10.3 Land Use

10.3.1 General

(1) Land is an asset for the owner

When land in possession of the owner is in excess of his own requirement or usage he lets it out to a party for financial consideration to earn a regular income for himself. The tenancy is thereby created, the terms and period of lease are mutually determined and agreed but these are generally in conformity with the laws applicable.

For the tenant this becomes an asset and he indulges in commercial exploitation to earn for himself an income which is far more than what he pays to the original owner (landlord).

Over a period of time (if on long term lease) or after periodical renewal of lease the tenant may sublet a part or the full land with structure thereon to another party for a consideration thereby creating sub-lease, with or without approval of the land lord. This process may continue over and over again.

(2) Land owned by Mumbai Port Trust

The land owned by Mumbai Port Trust is by - and - large land reclaimed on the foreshore from 1873 onwards while setting up wharves and cargo handling facilities on waterfront. These facilities also got buried under subsequent reclamation when the facilities had to be re-developed in accordance with requirements of the trade and shipping. Some of the areas still bear the names of the original wharves, such as Jackeria Bunder, Tank Bunder.

One of the most extensive and ambitious reclamation projects (covering 234 ha) undertaken by Mumbai Port was in 1909 -17 when Mazagaon - Sewri Reclamation (MSR) was carried out by pumping dredged material from the harbour. MSR had been planned for "Depots" for separate cargoes such as Cotton Depot, grain Depot. Coal Depot, Manganese Ore Depot.

Mumbai Port Trust at one time were the biggest landlords in the Island City of Mumbai virtually owning 1/8th of the area of the Island, comprising the Port on its eastern side which constituted the commercial harbour, some islands, and small pockets of land on the west coast (such as Chowpatty / Worli / Mahim Bunders). The total land under Mumbai Port's control is about 753 ha (1860 acres). This land which is contiguous with the land of the city of Mumbai has become a part and parcel of the city's land due to which the authorities vested with redevelopment of the city have covered this area also, care being taken that the Port's operations, functions and land usage are not substantially violated.

(3) Steep rise in Land Values

With the rapid urbanization and phenomenal growth in the population, development of new types of industries and commercial activities Mumbai has been facing an acute shortage of land, and the land values and real estate values have reached dizzying heights giving Mumbai the dubious distinction of being one of the most expensive cities in the World. The land and real estate values are so high that even multinationals find it unattractive to set up offices and residences in Mumbai in spite of all other advantages.

10.3.2 Present Land Use

The present land utilization has been investigated by the Team in consultation with Estate Department of MBPT and the results are compiled in the Land Utilization Map of MBPT Land with the classification as given in the Figure 10.5.1.

10.4 Law and Regulation System Concerning Redevelopment

10.4.1 Planning for Redevelopment

The State Govt. of Maharashtra is empowered to plan developments regionwise, citywise, townwise, from macro to micro level. The Act under which the State enjoys such powers is the "Maharashtra Regional Town Planning Act, 1966" together with the "Development control Rules" enacted separately.

Within the State Govt. these powers are vested with their Urban Development Dept., who in turn have delegated authority to Regional Development Authorities, one example is the Mumbai Metropolitan Region Development Authority (MMRDA). MMRDA prepare macro level plans. Micro level planning is relegated to other authorities such as Brihan Mumbai Mahanagar Palika (Municipal Corporation of Greater Mumbai, MCGB). It is under this authority vested in MCGB that they have prepared plans for planned redevelopment of the Metropolis to improve the quality of life and services in Mumbai. These plans also cover the area of Mumbai Port's property and are thus legally binding on the Port Trust. The plans presently valid are for the period 1981 - 2001.

The Port Authorities on their own have also been reviewing their requirements from time to time. The rapid growth in Port's traffic over the years, shift in general cargo traffic into containers have made heavy demands on Port's own land and every effort is made to rid occupation by non - conforming users / industries and utilize the land / property thus released for port's own operations. The various Inland Container Depots and Rail Container Depots set up by the Port Authorities and the link road exemplify Port's determination to meet the challenges of modern shipping trends.

10.4.2 Hurdles in Evicting Tenants

Obtaining vacant possession of plots / lands from the lessees is the most frustrating exercise. Lessees vacating land peacefully without or with compensation are a rare breed and the only course left open to the Port Authorities is to resort to court's intervention. The suits for evicting tenants fall under the civil courts jurisdiction where the number of cases pending is so astronomical that before the case is heard by the learned judge 18 - 20 years are passed. On being convinced by the genuineness of the Port's submission the learned judge may pass orders in favour of Mumbai Port Trust at one or more hearing. Physical vacation by tenant and obtaining possession by Port Authorities is further time consuming. Thus the entire process takes about 20 years.

The delay in justice has given the tenants an easy way to frustrate Port's plans.

Other problems encountered are :

a) Land not available in large areas - mostly in pockets, here and there

b) Occupation of vacant land by slum dwellers

10.4.3 Slum Clearance

Forcible and unauthorized occupation of vacant land by migrant labour has become a socio - political problem for the city and from the present trends the clearance thereof does not appear to be achievable. The continuous influx of population from outside Mumbai to the city has put severe pressure on land, services and has resulted in a low quality of life for the slum dwellers and surrounding areas. Many such slums can be found on Port's lands.

Construction of hutment and slums in an unplanned manner has proliferated and reached a line of no return.

Due to their inability to control inflow of such large population and under Socio political pressures these shanties and slums have been "regularized" by successive Govt. and from time to time have been provided with basic amenities to make their life more endurable.

In the year 1992, the Govt. of Maharashtra further enunciated a new slum redevelopment scheme with participation of slum dwellers and private builders. This scheme has not taken off to the extent planned by the Govt. Only a few projects are presently in hand. These schemes involve development of slum lands into well planned multistoried buildings, giving each dweller a floor area of 16.7 sq. M. (180 sq. Feet) with minimum amenities. The scheme involves heavy subsidy through funding agencies. Total eradication of slums is an unachievable target.

10.4.4 Cotton Depot

Amongst the several areas owned by Mumbai Port Trust, the area called the "Cotton Depot" lying to the west of the Messent road on Mazagson Sewri Reclamation provides a sizable land suitable for redevelopment of port related activities such as the container yard.

As the name implies this land was developed for storage of cotton bales during the boom period of Indian Textile mills, Mumbai itself accounting for roughly 1/3 rd of the cotton Textile Mills in the country. With the decline in the Textile Industry at Mumbai the need for storage of cotton (Import/export) has almost disappeared.

The Cotton Depot had a number of ferro-cement godowns constructed thereon with the most modern fire safety measures of that area. These godowns have deteriorated to such an extent that many godowns had to be demolished from consideration of safety.

Mumbai Port Authorities in consultation with the East India Cotton Association have agreed to shift the tenants from their premises west of Sir Purshottamdas Thakurdas road to the plots on the East side thereby obtaining vacant possession of the entire area west of Sir Purshottamdas Thakurdas road and upto harbour railway lines of Central Railway. This area can then be developed for container depot.

From present indication, the process of shifting the tenants to their alternative plots would require about 6 months to one year.

The present condition of the land utilization in the Cotton Depot is given in Table 10.4.1 and Figure 10.4.1 shows the location of these zones and the progress of suits.

Table 10.4.1 Land Use in Cotton Depot

Zone	Present Use of Real Estate	Lessee
A	Conventional Cargo Shed (port related)	Food Corporation of India
B	Docks / Customs Warehouse	Customs
CDE	Private Warehouse and Storage (non port related)	Various Companies
FG	Conventional Cargo Shed (port related)	Food Corporation of India
HJ	Private Warehouse and Storage (non port related)	Various Companies
K	Docks / Customs Warehouse	Customs
L	Private Warehouse and Storage (non port related)	Various Companies
M	MBPT Container Yard	
N	Defense Occupation	Indian Air Force

10.5 Land to be Possibly Converted from Existing Use to Port Related Use in MBP

The land estate owned by Mumbai Port Trust are generally distributed over the east coast of City of Mumbai, specifically, in a strip of land, extending over 10 Km north and south and 1 Km wide on the average, lying along the shoreline from the Indira Dock to Wadara District. However, the areas directly contributing to port functions at present is less than a half of the area. Larger than a half of the area is being utilized as part of commercial, industrial districts, and petrochemical industrial districts, or let to private enterprises.

The results of the investigations on the present state of land use of the areas owned by the Mumbai Port Trust are shown in Figure 10.5.1.

A district shaded in pink colour is being used for functions not related to Port functions. These lots in the district being provided with private sectors for use on lease contracts. and it is a usual practice to renew those contracts at the expire of the lease unless there are strong reasons on the part of the Port Trust for utilizing the land for port activities. Therefore, unless those districts are included into an authoritative and highly viable port development plan, reinstate of those districts to the Port cannot be expected.

As this report is intended to frame an authoritative port plan, the study team carried out investigations within such districts where the lots in the districts can practically be encroached without much difficulty into the plan for land use, which are shown in Table 10.5.1 below.

Table 10.5.1

Districts Expected for New Port Plan Near Future

Name of Districts	Area (m2)	Remakes
Gamadia Road Area	45,000	The eviction is expected to complete by the end of 2000
Cotton Depot West	90,000	- do -

Also shown in Table 10.5.2 are sites in use at present by the Port Trust for handling containers and godowns. Detail numerical values and locations within the port premises are shown in Figure 5.1.5 and Figure 5.1.6, respectively.

Table 10.5.2 Sites or Areas for Handling Containers and Godowns owned by MBPT

No.	Name of Area	Covered Area (m2)	Yard Area (m2)	Container Slots (TEUs)
	Container Handling Area			
1	Docks area (Indira, Victoria, Prince's)	-	135,500	2,991
2	Frere basin	10,336	32,180	676
3	Manganese ore depot	10,238	125,200	1,200
4	Cotton depot	11,003	28,850	200
5	Timber pond	14,020	185,990	2,565
6	Wadala area	2,890	57,960	820
	Warehouse Area			
1	Frere area	13,218	12,400	300
2	Manganese ore depot area	-	37,635	-
3	Cotton depot area	2,924	59,325	490
4	Timber pond area	34,000	26,940	-
5	Hay bunder and Haj bunder area	6,375	32,400	500
6	Wadara area	-	95,670	1,360

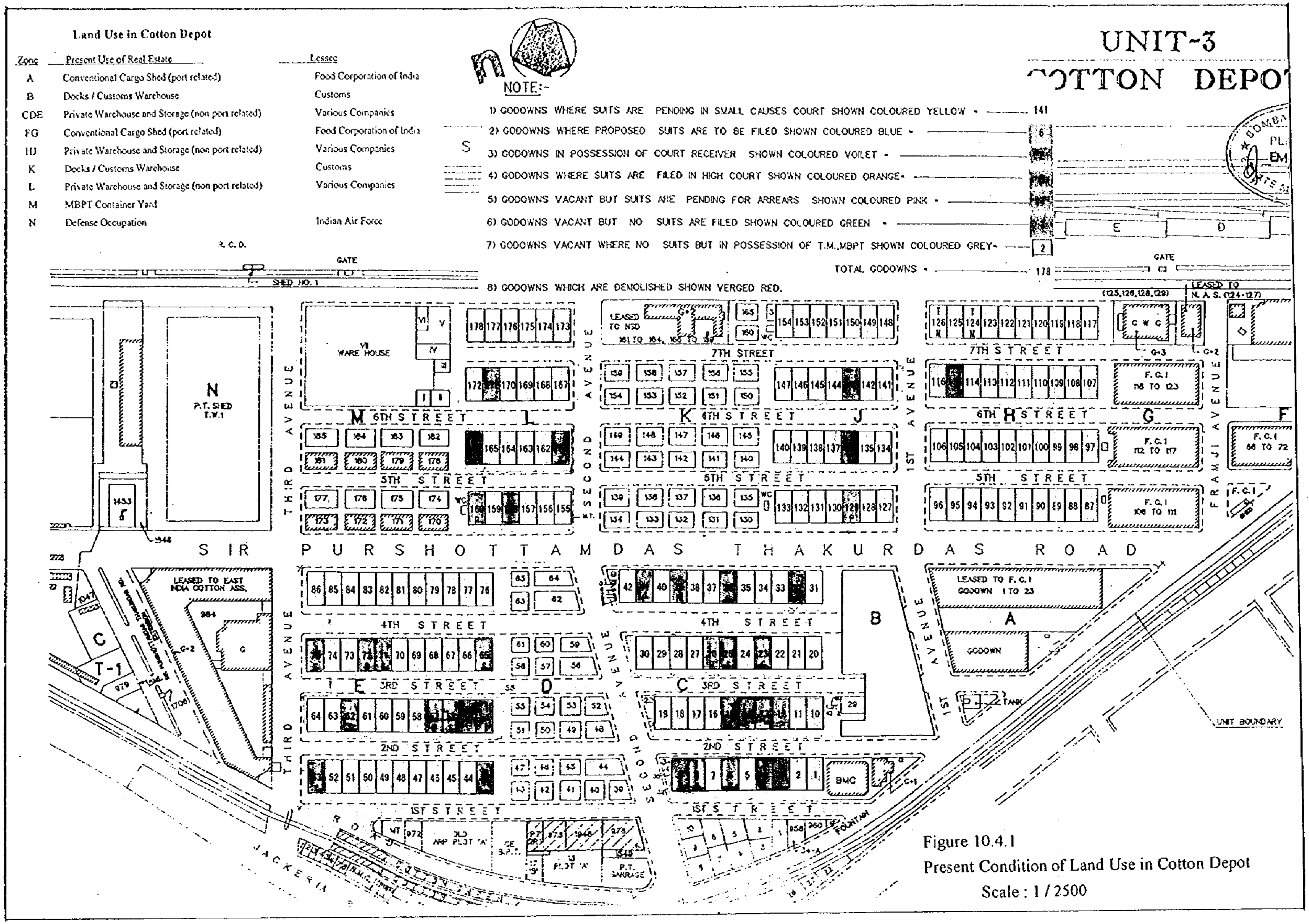


Figure 10.4.1
Present Condition of Land Use in Cotton Depot
Scale : 1 / 2500

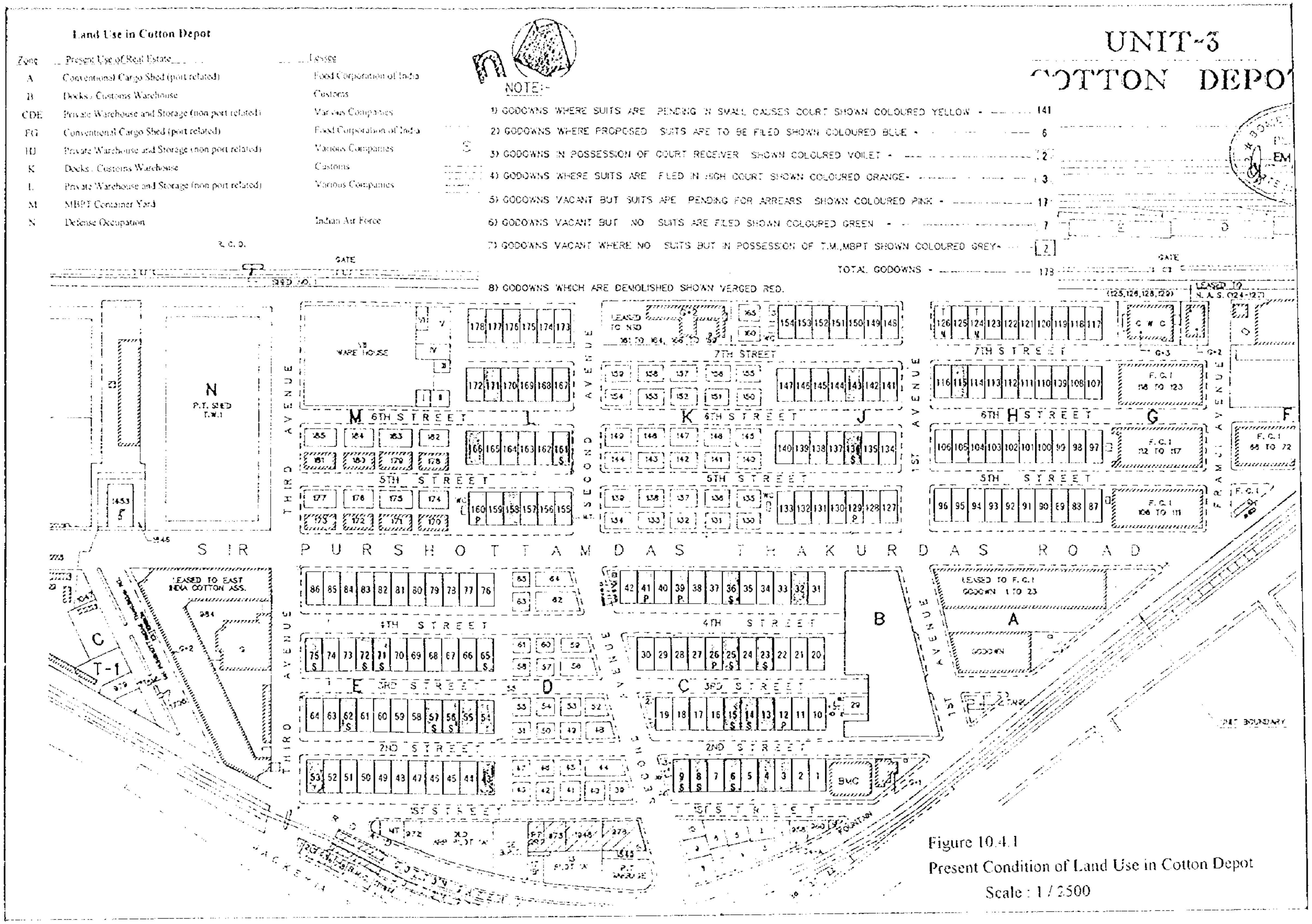
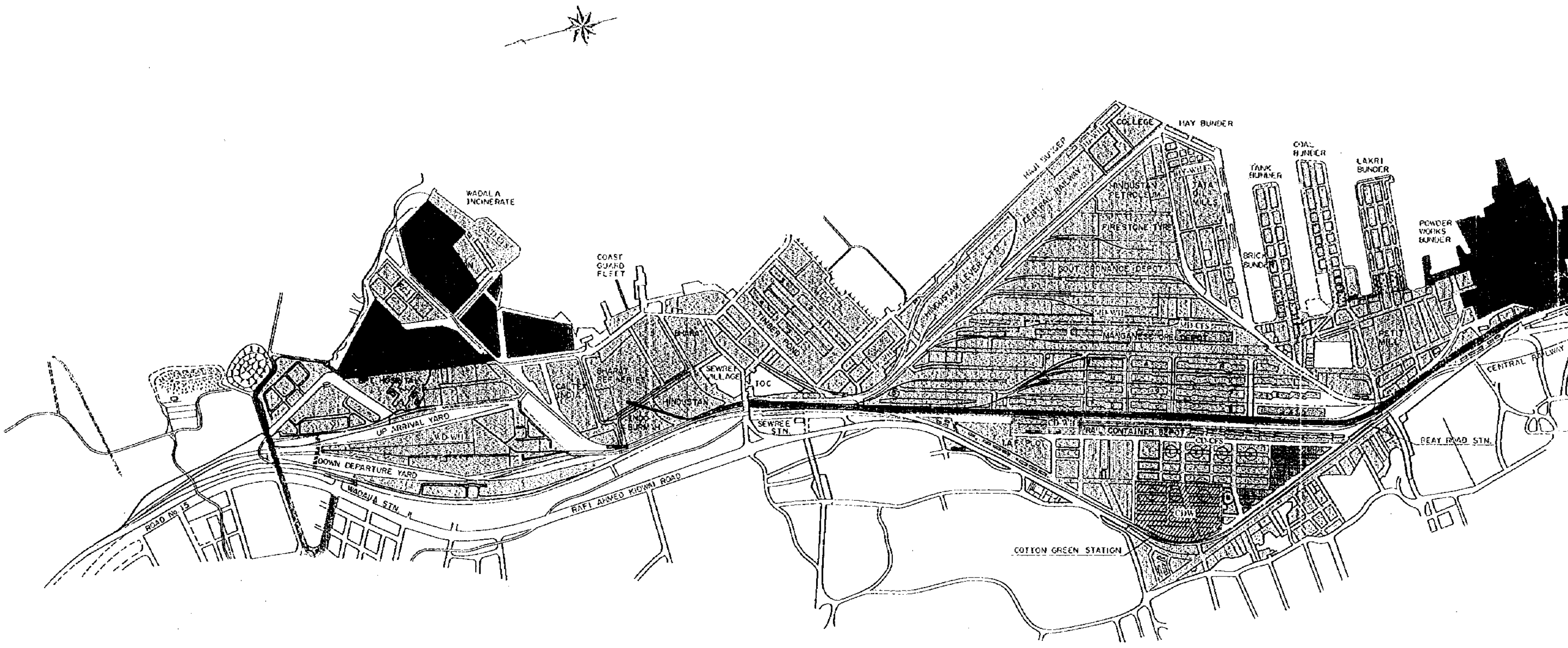


