PART III MASTER PLAN

Chapter 13 Master Plan for Takoradi Port

13.1 Planning Requirement for Master Plan

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 in Chapter 6. The bottlenecks of the port are listed below.

To become a middle-income country, the role of Takoradi Port is very important as the second largest port in Ghana. Takoradi 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, timber.
- Functioning as an import port of commodities consumed in West Ghana such as foodstuff 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.

Based on the appropriate role sharing between Takoradi Port and Tema 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**

13.2 Facility Requirement for Master Plan

(1) Cargo Handling Productivity

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 productivities which are used 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.

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

Vessel Type	2000		2020 (Standard Size)		
	Max.DWT (tons)	$DWT_{1/4}$ (tons)	DWT (tons)	Length (m)	Draft (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) Number of Berths for Master Plan

Based on studies above, the number of new berths for the master plan are determined. The result is shown in Table 13.2.3.

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	

13.3 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 double handling and lack of deep berths, and how to minimize the construction cost.

(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.

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.

Alternative-1-1 (see Fig. 13.3.1)

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

Alternative-1-2 (see Fig. 13.3.2)

In this plan, redevelopment of existing port area will be carried out at first and then the development of the north offshore side of Lee Breakwater will be carried out.

(2) 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.

(3) 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. Table 13.3.1 summarizes the evaluation of alternatives from many aspects. Alternative-1 is recommended as the master plan of Takoradi Port.

Table 13.3.1 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

Fig. 13.4.1 shows the detailed layout plan of port facilities of the selected alternative in chapter 13.3. 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	35 tons
Multipurpose crane	2	35 tons
Transfer crane	12	35 tons, 1 over 4
Top lifter	6	35 tons, 15 tons
Tractor head	24	For container cargo

(2) Priority on Projects

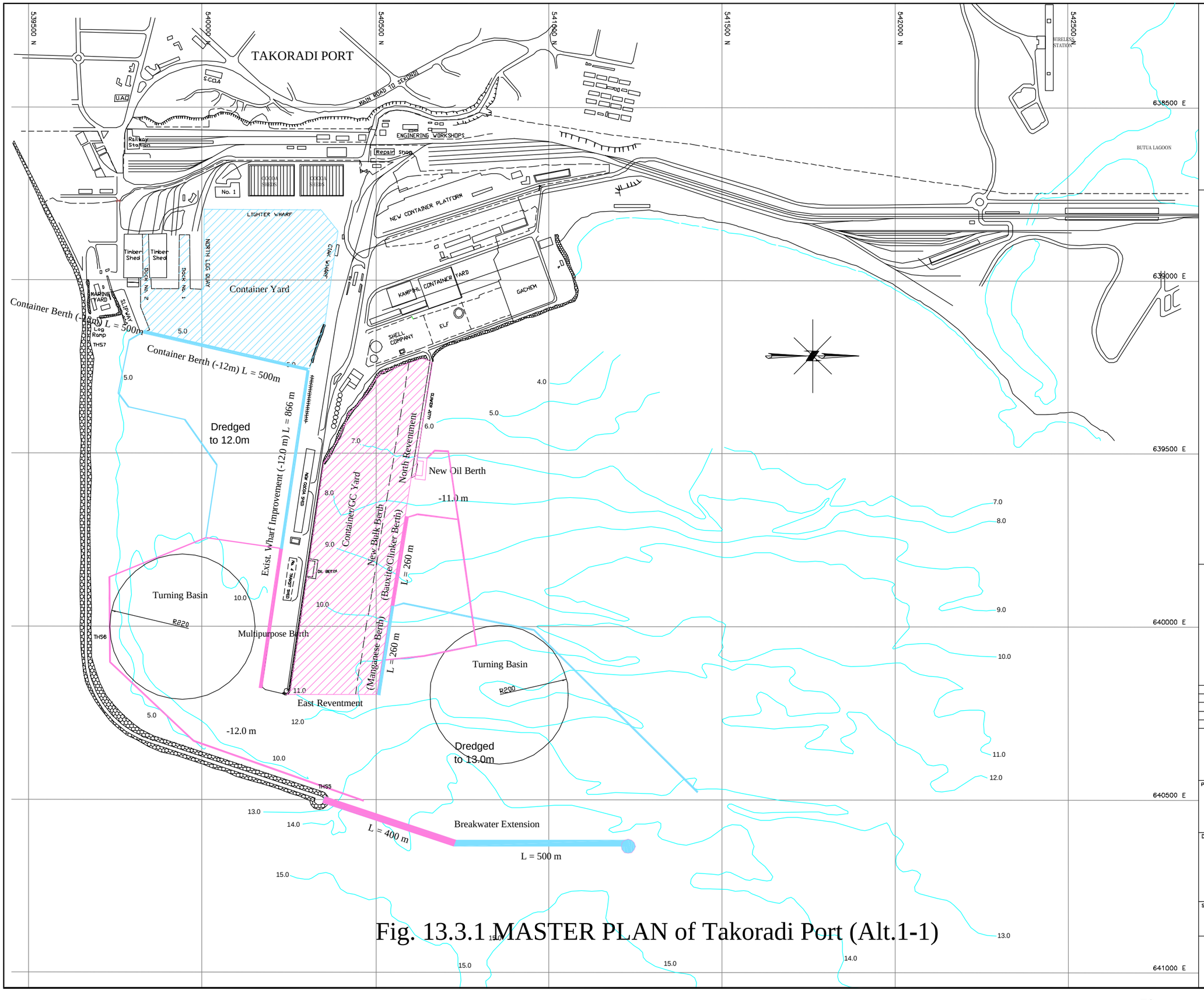
The main three projects are proposed in the master plan: new container berths, new bulk berths and new multipurpose berths (improvement of existing berths). The new container berths are the first dedicated container berths at Takoradi Port with sufficient container yards and sophisticated cargo handling 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. 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).

