SECTORAL REPORT II

PORT DEVELOPMENT PLAN

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II. PORT DEVELOPMENT PLAN

1. PRESENT CONDITIONS AND RESTRICTIONS IN BANGKOK PORT

1.1 Introduction

1.1.1 History

Before 1954, Bangkok Port could only be approached by small vessels or those having a light draught as the Bangkok bar channel depth was 15 - 16 feet (4.5 - 4.8 meters) at high water. Therefore, vessels of deeper draught were loaded and unloaded in the deep water anchorage off Ko Kichang, about 80 km southeast of Bangkok. Cargoes had to be sent up to Bangkok or brought down for shipment using lighters and barges, which was both time consuming and quite expensive.

These problems had confronted the Government for many years to consider the possibility of dredging the channel through the bar and constructing a new port within modern facilities. In 1936, a site for the new port was selected in the Klong Toei district where a large area was reserved for future expansion.

Construction of the new port was commenced in 1938 with the formation of the Bangkok Port Office. The construction was only partly completed in 1940 and came to a standstill due to World War II.

In 1951, the Port Authority of Thailand (P.A.T.) was established and took over the administration of the Port of Bangkok (Klong Toei Port) which had previously been in the hands of a Government Department.

Development from 1951 to 1954 created such port facilities as a 1,660 meter wharf (West Quay) with 9 transit sheds and an open storage area, which simultaneously accommodated 9 cargo vessels each 27 feet (8 m) in draught and 565 feet (172 m) in length.

By 1977 the East Quay had also been constructed adding 6 berths along 1,580 meters of wharf.

1.1.2 Location and Access

The port of Bangkok used for foreign general cargo is situated on the left side along the lower section of the Chao Phraya River between points of km 26 and km 29, while numerous private wharves are located along both sides of the river from its estuary to a point 47 km upstream (See Fig. II.1.1).

The entrance of the Chao Phraya River is marked by the Bangkok bar light beacon situated at lat. 13°26'N and long 100°35'E. The approach to the port is made through the bar channel which is 18 km in length, and 100 meters wide at the bend. The channel is dredged and maintained to a depth of -8.5 m below Mean Sea Level (MSL) or -6.3 meters below Lowest Low Water (LLW).

The depth of the River within the port area varies from -8.5 m to -11 m below MSL. The MSL depths at the Bangkok bar and at Klong Toei are respectively 2.3 m and 1.63 m above LLW.

Vessels entering the port are limited to a maximum length of 565 ft (172 m) and a draught of 27 ft (8 m).

1.1.3 The Organization and Function of the P.A.T.

The P.A.T.'s organization, with a total staff of about 6,000, is in the form of the following Bureaus:

1) Board of Port Commissioners Bureau

   - Office of Secretary to the Board

2) Administrations Bureau

   - Office of the Director General

     Office of Advisers
     Central Division
     Law Division
     Secrity Center
     Port Police

- Central Sector

    Technical Office
    Personnel Department
    Controllers' Department
    Engineering Department
    Marine Department

3) Port Operations Bureau

- Bangkok Port
- Sattahip Commercial Port

The organizational chart is shown in Fig. II.1.2.

The P.A.T. manages the port facilities and navigation areas making up the Port of Bangkok. Its responsibility also includes the supervision of stevedoring, the assistance of navigation, and the maintenance dredging of the river stretch ranging from the Memorial Bridge to the entrance of the bar channel.

1.2 Existing Facilities and Equipment

1.2.1 Port Facilities

According to the Laws on Navigation in Thai Waters B.E. 2493 (A.D 1950) and 2510 (A.D 1967), vessels carrying cargoes and/or passengers from foreign countries crossing the Bangkok bar and proceeding into the Chao Phraya River must berth and discharge their cargo and/or passengers at Bangkok Port facilities operated by the P.A.T., except when there is no available berth and/or special permission is granted.

The existing berthing facilities of Bangkok Port are summarized as follows:

P.A.T. Wharves (Klong Toei Port, See Fig. II.1.3)

- Original Wharves (West Quay)	1,660 m long		10 Berths
- Container Wharves (East Quay)	1,528 m	Container	6 "
		Lighter	2 "
- Dolphins			7 "
- Buoys			6 "
Private Wharves			85
Total:			116 Berths

(Refer to Appendix II-1)

The storage facilities shown in Table II.1.1 include 9 sheds totalling 52,500 sq. meters, located just behind the West Quay; 3 sheds totalling 23,200 sq. meters on the East Quay; and 2 container freight stations (CFS) totalling 51,400 sq. meters on the West Quay. There are about 423,000 m^2 of open storage area under PAT management area.

1.2.2 Cargo Handling Equipment

The list of cargo handling equipment currently owned by the P.A.T. and ETO (Express Transportation Organization) is summarized in Table II.1.2.