Figure 10.4.1
Present Condition of Land Use in Cotton Depot
Scale : 1 / 2500

Figure 10.5.1 Present Land Utilizati



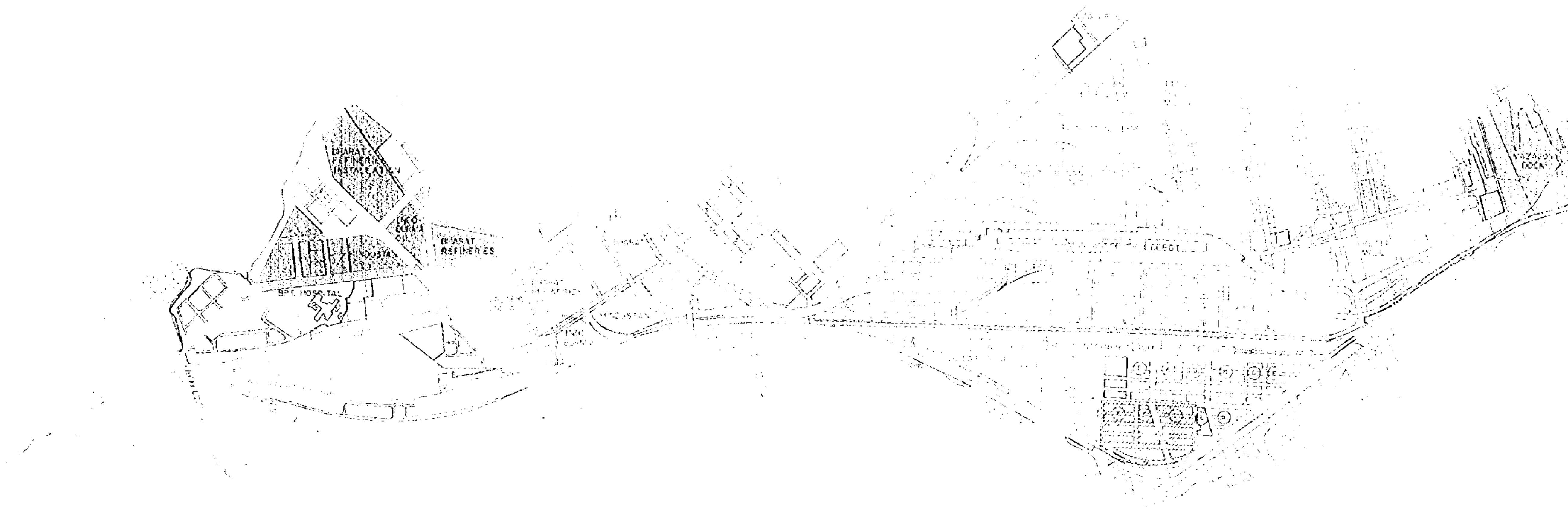
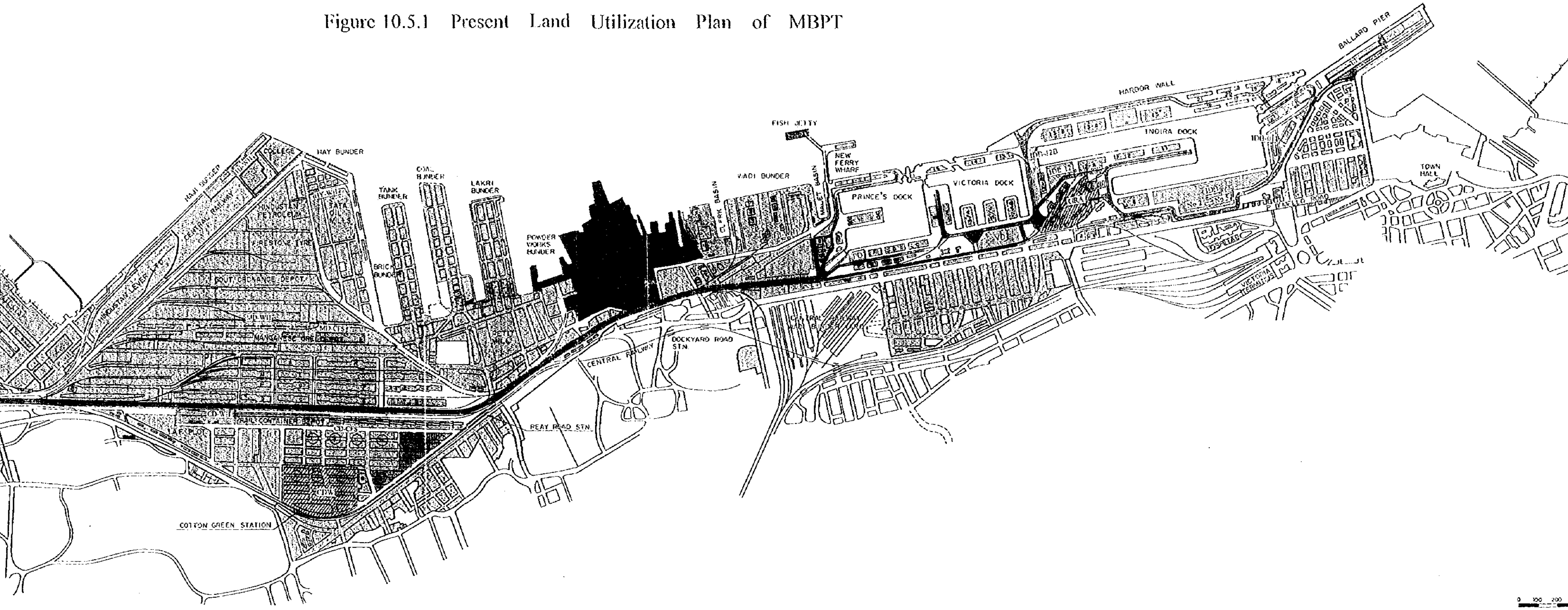
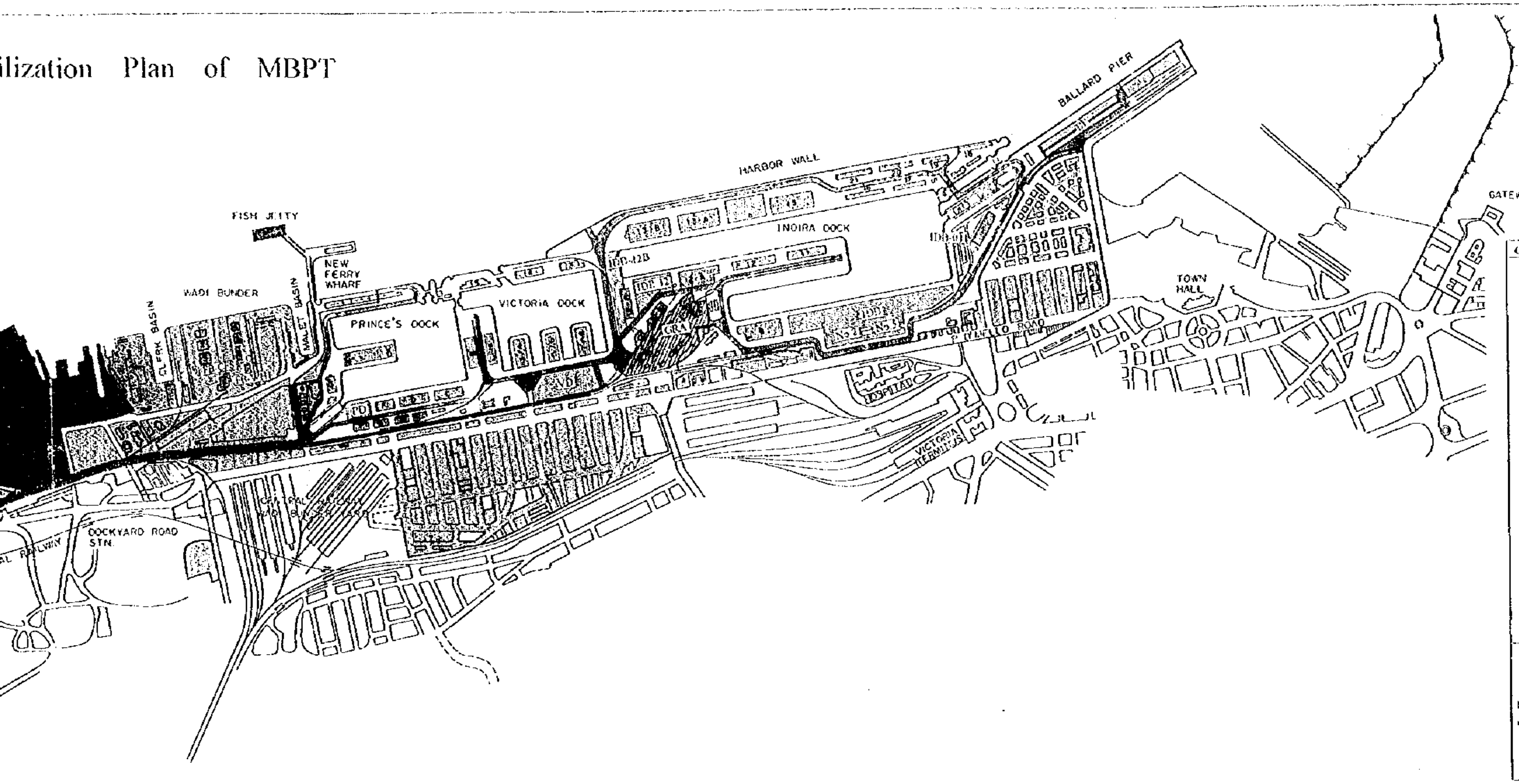


Figure 10.5.1 Present Land Utilization Plan of MBPT



ilization Plan of MBPT



Present Use of Landed Estate of Mumbai Port Trust

Category	Use of Landed Estate	Color	Mark
Port use	Shed (Container cargo)	Orange	SC
	Shed (Conventional general cargo)	Orange	SG
	Shed (Hazardous cargo)	Orange	SH
	Shed (Unclear/overtime cargo)	Orange	SU
	Warehouse for port cargo (Private)	Orange	SP
	Container stacking yard	L Blue	YC
	Open yard for conventional general cargo	L Blue	YG
	Open storage for port cargo (Private)	L Blue	YP
	Office building (MBPT)	Yellow	BM
	Office building of a public authority excluding MBPT	Yellow	BO
	Office building of a port-related private company	Yellow	BP
	Workshop (MBPT)	Yellow	WM
	Workshop for port machines (Private)	Yellow	WP
	Garage of port-cargo-handling machines	Yellow	GG
	Gate house	Yellow	GH
	Welfare facility (MBPT)	Yellow	WF
	MBPT's housing estate	Yellow	HM
	Passenger terminal	Yellow	PT
	Dock for vessel maintenance/repairs (MBPT)		DM
	Dock for vessel maintenance/repairs (Private)		DP
	Land of a port-related manufactory (Private)		
	Fishing port zone		
	Port road		
Non-port-use	Land of a non-port-related manufactory (Private)	Red	NMP
	Warehouse for non-port-related cargo (Private)	Red	NSP
	Open storage for non-port-related cargo (Private)	Red	NYP
	Commercial use	Red	COM
	Residential area	Red	RES
	Other non-port-related land use	Red	NO
	Indian Force	Red	IF
	Common road		

The eviction of this area is expected to complete by end of 2000

Chapter XI Functional Allotment of MBP and JNP

11.1 World Container Throughput and Trends[1]

East Asia provided an estimated 43.7 percent of world container port throughout (up from 25 percent in 1980) by 1995, Europe contributed 23.3 percent (31.6 percent in 1980) and North America accounted for 15.4 percent (27.3 percent in 1980). The remaining regions made up an estimated 17.5 percent of 1995 world container port throughput, compared with 16.1 percent in 1980 (Table 11.1.1).

Table 11.1.1 Container Throughput by Regions 1980-95

(unit: million TEUs)

Region	1980	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995*
1. East Asia	9.08	19.10	22.24	25.52	29.10	32.42	37.18	42.01	47.42	54.08	61.84
2. Europe	11.49	17.76	19.01	20.90	22.00	23.25	24.64	26.24	27.58	30.28	33.06
3. North America	9.92	13.42	14.24	15.00	16.04	16.49	16.96	17.95	18.48	20.31	21.85
4. Caribbean/C. America	0.96	2.68	3.01	3.06	3.28	3.56	3.08	3.42	4.59	5.05	5.39
5. South America	0.38	1.04	1.21	1.34	1.40	1.44	1.60	2.03	2.39	2.54	2.76
6. Middle East	1.38	2.32	2.36	2.48	2.70	2.90	3.71	4.37	4.77	5.10	5.40
7. Indian Subcontinent	0.26	1.08	1.27	1.50	1.61	1.83	1.97	2.13	2.55	2.92	3.17
8. Australia and Oceania	1.61	1.95	2.02	2.23	2.39	2.33	2.51	2.66	2.88	3.20	3.46
9.Africa	1.27	1.74	1.80	2.01	2.13	2.42	2.74	3.02	3.48	4.06	4.66
Grand Total	36.35	61.09	67.16	74.04	80.65	86.64	94.39	103.8	114.1	127.5	141.59

Remarks) * indicates estimated number. Figures have been rounded off.

Source) Ocean Shipping Consultants Ltd.

With growing global containerization, rising trade volumes have come via increasingly large vessels. This has focued on ports to continually update their capabilities in terms of quay

[1] Baskaran V. "The World Container Port Market to 2010", NIPM (National Institute of Port Management) News (1997-III)., pp. 25-31.

length and strength, container gantry crane specifications, berth depth and storage space.

The economics of operating large vessels requires port calls to be limited to large-volume ports, and to the minimize the length of stay. To remain competitive, major ports have had to become extremely efficient, and new technology is being employed increasingly at all stages of port operation, to rationalize, automate and accelerate processes.

With the majority of mainline vessel calling at fewer and only major ports, a tiered structure of regional "hub-and-spoke" operations, has been created, with mainline vessels being served by feeder vessels from surrounding lower-volume ports. This contrasts to the situation in the past, when the use of transshipment was often seen as a symptom of inadequate port capabilities and an insufficiency of ports suitable for direct calls, rather than an ideal solution to the economics of rapidly growing container trades.

The development of the containerized market is obviously linked to macro-economic development and is reflected in a long-term correlation between GDP growth, trade growth in general, and growth of containerized trades as a basis for forecasting future container port demand.

The evident opportunities presented by the worldwide growth of the container port market, coupled with the drive for efficiency and the need to find ways of financing the heavy port investments needed to accommodate successive generations of container vessels, have come at a time when governments all over the world have been turning increasingly to the private sector to supply the solutions to economic needs. The spate of privatization in the port sector has been spread as far afield as western and eastern Europe, China and the Far East, Australia and Latin America (ports in North America already operate privately, of course). Whereas some ports have been privatized entirely, the increasingly popular model is the privatization of port services on long-term leases.

11.2 Development of Neighboring Hub-Ports

11.2.1 Port of Singapore

Container traffic through the Port of Singapore has reached 10.8 million TEUs in 1995, a growth of 15% from the previous year. Transhipment traffic from the Indian ports is reported to have increased by 19%. The port is believed to be carrying out the most efficient port operations in the Asia and Pacific region.

The Port of Singapore Authority (PSA) operates six terminals, i.e. 1) Tanjong Pagar Terminal, 2) Keppel Terminal, 3) Brani Terminal, 4) Pasir Panjang Terminal, 5) Sembawang Terminal and 6) Jurong Port. Container terminals are 1) Tanjong Pagar Terminal, 2) Keppel Terminal, 3) Brani Terminal, whose productivity is said to be around 100 containers per hour although a maximum productivity of 180 containers per hour was recorded.

Profile of container terminals and cargo handling equipment is as shown in Table 11.2.1.

Table 11.2.1 Major Features of Container Terminals at Port of Singapore

	Tnajong Pagar Terminal	Keppel Terminal	Brani Terminal
1. Size	83 ha	96 ha	80 ha
2. Draft	-9.4 to -13 m	-10 to -13.6 m	-12 to -15 m
3. Berths	6 mains, 2 feeder	5 mains, 8 feeders	7 mains, 2 feeders
4. Quay-side Cranes	28	33	31
5. Yard Cranes	207 (shared)		101
6. Prime Movers	347 (shared)		143
7. Chassis	343 (shared)		146
8. Ground Slots	34,000 (G. Slots)		15,000 (G. Slots)
9. Reefer	1,812 points		1,300 points
10. Annual Capacity	8.2 million TEUs		5.5 million TEUs

Source) Port of Singapore Authority

The capacity of the existing container terminals is estimated at 13.7 million TEUs and will be exceeded by 1997. To accommodate the increase in container cargo throughput, PSA is building a new container terminal, Pasir Panjang, by reclaiming land, which is about 7 km from the west gate of the present three container terminals. Development of this new terminal was commenced in 1993 and operations are expected to start in 1998 with five berths. Completion of Phase I is expected in 2000.

The second phase commenced in 1995 and the first two berths will be completed in 2001. An additional 16 berths will be entered into service by 2009. When the two phases are completed, there will be a total of 26 berths and a capacity of 18.3 million TEUs, which is about 1.3 times the present capacity of the Port of Singapore.

In planning the new terminal, a berth is designed to handle 700,000 TEUs per annum. Brani Terminal was designed to handle about 600,000 TEUs per berth annum. Cost of Phase I is estimated at about S$2 billion per berth, and the cost of Phase II is assessed at S$5 billion, or S$280 per berth.

