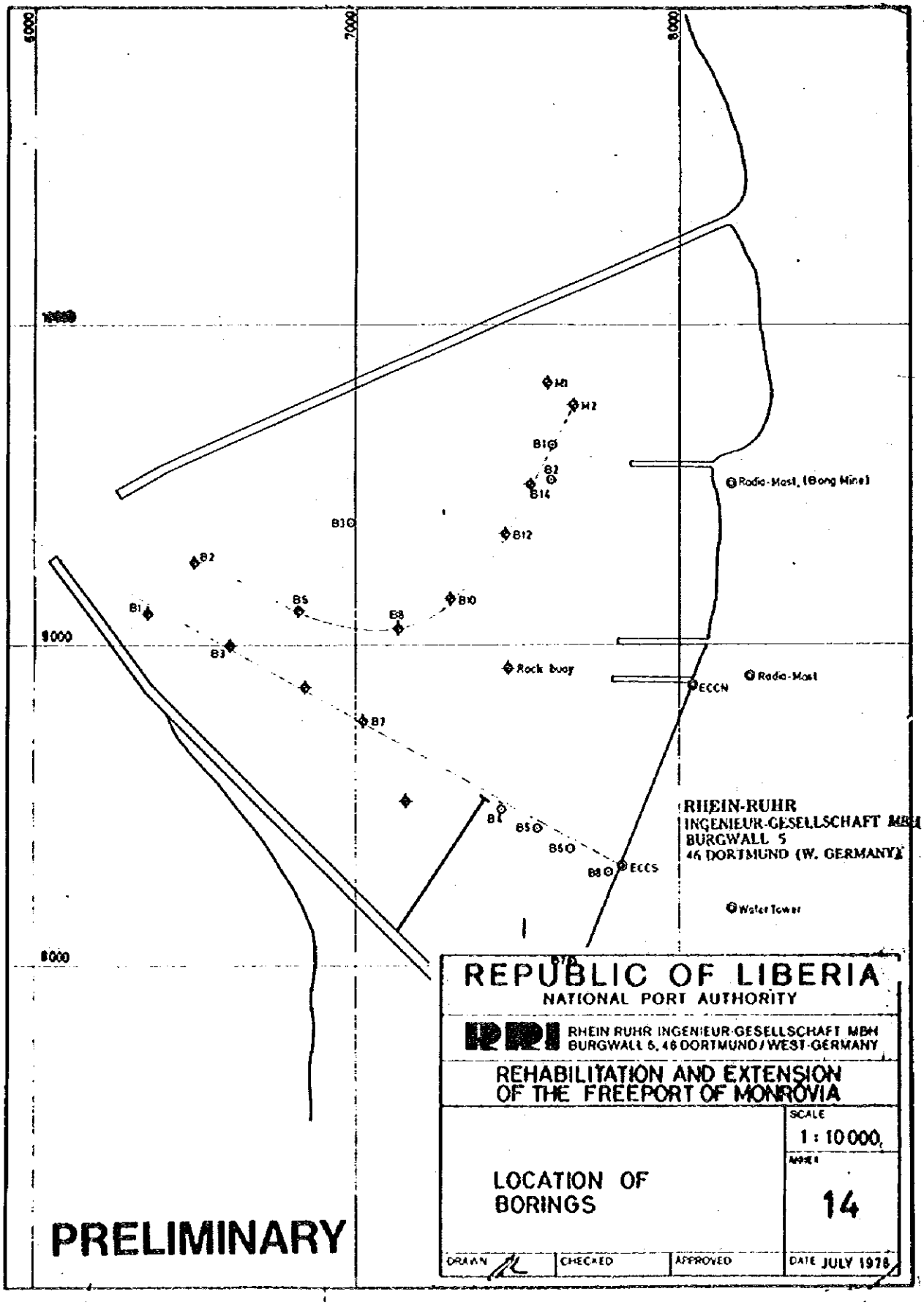
FIELD CORE LOG

Enclosure :