1.2.3 Dry Docks and Lighterage

The Bangkok Dock Company operates two dry docks each of which is 100 meters long.

Private companies operate more than 72 lighters with cargo capacities ranging from 100 to 380 gross tons.

1.2.4 The Bang Hua Sna Midstream Dolphins Project

In order to accommodate more vessels, the P.A.T. has set up the Bang Hua Sna midstream dolphins project. When this project is completed in the middle of 1985, a total of 25 midstream dolphins lying between km 13 and km 15 along the left side of the Chao Pharaya River at Bang Hua Sna, Samut Prakan Province, will accommodate 8 cargo vessels with a maximum draft of 27 ft (8 m) and maximum length of 565 ft (172 m).

This is expected to increase the capacity of Bangkok Port by about 1.0 million tons a year.

1.3 Port Activities (Refer to Appendix II-1-1 - II-1-2)

1.3.1 Pilotage

According to the Law on Navigation in Thai Water B.D. 2477 (A.D. 1934), it is compulsory to have a pilot on vessels of 500 gross register tons or more when they sail anywhere between the entrance of the Bangkok bar channel and the upper limit of the port in the River (km 56 Rama VI Bridge). Pilotage is under the supervision of the Harbour Department.

The pilot station is situated at Lat. 13°22'N, Long, 100°35', 22 km along the channel from the Phra Chullachomklao Fort.

1.3.2 Berthing

A meeting to decide berthing arrangements is held daily at 10 a.m. under the chairmanship of the Director of Bangkok Port. "First come, first served" is the P.A.T. regulation offered to vessels calling at Bangkok Port. With the arrival of a vessel at the mouth of the Chao Phraya River, the P.A.T. operators will communicate with the pilot on the vessel by radio telephone to give the berthing assignment.

1.3.3 Towage

Tugboats, rope handling boats and officers are always provided promptly to facilitate berthing at the time of a vessel's arrival in Bangkok Port. At present, eight tugboats fitted with fire fighting and salvage equipment are ready for full service.

1.3.4 Stevedoring and Handling Operation Times

Import and export cargoes are discharged or loaded by stevedore companies engaged by the shipping agents. All stevedore companies must be registered with the P.A.T. and the number of stevedore laborers registered as of Dec. 1982 was 10,589. (Refer to Appendix II-1-12)

The stevedoring companies are paid for their service by the shipping agents on a per tonnage basis.

Handling operation times are as follows:

Day Shift	(08:00 - 12:00 hours)
Day Shift	(13:00 - 16:30 hours)
Overtime (working through)	(16:30 - 18:00 hours)
First half - night shift	(19:00 - 24:00 hours)
Second half - night shift	(01:00 - 05:00 hours)
Overtime (working through, but should apply for P.A.T. approval)	(05:00 - 07:00 hours)
On Saturdays, Sundays and public holidays, the day shift finishes at 16:00 hours	

1.3.5 Utilization of the P.A.T. Wharf

1) Annual Cargo Traffic

The past records of annual cargo throughput are shown in Table II.1.3 and II.1.4.

2) Annual Container Traffic

Records of container traffic in the past eight years are summarized in Table II.1.5, including data on loaded and empty containers. The total container throughput in 1983 reached 304,524 TEU including 269, 828 TEU (89%) of loaded containers and 34,696 TEU (11%) of empty containers. The numbers of import and export containers in TEU, including empty containers, have been very close or almost balanced.

3) Type and Number of Vessels

There are three types of cargo vessels presently calling at Klong Toei Port (P.A.T. Wharf), i.e. container (feeder), combination (combo) and conventional vessels.

The past record of the number of ships called at the P.A.T. Wharf is shown in Table II.1.6.

1.4 Restrictions in Klong Toei Port

1) Draft and Length Limitations

Currently vessels calling at Bangkok Port are limited to a length of 565 ft (172 m) and a draft of 27 ft (8 m). This restriction means that vessels are limited to approximately 10,000 - 12,000 DWT for dry bulk carriers and cargo ships. This channel restriction particularly affects the export of agricultural products which are usually transported by bulk carrier. Maintenance dredging and also further deepening of the channel depth are inevitable, but they require enormous expenditure which is not justifiable under the present financial situation.

2) Limitations to Further Expansion

The extension and rehabilitation of facilities in the immediate vicinity of Klong Toei Port would be very difficult and involve the serious problem of rehabilitating the slum area which was formed as the result of the exessive concentration of population in the Bangkok area.

At Klong Toei Port which was developed close to the central urban area, the cramped layout has resulted in a relatively inefficient working environment.

Land transportation in the Bangkok Metropolitan area suffers from extensive traffic jams. Increase of trucks transporting goods to and from the port would further aggravate this congestion.