Since the development of Phase I and Phase II is on-going, further development, Phase III and IV, are envisaged in the east wing of Phase II development. There will be a total of 49 berths after the completion of all phases, having a capacity of 36 million TEUs, which is about three times the existing capacity.

Table 11.2.2 Phase Plan of Development of the Port of Singapore

Phase of Development	No. of Berths
Phase I	8
Phase II	18
Phase II	14
Phase IV	9
Total	49

11.2.2 Port of Dubai

Situated at a major crossroads of the worlds routes, Dubai is the leading hub-port between Europe and the Far East, and serves not only the Gulf and Indian subcontinent but, increasingly, the emerging C.I.S. republics and South and East African ports.

Dubai Port Authority also guarantees high-productivity, fast vessel turnaround, state-of-the-art equipment, and well-trained, inexpensive staff of the twin terminals, Jebel Ali Terminal and Port Rashid Terminal. These facts have earned Dubai the reputation of being the best port in the Middle-East and one of the finest in the world.

The twin terminals also handled 2.07 million TEUs of containers in 1995, representing a 10.1 % increase, along with a growing capacity for non-containerized cargo such as mineral, timber, steel products and frozen foods.

Table 11.2.3 Major Features of Container Terminals at Port of Dubai

	Jebel Ali Terminal	Port Rashid Terminal
1. Size	-	43 ha
2. Draft	-14 m	-11.5 m / -12.8 m
3. Berths	5 (with QGC), 4 (with Mobile Cranes)	1 (-11.5m), 4 (-12.8m)
4. Quay-side Cranes	14	11
5. Yard Cranes	34	25 (Straddle Carrier)
6. Tractor and Trailer	195	178
7. Top Lifter	9	4
8. Ground Slots	57,000 (TEUs)	40,000 TEUs
9. Reefer	690 points	180 point
10. Annual Capacity	--- million TEUs	--- million TEUs

Source) Port of Dubai Authority

In 1995 the number of quay side cranes at the two terminals increased up to 25, including two 51 ton-capacity second trolley-type cranes, the most technically advanced in the world. Dubai is now the only port in the Middle East which has eight post-Panamax type quay side cranes which accommodate the most modern ships, while two new quay side cranes were installed in October 1996.

11.2.3 Port of Colombo

Port of Colombo is a south Asian shipping hub, which has seen a surge in transshipment traffic since it upgraded its facilities to accommodate bigger container vessels. An alliance of shipping companies including P&O, Hapag Lloyd, Neptune Orient Lines and another alliance of Denmark's Maersk shipping Line and Sealand Services Inc. have promised an offtake of 250,000 TEUs a year. Post-panamax ships owned by these two alliances began calling at Colombo from June 1996 after its access channel and harbour were deepened to accommodate the largest container ship in service. Shipping lines broke up a joint consortium and formed new global alliances in early 1996. Other shipping lines using Colombo include Evergreen Marine, Lloyds Trestno, Norasia. Mediterranean Shipping Co. Yang Ming and NYK.

There are two major container terminals, i.e. Queen Elizabeth Container Terminal (QCT) and Jaya Container Terminal (JCT) in the Port of Colombo.

Table 11.2.4 Major Features of Container Terminals at Port of Colombo

	Queen Elizabeth Container Terminal (QCT)	Jaya Container Terminal (JCT)
1. Size	8.5 ha	45.5 ha
2. Draft	- 9.2 m to -10.8 m	-12.0 m / -14.0 m
3. Berths	2	4
4. Quay-side Cranes	3	11
5. Yard Cranes	19 (Top Lifter)	33 (Transfer Crane)
6. Tractor and Trailer	---	---
7. Forklift	79	---
8. Ground Slots	1,700 (TEUs)	10,209 TEUs
9. Reefer	64 points	1,500 points

Source) Sri Lanka Port Authority

Port of Colombo handled 1.04 million TEUs in 1995. 73 % of which represented transshipment containers. Almost 60% of the total tonnage handled at Port of Colombo is containerized cargo. Container handling capacity is said to be at 1.2 million TEUs and to increase up to 1.6 million TEUs shortly.

11.3 Future Plan of Major Ports along the West Coast of India

In order to examine functional allotment of MBP and JNP among ports along the west coast of India, it is necessary to gain a general understanding of the present cargo movement in India and features of the major ports along the west coast of India. The important features of those ports are dominant commodities of cargo handled through them and their hinterland, and their future development plans.

Those features of Port of Cochin, Port of New Mangalore, Port of Mormugao and Port of Kandla are focused on and summarized in the following section.

11.3.1 Present Cargo Movements through Major Ports along the West Coast

There are 11 major ports in India. Five of them, Calcutta (Haldia), Visakhapatnam, Chennai and Tuticorin are located along the east coast. The remaining six major ports are located along the west coast; Cochin, New Mangalore, Mormugao, JNP, MBP and Kandla. In addition, there are also about 140 operable intermediate/minor ports.

Table 11.3.1 Cargo Volume through Major Ports along the East and West Coast in 1995/96

(Unit: thousand tons)

Name of Port	Import	Export	Tranship	Total
Calcutta	4,250	1,874	-	6,124
Haldia	10,865	4,526	-	15,391
Paradip	4,196	7,059	4	11,259
Visakhapatnam	14,738	13,046	5,033	32,817
Madras	19,571	9,430	1,719	30,720
Tuticorin	7,955	1,331	-	9,286
Cochin	9,111	2,380	-	11,491
New Mangalore	1,883	7,001	-	8,884
Mormugao	1,948	15,276	871	18,095
Mumbai	17,064	16,617	367	34,048
JNP	4,139	2,558	176	6,873
Kandla	24,658	4,466	1,214	30,338
Total	120,378	85,564	9,384	215,326

Source) "Major Ports of India, A Profile:1995-96", Indian Ports Association

The total cargo handled through major ports in India in 1995/96 is 215.33 million tons whereas all minor ports put together handled just 20.30 million tons. Major ports handle more than 90% of the sea-borne traffic of India and the minor ports account for less than 10%.

105.6 million tons of cargo (49.0% of the total traffic through the major ports) was handled through major ports along the east coast and 109.7 million tons (51.0%) was handled through those along the west coast (Table 11.3.1 and Table 11.3.2). Those figures reveal that major ports in India are well allocated along the coast especially between the east and west coast.

Table 11.3.2 Cargo Volume by Major Commodities through Major Ports in 1995/96

(Unit: thousand tons)

Port	POL and Crude Oil	Iron Ore	Finishe Fertilizer	Raw Facrtilize	Thermal Coal	Coking Coal	Container (tons)	Container (TEUs)	Others	Total
Calcutta	2,524	-	119	88	-	-	1,814	121	1,579	6,124
Haldai	8,218	-	43	276	3,117	2,626	51	4	1,060	15,391
Paradip	1,066	1,691	163	335	4,232	1,833	-	-	1,939	11,259
Visakhapatnan	12,535	5,710	1,132	846	3,045	5,099	94	8	4,356	32,817
Madras	11,568	4,905	954	387	5,122	475	2,308	227	5,001	30,720
Tuticorin	441	-	412	241	5,465	17	758	69	1,952	9,286
Cochin	9,356	-	225	338	-	-	784	96	788	11,491
New Mangaloı	956	6,639	205	16	-	-	-	-	1,068	8,884
Mormugao	1,911	14,923	56	-	-	-	19	2	1,186	18,095
Mumbai	20,518	-	78	730	-	-	6,748	518	5,974	34,048
JNP	-	649	1,716	179	-	-	4,069	339	260	6,873
Kandla	22,339	-	676	399	-	23	961	65	5,940	30,338
Grand Total	91,432	34,517	5,779	3,835	20,981	10,073	17,606	1,449	31,103	215,326

Source) "Major Ports of India, A Profile: 1995-96", Indian Ports Association

11.3.2 Port of Cochin

Port of Cochin is located in Kerala State at the south tip of the Indian subcontinent. Port of Cochin handled 11.49 million tons in 1995-96. POL is the major cargo which accounts for 81% of the total cargo handled through Port of Cochin. Port of Cochin handled containers of 96 thousand TEUs in 1995-96, which account for 6.6% of the total container cargo handled in India in 1995-96.

The hinterland of the port includes the whole of Kerala State and parts of Tamilnadu and Karnataka States. According to a study on the traffic flow in the hinterland of the port, about

97% of the total volume of traffic is through Kerala State.

The upgrade project of Rajiv Gandhi Container Terminal envisages deepening berths Q6 and Q7 to receive vessels with 12 meters draft. This would provide additional quay length of 340 meters to the existing terminal. Three more quay-side cranes may be required at Q6 and Q7 berths.

Table 11.3.3 Major Features of Container Terminals at Port of Cochin

	Rajiv Gandhi Container Terminal
1. Size	6.5 ha
2. Draft	-10.7 m
3. Berths	2
4. Quay-side Cranes	2
5. Yard Cranes	4 (Transfer Crane), 2 (Reach Stacker), 25 (Forklift)
6. Prime Movers	6 (Heavy Duty Truck)
7. Chassis	35
8. Ground Slots	936 (G. Slots)
9. Reefer	111 points
10. Annual Capacity	---

Source) Cochin Port Trust

Cochin has about 140 hectares of reclaimed green field area in Vallarpadam adjacent to the port's deep water channel. Cochin is an ideal location for developing a container transshipment terminal. According to the study conducted by M/s Federic R. Harris of the Netherlands, traffic projections would be in the range of 116,000 to 349,000 TEUs by 2005. Proposed phase I development of the terminal is based on receiving a design container vessel of 54,000 DWT size, 275 m long, 12.5 m draft and carrying capacity of 4,300 TEUs. Phase I development mainly envisages provision of two of 300 m long berths, two quay-side gantry cranes and three RTGs at each berth.

11.3.3 Port of New Mangalore

Port of New Mangalore is located in Karnataka State at the south-west coast of the Indian subcontinent. Port of New Mangalore handled 8.88 million tons in 1995-96. Iron Ore is the major cargo which accounts for 75% of the total cargo handled through the Port of New

Mangalore. Port of New Mangalore handled a very small number of containers in 1995-96.

Although container traffic through the port is still small, recently a new container freight station has been developed by the private sector which will commence commercial activity soon. A variety of commodities such coffee, brake drums, cashew shell liquid, tomb stones, plywood etc. are exported through containers.

Table 11.3.4 Major Features of Port Facilities at Port of New Mangalore

Berth Name	Draft (m)	Length (m)	Capacity (million tons/year)	Commodities Handled
Berth No.1	7.0	125	1.5	
Berth No.2	10.1	198	1.5	
Berth No.3	10.1	198	1.5	
Berth No.4	9.5	198	1.5	General Cargo, Dry
Berth No.5	9.2	198	1.5	Bulk, Containers
Berth No.6	7.0	198	1.5	
Berth No.7	9.2	198	1.5	
Berth No.8	10.1	330	1.0	LPG
Berth No.9	12.5	300	7.5	Iron Ore, Pellet
MRPL Jetty	16.1	---	---	Crude Oil, POL

Source) New Mangalore Port Trust

11.3.4 Port of Mormugao

Port of Mormugao is located in Goa State at the south-west coast of the Indian subcontinent. Port of Mormugao handled 18.10 million tons in 1995-96. Iron Ore is the major cargo which accounts for 82% of the total cargo handled through the Port of Mormugao. Port of Mormugao handled only 2 thousand TEUs of containers in 1995-96.

The port has 9 operational berths including six conventional berths with a total berth length of 841 m. It has a specialized crib type ore berth, an oil berth and a lighterage berth.

Mormugao Port Trust is going ahead with a Rs. 22 billion outer harbour project. Breakwater berths and two offshore breakwater berths for handling liquefied petroleum gas

(LPG) and other POL products have been constructed, all of which will be given to the private sector. It will have 11 multi-purpose cargo berths and two LPG mooring berths. Once operations begin by the year 2005, port's throughput is expected to reach 4.4 million tons of general cargo, and another 4 million tons of coal and iron ore. As many as 42 parties have applied for executing the project on BOOT basis, but they have not conformed to the guidelines prescribed by the Central Government.

11.3.5 Port of Kandla

Port of Kandla is located in Gujarat State at the border between India and Pakistan. Port of Kandla handled 30.34 million tons in 1995-96. POL is the major cargo which accounts for 74% of the total cargo handled through the Port of Kandla. Port of Kandla handled containers of 65 thousand TEUs in 1995-96, which account for 4.5% of the container cargo handled in India in 1995-96.

Hinterland of Port of Kandla includes Kndla, Rajasthan, Punjab and Haryana States.

Table 11.3.5 Major Berths Features at Port of Kandla

Berth Type	Berthing Capacity	Total Length	Permissible Draft
1. Cargo Jetty	9 to 10 ships	1,734 m	9.75 m
2. Oil Jetty-I	1 ship	91.4 m	10.36 m
3. Oil Jetty-II	1ship	84.5 m	9.14 m
4. Oil Jetty-III	1ship	91.4 m	9.45 m

Source) Kandla Port Trust

Port of Kandla is projected to handle 100 million tons by 2000 according to the pre-feasibility study conducted. The major future cargoes include 33 million tons of crude oil import and 14 million tons of petroleum products exports from the two refineries located at Jamnagar. In addition, Mrga cement plants under construction will contribute another 10 million tons of cargo in terms of export of clinker/cement and import of coal.

11.4 World Container Fleet

11.4.1 World Container Fleet to be able to Enter Indira Dock at MBP

There are approximately two thousand container vessels in the world. When preparing alternative plan to modernize Indira Dock at MBP, it is necessary to know how much of the existing container vessels in the world can enter Indira Dock through the lock gate. Dimensions of the lock gate are as follows; length of 229.0 m, width of 30.5 m and depth of 10.7 m.

Distribution of world container fleet in terms of LOA and Breadth are shown in Table11.4.1 and 11.4.2.

51.6% and 61.7% of the world container vessels are able to enter Indira Dock through the lock gate in terms of LOA and Breadth respectively. Only one half of the container vessels in the world can currently enter Indira Dock through the lock gate. However, average size of newly built container vessels is growing in the world, which increases the size of not only main-line vessels but also feeder-line vessels. For long-term planning, it will be necessary to consider the water depth of container berths at MBP

Table 11.4.1 LOA of World Container Fleet

LOA (m)	No. of Vessels	Accumulated Percentage (%)
up to 120	252	12.7
120 - 150	377	31.7
150 - 180	395	51.6
180 - 220	405	72.0
220 - 250	274	85.8
250 plus	282	100.0
Grand Total	1985	100.0

Table 11.4.2 Breadth of World Container Fleet

Breadth (m)	No. of Vessels	Accumulated Percentage (%)
up to 20.0	298	15.0
20.0 - 25.0	611	45.8
25.0 - 28.0	316	61.7
28.0 - 32.2	617	92.8
32.2 plus	143	100.0
Grand Total	1985	100.0

11.4.2 Growing Size of World Container Fleet

When preparing alternative plans to develop new container berths at MBP, water depth of the container berths would be the most important key factor to compete with other container ports' draft in and around India. It is also essential to understand the current distribution of container vessels and growing trend of their draft.

Table 11.4.3 shows the growing trend of container vessel size. Container berth with water depth of 10.0 meter only accommodates 11% and 35% of container vessels in the world in terms of loading capacity and number of vessels respectively (Figure 11.4.1).

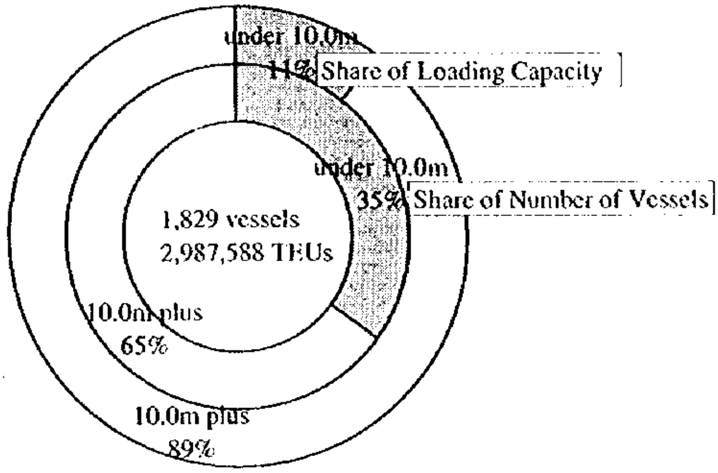


Figure 11.4.1 Percentage of Container Vessels Accommodated by 10.0m Container Berth

Container berth with water depth of 12.0 meters only accommodates 25% and 55% of container vessels in the world in terms of loading capacity and number of vessels respectively (Figure 11.4.2).

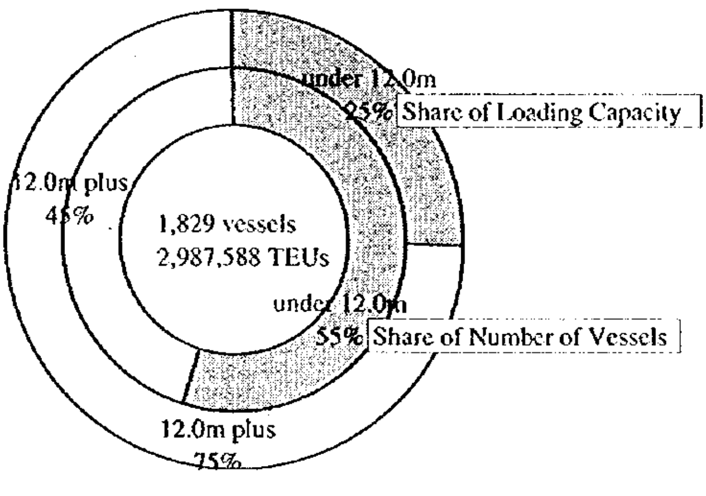


Figure 11.4.2 Percentage of Container Vessels Accommodated by 12.0m Container Berth

Container berth with water depth of 13.0 meter accommodates 41% and 69% of container vessels in the world in terms of loading capacity and number of vessels respectively (Figure 11.4.3).

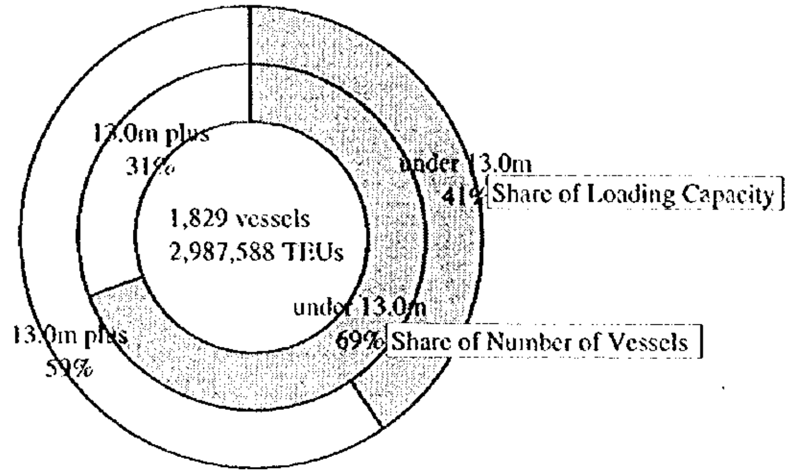


Figure 11.4.3 Percentage of Container Vessels Accommodated by 13.0m Container Berth

11.5 A Basic Functional Allotment of MBP and JNP along the West Coast of India

11.5.1 MBP for Conventional Break Bulk, Liquid Bulk and Container Cargo

According to the historical background of the past development of MBP, MBP is a specialized port for handling conventional break bulk cargo and liquid bulk cargo. In addition, MBP has increased its volume of handling containers due to the rapid progress of containerization in the world. Since the last major development which dates back to the early 1970s, the volume of cargo handling at MBP has increased continuously along with the economic growth of India, which has resulted in serious port congestion.