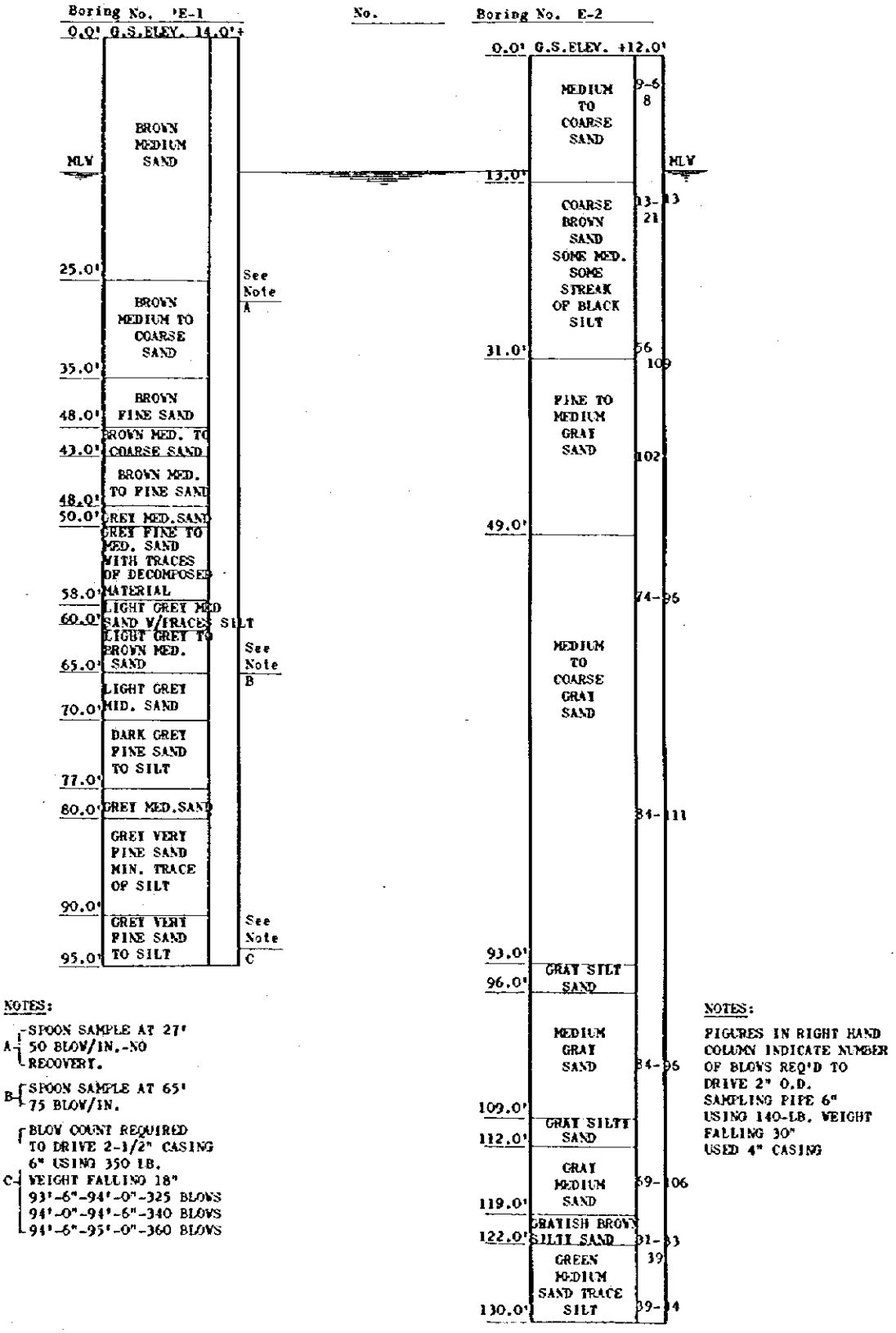
Order No : 369 7635

Boring No : B 8 **Date :**

Scale (m)	Reference from mudline (m)	Sample from - to (m)	description of sample	S P T N blows	U.C.S (kp/cm²)
17.0		17.76 - 18.16	brownish coarse sand with some fine gravels, medium dense		
18.0	18.16				
	18.76	18.16 - 18.70	grey cohesive medium sand with silt, very stiff		2.25
19.0			End of boring		
20.0					


6000
7000
8000
9000
M1
M2
B10
B2
B14
B12
B10
B2
B1
B5
B8
B10
B3
B7
Rock buoy
ECCN
Radio-Mast
Radio-Mast, (Bong Mine)
B1
B5
B6
B8
ECCS
Water Tower
B9
RHEIN-RUHR
INGENIEUR-GESELLSCHAFT MBH
BURGWALL 5
46 DORTMUND (W. GERMANY)
REPUBLIC OF LIBERIA
NATIONAL PORT AUTHORITY
RRI
RHEIN RUHR INGENIEUR-GESELLSCHAFT MBH
BURGWALL 5, 46 DORTMUND / WEST-GERMANY
REHABILITATION AND EXTENSION
OF THE FREEPORT OF MONROVIA
SCALE
1 : 10000
LOCATION OF
BORINGS
14
DRAWN
CHECKED
APPROVED
DATE JULY 1978
PRELIMINARY

TEST BORING RECORD



NOTES:

A- SPOON SAMPLE AT 27' 50 BLOW/IN.-NO RECOVERY.