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 berths	Existing berth has sufficient depth in a mean while	Sufficient container handling space, provision of deep berths	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



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

TAKORADI PORT
MASTER PLAN

SCALE	DATE	Drawing No.	Rev. No.
1:			

THE OVERSEAS COASTAL AREA DEVELOPMENT INSTITUTE OF JAPAN (OCDI)

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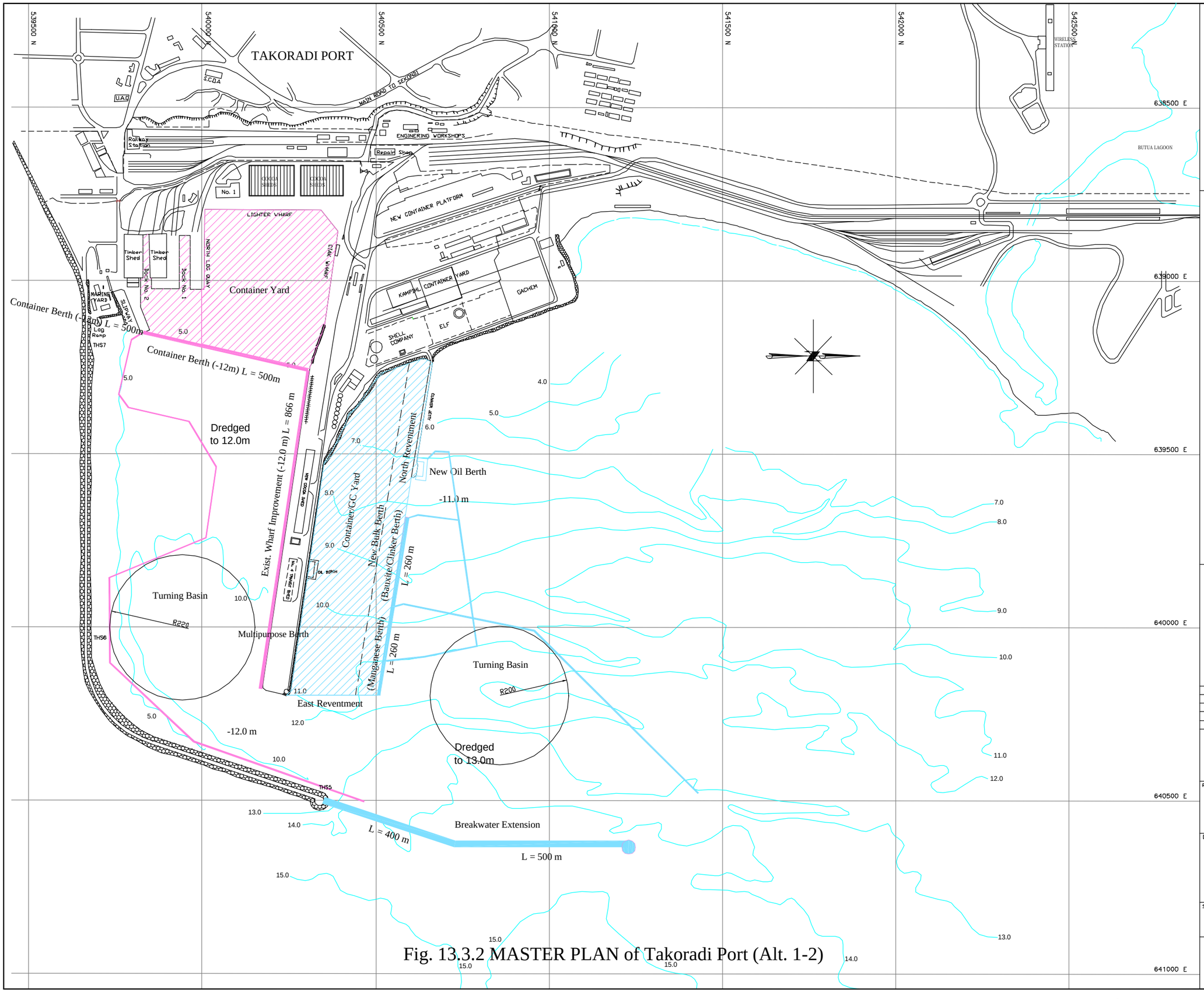
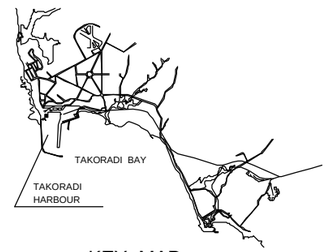
Fig. 13.3.1 MASTER PLAN of Takoradi Port (Alt.1-1)





KEY MAP

NOTES:

