PART III MASTER PLAN

Chapter 13 Master Plan for Takoradi Port

13.1 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.

13.1.1 Role of Takoradi Port

(1) Bottlenecks of the Port

The master plan has to propose solutions to the bottlenecks that the port currently faces. The present condition of the port including bottlenecks is analyzed. 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 and forces double cargo handling operation.
- ♦ Space restriction for cargo operation hampers efficient cargo handling.
- ♦ Cargo handling productivity is low due to the reasons mentioned above and inappropriate cargo handling procedures
- ♦ Volume of containerized imports and exports is greatly imbalanced.
- ♦ 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, Takoradi 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 West Ghana.

- ♦ The port has a railway linkage with Ashanti Region, which has the largest population in Ghana and the major center of agriculture and industry, and bauxite mining site and manganese mining site.
- ♦ The port has good road connections to most of regions of Ghana and landlocked countries through them.
- ♦ Port congestion is not so severe compared with Tema Port and customs clearance is smoother.
- ♦ The port has base cargoes such as bauxite, manganese, clinker, sawn timber and cocoa beans.

(3) Role of the Port

Takoradi Port is now playing an important role as an export port of West Ghana, where main export goods of Ghana such as cocoa beans, timber, manganese and bauxite are produced. Beyond this, however, the port is expected to function as an import port of West Ghana to establish a rational physical distribution system in the country. To become a middle-income country, the role of the port is very important as the second largest port in Ghana. The port is expected to fulfill the roles listed below.

- Functioning as the main export port of commodities produced in West Ghana such as manganese, bauxite, cocoa and timber.
- Functioning as an import port of commodities consumed in West Ghana such as foodstuffs and consumer goods (Appropriate role sharing with Tema Port will be important in this regard).
- Enhancing the potential of a bulk cargo distribution base for items such as manganese, bauxite, clinker and wheat.
- Supporting industrial development 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 opportunities for persons in western region in direct port services as well as numerous ancillary services.

13.1.2 Future Cargo Demand

Based on the appropriate role sharing between Takoradi Port and Teme Port, future cargo throughput at Takoradi Port is estimated. Results of the cargo forecast are summarized from Table 13.1.1 to Table 13.1.2.

Table 13.1.1 Future Cargo Demand Forecast in Takoradi Port

(tons)

IMPORT	1991	2000	2010	2020
Dry Bulk	413,040	891,815	1,258,530	1,823,978
Clinker	323,538	694,374	991,760	1,458,160
Liquid Bulk	92,284	157,012	224,787	366,154
Bagged Cargo	2,514	5,770	51,839	106,104
General Cargo	20,868	26,619	222,250	682,675
Containerized Cargo	20,610	62,102	509,022	2,366,337
Total	**549,316**	**1,143,318**	**2,266,428**	**5,345,248**

Export	1991	2000	2010	2020
Dry Bulk	644,310	1,461,732	2,000,000	2,500,000
Bauxite	324,313	503,823	1,000,000	1,500,000
Manganese	319,997	929,296	1,000,000	1,000,000
Liquid Bulk	0	6,551	8,386	12,413
Bagged Cargo	106,772	70,368	21,944	29,062
General Cargo	292,888	102,658	37,517	37,977
Containerized Cargo	46,182	271,889	789,981	1,273,734
Total	**1,090,152**	**1,913,198**	**2,857,828**	**3,853,186**
Grand Total	**1,639,468**	**3,056,516**	**5,124,256**	**9,198,434**

Table 13.1.2 Future Container Cargo Demand Forecast at Takoradi Port

(TEUs)

	1991	2000	2010	2020
Import	4,422	15,387	66,894	202,004
Export	4,690	24,418	68,098	203,871
Transit			1,204	1,867
Total	**9,112**	**39,805**	**136,196**	**407,742**

13.1.3 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 Takoradi Port to play the roles described above, it is necessary to develop and modify the port into a modern port. Issues which need to be addressed in the master plan of the port are listed below.

- To solve the present problems such as lack/shortage of deep berths, double operation of cargo handling, 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.
- As for facility development, deep berths are to be developed to eliminate double handling

operation and to allow large vessels to enter the port.

- ♦ Dedicated berth system is to be adapted to handle specific cargoes by using special cargo handling equipment for the sake of optimizing cargo handling productivity.
- ♦ To develop aprons and cargo handling yards with sufficient space just behind berths.
- ♦ To segregate berths for container and break bulk cargoes from berths for mineral bulk cargoes.
- ♦ To propose the appropriate port administration and operation system.

13.2 Facility Requirement for Master Plan

13.2.1 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 are adopted and an appropriate institutional framework is set up.

Target of cargo handling productivities is set considering improved future cargo handling conditions which are proposed in the master plan and cargo handling productivities of foreign ports. Cargo handling productivity used for estimation purpose are given in Table 13.2.1.

Table 13.2.1 Gross Cargo Handling Productivity at Takoradi Port in 2000 and 2020

Type	Commodity	Unit	Productivity 2000	Productivity 2020	Equipment 2020
IMPORT					
DB	Clinker/Gypsum	t/hour/vessel	270	600	Grab, Belt conver
DB	Wheat	t/hour/vessel	90	150	Grab, hopper
LB	Petro products	t/hour/vessel	80	200	Pipeline
BC	Rice, Fertilizer	t/hour/vessel	40	80	Multi. Crane/ship gear
GC	Cars, Steel product	t/hour/vessel	70	100	Multi. Crane/ship gear
GC	Chemical	t/hour/vessel	58	90	Multi. Crane/ship gear
RO	RoRo cargo	t/hour/vessel	68	100	RoRo ramp
CO	Container	box/hour/vessel	9	30	Container crane
EXPORT					
DB	Bauxite	t/hour/vessel	190	600	Loader, belt conveyor
DB	Manganese	t/hour/vessel	210	600	Loader, belt conveyor
DB	Cocoa beans	t/hour/vessel	70	100	Belt conver
BC	Cocoa beans	t/hour/vessel	30	80	Multi. Crane/ship gear
GC	Sawn Timber	t/hour/vessel	30	80	Multi. Crane/ship gear
RO	RoRo cargo	t/hour/vessel	68	100	RoRo ramp
CO	Container	box/hour/vessel	9	30	Container crane

Note: Productivity of the year 2000 is calculated from vessel berthing data

(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 13.2.2.

As for bulk carriers, the present maximum vessel in terms of DWT is the vessel for clinker, of which DWT is 51,694. Maximum sizes of bulk carriers for manganese and bauxite exceed 45,000 DWT. These large vessels enter the port after adjusting their drafts. Bulk carriers for clinker call at Takoradi Port at first and then call at Tema Port. At Takoradi Port the 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 a depth of 11.5m in Tema Port as soon as possible. Ghana Manganese Company and Ghana Bauxite Company desire to operate 40,000 DWT vessel at full draft. According to the bulk vessel statistics of Lloyd there is a peak at 40,000 DWT with less than full draft of 12m and 70% of world bulk carriers is less than 40,000 DWT. Therefore, vessel size of bulk carriers at the target year is set at 40,000 DWT.

The present size of tankers calling at the port is rather small compared with bulk carriers. The maximum size is 17,925 DWT in 2000 and $DWT_{1/4}$ is only 3,237 tons. Tankers carry petroleum products from Tema Port. The amount of petrol products which will be imported at the port is estimated to increase threefold in 2020 compared with 2000. Tanker size is set at 20,000 DWT.

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 31,057 DWT with the full draft of 11.6m and this vessel has the capacity of 2,000 TEUs. This vessel enters the port with shallow draft. According to interviews with shipping companies, in the 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 accept can 2,000 TEUs class container vessels with full draft and 3,000 TEUs class vessels after adjusting draft.

The size of RoRo vessels is slightly larger than that of container vessels. The maximum size of RoRo vessels calling at port is 31,311 DWT with the draft of 11.9m. Main RoRo cargoes are containers, sawn timber, machinery and equipment. Due to inadequate container handling equipment and shallow berths these cargoes are carried by RoRo vessels, however, these RoRo cargoes will be shifted to container vessels after new multipurpose or container berths are completed. A shipping agent representative mentioned that most RoRo vessels operated in West Africa were built more than 20 years ago and that in the next 10 years they will be retired. And it is hard to imagine new RoRo vessels will be built because of high building cost of such vessels.

Table 13.2.2 Vessel Size at the Target Year 2020 at Takoradi Port

Vessel Type	2000		2020 (Standard Size)		
	Max.DWT	$DWT_{1/4}$	DWT	Length	Draft
	(tons)	(tons)	(tons)	(m)	(m)
Bulk carrier	51,694	43,685	40,000	200	11.8
Tanker	17,925	3,237	20,000	158	9.6
Cellular container	31,057	25,375	30,000	218	11.1
RO-RO	31,311	27,601	28,000	210	11.0

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

(3) Berth Type

Main cargoes handled at Takoradi Port at the target year of 2020 are clinker/gypsum, bauxite, manganese, petroleum products and container cargo. Estimated volumes of these cargoes are large enough to be handled at dedicated berths with special handling equipment for each cargo to optimize handling productivity. Other cargoes are handled at multipurpose berths. Therefore, berth types at the port are classified into four categories, that is bulk berth for dry mineral bulk cargoes such as clinker, bauxite and manganese, oil berth for petroleum products imported from Tema Port, container berth and multipurpose berth. Each berth type is summarized in Table 13.2.3.

Table 13.2.3 Berth Type at Takoradi Port in 2020

Type	Commodity	Vessel Type
Bulk Berth	Clinker, Bauxite, Manganese, Gypsum, Limestone	Bulk carrier
Oil Berth	Petroleum products	Tanker
Container Berth	Container	Container
Multipurpose Berth	General cargo, RoRo cargo, Bagged cargo, Wheat etc.	RoRo, General cargo carrier, Bulk carrier etc.

(4) Number of Berths Required

Number of berths by berth type required for the master plan is determined considering Berth Occupancy Ratio (BOR) of each berth type. UNCTAD[1] recommends that BOR for general cargo operations should be set so as to exceed the figures in Table 14.2.4. In this study these figures are used as criteria for common users' berths such as container berths and multipurpose berths. Supposed that 15% of container cargo will be handled at multipurpose berths in 2020.