B- SPOON SAMPLE AT 65' 75 BLOW/IN.

C- BLOW COUNT REQUIRED TO DRIVE 2-1/2" CASING 6" USING 350 LB. WEIGHT FALLING 18"
93'-6"-94'-0"-325 BLOWS
94'-0"-94'-6"-340 BLOWS
94'-6"-95'-0"-360 BLOWS

NOTES:

FIGURES IN RIGHT HAND COLUMN INDICATE NUMBER OF BLOWS REQ'D TO DRIVE 2" O.D. SAMPLING PIPE 6" USING 140-LB. WEIGHT FALLING 30" USED 4" CASING

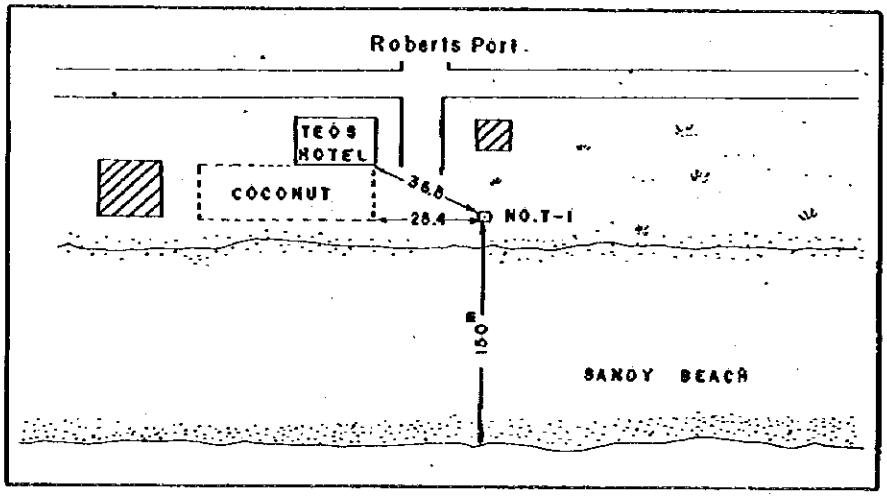
Location of Borings: Robertsport, Liberia Site 2

All borings are plotted to a scale of 1" 8ft. using Mean Low Water as a fixed datum.

