Chapter 14 Master Plan for Tema Port

14.1 Planning Requirement for Master Plan

The purpose of the master plan for the target year 2020 is to serve as a target and a guideline for phase plans including the Short-term Development Plan for the target year 2010. The master plan shall be an integrated plan which reveals the development direction of the port and includes not only the physical development plan of major port facilities but also the management and operation plan.

14.1.1 Bottlenecks of Tema Port

(1) Bottlenecks of the Port

Master Plan has to propose solutions to the bottlenecks that the port currently faces. The present condition is analyzed and bottlenecks are identified in Chapter 7. The bottlenecks of the port are listed below.

- Shortage/lack of deep berths prevents vessels from calling the port with full draft, forces vessels to wait a long time for berthing and/or to shift to shallow berths when vessels' draft is less.
- Space restriction for cargo operation hampers efficient cargo handling.
- Cargo handling productivity is due to the reasons mentioned above and inappropriate cargo handling procedures
- Restriction of night navigation for vessels to/from Oil Berth and Valco Berth causes additional cost.
- Lack of practical competition in port operation and vague responsibility demarcation system between the port authority and port users make the responsibility for cargo handling ambiguous and weakens the initiative of both sides to improve operation.

(2) Advantages of the Port

On the other hand, Tema Port has advantages for future development as listed below. By making the most use of these advantages, the port can be developed as a main gateway to Ghana.

- The port is located at Great Accra Region, which is the center of economic activities in Ghana.
- Behind the port there are many industrial estates and a new enclave of EPZ in now under construction.
- There are plenty of spaces for future development behind the port area.
- The port has good road connections to most of regions of Ghana and landlocked countries.

(3) Role of Tema Port

As the largest port in Ghana, Tema Port has played a very important role in the Ghanaian economy. In 2000, Tema Port handled 80% of import cargo and containerized cargo in Ghana, although it handled only 33% of export cargo. In line with economic development of Ghana experienced in future, export volume of non-traditional goods will increase rapidly and Tema is expected to enhance its function as an export port. To become a middle-income country, the role of Tema Port as the gateway of Ghana is very important. Tema Port is expected to fulfill the roles listed below.

- Sustaining and developing physical distribution of Ghana as the largest port.
- Functioning as a leading container port in West Africa.
- Functioning as a main import port of commodities consumed in Ghana such as foodstuffs, consumer goods and materials.
- Functioning as an export port of commodities produced in the east part of Ghana such as aluminium, petrol products, other manufactured goods, cocoa products and other foodstuffs.
- Supporting EPZ and industrial estates by providing necessary facilities for import of materials and export of manufactured goods.
- Supporting agriculture by providing necessary facilities for import of fertilizer and export of crops.
- Providing employment opportunity in direct services as well as numerous ancillary services.

14.1.2 Future Cargo Demand

Based on the appropriate role sharing between Tema Port and Takoradi Port, future cargo throughput at Tema Port is estimated. Results of the cargo forecast are summarized from Table 14.1.1 to Table 14.1.2.

Table 14.1.1 Future Cargo Demand Forecast at Tema Port

(tons)

IMPORT	1991	2000	2010	2020
Dry Bulk	1,061,685	1,652,557	2,157,747	3,426,302
Alumina	365,906	301,775	384,950	800,645
Clinker	470,277	972,772	1,262,240	1,855,840
Liquid Bulk	1,106,336	1,853,315	3,439,000	5,815,000
Crude Oil	165,112	1,000,000	2,575,747	4,357,500
Petrol Products	168,901	850,000	858,500	1,452,500
Bagged Cargo	301,253	537,553	597,518	618,367
General Cargo	201,898	235,135	701,388	1,326,602
Containerized Cargo	397,663	833,529	1,875,000	4,423,300
Total	**3,068,835**	**5,112,088**	**8,770,653**	**15,609,571**

EXPORT	1991	2000	2010	2020
Liquid Bulk	198,070	246,584	401,659	867,152
Bagged Cargo	84,092	104,370	26,891	25,062
General Cargo	192,109	156,230	106,734	103,908
Containerized Cargo	103,904	382,371	820,835	1,728,055
Total	**578,175**	**889,555**	**1,356,118**	**2,725,276**
Grand Total	**3,647,010**	**6,001,643**	**10,126,771**	**18,334,847**

Table 14.1.2 Future Container Cargo Demand Forecast at Tema Port

(TEUs)

	1991	2000	2010	2020
Import	35,071	81,861	202,447	468,693
Export	35,852	79,782	213,282	485,494
Transit		2,648	10,835	16,801
Transshipment		1,858	58,749	78,952
Total	**70,923**	**166,149**	**485,313**	**1,049,940**

14.1.3 Issues to be addressed in the Master Plan

Not only to solve the present problems and meet the increasing demand for handling cargo in the future, but also for Tema Port to play the roles described above, it is necessary to develop and modify Tema Port into a modern port. Basic points of view for formulating a master plan of the port are listed below.

- To solve the present problems such as lack/shortage of deep berths, shortage of cargo handling yards and resultant inefficient operation.
- To propose appropriate cargo handling system to enhance productivity of cargo handling and through it to minimize facility development.
- To cope with rapid increase of container cargo.

- As for facility development, deep berths are to be developed for large vessels to enter the port.
- To develop aprons and cargo handling yards with sufficient space just behind berths as much as possible.
- To segregate berths for container and break bulk cargoes from berths for mineral bulk cargoes.
- To propose the appropriate port administration and operation system.

14.2 Facility Requirement for Master Plan

14.2.1 Berthing Facilities

(1) Cargo Handling Productivity

Based on future cargo forecast and cargo handling capacity of existing facilities, facilities to meet the traffic demand in the target years are determined. When the scale of new facilities is calculated, improved cargo handling productivities are used. This is because although the present cargo handling productivities are low due to insufficient facilities, equipment and vague responsibility demarcation system of cargo handling between the port authority and port users, there is much room to improve cargo handling productivities once appropriate facilities are developed, appropriate methods is adopted and an appropriate institutional framework is set up. Target of cargo handling productivities are set considering improved future cargo handling conditions which are proposed in the master plan and cargo handling productivities of foreign ports. Cargo handling productivities which are used are given in Table 14.2.1.

Table 14.2.1 Gross Cargo Handling Productivity at Tema Port in 2000 and 2020

Type	Commodity	Unit	Productivity 2000	Productivity 2020	Remark
IMPORT					
DB	Alumina	t/hour/vessel	210	210	Belt conveyor
DB	Clinker/Gypsum	t/hour/vessel	300	500	Ship gear, grab
DB	Wheat	t/hour/vessel	70	150	Ship gear, grab
LB	Petro products	t/hour/vessel	385	600	Pipeline
BC	Rice, Fertilizer	t/hour/vessel	50	100	Ship gear
GC	Cars, Steel product	t/hour/vessel	70	100	Ship gear, grab
GC	Gen. Valco	t/hour/vessel	125	125	
CO	Container	box/hour/vessel	16	30	Container crane
EXPORT					
LB	Petro products	t/hour/vessel	385	385	Pipeline
DB	Cocoa beans	t/hour/vessel	35	100	Belt conveyor
BC	Aluminuim	t/hour/vessel	84	100	Ship gear
BC	Cocoa beans	t/hour/vessel	30	100	Ship gear
GC	Cocoa products	t/hour/vessel	30	100	Ship gear
GC	S/Timber, Wood product	t/hour/vessel	30	100	Ship gear
CO	Container	box/hour/vessel	16	30	Container crane

Note: Productivity 2000 is calculated from data of Jan. to Nov. in 2000

(2) Vessel Size at Target Year

Vessel sizes in the target year are set based on the present calling vessels' size distribution, users' intention and trend of world fleet considering development cost. Vessel sizes in the target year are listed in Table 14.2.2.

As for bulk carriers, the present maximum vessel in terms of DWT is the vessel for clinker, of which DWT is 51,694. Bulk carriers for clinker call at Takoradi Port at first and then call at Tema Port. At Takoradi Port average amount of clinker discharged per vessel is about 15,000 tons. That of Tema Port is about 20,000 tons. Ghacem has requested GPHA to construct a berth with the depth of 11.5m in Tema Port as soon as possible. The size of bulk carrier for alumina is 29,000 DWT with the full draft of 10.4m. As Valco Berth is located inside Lee Breakwater and Ghacem is located behind Quay 1, it is unlikely that new berths for alumina or clinker will be constructed outside the existing port. Dredging of the access channel and turning to secure respective depth of basin have almost been dredged to 12.5m and 11.5m has almost been completed. It is reasonable to restrict the size of bulk carriers to vessels with drafts less than 11.5m.

The maximum size of tankers calling at the port is 87,307 DWT. Tema Oil Refinery has a plan to construct a single buoy mooring facility on a BOT basis, which is expected to be completed in April 2002. The proposed site is 4 nautical miles east from the entrance to Tema Port at a depth of 23m. The single buoy can accommodate 135,000 DWT tankers. Crude oil will be imported through the single buoy. Petroleum products will continue to be imported and exported from Oil Berth. From the same reason given above the size of tankers for petroleum products will be limited to vessels with drafts less than 11.5m.

The maximum capacity of container ships which are now in operation in West Africa is 2,000 TEUs. The maximum size of container vessels calling the port is 31,975 DWT and this vessel has the capacity of almost 2,000 TEUs. This vessel enters the port with adjusting their draft. According to interviews with shipping companies, in future there is a possibility that 3,000 TEUs class container vessels will be operated in West Africa and call at selected ports. In the master plan of the port, container terminals are to be planned that can accept 3,000 TEUs class container vessels with full draft.

Table 14.2.2 Vessel Size at the Target Year 2020 at Tema Port

Vessel type	2000		2020 (Standard Size)		
	Max. DWT	DWT1/4	DWT	Length	Draft
	(tons)	(tons)	(tons)	(m)	(m)
Bulk carrier	51,694	47,263	30,000	185	11.0
Tanker	87,307	n.a.	30,000	180	10.9
Cellular container	31,975	20,245	50,000	290	13.0
RO-RO	39,900	28,175	28,000	210	11.0

Note: $DWT_{1/4}$ means DWT of one fourths largest vessel

(3) Number of Berths Required

Based on studies above, the number of new berths for the master plan is determined. The result is shown in Table 14.2.3. In addition to these berths water facilities such as breakwaters, basins and access channels, cargo handling/storage yards, cargo handling equipment and other necessary facilities will be considered when alternatives of the port facility layout plan for the master plan are proposed.

Table 14.2.3 Scale of New Berths for Master Plan of Tema Port

Berth	Commodity	Number	Depth	Length / berth
Container Berth	Container	4	13 – 14m	300 – 350m
Multi-purpose Berth	RoRo, Clinker	2	11.5m	280m
Valco Berth	Alumina	1	11.5m	240m
Oil Berth	Petroleum products	1	11.5m	Dolpin
Total		8		

14.2.2 Water Facilities

(1) Entrance Channel

Number of vessels calling at Tema Port is estimated at about 2000 in the year 2020. Six ships will use the entrance channel on average per day. One way channel is sufficient to handle this traffic level. The width of the entrance channel is determined using methods proposed by PIANC[1] and UNCTAD[2].

According to PIANC proposal, the bottom width of the entrance channel is given for a one way channel by:

$$\mathbf{W = Wbm + \sum Wi + Wbr + Wbg}$$

where,

Additional width	Items	Characteristics of Tema Port	Width
Wbm	Ship maneuverability	Poor	1.8B
W1	Vessel speed	Slow	0.0B
W2	Prevailing cross winds	Moderate	0.5B
W3	Prevailing cross current	Negligible	0.0B
W4	Prevailing longitudinal current	Low	0.0B
W5	Significant wave height and length	1 < Hs < 3	0.5B
W6	Aids to navigation	Moderate with infrequent poor visibility	0.2B
W7	Bottom surface	Rough and hard	0.2B
W8	Depth of waterway	<1.25T	0.4B
W9	Cargo hazard level	Low	0.0B

[1] Approach Channels, A Guide for Design, Final Report of the Joint PIANC-IAPH Working Group II-30 in cooperation with IMPA and IALA, June 1997

[2] Same as 1

Wbr	Bank clearance (red side)	Steep and hard embankments, structures	0.5B
Wbg	Bank clearance (green side)		0.5B
Total			4.7B

B: beam of vessel, Hs: significant wave height, T: draught of vessel

On the other hand, UNCTAD proposes 5B (B is beam of vessel) for the width of a one way channel. 5B for the bottom width of the approach channel is proposed. As many kinds of cargo vessels such as bulk carriers, RoRo ships and container ships will use the approach channel, 32m is adapted as B taking account of possible beam range of vessels calling at the new deep berths covering bulk carriers, container vessels and RoRo ships.

Width of approach channel = 5.0×32m = 160m

(2) Turning Basin

Turning basins are to be located in front of new berths and have a diameter of two times the overall length of design vessel.

14.2.3 Breakwater

Alignment of breakwater will be planned to protect port facilities and maintain water calmness in the port at the appropriate level for safe navigation and smooth cargo handling.

14.2.4 Storage Area

One of the most serious problems of Tema Port is the narrow apron and limited space for cargo handling, especially for containers. In addition, storage areas are segmented and separated. These problems shall be solved in the master plan.

(1) Container Yards

The critical problem of demand for storage areas in the master plan is container storage areas. Necessary area for container yards depends on container operation system in yards. Yard operation systems are classified into three types by container handling equipment, that is RTG (Rubber Tire Mounted Gantry Crane) type, Straddle Carrier Type and Top Lifter/Reach Stacker type. In this project, RTG system is selected because of high operational efficiency, low maintenance cost and high working safety (the detail is explained in chapter 14.5).

Estimated container throughput at the port in 2020 is 1,050 thousands TEUs and new four berths will be developed. In RTG type operation the standard width of container yards is 300m – 350m. Therefore, total area needed as container yards is calculated at 39ha – 45ha.

(2) CFS

Required floor space of CFS is estimated using the following formula. As for export containers, sawn timber, cocoa products and manufactured goods, which comprise the majority of export container, are usually vanned outside the port. Therefore, only import containers are taken into consideration. It is estimated that 10 % of import containers are devanned in the port and 20 % of them must be devanned in house. To avoid congestion and secure smooth operation it is advisable to construct CFS outside the port area. The most suitable site for new CFS is the west side of the port where bonded off-dock container yards have been built by private companies.

$$A = VP \times t \times AD / (\mu \times (1 - \xi) \times \varepsilon)$$

Where,

VP	642	TEUs at peak time
t	13.1	Tons/teu(laden)
AD	0.3	Ratio of devanned in house
μ	2.0	Unit load per square meter for storage
ξ	0.6	Passage ratio
ε	0.75	Operational factor
A	4,205	m2

(3) Shed

There are 6 main sheds at Tema Port, which exclude the sheds scheduled to be demolished. One of them is CFS. The total area is about 29,000m^2. The required dimensions of sheds were estimated using the following formula for the storage of bagged cargoes and general cargoes. Required area of sheds is calculated at 27,000m^2. When a new container terminal will be constructed, existing CFS will be converted to an ordinal shed. New sheds are not planned in the master plan.

$$A = (V / T \times \lambda \times \delta) / (\mu \times (1 - \xi) \times \varepsilon)$$

Where、

V	:	1,345,095	Annual cargo throughput of conventional cargo (tons)
T	:	363	Annual working days
λ	:	1.5	Peaking factor to the daily average handling demand
δ	:	7	Average dwelling time (days)
μ	:	3	Unit load for storage (tons/sq. m)
ξ	:	0.4	Passage ratio
ε	:	0.8	Operational factor
A	:	27,019	Floor space (sq. m)

(4) Open Yard

The required dimensions of open stock yards were estimated using the following formula for Iron / Steel. Required area of open yards is calculated at 25,500m^2. After a new container terminal with sufficient container yards is established, open space in the Quay 1, which is now used as container yards, will be converted for open yards for another cargoes.

$$A = (V / T \times \lambda \times \delta) / (\mu \times \xi \times \varepsilon)$$

Where、

V	328,991	Annual cargo throughput of conventional cargo (tons)
T	363	Annual working days
λ	1.5	Peaking factor to the daily average handling demand
δ	7	Average dwelling time (days)
μ	1	Unit load for storage (tons/sq.m)
ξ	0.5	Passage ratio
ε	0.75	Operational factor
A	25,377	Open stock yard space (sq.m)

13.2.5 Inland Transportation Facilities

(1) Road

The study team proposes that trucks for containers and trucks for conventional cargoes be separated. When a new container terminal will be constructed a new road for container traffic will be planned.

(a) New Access Road for Container

A new access road for container traffic is proposed. The traffic volume generated by container operation is estimated by applying the following equation. According to the estimated traffic volume, 4 lanes are required. This road is directly connected with the new container terminal.

$$V = \upsilon / 24 \times \sigma / \delta / \varepsilon$$

Where,

υ	3,196	Number of trucks at peak day
σ	4.0	Variation ratio per hour
δ	0.5	Cargo related vehicle ratio
ε	0.5	Ratio of vehicle with load
V	2,131	Number of vehicles at peak hour

(b) Main Harbour Road

The present problem of road traffic in the port area is that vehicles which enter the port from gate 2 have to cross the opposite lane of the road and it causes delays. Therefore, a one-way traffic road for vehicles to enter the port from gate 2 and to depart from gate 3 is proposed as a main harbour road. This road will be used by trucks for conventional cargoes and passenger cars. The traffic volume generated by port activities is estimated by applying the following equation. Considering the estimated traffic volume, a two-lane road is proposed.

$$V = \upsilon / 24 \times \sigma / \delta / \varepsilon$$

Where,

υ	1,041	Number of trucks at peak day
σ	4.0	Variation ratio per hour
δ	0.7	Cargo related vehicle ratio
ε	0.5	Ratio of vehicle with load
V	496	Number of vehicles at peak hour

(c) Parking Space of Trucks for Transit Cargo to Landlocked Countries

According to the future cargo estimate, transit cargo to landlocked countries will increase steadily. Now truces which carry transit cargo to landlocked countries wait for permission for departure at a roundabout near the control point No.2. This situation worsens road conditions and hinders the smooth traffic inside the port. A new parking area for trucks for transit cargo is proposed. The necessary area for parking space is estimated by applying the following equation. The new parking area is proposed to construct near gate 3.

$$A = (V / T \times \lambda \times \delta / \mu) \times U$$

Where、

V	:	319,089	Annual throughput of transit cargo (tons)
T	:	363	Annual working days
λ	:	2	Peaking factor to the daily average
δ	:	1	Average dwelling time (days)
μ	:	15	Unit load per truck (tons/truck)
U	:	140	Unit parking area per truck (sq.m)
A	:	16,409	Parking space (sq. m)

(2) Rail

There was a railway linkage between Tema Port and Accra and the railway reached to storage facilities in and adjacent to the port. But operation stopped more than 20 years ago. Nowadays, rails are removed at almost all sections between the port and Accra and only the railway premise exists.