[1] Port Development, A handbook for planners in developing countries, Second edition revised and expanded, United Nations Conference on Trade and Development, 1985

Table 13.2.4 Recommended maximum BOR
(Berth Occupancy Ratio)

Number of berths in the group	Recommended maximum berth ocdcupancy ratio
1	40%
2	50%
3	55%
4	60%
5	65%
6-10	70%

As for bulk berths, as users of berths are limited and it is easier to adjust arrival time of calling vessels, maximum BOR could be set higher than common users' berths. The result of required berth number by berth type is shown in Table 13.2.5. As the removal of Manganese Berth (Berth No.1) is not feasible because of high relocation cost of railway and cargo handling equipment and uncertainty of future mining period of manganese, Manganese Berth will be improved at the present existing site.

Table 13.2.5 Scale of New Berths for Master Plan at Takoradi Port

Berth	Commodity	Number	Depth
Manganese Berth	Manganese	1	12m
Bauxite Berth	Bauxite	1	13m
Clinker Berth	Clinker	1	13m
Oil Berth	Petroleum products	1	11m
Container Berth	Container	2	12m
Multi-purpose Berth	Break bulk, wheat etc.	3	12m
Total		9	

13.2.2 Water Facilities

(1) Entrance Channel

Number of vessels calling at Takoradi Port is estimated at about 900 in the year 2020. Three ships will use the approach channel on average per day. One way channel is sufficient to handle this traffic level. The width of the approach channel is determined using methods proposed by PIANC[2] and UNCTAD[3].

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[2] 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

[3] Same as 1

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

W = Wbm + ∑Wi + Wbr + Wbg

where,

Additional width	Items	Characteristics of Takoradi 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
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 entrance channel is proposed. As many kinds of cargo vessels such as bulk carriers, RoRo ships and container ships will use the entrance 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 entrance 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.

13.2.3 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.

13.2.4 Storage Area

One of the most serious problems of Takoradi port is the narrow apron and limited space for cargo handling, which hamper efficient cargo handling. Width of main wharves is only 70m and sheds and pipelines on the wharves make them narrower. Another problem of storage areas is that they are segmented and separated. And since the main road connecting storage areas crosses the railway, vehicles are occasionally forced to wait until trains pass.

These problems shall be solved in the master plan. However, it is difficult to solve the last problem fundamentally because the relocation of Manganese Berth (manganese is transported by rail) is not feasible taking into account the relocation cost including the railway and cargo handling equipment and uncertainty of future mining period of manganese. Now 4 – 5 trains per day carrying manganese come to the port and this number will be maintained up to 2020. As each train blocks the traffic for about 5 minutes on average, the total blocking time is about 25 minutes at most per day. The practical solution is to provide enough cargo handling and storage space behind Berth No.2 – Berth No.6 and to inform the people concerned of arrival of trains in advance.

(1) Container Yards

The critical problem of demand for storage areas in the master plan is container storage areas. Storage facilities such as sheds and warehouses for sawn timber, cocoa beans and break-bulk cargoes will not cause serious problems. This is because these cargoes will be more containerized and fair portion of cargoes will come to the port as FCL cargoes vanned at inland container depots like planned Kumasi Inland Port.

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 408 thousands TEUs and two 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 18ha – 21ha.

(2) CFS

Required floor space of CFS is estimated using the following formula. As for export containers, sawn timber, cocoa beans and cocoa products, that are the majority of export container, are vanned at existing sheds. 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 are required to be devanned in house. As the required floor space of CFS is small, it is proposed to allocate same space for the CFS cargoes in the new sheds to be used mainly for the storage of conventional cargo.

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

Where,

VP	316	TEUs at peak time
t	13.1	Tons/teu(laden)
AD	0.2	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	1,381	m2

(3) Shed

There are 9 sheds at Takoradi Port. Four sheds are for cocoa, two for timber, one for general cargo, one for copra and one for CFS. The required dimensions of sheds were estimated using the following formula for the storage of bagged cargoes and paper reels. Required area of sheds is calculated at 8,000 sq.m. Although Shed No.4, which is 3,600 sq.m, is used for bagged cargo, it will be demolished or removed to increase cargo handling space behind Berth No.4.

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

Where、

V	:	397,422	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	:	3.0	Unit load for storage (tons/sq. m)
ξ	:	0.4	Passage ratio
ε	:	0.75	Operational factor
A	:	7,983	Floor space (sq. m)

(4) Open Yard

The required dimensions of open stock yards were estimated using the following formula for Iron / Steel. Considering the need of marshaling yard for enhancement of cargo handling productivity, area of open yards is proposed at 13,000 sq.m.

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

Where、

V	155,726	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	1.0	Unit load for storage (tons/sq.m)
ξ	0.5	Passage ratio
ε	0.75	Operational factor
A	12,012	Open stock yard space (sq.m)

(5) Area for Industries

According to the future cargo estimation, throughput of wheat and other foodstuffs will amount to 298,000 tons, which is double of that in the year 2000. A site for food factory and other factories with silos will be planned. This area will be used to enhance the port's function as a cargo distribution center. For example, Takoradi Flour Mill imports about 100,000 tons of wheat from

U.S.A. annually and has a milling capacity of 500 t/day. The total storage capacity of its 16 silos is 26,000 tons and annual turnover time is 4.6. Irani Brothers and Others located at Tema has almost the same milling capacity and GAFCO also located at Tema has the half that capacity. Considering these three existing flourmills, a site with 2.0 ha is sufficient to a flourmill with the milling capacity of 600 t/day and silos of 30,000 tons.

13.2.5 Inland Transportation Facilities

(1) Road

At present almost all port cargoes except manganese and bauxite are transported to/from Takoradi Port by tracks. Therefore, the attractiveness of the port heavily depends on road infrastructure in the hinterland. Recently, the road network between the port and Central Region and Ashanti Region has been remarkably improved and even the roads to Northern Region and Upper Regions through Kumasi have been improved. This situation is favourable to the port development.

(a) Access Road

There are three existing access roads to the port. One is the road from the south gate to Axim Road passing by the railway station (Access Road 1). Another is the road from the main gate (Gate 7) to Sekondi Road through Harbour Road (Access Road 2). The other is the road from the north gate (Gate 10) to Secondi Roundabout through New Takoradi Hourbour Road (Access Road 3). All three access roads have problems. They are steep, narrow and bent (see Fig.13.2.1).

The traffic volume generated by port activities is estimated by applying the following equation.

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

Where,

υ	2,442	Number of trucks at peak day
σ	2.0	Variation ratio per hour
δ	0.2	Cargo related vehicle ratio
ε	0.5	Ratio of vehicle with load
V	2,035	Number of vehicles at peak hour

According to the estimated traffic volume, 6 lanes are required. The most desirable access route to the trunk road is the route along coastal area to the north which overpasses a river and the railway although construction cost is huge. The practical way is to improve the existing three access roads with two-lane each. It might be difficult to improve Access Road 3 due to the forest conservation regulation.

- Access Road 1 from the south gate to Africana Roundabout should be paved and widened for two heavy lorries to pass by each other.
- Access Road 2 from the main Gate to Sekondi Road should be also widened and its alignment should be modified.

(b) Main Harbour Road

The main harbour road between the main gate and the multipurpose berth is planned. The traffic volume generated by port activities is estimated by applying the following equation.

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

Where,

υ	1,749	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	833	Number of vehicles at peak hour

Considering the estimated traffic volume, a four-lane road is proposed.

(2) Rail

Railways link with other areas such as Kumasi and mining sites is one of the important attributes of Takoradi Port although the railway has problems in transportation capacity and service level. Most part of the railway is single line and only 30km (between Takoradi and Manso) of total 1,300km is double line. The network is characterized by numerous sharp curves and signaling and telecommunications system are based on overhead cables, which are frequently damaged. Nevertheless, railway is indispensable for the port to develop and efforts to improve railway conditions are being carried.

In 2000 60% of manganese and 85% of bauxite are transported by rail. Ghana Manganese Company and Ghana Bauxite Company would like to increase the railway ratio and are assisting Ghana Railway Corporation to enhance railway capacity by providing new wagons. Now 4 - 5 trains per day transport manganese and 3 – 4 trains per day transport bauxite. In 2020, number of manganese trains per day will be the same but number of bauxite trains will increase 4 –5 trains per day. As mineral companies provide new wagons, there is not a serious problem in train capacity for mineral transportation.

The viability of container transportation by rail will be examined as a long-term matter with the cooperation of rail related people taking into account the advantages of rail linkage with Kumasi, where Kumasi Inland Port will be developed. There are several potential sites for the intermodal terminal: the train marshalling yards next to New Container Platform, the railroad siding in front of Cocoa Sheds and the railroad siding used by manganese train. Competitiveness of the railway to trucks will have to be analyzed carefully from the viewpoints of cost, speed, frequency and reliability.