Therefore, it is undesirable to expand the capacity of the faicilities at Klong Toei Port.

1.5 Capacity of Klong Toei Port

Several studies have been made to determine the ultimate capacity of Klong Toei Port for total traffic and containerized cargo. The capacities estimated by past studies are summarized in Table II.1.7.

The following data (1982) were collected and evaluated to determine the present situation in Klong Toei Port.

- annual throughput per berth for containers	:	377,000 ton/berth
- annual throughput per unit length for conventional berths	:	1,538 ton/m
- total waiting hours of ships calling P.A.T. wharves	:	368 ship.day
- berth occupancy ratio	:	70% East Quay 75% West Quay (from Oct. 1982 to June 1983)
- average loading and unloading rate	:	9.7 TEU/hour or 7.6 box/hour
- actual cargo handling rate of the mobile crane	:	10 box/hour

An analysis of these figures implies that all of the facilities in Klong Toei Port are fully utilized and any significant increase of the throughput capacity is almost impossible without some drastic rehabilitation.

The capacities of Klong Toei Port estimated by the MOC and P.A.T. were 3.5 and 3.0 million tons per annum for conventional cargo (West Quay, etc.) and container cargo (East Quay) respectively.

In addition, the P.A.T. is now planning to construct 8 new midstream dolphin berths at Bang Hua Sna by the middle of 1985, which are expected to increase the capacity by about 1.0 million tons per annum.

Therefore, the capacity of Klong Toei Port is estimated to total 7.5 million tons per annum; 4.5 and 3.0 million tons for conventional and container cargo respectively.

Table II.1.1 Storage Facilities in PAT Areas (1/2)

No.	Building	Size (m.)	Total Area sq.m.	Storage Area sq.m.	Floor Load (Ton Per -sq.m.)	Storage Capacity (Ton)	Remarks
1.	Shed No.1	40 / 150	6,000	4,140	2.75	11,385	
	Platform	1.5 / 150	225	180	1.50	270	For calculating the storage area, the following spaces are deducted from the total area: A. Office Room B. Store Room for valuable cargo C. Store Room for damaged cargo
2.	Shed No.2	40 / 150	6,000	4,140	2.75	11,385	
	Platform	1.5 / 150	225	180	1.50	270	
3.	Shed No.3	40 / 150	6,000	4,140	2.75	11,385	
	Platform	1.5 / 150	225	180	1.50	270	
4.	Shed No.4	40 / 150	6,000	4,140	2.75	11,385	
	Platform	1.5 / 150	225	180	1.50	270	
5.	Shed No.5	32 / 150	4,800	3,300	2.75	9,075	
	Platform	1.5 / 150	225	180	1.50	270	
6.	Shed No.6	32 / 150	4,547	3,088	2.75	8,411	Area in Shed No.6
	Platform	1.5 / 118	177	142	1.50	173	Deduct space 263m^2
7.	Shed No.7	32 / 150	4,680	3,332	2.75	9,150	
	Platform	8 / 150	1,200	960	1.50	1,440	Area in Shed No.7
8.	Shed No.8	32 / 150	4,800	3,300	2.75	9,075	
	Platform	8 / 150	1,200	960	1.50	1,440	Deduct space 120m^2
9.	Shed No.9	32 / 150	4,800	3,300	2.75	9,075	
	Platform	8 / 150	1,200	960	1.50	1,440	
	Total	-	52,529	36,802	-	96,169	
10.	Additional Shed (Wooden Shed)	12 / 135	1,620	1,300	2.00	2,600	Behind Shed No.1
11.	" - "	12 / 100	1,200	960	2.00	1,920	" Shed No.3
12.	" - "	12 / 130	1,560	1,250	2.00	2,500	" Shed No.6
13.	" - "	12 / 150	1,800	1,440	2.00	2,880	" Shed No.7
14.	" - "	12 / 50	600	480	2.00	960	" Shed No.8
15.	" - "	12 / 120	1,440	1,150	2.00	2,300	" Shed No.9
	Total	-	8,200	6,580	-	13,160	
16.	Additional Shed (Cement Wall)	20 / 100	2,000	1,600	2.00	3,200	Behind Shed No.4
	" - "	20 / 100	2,000	1,600	2.00	3,200	" Shed No.6
17.	" - "	20 / 100	2,000	1,600	2.00	3,200	" Shed No.7
18.	" - "	20 / 100	2,000	1,600	2.00	3,200	" Shed No.8
19.	" - "	20 / 100	2,000	1,600	2.00	3,200	" Shed No.9
20.	" - "	15 / 56	840	550	2.00	1,100	" Shed No.5
21.	(Former Dangerous Cargo)						
	Total	-	10,840	8,550	-	17,100	
22.	Supplementary Shed 1	78 / 160	12,480	9,800	2.5	24,500	
23.	Supplementary Shed 2	78 / 260	20,280	16,000	2.5	40,000	Storage Warehouse Shed 10
	- Auction Warehouse	78 / 45.5	3,549	2,500	2.5	6,250	Part of Sub Shed 2
24.	Supplementary Shed 3	78 / 340	26,520	21,200	2.5	53,000	
	Total	-	62,829	49,500	-	123,750	
25.	Shed for Jute Cotton And Kapok	20 / 200	4,000	3,200	1.5	4,800	
26.	Shed For Jute Cotton And Kapok	24 / 180	4,220	3,370	2.00	6,740	
	Total	-	8,220	6,570	-	11,540	
27.	3 - Storey Warehouse						
	- First Floor	25 / 120	3,000	2,250	1.4	3,150	
	- Second Floor	25 / 120	3,000	2,575	1.00	2,575	
	- Third Floor	25 / 120	3,000	2,575	1.00	2,575	
	Total	-	9,000	7,400	-	8,300	