11.5.2 JNP for Dry Bulk and Container Cargo

JNP was constructed at Sheva Island in the Mumbai harbour and opened in 1989 as a deep-sea port specialized for handling dry bulk and container cargo so as to receive overflowed container cargo from MBP.

Table 11.4.3 Growing Trend of Container Vessels in terms of Vessel Number and Loading Capacity

		Current Fleet		Order Book for 1997				Order Book for 1998			
Loading Capacity	Matching Berth Depth	No. of Vessels	Loading Capacity	No. of Vessel	Percentage Change	Loading Capacity	Percentage Change	No. of Vessel	Percentage Change	Loading Capacity	Percentage Change
(TEUs)	(m)		(TEUs)		(%)	(TEUs)	(%)		(%)	(TEUs)	(%)
0 - 500	-9.0	344	102,891	31	9.0%	9,886	9.6%	9	2.6%	2,663	2.6%
500 - 1,000	-10.0	295	214,189	59	20.0%	41,508	19.4%	27	9.2%	20,393	9.5%
1,000 - 1,500	-12.0	365	440,829	41	11.2%	46,032	10.4%	31	8.5%	37,740	8.6%
1,500 - 2,000	-13.0	264	452,653	56	21.2%	83,003	18.3%	40	15.2%	67,214	14.8%
2,000 - 2,500	-14.0	122	274,584	37	30.3%	80,722	29.4%	42	34.4%	91,955	33.5%
2,500 - 3,000	-14.0	182	494,316	18	9.9%	49,619	10.0%	7	3.8%	18,900	3.8%
3,000 - 3,500	-15.0	83	272,829	6	7.2%	20,424	7.5%	3	3.6%	1,000	0.4%
3,500 - 4,000	-15.0	65	239,922	10	15.4%	37,147	15.5%	12	18.5%	45,217	18.8%
4,000 - 4,500	-15.0	72	304,222	13	18.1%	53,986	17.7%	11	15.3%	45,938	15.1%
4,500 - 5,000	-15.0	20	97,027	19	95.0%	90,756	93.5%	14	70.0%	67,564	69.6%
5,000 plus	-15.0	17	94,124	13	76.5%	69,900	74.3%	13	76.5%	76,996	81.8%
Grand Total		1,829	2,987,586	303	16.6%	582,983	19.5%	209	11.4%	475,580	15.9%
		No. of	Loading Capacity								
0 - 1,000	under 10.0m	639	317,080	90	14.1%	51,394	16.2%	36	5.6%	23,056	7.3%
1,000 plus	10.0m plus	1,190	2,670,506	213	17.9%	531,589	19.9%	173	14.5%	452,524	16.9%
		No. of	Loading Capacity								
0 - 1,500	under 12.0m	1,004	757,909	131	13.0%	97,426	12.9%	67	6.7%	60,796	8.0%
1,500 plus	12.0m plus	825	2,229,677	172	20.8%	485,557	21.8%	142	17.2%	414,784	18.6%
		No. of	Loading Capacity								
0 - 2,000	under 13.0m	1,268	1,210,562	187	14.7%	180,429	14.9%	107	8.4%	128,010	10.6%
2,000 plus	13.0m plus	561	1,777,024	116	20.7%	402,554	22.7%	102	18.2%	347,570	19.6%

Source : Drewry Shipping Consultans

11.5.3 Over-lapped Function for Containers between MBP and JNP

As mentioned above, the functions of MBP and JNP for handling containers are over-lapped at present. It is necessary to identify respective hinterlands, trading partners and vessel size on the shipping network, so as to identify the functional allotment of handling containers between MBP and JNP. They are studied in the following sections focusing on the function of handling container cargo.

11.6 Hinterland of Container Cargo through MBP and JNP

Distribution of the final destinations of containers through MBP and JNP shows that Maharashtra State accounts for the largest share of 44% and the northern region of India also accounts for 42% consisting of Gujarat (14%), Rajasthan (1%), Haryana (5%), Punjab (5%), Delhi (13%) and Uttar Pradesh (4%). When focusing on shares of cities within Maharashtra State, Mumbai with the largest share of 28% is followed by New Mumbai (5%), Pune (4%) and Thane (2%) (see Table 11.6.1 and Fig.11.6.1).

Table 11.6.1 Hinterland's Share of Containers through MBP and JNP estimated by Manifest

State	City	Percentage (%)	Number of Containers (in 2017) (thousand TEUs)
1. Maharashtra		44	2,611
	Mumbai	28	1,662
	New Mumbai	5	297
	Pune	4	237
	Thane	2	118
	Others	5	297
2. Gujarat		14	831
3. Delhi		13	771
4. West Bengal		5	297
5. Punjab		5	297
6. Haryana		5	297
7. Utter Pradesh		4	237
8. Rajasthan		1	59
9. Other States		9	534
Grand Total		100	5,934

Source) Data from MBPT and JNPT analyzed by the Study Team

Target volume of containers to be handled at both MBP and JNP in 2017 is estimated as 5.93 million TEUs (see Chapter 9). Assuming the future hinterland's share of Mumbai City is as it is at present, 1.66 million TEUs of containers through MBP and JNP are estimated to be destined to or originating from Mumbai City.

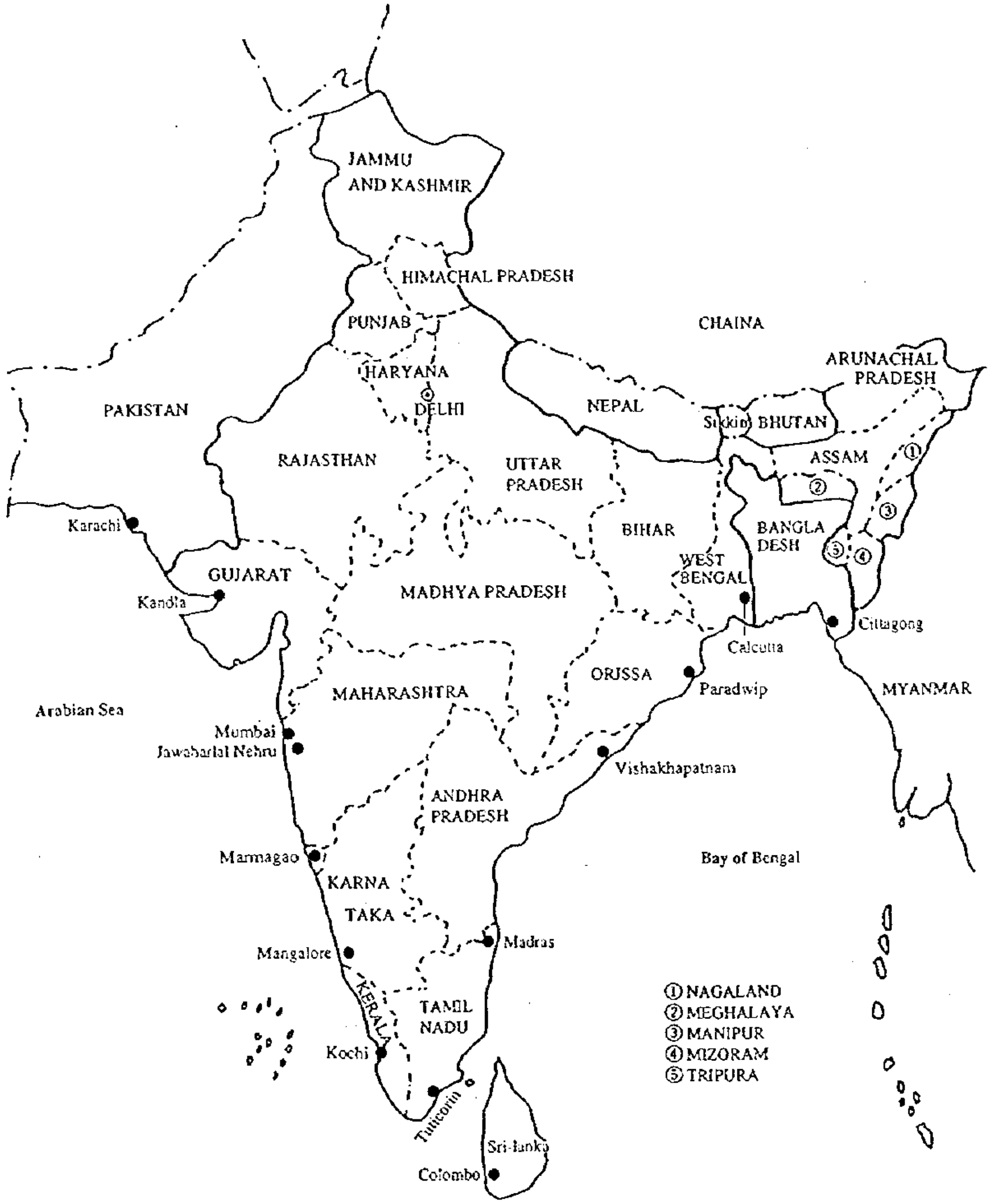


Fig 11.6.1 Hinterland's Share of Containers through MBP and JNP

11.7 Trading Partners of Container Cargo through MBP and JNP

Concerning the trading partners of containers through MBP and JNP, Europe ranks first accounting for 36.9% of the total trade in 1995/96, followed by the Middle East (19.8%), Southeast Asia (15.2%), North America (7.2%), South Asia (6.3%), East Asia (5.8%) and Africa (5.3%). These containers are transported by direct shipping services (approximately 70% of the total trade) and by feeder services (approximately 30%). As to feeder services, containers are transhipped mainly at Singapore, Colombo and Dubai.

Table 11.7.1 Share of Region and Distance of Origin and Destination Ports of Containers through MBP and JNP

Region	Share (%)	Distance (miles)	O / D Port
Europe	36.9	6,619	(Hamburg)
Middle East	19.1	1,150	(Dubai)
Africa	5.3	2,500	(Dar Es Salaam)
South Asia	6.3	881	(Colombo)
East Asia	5.8	4,937	(Busan)
Southeast Asia	15.2	2,451	(Singapore)
Oceania	0.5	4,684	(Fremantle)
North America (East Coast)	7.2	8,673	(Savannah)
North America (West Coast)	1.7	9,801	(Oakland)
South America	0.7	8,051	(Santos)
Others	1.7	1,150	(--------)

Source) Data from MBPT and JNPT analyzed by the Study Team

11. 8 Economical Size of Container Vessels Calling at MBP by Shipping Route

Main factors to determine economical size of container vessels on some shipping routes connecting specified ports are navigational distance, the maximum permissible limits of vessel drafts at the ports and the sum of container traffic volume during a certain period in view of viability of direct shipping services.

The amount of container traffic on the long distance routes connecting MBP and JNP with Indian trade partners such as Europe, North America (East Coast) and East Asia accounted for 53% of the total container traffic in 1995/96. If deeper container berths are prepared off the Indira Dock where the maintained water depth is only 9.8m and a container vessel size of 800TEUs in loading capacity is the limit in fully-loaded condition, containers are transported more economically by direct shipping services rather than feeder services operated with larger container vessels than small ones in operations at present on the above long distance routes.

On the other hand, the amount of container traffic on the short distance routes connecting the Middle East, Southeast Asia and South Asia accounted for the remaining 47% of the total container traffic in the same year. On these routes, containers seem to be transported by feeder services with vessels of moderate size rather than direct shipping services considering that the principal container ports are widely scattered among these trade partners; the result being that the number of containers to/from MBP and loaded/discharged at each port seems to be too small to open the direct services even in the future. The international hub ports of Singapore, Colombo and Dubai, which handled 10.8, 1.04 and 2.07 million TEUs respectively in 1995, are expected to receive the feeder vessels from/to MBP as they do at present.

Although feeder vessel size is smaller compared with mother vessels, there is a trend of growing feeder vessel size. In international shipping circles, average feeder vessel size is said to increase up to 1,200 - 1,500 TEUs in loading capacity from the present level of 600 TEU. In addition, according to the cost analyses in the case of short distance routes from/to MBP, the most economical feeder vessel size is estimated in the range of 1,500 - 2,000 TEUs in loading capacity. Due to the short navigational distances, there is no decisive difference in transport cost between 1,500 TEUs and 2,000 TEUs. Hence, if deeper container berths are prepared at MBP, feeder vessels of larger size than currently in operations will call.

To estimate an economical size of container vessel by shipping routes from/to Mumbai in the stage of the Master Plan, a water depth along container berths needs to be assumed as a given condition. For this purpose, the six alternative plans with different water depths in the range of 9.8 - 13.5m (below C.D.) are considered.

The results of the comparison of container transport cost by vessel size and by shipping route is shown below in the case new container berths with a water depth of 13.5m (the maximum vessel size is 2,500 TEUs in loading capacity on fully-loaded condition) are created.

1) Europe (Hamburg as a representative port)

Case No	Kind of Services	Shipping Route	Ship Size (TEU capacity)	Index of Unit Transport Cost
1-1	Direct services	MBP- Hamburg	1,200TEUs	123
1-2	Direct services	MBP- Hamburg	1,500TEUs	114
1-3	Direct services	MBP- Hamburg	2,000TEUs	105
1-4	Direct services	MBP- Hamburg	2,500TEUs	100*
1-5	Feeder services	MBP-Dubai-Hamburg	1,500TEUs -3,000TEUs	156

2) North America East Coast (Savanna as a representative port)

Case No	Kind of Services	Shipping Route	Ship Size (TEU capacity)	Index of Unit Transport Cost
1-1	Direct services	MBP- Savannah	1,200TEUs	152
1-2	Direct services	MBP- Savannah	1,500TEUs	141
1-3	Direct services	MBP- Savannah	2,000TEUs	131
1-4	Direct services	MBP- Savannah	2,500TEUs	100*
1-5	Feeder services	MBP-Dubai-Savannah	1,500TEUs-3,000TEUs	138

3) East Asia (Busan as a representative port)

Case No	Kind of Services	Shipping Route	Ship Size (TEU capacity)	Index of Unit Transport Cost
1-1	Direct services	MBP- Busan	1,200TEUs	114
1-2	Direct services	MBP- Busan	1,500TEUs	108
1-3	Direct services	MBP- Busan	2,000TEUs	103
1-4	Direct services	MBP- Busan	2,500TEUs	100*

4) South East Asia (Singapore as a hub port)

Case No	Kind of Services	Shipping Route	Ship Size (TEU capacity)	Index of Unit Transport Cost
1-1	Feeder services	MBP- Singapore	1,200TEUs	109
1-2	Feeder services	MBP- Singapore	1,500TEUs	105
1-3	Feeder services	MBP- Singapore	2,000TEUs	102
1-4	Feeder services	MBP- Singapore	2,500TEUs	100*

5) Middle East (Dubai as a hub port)

Case No	Kind of Services	Shipping Route	Ship Size (TEU capacity)	Index of Unit Transport Cost
1-1	Feeder services	MBP- Dubai	1,200TEUs	102
1-2	Feeder services	MBP- Dubai	1,500TEUs	101
1-3	Feeder services	MBP- Dubai	2,000TEUs	100*
1-4	Feeder services	MBP- Dubai	2,500TEUs	100*

6) South Asia (Colombo as a hub port)

Case No	Kind of Services	Shipping Route	Ship Size (TEU capacity)	Index of Unit Transport Cost
1-1	Feeder services	MBP- Colombo	1,200TEUs	100*
1-2	Feeder services	MBP- Colombo	1,500TEUs	100*
1-3	Feeder services	MBP- Colombo	2,000TEUs	100*
1-4	Feeder services	MBP- Colombo	2,500TEUs	100*

From the above, in the case new container berths with a water depth of 13.5m are constructed, the economical vessel size is estimated to be 2,500 TEUs in loading capacity (40,000 DWT) in both direct and feeder services, the same as the maximum vessel size which can be permitted by the berth in fully-loaded condition.

On the other hand, in the other three alternative plans preparing berths with different water depths of 9.8m, 11.0m, 12.0m and 13.0m, economical vessel sizes are 800 TEUs, 1,200 TEUs, 1,500 and 2,000 TEUs respectively in container loading capacity. These four alternative berth depths are compared with each other from the economical point of view, taking account of both transport cost by container vessels of economical size as mentioned above and construction costs of a new container terminal. According to the results of the comparison, the plan to prepare a new container terminal with a water depth of 13.5m is considered to be the most economical (see Section 12.2.4).

11.9 Functional Allotment of Container-Handling between MBP and JNP

To handle the forecast container volume of 5.9 million TEUs in 2017, the functional allotment between MBP and JNP must be determined based on various factors including potential capacity of container handling, hinterlands and transport costs from the stand point of the Indian national economy.

As to potential capacity in container-handling, the capacity of MBP is estimated to be approximately one million TEUs provided that a new container terminal with off-shore jetty-type berths and a water depth of 13.5m will be built and the existing land being used for conventional cargo at present will be converted into a container stacking yard.

On the other hand, JNP has a potential to receive a large amount of containers by constructing further container terminals with berths with a water depth of at least 13.5m which can receive container vessels of 2,500 - 3,000 TEUs in loading capacity and by converting a spacious vacant space into the future container stacking yards. If deeper berths of 14.5m are constructed together with deepening the existing main channel by capital dredging, post-panamax type container vessels of over 4,500 TEUs in loading capacity could be received.

As mentioned in Section 11.6, 28% of the total containers through MBP and JNP originates from or is destined to Mumbai City at present. Assuming the same percentage will be kept in the future, 1.7 million containers in TEU are estimated to originate from or be destined to Mumbai City. To reduce the detour transport of containers originating from or destined to Mumbai City through JNP, it is necessary to receive such containers at MBP as much as possible in terms of avoiding excessive road traffic congestion and consequent air and noise pollution caused by intricate hauling of tractor-trailer units for containers. In addition, not only from the environmental point of view but also from the economic point of view, it is justified to make the most of MBP in container-handling as mentioned below.

In case of short shipping distance routes to/from the Middle East, Southeast Asia, South Asia, etc., there is no decisive difference in feeder vessel size between MBP and JNP resulting in the same ocean freight and therefore the total transport cost through JNP is higher than through MBP by land transport cost between JNP and Mumbai City. On the other hand, in case of long distance routes to/from Europe, North America East Coast, East Asia, etc., if water depths of JNP's container berths are kept intact, the maximum permissible limit to vessel drafts at MBP is the same as at JNP. In case when deeper berths are constructed at JNP and post-panamax type vessels of 4,500 TEUs in loading capacity are used, ocean freight reduction exceeds the land transport cost between JNP and Mumbai City. In this case, however, costs for deepening the existing main channel from the present level and subsequent maintenance dredging must be burdened to use post-panamax typed vessels, resulting no decisive difference in the total transport cost between the cases of MBP and JNP.