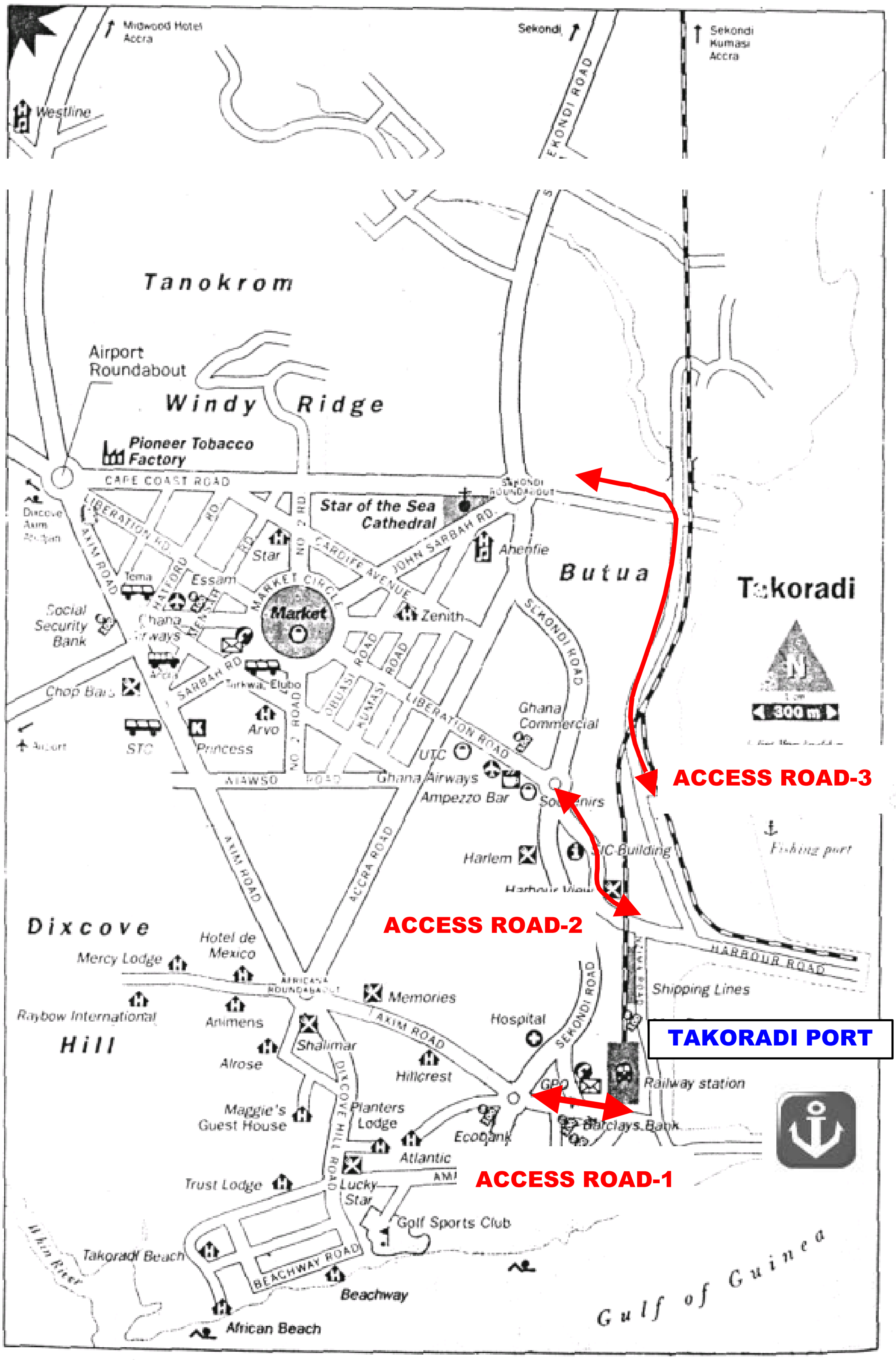

Figure 13.2.1 Access Road Map

13.3 Alternatives of Port Facility Layout Plan

13.3.1 Alternatives of Port Facility Layout Plan

Based on field surveys, cargo demand forecast and other study results, two (2) 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 double handling and lack of deep berths, and how to minimize the construction cost. As for construction cost, the difficulty lies in how to layout new berths and water facilities which involve hard rock dredging works and position breakwaters so that they sufficiently protect berths and water facilities from wave while also maintaining economic viability.

(1) Alternative-1 (Redevelopment of existing port and expansion to the north)

Offshore side of Lee Breakwater will be reclaimed with a width of 300m and new bulk berths will be constructed there. Berth No. 1 to Berth No. 6 will be deepened to 12m and will be used for container and multipurpose berths. Inner port area will be reclaimed and a new container berth will be constructed there. The advantages of this plan are that narrow berths will disappear and bulk cargoes and general cargoes will be segregated, and the inner port area, which is not used any more because of its shallowness, will be converted to deep berths and a wide storage area. The problem with this plan is that as the transfer of Clinker Berth, Oil Berth and Bauxite Berth is required, measures to secure cargo handling of such commodities without interruptions will need to be taken. This will also involve obtaining the cooperation of users of these berths.

This plan is further divided into two (2) sub-alternatives as mentioned below according to the implementation procedures. Because of the difference of implementation schedule allocation of commodities to berths in the short-term becomes different between the two alternatives.

(2) Alternative-1-1 (see Fig. 13.3.1)

In this plan, redevelopment of the existing port area and development of the north offshore side of Lee Breakwater will be at the same time.

The advantages of the plan compared with alternative-1-2 described below are that cargo handling conditions of existing berths will be improved dramatically because cargo handling yards behinds berths will be provided, break bulk cargo area and mineral bulk cargo area will be segregated clearly and new berths constructed outside the existing port will become seeds for smooth implementation of construction projects. The disadvantages of the plan are that the construction of dedicated container berths is planned at the latter stage and the construction of a breakwater is necessary at the short-term development plan.

(3) Alternative-1-2 (see Fig. 13.3.2)

In this plan, redevelopment of existing port area will be carried out at first as the short-term development plan and then the development of the north offshore side of Lee Breakwater will be carried out. New berths which will be constructed at inner harbour area are used as multi purpose berths for container cargoes and RORO cargoes. Redeveloped berths of Berth No.4 to Berth No.6 will be used as bulk berths for manganese, clinker and other dry bulk cargoes on a temporary basis. After the new berths are constructed at the north offshore side of Lee Breakwater, these cargoes will be transferred to the new berths.

The advantage of the plan compared with alternative-1-1 is that construction of a new breakwater will not be needed in the short-term development plan. The disadvantages of the plan are necessity of shifting berth allocation for mineral cargoes and that the cargo handling condition in the short-term will not be improved.

(4) Alternative-2 (see Fig. 13.3.3)

In this plan, development of the offshore side of Lee Breakwater has priority and development of existing port area is limited to minimize the dredging work of rock soil. Berth No. 1 to Berth No. 6 will be redeveloped and deepened to 12m and the minimum area necessary for vessels' berthing will be dredged. In the offshore side of Lee Breakwater, area will be reclaimed and a new container berth and new bulk berths will be constructed.

13.3.2 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

One of the problems of the port is that apron and cargo handling yards behind berths are very narrow and this results in inefficient cargo handling. Among alternatives alternative-1-2 and alternative-2 will still have this problem after the short-term development plan. However, alternative-1-2 will have a dedicated container terminal earlier than other alternatives.

(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. 13.3.1. The criterion of container berths is that the non-excess probability under 0.5m in wave height is 95%. And that of bulk berths is that the non-excess probability under 0.7m in wave height is 95%. Both alternatives satisfy the criteria.

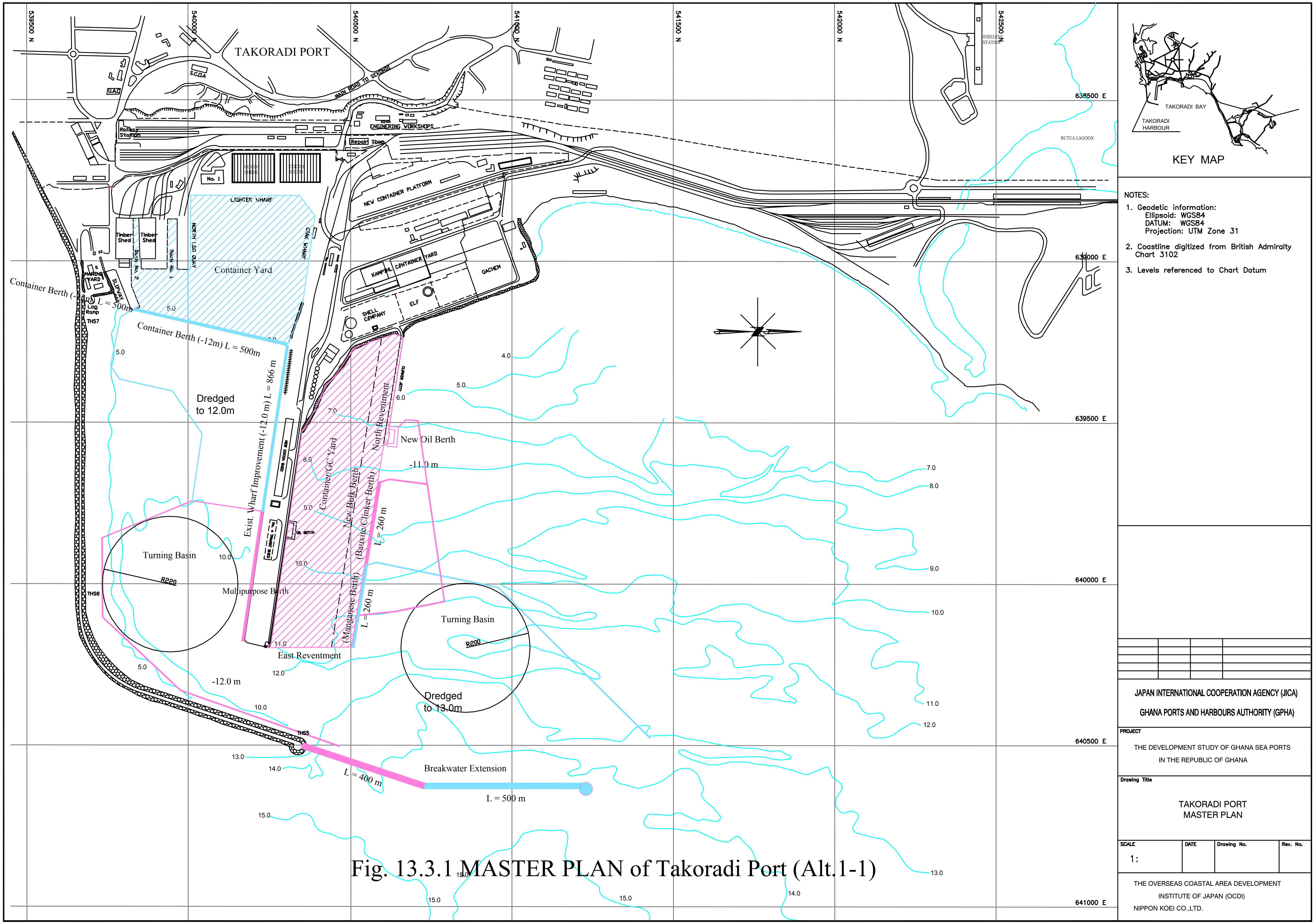

Fig. 13.3.1 MASTER PLAN of Takoradi Port (Alt.1-1)