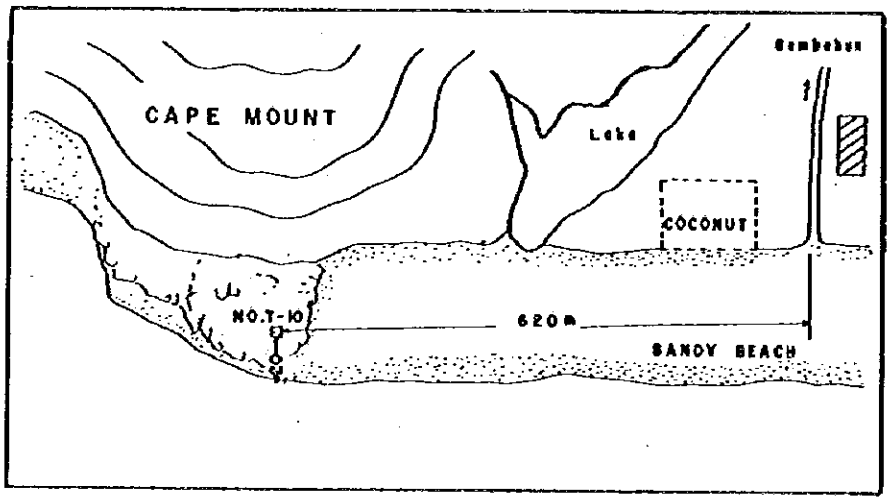
APPENDIX C-1

LOCATION MAP OF TRAVERSE POINTS

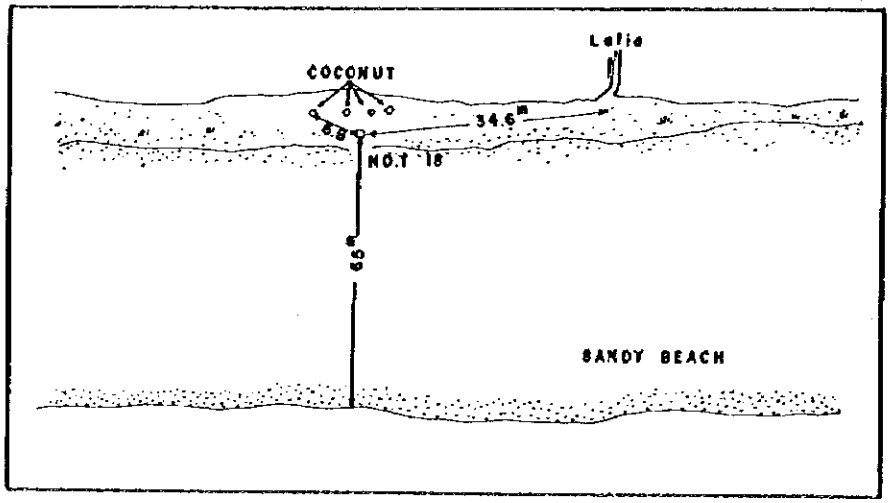
NO. T-1