Containers and bulk cargoes are suitable cargoes for rail transport. Under appropriate conditions railway transportation is economically advantageous; it is also an environmental- friendly transportation mode. Container transportation by rail is popular in Europe and North America. As containers handled at Tema Port is projected to increase rapidly, the possibility of container transportation by rail shall be considered at appropriate time in future. However, viability of container transportation by rail depends on the quantity of containers transported and distance of transportation. As the distance between Tema and Accra is too short for rail transportation of container, other areas such as Kumasi should be considered. And investment cost of laying railway and special equipment and maintenance cost should be estimated carefully.

14.3 Alternatives of Port Facility Layout Plan

14.3.1 Alternatives of Port Facility Layout Plan

Based on field surveys, cargo demand forecast and other study results, three (3) alternative port facility layout plans are proposed. There are two main concerns in formulating these alternatives, that is, how to solve the present problems such as lack of deep berths and shortage of yards, and how to minimize the construction cost. As for construction cost, it is difficult to construct deep berths inside existing breakwaters because of high cost of hard rock dredging and limited space Therefore, new deep berths have to be constructed outside existing breakwaters and new breakwaters have to be constructed to protect the berths.

The main issues of the layout plan is where and how new container berths will be planned. Focusing on new container berths, 3 alternatives are formulated. Alternatives are shown in Fig. 14.3.1 to Fig. 14.3.3.

(1) Preconditions for Alternatives

- ♦ Quay No. 2 extension project with dredging works of entrance channel (12.5m) and turning basins (11.5m) is completed.
- ♦ Crude oil will be handled at a new single buoy mooring facility, which is expected to be completed in April 2002.

(2) Alternative-1 New container berths consecutive with Quay 2 at the west side of the port (see Fig. 14.3.1)

New container berths will be constructed continuously with Quay 2 and a new breakwater will be constructed to protect the berths. There are several advantages of this alternative. One is that enough space for container handling and storage is available by reclamation. Space for backup of container transportation such as off-dock container yards is also available on land very near to new berths. As new berths will be constructed next to Quay 2, the new berths and Quay 2 could be operated simultaneously. Some part of the main breakwater will be removed, if necessary. The disadvantage of this alternative is that some part of the new breakwater will have to be removed due to the extension of the new port area because main wave comes from the south to the southeast.

(3) Alternative-2 New container berths parallel to the west part of the main breakwater at the west side of the port (see Fig. 14.3.2)

Similar to alternative-1, new container berths will be constructed at the west side of the port. However, the new berths in this alternative-1 will run parallel to the west part of the main breakwater and thereby decrease the volume of dredging works. The length of a new breakwater, however will become longer.

(4) Alternative-3 New container berths and breakwater at the offshore side of the existing breakwater (see Fig. 14.3.3)

New container berths will be constructed at the offshore side of the main breakwater and a new breakwater will be constructed to protect the berths. And a new connecting road to Quay 2 will be constructed. The disadvantages of this alternative are that the new container terminal is isolated from other terminals and further expansion space is very limited. The advantage is that there is no need to dredge soil and rock and it is suitable to construct deep berths although construction cost of the new breakwater and berths will be increased.

14.3.2 Comparison of Alternatives

Alternatives are evaluated by 7 items: quality of berths, calmness of water, navigational safety, future development, disturbance to existing facility, harmonization with environment and cost.

(1) Quality of Berths

Alternative-3 has some problems in terms of berth quality. As new berths will be constructed at the offshore side of the port and are isolated from other facilities, transportation cost of containers within the port and to/from outside port will become higher. Yard space might be limited because reclamation cost is high.

(2) Calmness of Water

The wave height in front of the quay is a key factor affecting cargo handling efficiency. The degree of calmness of water in front of quays is calculated for alternative-1 and –2 in a preliminary manner and the result is shown in Table. 14.3.1. The criterion of container berths is the non-excess probability under 0.5m in wave height is 95%. Berths are numbered from east to south. As for alternative-3, the lengths of new breakwaters are determined not by securing calmness of water in front of berths but by protecting a turning basin. Water calmness in front of new berths of alternative-3 apparently satisfies the criterion.

Table 14.3.1 Degree of Calmness

Wave height	< 0.5m
Alternative-1	
Berth No.1	98.8%
Berth No.2	99.0%
Berth No.3	99.3%
Berth No.4	98.3%
Alternative-2	
Berth No.1	98.2%
Berth No.2	98.6%
Berth No.3	98.6%
Berth No.4	96.7%

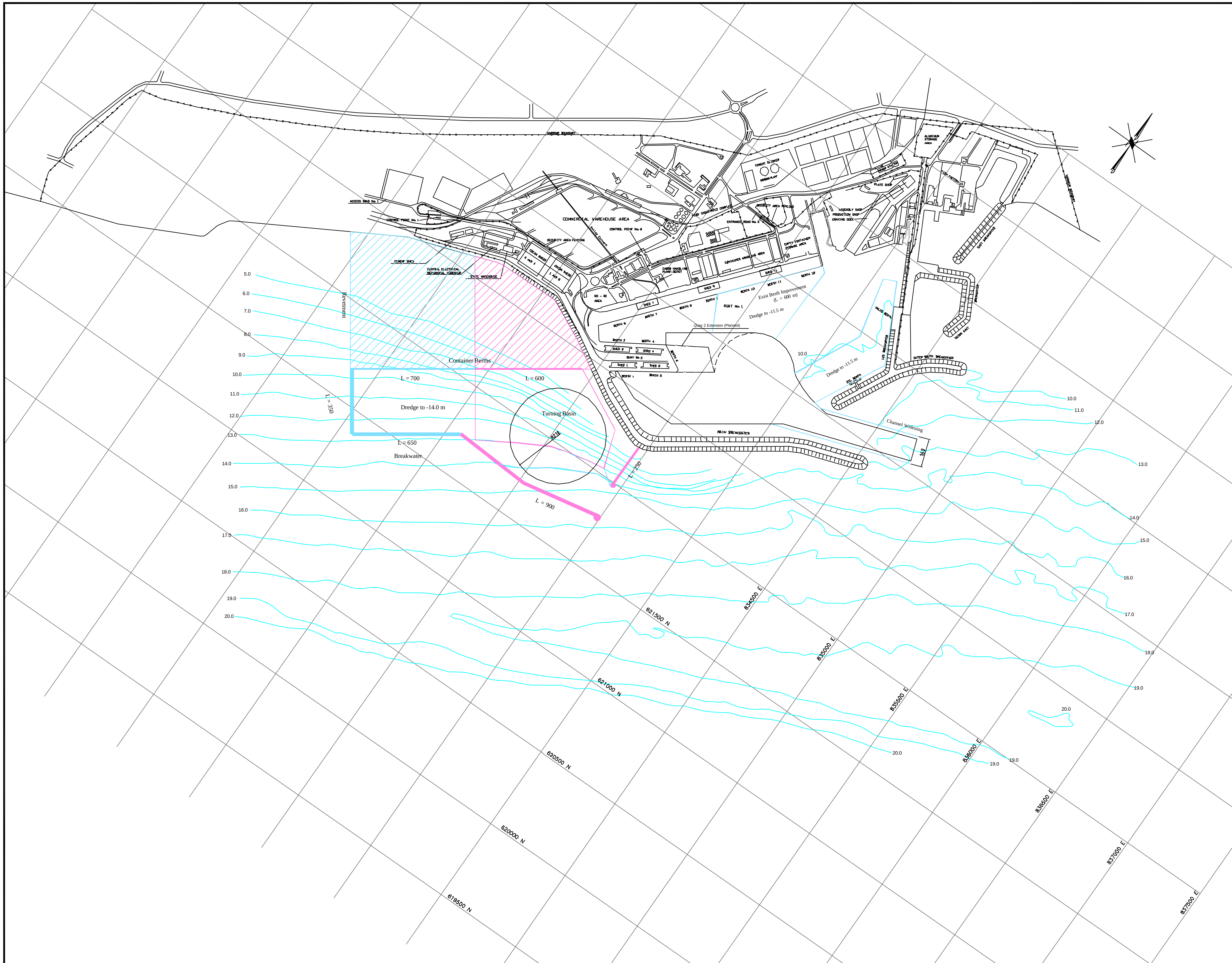

Fig. 14.3.1 MASTER PLAN of Tema Port (Alt. 1)

NOTES:

1. Geodetic information:
   Ellipsoid: WGS84
   DATUM: WGS84
   Projection: UTM Zone 31
2. Coastline digitized from British Admiralty Chart 3102
3. Levels referenced to Chart Datum

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

GHANA PORTS AND HARBOURS AUTHORITY (GPHA)

PROJECT

THE DEVELOPMENT STUDY OF GHANA SEA PORTS IN THE REPUBLIC OF GHANA

Drawing Title

TEMA PORT MASTER PLAN

SCALE	DATE	Drawing No.	Rev. No.
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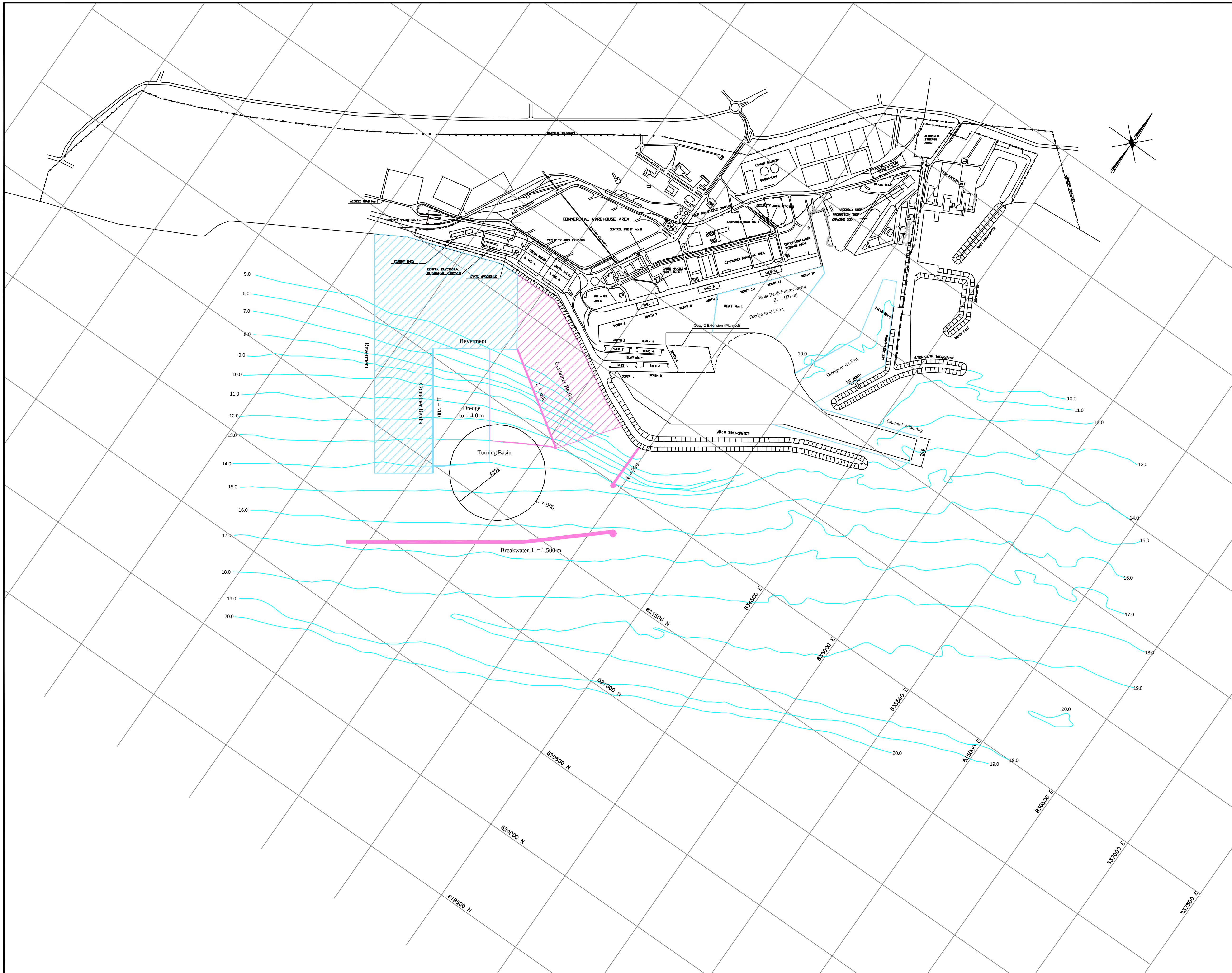

NOTES:

1. Geodetic information:
   Ellipsoid: WGS84
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Fig. 14.3.2 MASTER PLAN of Tema Port (Alt. 2)

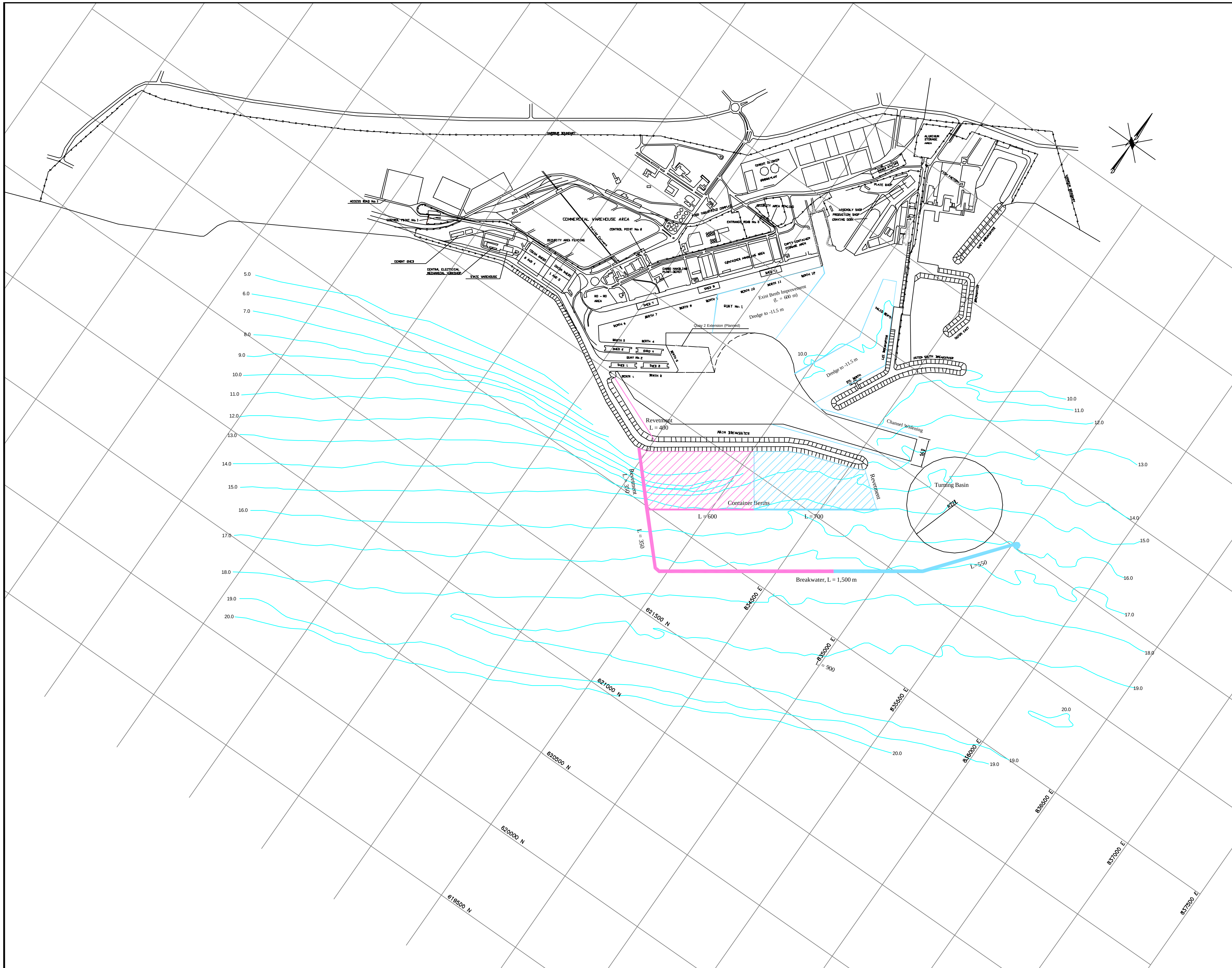

Fig. 14.3.3 MASTER PLAN of Tema Port (Alt. 3)

NOTES:

1. Geodetic information:
   Ellipsoid: WGS84
   DATUM: WGS84
   Projection: UTM Zone 31
2. Coastline digitized from British Admiralty Chart 3102
3. Levels referenced to Chart Datum

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(3) Navigational Safety

Navigational safety is examined and checked from three items.

- Congestion of channel

In alternative-1 and –2, a new entrance channel to container berths will be constructed. In alternative-3, container vessels will use the same access route of other vessels. Number of container vessels in the future will increase rapidly according to the increase of container throughput and number of container vessels will be expected to reach about 800 in year 2020. This would be a heavy burden to the access route.

- Stopping distance

Generally speaking a vessel requires “stopping distance” of five times her length to stop safely after reducing her speed although necessary distance varies according to vessels’ maneuverability and wave condition. Although more study is needed to decide the necessary length of breakwaters for secure the stopping distance the high cost of alternative-3 makes it the most difficult to secure necessary stopping distance.

- Wave on vessel

It becomes more difficult to maneuver vessels when waves flow from their stern, especially vessels at low speed. As main waves flow from their stem, the situation is preferable for vessels to enter the port in all alternatives.

(4) Future development

Alternative-3 has limitation for further expansion because of high expansion cost. In case of expanding to offshore side facilities have to be constructed in deep sea and in case of expanding to the west a huge breakwater is needed.