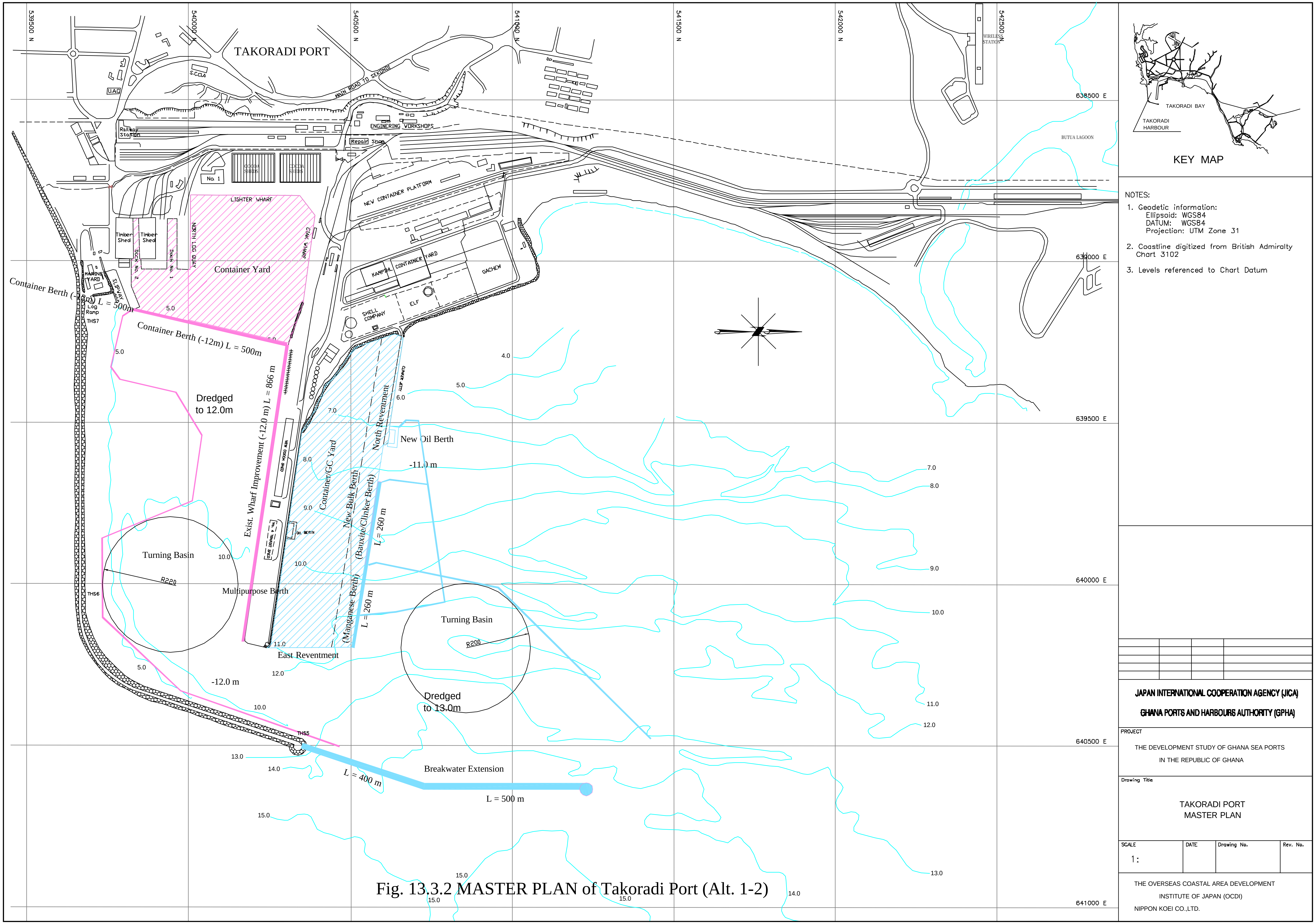

Fig. 13.3.2 MASTER PLAN of Takoradi Port (Alt. 1-2)

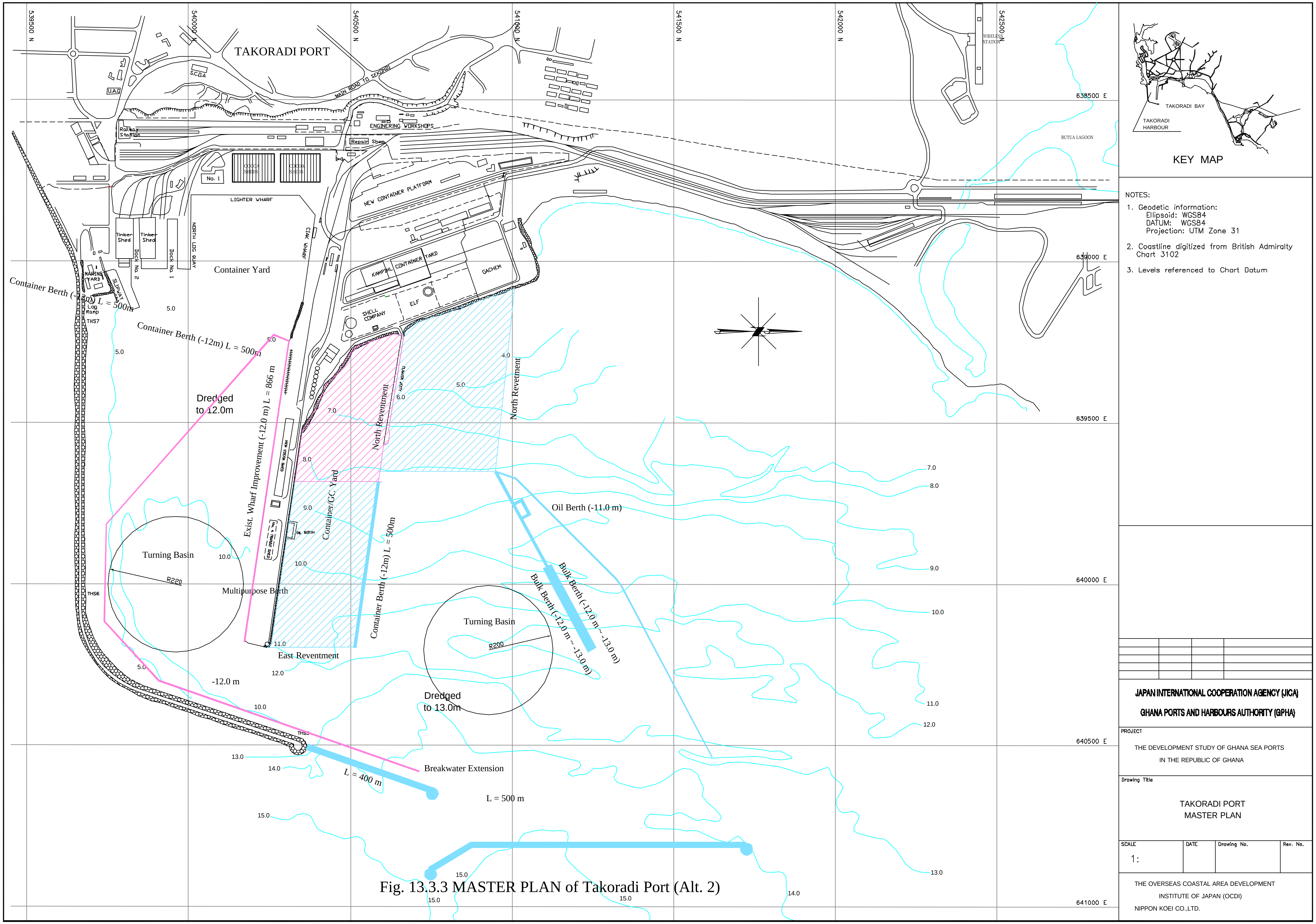

Fig. 13.3.3 MASTER PLAN of Takoradi Port (Alt. 2)

Table 13.3.1 Degree of Calmness

Wave height	< 0.5m	< 0.7m
Alternative-1		
Manganese berth	96.9%	98.0%
Bauxite/clinker berth	96.7%	97.9%
Alternative-2		
Manganese berth	96.7%	97.8%
Bauxite/clinker berth	96.7%	98.0%
New container berth	98.0%	-

(3) Navigational Safety

Navigational safety is examined and checked from two items. All alternatives satisfy all items and there is little deference in terms of navigational safety among alternatives.

- Stopping distance

A vessel requires "stopping distance" of five times her length to stop safely after reducing her speed. At present stopping distance protected by breakwaters is not enough. As vessels have to turn by 90 degrees to berth, they have to decrease their speed to a certain level before reaching the sheltered water area. This problem will be solved in all alternatives.

- Wave on vessel

It becomes more difficult to maneuver vessels when waves flow from a vessel's stern, especially vessels at low speed. As in all alternatives main waves flow from a vessel's stem, the situation is preferable for vessels to enter the port. The situation will be maintained in future.

(4) Future development

Takoradi Port has expansion area in the north up to New Takoradi Area. Expansion is easier here than at Tema Port, because the expansion direction is coincident with the leeword of wave. Alternative-2 has some restrictions for further expansion to the north because of the bulk dolphin berths.

(5) Disturbance to existing facilities

As dredging works of basins in existing port area restricts vessel movement in the port, it is preferable to construct new berths outside the existing port area. Among alternatives, alternative-1-1 and -1-2 have the plan to construct a new berth at early stage of the master plan. By using the new berth reallocation of commodities to berths will be carried out smoothly.

(6) Harmonization with environment

Differences in the environmental impact on land environment will be minimum for both alternatives. In both alternatives, land filling and dredging sites are not exposed to the major current flow, thus disturbance in the major current flow should be negligible. The most significant difference in both alternatives, environmental impact wise, is the layout of the breakwater and the existing port basin.