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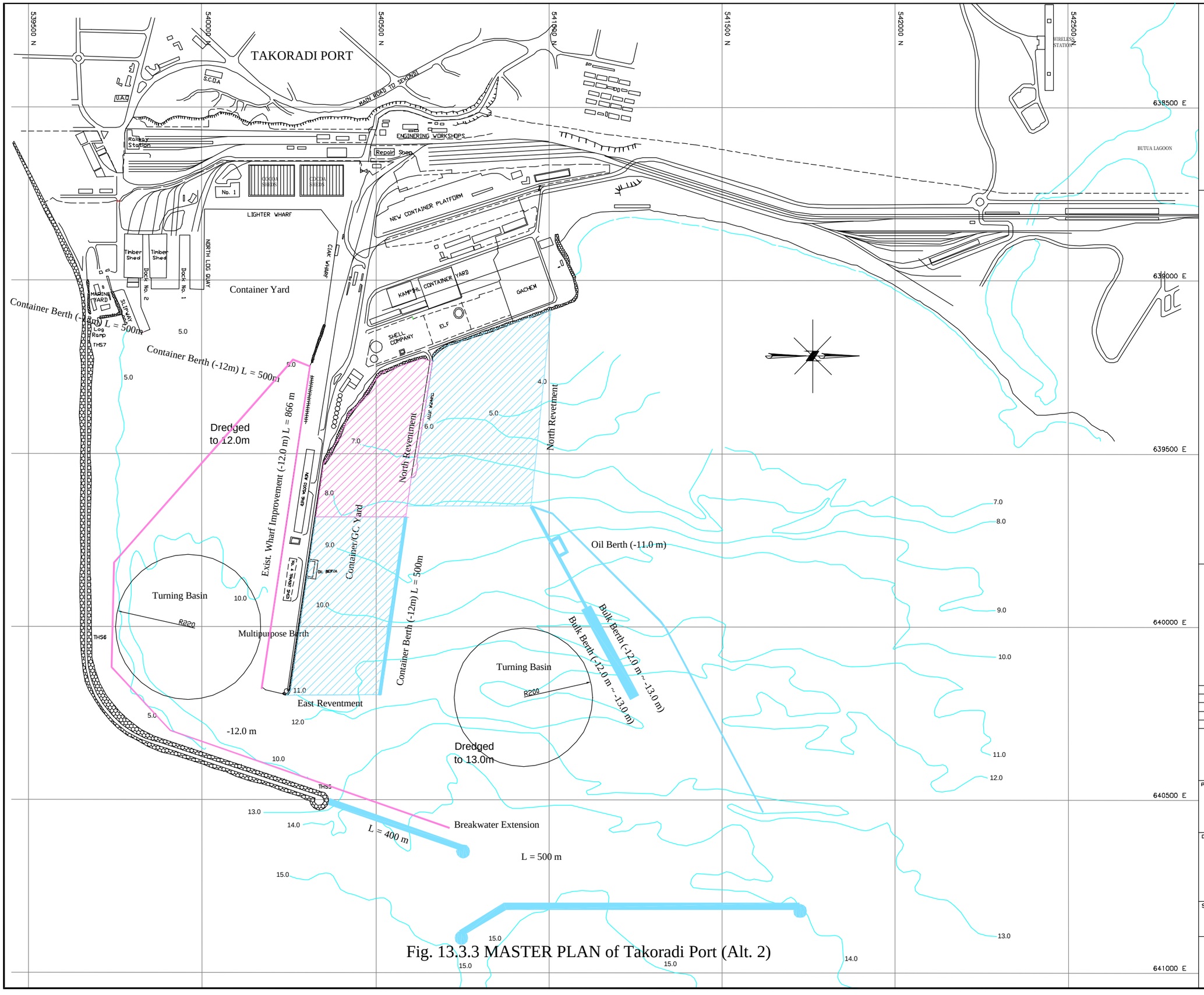
Fig. 13.3.2 MASTER PLAN of Takoradi Port (Alt. 1-2)