(5) Disturbance to existing facilities

Tema Port has a shortage of deep berths and vessels have to wait long time to berth limited deep berths. As new deep container berths are constructed outside the existing port in all alternatives, disturbance to existing berths is avoidable. After the completion of new berths redevelopment works of existing berths will start to minimize the influence of construction works. As for alternative-3, construction works of a breakwater and new berths affect vessel navigation and construction works of connecting roads affect the utilization of Berth No.1 Alternative-1 and -2 don’t have any influence to port activities.

(6) Harmonization with environment

All alternatives involve the following activities; Land filling, dredging, securing yard space, increase in cargo handling and cargo transportation. All alternatives will have a certain impact on the major current flow pattern (eastward flow), though at different degrees. Alternative 2 and 3 will have a greater impact on the current flow than Alternative 1 due to the more extended breakwater offshore, which obstructs the prevailing current flow and may deteriorate the water quality and ecosystem in the existing port area.

(7) Cost

Construction costs of alternative-1 to –3 are shown in Table 14.3.2. The Construction cost of alternative-2 is the highest followed by alternative-3. Although the dredging cost of alternative-1 is the highest among all alternatives, the cheap reclamation cost compensates enough. Details of construction cost of each alternative are attached in appendix.

Table 14.3.2 Construction Cost

(US$ million)

	Alternative-1	Alternative-2	Alternative-3
Cost	365,164	408,668	392,152
Cost index	100	112	107

14.3.3 Evaluation of Alternatives

Table 14.3.3 summarizes the evaluation of alternatives from many aspects. Alternative-1 is recommended as the master plan of Tema Port.

Table 14.3.3 Comparison of Alternatives

	Alternative-1	Alternative-2	Alternative-3
Quality of berths	***	***	**
Calmness of water	***	***	**
Navigational safety	***	***	**
Future development	***	***	**
Disturbing existing port facility	***	***	***
Harmonization with environment	***	***	***
Cost Index	100	112	107

Note *** Good ** Fair * Poor

14.4 Port Facility Layout Plan and Priority on Projects

14.4.1 Port Facility Layout Plan

Fig. 14.4.1 and 14.4.2 show the detailed layout plan of port facilities of the selected alternative in chapter 14.3. Table 14.4.1 shows the list of main facilities of the master plan.

Table 14.4.1 List of Main Facilities for Master Plan of Tema Port

Facility	No.	Dimension / Capacity
Container Berths	4	Length 300 - 350m, depth 13-14m
Multipurpose Berths	2	Length 274m, depth 11.5m
Valco Berth	1	Length 240m, depth 11.5m
Oil Berth	1	Dolphin, depth 11.5m
Navigational aids	1	4 Light beacons, 4 Buoys
Tug boat	2	2,500 Hp
Existing entrance channel	1	One way, width 160m, depth 12.5m
New entrance channel	1	One way, width 160m
New turning basin	1	Radius 290m, depth 14m
Container yard	1	45.5 ha
New breakwater	1	2,150m
Revetment	1	700m
Main road development	1	1 set
Inner harbour road	1	1 set
Parking space	1	16,500m^2
Container crane	8	45 tons
Transfer crane	24	40 tons, 1 over 4
Tractor head	32	For container cargo

14.4.2 Priority on Projects

Three main projects are proposed in the master plan: new container berths and new bulk berths and new multipurpose berths (improvement of existing berths). The new container berths are the second dedicated container berths at Tema Port next to New Quay 2 Terminal. But New Quay 2 Terminal has restrictions of berth depth and container yard area. The quality of New Quay 2 Terminal is at the same level of a container terminal in Abidjan Port. The new container terminal proposed in the master plan is more sophisticated and advanced container terminals.

The deep bulk berths are proposed for Oil Berth and Valco Berth to accommodate larger bulk vessels with full draft. The multipurpose berth project are also proposed for larger vessels such as Ro-Ro and bulk carriers to berth quays with full draft

Among the projects, new container berth project has the first priority because of its effectiveness, urgency, high social needs and severe competition from other ports. These evaluation criteria are explained in chapter 13.4.2. The second priority is put on new bulk berths because of strong request from users. As a beep berth (11.5m) for Ro-Ro vessels and other carriers is planned to be constructed in the Quay 2 extension project, the multipurpose berth project has the third priority.

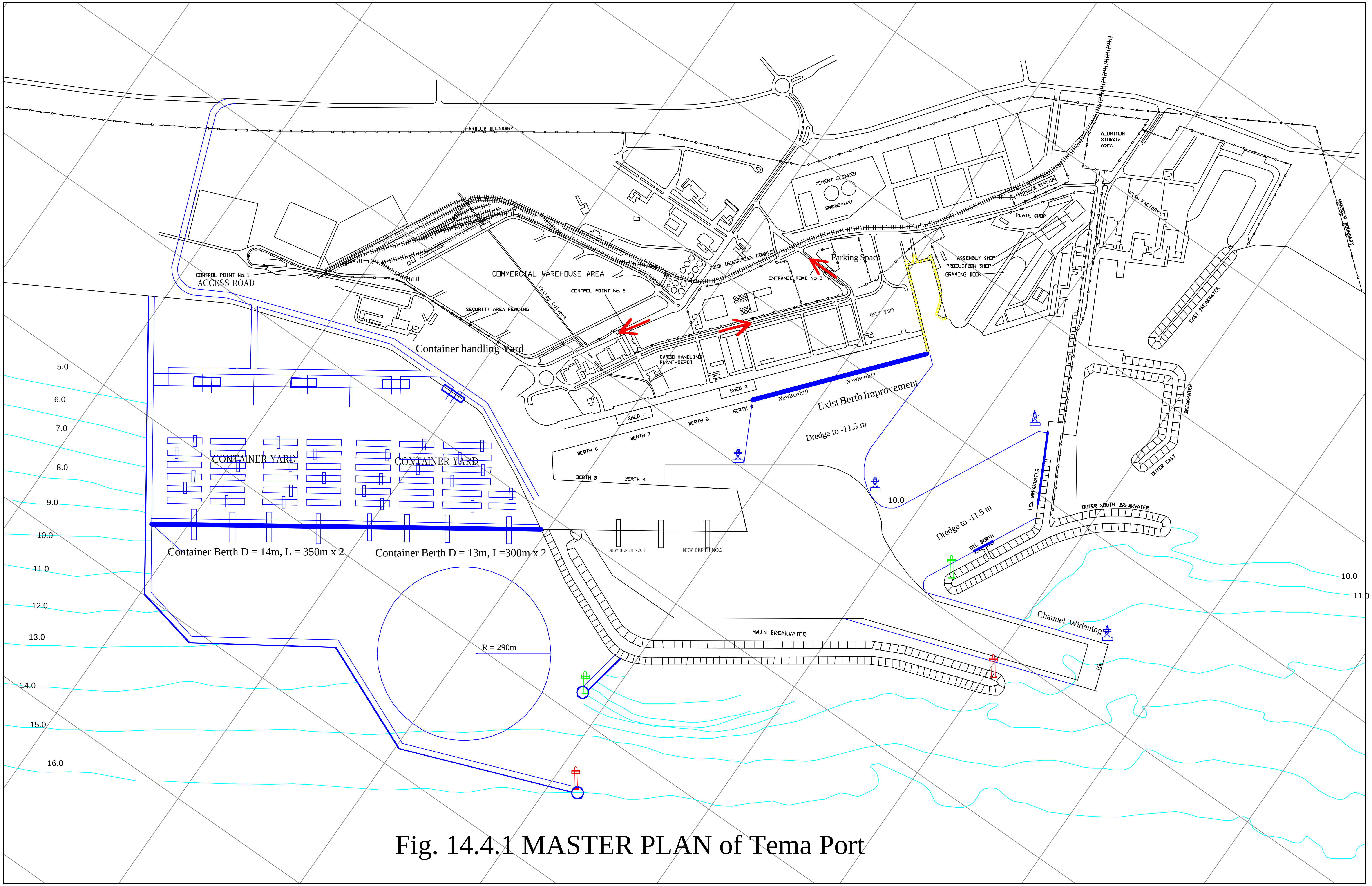


Fig. 14.4.1 MASTER PLAN of Tema Port

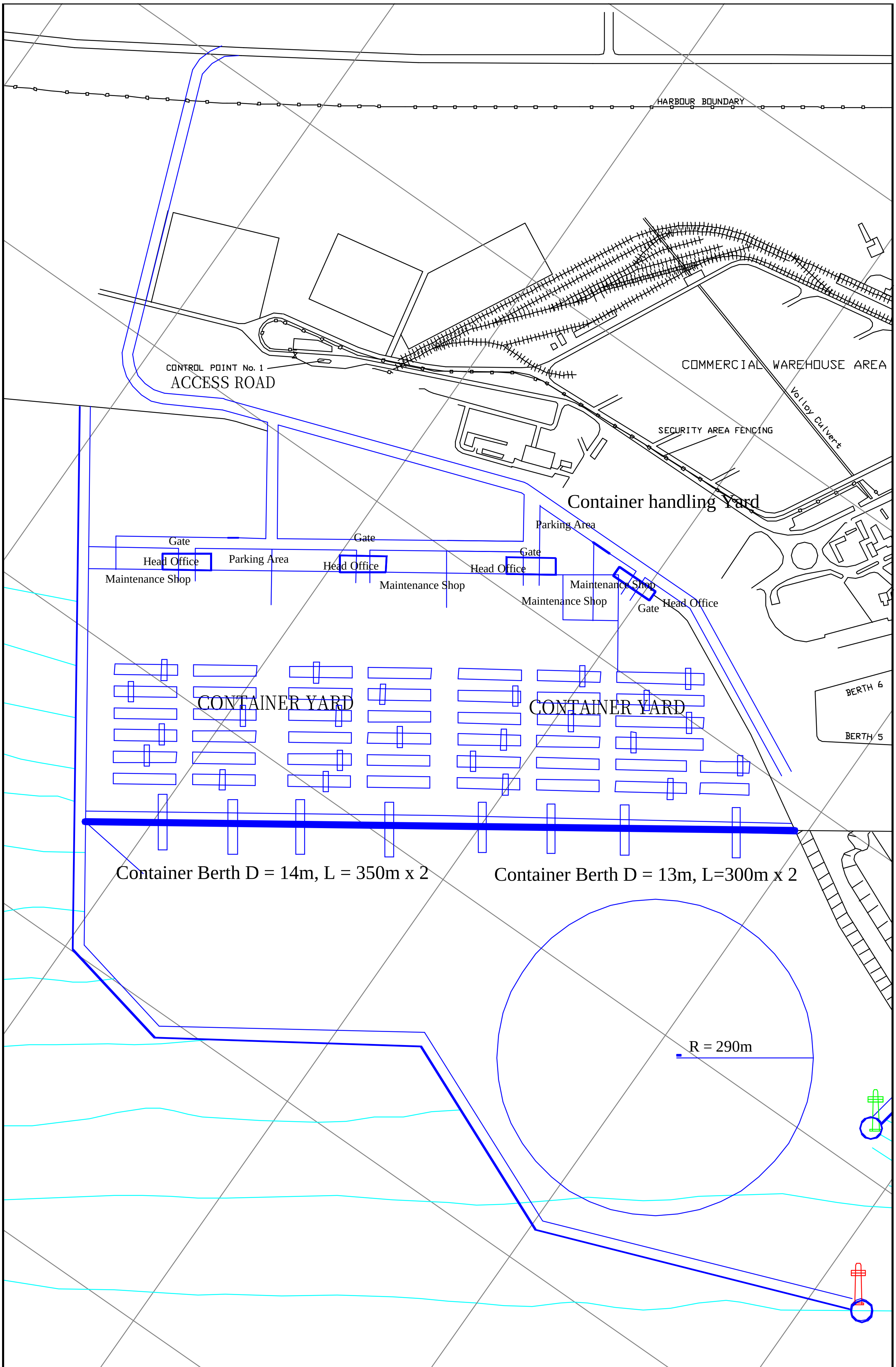


Fig. 14.4.2 MASTER PLAN of Tema Port (Main Facilities)

14.5 Proposal for Efficient Port Operation

14.5.1 General Principles of Port Management and Operation

Refer to Chapter 13.5.1.

14.5.2 Proposal for Efficient Cargo Handling System

(1) Container Cargo

(a) Selection of Container Handling Equipment

Generally speaking there are three types of container handling equipment as listed below;

Type : Rubber Tire Mounted Gantry Crane (Transfer Crane)
: Straddle Carrier
: Top Lifter / Reach Stacker

Items to be taken into account;

1. Scale size of container marshalling yard.
2. Initial container volume, forecasted future increase, as well as the possibility of marshalling yard expansion in future.
3. Initial investment for purchasing equipment.
4. Service life of equipment (depreciation period).
5. Running cost (maintenance cost) of equipment.
6. Working (quick response) as well as safety of the container operation.
7. Degree of mechanical development of equipment.
8. Condition of the marshalling yard foundation.

The advantages and disadvantages of each type of equipment are described below.

(i) Rubber Tire Mounted Gantry Crane = RTG (Transfer Crane)

Advantages;

- Although dependent on the size of the marshalling yard, this type has the maximum container storage capacity per each unit area among the three types.
- As the place for running (track) is fixed in the marshalling yard, total pavement costs will be reduced since pavement is required only for running lane.
- As the running lane inside marshalling yard is fixed, safety can be expected in connection with other vehicles and passage of personnel.
- Running cost (maintenance and repair cost) of this type is approximately half of straddle carrier.
- As the engine is connected directly with generator, engine can rotate at a constant speed thus it offers economy and a longer life.
- Heavy or long cargo other than containers may be handled by using wire sling.
- Systematic operation by computer is conducted from management office or gate booth, and each piece of equipment can be operated easily by means of

computerization in future.

Disadvantages;
- Compared with other container handling equipment, this type moves a little bit slower in the marshalling yard due to its large size.
- Main function of this type is to load and unload containers on to trailers, and tractor should be used in transverse of containers, thus larger initial investment is required compared to other systems.
- Work other than inside marshalling yards and running lane cannot be carried out.
- Container will be laid on block of six lines pile in marshalling yard, which makes it difficult to check the condition in the yard

Figure 14.5.1 Transfer Crane

(ii) Straddle Carrier

Advantage;
- This type of equipment can swiftly load and unload containers on trailer / tractor and shift them transversely without any aid from other equipment.
- Unlike the rubber tire mounted gantry crane, this type can handle containers in every corner of the marshalling yard.
- Work can be carried out without using tractor and trailer, thereby reducing the initial investment.
- As there area few containers in the marshalling yard, inventory control is easier compared with the rubber tire mounted gantry crane.
- Its unit price is approximately 30% lower than that of rubber tire mounted gantry crane.
- As containers are placed in one line inside the marshalling yard, it is easy to check containers in the marshalling yard.

Disadvantage;
- It is necessary to pave the entire marshalling yard due to this type's operating scope.
- On account of its structure, this type cannot handle heavier or longer cargo than container.
- This type has many dead angles due to its transverse operation cabin, making it dangerous for other vehicles and personnel in the marshalling yard.

- Due to its many parts, the annual maintenance and repair cost of a straddle carrier will eventually become higher than the rubber tire mounted gantry crane.
- Its lay out in the marshalling yard is made of one line, which is weak against natural phenomenon such as strong wind, and if one container is got out of shape, it will collapse like domino, and cause serious damage to containers.
- It is observed that housing number of containers of this type is smaller than that of rubber tire mounted gantry crane in the marshalling yard.
- It is difficult to have a systematic operation by means of computerization in future.

Figure 14.5.2 Straddle Carrier

(iii) Top Lifter / Reach Stacker

Advantages;

- Top Lift / Reach Stacker is a sort of variation of fork-lift truck and it is a completed machinery in view of mechanical structure. It rarely breaks down and its service life is long.
- Compared with other types, small initial investment is required.
- This type can handle heavy or lengthy cargoes besides containers, by providing eye plate with spreader and by using wire sling.
- This type has a better safety record, because its running speed is slower and it has less dead angle than that of straddle carrier.
- This type has less driving and movable part than those of other types, and its running cost (maintenance and repair cost) is quite small.
- Net body weight of the top lifter is l5% more than that of straddle carrier, but because it has a larger plane area of vehicle, and larger ground touching area of tires, and furthermore slower speed, pavement cost is least among the three types.

Disadvantages;

- Scope of operation (passage) of top lifter is larger than that of other types, so the storage number of containers is small against unit area.
- Lifting capacity of Top lift /Reach Stacker becomes lower (this is because of its mechanical structure) than other types, the more containers are placed on

top of other containers than others.
- Main function of Top lift / Reach Stacker is to load and unload containers on trailers / tractors, and so transverse movement can only done by means of trailer / tractor, as in the case of rubber tire mounted gantry crane.
- As the container handling in the marshalling yard occurs often, it is quite difficult to execute real time inventory control.

Figure 14.5.3 Top Lifter

Table 14.5.4 Comparison of Container Handling Equipment System

Item	RTG	Straddle Carrier	Top Lift / stacker	On Trailer
Required marshalling yard area	Small	Medium	Rather Large	Huge
Investment costs	Medium	Medium	Low	High
Balance to the capacity of gantry crane	Good	Excellent	Good	Good
Efficiency of operation	Medium	Medium	Low	High
Flexibility of operation	Low	High	Medium	High
Damage ratio of container	Low	Medium	Medium	Very Low
Maintenance/Repair cost and down time	Medium	High	High	Low
Introduction of computerized operation	Easy	Medium	Medium	Easy
Construction cost and Pavement cost	Medium	Heavy	Heavy	Low
Working safety	Excellent	Medium	Low	Excellent

(b) Container Handling System at New Container Terminals

Table 14.5.5 Estimated Storage Area for Container Cargo

Port of Tema		2000	2010	2020	unit
Volume of Container Cargo		166,149	485,313	1,049,940	TEU
Volume of Container Cargo		128,798	376,212	813,907	Box
Productivity		16	24	30	box/hour/vessel
Working day		365	365	365	day
Cargo throughput in a day		455	1,330	2,877	TEU/day
Average Dwelling Time(Target)		12	6	4	day
Peak Ratio		1.3	1.3	1.3	
		2000	2010	2020	
Required Capacity Volume for Container storage		7,098	10,374	14,960	TEU
Required Area for Container Storage	2 tiers	88,725	129,675	187,005	m2
	3 tiers	59,150	86,450	124,670	m2
	4 tiers	**44,363**	**64,838**	**93,503**	**m2**

Size of 20ft Container	
Length(l)	6.058 m
Widgh(w)	2.438 m
Height(h)	2.438 m
Bottom Area(=l x w)	15 m2
Area for 1slot	
(+ 50cm space on each side)	
lengh + 50cm x 2(ls)	7.058 m
widgh + 50cm x 2(ws)	3.438 m
Bottom Area(=ls x ws)	25 m2

・The construction of new container terminals at the western side of Tema is proposed in the Master plan (depth -14m x 300m x 2berths and depth -14m x 350m x 2berths). The transfer crane method is suitable for both terminals because it results in the most effective storage capacity in the same area.