The extended breakwater in Alternative 1 will reduce water exchange between the port and offshore waters, thus enhancing sedimentation, turbidity and deterioration of water quality. Inversely, land filling in the innermost port basin in Alternative 1 will improve the stagnation of water. Instead, Alternative 2 has an offshore breakwater thus water exchange is not as restricted as in Alternative 1. Therefore, Alternative 1 and 2 will likely have a similar magnitude of impact on the environment.

(7) Cost

Construction costs of alternative-1 and –2 are shown in Table 13.3.2. The difference in construction costs between alternatives comes from the difference in the length of breakwaters and volume of dredging materials. Cost of cargo handling equipment for mineral bulk cargoes is not included. Details of construction cost of each alternative are attached in appendix.

Table 13.3.2 Construction Cost

(US$ million)

	Alternative-1	Alternative-2
Cost	249,651	272,000
Cost index	100	109

13.3.3 Evaluation of Alternatives

Table 13.3.3 summarizes the evaluation of alternatives from many aspects. Alternative-1 is recommended as the master plan of Takoradi Port. Implementation procedure of port facilities is examined in the short-term development plan.

Table 13.3.3 Comparison of Alternatives

	Alternative-1-1	Alternative-1-2	Alternative-2
Quality of berths	***	***	**
Calmness of water	***	***	***
Navigational safety	***	***	***
Future development	***	***	**
Disturbing existing port facility	***	***	**
Harmonization with environment	***	***	***
Cost Index	100	100	109

Note *** Good ** Fair * Poor

13.4 Port Facility Layout Plan and Priority on Projects

13.4.1 Port Facility Layout Plan

Based on the scale of necessary facilities for the master plan, alternatives of port facility layout are formulated and the best alternatives is selected as port facility layout plan for the master plan (please refer to the Interim Report (1)). Fig. 13.4.1 and 13.4.2 show the port facility layout selected and Table 13.4.1 shows the list of main facilities of the master plan.

Table 13.4.1 List of Main Facilities for Master Plan of Takoradi Port

Facility	No.	Dimension / Capacity
Container Berths	2	Length 300m, depth 12m
Multipurpose Berths	3	Length 300m, depth 12m
Manganese Berth	1	Length 200m, depth 12m
Clinker Berth	1	Length 260m, depth 13m
Bauxite Berth	1	Length 260m, depth 13m
Berth for small craft	1	Length 150, depth 5m
Breakwater extension	1	900m
New entrance channel	1	One way, width 160m, depth 13m
Turning basin 1	1	Radius 220m, depth 12m
Turning basin 2	1	Radius 200m, depth 13m
Container yard	1	14.5 ha, 7.5ha
Shed	2	4,000m^2
Revetment	1	480m, 270m, 160m
Access road improvement	1	1 set
Inner harbour road	1	1 set
Navigational aids	1	1 Light beacons, 1 Buoys, 2 Light pole
Tugboat	1	2,420Hp
Container crane	4	45 tons
Multipurpose crane	2	45 tons
Transfer crane	12	40 tons, 1 over 4
Top lifter	6	35 tons, 15 tons
Tractor head	24	For container cargo

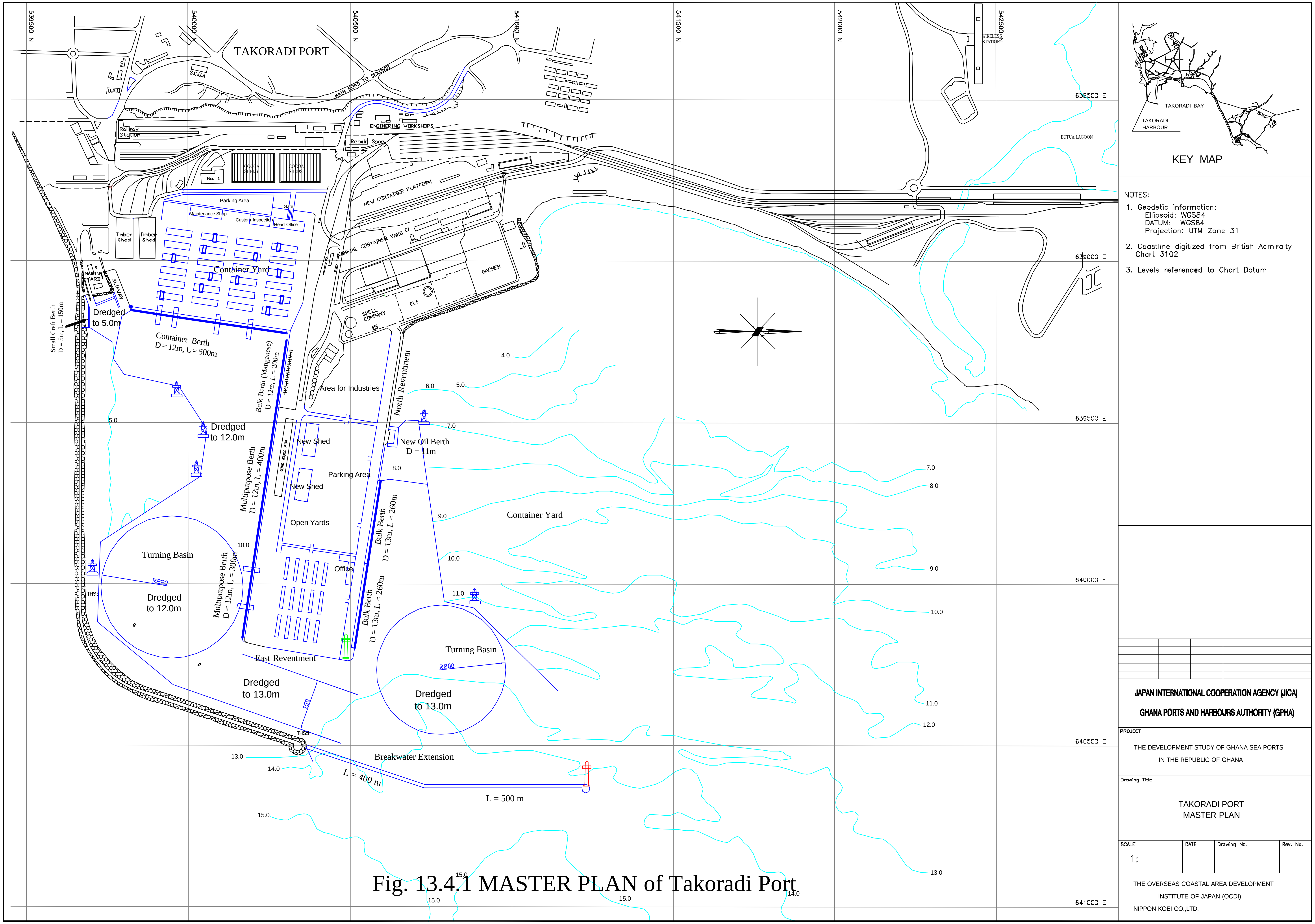

Fig. 13.4.1 MASTER PLAN of Takoradi Port

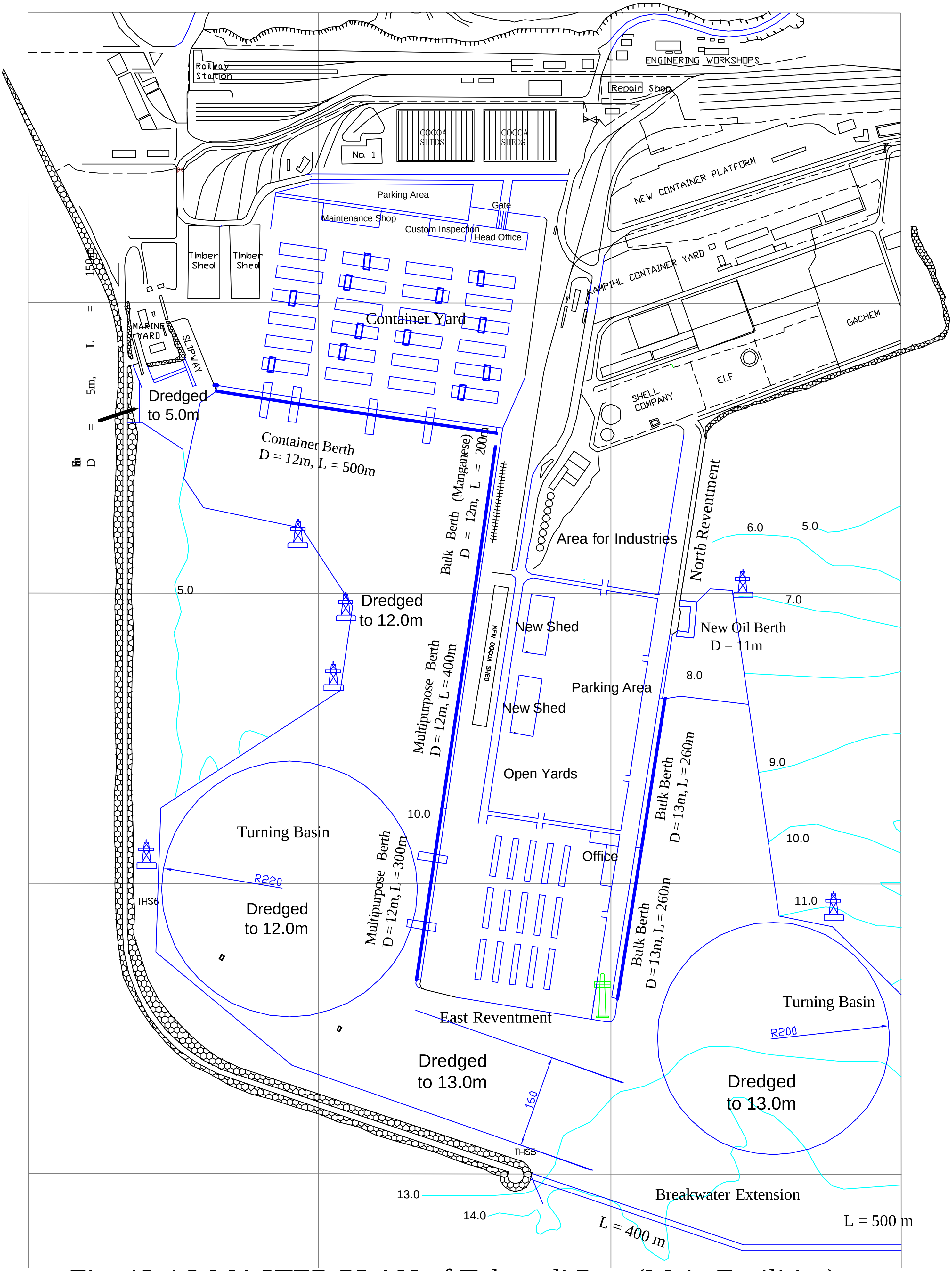

Fig. 13.4.2 MASTER PLAN of Takoradi Port (Main Facilities)

13.4.2 Priority on Projects

The main three projects are proposed in the master plan: new container berths, new bulk berths and new multipurpose berths (improvement of existing berths). The new container berths are the first dedicated container berths at Takoradi Port with sufficient container yards and sophisticated cargo handling equipment. The deep bulk berths are proposed to eliminate double handling operation and for bulk carriers to enter the port at full drafts. In the multipurpose berth project, narrow and shallow berths will be converted to modern deep berths with sufficient cargo handling space.