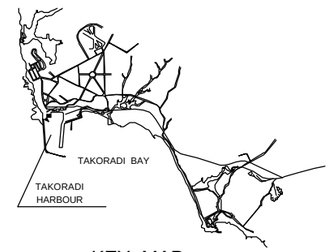


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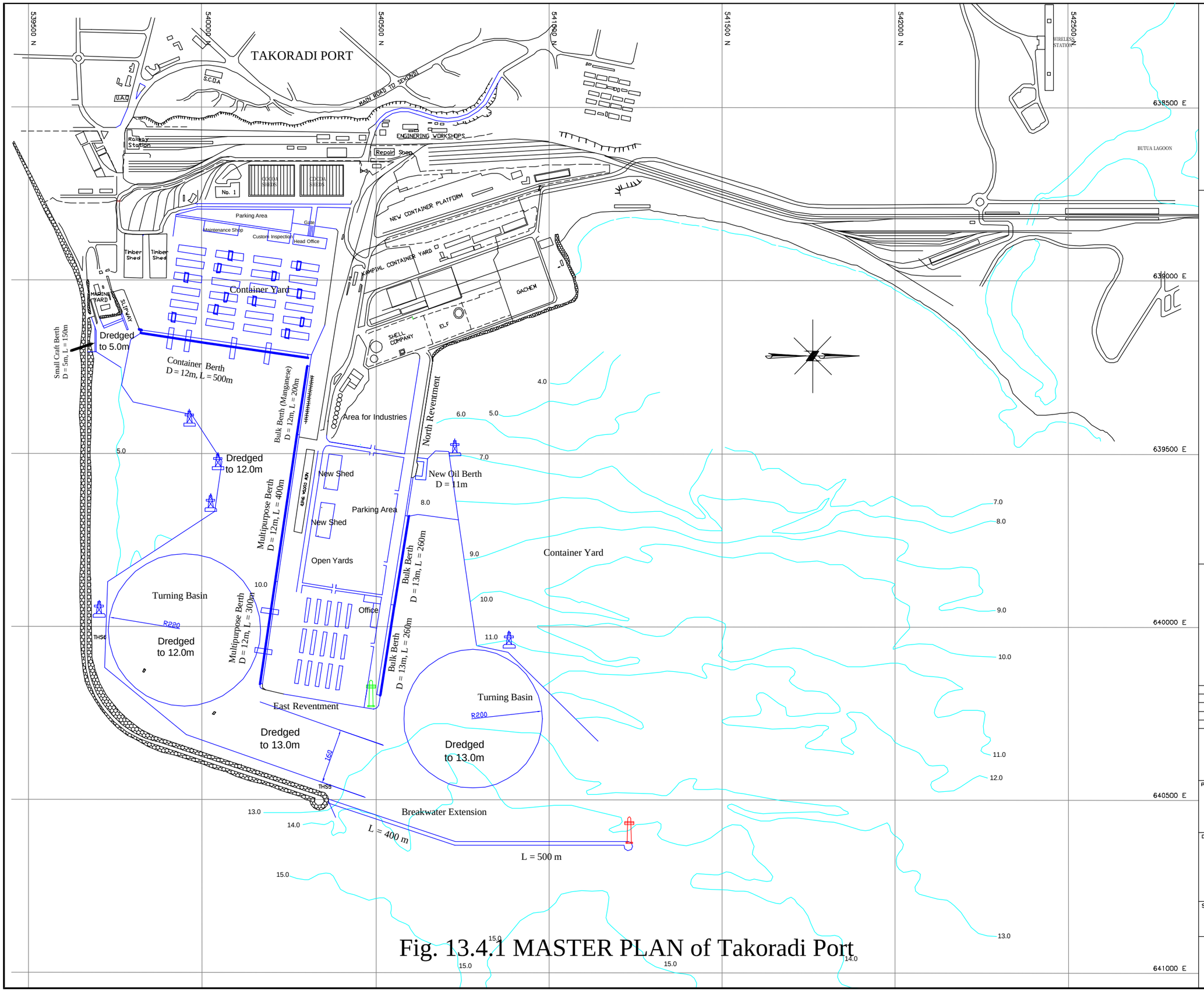
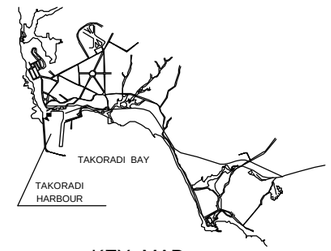
Fig. 13.3.3 MASTER PLAN of Takoradi Port (Alt. 2)





KEY MAP

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Fig. 13.4.1 MASTER PLAN of Takoradi Port

13.5 Proposal for Efficient and Reliable Port Operation

13.5.1 General Principles of Port Management and Operation

(1) Efficient services

High productivity of cargo handling, seamless smooth operation and speedy procedure for cargo clearance are indispensable.

(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.

(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 cargo and 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 x 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 (fifteen percent) 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.
- Four gantry cranes are proposed to be installed at the new container berth (Two cranes at each berth).
- The required number of transfer cranes for the new container terminal is 12 units
- Between quay side and the marshalling yard, container cargo will be carried by yard tractor-trailers.
- The required number of yard tractor-trailers for each gantry crane is 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)