・Eighty percent of container cargo will be handled at the new container terminal, and the rest (20%) will be handled at the existent berths of Quay1 and Quay2.

Table 14.5.6 Estimated Storage Area for Container Cargo at New Container Terminals

		0%	55%	80%	
Port of Tema (New Cont.T)		2000	2010	2020	unit
Volume of Container Cargo		0	266,922	839,952	TEU
Volume of Container Cargo		0	210,175	661,380	Box
Productivity		16	24	30	box/hour/vessel
Working day		365	365	365	day
Cargo throughput in a day		0	731	2,301	TEU/day
Average Dwelling Time(Target)		12	6	4	day
Peak Ratio		1.3	1.3	1.3	
		2000	2010	2020	
Required Capacity Volume for Container storage		0	5,702	11,965	TEU
Required Area for Container Storage	2 tiers	0	71,273	149,565	m2
	3 tiers	0	47,515	99,710	m2
	4 tiers	**0**	**35,637**	**74,783**	**m2**

Size of 20ft Container	
Length(l)	6.058 m
Widgh(w)	2.438 m
Height(h)	2.438 m
Bottom Area(=l x w)	15 m2
Area for 1slot	
(+ 50cm space on each side)	
lengh + 50cm x 2(ls)	7.058 m
widgh + 50cm x 2(ws)	3.438 m
Bottom Area(=ls x ws)	25 m2

・At Tema port, the forecasted volume of container cargo in 2020 is 1,049,940TEUs(refer to Table 14.5.5). Assuming that 80% of the forecasted volume of container cargo will be handled at the 4 new berths, and the rest will be handled at the Quay2 container berth and Quay1 berths, container handling volume at the new container berths is estimated as below:

Daily container handling volume at new container berths
= 1,049,940 x 80% / 365 = 2,301 TEUs/day
Average dwelling day = 4 days (as Target value in 2020)
Container storage capacity at new container terminals = 2,301 x 4 x 1.3 = 11,965 TEUs
Minimum area for container storage = (11,965 / 4) x 25m^2 = 74,783 m^2
(4 tiers high, 1TEU=25m^2)

The layout of the new container berth is shown in Figure 14.5.7 and Figure 14.5.8. The storage area under these layouts is 15,460 TEUs and is sufficient for the estimated container throughput.

- 8 gantry cranes should be installed in the new container berths (2 gantry cranes in 1 berth x 4 berths).
- The required number of transfer crane (RTG) for gantry cranes (Ntc) is estimated as below.

Ntc = Nqsc x 2 + A/(T x Ptc x E) +Ntc-backup
= 16 + 3.75 + 4 = 23.75 → 24 units

Nqsc = Number of Quay Side Gantry Cranes	8 units
A = Annual Throughput in TEUs	839,952 TEUs
T = Annual Maximum available working hours	8,760 hours/year
Ptc = Net Productivity of Transfer Cranes	20 boxes/hour/Tcrane
E = Conversion rate (TEU/box)	1.28 TEUs/Box
Ntc-backup = Number of Transfer Crane for backup	4 units

- Between quay side and marshaling yard, container cargo should be carried by yard tractor-trailers. The required number of yard tractor-trailers for each gantry crane Nytt is estimated as below.

Nytt = (Ttr＋Lytt /(Vytt/60)) / Tqsc＋Nbackup
= 2.33 + 1 = 3.33 → 4 units

Ttr = Handling time under transfer crane	3 minutes/cycle
Lytt = Average travelling length of yard tractors(1km)	1 km/cycle
Vytt = Average travel speed of yard tractor-trailers	15 km/h
Tqsc = Handling time under quay-side crane	3 minutes/cycle
Nbackup = Number of Yard Tractor-Trailer for backup	1 unit

Therefore, the required number of yard tractor-trailers is estimated as 32 units for 8 gantry cranes.

In total for new container terminals:	Quay side gantry crane:	8 units
	Transfer crane:	24 units
	Yard tractor trailer:	32 units
	Storage capacity:	15,460 TEUs
	(layouts	Figure 14.5.7 and 14.5.8)

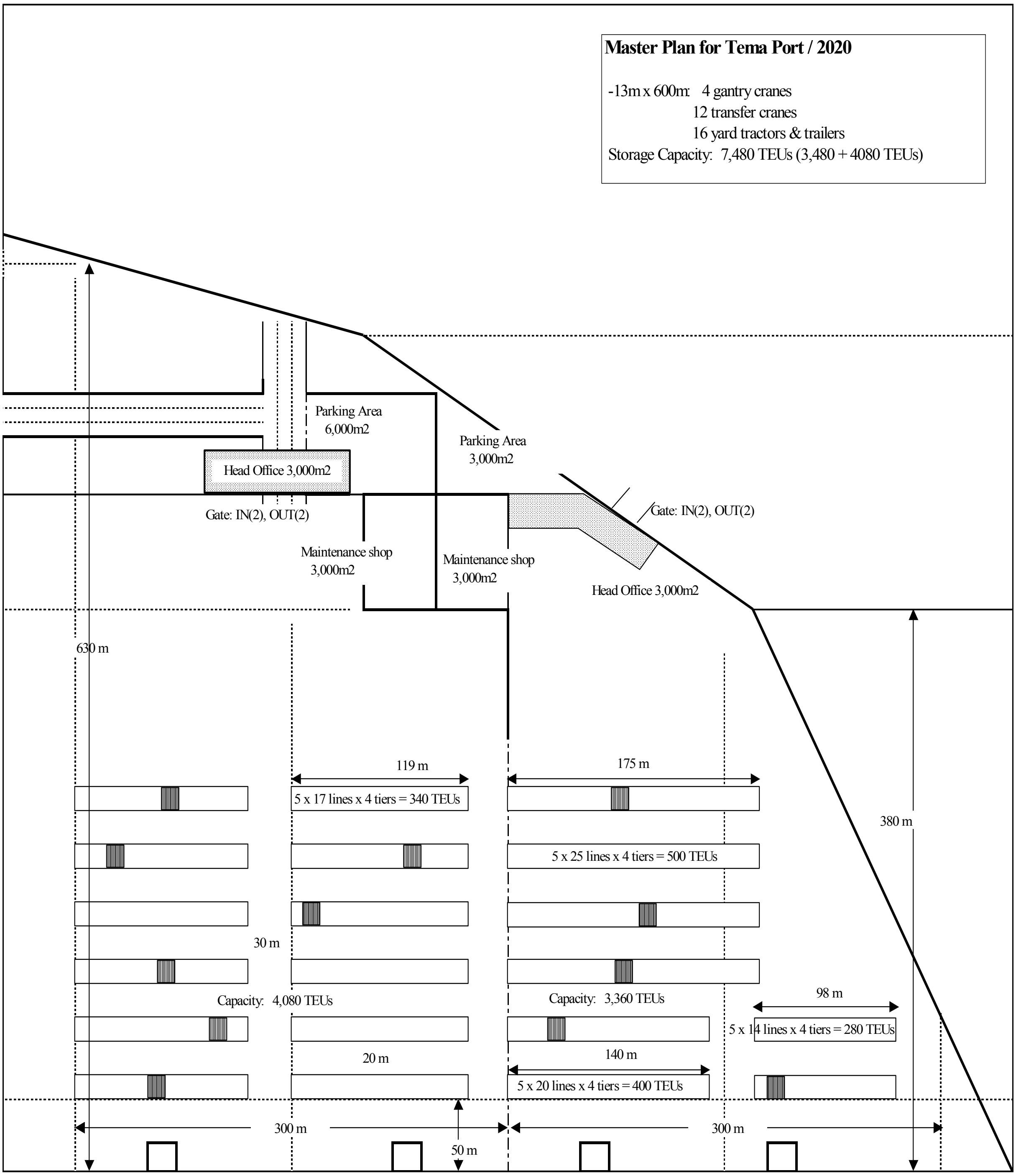


Figure 14.5.7 Layout of New Container Berths -1 (Depth -13m, 300m x 2 berths)

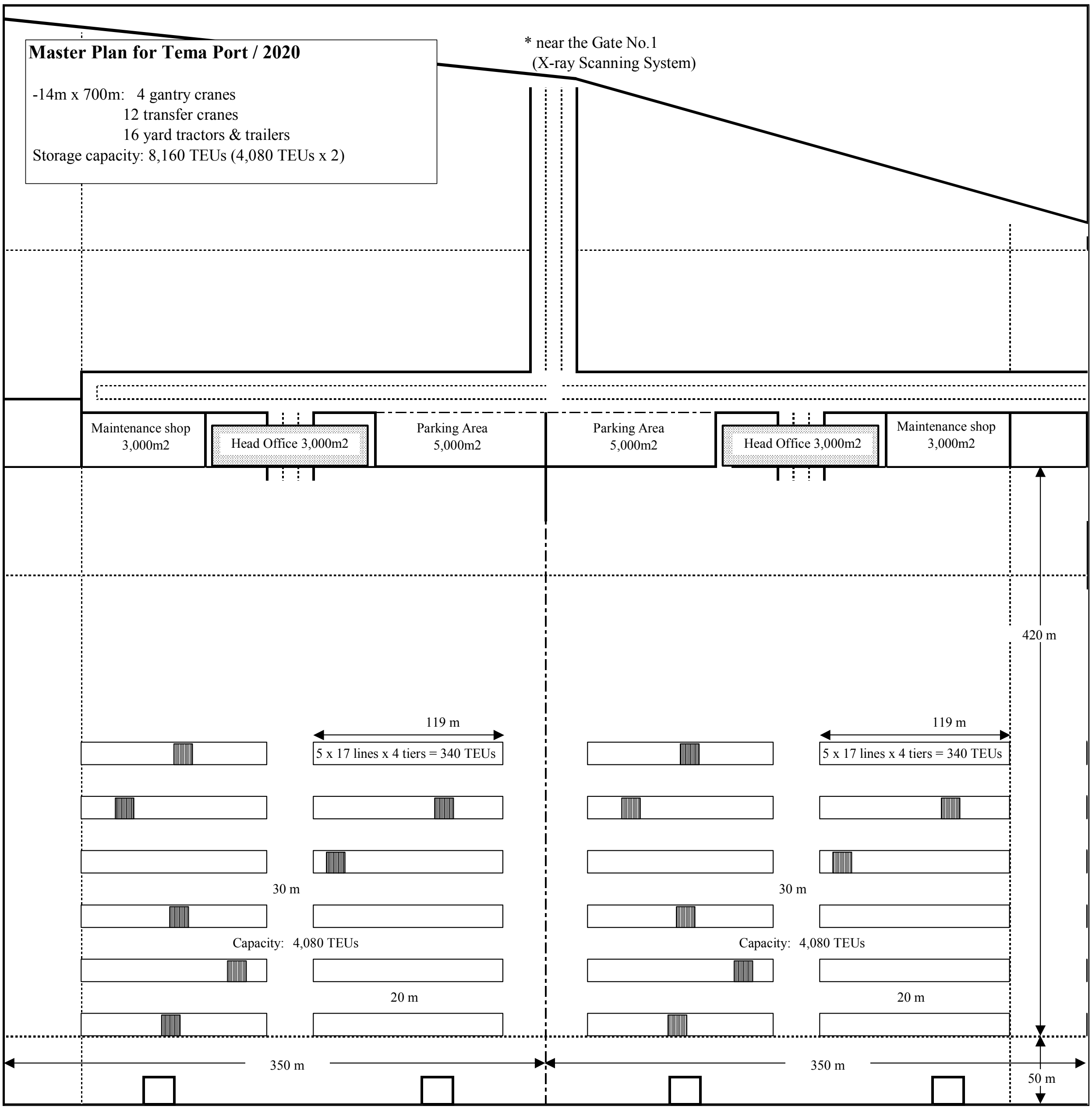


Figure 14.5.8 Layout of New Container Berths -2 (Depth -14m, 350m x 2 berths)

(c) The Container Yard at the Existing Port Area (Quay1 and Quay2)

Container handling volume inside the existing port (Quay1 and Quay2) is calculated in Table 14.5.9.

Table 14.5.9 Estimated Storage Area for Container cargo at Quay1 and Quay2

		100%	45%	20%	
Port of Tema (Quay1 &2)		2000	2010	2020	unit
Volume of Container Cargo		166,149	218,391	209,988	TEU
Volume of Container Cargo		130,826	171,961	165,345	Box
Productivity		16	24	30	box/hour/vessel
Working day		365	365	365	day
Cargo throughput in a day		455	598	575	TEU/day
Average Dwelling Time(Target)		12	6	4	day
Peak Ratio		1.3	1.3	1.3	
		2000	2010	2020	
Required Capacity Volume for Container storage		7,098	4,664	2,990	TEU
Required Area for Container Storage	2 tiers	88,725	58,305	37,375	m2
	3 tiers	59,150	38,870	24,917	m2
	4 tiers	44,363	29,153	18,688	m2

Size of 20ft Container	
Length(l)	6.058 m
Widgh(w)	2.438 m
Height(h)	2.438 m
Bottom Area(=l x w)	15 m2
Area for 1slot	
(+ 50cm space on each side)	
lengh + 50cm x 2(ls)	7.058 m
widgh + 50cm x 2(ws)	3.438 m
Bottom Area(=ls x ws)	25 m2

・Twenty percent of container cargo (209,988 TEUs) will be handled at the Quay1 and Quay2 which will be re-constructed as container berths. Container handling volume at the Quay2 is estimated as below.

Daily container handling volume at Quay1and Quay2
= 1,049,940 x 20% / 365 = 575 TEUs/day
Average dwelling day = 4 days (as Target value in 2020)
Container Storage capacity at Quay1 and Quay2 = 575 x 4 x 1.3 = 2,990 TEUs
Minimum area for container storage = (2,990 / 3) x 25m^2 = 24,917 m^2
(3 tiers high, 1TEU=25m^2)

The required minimum area for container storage at the existing port area is calculated as about 25,000m^2. At present, there are some container yards behind berths 10-11 (about 37,000m^2). In addition, GPHA plans to establish a new container yard at the Quay2 (945 slots, 23,625 m^2) in the area where at the cocoa shed is currently located (about 52,000m^2). These container yards behind berth 10-11 and the new container yard are sufficient for future container storage (3-tiers stacking) at the existing port area. However, computer management for container storage will be required as same as new container terminals.

(d) Additional Measures to Increase Efficiency of Port Operation

Additional measures such as the introduction of a computer system and new customs inspection for container handling are required at Tema and Takoradi. These systems are described below:

(i) Introduction of Computer Systems

New computer system for container operation will be installed in the new container terminal and new multipurpose berth. For efficient operation with gantry cranes and transfer cranes, rapid control of their operation is required and this work is difficult to do without computers. Operation control system by computers will be also connected to port EDI system or some system of shipping companies for rapid information exchange for operation control. Yard planning system will be also introduced for efficient control of container inventory and container delivery/receiving. The optimum location plan of containers in the container yard should be decided in consideration of the vessels' calling schedules and the shippers' delivery/receiving schedules.

Following operation works will be done by computer system;

- Vessel Operation（Loading/Discharging Operation Control）
- Gantry Crane Allocation
- Transfer Crane Allocation
- Yard Planning
- Container Inventory Control
- Container Delivery/Receiving Control（Gate Operation）

(ii) Customs Inspection for Container Cargo

Present Customs Inspection is based on the "Destination Inspection Scheme" and all of import containers are opened for inspection. For efficient container handling without long retention in container yards, it is proposed that number of containers subject to mandatory inspection is desirable to be at least less than 10% of all import containers.

（2）Bulk Cargo（Alumina, Clinker）

Alumina is handled at Valco berth. Dredging the basin and deepening Valco berth is proposed in the master plan to increase cargo handling efficiency. A lighting system also needs to be introduced to make night navigation possible.

Volume of clinker being handled at Tema port is increasing. However, bulk vessels for clinker cannot be accommodated at berth 12 with their full draft because of insufficient depth. The deepening of berth 12 will eliminate the need for these vessels to shift berths and also increase handling productivity. For highly bulk cargo handling efficiency, these bulk cargo such as clinker, gypsum are supposed to be handled mainly at the berths 10-12.

From the forecasted volume of bulk cargo in 2020, the required bulk cargo storage area at berth 12 is estimated as shown in Table 14.5.10.

Table 14.5.10 Estimated Storage Area for Bulk Cargoes

Bulk cargo volume		2000	2010	2020	unit
Alumina		301,755	384,950	800,645	ton
Clinker, Gypsum		1,113,669	1,402,016	2,044,504	ton
Productivity	Alumina	210	210	210	ton/hour/vessel
	Clinker	299	350	500	ton/hour/vessel
Working Day		365	365	365	day
Cargo throughput	Alumina	827	1,055	2,194	ton/day
in a day	Clinker	3,051	3,841	5,601	ton/day
Average Dwell Time	Alumina	14	14	14	day
	Clinker	14	14	14	day
Estimated Minimum Capacity	Alumina	11,574	14,765	30,710	ton
for Storage	Clinker	42,716	53,776	78,419	ton
Required Storage Capacity	Alumina	12,000	15,000	32,000	ton
for Storage(Shed)	Clinker	43,000	55,000	80,000	ton

(3) Liquid Bulk(Crude Oil, Petrol Product)

Liquid bulk cargo such as crude oil, petrol product is handled at the oil berth. Crude oil will be handled at a single buoy under construction. In the master plan, deepening of oil berth to cope with the growing size of vessels is proposed. Introduction of a lighting system is also required at the oil berth to allow night navigation. Cargoes will be handled more efficiently once these projects are carried out.

(4) Bagged Cargo

Wheat and Rice are imported as bagged cargo in Tema port. These cargoes are handled by sling nets or pallets by ship gears. In the case of unloading, palletized cargoes are lifted to the apron by ship gears and then onto the trucks by forklift, or lifted directly to the truck by ship gear. These cargoes are de-palletized by hand on the trucks, which greatly reduces efficiency. These cargoes should be carried with pallet or net and be de-palletized at a shed or another appropriate place. And the same number of extra sling nets or pallets should be prepared for the next loading/unloading at vessels. This system will make the performance of bagged cargo handling better.