Although all projects are very important for future development of the port, because of limited resource, especially funds, it is important to evaluate and prioritize each project. Criteria used to evaluate each projects are explained below. As the result, new container has the first priority, bulk berths the second, multipurpose berths the third and oil berth the fourth (see Table 13.4.2).

(1) Effectiveness

Effectiveness of projects is evaluated by indexes such as B/C (benefit/cost), EIRR and FIRR. These indexes are analyzed in a latter chapter. Here, only a rough calculation is possible. As the proportion of construction cost of multipurpose berths, which includes redevelopment of existing berths, dredging works and reclamation, to the increase of cargoes handled there is high compared with other projects, its effectiveness is lower. As for bulk berth project, transportation cost saving of minerals is high if double handling operation is eliminated and larger vessels can enter the port with full draft.

(2) Urgency

Urgency is evaluated by seriousness of the present problems and sharpness of estimated volume increase. Throughput of manganese has increased rapidly in the recent two years and that of bauxite is expected to increase rapidly in the near future. Even at present, double handling operation and congestion of Buoy No.1 increase the transportation cost and the condition will become worse in the future.

Container cargo is estimated to increase rapidly (average annual increase rate is 13% up to 2010). To handle the large number of containers advanced and dedicated container terminals are indispensable.

(3) Social Needs

The magnitude of social needs is evaluated by the range of persons benefited by each project. As containers carry many kinds of cargoes including Ghanaian traditional and non-traditional products for export and consumer goods and intermediate for import, many Ghanaian people and companies from small-medium size to large size can get benefits from the rationalization of container transport. On the other hand, the number of people who will get benefit from bulk berth project is limited.

(4) Competition with Other Ports

Takoradi Port competes with other ports such as Tema Port and Abidjan Port for cargoes. Investment that is necessary to attract cargoes should be done timely, otherwise the port will lose potential cargoes. In this sense, container cargo is the most critical.

Table 13.4.2. Comparison of Projects

Project Name	Bulk Berth	Oil Berth	Container Berth	Multipurpose Berth
Effectiveness (benefit/cost)	***	**	***	**
	Elimination of double handling, provision of of deep	Existing berth has sufficient depth in a mean while	Sufficient container handling space, provision of deep	Provision of deep berths
Urgency (degree of existing problems, shrapness of cargo volume increase)	***	**	***	**
	Serious, cargo increase is rapid	Cargo increase is moderate	Serious, cargo volume increase is rapid	Cargo increase is moderate
Social needs	*	**	***	**
	Limited companies	One company but consumer goods	Wide range of cargoes	Fairly wide range of cargoes
Competition with other ports	*	*	***	**
	Not critical	Not critical	Critical	
Priority	**2**	**4**	**1**	**3**

Note *** High ** Medium * Law

13.5 Proposal for Efficient and Reliable Port Operation

13.5.1 General Principles of Port Management and Operation

Port authorities should focus on the following three points for port management and operation to attract port users, especially foreign shipping lines.

(1) Efficient services

High productivity of cargo handling, seamless smooth operation and speedy procedure for cargo clearance are indispensable. These guarantee port users that the transportation cost through a port will be minimized.

(2) Reliability and availability of port facilities

Port facilities and cargo handling equipment must be well maintained so that port users can make full use of facilities and equipment. Breakdown time has to be minimized. Storage facilities should be properly designed to prevent cargo damages. Security measures for cargoes or countermeasures against pilferage must be taken effectively. Cargo handling operation must be precise, careful and safe.

(3) Reasonable tariff

Port charges should be competitive but must cover the cost of construction, management and maintenance of port facilities. Furthermore, tariff structure should encourage port users to use port facilities efficiently.

13.5.2 Proposal for Efficient Port Operation System

(1) Container Cargo

Container handling is mainly conducted at berths 2-6 by container ship (CO), container/multipurpose ship (CM) and Ro/Ro ship (RO). However, other cargoes such as general cargo and bagged cargo are also handled at these berths together which results in congestion and reduced cargo-handling productivity. It is necessary to increase the efficiency of operation in Takoradi Port. These cargoes should be handled exclusively at a separate berth.

(a) Container handling berth in Takoradi

- New container terminal (length 500m, 2 berth, depth 12m) with a sufficient container yard will be constructed at the inner port area. This is the first dedicated container terminal at Takoradi Port with sufficient container yards and sophisticated cargo handling equipment.
- Berths 5-6 will be redeveloped as a multipurpose berth (length 300m) for container and Ro/Ro vessels with a depth of 12m.
- Container cargo will be handled at both the new container terminal and the new multipurpose

berth.

(b) Basic policy of container handling in Takoradi

- Eighty-five percent of container cargo will be handled at the new container terminal, and the rest (15%) will be handled at the new multipurpose berth.
- Until the container yard behind the new multipurpose berth is constructed, container cargoes should be carried to the New Container Platform (NCP) or GPHA's new container yard near the gate (KAMPIHL Container Yard, opened in August 2001). Users of the new multipurpose berth have priority to utilize New Container Platform (NCP) and KAMPIHL Container Yard.
- After the opening of the new container yard behind the new multipurpose berth, NCP and KAMPIHL Container Yard will be utilized as a backup yard area or empty container storage area.

Table 13.5.1 Estimated Storage Area for Container Cargo

Port of Takoradi		2000	2010	2020	unit
Volume of Container Cargo		39,966	136,196	407,742	TEU
Volume of Container Cargo		31,469	107,241	321,057	Box
Productivity		9	24	30	box/hour/vessel
Working day		365	365	365	day
Cargo throughput in a day		109	373	1,117	TEU/day
Average Dwell Time(Target)		12	6	4	day
Peak Ratio		1.3	1.3	1.3	
		2000	2010	2020	
Mininum Volume		1,700	2,909	5,808	TEU
for Container storage					
Mininum Area	2 tiers	21,255	36,368	72,605	m2
for Container Storage	3 tiers	14,170	24,245	48,404	m2
	4 tiers	**10,628**	**18,184**	**36,303**	**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

(c) New Container Terminal at Inner Port Area

- In the master plan, a new container terminal with 2 berths (length 500m, depth 12m) is proposed to be constructed at the inner port area. For the most efficient use of this area, transfer-crane method should be introduced to handle the maximum volume of container cargoes. (The merits and demerits of transfer-crane method are described in Chapter 14.5.1.)

- At Takoradi Port, the forecasted volume of container cargo in 2020 is 407,742 TEUs. It is assumed that 85% of the forecasted volume of container cargo will be handled at the new container terminal, and the rest (15%) will be handled at the new multipurpose berth. Container handling volume at the new container terminal is calculated in Table 13.5.2.

Table 13.5.2 Estimated Storage Area for New Container Terminal

			70%	85%	
Port of Takoradi (New Cont.T)		2000	2010	2020	unit
Volume of Container Cargo		0	95,338	346,581	TEU
Volume of Container Cargo		0	75,069	272,898	Box
Productivity		9	24	30	box/hour/vessel
Working day		365	365	365	day
Cargo throughput in a day		0	261	950	TEU/day
Average Dwell Time(Target)		12	6	4	day
Peak Ratio		1.3	1.3	1.3	
		2000	2010	2020	
Mininum Volume		0	2,036	4,940	TEU
for Container storage					
Mininum Area	2 tiers	0	25,448	61,750	m2
for Container Storage	3 tiers	0	16,965	41,167	m2
	4 tiers	**0**	**12,724**	**30,875**	**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

Dairy container handling volume at the new container terminal
= 407,742 x 85% / 365 = 950 TEUs/day
Average dwelling time = 4 days (as target value in 2020)
Container storage capacity at the new container terminal = 950 x 4 x 1.3 = 4,940 TEUs
Minimum area for container storage = (4,940/4) x 25m^2 = 30,875 m^2
(4 tiers high, 1TEU=25m^2)

The layout of the new container terminal is envisioned in Figure 13.5.4. The storage capacity under this layout is 6,240 TEUs and is sufficient for the estimated container throughput.

- Four gantry cranes are proposed to be installed at the new container berth. (2 cranes at each berth).
- The required number of transfer cranes for the new container terminal (Ntc) is estimated as below.

Ntc = Nqsc x 2 + A/(T x Ptc x E) +Ntc-backup
= 8 + 1.55 + 2 = 11.55 → 12 units

Nqsc = Number of quay side gantry cranes	4 units
A = Annual throughput in TEUs	346,581 TEUs
T = Maximum available working hours per year	8,760 hours/year
Ptc = Net productivity of transfer cranes	20 boxes/hour/Tcrane
E = Conversion rate (TEU/box)	1.27 TEUs/Box
Ntc-backup = Number of transfer cranes for backup	2 units

- Between quay side and marshalling yard, container cargo will 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-trailer is estimated at 16 units for 4 gantry cranes.