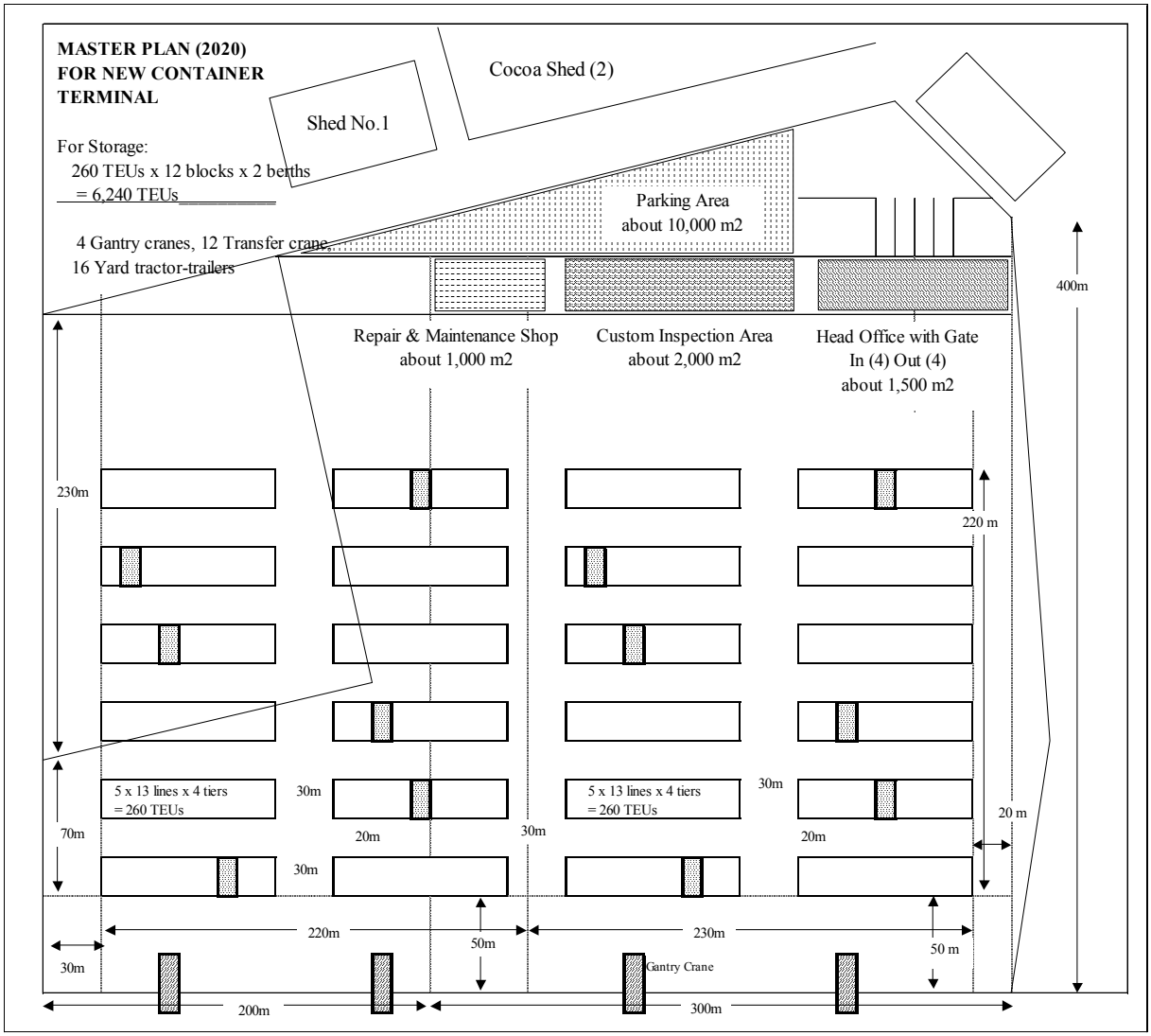


Figure 13.5.4　Layout of New Container Terminal in 2020

(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.
- Three top lifters are required for one crane (one for import, one for export, one for container relocation and backup). In total, six 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 is 8 units.

Total for the new multipurpose berth, Quay side gantry crane: 2 units
Top lifter: 6 units
Yard tractor trailer: 8 units
(layout: Figure 13.5.7)

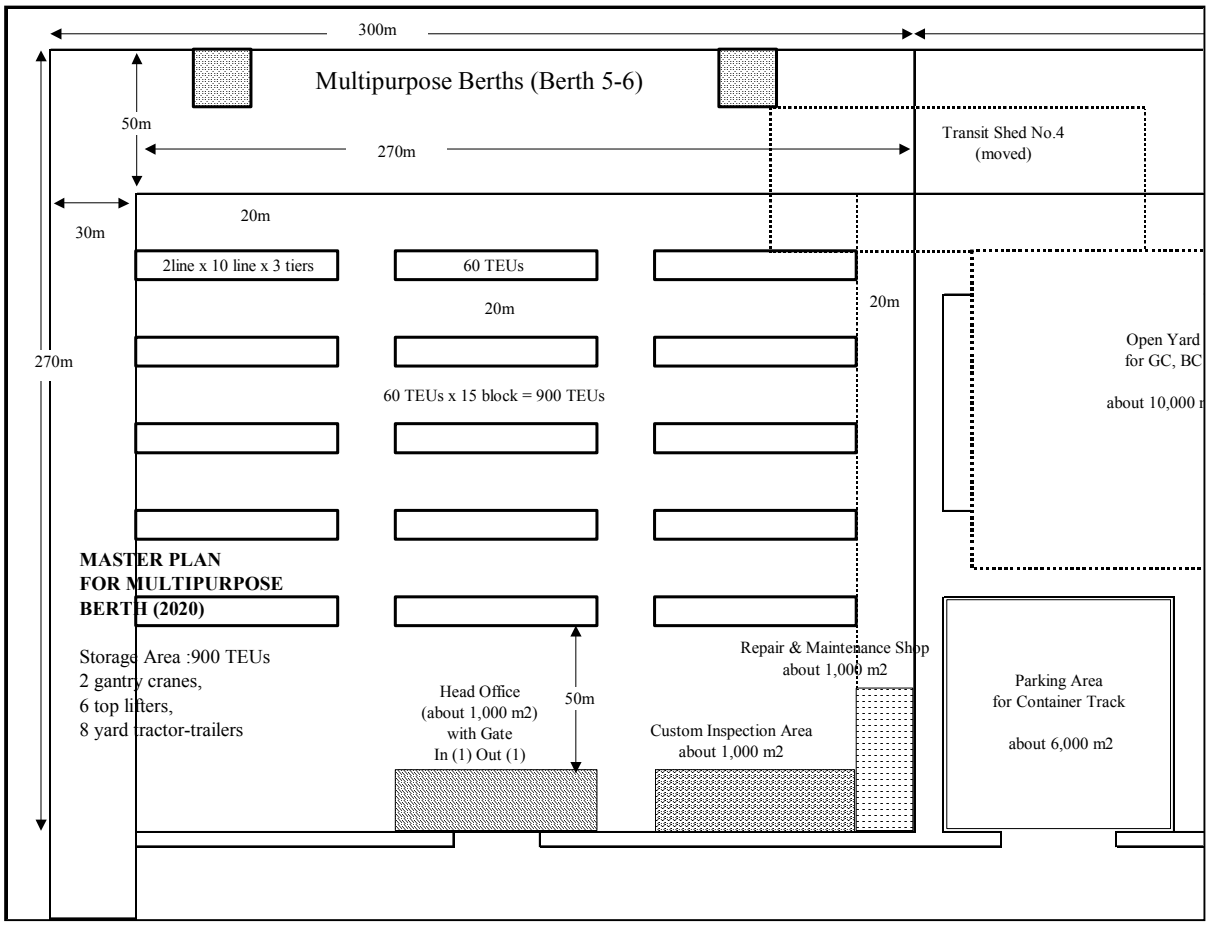


Figure 13.5.7　Layout of Container Yard at New Multipurpose Berth

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

・KAMPIHL Container Yard 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

(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.
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. 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 and 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.