At present, bagged cargo is handled at most berths of Tema Port. To increase handling efficiency, bagged cargo handling should be concentrated at berths 6-9. (Container cargo handling will be concentrated at berths 1-4 and new container terminals, and bulk cargo handling will be concentrated at berths 10-12, Valco berth and oil berth)

To further improve efficiency, the introduction of a three-shift (24 hours) working system is desirable. (At present, handling is only conducted from 7:30 to 18:00.)

From the forecasted volume of bagged cargo in 2020, the required bagged cargo storage area at Tema is estimated as shown in Table 14.5.11.

Table 14.5.11 Estimated Storage Area for Bagged Cargo

Bagged cargo volume	2000	2010	2020	unit
Import	537,752	597,518	618,367	ton
Export	104,370	26,891	26,161	ton
Total	642,122	624,409	644,528	ton
Productivity	60	100	100	ton/hour/vessel
Working Day	365	365	365	day
Cargo throughput in a day	1,473	1,637	1,694	ton/day
Average Dwell Time	7	7	7	day
Estimated Minimum Capacity for Storage	10,313	11,459	11,859	ton
Estimated Minimum Area for Storage(Shed)	4,125	4,584	4,744	m2

(5) Ro/Ro Cargo, General Cargo

Ro/Ro cargo and general cargo are handled at berths 1-11. Berths 1-11 will be more available because the handling efficiency of the other cargo such as container or bulk will be better. The congestion will be expected to decrease and Ro/Ro and general cargo can be handled more efficiently. Ro/Ro vessels usually carry a lot of container cargoes. Container with Ro/Ro should be handled in berths 1-4 in Quay2 with other containers in the same place.

Wheat is also imported as a grain bulk cargo, and is discharged using ship gear, grab bucket and hopper to trucks. These grain bulk wheat is desired to handle at mainly berths 6-9.

(6) Introduction of a Three-Shift Working System and Training System.

Two-shift working schedule for dock workers is now adapted, that is from 7:30 to 19:30 for the 1st shift and from 19:30 to 7:30 for the 2nd shift (with overtime period 17:00 to 19:30 for 1st shift, 3:30 to 7:30 for 2nd shift). It is difficult to realize continuous works under this system. The introduction of a third-shift (for 8 hours) is required to achieve more effective cargo handling by workers. Continuous 24 hours cargo handling needs to be maintained.

To effectively utilize new equipment such as cargo handling machines (gantry crane, transfer crane, etc.) and the computer system for container handling, periodic training for workers is desirable. This will help to prevent accidents as well as enhance the skill level of workers.

(7) Introduction of the Port EDI System

The port EDI system is described in Chapter 15.1.4.

14.6 Preliminary Design

14.6.1 Design Criteria and Condition

(1) Most of the design criteria and conditions taken in the design for the Master Plan of Takoradi Port will be applicable. It is therefore intended that only differed conditions from those used in the Takoradi Port Master Plan is presented.

(2) Tidal Condition

The following tidal conditions are applied in the design;

- Design High Water Level (H.W.L) : C.D + 1.60 m (MHWS)
- Design Low Water Level (L.W.L) : C.D + 0.00 m

(3) Subsoil Conditions

The following subsoil conditions are applied based on the available subsoil data;

Table 14.6.1 Subsoil Conditions

Location	Design Parameters of Subsoil
New Container Berths Area (west side of Exist. Port)	Micaseous quartz gneiss Unit Weight : 24.5 KN/m^3 Compressive Strength : max. 60 Mpa
Existing Port Basin (Improvement Area)	Ferric/granitic quartz gneiss Unit Weight : 29.9 KN/m^3 Compressive Strength : 150~250 Mpa

(4) Objective Vessels

Table 14.6.2 Objective Vessels for Tema Port

Vessel Type	DWT	Length Overall (LOA) m	Breadth (B) m	Max. Draft (Df) m
Bulk Carrier	30,000	185	27.5	11.0
Container Ship	50,000	266	32.3	13.0
Ro/Ro Ship	28,000	210	-	11.0
Oil Tanker	30,000	180	29.2	10.9

14.6.2 Structural Design of Main Facilities

(1) Breakwater

The breakwaters proposed in the Master Plan are located at the areas where water depth ranges from –9.0 m to－16.0 m (averaged depth is –13.0~-14.0 m). It is therefore intended to adopt same design which is recommended in the Master Plan for Takoradi Port (Rubble Mound type ,-15.0 m design depth).

The proposed typical section of the breakwater is shown in Figure 14.6.1.

(2) New Container Berth

New container berths with total length at 1,300 m and required water depth of –13.0 to-14.0 m are planned at the west side of the existing port having about same alignment with Quay No.2.

The structural type for these berths proposed in the design is a concrete caisson type as recommended in Section 13.6 (Master Plan for Takoradi Port).

The typical section proposed for the new container berths is shown in Figure 14.6.2.

The design crown elevation of the berths is set at C.D +3.30 m taking into account the recommended clearance and the existing berths crown elevations that are mostly around C.D +3.30 m.

(3) Existing Port Improvement and Valco Berth

1) Existing Berths Deepening at Quay No.1
Same design which is proposed in the design of Takoradi Port Master Plan for the existing wharf improvement is applied since the design conditions are very similar. The typical section of the structure is indicated in Figure 14.6.3.

2) Valco Berth Improvement

The existing Valco berth is constructed with Concrete Block Type Structure. Though no detail of the structure is available, it is expected that a similar type of construction with the existing quaywalls is adopted.

The current berth length is about 175m whilst the required length of the improved berth is 240m, by which at least 65m of new berth will be required as a new construction.

For Valco berth, it is also required to maintain the existing berth line in order not to lessen the existing cargo handling capacity.

In order to minimize the interruption of the berth operation and to maintain the existing berth line, it is proposed to construct a new 175m-long berth extended from the south end of the existing berth and shift the operation to newly constructed berth.

By this arrangement, the remaining 65m will be provided from reinforcing the existing Valco berth to withstand deepened berth front water depth without any difficulty on the operational issues during the construction.

The structural type of the extension of the berth is recommended to be a same type of the existing structure, i.e. concrete block wall type, and the reinforcement of the existing berth can be done adopting the similar method used for the deepened existing quaywalls at Quay No. 2 in the Port.

The typical section of the new construction for the Valco berth is shown in Figure 14.6.4.

3) Oil Berth Modification

The existing oil berth construction is concrete block dolphin structures.

No. 1 and No. 3 dolphins are used as berthing dolphins and Dolphin No. 2 is used as working platform with four (4) numbers of loading arms.

In order to meet the deepened berth conditions, the following two options for the improvement of the existing berth will be possible (ref. Figure 14.6.5 and Figure 14.6.6 respectively);

- Alternative A: Provide new berthing dolphins (inner and outer dolphins each side) to meet the new berthing line.
- Alternative B: Extend to dolphin decks to meet the new berthing line with scouring protection.

Alternative A is based on an idea that the dredging will be made without any adverse effect to the existing dolphins, but requires at least 4.5m distance to the new berthing line. And during the construction of the berthing dolphins, temporary facilities for berthing and working platform will be required to maintain its operation.

The dolphins in this case will be constructed by drilled pile type structure as seabed is expected to be hard rock (over 150 MPA of compressive strength) and located at sloped area. (at sloped area, a jacket type or concrete block work is difficult)

Alternative B is based on a simple strengthening works with a minimum offset of new berth line to meet the deepened water depth providing just scouring protection for its stability which may be weakened by the closed excavation.

For long-term operation and the reliability on its stability, Alternative A is desirable, it is however alternative B is proposed in the development plan due to economical advantages and less interruption of the operation.

(4) Others

A concrete block paving for yards and aprons will be used under same considerations described in Section 13.6.

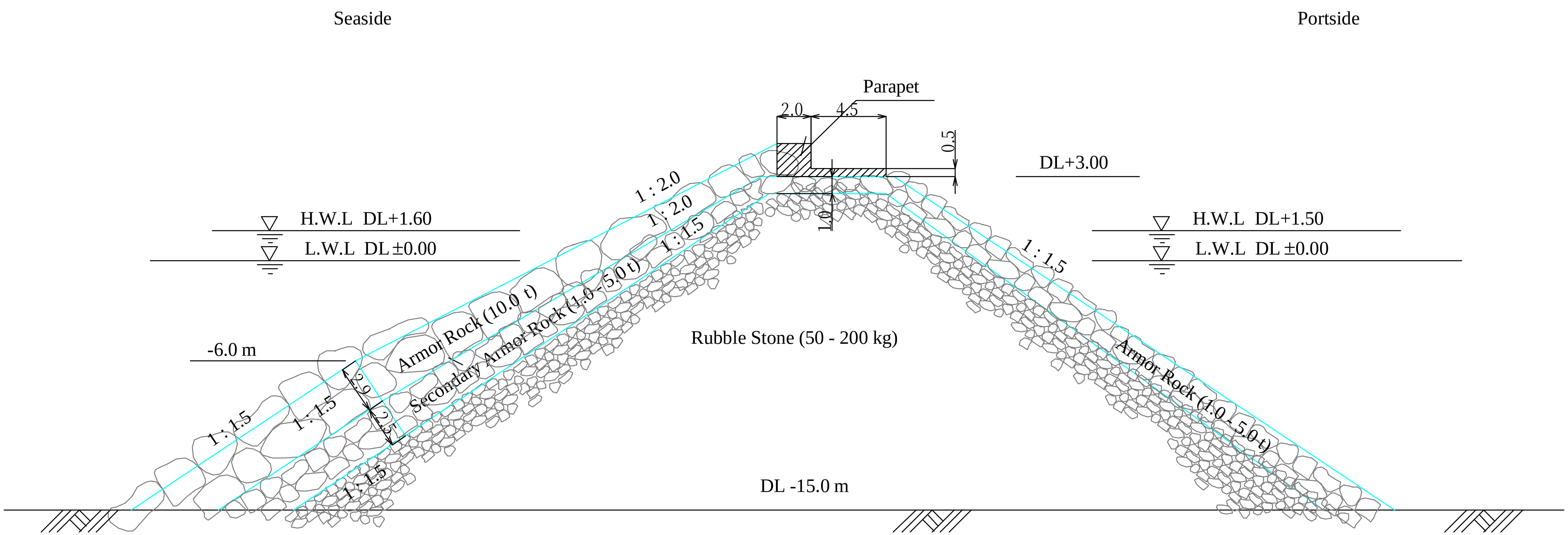


Figure 14.6.1 Typical Section of Breakwater (Rubble Mound Type)

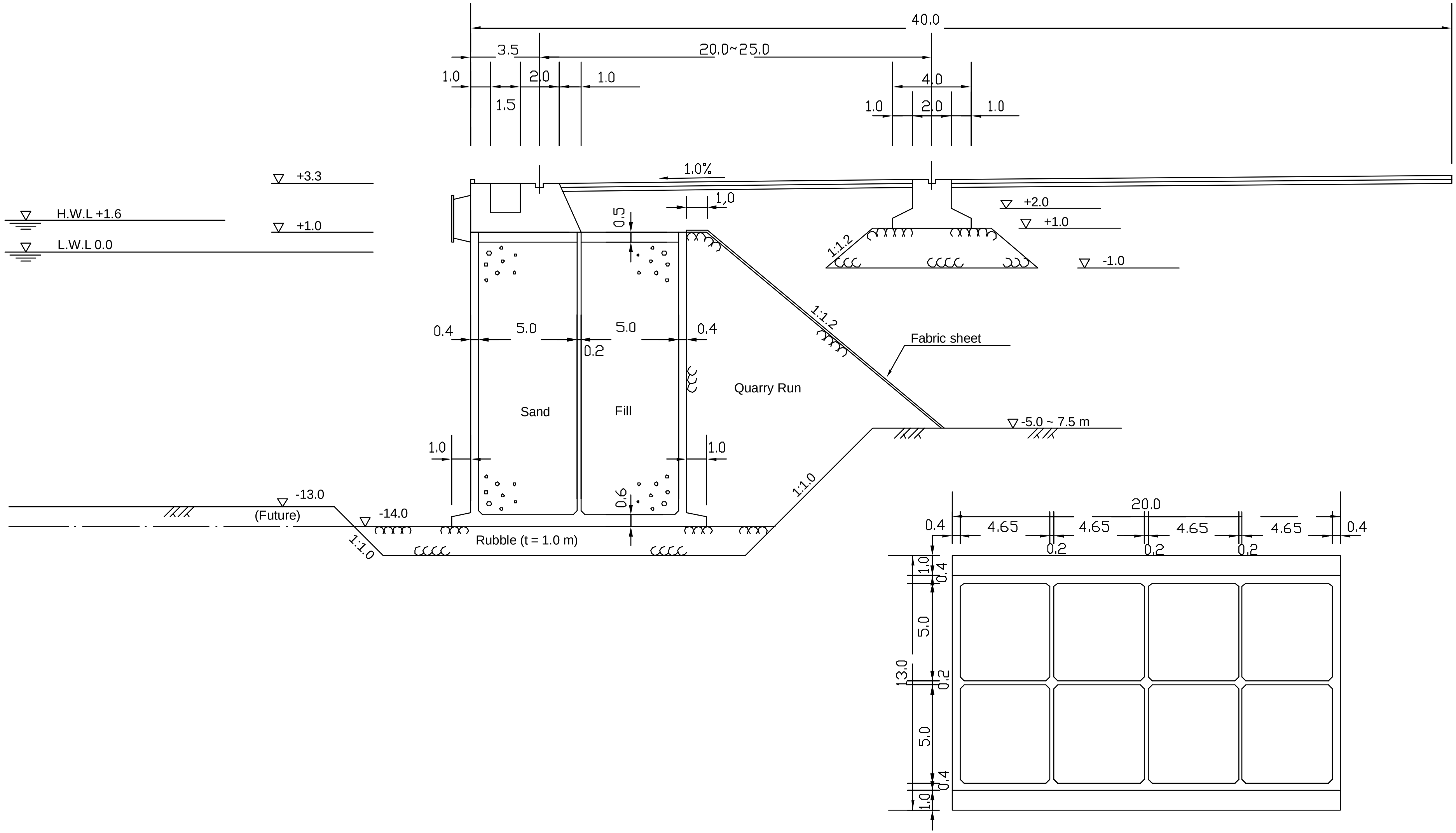


Figure 14.6.2 Typical Section of New Container Berth (-14.0m)