From the above, one million containers out of the total forecast traffic of 5.9 million containers in TEU through the two ports is assigned to MBP and the remaining 4.9 million to JNP. Thus, MBP is expected to establish all-directional shipping network towards the next century, even if JNP is developed as a deep sea port to accommodate post-panamax type container vessels.

In this study, containers of one million TEUs are allocated to MBP, and the remaining volume is allocated to JNP out of the total demand for container handling on the assumption that JNPT has a sufficient potential container handling capacity to compensate for the conservative allocation to MBP. However, it must be noted that JNP's container handling capacity is not limitless. According to the conceptual plan made by JNPT, the total container handling capacity per annum does not seem to exceed 4 million TEUs. In this view, the possibility of constructing additional off-shore container jetties next to the jetties proposed in Master Plan should not be completely ruled out.

Chapter XII Master Plan for MBP

12.1 The Basic Concept of Master Plan for MBP

The purpose of the Master Plan (target year 2017) is to serve as a target and a guideline for phase plans including the Short-Term Plan (target year 2007). The Master Plan shall be an integrated plan covering the layout plans for additional container handling facilities, modernized existing facilities and effective management and operation systems. In making the Master Plan for the MBP, the following various aspects are recognized.

12.1.1 Container-Handling

(1) Insufficient Water Depth along the Existing Container Berths

Since the major container berths at MBP are located inside the docks of Indira, Victoria and Prince's connected with the open sea through the lock gates, maximum depth of those berths is only -9.8m, which means that only relatively small container vessels can be accommodated despite the recent trend to enlarge container vessel size. On the other hand, JNP started its container handling operation with new deeper berths of -13.5m deep in 1989/90. Even though a considerable volume of container cargo diverted from MBP to JNP, the number of containers discharged/loaded at the two ports increased sharply from 342,000 TEUs to 858,000 TEUs showing an average growth rate of 16.6% per annum.

Large container vessels provide a relatively low transportation cost, especially for long distance routes such as India-Europe, India-East Asia and India-East Coast of America. Deeper container berths are required so as to reduce transportation costs to/from those countries at a long distance from India. In addition, even on short distance routes such as India-the Middle East, India-Southeast Asia and India-South Asia where containers are transported mainly by feeder services, feeder vessel size has shown an increasing trend. Thus, deeper berths are required.

(2) Excessively-low Container-Handling Productivity due to the Current Operational Manner

A marine container terminal is generally operated and controlled by a single terminal operator who takes full responsibility of containers from the gate to container vessels within the terminal in export and vice versa in import. Containers are stacked in order on a marshaling yard behind berths according to yard plan after being received from land side and loaded onto a container vessel according to loading sequence plan made by the terminal operator based on a vessel stowage plan in export and vice versa in import. This modernized terminal operation system enables swift, safe and economical container handling at marine container terminals and is widely adopted throughout the world. However, this system has not yet been introduced to the container terminals at MBP.

Container terminals at MBP should be managed and operated by a single terminal operator so as to increase container handling productivity and secure efficient and safe operations.

(3) Shortage of Container Handling Equipment

As to container handling machines, two quay-side gantry cranes are installed only at Ballard Pier Station and ship's cranes are used to lift containers alongside at the remaining container berths of Indira No. 1-5. The shortage of quay-side container gantry cranes is one of the major reasons of the seriously-low container handling productivity at Indira No. 1-5. Average productivity at Indira No. 1-5 is only 3.2 boxes per hour per gang, which is much less than 11.6 boxes per hour per gang at Ballard Pier Station (BPS) in 1995/96.

Moreover, only three RTGs (Rubber-Tired Gantry) are installed on the container park behind BPS. On the other hand, reach-stackers are mainly used on the remaining container parks inside the docks. Although reach-stackers are conventionally used in narrow space, they require more maneuvering space compared with RTGs. That means stacking yard is less utilized due to shortage of efficient handling machines such as RTGs.

(4) Effective Utilization of the Existing Facilities

In making the Master Plan, the effective utilization of the existing facilities to meet port requirements needs to be examined so as to save investment cost for a new project as much as possible along with improvement and operation systems of the port aiming at efficient cargo-handling.

(5) Potential Capacity of MBP in Container Handling

As mentioned in Section 12.2.2, the potential capacity in container-handling of MBP is estimated to be approximately one million TEUs if a new container terminal with off-shore jetty-typed berths is built and the existing land being used for conventional cargo at present is converted into a container stacking yard. By making the most of the existing facilities, it would not be necessary to create land by open sea reclamation.

(6) Future Port Requirements and Functional Allotment of Container Handling between MBP and JNP

As mentioned in Chapter 12, one million containers out of the total forecast traffic of 5.9 million TEU containers through the two ports, MBP and JNP, in the year 2017 is assigned to MBP and the remaining 4.9 million TEUs to JNP considering various factors including potential capacity of container handling, hinterlands and transport costs.

(7) Economical Transportation

In making the port investment plan, it is necessary to put emphasis on economical transportation, considering both the investment cost for port facilities and ship transportation cost from the standpoint of the Indian national economy.

(8) Generation of Employment Opportunity

Considering the number of employees of MBPT and the high unemployment rate of over 40% in India at present, port activities at MBP are expected to generate employment opportunities in the future, though the modernization of the port results in job losses for the dock workers. Therefore, MBP needs to attract more port traffic through strengthening competitiveness in the international shipping market.

(9) Environmental Impact on Areas around the Port Induced by the Port Development

In the port development, environmental impact on the area both during the periods under construction and after the start of operations must be considered.

Based on the above issues, the following concept of modernizing container-handling of MBP is proposed for the purpose of achieving safe, efficient and reliable operations for the customers.

(1) Establishment of a Full-Scale New Container Terminal with Deeper Berths

To receive one million TEU containers assigned to MBP in the stage of the Master Plan, a full-scale new container terminal with deeper berths will be required.

(2) Introduction of a Closed Terminal System to the New Container Terminal

It is advisable to introduce a closed terminal system controlled by a terminal operator that takes the responsibility of receipt, storage and delivery of containers at the terminal by conducting yard planning and inventory control of containers which is indispensable for a modernized container terminal.

(3) Deepening the Approach Channel to MBP

To receive larger container vessels approaching to the new container terminal with deeper berths than the existing ones inside Indira Dock, it is necessary to deepen the existing approach channel from the currently maintained level.

(4) Preparation of the Off-Dock Container Depots within the Landed Estate of MBPT

To back up the container-handling operations at the new container terminal within a limited space, it is indispensable to prepare off-dock container depots as back-up facilities to be placed within the landed estate of MBPT. For this purpose, it is necessary to evict the leased lands which are no longer used for port-related activities within its estate.

12.1.2 Conventional Cargo Handling

The volume of non-containerized break and dry bulk cargoes through MBP and JNP has steadily increased from 5.4 to 7.7 million tons in the period of 1989/90 to 1995/96 showing an average annual growth rate of 6.2%. 7.7 million tons mainly comprises finished fertilizer in dry bulk of 2.8 million tons accounting for 36.4% of the total volume. Future volume of break and dry bulk cargo to be handled at MBP in 2017 is estimated at 7.9 million tons (see **Chapter 9**).

In making the Master Plan for the existing conventional cargo handling facilities, the following aspects concerning the port modernization are recognized.

(1) Mixed Use of Berths in the Docks

Various conventional cargoes are not well classified and assigned to the specified berths in Indira, Victoria and Prince's Docks. Conventional cargo handling conditions at present are chaotic.

(2) Shortage of Forklift Trucks in Number and Lifting Capacity for Long and Heavy Cargo

In handling heavy cargo such as coils, pipes and plates of steel products on dock-side, a shortage of forklift trucks is found in number and lifting capacity. In addition, suitable attachments of forklift trucks designed to lift above-specified cargo efficiently and safely are not well prepared.

Based on the above issues, the following concept of modernizing conventional cargo-handling of MBP is proposed for the purpose of achieving safe, efficient and reliable operations for customers. Conventional cargo is required to be well classified and assigned to specified berths in Indira, Victoria and Prince's Docks, in order to achieve safe and efficient operations.

12.1.3 Marine Oil Terminal

MBP is playing various roles in petroleum handling by supplying imported crude petroleum to the refineries at Trombay or POL to the storage tanks there, and by conversely shipping Bombay High Crude produced at off-shore oil wells or POL to the other coastal regions.

(1) Increasing Volume of POL handled at JD-1 to JD-3 and Old Pir Pau Pier

The demand of POL (refined petroleum products and lubricant) distributed from Mumbai to its hinterland by land has already exceeded the refining capacity of 12 million tons per annum which is the total of the two refineries at Trombay. The shortage of supply is balanced by the imported POL from overseas.

POL of 1.6 million tons was shipped in 1995/96 by coastal shipping due to inter-regional supply-demand imbalance in terms of POL grades, although the shipped volume showed a downward trend recently in inverse proportion to an increase of imported POL. POL has been discharged/loaded from/onto petroleum tankers mainly at jetties of JD-1 to JD-3, and to a lesser extent at the berth of Old Pir Pau Pier along with chemical products.

(2) Shortage of Discharging Capacity of Pipeline of JD Nos. 1 to 3

The shortage of discharging capacity of pipelines is a present bottleneck to handle petroleum, connecting the JD jetties Nos.1 to 3 at Butcher Island and the refineries at Trombay which were designed to meet the original refining capacity of 3.5 million tons per annum. The pipelines have been left without replacement even after the expansion of refining capacity up to 12 million tons per annum. The bottleneck is found in discharging and loading petroleum through the jetties, resulting in excessively long berth waiting times of petroleum tankers, indicating 5.2 days per vessel on average in 1995/96. A large increase in the traffic volume of POL tankers which need much longer berthing times than crude petroleum tankers aggravates the congestion. MBPT has a plan to replace the existing pipelines of 12 to 24 inches in diameter by larger-sized pipelines of 30 to 42 inches along with the installation of discharging / loading facilities at the JD Nos. 1-3 jetties including loading arms.

Phase-I project of replacing the pipelines will start from April, 1998.

Based on the above issues, on-going replacement project of pipelines needs to be examined if the target volume of POL at the year 2017 can be handled by replaced pipelines and New Pir Pau berth.

12.1.4 Port Traffic Facilities

When planning the container yards and depots inside and outside the docks, it is necessary to put emphasis on connecting separated yards and depots by dedicated fly-over type and elevated port roads with adequate capacity compared with planned container flows. In addition, as the port roads which connect to the common roads outside the port are already congested, it is also necessary to plan the connection points as far as possible from the city center from the environmental point of view.

12.1.5 Main Channel, Approach Channel and Basin

The tidal range of the MBP and JNP is 5.2 m. If the depth of the main channel is 2.6 m less than that of the berths, vessels with maximum draft matching to the berth's dimension are theoretically able to enter/depart the port during approximately 50% of the year.

The depth of the existing main channel ranges from -10.8 m to -11.0 m. The difference of depths between the channel (-10.8 m) and JD-4 (-14.3 m) for crude oil is 3.5 m. Similarly, the difference of the depths between the main channel (-10.8 m) and the existing container berths at JNP (-13.5 m) is 2.7 m. Those differences imply that MBP and JNP identified the most cost-effective depth for the development project in the past.

Deepening the main channel is required to serve larger tankers of crude oil visiting JD-4 and larger container vessels visiting JNP with less time constraints when entering/departing the ports.

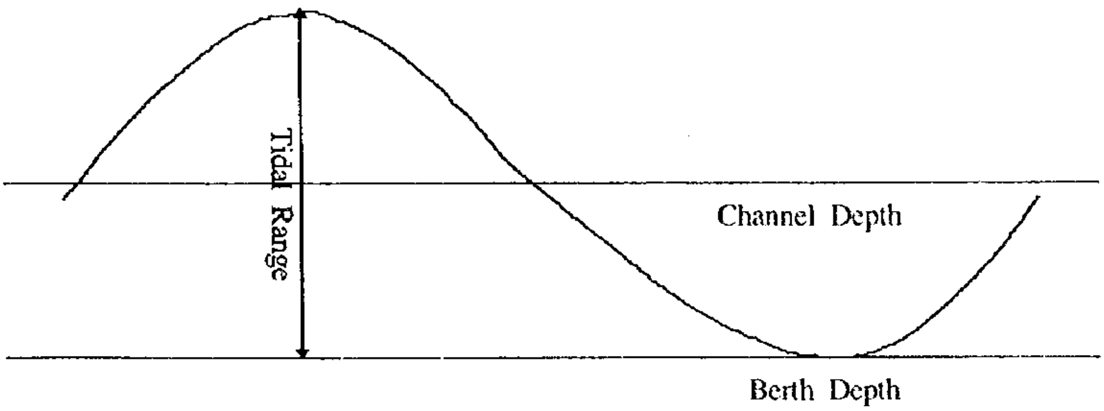


Figure 12.1.1 Conceptual Image of Time Constraints Caused by Tidal Range

12.2 The Master Plan for Container-Handling

12.2.1 Land Preparation for the Future Port Activities

(1) Land Preparation by Evicting Landed Estate under MBPT's Control

The total area of landed estate under MBPT's control is about 753 hectares, most of which was created by reclamation from 1873 to 1907. On the other hand, the land outside the docks was leased to the private sector on a long-term basis and used for depots of port cargoes such as raw cotton, grains, coal, timbers in log and manganese ore, or for port-related industries which imported raw materials or exported finished goods through MBP. Since then the composition of port cargo commodities and package styles has changed drastically reflecting the structural change of Indian industries. Raw materials are converted into finished products through ports and this has promoted a subsequent increase in containerization in international trade through MBP.

To cope with the dramatic progress of containerization, MBPT has converted some areas into container depots under its control outside the docks which fell out of use or were no longer used for port-related activities after evicting the land from the former lessees. Despite the effort of land eviction by MBPT and growing needs for more land to back-up dockside operation, a considerable portion of land is still left in non-port-related use.

As indicated in Chapter 10, there is a certain amount of land which will be possibly converted from existing use to port-related use by MBPT in a couple of years. Total area of the land is about 14 hectares. The scale of two areas is about 5 and 9 hectares, which enables an efficient use of the land for an off-dock container stacking yard, empty container stacking yard or CFSs.

(2) Possibility of Creating New Land by Reclamation

Any development activities within the coastal zone are regulated by the *"Coastal Regulation Zone Notification" (dated 19th February, 1991)* in India. According to the notification, no reclamation except for *"operational construction"* which actually needs waterfront for port-related activities is permissible. All reclamation projects require *"environmental clearance"* which is stipulated by *"Notification on Environmental Impact Assessment of Development Project" (dated*

27th January, 1994) by the Ministry of Environment and Forests. However, obtaining environmental clearance for a large-scale reclamation project seems to be very difficult, as the need for environmental consideration has become a focal point in government circles.

12.2.2 Required Additional Container Handling Facilities

(1) Target Volume of Containers to be handled at MBP in 2017

Total volume of container cargo at the year 2017 through two ports, MBP and JNP is estimated to be 5,934,000 TEUs (see Chapter 9). Since JNP has deep (-13.5m) container berths and spacious land for container stacking yard, most of the containers will be handled at JNP. According to functional allotment between the two ports mentioned in Chapter 11, MBP is assumed to handle containers up to its full capacity. The remaining volume of containers will be handled at JNP.

Potential capacity of handling containers at MBP is largely dependent on the capacity of the container stacking yard. Taking into consideration the total land which may be evicted by MBPT for container stacking yard outside the docks and the land which could be converted into container yard inside the docks, the capacity of handling containers at MBP is estimated to be approximately one million TEUs (see Table 12.2.1.)

Table 12.2.1 Target Volume of Containers to be Handled at MBP in 2017

(Unit: thousand TEUs)

	(2017) Import			(2017) Export			(2017) Total			(1995/6) Total
Port Name	Laden	Empty	Total	Laden	Empty	Total	Laden	Empty	Total	Total
MBP	306	194	500	475	25	500	781	219	1,000	518
JNP	1,510	957	2,467	2,344	123	2,467	3,854	1,080	4,934	325
Total	1,816	1,151	2,967	2,819	148	2,967	4,635	1,299	5,934	843

(2) Dimensions of Required Additional Container Handling Facilities

The required number of container berths, required scales of container marshaling yard, empty container yard and CFS are revealed by using computer simulation on assumed container operational conditions (see Table 12.2.2) Actual berthing schedule of container vessels was referred in assuming the future arrival of service vessels.

Total number of four berths are required to handle one million TEUs at MBP, which gives berth occupancy rate of 58.1% and average pre-berthing time per vessel of 2.3 hours. The required scales of container marshaling yard, empty container yard and CFS are shown in Table 12.2.3.

Table 12.2.2 Container Operational Conditions for Computer Simulation

Item	Operational Conditions
1. Total Number of Container to be Handled	1,000,000 TEUs/year
2. Number of Container Vessel Calls	881 calls/year (Berth Depth: -11.0m) 705 calls/year (Berth Depth: -12.0m) 529 calls/year (Berth Depth: -13.0m) 423 calls/year (Berth Depth: -13.5m)
3. Productivity (Gross)	24 boxes / hour/crane
4. No. of Gantry Cranes per Berth	2 cranes / berth
5. TUE/Box Ratio	1.44 TEUs / box
6. CFS Container Ratio	30% (Import) 30% (Export)
7. Arrival Distribution of Exporting Container Delivery at Marshaling Yard	1 to 6 days before ship arrival
8. Dwelling Time Distribution of Importing Container Cargo at CFS	1 to 6 days after unloading at the berth

Table 12.2.3 Required Dimensions of Container Handing Facilities

Item	Peaking Condition (TEUs/day)	Peaking Factor*	Required Dimensions of Facilities
1. Required Number of Berths	---	---	4 berths
2. Total Number of Containers	---	---	1,000,000 TEUs/year
3. Berth Occupancy Rate	---	---	58.1%
4. Average Detention Time	---	---	2.3 hours
5. Daily Maximum Number of Loading Containers dwelling at Marshaling Yard	10,337	(1.65)	3,446 G. slots
6. Daily Maximum Number of Empty Containers dwelling at Container Yard	10,024	(2.30)	3,341 G. slots
7. Daily Maximum Number of Loading Containers (Export) dwelling at CFS	1,835	(2.14)	36,005 sq.m
8. Daily Maximum Number of Unloading Containers (Import) dwelling at CFS	1,344	(1.52)	28,326 sq.m

Remarks) * represents ratio of annual peaking condition to daily average condition.

The existing container handling facilities will be utilized as a part of required facilities. Required dimensions of the facilities are summarized in Table 12.2.3.

12.2.3 Preparing Alternative Plans for Container-Handling

Six different alternative plans are prepared for the container-handling of the Master Plan (M/P). When making those alternatives to meet facility requirements, space limitation in MBP is taken into account. Major features of the six alternative plans are summarized in Table 12.2.4.

One alternative plan (Alternative-1) utilizes the existing Indira Dock Nos.2 to 5 berths as new container berths of which water depth is -9.8m with quay-side gantry cranes. These new container berths accommodate container vessel of about 800 TEUs in loading capacity, which remains as the status quo.