In total for the new container berth:	Quay side gantry crane:	4 units
	Transfer crane:	12 units
	Yard tractor trailer:	16 units
	Storage capacity:	6,240 TEUs
	（layout:	Figure 13.5.4）

Figure 13.5.3 Container Terminal with Gantry Cranes and Transfer Cranes

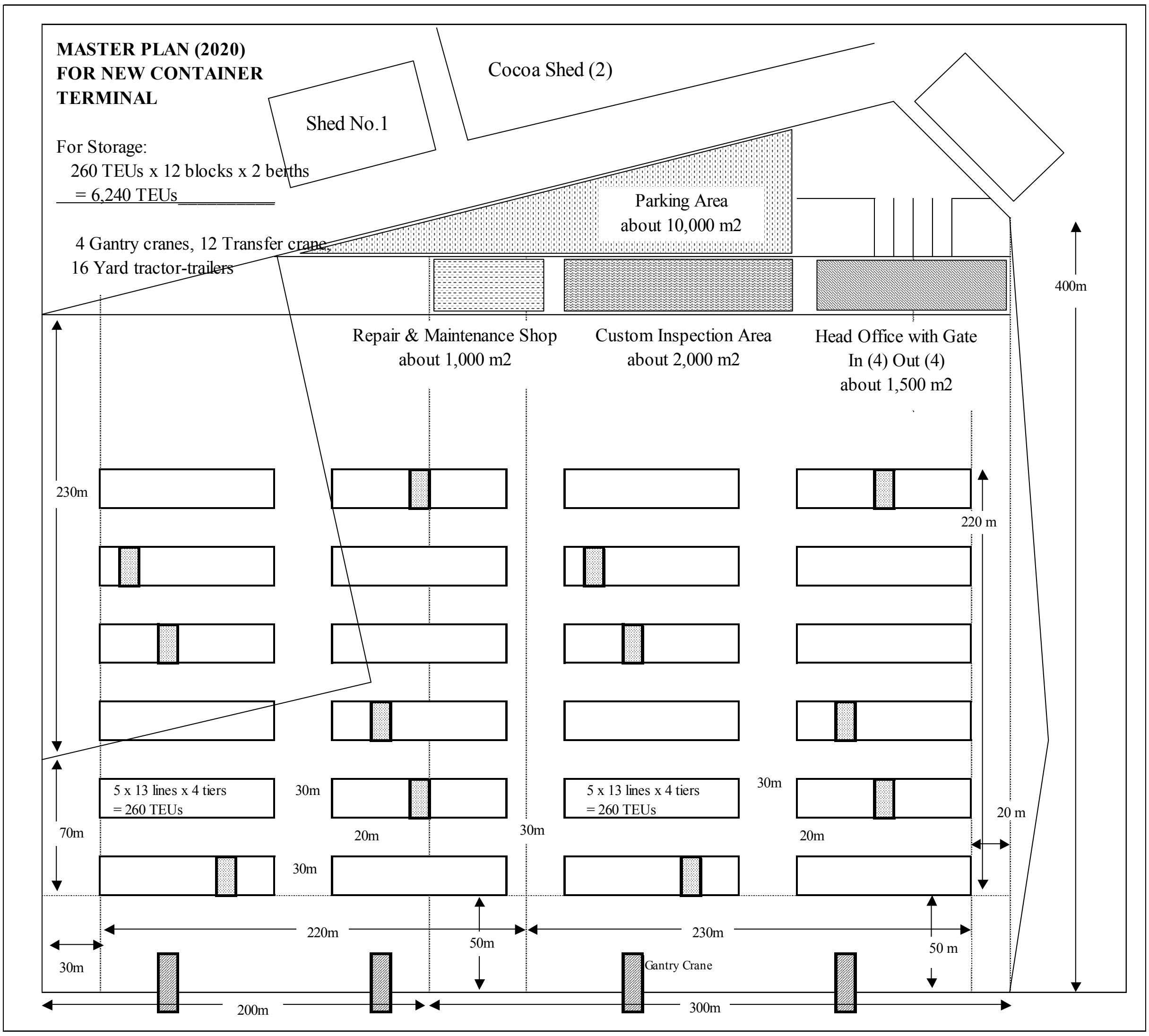

Figure 13.5.4 Layout of New Container Terminal in 2020

(d) New Multipurpose Berth (Berths 5-6)

- Top-lifter method is the most convenient for container handling in the new multipurpose berth because it is easier to change the cargo handling layout.
- A new container yard is indispensable behind the new multipurpose berth.
- Before opening the container yard behind the multipurpose berth, NCP and KAMPIHL Container Yard is utilized for the new multipurpose berth.
- At the new multipurpose berth, it is necessary to introduce two gantry cranes with multi-use-attachment (new multipurpose berth will be utilized as two continuous berths) for container handling and other heavy cargoes.

Figure 13.5.5　Gantry Crane

・At Takoradi Port, the forecasted volume of container cargo in 2020 is 407,742 TEUs (refer to Table 13.5.1). Assuming that 15% of the forecasted volume of container cargo will be handled at the new multipurpose berth, and the rest will be handled at the new container terminal (2 berths), the container yard area behind the new multipurpose berth is calculated in Table 13.5.6.

Table 13.5.6　Estimated Storage Area for New Multipurpose Berth

			30%	15%	
Port of Takoradi (Multipurpose)		2000	2010	2020	unit
Volume of Container Cargo		39,966	40,858	61,161	TEU
Volume of Container Cargo		31,469	32,172	48,159	Box
Productivity		9	24	30	box/hour/vessel
Working day		365	365	365	day
Cargo throughput in a day		109	112	168	TEU/day
Average Dwell Time(Target)		12	6	4	day
Peak Ratio		1.3	1.3	1.3	
		2000	2010	2020	
Mininum Volume		1,700	874	874	TEU
for Container storage					
Mininum Area	2 tiers	21,255	10,920	10,920	m2
for Container Storage	**3 tiers**	**14,170**	**7,280**	**7,280**	**m2**
	4 tiers	10,628	5,460	5,460	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

Dairy container handling volume at the new multipurpose berth
= 407,742 x 15% / 365 = 168 TEUs/day
Average dwelling time = 4 days (as target value at 2020)
Container storage capacity at the new multipurpose berth = 168 x 4 x 1.3 = 874 TEUs
Minimum area for container Storage = (874/3) x 25 m^2 = 7,280 m^2
(3 tiers high for top lifter method, 1 TEU = 25 m^2)

The layout of the new container yard behind the new multipurpose berth is envisioned in Figure 13.5.7. The storage capacity under this layout is 900 TEUs and is sufficient for the required capacity of 874 TEUs.

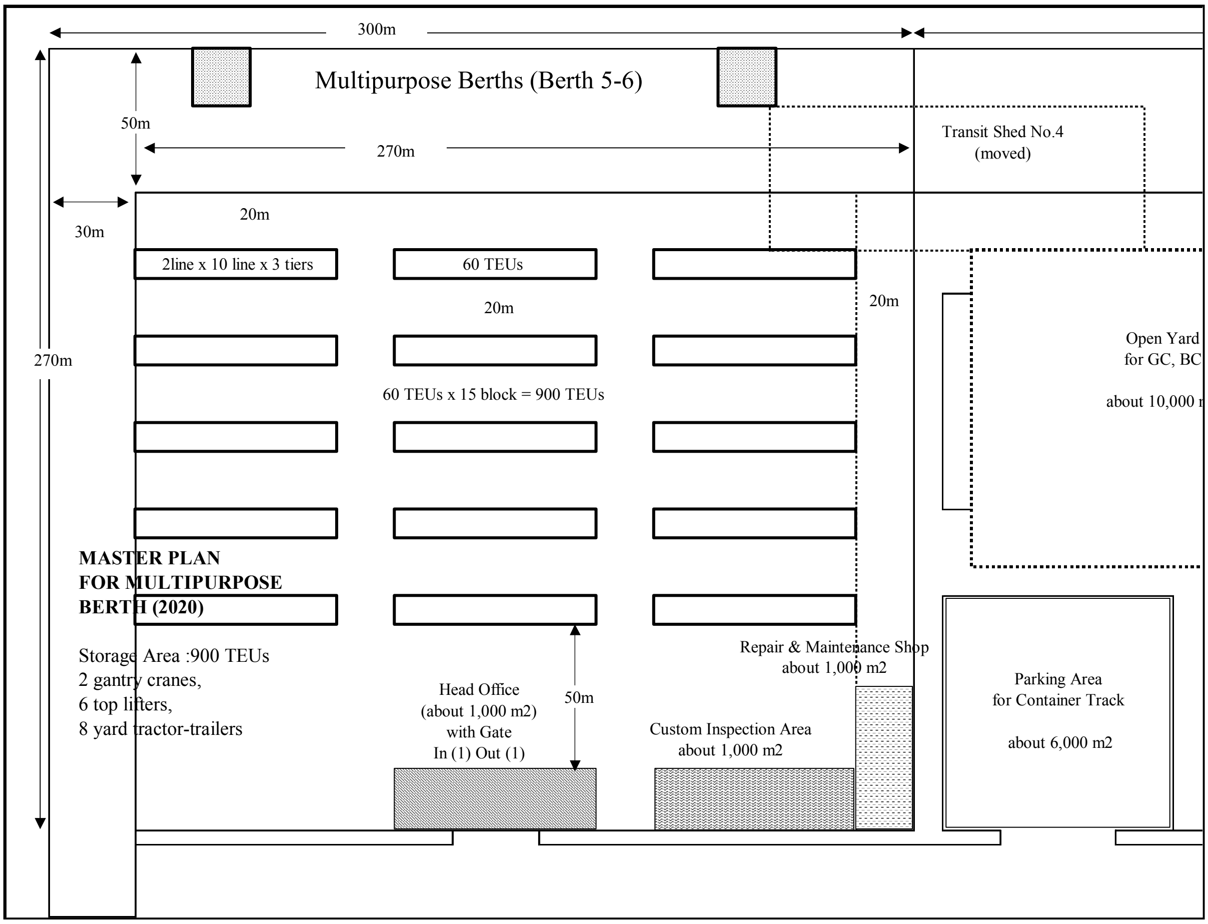

Figure 13.5.7 Layout of Container Yard at New Multipurpose Berth

・For container handling at the new multipurpose berth, 3 top lifters are required for 1 crane (1 for import, 1 for export, 1 for container relocation and backup). In total, 6 top lifters are required for the new multipurpose berth.