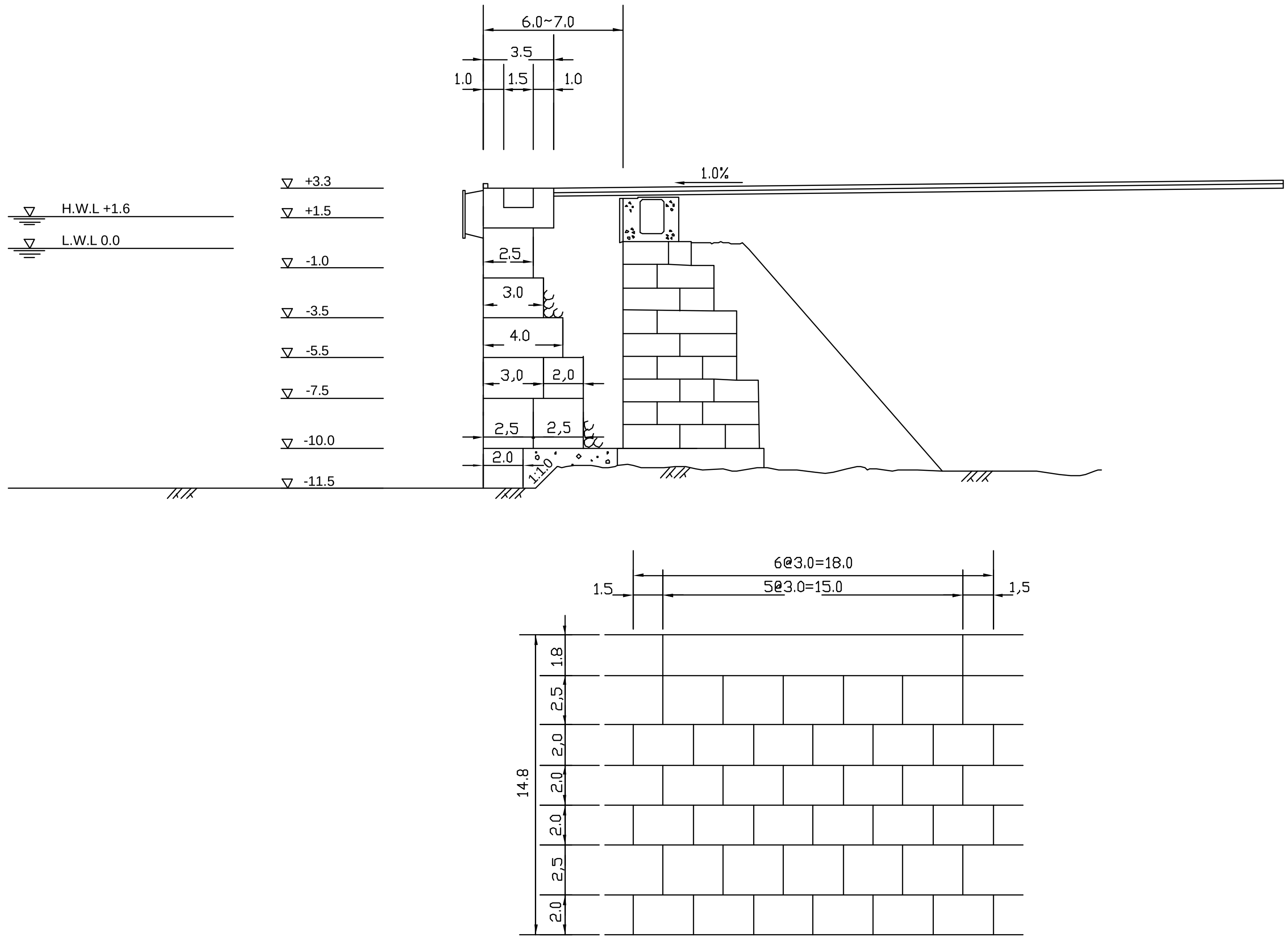


Figure 14.6.3 Typical Section of Exist. Wharf Improvement

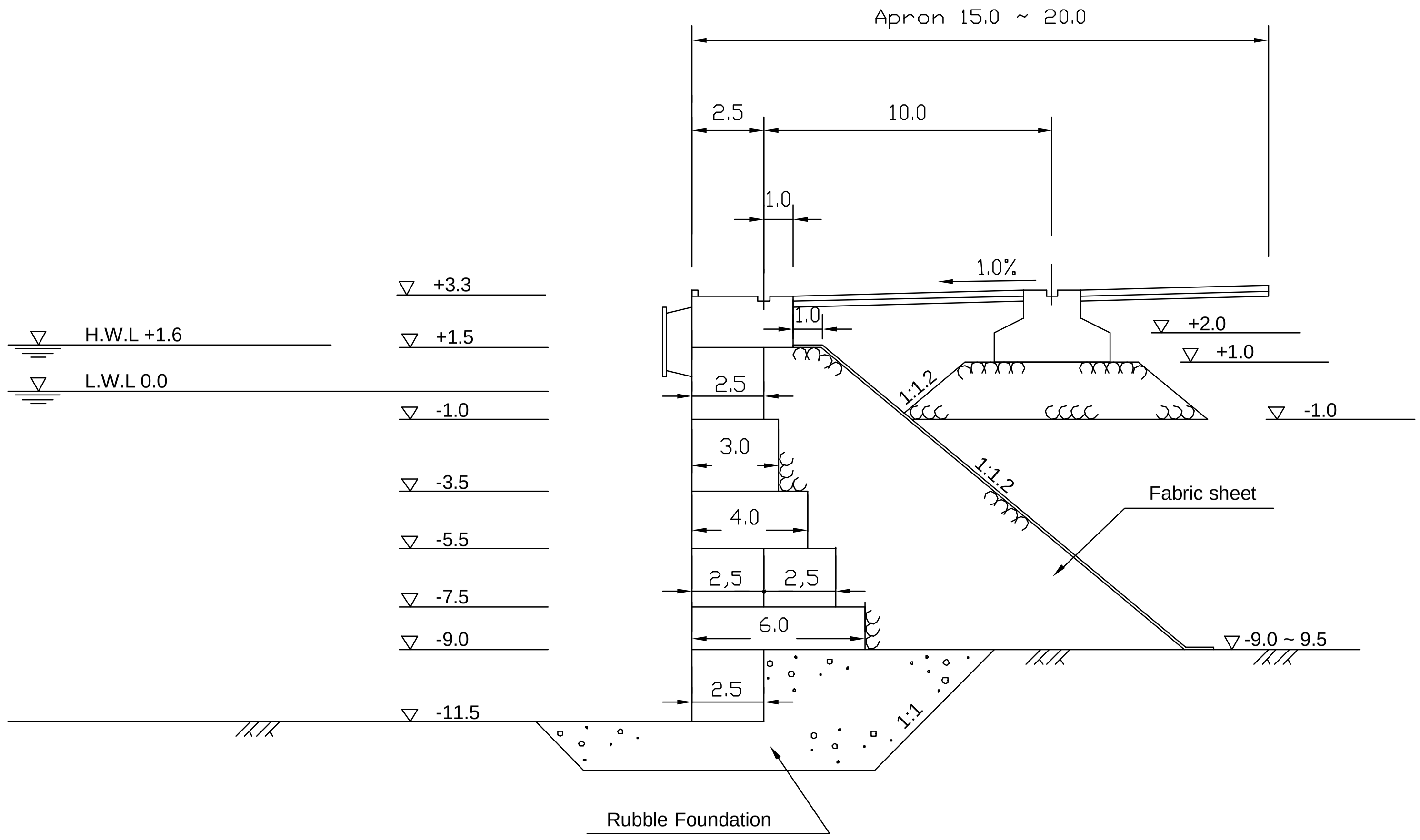
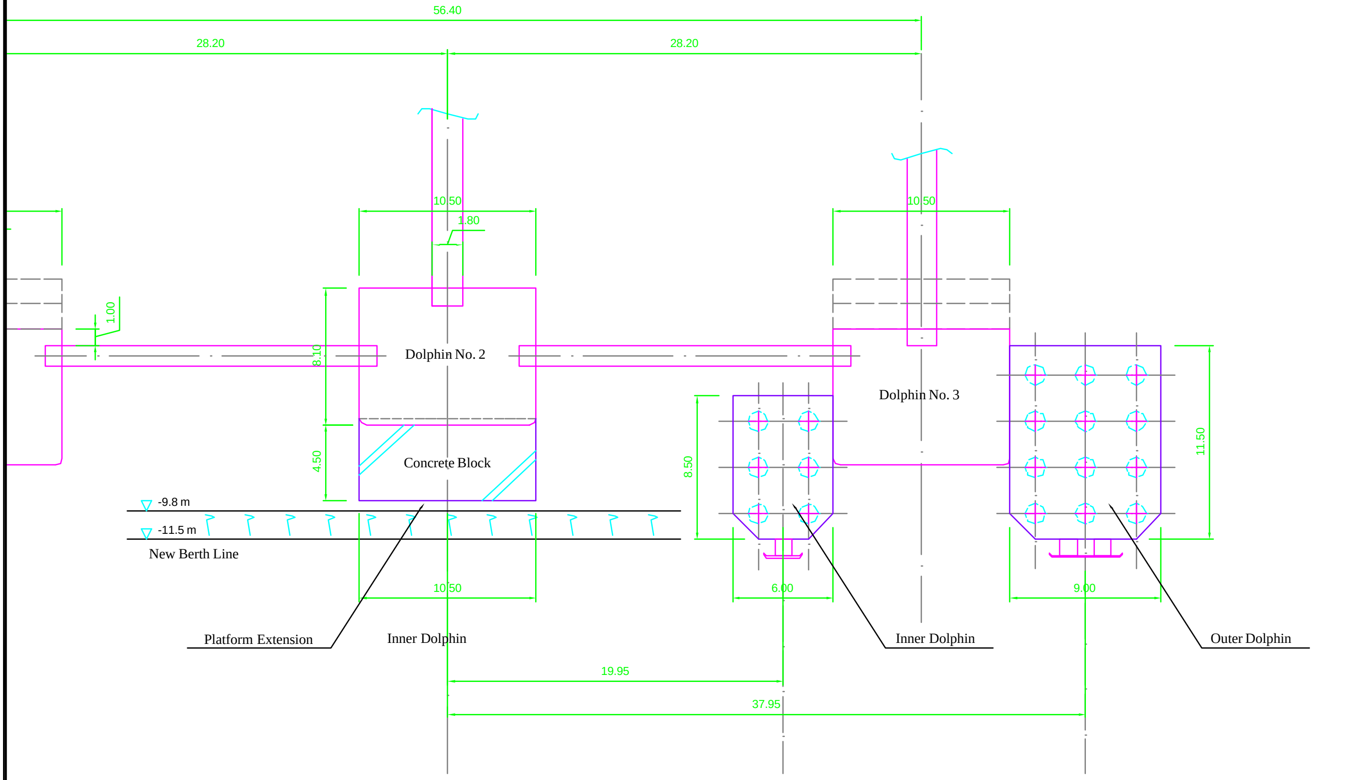
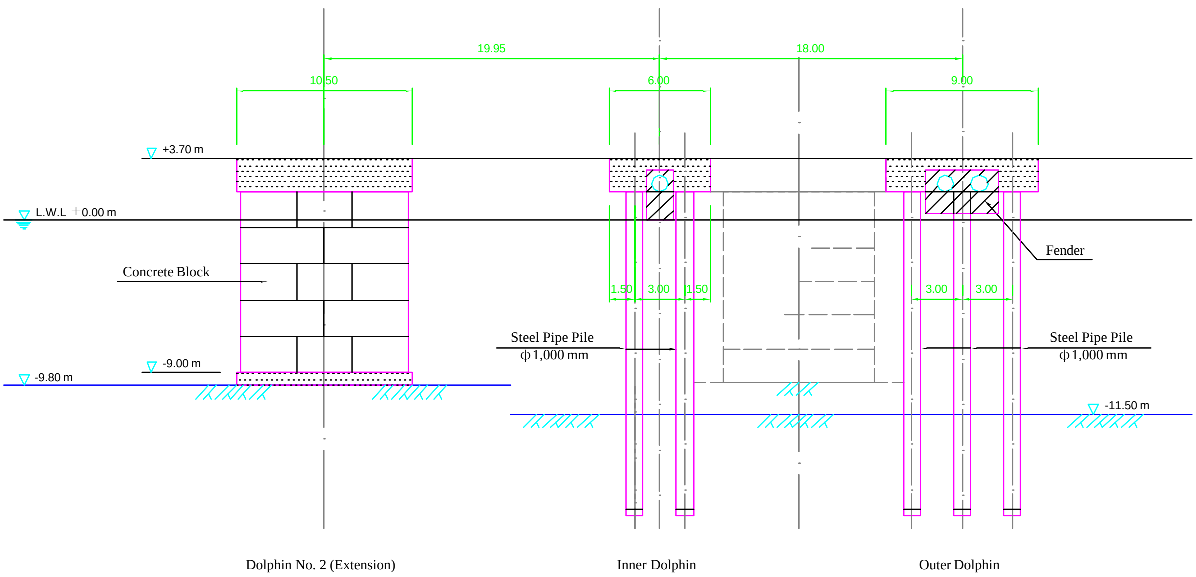


Figure 14.6.4 Typical Section of New VALCO Berth



PLAN



ELEVATION

Fig. 14.6.5 Oil Berth Improvement (Alternative A)

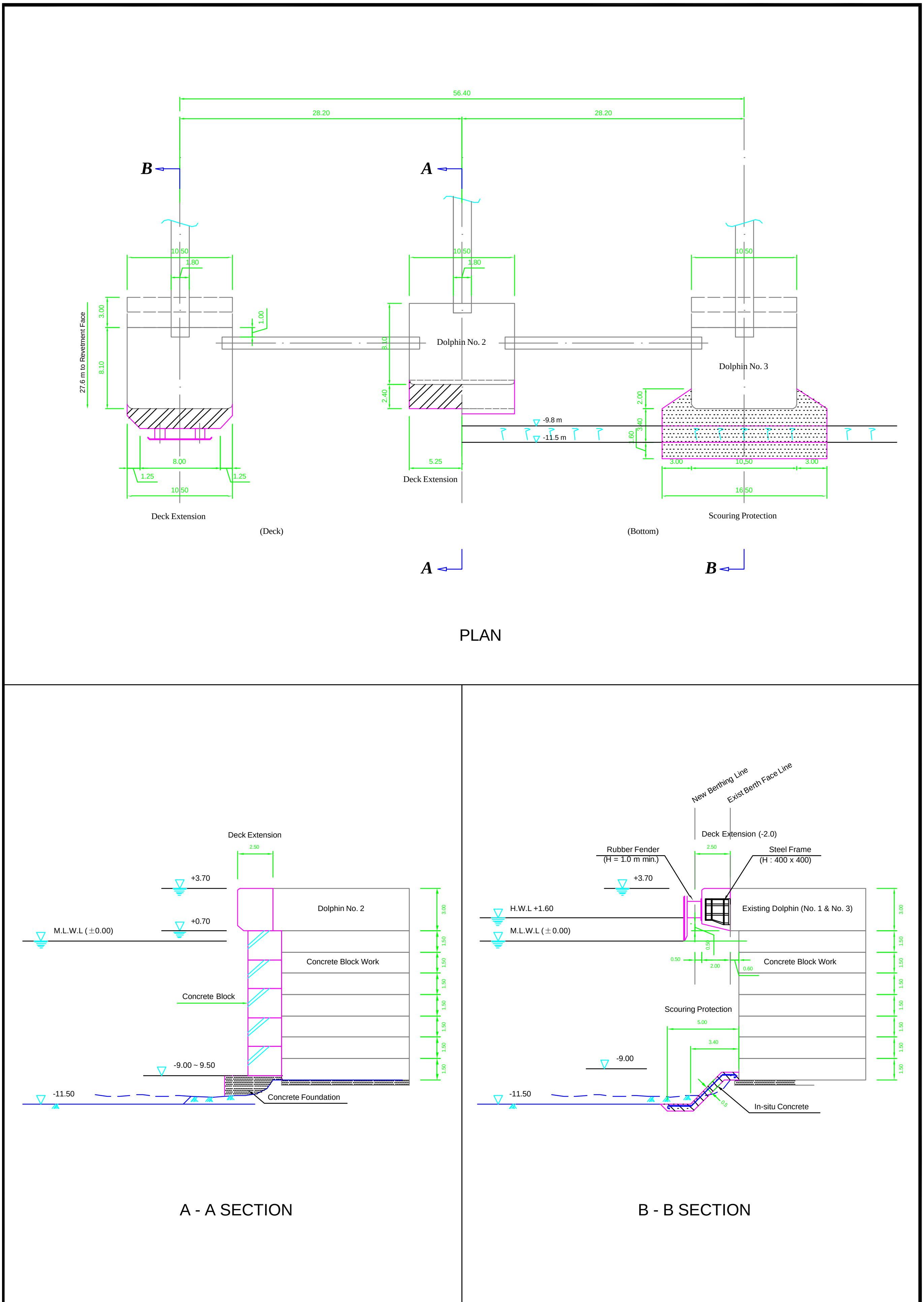


Fig. 14.6.6 Oil Berth Improvement (Alternative B)

14.7 Implementation Plan and Preliminary Cost Estimate

14.7.1 Implementation Plan

(1) Construction Component of Master Plan

The following facilities construction is planned in the Master Plan;

Table 14.7.1 Construction Component of Master Plan

Facilities	Description	Quality
1. Dredging and Reclamation		
1) Dredging	Rock and Soil	1,870,000 m^3
2) Reclamation		4,020,000 m^3
2. Breakwater		
-15.0 m (average)	Rubble Mound	L = 900 m
-10.0 m (average)	Rubble Mound	L = 1,250 m
3. Wharf and Berth		
1) New Container Berth (-13.0 ~ -14.0 m)	Concrete Caisson	L = 1,300 m
4. Revetment		
1) -5.0 m to –10.0 m depth	Rubble Mound	L = 350 m
2) Less –5.0 m depth	Rubble Mound	L = 350 m
5. Exist. Port Improvement		
1) Dredging	Rock/Soil	569,000 m^3
2) Existing Berths Improvement	Concrete block	600 m
3) Valco Berth Modification	Concrete block	240 m
4) Oil Berth Modification	Dolphins	1 set
6. Paving/Miscellaneous Works	Yard, Road, Drainage	1 set
7. Buildings and Utilities	Gate, Maintenance shop, Electrical/Mechanical Works	1 set

Note: Procurement of Equipment is excluded

(2) General Considerations of Construction Methods and Procedures

The following assumptions and considerations are made for the construction of the required facilities proposed in the Master Plan.

(a) Dredging and Reclamation

The dredging volume is in the order of 1.9 million m^3, and the most of the materials to be dredged are rocks represented by Ferric/Micaseous quartz gneiss. The characteristics of the rocks expressed in terms of compression strength are between 60 Mpa and 150 Mpa, which is generally regarded as a hard rock. It is therefore required to use blasting for rock dredging.

The blasted rock will be removed by cutter suction dredger or grab dredger together with general soil overlaid the rocks. The dredged material will also be used for reclamation work as much as possible.

(b) New Berths Construction

Concrete caisson type is recommended. The same construction procedure described in Section 13.7.1 will be applied.

(c) Existing Port Improvement

Same construction method applied to Takoradi Port Exist. Wharf improvement will be employed as the similar design is recommended for the deepening of the existing berths at Quay No. 1.

(3) Construction Duration

Similar to Takoradi Port Master Plan at least 5 years will be necessary for the construction of the facilities required when to be carried out in one (1) construction package as shown in Figure 14.7.1.

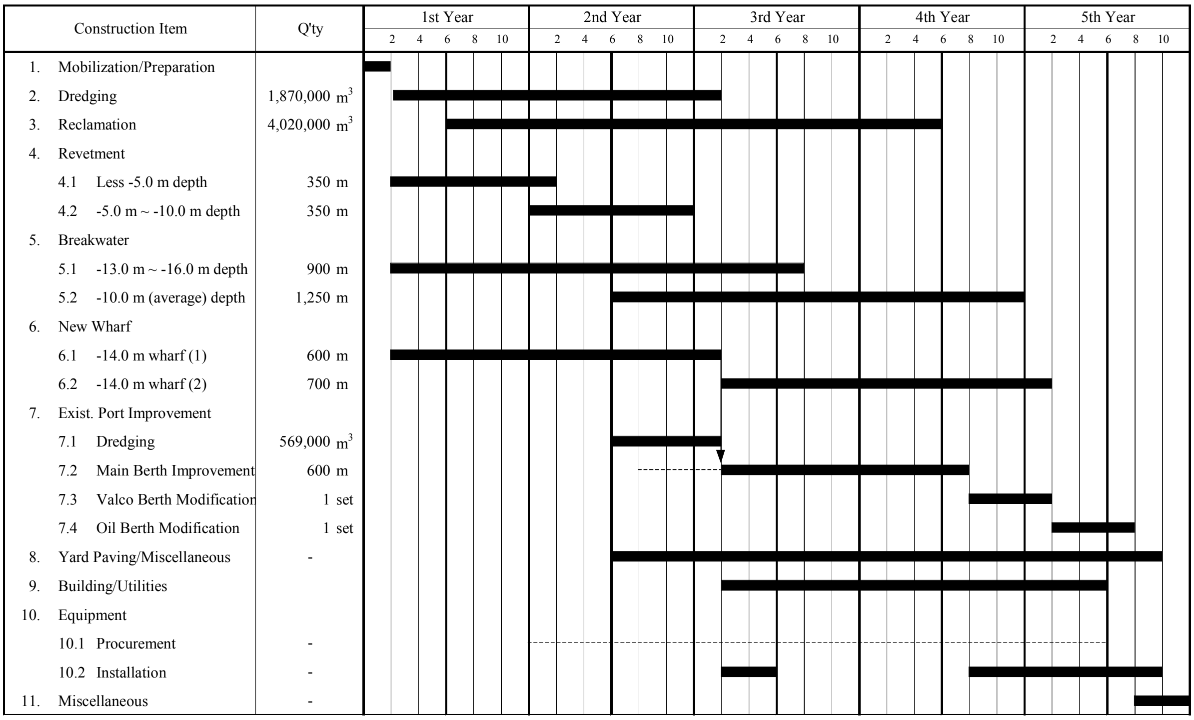


Figure 14.7.1 Implementation Plan for Tema Port Master Plan

14.7.2. Preliminary Cost Estimate

- The same conditions for the cost estimate used for Takoradi Port Master Plan are applied.