Four alternative plans (Alternative-2 to 5) seek deeper container berths toward the open sea without full-scale reclamation, taking above-mentioned environmental constraints into account. Optimum water depth for proposed container berths is evaluated so as to balance capital and maintenance costs with benefit in the following section.

The remaining alternative plan (Alternative-6) also seeks deeper container berths toward the open sea without full-scale reclamation. However, this alternative converts Victoria Dock into a container yard by reclamation though impact on environment is considered significantly small.

(1) Alternative-1

Alternative-1 is a plan to utilize the present Indira Dock Nos.2-5 berths as additional three container berths with quay-side gantry cranes and container marshaling yard behind those berths with transfer cranes. The existing Ballard Pier Station (BPS) with container marshaling yard of 516 G. slots will be also utilized as a container berth.

Since the container marshaling yard behind Indira No.2-5 berths accommodates only 1,224 G. slots, the remaining required container stacking yards of 1,706 G. slots are prepared at Indira No.1 (240 G. slots), Cotton Depot West (CDW) (972 G. slots), Timber Pond South (TPS) (494 G. slots). As to empty container yard, TPS accommodates 646 G. slots. Since the required dimension of empty container yard is 3,341 G. slots, however, the remaining required empty container yard of 2,695 G. slots will be in short supply and needs to be prepared outside the port.

The layout plan of major facilities for Alternative-1 is shown in Figure 12.2.1. The facility dimensions are summarized in Table 12.2.4.

Table 12.2.4 Major Features of Six Alternatives Plans for Container Handling

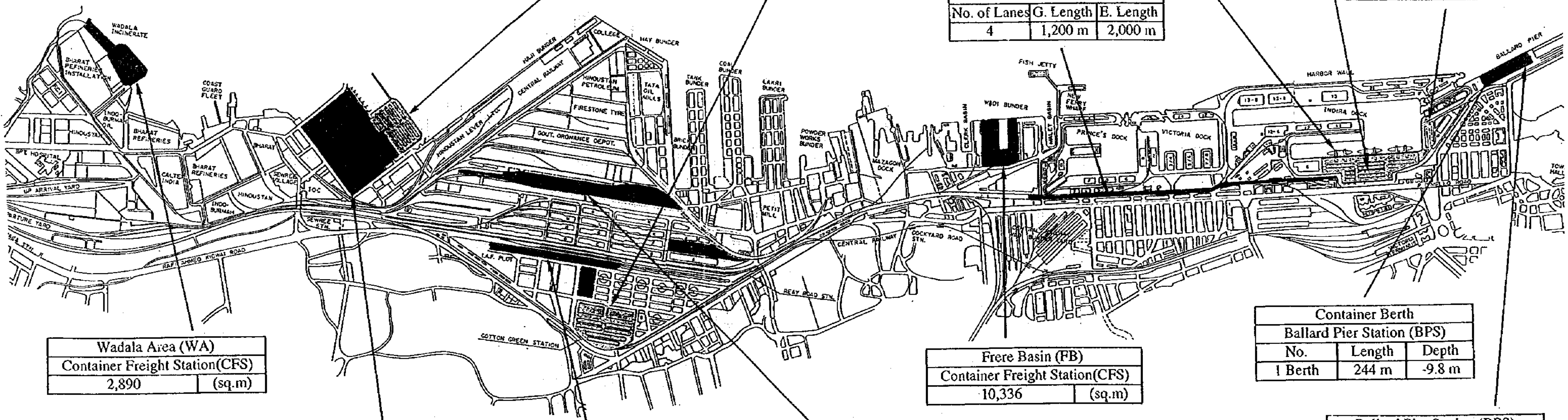
Features	Unit	Alternative-1	Alternative-2	Alternative-3	Alternative-4	Alternative-5	Alternative-6
1.Existing Container Berth							
1.Number of Berths		1	1	1	1	1	1
2.Berth Depth	(m)	-9.8	-9.8	-9.8	-9.8	-9.8	-9.8
3.Berth Length	(m)	244	244	244	244	244	244
4.Berth Location		BPS	BPS	BPS	BPS	BPS	BPS
2.Proposed Container Berth							
1.Number of Berths		3	3	3	3	3	3
2.Berth Depth	(m)	-9.8	-11 to -13	-11 to -13	-11 to -13	-11 to -13	-11 to -13.5
3.Berth Length	(m)	210	250 to 300	250 to 300	250 to 300	250 to 300	250 to 300
4.Berth Location		ID-2 to 5	ID-HW	800 m off ID-HW	800 m off ID-HW	800 m off ID-HW	800 m off ID-HW
3.Container Marshaling Yard	(G.slots)	3,446	3,446	3,446	3,446	3,446	3,446
1.Existing Yard	(G.slots)	516	516	516	516	516	516
2.Proposed Yard	(G.slots)	2,930	2,930	2,930	2,930	2,930	2,930
1.ID-1	(G.slots)	240	240	240	240	240	0
2.ID-2 to 5	(G.slots)	1,224	0	0	0	2,184	0
3.ID-HW	(G.slots)	0	2,376	2,376	2,376	0	0
4.Victoria Dock	(G.slots)	0	0	0	0	0	2,930
5.CDW	(G.slots)	972	0	0	0	506	0
6.TPS	(G.slots)	494	314	314	314	0	0
7.CRS	(G.slots)	0	0	0	0	0	0
4.Empty Container Yard	(G.slots)	3,341	3,341	3,341	3,341	3,341	3,341
1.Existing Yard	(G.slots)	0	0	0	0	0	0
2.Proposed Yard	(G.slots)	646	1,798	1,798	1,798	1,606	3,154
1.ID-1	(G.slots)	0	0	0	0	0	240
2.Victoria Dock	(G.slots)	0	0	0	0	0	802
3.CDW	(G.slots)	0	972	972	972	466	972
4.TPS	(G.slots)	646	826	826	826	1,140	1,140
5.CRS	(G.slots)	0	0	0	0	0	0
3.Shortage of Yard	(G.slots)	2,695	1,543	1,543	1,543	1,735	187
5.Container Freight Station	(sq.m)	67,687	67,687	67,687	67,687	67,687	67,687
1.Existing CFS	(sq.m)	48,487	48,487	48,487	48,487	48,487	48,487
2.Proposed CFS	(sq.m)	19,200	19,200	19,200	19,200	19,200	19,200
CDW	(sq.m)	19,200	19,200	19,200	19,200	19,200	19,200
6. Dedicated Road for Containers							
1. No. of Lanes	(lanes)	4	4	4	4	4	4
2. Ground Length	(m)	1,200	2,200	2,200	2,200	3,100	1,000
3. Elevated Length	(m)	2,000	2,200	2,200	2,200	3,100	700

Remarks) BPS: Ballard Pier Station, ID-1: Indira Dock No.1, ID-2 to 5: Indira Dock Nos.2 to 5, ID-HW: Indira Dock Harbour Wall,
Victoria Dock: Reclamed Victoria Dock, CDW: Cotton Depot West, TPS: Timber Pond South, CRS: Central Railway Stores

Figure 12.2.1 Layout Plan of Major Facilities for Alternative-1

Summary of Alternative Projects for Container Handling Facilities at MBP

Facilities	Unit	Alternative-1
1.Existing Container Berth		
1.Number of Berths		1
2.Berth Depth	(m)	-9.8
3.Berth Length	(m)	244
4.Berth Location		BPS
2.Proposed Container Berth		
1.Number of Berths		3
2.Berth Depth	(m)	-9.8
3.Berth Length	(m)	210
4.Berth Location		ID-2 to 5
3.Container Marshaling Yard	(G.slots)	3,446
1.Existing Yard	(G.slots)	516
2.Proposed Yard	(G.slots)	2,930
1.ID-1	(G.slots)	240
2.ID-2 to 5	(G.slots)	1,224
3.ID-HW	(G.slots)	0
4.Victoria Dock	(G.slots)	0
5.CDW	(G.slots)	972
6.TPS	(G.slots)	494
7.CRS	(G.slots)	0
4.Empty Container Yard	(G.slots)	3,341
1.Existing Yard	(G.slots)	0
2.Proposed Yard	(G.slots)	646
1.ID-1	(G.slots)	0
2.Victoria Dock	(G.slots)	0
3.CDW	(G.slots)	0
4.TPS	(G.slots)	646
5.CRS	(G.slots)	0
3.Shortage of Yard	(G.slots)	2,695
5.Container Freight Station	(sq.m)	67,687
1.Existing CFS	(sq.m)	48,487
2.Proposed CFS	(sq.m)	19,200
CDW	(sq.m)	19,200
6. Dedicated Road for Containers		
1. No. of Lanes	(lanes)	4
2. Ground Length	(m)	1,200
3. Elevated Length	(m)	2,000



Timber Pond South (TPS)		
Marshaling Yard	Empty Container Yard	Container Freight Station
(G.Slots)	(G.Slots)	(sq.m)
494	646	-

Cotton Depot West (CDW)		
Marshaling Yard	Empty Container Yard	Container Freight Station
(G.Slots)	(G.Slots)	(sq.m)
972	-	19,200

Indira Dock No.2-5 (ID-2-5)	
Marshaling Yard (G.Slots)	
1,224	(G.Slots)

Container Berth		
Indira Dock No.2-5 (ID-2-5)		
No.	Length	Depth
3 Berths	210 m	-9.8 m

Indira Dock No.1 (ID-1)	
Empty Container Yard	
240	(G.Slots)

Dedicated Road for Containers		
No. of Lanes	G. Length	E. Length
4	1,200 m	2,000 m

Wadala Area (WA)	
Container Freight Station(CFS)	
2,890	(sq.m)

Timber Pond (TP)	
Container Freight Station(CFS)	
14,020	(sq.m)

Cotton Depot (COD)	
Container Freight Station(CFS)	
11,003	(sq.m)

Manganese Ore Depot(MOD)	
Container Freight Station(CFS)	
10,238	(sq.m)

Frere Basin (FB)	
Container Freight Station(CFS)	
10,336	(sq.m)

Container Berth		
Ballard Pier Station (BPS)		
No.	Length	Depth
1 Berth	244 m	-9.8 m

Ballard Pier Station (BPS)	
Marshaling Yard	
516	(G.Slots)

(2) Alternative-2

Alternative-2 is a plan to deepen and utilize the existing Indira Dock Harbour Wall as open-sea container berths with quay-side gantry cranes and container marshaling yard behind those berths with transfer cranes.

The existing Ballard Pier Station (BPS) with container marshaling yard of 516 G. slots will be utilized as container berth.

Since the container marshaling yard within Indira Dock Harbour Wall accommodates 2,376 G. slots, the remaining required container marshaling yards of 554 G. slots are prepared at Indira No.1 (240 G. slots) and TPS (314 G. slots). As to empty container yard, CDW and TPS accommodate 972 G. slots and 826 G. slots respectively. Since the required dimensions of empty container yard is 3,341 G. slots, however, the remaining required empty container yard of 1,543 G. slots will be in short supply and needs to be prepared outside the port area.

The layout plan of major facilities for Alternative-2 is shown in Figure 12.2.2. The facility dimensions are summarized in Table 12.2.4.

(3) Alternative-3

Alternative-3 is a plan to build off-shore jetty-type container berths approximately 800 meters off the Indira Dock Harbour Wall (ID-HW) connected with its land-side by access bridges using water-through structure such as pile-structure. Hard material lays under the seabed with a depth ranging from -4.0 to -10.0 meters within the area up to about 800 meters off the front of the Harbour Wall. Detailed information of hard materials distribution is given in Chapter 2.

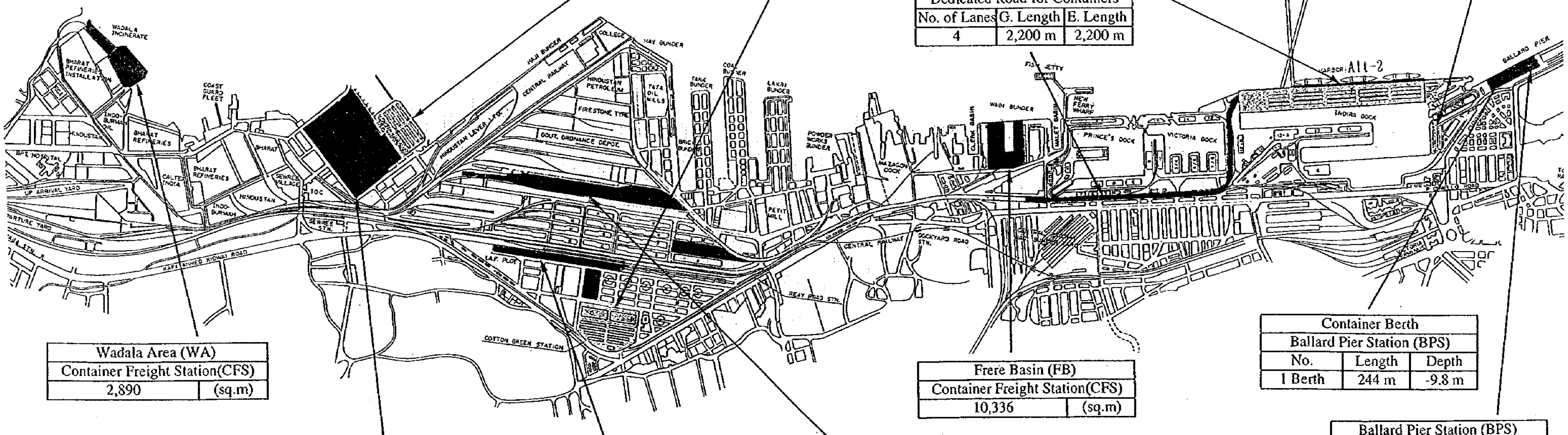
Berth alignment of Alternative-3 is proposed to be parallel to the Harbour Wall so as to ensure more tranquillity for mooring vessels and container-handling operations, considering the tidal flows.

The dimensions and layout of other container handling facilities except the jetty are exactly the same as those of Alternative-2. The layout plan of major facilities for Alternative-3 is shown in Figure 12.2.2. The facility dimensions are summarized in Table 12.2.4.

Figure 12.2.2 Layout Plan of Major Facilities for Alternative-2 to 4

Summary of Alternative Projects for Container Handling Facilities at MBP

Facilities	Unit	Alternative-2 / 3 / 4
1.Existing Container Berth		
1.Number of Berths		1
2.Berth Depth	(m)	-9.8
3.Berth Length	(m)	244
4.Berth Location		BPS
2.Proposed Container Berth		
1.Number of Berths		3
2.Berth Depth	(m)	-11 to -13
3.Berth Length	(m)	250 to 300
4.Berth Location		ID-HW / 800m off HW
3.Container Marshaling Yard	(G.slots)	3,446
1.Existing Yard	(G.slots)	516
2.Proposed Yard	(G.slots)	2,930
1.ID-1	(G.slots)	240
2.ID-2 to 5	(G.slots)	0
3.ID-HW	(G.slots)	2,376
4.Victoria Dock	(G.slots)	0
5.CDW	(G.slots)	0
6.TPS	(G.slots)	314
7.CRS	(G.slots)	0
4.Empty Container Yard	(G.slots)	3,341
1.Existing Yard	(G.slots)	0
2.Proposed Yard	(G.slots)	1,798
1.ID-1	(G.slots)	0
2.Victoria Dock	(G.slots)	0
3.CDW	(G.slots)	972
4.TPS	(G.slots)	826
5.CRS	(G.slots)	0
3.Shortage of Yard	(G.slots)	1,543
5.Container Freight Station	(sq.m)	67,687
1.Existing CFS	(sq.m)	48,487
2.Proposed CFS	(sq.m)	19,200
CDW	(sq.m)	19,200
6. Dedicated Road for Containers		
1. No. of Lanes	(lanes)	4
2. Ground Length	(m)	2,200
3. Elevated Length	(m)	2,200



Timber Pond South (TPS)		
Marshaling Yard	Empty Container Yard	Container Freight Station
(G.Slots)	(G.Slots)	(sq.m)
314	826	-

Cotton Depot West (CDW)		
Marshaling Yard	Empty Container Yard	Container Freight Station
(G.Slots)	(G.Slots)	(sq.m)
-	972	19,200

Container Berth		
Indira Dock Harbor Wall(ID-HW)		
No.	Length	Depth
3 Berths	250 m to 300 m	-11.0m to -13.0m

Indira Dock No.1 (ID-1)	
Empty Container Yard	
240	(G.Slots)

Indira Dock Harbor Wall(ID-HW)	
Marshaling Yard (G.Slots)	
2,376	(G.Slots)

Dedicated Road for Containers		
No. of Lanes	G. Length	E. Length
4	2,200 m	2,200 m

Wadala Area (WA)	
Container Freight Station(CFS)	
2,890	(sq.m)

Container Berth		
Ballard Pier Station (BPS)		
No.	Length	Depth
1 Berth	244 m	-9.8 m

Frere Basin (FB)	
Container Freight Station(CFS)	
10,336	(sq.m)

Timber Pond (TP)	
Container Freight Station(CFS)	
14,020	(sq.m)

Cotton Depot (COD)	
Container Freight Station(CFS)	
11,003	(sq.m)

Manganese Ore Depot(MOD)	
Container Freight Station(CFS)	
10,238	(sq.m)

Ballard Pier Station (BPS)	
Marshaling Yard	
516	(G.Slots)

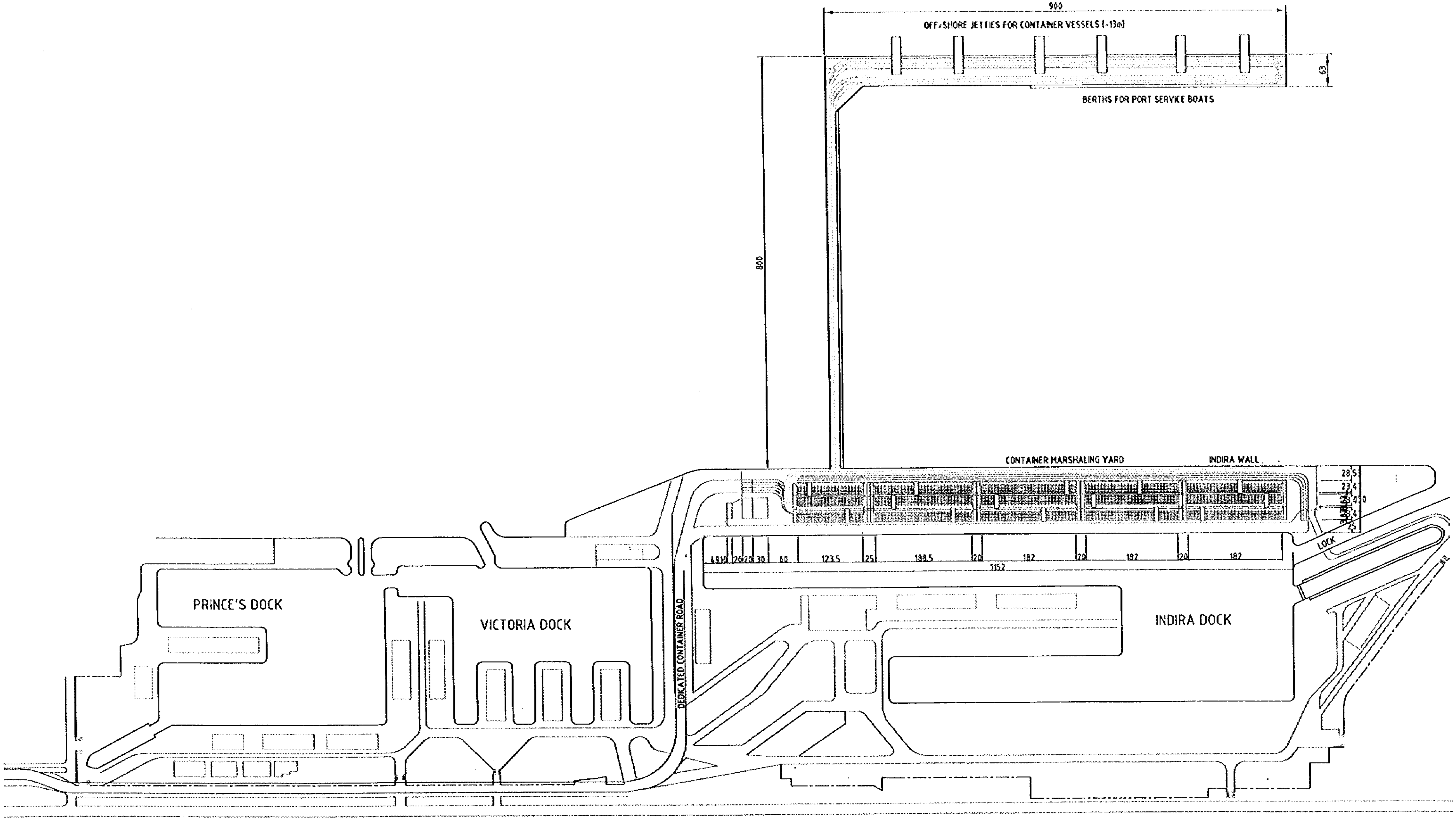


Figure 12.2.2.(2) LAYOUT PLAN OF A NEW CONTAINER TERMINAL AT INDIRA HARBOUR WEALL (ALTERNATIVE-3)

SCALE 1:7,000

(4) Alternative-4

Alternative-4 is a plan to build off-shore jetty-type container berths approximately 900 meters off the Indira Dock Harbour Wall (ID-HW) connected with its ID-HW by access bridges using water-through structure such as pile-structure. Hard material lays under the seabed with a depth ranging from -4.0 to -10.0 meters within the area up to about 800 meters off the front of the Harbour Wall. Detailed information of hard materials distribution is given in Chapter 2.