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.

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

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. 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

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

Two-shift working schedule for dock workers is now adapted. 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 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.

13.6 Preliminary Design

(1) Design Criteria and Conditions

1) Codes and Standards for Port Facilities

In Ghana no design code/standard for the port facilities is available, however generally related British Standards (B.S) are used when necessary. Thus the following standards are referred to in the design;

- Technical Standards for Port and Harbor Facilities in Japan
- British Standard Code of Practice for Maritime Structures (B.S 6349 Part 1 to Part 7)

2) Natural Conditions

Table 13.6.1 Natural Conditions

Item	Design Conditions			
Oceanographic condition - Tide	HWL: CD+1.50m, LWL: CD 0.00m			
- Deep water waves	Wave direction	SW	S	SE
	Wave Height(Ho) Wave Period (To)	5.0m 9-11 sec.	5.4m 9-11 sec.	4.8m 9-11 sec.
- Current	Design max. velocity : 1.0 m/sec.			
Subsoil condition	Rock type	Unit weight	Compressive strength	
- Southern part of exist. Port basin area	Sandstone	24.5 KN/m^3	80 MPa	
- Other areas	Sandstone/silt stone	24.5 KN/m^3	10~50 MPa	
Seismic Force	Seismic coefficient : 0.15			

2) Objective Vessels

3)

Table 13.6.2 Objective Vessels for Takoradi Port

Vessel Type	DWT	Length Overall (L.O.A) m	Breadth (B) m	Max. Draft (Df) m
Bulk Carrier	40,000	200	29.9	11.8
General Cargo Ship	30,000	185	27.5	11.0
Container Ship	30,000	220	30.2	11.1
Ro/Ro Ship	28,000	210	-	11.0
Oil Tanker	20,000	158	25.8	9.6

4) External Loads

	Normal Condition	Seismic Condition
Crane Load	400 KN/wheel	400 KN/wheel
Surcharge	20 KN/m^2	10 KN/m^2

(2) Structural Design of Main Facilities

1) Breakwater

The existing main breakwater is required to be extended at length of about 900m to obtain a calm water area for the new bulk berths. The structural type of the existing breakwater is rubble mound type. An alternative study to select the optimum structural type for the extension has been carried out between the rubble mound type and a concrete caisson type, and the rubble mound type is recommended under the following reasons;

- Costwise no significant difference or slightly more economical
- Possible to utilize rock materials which is sufficiently produced at local quarries.
- Construction method is simple thus easier.

2) New Berths

The following new berths are planned in the Master Plan;

Usage	Length	Water Depth	Design Vessel Size
New Bulk Berths	520 m	-13.0 m	40,000 DWT
New Container Berth	500 m	-12.0 m	30,000/28,000 DWT
Small Craft Berth	150m	-5.0m	250 GT

In order to select the optimum structural type for the new berths, the alternative studies have been carried out and the following structural types are recommended;

- New Bulk Berth/ New Container Berth : Concrete caisson type
- Small Craft Berth : Concrete block type

3) Main Wharf Improvement

In the Master Plan, it is proposed to improve the existing main wharf (Berths No. 1 to No. 6; total length approximately. 900 m) by deepening the wharf front water depth up to –12.0m below C.D.

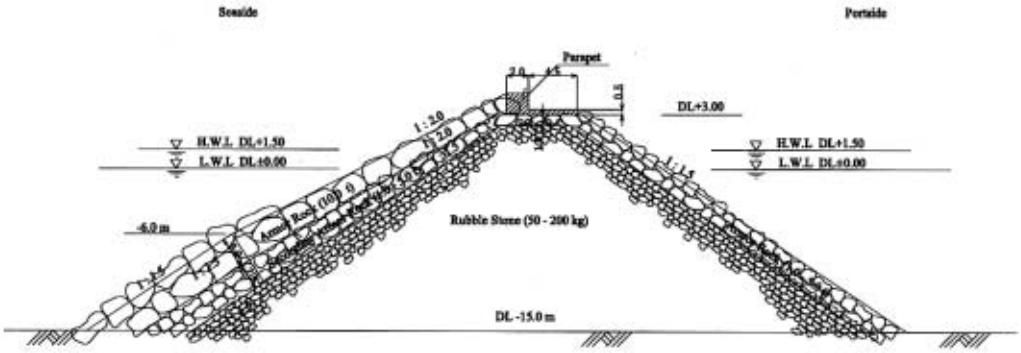
Among the several options for the improvement, a concrete block type structure is recommended as most reliable for obtaining the necessary stability of different structural types of the existing wharf under the deepened condition.

4) Other Facilities

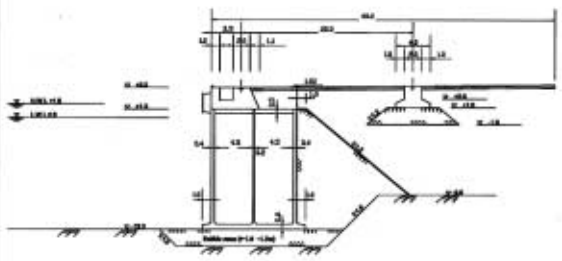
(a) Revetment : Rubble stone revetment is considered for all the revetment works as rock materials are available locally and are generally economical.