- Implementation period is also 5 years.

- The total cost required for the implementation of the Master Plan is estimated as approximately U.S. $ 365 Million.

- The breakdown of the implementation cost is indicated in Table 14.7.2.

Table 14.7.2 Implementation Cost of Master Plan for Tema Port

Item	Description			Construction Cost	Remarks
	Type/Material	Unit	Quantity	(USD)	
1. Civil & Building Works					
1.1 Dredging and Reclamation					
・Dredging work	Rock/Soil	m^3	1,870,000	51,954,000	
・Reclamation work		m^3	4,020,000	22,973,000	
1.2 Breakwater					
・Breakwater (-15.0m)	Rubble mound	m	900	28,800,000	
・Breakwater (-10.0m)	Ditto	m	1,250	24,375,000	
1.3 Wharf					
・-14m New Bulk Berth	R.C. Caisson	m	1,300	47,840,000	
1.4 Revetment					
・-5.0m to -10.0m Revetment	Rubble mound	m	350	2,100,000	
・Less -5.0m	Rubble mound	m	350	3,500,000	
1.5 Exist. Port Improvement					
・Dredging	Rock/soil	m^3	569,000	30,880,000	
・Main Berth Deepening	Concrete block	m	600	13,200,000	
・Valco Berth modification	Concrete block	m	1	2,840,000	
・Oil Berth modification	Additional dolphins	L.S	1	2,000,000	
1.5 Paving & Miscellaneous works		L.S	1	13,000,000	
1.6 Buildings & Utilities Works		L..S	1	6,800,000	
Sub-total				**250,262,000**	
2. Equipment					
2.1 Cargo Handling Equipment		L.S	1	74,000,000	
2.2 Other Equipment		L.S	1	5,200,000	
Sub-total				**79,200,000**	
Total				**329,462,000**	
3. Phisical Contingency	8% of 1,4% of 2	L.S	1	23,188,960	
4. Engineering Cost	5% of Item 1	L.S	1	12,513,100	
Grand Total				**365,164,060**	

14.8 Initial Environmental Examination

14.8.1 Background

The steadily growing economy of Ghana for the past two decades has resulted in the rapid increase in import/export shipping load, while the existing ports are struggling in handling the load efficiently. The Ghanaian government under the Ghana Vision 2020 intends on making Ghana Sea Ports the gateway of West Africa by modifying the outdated sea ports into more advanced and efficient facilities.

14.8.2 Location and Description of Tema Port

Tema Port is located about 30km east of Accra and a Ramsar site exists 2 – 3km west of Tema. About 80% of imported goods to Ghana are handled in Tema Port. The port is protected from waves by 2 breakwaters. There are 14 berths with 2 berths used as an oil and valco birth. Water depth ranges from 7.5 to 10.5m and the deepest berth has a water depth of 9.6m. Water depth has been reduced in some areas of the port, since the last dredging conducted in 1992.

14.8.3 Description of the Proposed Project

- Expansion of port area to achieve more efficient cargo handling, through land reclamation and reconstruction of port structure.
- Construction of new berths for handling import/export products.
- Construction of breakwaters.
- Dredging along berth to secure sufficient water depth for large vessels.
- Reconstruction of access roads to relieve traffic congestion.
- Land clearing to secure space for stock and container yards.

Three alternative project plans have been proposed to satisfy the above objectives. The environmental evaluation was done for all plans as stated in Section 14.3.2 (6).

14.8.4 Identification of Potential Environmental Impacts

As a part of the scoping process, key issues of pollution, social and biophysical environmental concerns in respect of the harbour development project in Tema have been identified. Based on the Master Plan of Tema Port, 14 environmental factors were identified for the EIA. Environmental factors with the rating A, B or C in Table 14.8.1 should be subject to the EIA.

Table 14.8.1 Scoping Checklist

Environmental factors		Rating	Justification
Pollution	Air quality	B	Increase in numbers of calling ships and vehicle traffic.
	Water quality	B	Dredging, landfill, breakwater, increase in port activity
	Bottom sediment quality	B	Dredging, landfill, stagnation of water in the port
	Noise/vibration	B	Increase in vehicle traffic, port activity
	Odor	B	Smell from wastewater and commodities
	Land subsidence	D	Stable substrate (bed rock)
Biophysical environment	Topography, geology, soils	D	No important topography and geology
	Erosion	B	Active littoral drift at present
	Groundwater	D	No influence to the groundwater
	Lake/River flow	D	No lakes or rivers in the surrounding vicinity
	Coast/sea area	D	No important coastline
	Flora/fauna	B	Impacts on the aquatic ecosystem and the Ramsar site
	Landscape	D	No scenic value due to the existing port structure
Social environment	Economic activities	B	Increase in revenue of local community and employment opportunity
	Resettlement	C	Possible minor relocation of residential area and factories located near the port
	Infrastructure	C	Upgrade of infrastructure is expected accompanied with port expansion
	Cultural assets	D	No significant cultural assets in and around the port area
	Fisheries	B	Minor extinction of fishing ground for local fisherman
	Land use	C	Minor change expected
	Natural disaster	D	No influence to the occurrence of natural disaster
	Waste	B	Increase in calling ships and port activity
	Public health and safety	B	Possible traffic accidents

A Significant potential impact

B Potential impact of less significance

C Undecided (Possible impact in the future)

D No potential impact

The above scoping list can apply for both Master Plan and Short-term Plan because both plans have the same project components, though the scale of the Short-term Plan is smaller than that of the Master Plan. Based on the table above, TOR for EIA was prepared and attached to the Appendix B.

14.9 Preliminary Economic Analysis

14.9.1 Methodology

The method of analysis in this case is the same as that of Takoradi Port mentioned in Chapter 13.9.

14.9.2 Prerequisites of Analysis

(1) Base Year

2001 is set as the "Base Year" for this study.

(2) Project Life

Taking into consideration the depreciation period of the main facilities of 30 years and the construction period of 5 years, the period of calculation (project life) in the economic analysis is assumed to be 35 years from the beginning of construction.

(3) Foreign Exchange Rate

The exchange rate adopted for this analysis is US$ 1.00 = 6,700 Cedi, the same rate as used in the cost estimation.

(4) "With" Case

The "With" case scenario includes all improvements in productivity and all expansions of port facilities for the master plan.

(5) "Without" Case

A cost-benefit analysis is conducted on the difference between the "With" and "Without" investment cases. In this study, the following conditions are adopted as the "Without" case.

1) No investment is made for the port.

2) Berthing facility use models are made based on the present condition. (Table 14.9.1) Model-0 is the prototype model assuming that all the berthing facilities are available to any calling vessels. Model-1 could be applicable to the master plan.

3) In the model-1, berthing facilities are divided into the 5 groups. Berthing time and waiting time are estimated by the group.

4) As for the container cargo, ships' waiting time is set within about three hours, because container ships should not wait long time due to the competition with the neighboring major ports. The overflowed container cargoes are assumed to be handled in a foreign port and transported by land between Tema Port and a foreign port.

5) As for the other cargoes, the upper limit of berth occupancy ratio is assumed to be 0.82. The overflowed dry bulk cargoes are to be handled in a foreign port and carried by land between Tema Port and a foreign port.

6) The distribution of ships and the working efficiency of cargo handling are the same as that in the year 2000. (Table 14.9.2)

Table 14.9.2 Cargo Volume and Time at Berth by Ship Type in Both Cases

Tema Port

Berth	Ship Type	W/O.			
		Ave.Ship Size (GRT)	Ave.Ship Size (DWT)	Ave. Cargo Vol/Ship (MT/Ship)	Time at Berth (Hrs/Ship)
GPHA	BU(1)	21,923	35,000	20,266	86.93
	BU(2)	21,923	35,000	15,751	86.93
	CM	14,346	22,000	1,969	21.23
	CO	17,683	26,500	2,403	21.23
	GC	12,802	19,000	1,774	70.17
	OT	9,012	14,000	1,225	9.49
	RO	28,997	43,000	4,206	22.26
	TK	4,357	7,000	604	25.14
Oil Berth	TK	22,614	38,000	21,211	51.80
BALCO	BU(3)	21,923	35,000	30,176	90.74
	CM	14,346	22,000	4,232	21.23
	GC	12,802	19,000	3,777	70.17

Berth	Ship Type	W/.			
		Ave.Ship Size (GRT)	Ave.Ship Size (DWT)	Ave. Cargo Vol/Ship (MT/Ship)	Time at Berth (Hrs/Ship)
GPHA	BU(1)	21,923	35,000	26,346	86.93
	BU(2)	21,923	35,000	20,476	86.93
	CM	14,346	22,000	2,560	21.23
	CO	17,683	26,500	3,124	21.23
	GC	12,802	19,000	2,306	70.17
	OT	9,012	14,000	1,593	9.49
	RO	28,997	43,000	5,468	22.26
	TK	4,357	7,000	785	25.14
Oil Berth	TK	22,614	38,000	27,574	51.80
BALCO	BU(3)	21,923	35,000	39,229	90.74
	CM	14,346	22,000	5,502	21.23
	GC	12,802	19,000	4,910	70.17

BU: DWT/GRT=1.6
TK: DWT/GRT=1.7
Others: DWT/GRT=1.5

Table 14.9.1(1) Facility Use Model (2020) - W/O. (1)

Items	Unit	***Model-0***	***Model-1***				
		All Facilities	Oil Berth**	VALCO Berth	Dry Bulk Berth W12	Container Berth W1,2,4,5,10,1	Other Facilities W6,7,8,9
Nos. of Berth	Berth	13	1	1	1	6	4
Nos. of Calling Ships	Ship	4,244	145	34	92	3,601	461
Ave. Ship Size	GRT	17,710	22,614	20,136	21,923	18,064	13,289
Cargo Handling Volume	MT	15,046,738	2,324,652	829,763	1,855,840	8,523,005	1,513,478
Ave. Cargo Volume per Ship	MT/ship	3,545	16,064	24,768	20,266	2,367	3,281
Berthing Time per Ship	Hrs/ship	29.4	51.8	83.6	86.9	19.9	69.4
Berthing Time per Year	Days	5,198	312	117	332	2,986	1,334
		5,198	5,081				
Berth Occupancy Ratio	-	1.14	0.89	0.33	0.95	1.42	0.95
Waiting Time Factor *($M/E_2/n$)**	-	-	6.10	0.36	-	-	-
Waiting Time per Year	Days	-	1,905	42	-	-	-
		-	-				

** Random arrivals, Erlang 2-distributed service time*
***Oil berth handles petrol products.*

Table 14.9.1(2) Facility Use Model (2020) - W/O. (2)

Items	Unit	***Model-0***	***Model-1***				
		All Facilities	Oil Berth**	VALCO Berth	Dry Bulk Berth W12	Container Berth W1,2,4,5,10,1	Other Facilities W6,7,8,9
Nos. of Berth	Berth	13	1	1	1	6	4
Nos. of Calling Ships	Ship	3,047	133	34	79	1,798	414
Ave. Ship Size	GRT	17,710	22,614	20,136	21,923	18,060	13,394
Cargo Handling Volume	MT	10,800,731	2,136,078	829,761	1,605,800	4,146,628	1,325,507
Ave. Cargo Volume per Ship	MT/ship	3,545	16,064	24,768	20,266	2,306	3,199
Berthing Time per Ship	Hrs/ship	29.4	51.8	83.6	86.9	19.9	69.5
Berthing Time per Year	Days	3,731	287	117	287	1,491	1,200
		3,731	3,382				
Berth Occupancy Ratio	-	0.82	0.82	0.33	0.82	0.71	0.86
Waiting Time Factor *($M/E_2/n$)**	-	0.14	3.45	0.36	3.45	0.15	0.98
Waiting Time per Year	Days	522	990	42	990	224	1,176
		522	3,422				
Navigation Time per Year	Days	212	9	2	6	125	29
		212	171				
Staying Time at Port per Year	Days	4,465	1,286	161	1,283	1,840	2,405
		4,465	6,975				

** Random arrivals, Erlang 2-distributed service time*
***Oil berth handles petrol products.*

Table 14.9.1(3) Facility Use Model (2020) - W/.

Items	Unit	***Model-0***	***Model-1***				
		All Facilities	Oil Berth**	VALCO Berth	Dry Bulk Berth W12	Container Berth W1,2,4,5,10,1	Other Facilities W6,7,8,9
Nos. of Berth	Berth	17	1	1	1	10	4
Nos. of Calling Ships	Ship	3,178	84	26	70	2,619	372
Ave. Ship Size	GRT	17,682	22,614	19,937	21,923	18,020	13,255
Cargo Handling Volume	MT	15,046,738	2,324,652	829,763	1,855,840	8,523,005	1,513,478
Ave. Cargo Volume per Ship	MT/ship	4,734	27,574	31,355	26,346	3,254	4,067
Berthing Time per Ship	Hrs/ship	28.6	51.8	82.2	86.9	19.9	69.3
Berthing Time per Year	Days	3,781	182	91	255	2,170	1,075
		3,781	3,773				
Berth Occupancy Ratio	-	0.64	0.52	0.26	0.73	0.62	0.77
Waiting Time Factor *($M/E_2/n$)**	-	0.00	0.78	0.00	1.99	0.03	0.45
Waiting Time per Year	Days	0	142	0	508	65	9
		0	724				
Navigation Time per Year	Days	221	6	2	5	182	26
		221	221				
Staying Time at Port per Year	Days	4,002	330	93	768	2,417	1,110
		4,002	4,717				

** Random arrivals, Erlang 2-distributed service time*
***Oil berth handles petrol products.*

14.9.3 Costs of the Projects

The items that should be considered as costs of the projects are construction costs and maintenance costs.

(1) Construction Costs

Construction costs are divided into such categories as civil costs and mechanical costs. Main mechanical costs are purchasing of cargo handling equipment.

(2) Maintenance Costs

The costs of maintaining of port facilities are estimated as a fixed proportion (1 % for structures, 4 % for handling equipment) of the original construction costs excluding the costs of dredging and reclamation costs.

(3) Renewal Investment Costs

The renewal costs for cargo handling equipment after their economic durable periods should be considered. The economic durable periods of equipment are planned as follows.

Table 14.9.3.1 Economic Durable Periods and Costs of Equipment

Equipment	Durable Periods	Costs('000US$)
Gantry Crane, Transfer Crane, Tug Boat	20 Years	79,200

Table 14.9.3.2 Costs of the Projects for Master Plan – Tema Port

(Unit: Thousand US$)

Items	Costs
Civil Works	250,262
Equipment	79,200
Total	329,462
Maintenance Costs for Structure	1,313
Maintenance Costs for Equipment	3,168
Total (per year)	4,481

14.9.4 Benefits of the Projects

(1) Benefit Items

As benefits brought about by the master plan of the study port, the following items are identified.

1) Savings in staying costs of ships

2) Savings in water transportation cost by increase of cargo volume per ship

3) Savings in land transportation costs

4) Earnings of foreign currency in handling transshipment cargoes

5) Savings of costs in cargo handling

6) Savings in interest of cargo costs

7) Reduction of cargo damage and accidents at the port

8) Promotion of regional economic development

9) Increase in employment opportunities and incomes

Of the above, items 1) to 4) are considered countable and in this study the monetary benefits of these items are calculated.

(2) Calculation of Benefits

1) Savings in staying costs of ships

In accordance with the implementation of the projects, the total ship staying time, namely ship waiting time for berthing and ship mooring time for unloading/loading in the port, will be greatly decreased. The reduction of the ship staying time under the "With" case is one of the major benefits of the projects. The benefits that will accrue to Ghana from the projects can be calculated by the following formula.

Savings in ships' staying costs = Difference in staying time between "With" and "Without" cases x Ships' staying cost (unit cost) x Share of benefits accruing to Ghana (= 0.5)

Whereby,

Savings in ships' staying costs = *(6,975-4,717)days x 7,608$/day x 0.5 = 8,589,432US$*

Ship cost is estimated by accumulating the component factors of cost such as depreciation, wages, maintenance cost and so forth. Although it is conceivable to estimate ship cost based on charter rate, this rate has been fluctuating so much according to the market conditions that it is not appropriate for economic price of ship cost.

Table 14.9.4.1-2 shows the ship waiting cost estimated by the Study Team based on the estimation made by some Japanese shipping companies. These data are used as unit cost of ship staying.

Table 14.9.4.1 Ship Cost by Ship Size (General Cargo)

(Unit:US$ per day)

DWT	Tons	Navigation	Anchorage	Knot
5,000	4,500	7,442	6,067	13.0
8,000	7,200	7,883	6,533	13.0
10,000	9,000	8,100	6,775	13.0
20,000	18,000	8,925	7,608	13.0
30,000	27,000	9,550	8,183	13.0

Table 14.9.4.2 Ship Cost by Ship Size (Container Cargo)

(Unit: US$ per day)

DWT	TEUs	Navigation	Anchorage	Knot
4,500	200	9,042	7,917	12.0
5,900	300	10,800	9,475	13.0
8,800	500	15,008	12,975	15.0
22,000	1,200	29,250	23,433	20.0
35,000	2,000	40,258	32,450	22.0

The savings in staying costs of vessels are primarily realized by shipping companies. Since Ghana has no national shipping company at present, these benefits accrue to other countries. However, some portion of these benefits should be returned to Ghana after some time lag. It is possible for Ghana to acquire some of the benefits by, for instance, decreasing freight rates reflecting the reduced incidence of delays at the port. In this Study, it is assumed that 50% of the benefits attributed to foreign ship operators will be transferred to the Ghana economy.

2) Savings in water transportation cost by increase of cargo volume per ship

At present, calling ships at Takoradi Port cannot transport the cargoes fully loaded due to the shallow berths. When the deep-water berths are materialized in the master plan, they can call at Takoradi with full load. Therefore, average cargo volume per ship will increase resulting the lower water transportation cost. These savings are marked in the container and general cargoes.

Savings in water transportation costs = Difference in water transportation costs between "With" and "Without" cases (unit cost) x Total cargo volume x Share of benefits accruing to Ghana (= 0.5)

Whereby,

Savings in water transportation costs $= (67.41-\frac{67.41}{1.3})\$/MT \times 0.2 \times 10,043,774MT \times 0.5$

$=15,624,249US\ \$$

3) Savings in land transportation costs

In the following two cases, it is assumed that the cargoes will be handled in other foreign ports and then be transported to Ghana by land.