Berth alignment of Alternative-4 is proposed to be parallel to NNE direction so as to minimize the capital dredging volume of hard materials, considering the tidal flows.

The scale and layout of other container handling facilities except the jetty are exactly the same as Alternative-2 and Alternative-3. The layout plan of major facilities for Alternative-4 is shown in Figure 12.2.2. The facility dimensions are summarized in Table 12.2.4.

(5) Alternative-5

Alternative-5 is a plan to build off-shore jetty container berths approximately 800 meters off the Indira Dock Harbour Wall connected with its ID-2 to 5 by access bridge using water-through structure such as pile-structure.

Hard material lays under the seabed with a depth ranging from -4.0 to -10.0 meters within the area up to about 800 meters off the front of the Harbour Wall. Detailed information of hard materials distribution is given in Chapter 2. Berth alignment of Alternative-5 is proposed to be parallel to the Harbour Wall so as to ensure more tranquillity for mooring vessels and container-handling operations, considering the tidal flows.

The existing Ballard Pier Station (BPS) with container marshaling yard of 516 G. slots will be also utilized as a container berth.

Since the container marshaling yard behind Indira Nos.2-5 berths accommodates only 2,184 G. slots, the remaining required container yards of 746 G. slots are prepared at Indira No.1 (240 G. slots) and Cotton Depot West (CDW) (506 G. slots). As to empty container yard, CDW and TPS accommodate 466 G. slots and 1,140 G. slots respectively. Since the required dimension of empty container yard is 3,341 G. slots, however, the remaining required empty container yard of 1,735 G. slots will be in short supply and need to be prepared outside the port.

Facilities	Unit	Alternative-5
1.Existing Container Berth		
1.Number of Berths		1
2.Berth Depth	(m)	-9.8
3.Berth Length	(m)	244
4.Berth Location		BPS
2.Proposed Container Berth		
1.Number of Berths		3
2.Berth Depth	(m)	-11 to -13
3.Berth Length	(m)	250 to 300
4.Berth Location		800 m off HW
3.Container Marshaling Yard	(G.slots)	3,446
1.Existing Yard	(G.slots)	516
2.Proposed Yard	(G.slots)	2,930
1.ID-1	(G.slots)	240
2.ID-2 to 5	(G.slots)	2,184
3.ID-HW	(G.slots)	0
4.Victoria Dock	(G.slots)	0
5.CDW	(G.slots)	506
6.TPS	(G.slots)	0
7.CRS	(G.slots)	0
4.Empty Container Yard	(G.slots)	3,341
1.Existing Yard	(G.slots)	0
2.Proposed Yard	(G.slots)	1,606
1.ID-1	(G.slots)	0
2.Victoria Dock	(G.slots)	0
3.CDW	(G.slots)	466
4.TPS	(G.slots)	1,140
5.CRS	(G.slots)	0
3.Shortage of Yard	(G.slots)	1,735
5.Container Freight Station	(sq.m)	67,687
1.Existing CFS	(sq.m)	48,487
2.Proposed CFS	(sq.m)	19,200
CDW	(sq.m)	19,200
6. Dedicated Road for Containers		
1. No. of Lanes	(lanes)	4
2. Ground Length	(m)	3,100
3. Elevated Length	(m)	3,100

Figure 12.2.3 Layout Plan of Major Facilities for Alternative-5

Summary of Alternative Projects for Container Handling Facilities at MBP

Container Berth		
800 m off ID-HW]		
No.	Length	Depth
3 Berths	250 m to 300 m	-11.0m to -13.0m

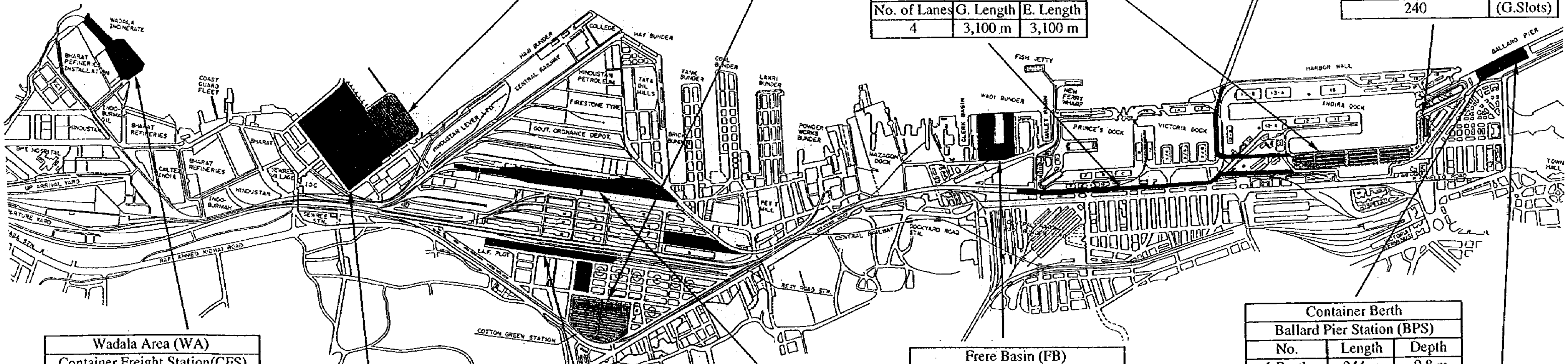
Cotton Depot West (CDW)		
Marshaling Yard	Empty Container Yard	Container Freight Station
(G.Slots)	(G.Slots)	(sq.m)
506	466	19,200

Timber Pond South (TPS)		
Marshaling Yard	Empty Container Yard	Container Freight Station
(G.Slots)	(G.Slots)	(sq.m)
0	1,140	-

Indira Dock No.2-5 (ID-2-5)	
Marshaling Yard (G.Slots)	
2,184	(G.Slots)

Indira Dock No.1 (ID-1)	
Empty Container Yard	
240	(G.Slots)

Dedicated Road for Containers		
No. of Lanes	G. Length	E. Length
4	3,100 m	3,100 m



Wadala Area (WA)	
Container Freight Station(CFS)	
2,890	(sq.m)

Frere Basin (FB)	
Container Freight Station(CFS)	
10,336	(sq.m)

Container Berth		
Ballard Pier Station (BPS)		
No.	Length	Depth
1 Berth	244 m	-9.8 m

Timber Pond (TP)	
Container Freight Station(CFS)	
14,020	(sq.m)

Cotton Depot (COD)	
Container Freight Station(CFS)	
11,003	(sq.m)

Manganese Ore Depot(MOD)	
Container Freight Station(CFS)	
10,238	(sq.m)

Ballard Pier Station (BPS)	
Marshaling Yard	
516	(G.Slots)

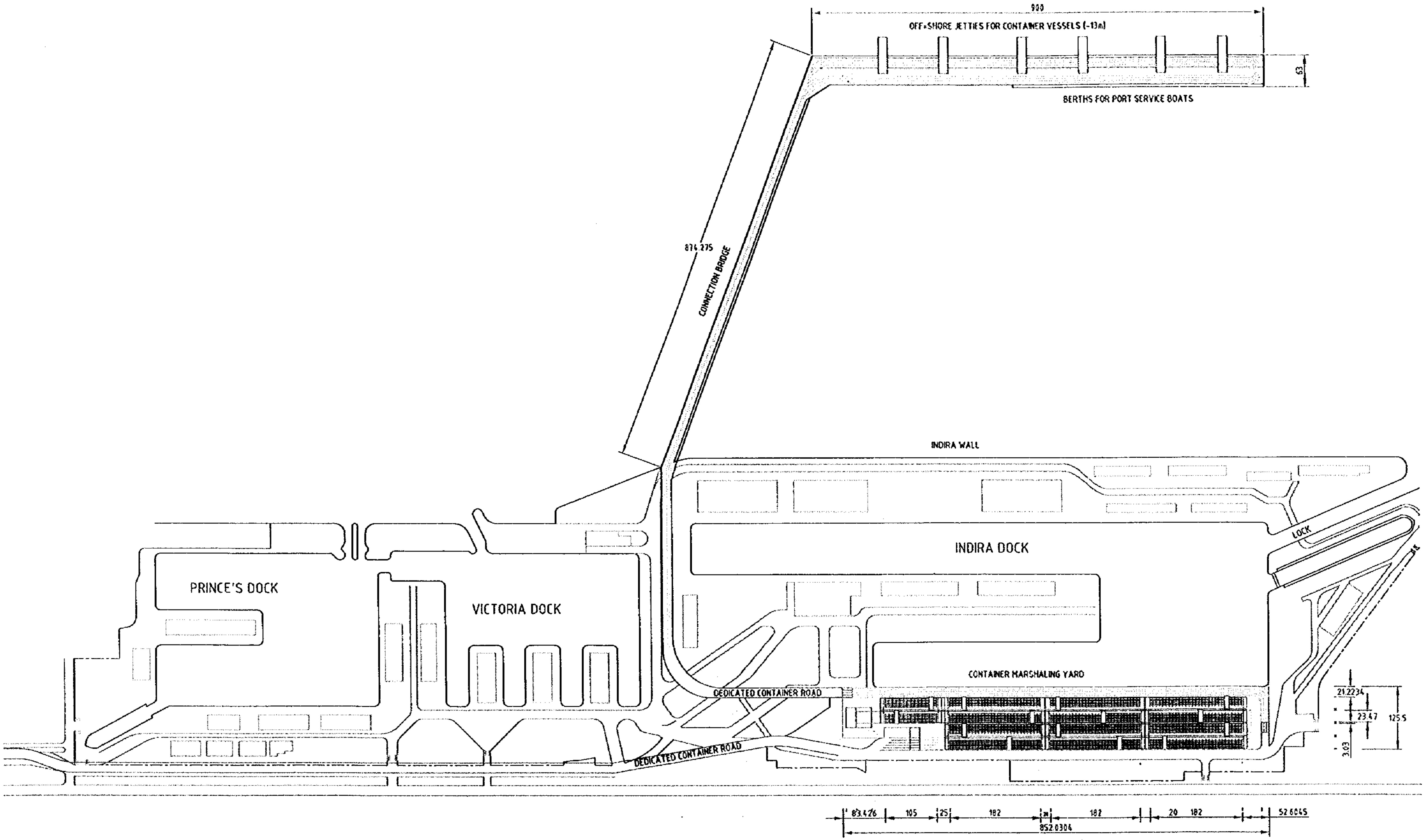


Figure 12.2.3 (2) LAYOUT PLAN OF A NEW CONTAINER TERMINAL AT ID2-ID6 (ALTERNATIVE-5)

SCALE 1:7,000

The layout plan of major facilities for Alternative-5 is shown in Figure 12.2.3. The facility dimensions are summarized in Table 12.2.4.

(6) Alternative-6

Alternative-6 is a plan to build off-shore jetty container berths approximately 800 meters off the Indira Dock Harbour Wall connected with Victoria Dock filled up as container yard by access bridge using water-through structure such as pile-structure. This access bridge is planned to connect to the north east corner of Victoria Dock from the viewpoint of smooth container traffic flow. Container traffic between container yard and off-dock CFSs is planned to flow clockwise. On the other hand, container traffic between container yard and off-shore berths is planned to flow counter-clockwise. Both traffic comes in and out at yard-gates located on the one end of container yard so as to avoid merging of any traffic within the container yard. Moreover, since there are four edible oil tanks located at the south east corner of Victoria Dock, which are currently heavily used and mainly evacuated by rail, connection of the access bridge with the south east corner was avoided to keep the existing edible oil tanks operational as long as possible.

Hard material lays under the seabed with a depth ranging from -4.0 to -10.0 meters within the area up to about 800 meters off the front of the Harbour Wall. Detailed information of hard materials distribution is given in Chapter 2. Berth alignment of Alternative-6 is proposed to be parallel to the Harbour Wall so as to ensure more tranquillity for mooring vessels and container-handling operations, considering the tidal flows.

The existing Ballard Pier Station (BPS) with container marshaling yard of 516 G. slots will be utilized as a container berth.

The container yard at Victoria Dock accommodates 2,930 G. slots of laden containers and 802 G. slots of empty containers. As to empty container yard Cotton Depot West (CDW) and TPS accommodate 972 G. slots and 1,140 G. slots respectively. Since the required dimension of empty container yard is 3,341 G. slots, however, the remaining required empty container yard of 187 G. slots will be in short supply and need to be prepared outside the port.

The layout plan of major facilities for Alternative-6 is shown in Figure 12.2.4. The facility dimensions are summarized in Table 12.2.4.

Figure 12.2.4 Layout Plan of Major Facilities for Alternative-6

Summary of Alternative Projects for Container Handling Facilities at MBP

Ficilities	Unit	Alternative-6
1.Existing Container Berth		
1.Number of Berths		1
2.Berth Depth	(m)	-9.8
3.Berth Length	(m)	244
4.Berth Location		BPS
2.Proposed Container Berth		
1.Number of Berths		3
2.Berth Depth	(m)	-11 to -13.5
3.Berth Length	(m)	250 to 300
4.Berth Location		800 m off HW
3.Container Marshaling Yard	(G.slots)	3,446
1.Existing Yard	(G.slots)	516
2.Proposed Yard	(G.slots)	2,930
1.ID-1	(G.slots)	0
2.ID-2 to 5	(G.slots)	0
3.ID-HW	(G.slots)	0
4.Victoria Dock	(G.slots)	2,930
5.CDW	(G.slots)	0
6.TPS	(G.slots)	0
7.CRS	(G.slots)	0
4.Empty Container Yard	(G.slots)	3,341
1.Existing Yard	(G.slots)	0
2.Proposed Yard	(G.slots)	3,154
1.ID-1	(G.slots)	240
2.Victoria Dock	(G.slots)	802
3.CDW	(G.slots)	972
4.TPS	(G.slots)	1,140
5.CRS	(G.slots)	0
3.Shortage of Yard	(G.slots)	187
5.Container Freight Station	(sq.m)	67,687
1.Existing CFS	(sq.m)	48,487
2.Proposed CFS	(sq.m)	19,200
CDW	(sq.m)	19,200
6. Dedicated Road for Containers		
1. No. of Lanes	(lanes)	4
2. Ground Length	(m)	1,000
3. Elevated Length	(m)	700

Container Berth		
800 m off ID-HW		
No.	Length	Depth
3 Berths	250 m to 300 m	-11.0m to -13.5m

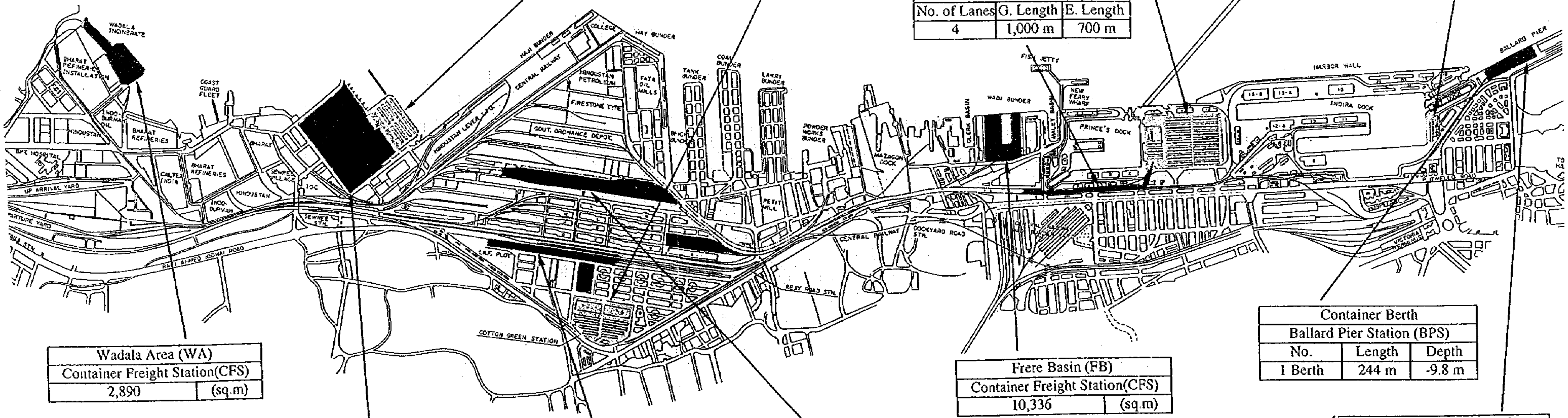
Cotton Depot West (CDW)		
Marshaling Yard	Empty Container Yard	Container Freight Station
(G.Slots)	(G.Slots)	(sq.m)
0	972	19,200

Victoria Dock Container Yard		
Marshaling Yard	Empty Container Yard	Container Freight Station
(G.Slots)	(G.Slots)	(sq.m)
2,930	802	-

Indira Dock No.1 (ID-1)	
Empty Container Yard	
240	(G.Slots)