Between the new multipurpose berth and the container yard behind the berths, container cargo should be carried by yard tractor with trailers. The required number of yard tractor-trailers for each quay-side crane Nytt(1) is estimated as follows.

$$Nytt(1) = (Ttp + Lytt/(Vytt/60)) / Tqsc + Nbackup$$
$$= (3+1(15/60))/3+1 = 2.33 + 1 = 3.33 \text{ units} \rightarrow 4 \text{ units}$$

Ttp = Handling time under top lifter = 3 minutes/cycle
Lytt = Average travelling length of yard tractors = 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

The required number of yard tractor-trailers is estimated as 4 units for each quay-side crane. Therefore, 8 units of yard tractor-trailers are required for the new multipurpose berth.

Total for the new multipurpose berth;	Quay side gantry crane:	2 units
	Top lifter:	6 units
	Yard tractor trailer:	8 units

(e) KAMPIHL Container Yard and New Container Platform (NCP)

・KAMPIHL Container Yard was opened near the gate in August 2001 and storage capacity is 786 TEUs. The storage area is allocated by shipping companies and can be used more efficiently than NCP (New Container Platform). At the NCP, all kinds containers (such as loaded, empty, chemical, dry) are put together in the same area. A partitioning system separated by types of container or shipping companies is desirable to be introduced at the NCP immediately.

(f) Additional Measures to Increase the 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 (Manganese, Bauxite, Clinker)

Improving bulk cargo handling productivity is one of the most important tasks for Takoradi Port. Most bulk vessels are quite large and are supposed to berth at Buoy 1 because of their draft. Most bulk vessels cannot berth directly and have to wait for a long time (manganese berth, bauxite berth and clinker jetty). Bulk cargo such as manganese, bauxite and clinker is usually transported by means of lighterage. This double-handling greatly reduces the bulk cargo handling productivity.

Therefore, deepening the bulk berths (manganese berth, bauxite berth) will resolve the double-handling problem and result in higher bulk cargo handling productivity. (In case of manganese, the productivity of manganese handling at manganese berth is about 6,000 ton/day, meanwhile the productivity by lighter is about only 3,000 ton/day). Therefore, the master plan calls for the improvement of the manganese berth and the construction of new bulk berths for bauxite and clinker adjacent to the clinker jetty.

At Takoradi Port, bauxite and clinker are usually handled at the same facility; belt conveyors for each cargo are appropriately located so as not to interfere with one another. The improvement of bulk cargo handling productivity will be achieved by eliminating the double-handling.

In addition, a new bulk berth for manganese will be constructed to resolve the double-handling problem.

- Bulk cargo volume forecast in Takoradi Port is shown in Table 13.5.8. The required bulk storage area is also estimated in Table 13.5.8 based on the average daily bulk volume and average dwelling time of bulk cargoes. For these bulk cargoes, enough storage area is already provided in the port.

- With the construction of the new bulk berths and improvement of the manganese berth, manganese, bauxite and clinker will be able to be loaded and discharged directly to/from vessels at these berths. Present conveyor belt system for these bulk cargoes will be improved and extended for direct handling to/from vessels. For example, the present productivity of conveyor belt is 6,000 t/day (about 300 t/hour) for manganese, 500 t/hour for bauxite, and 700 t/hour for clinker. These conveyor belt systems are almost sufficient to achieve the estimated productivity.

- The location of new bulk berths is shown in Figure 14.3.1. In this plan, conveyor belt systems for bauxite and clinker need to be extended from their present position to the new bulk berths. These extension works will be done by mining companies.

Table 13.5.8 Estimated Storage Area of Bulk Cargoes

MINERAL BULK CARGO VOLUME AT TAKORADI		2000	2010	2020
Manganese (ton)		929,296	1,000,000	1,000,000
Bauxite (ton)		503,823	1,000,000	1,500,000
Clinker (ton)		694,374	991,760	1,458,160
Productivity	Manganese	210	600	600
	Bauxite	190	600	600
(ton/hour/vessel)	Clinker	270	600	600
Working Day (day)		365	365	365
Cargo throughput	Manganese	2,546	2,740	2,740
in a day	Bauxite	1,380	2,740	4,110
(ton/day)	Clinker	1,902	2,717	3,995
Average Dwelling Time	Manganese	14	14	14
	Bauxite	35	28	28
(day)	Clinker	14	14	14
Estimated Required Capacity	Manganese	35,644	38,356	38,356
	Bauxite	48,312	76,712	115,068
(ton)	Clinker	26,634	38,040	55,929
Required Storage Capacity	Manganese	**40,000**	40,000	40,000
***2000: present capacity**	Bauxite	**120,000**	120,000	120,000
(ton)	Clinker	**80,000**	80,000	80,000

(3) Ro-Ro Cargo, General Cargo and Others

Ro-Ro cargo is handled mainly at Berths 6 because of the draft of Ro-Ro vessels. Container cargo, paper reels, and sawn timber are mainly loaded and discharged as Ro-Ro cargo. Ro-Ro cargo is necessary to be loaded or discharged at the berth as soon as possible, and to be transferred to the container yard or shed immediately to make marshalling yard free.

Sawn timber is handled by a combination of forklifts and trailers in the yard and apron. Some sawn timber is also handled as container cargo and some vanning operations of sawn timbers is done behind Berth 6 resulting in some congestion. These vanning activities should be done at the timber shed or transit shed.

Wheat is imported as a grain bulk by Takoradi Flour Mill, using ship gear, grab bucket and hopper and load directly to the trucks, and then carry out to the silo of Takoradi Flour Mill.

The estimated storage area for general cargo and bagged cargo in Takoradi is shown in Chapter 14.2.4. In consideration of passage and parking area, the proposed layout of Berths 2-4 is shown in Figure 13.5.9.

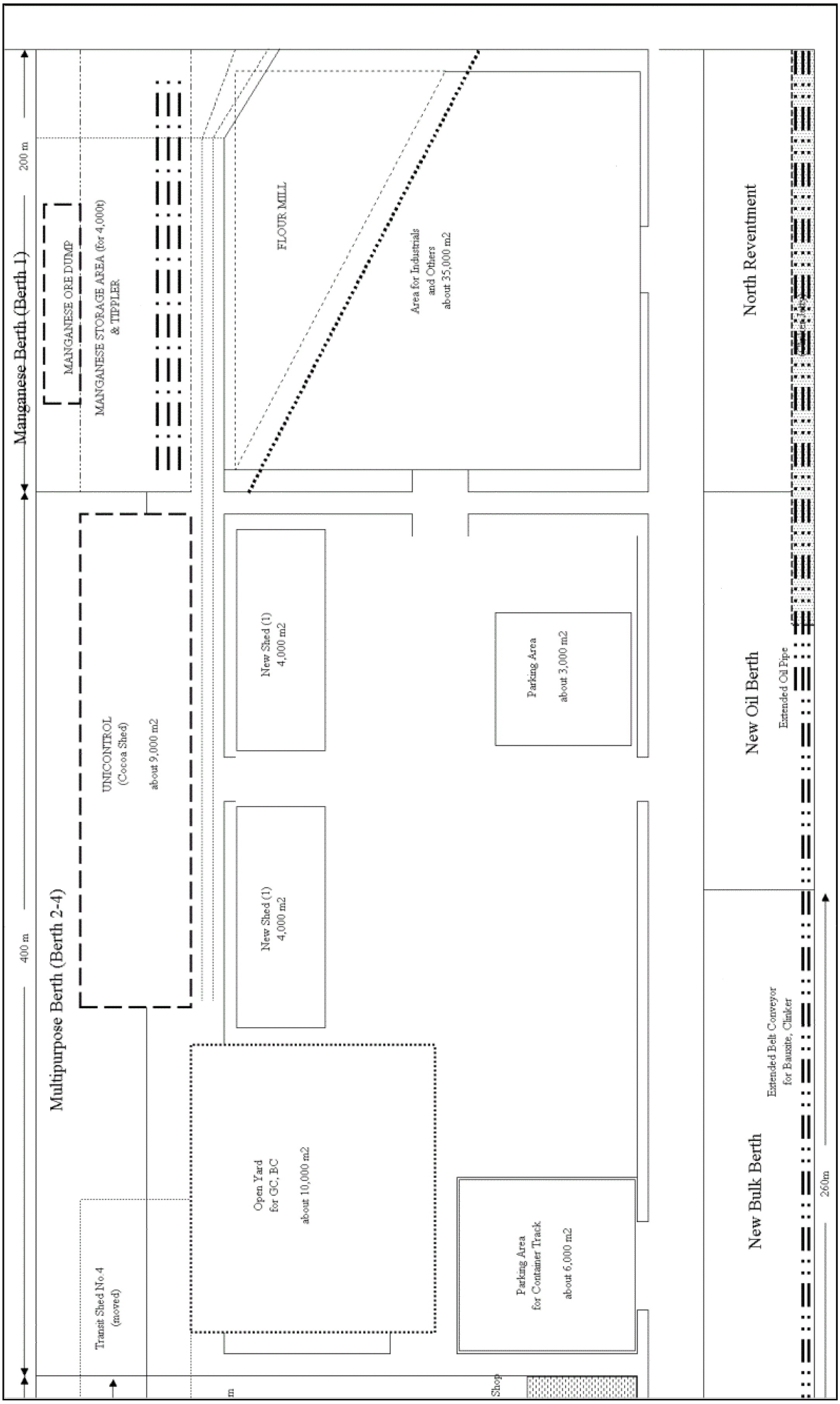

Figure 13.5.9 Proposed Layout Plan behind Berths 1-4

(4) 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.

(5) Introduction of the Port EDI System

The port EDI system is described in Chapter 15.1.4.