- Handling volume reaches the maximum volume of handling capacity of the port.
- As for the container cargoes excluding transshipment cargoes, ships' waiting time is over three hours.

In accordance with the implementation of the projects, it is not necessary to transport the cargoes by land. The benefit that will accrue to Ghana from the projects can be calculated by the followings.

Savings in land transportation costs = Difference in handling cargo volume between "With" and "Without" cases x Land transportation cost (unit cost)

Whereby,

Savings in land transportation costs = *(15,046,738-10,043,774-1,069,390*)MT x 9.14$/MT*
= 3,933, 574MT x9.14$/MT =35,952,848US$
** Transit and transshipment cargo (See, Table 28.2.2.1)*

4) Earnings of foreign currency in handling transshipment cargoes

In "Without" case, transshipment cargoes will be handled in the competitive foreign ports due to the lack of sufficient facilities and the increase of waiting time. The benefit that will accrue to Ghana from the projects can be calculated by the following formula.

Earnings of foreign currency = Difference in handling cargo volume between "With" and "Without" cases x Cargo handling fee per TEU

Whereby,

Earnings of foreign currency = *(16,312+78,952)*TEU x 127.98$/TEU = 12,191,887 US$*
** Transit and transshipment cargo (See, Table 28.2.2.1)*

(3) Calculation Result of Benefits

Benefits of the projects are summarized in the following table.

Table 14.9.4.3 Benefits of the Projects for Master Plan – Tema Port
(Unit: thousand US$)

Items	Benefits
Ships' Staying Time	8,589
Water Transportation	15,624
Land Transportation	35,953
Earnings of Foreign Currency	12,192
Total	72,358

14.9.5 Evaluation of the Projects

(1) Calculation of the EIRR

The economic internal rate of return (EIRR) based on a cost-benefit analysis is used to appraise the economic feasibility of the project.

The EIRR of the master plan is calculated as 14.8%. The results of calculation are shown in Table 14.9.5.1.

(2) Evaluation

As for this project, even though the economic calculation only takes into account the items which are easily quantified, the EIRR exceeds 8%. Therefore, this master plan development project is feasible from the viewpoint of the national economy.

Table 14.9.5.1 Cost/Benefit Analysis of Master Plan for Tema Port

Name of Port: :Tema
Table ____ (1/1)
Economic Evaluation
(In constant 2000 prices, 1000US$)

Year	Costs			Benefits	Net Benefits
	Investment	O&M	Total	Total	
2015	65,892	-	65,892	-	(65,892)
2016	65,892	-	65,892	-	(65,892)
2017	65,892	-	65,892	-	(65,892)
2018	65,892	-	65,892	-	(65,892)
2019	65,892	-	65,892	-	(65,892)
2020		4,481	4,481	72,358	67,877
2021		4,481	4,481	72,358	67,877
2022		4,481	4,481	72,358	67,877
2023		4,481	4,481	72,358	67,877
2024		4,481	4,481	72,358	67,877
2025		4,481	4,481	72,358	67,877
2026		4,481	4,481	72,358	67,877
2027		4,481	4,481	72,358	67,877
2028		4,481	4,481	72,358	67,877
2029		4,481	4,481	72,358	67,877
2030		4,481	4,481	72,358	67,877
2031		4,481	4,481	72,358	67,877
2032		4,481	4,481	72,358	67,877
2033		4,481	4,481	72,358	67,877
2034		4,481	4,481	72,358	67,877
2035	39,600	4,481	44,081	72,358	28,277
2036	39,600	4,481	44,081	72,358	28,277
2037		4,481	4,481	72,358	67,877
2038		4,481	4,481	72,358	67,877
2039		4,481	4,481	72,358	67,877
2040		4,481	4,481	72,358	67,877
2041		4,481	4,481	72,358	67,877
2042		4,481	4,481	72,358	67,877
2043		4,481	4,481	72,358	67,877
2044		4,481	4,481	72,358	67,877
2045		4,481	4,481	72,358	67,877
2046		4,481	4,481	72,358	67,877
2047		4,481	4,481	72,358	67,877
2048		4,481	4,481	72,358	67,877
2049		4,481	4,481	72,358	67,877
Total	**408,660**	**134,430**	**543,090**	**2,170,740**	**1,627,650**
Economic Internal Rate of Return (EIRR):					**14.8%**

Sensitivity Analysis

	EIRR	Increase in Investment Cost		
	14.8%	0%	10%	20%
Decrease Benefits	0%	14.8%	13.6%	12.5%
	10%	13.5%	12.3%	11.3%
	20%	12.0%	10.9%	9.9%

Chapter 15 Improvement Plan of Port Management and Operation

15.1 Principles of Port Management and Operation

15.1.1 Background on Management, Operation and Institutional Matters of Ghana Sea Ports

Ghana Sea Ports are service ports, and GPHA has to do all of the maintenance, management and operation of the port. Cargo-handling operations are carried out by GPHA and 3 private stevedoring companies, but competition does not truly exist because cargo handling operations are allocated by a fixed share as shown in Chapter 5.3.1. However, in line with the Government's port development policy, GPHA drafted the Landlord Port Bill in July 2000 and the Bill is being deliberated by the Government now. When the Bill is passed by parliament, Ghana Sea Ports will be a Landlord Port, in other words, GPHA will own the land while private companies will participate in the port operations.

15.1.2 Privatization of Port Management and Operation

(1) Basic Concept and Pattern of Port Management and Operation

Ports are managed in a variety of ways depending on the state system, local characteristics, economic conditions etc. In order to raise the ability of the port authority to its highest level, it is necessary to adhere to the following essential principles.

1) Autonomy
Because of the importance of the port activities to the national economy, it is desirable that proper relations be established with the central government while maintaining the independence of the port authority.

2) Financial independence
The management system is required to have its own budget and maintain a reasonable level of port charges, in order to maintain port facilities in good conditions and develop necessary facilities.

3) Principle of competition
For port management, it is essential to have a clear definition of responsibilities and a rational organization based on it, so that an adequate profit level can be maintained with considering competition with other ports in the world.

4) Unitary management
It is vital for the management system to have the necessary and sufficient authority over the port area and main functions.

(2) Patterns of Port Development, Management and Operation Body

Port management and operation systems differ by each port. Possible patterns of development, management and operations for the new port are shown in Table 15.1.1.

Table 15.1.1 Patterns of Port Development, Management and Operations Body

<table>
<tr><th colspan="2">Pattern</th><th>A</th><th>B</th><th>C</th><th>D</th><th>E</th><th>F</th></tr>
<tr><td colspan="2">Master Plan</td><td colspan="6">○</td></tr>
<tr><td rowspan="4">Construction</td><td>Channels</td><td colspan="2" rowspan="4">○</td><td colspan="2" rowspan="3">○</td><td rowspan="2">○</td><td rowspan="2">○</td></tr>
<tr><td>Breakwater</td></tr>
<tr><td>Infrastructure</td><td rowspan="2">●</td><td rowspan="2">●</td></tr>
<tr><td>Superstructure</td><td>○</td><td>●</td></tr>
<tr><td rowspan="2">Ownership</td><td>Land</td><td colspan="2" rowspan="2">○</td><td>○</td><td>○</td><td>○</td><td>●</td></tr>
<tr><td>Terminal Facilities</td><td>●*2</td><td>●*2</td><td>●*2</td><td>●</td></tr>
<tr><td colspan="2">Berthing Scheme</td><td>○</td><td>○*1</td><td>●</td><td>●</td><td>●</td><td>●</td></tr>
<tr><td colspan="2">Terminal Operations</td><td>○</td><td>●</td><td>●</td><td>●</td><td>●</td><td>●</td></tr>
<tr><td colspan="2">Tug & Pilotage</td><td colspan="6">○ or ●</td></tr>
</table>

Note 1 ○: Public ●: Private

Note 2 *1: Exclusive system *2: Land lease system

The main advantages and disadvantages of each pattern are as follows.

Case A, B

1) Advantages

- Since public sector owns the berths, public sector can improve facilities or equipment easily in case of need according to a master plan in the future.
- (Case B) Generally speaking, cargo handling performed by private stevedoring companies is more efficient than that by public sector.

2) Disadvantages

- (Case A) Generally speaking, cargo handling efficiency of the public sector is lower compared with the private sector due to the absence of competition in the market.
- (Case B) There is possibility that only some selected shipping companies can use the berth and other shipping companies stop calling to the port.

Case C, D

1) Advantages

- In case of need for the master plan in the future, public sector can improve facilities or equipment since it owns the land, although the berths are occupied by a private company.
- (Case D) Since the superstructure is built by the private sector, this type is useful when the public sector does not have sufficient funds and the construction of port facilities is urgent.

2) Disadvantages

・(Case C) Since the public sector is responsible for construction work, public sector needs to provide funds.

Case E

1) Advantages

・In case of need according to a master plan in the future, public sector can improve facilities or equipment since it owns the land, although the berths are occupied by a private company.

・Since a private company reclaims land from the sea and builds the berth, public sector does not need to provide funds.

2) Disadvantages

・In the case that a private company performs reclamation, inappropriate development of public property can not be prevented. Therefore the master plan should be drawn by the public sector.

Case F

1) Advantages

・Since a private company reclaims land from the sea and builds the berth, public sector does not need to provide funds.

2) Disadvantage

・Because the berths are owned by a private company for a long time, public sector can not improve port facilities or equipment easily in case of need for the implementation of its own development plan in the future. In particular, in the case that main berths of the port are occupied by specific shipping companies, there is a risk that public sector cannot control the port.

(3) General Problem for the Privatization

Ghana Sea Ports is a Service port (shown as Case A in Table 15.1.1), but will become a landlord port after passage of the Landlord Port Bill (Draft). GPHA will own land and private companies can participate in the port management and operations, and this is a rapid and efficient way to provide high-level port services to port users.

To attract a number of private companies to the port, it is recommended that the government authorities concerned take the following measures.

1) Basic philosophy of private sector participation shall be established and reaffirmed among relevant agencies. In this case, the concept of "fairness of opportunity", "transparency" and "competition" shall be emphasized
2) Legal framework (relevant laws and regulations) shall be arranged so that private sector can participate in terminal operations as freely as possible.
3) In addition, legal framework regarding foreign investment shall be carefully considered. In this case, guarantee of rights of foreign investors shall be emphasized.
4) It is advisable for the government to establish guidelines for Private Sector Participation based on clear legal frameworks.
5) The guidelines shall clarify working fields of port services that the private sector can participate in.

6) Competitive bidding needs to be promoted to select the responsive terminal operators beneficial to the national economy.
7) Desirable environment where private sector can easily take part in needs to be created.

(4) Measures to Mitigate the Impact brought by Privatization and Private Sector Participation

On the other hand, for the existing state-owned companies, privatization and subsequent competition among private companies would bring considerable impact on both management and employees due to possible restructuring and downsizing. They may opt to reduce their personnel. In such cases, the following mitigation measures shall be taken.

1) To conduct gradual and prudent restructuring so as not to cause social unrest due to unemployment.
2) To retrain the current employees so as to enable them to find new jobs.
3) To provide government assistance for displaced workers looking for new jobs.
4) To generate new employment opportunities within the port through the increase in port capacity and promotion of new port business by GPHA.

(5) Proposal for the Privatization in Ghana Sea Ports

For Ghana Sea ports, Case D form of privatization is recommendable as appropriate role sharing between the public sector and the private sector for the following reasons;

・Private sector can avoid the risk of huge initial investment cost.
・Public sector can utilize cargo handling know-how and flexibility of the private sector.
・The public sector (GPHA) can control overall port development and management.

However, different approaches should be taken in some instances. Details are as follows;

1) In the case of Takoradi Port

・Management and operation of manganese, bauxite, clinker, and oil handling berth would be the responsibility of private companies. Private companies can be expected to adopt the most efficient way of providing services and handling cargoes in these berths.
・Container cargo would be handled mainly at berths 5-6 and the new container berth at the inner port area. Since berths 5-6 will function as the multipurpose berths, it is appropriate for them to be managed by GPHA, including facilities and equipment such as quay-side gantry cranes. Maintenance of facilities and equipment will be done by GPHA or contracted to private company.
・New container terminal at the inner port area should be leased to a single operator as a public berth because many companies will utilize this single container terminal. GPHA constructs the basic facilities and the operation company procures cargo handling equipment, and operates this new container terminal. However, there are plural possibilities concerning the make-up of that single operator.

- One private company such as shipping company, stevedoring company
- One joint venture company of private companies.
- One joint venture company of these private companies and GPHA

2) In the case of Tema Port

・All of the new container berths (4 berths) on the western side of Tema port are desired to be leased one by one to private companies as public berths or commercial berth. For the first 2 container berths, GPHA should construct the facilities (reclaiming and pavement) and then lease these berths to a single operator such as;
  - One private company such as shipping company, stevedoring company
  - One joint venture company of private companies.
  - One joint venture company of these private companies and GPHA
・For subsequent berths, a different strategy such as "BOT scheme" might be considered. GPHA has a few options in this regard.
  (i) Full construction (includes dredging and reclaiming) is done under BOT scheme or;
  (ii) Dredging, reclaiming and pavement is done by GPHA and the rest of construction is done under BOT scheme by
    - One private company such as shipping company, stevedoring company
    - One joint venture company of private companies.
    - One joint venture company of these private companies and GPHA

    However because of the high construction cost of the new container terminal, option(ii) is recommended. Land reclamation and dredging will be done by GPHA while the superstructure will be built by the private sector.
・Valco berth and Oil berth are desired to be leased to private companies for exclusive use.
・New berth11 (for Clinker) in Quay1 is desired to be leased to a private company as an exclusive berth. Maintenance of equipment and operation would be in the hands of the private company. Berths 6-10 in Quay1, where general cargo and bagged cargo are mainly handled, should be managed by GPHA as public berths and operated by private companies. Maintenance of facilities and equipment will be done by GPHA or private companies by contract with GPHA.

15.1.3 Monitoring the Performance of Operation

As mentioned in the Landlord Port Bill, private companies are allowed to perform cargo-handling activities. GPHA should monitor the performance of operators and recommend the improvement of productivity if the performance is poor and reject the renewal of lease contract if improvement is not expected. GPHA needs to put pressure on port operators to improve the productivity of operation.

If GPHA participates in the joint venture with private companies in future, GPHA is required to keep its monitoring section independent from the operating section. Operation activities within landlord GPHA and private companies need to be closely monitored.

15.1.4 Introduction of Port EDI System

The GCNET, new custom EDI system developed by CEPS (the Customs Exercise and Preventive Service), is linked to all stockholders such as CEPS, GPHA, Ministry of Finance, Ministry of Trade and Industry, Ghana Statistics Service Ghana Shipping Council, Social General de Surveillance and so on (refer to Chapter 5.4). Referring to the GCNET, the introduction of new port EDI system is required. Ghana Sea Ports will be more convenient with this port EDI system. However, it is necessary to provide training to staff who operate the port EDI system to avoid delays and mistakes. GPHA has to make efforts to encourage port related companies to participate in this port EDI system by highlighting the merits of this EDI system. And it is worth considering that GPHA or a community of port related companies jointly establish a governing body of this port EDI system. Excellent example of a port EDI system is "ADEMAR+" utilized at Le Havre Port in France. This system is operated by a company established by the port authority, shipping agent, the chamber of commerce and others.

15.2 Proposal for Efficient Port Promotion

To increase cargo volume and number of vessels calling in Ghana Sea Ports, port promotional activities are important. At GPHA, the marketing unit was established in 1994, and some port promotion activities are carried out now. Current activities for port promotion/sales are listed below:

1) Advertising in international maritime trade journal to attract vessels to Ghana Sea Ports.
2) Exhibiting port facilities and services at local and international fairs.
3) Occasional trade missions to landlocked countries (Burkina Faso) to attract their trade through the Ghanaian corridor.
4) Trade visit to shippers in Kumasi and northern parts of the country to attract shippers to use Takoradi Port.
5) Trade visit to shipping companies/agents to identify their problems and propose measures to resolve them.

Port promotional activities are divided into "regular activities" and "irregular activities".
Regular activities are similar to trade visit activities to shippers and shipping companies as shown above 2) 4) 5). 1) and 3) are irregular activities and are more expensive. Regular activities should be repeated frequently and irregular activities should be held at the time when the promotion efficiency would be maximized (for example, port promotional reception should be held when the most guests can attend).

In West Africa, Ghana Sea Ports enjoy a reputation for reliability thanks to the stability of the Ghanaian government. Recently, some seaports in neighbouring countries have problems concerning reliability, and some shipping companies plan to shift their cargo-handling to Ghana Sea ports. Important points for promoting Ghana Sea Ports in future are below:

- To emphasize the high stability and reliability of Ghana Sea Ports.
- To emphasize the greater convenience and performance of Ghana Sea Ports that can be effected once the Landlord Port Bill is passed.

15.2.1 Port Promotional Activities in Ghana

Port promotion activities in Ghana should be done in cooperation with organizations concerned such as Ghana Export Promotion Council. In addition, GPHA should have periodic meetings with port users such as shipping companies and agents to identify their problems and propose measures to resolve them.

15.2.2 Port Promotional Activities in Landlocked Countries

At present, GPHA sends occasional trade missions to landlocked countries to attract their trade through the Ghanaian corridor. In future, it will be necessary to continue this activity in liaison with organizations concerned such as Ghana office of Burkina Faso, Mari and other private companies of landlocked countries.

15.2.3 Port Promotional Activities in Foreign Countries

In the near future, GPHA should expand their port promotion activities to attract more cargo volume to/from important regions such as North America, Europe and Asia. GPHA should frequently visit headquarters of foreign shipping companies that have routes with Ghana and increase participation in Trade Fairs and Exhibitions in foreign countries.

15.2.4 Port Promotional Activities for Cruise

There are many historically valuable and attractive ruins in Ghana such as Cape Coast where the sightseeing potential is high. When a cruise ship comes to Ghana as a tramper (non-periodically), GPHA should accept the vessel if possible. According to Ghana Tourist Development Company, Ghana Tourist Board and Ministry of Tourism, the target number of tourists in 2004 is about 1 million people. Promotional activities to attract cruising vessels are also important from the viewpoint of not only national economy but the increase of port revenue.