Timber Pond South (TPS)		
Marshaling Yard	Empty Container Yard	Container Freight Station
(G.Slots)	(G.Slots)	(sq.m)
0	1,140	-

Dedicated Road for Containers		
No. of Lanes	G. Length	E. Length
4	1,000 m	700 m



Container Berth		
Ballard Pier Station (BPS)		
No.	Length	Depth
1 Berth	244 m	-9.8 m

Wadala Area (WA)	
Container Freight Station(CFS)	
2,890	(sq.m)

Frere Basin (FB)	
Container Freight Station(CFS)	
10,336	(sq.m)

Ballard Pier Station (BPS)	
Marshaling Yard	
516	(G.Slots)

Timber Pond (TP)	
Container Freight Station(CFS)	
14,020	(sq.m)

Cotton Depot (COD)	
Container Freight Station(CFS)	
11,003	(sq.m)

Manganese Ore Depot(MOD)	
Container Freight Station(CFS)	
10,238	(sq.m)

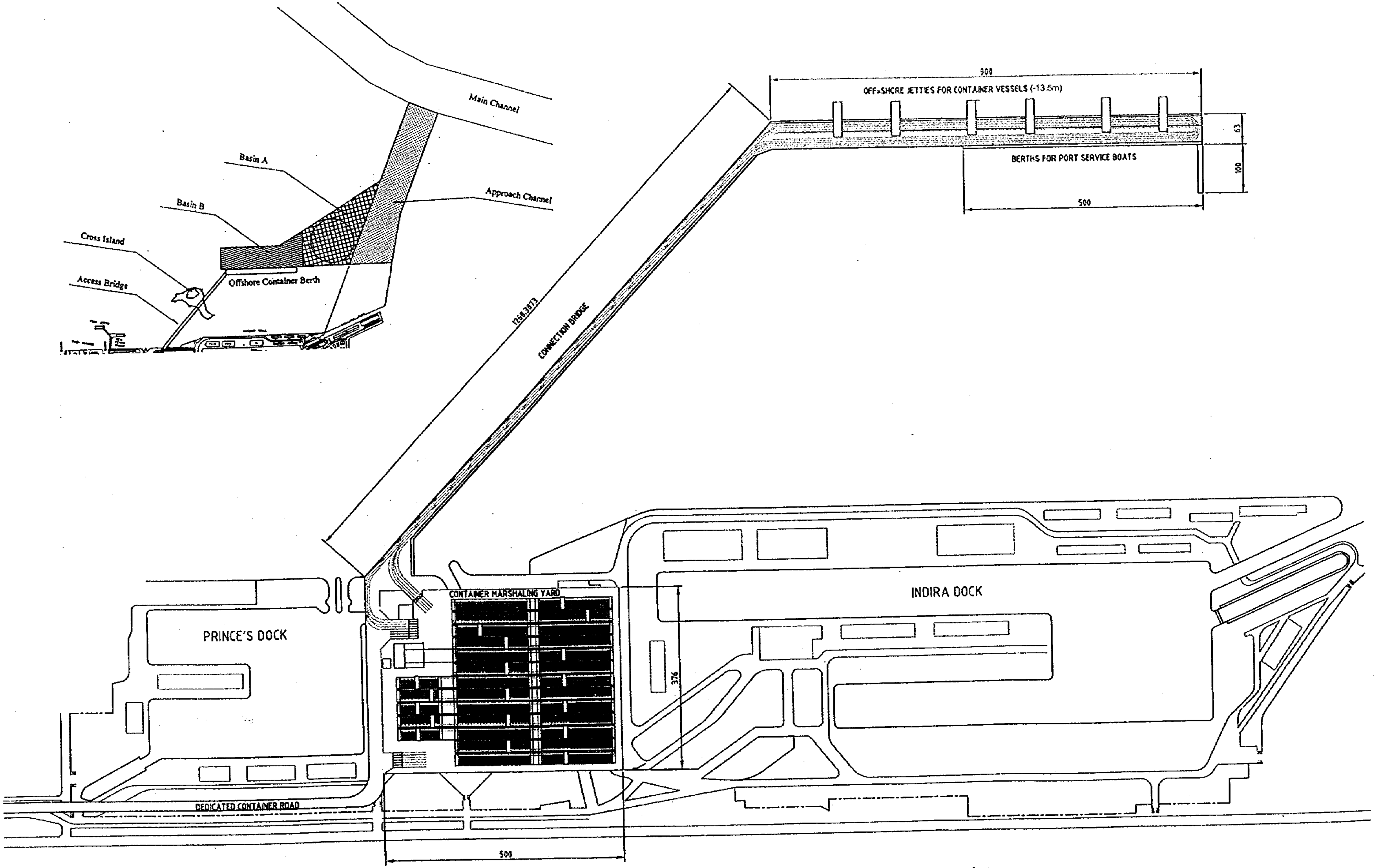


Figure 12.2.4 (2) LAYOUT PLAN OF A NEW CONTAINER TERMINAL AT VICTORIA DOCK (ALTERNATIVE-6)
SCALE1:7,000

12.2.4 Evaluation of the Alternative Plans, Berth and Approach Channel Depths

(1) Alternative Dimensions of Proposed Container Berth

When planning the container berth, dimensions of standardized container vessels and standardized container berths are essential information (see Table 12.2.5). Alternative berth depths of -9.8 m, -11.0 m, -12.0 m and -13.0 m are examined for new container berth at MBP in this study, taking dimensions of the existing facilities and increasing trend of container vessel size in the future into account.

Table 12.2.5 Dimensions of Standardized Container Vessels and Standardized Container Berths

Dimensions of Container Vessels					Dimensions of Container Berth		
Loading Capacity (TEU)	DWT (tons)	Full Draft (m)	LOA (m)	Breadth (m)	Berth Depth (m)	Berth Length (m)	Remarks
500	12,000	8.0	140	21.0	9.0	170	
800	16,000	9.0	170	23.0	10.0	200	
1,200	22,000	10.0	210	31.0	11.0	250	
1,500	27,000	11.0	230	32.2	12.0	280	
2,000	35,000	12.0	260	32.2	13.0	300	
2,500	40,000	12.5	260	32.2	13.5	300	
3,000	50,000	13.0	290	32.2	14.0	350	Panamax
4,500	60,000	13.5	290	39.4	15.0	350	Post-Panamax

(2) Method of Evaluation

Alternative plans are evaluated by comparing the total transportation costs to handle a container volume of one million TEUs at MBP. The total cost consists of 1) ship-waiting and ship-staying costs at the port, 2) transportation cost, 3) construction cost of additional facilities, and 4) maintenance cost of additional facilities.

The ship-waiting and ship-staying costs are revealed using the computer simulation results of off-shore waiting time for container vessels at MBP on the container operational conditions.

The transportation cost is calculated by summing up the transportation costs for each route over the one million TEUs.

The construction cost includes additional container berths, access bridges, container marshaling yards, empty container yards, CFSs and dedicated road for container traffic, and capital dredging of the access channel to Indira Dock. Alternative depths of -11.0 m, -12.0 m, and -13.0 m are assumed for the container berths which accommodate 1,200 TEU-size, 1,500 TEU-size and 2,000 TEU-size container vessels respectively. As it is known that hard material lays under the seabed at the depth between -4.0 m to -10.0 m at the front of Indira Dock Harbour Wall, capital dredging cost to the same depth of the proposed berths seems fairly high compared with the construction cost of the major container handling facilities. Therefore, the depth of the approach channel to Indira Dock for each alternative plan is assumed 2.5 m less than the depth of the berth, taking into consideration the tidal range of 5.2 m at MBP, and difference of 2.26 m (9.86-7.6 = 2.26 m) between the berth and channel depths at BPS and difference of 2.5 m (13.5-11.0 = 2.5 m) at JNP.

(3) Evaluation Flowchart

The optimum depth of the additional container berths is determined by comparing the alternatives. Then, the optimum depth of the approach channel is sought. This evaluation flowchart is shown in Figure 12.2.5 and Figure 12.2.6.

(4) Total Cost

Total cost to build and maintain three additional container berths (Alternative-6) with various berth depths and various approach channel depths are estimated and the results are shown in Table 12.2.6 (1), Table 12.2.6 (2), Table 12.2.7 and Table 12.2.8.

Table 12.2.6 (1) shows that a berth depth of -13.0 m gives the minimum total cost for Alternative-6. Therefore, the berth depth of -13.0 m is considered as the optimum berth depth for Alternative-6.

Then the optimum alternative with the berth depth of -13.0 m is also sought by comparing Alternative-1 to 6. Table 12.2.7 shows that Alternative-6 give the minimum total cost.

Again the optimum approach channel depth for Alternative-6 with the berth depth of -13.0 m is sought. Table 12.2.8 shows that an approach channel of -10.5 m depth gives the minimum total cost.

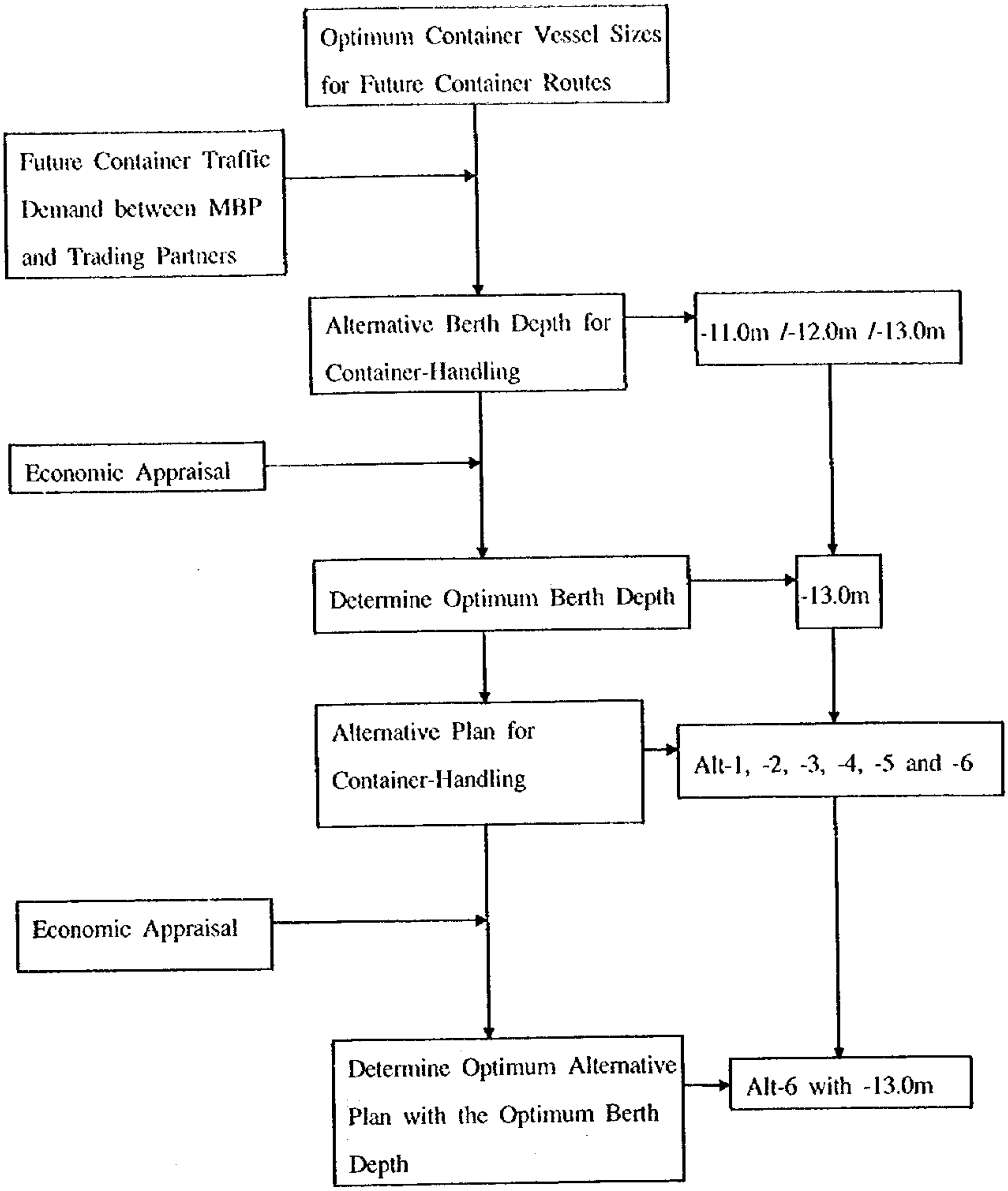


Figure 12.2.5 Evaluation Flowchart of Determining the Optimum Berth Depth and Alternative Plan for Container-Handling

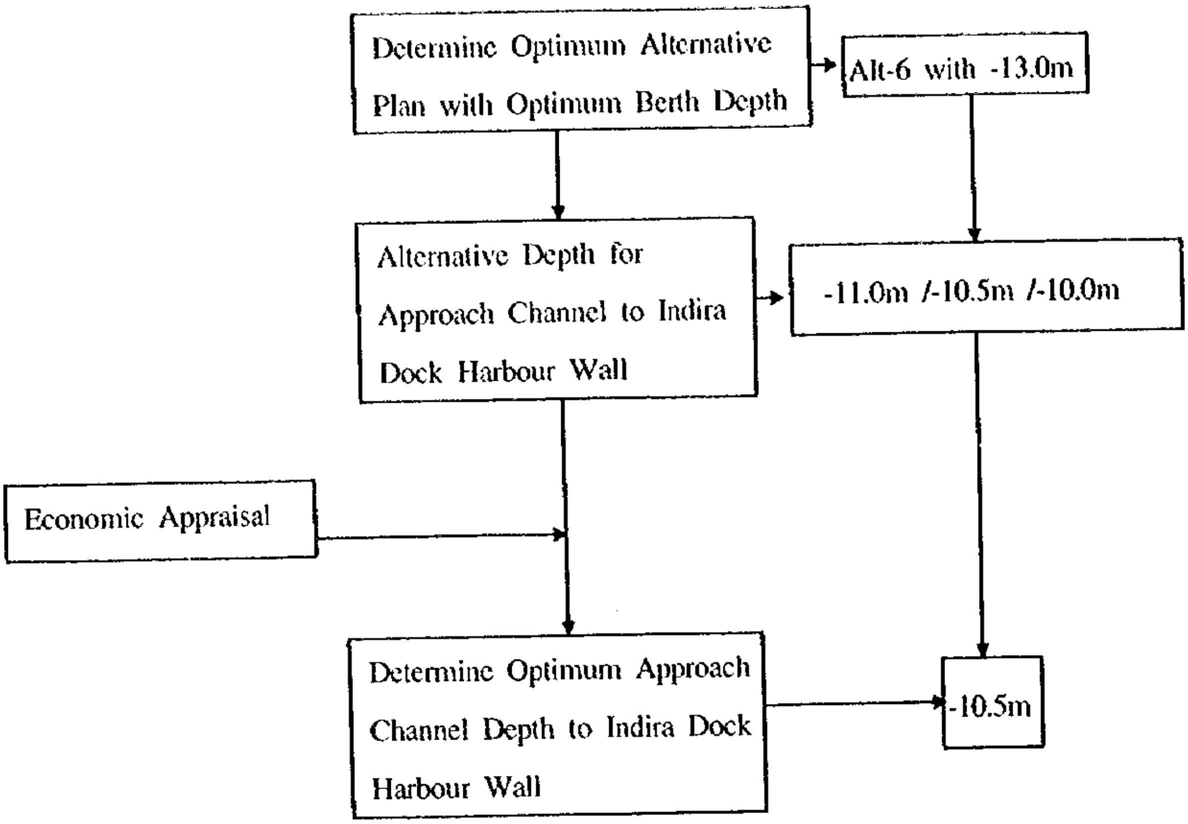


Figure 12.2.6 Flowchart of Determining Optimum Depth of a Container Berth and an Approach Channel

Table 12.2.6 (1) Total Cost for Alternative-6 with Berth Depth and Approach Channel Depth

(unit: million)

Berth Depth (m)	Channel Depth (m)	Ship-waiting Cost (Rs./year)	Transportation Cost (Rs./Year)	Construction Cost (Rs.)	Maintenance Dredging Cost (Rs./year)	Total Cost (Rs.)
-11.0	-8.5	84	11,737	13,110	92	124,726
-12.0	-9.5	78	11,326	14,998	122	122,987
-13.0	-10.5	70	11,002	16,891	152	122,050*

Remarks) Discount rate of 10% and project life of 30 years are assumed.
Asterisk indicates the minimum total cost.

Table 12.2.7 Total Costs for Alternative 1 to 6 with Berth Depth of -13.0 m

(unit: million)

Alternative Name	Channel Depth (m)	Ship-waiting Cost (Rs./year)	Transportation Cost (Rs./Year)	Construction Cost (Rs.)	Maintenance Dredging Cost (Rs./year)	Total Cost (Rs.)
Alt-1 (-9.8m)	-7.6	410	13,896	6,767	0	140,811
Alt-2 (-13m)	-10.5	70	11,002	17,619	152	122,779
Alt-3 (-13m)	-10.5	70	11,002	17,068	152	122,228
Alt-4 (-13m)	-10.5	70	11,002	17,562	152	122,721
Alt-5 (-13m)	-10.5	70	11,002	17,919	152	123,079
Alt-6 (-13m)	-10.5	70	11,002	16,891	152	122,050*

Remarks) Discount rate of 10% and project life of 30 years are assumed.
Asterisk indicates the minimum total cost.

Table 12.2.8 Total Costs for Alternative 6 with Berth Depth of -13.0 m and Various Approach Channel Depths

(unit: million)

Alternative Name	Channel Depth (m)	Ship-waiting / -staying Cost (Rs./year)	Transportation Cost (Rs./Year)	Construction Cost (Rs.)	Maintenance Dredging Cost (Rs./year)	Total Cost (Rs.)
Alt-6 (-13m)	-11.0	453	11,002	17,273	166	126,148
Alt-6 (-13m)	-10.5	471	11,002	16,891	152	125,803*
Alt-6 (-13m)	-10.0	533	11,002	16,453	137	125,815

Remarks) Discount rate of 10% and project life of 30 years are assumed.
Asterisk indicates the minimum total cost.

Two more berth and channel depth combinations for Alternative-6, i) berth depth = -13.5 m / channel depth = -11.0 m and ii) berth depth = -14.0 m / channel depth = -11.5 m, were additionally examined by request of MBPT. Total costs for these combinations were estimated and compared with other combinations presented in Table 12.2.6 (2). Table 12.2.6 (2) shown that Alternative-6 with berth depth of 13.5 m and approach channel of 11.0 m gives absolutely the minimum total cost.

Table 12.2.6 (2) Total Cost for Alternative-6 with Berth Depth and Approach Channel Depth

(unit: million)

Berth Depth (m)	Channel Depth (m)	Ship-waiting Cost (Rs./year)	Transportation Cost (Rs./Year)	Construction Cost (Rs.)	Maintenance Dredging Cost (Rs./year)	Total Cost (Rs.)
-13.0	-10.5	70	11,002	16,891	152	122,050
-13.5	-11.0	65	10,777	18,865	164	121,996*
-14.0	-11.5	60	10,661	21,248	179	123,376

Remarks) Discount rate of 10% and project life of 30 years are assumed.
Asterisk indicates the minimum total cost.