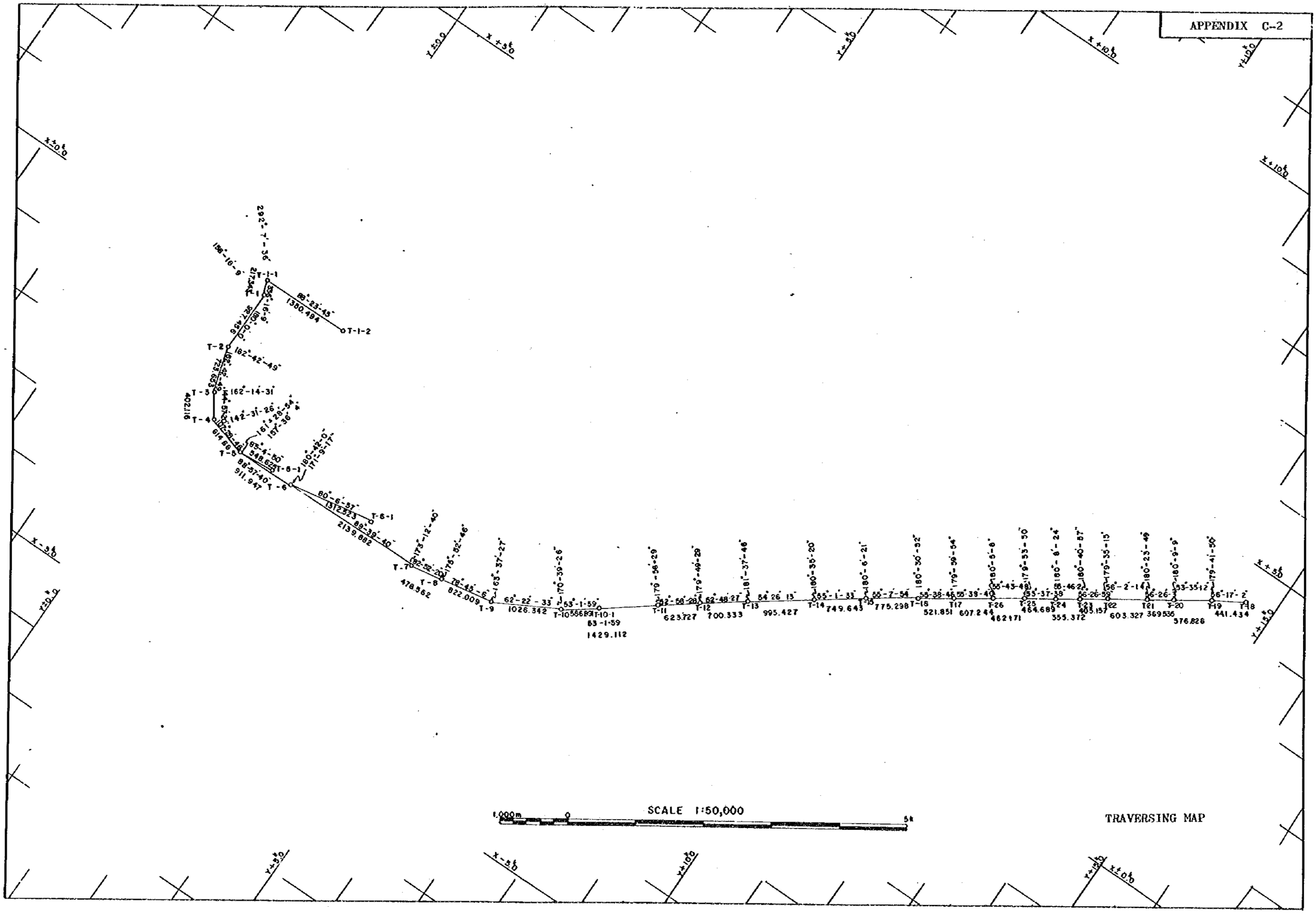


NO. T-10



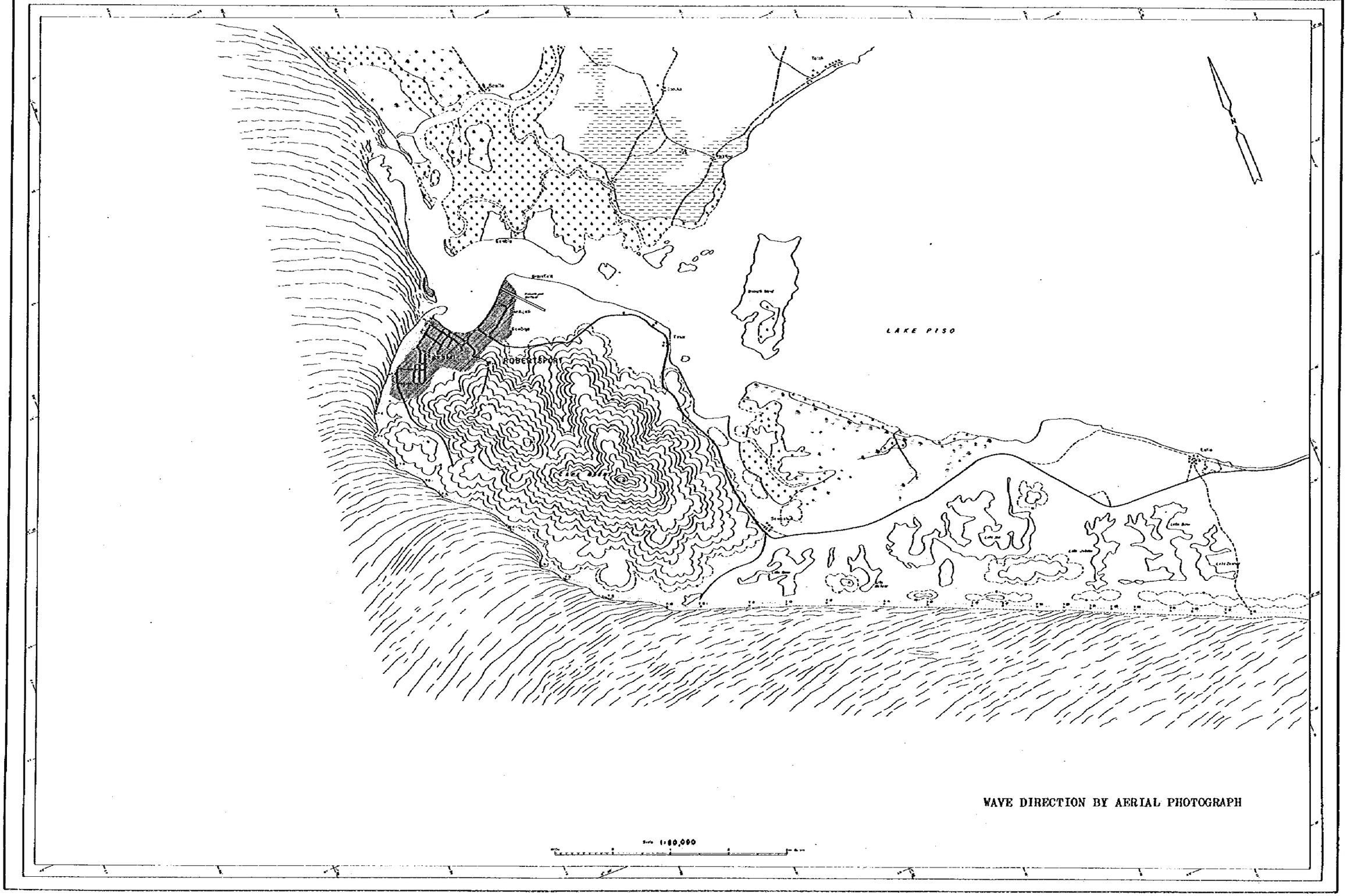
NO. T-18





TRAVERSING MAP

APPENDIX C-3



WAVE DIRECTION BY AERIAL PHOTOGRAPH