(b) Yard Paving : In Takoradi Port, most of the paving for yards including wharf aprons are made with concrete blocks. Taking this situation and relatively easy maintenance into account, concrete block paving is adopted in the design.

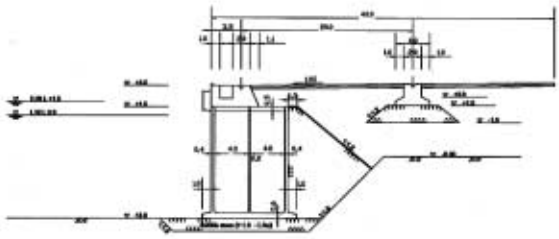
The typical sections of main facilities are shown in Figure 13.6.1.



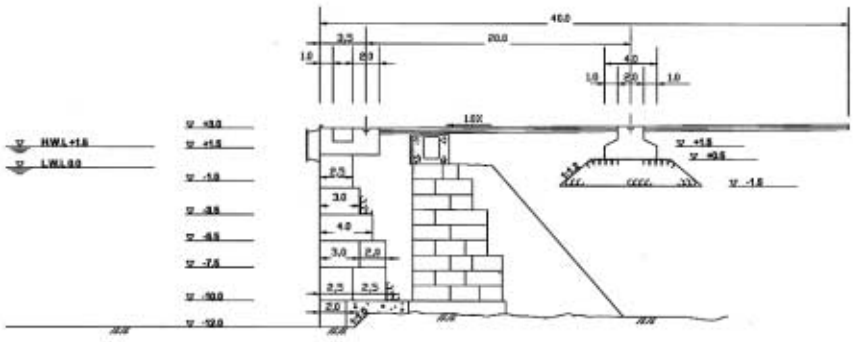
Typical Section of Breakwater (Rubble Mound Type)



Typical Section of Concrete Caisson Type New Wharf (-13 m)



Typical Section of Concrete Caisson Type New Wharf (-12 m)



Typical Section of Exist. Wharf Improvement

Figure 13.6.1 Typical Sections of Main Facilities

13.7 Implementation Plan and Preliminary Cost Estimate

(1) Implementation Plan

The construction component proposed in the Master Plan is shown in Table 13.7.1, and the estimated construction schedule is 5 years as shown in Figure 13.7.1.

Table 13.7.1 Construction Component of Master Plan

Facilities	Description	Quantity
1. Dredging and Reclamation		
1) Dredging	Rock and Soil	1,980,000 m^3
2) Reclamation		4,500,000 m^3
2. Breakwater (-14.0 ~15.0 m)	Rubble Mound	L = 900 m
3. Wharf and Berth		
1) New Bulk Berth (-13.0 m)	Concrete Caisson	L = 520 m
2) New Container/Ro-Ro Berth (-12.0 m)	Concrete Caisson	L = 500 m
3) Exist. Wharf Improvement (-12.0 m)	Concrete Block	L = 900 m
4) New Oil Berth (-11.0 m)	Dolphins	1 berth
5) Small Craft Berth (-5.0 m)	Concrete Block	L＝150 m
4. Revetment		
1) North Revetment	Rubble Mound	L = 480 m
2) East Revetment	Rubble Mound	L = 270 m
5. Paving/Miscellaneous Works	Yard, Road, Drainage	1 set
6. Buildings and Utilities	Gate, Maintenance shop, Electrical/Mechanical Works	1 set

Note: Procurement of Equipment is excluded

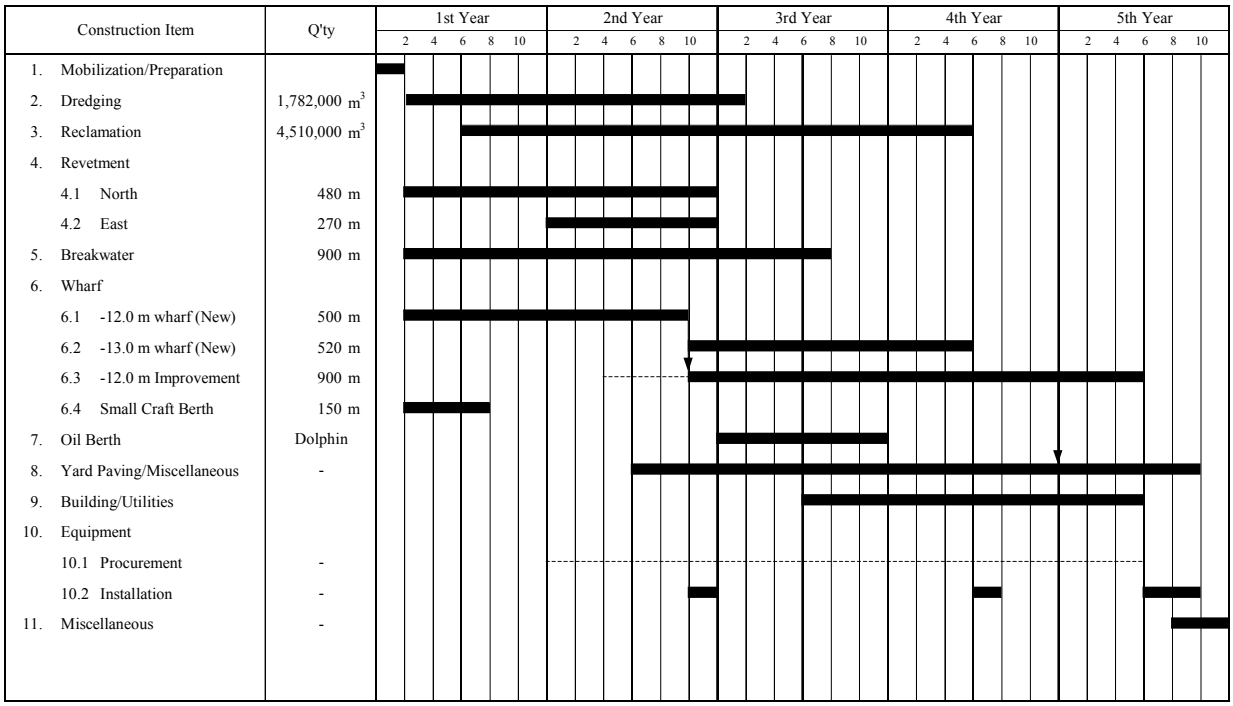


Figure 13.7.1 Implementation Plan for Master Plan of Takoradi Port

(2) Estimated Cost for the Master Plan

The total estimated cost for the implementation of the Master Plan of the Takoradi Port is approximately US $ 250 million as indicated in Table 13.7.2.

Table 13.7.2 Implementation Cost of Master Plan for Takoradi Port

Item	Description			Construction Cost (USD)
	Type/Material	Unit	Quantity	
1. Civil & Building Works				
1.1 Dredging and Reclamation				
・ Dredging work	Rock/Soil	m^3	1,980,000	49,509,000
・ Reclamation work		m^3	4,500,000	25,979,000
1.2 Breakwater				
・Breakwater extension(-14.0m)	Rubble mound	m	900	26,550,000
1.3 Wharf & Berth				
・-12m New Container/Berth	R.C. Caisson	m	500	15,800,000
・-13m New Bulk Berth	R.C. Caisson	m	520	17,784,000
・Exist. Berth Improvement (-12m)	Concrete block	m	900	19,800,000
・New Oil Berth	Dolphin	L.S	1	6,000,000
・Small Craft Berth	Concrete block	m	150	1,500,000
1.4 Revetment				
・North revetment	Rubble mound	m	480	4,800,000
・East revetment	Rubble mound	m	270	4,860,000
1.5 Paving & Miscellaneous works		L.S	1	12,500,000
1.6 Buildings & Utilities Works		L.S	1	5,200,000
Sub-total				**190,282,000**
2. Equipment				
2.1 Cargo Handling Equipment		L.S	1	31,000,000
2.2 Other Equipment		L.S	1	2,300,000
Sub-total				**33,300,000**
Total				**223,582,000**
3. Physical Contingency	8% of 1,4% of 2	L.S	1	16,554,560
4. Engineering Cost	5% of Item 1	L.S	1	9,514,100
Grand Total				**249,650,660**

13.8 Initial Environmental Examination (IEE)

An IEE was conducted based on the Master Plan of Takoradi Port and the results were compiled in a form of Scoping Report following the EIA Guidelines of Ghana. Fourteen (14) environmental factors were identified for the EIA (Table 13.8.1) through the scoping. Environmental factors with the ratings A, B, or C in Table 13.8.1 should be subject to the EIA. A TOR for EIA were prepared for the master plan (see Appendix A of Main Report).

Table 13.8.1 Scoping Checklist (Takoradi Port)

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 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
	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

13.9 Preliminary Economic Analysis

13.9.1 Methodology

An economic analysis was carried out applying the following method. Master plan for Takoradi Port was defined. and it was compared to the "Without" case. All the benefits and costs accruing from the difference between "With" and "Without" cases were calculated in market prices. Here, the economic internal return (EIRR) based on a cost-benefit analysis was used to appraise the feasibility of the project.

13.9.2 Costs of the Projects

The items that should be considered as costs of the projects are construction costs, maintenance costs and renewal 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 13.9.1 Economic Durable Periods and Costs of Equipment

Equipment	Durable Periods	Costs('000US$)
Gantry Crane, Transfer Crane, Tug Boat	20 Years	33,300

Costs of the projects are summarized in the following table.

Table 13.9.2 Costs of the Projects for Master Plan – Takoradi Port

Items	Costs('000US$)
Civil Works	190,282
Equipment	33,300
Total	223,582
Maintenance Costs for Structure	1,072
Maintenance Costs for Equipment	1,332
Total (per year)	2,404

13.9.3 Benefits of the Projects

The following items are considered as tangible benefits in terms of the cost-benefit analysis in this study.

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

Benefits of the projects are summarized in the following table.

Table 13.9.3 Benefits of the Projects for Master Plan – Takoradi Port

(Unit: thousand US$)

Items	Benefits
Ships' Staying	12,903
Water Transportation	10,133
Land Transportation	36,509
Earnings of Foreign Currency	232
Total	59,777

13.9.4 Benefits of the Projects

The EIRR of the master plan for Takoradi Port is calculated as 17.8%. The results of calculation are shown in Table 13.9.4.1.

It is generally recognized that the project is feasible if the EIRR exceeds the opportunity cost of capital. Usually, the opportunity cost of capital is considered to range from 8% to 10% according to the degree of development in each country. It is acceptable that a project with an EIRR of more than 8% is economically feasible for infrastructure or social service projects.
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 13.9.4 Results of Sensitivity Analysis on Master Plan for Takoradi Port

	EIRR	Increase in Investment Cost		
	17.8%	0%	10%	20%
Decrease Benefits	0%	17.8%	16.5%	15.4%
	10%	16.4%	15.1%	14.0%
	20%	14.9%	13.7%	12.6%