Table II.1.1 Storage Facilities in PAT Areas (2/2)

No.	Building	Size (m.)	Total Area Sq.m.	Storage Area sq.m.	Floor Load (Ton Per sq.m.)	Storage Capacity (Ton)	Remarks
28.	In-Transit Warehouse	35 / 156	5,460	4,280	2.5	10,700	
	- Floor Storage Outside The Building	-	15,680	12,550	2.00	25,100	
	Total	-	21,140	16,830	-	35,800	
29.	Military Warehouse	20 / 80	1,600	1,200	2.5	3,000	
	- Floor Storage Outside The Building	-	2,295	1,800	2.00	3,600	Under Construction
	Total	-	3,895	3,000	-	6,600	
30.	Dangerous Cargo Warehouse 1	25 / 40	1,000	800	2.00	1,600	For Inflamable Cargo
31.	Dangerous Cargo Warehouse 2	10 / 40	400	320	2.00	640	" - "
32.	Dangerous Cargo Warehouse 3	25 / 40	1,000	800	2.00	1,600	" - "
33.	Dangerous Cargo Warehouse 4	25 / 40	1,000	800	2.00	1,600	" - "
34.	Dangerous Cargo Warehouse 5	25 / 40	1,000	800	2.00	1,600	" - "
	Total	-	4,400	3,520	-	7,040	
35.	Container Freight, Station I	126 / 43.4	5,468.40	3,690	3.00	11,070	Handed Over To PAT. Feb.1982
	-Outside Area	-	30,450	Only For Working And Transportaiton Area			" - "
36.	Container Freight, Station II	126 / 43.4	5,468.40	3,690	3.00	11,070	
	-Outside Area	-	10,063	Only For Working And Transportation Area			" - "
	Total	-	51,449.80	7,650	-	22,140	
37.	East Quay Shed No.1	150 / 60	9,000	8,000	3.00	24,000	Shed No.11
38.	East Quay Shed No.2	150 / 60	9,000	8,000	3.00	24,000	Shed No.12
39.	East Quay Cargo Warehouse	80 / 65	5,200	3,640	3.00	10,920	Former Rice Shed.
	Total	-	23,200	19,640	-	58,920	
40.	Steel-Storage Area	-	25,800	20,000	2.00	40,000	Outside Wharf Area.
41.	Automobiles Storage Area (Existing)	-	16,340	13,000	1.5	19,500	Wharf Area
42.	West Quay						
	- Open Storage Area	-	128,400	102,720	2.00	205,440	Wharf Area
	- Container Terminal	-	31,440	25,152	3.00	75,456	Behind Sub Shed 3.
	Area	-	60,800	Future Extension:For Container System.			Under Construction.
43.	East Quay						
	- Open Storage Area	-	-	-	-	-	
	- Container Terminal	-	131,000	104,800	3.00	314,400	Wharf Area.
	Area.	-	29,490	23,590	3.00	70,770	Under Construction
	Total	-	423,270	289,262	-	725,566	

Remarks : The height of cargo must not be less than 60 cm. from eaves or ceiling and subject to each type of cargo. (to calculate from weight to each type of cargo)

Source : Engineering Section, PAT
Handbook of Port Authority of Thailand, 1983

Table II.1.2 CARGO HANDLING EQUIPMENT AT BANGKOK PORT (AS OF JULY 1983)

(a) P.A.T.

Type	Capacity	Q'ty	Condition*	Remarks
Semi Portal Crane	3 tons	8	3 R 37.5%	on the West Quay for general cargo
	5 tons	4	1 R 25	
Mobile crane	6-12 tons	2	2 R 100	
	5 tons	3	AG	
	10 tons	5	AG	
	30 tons	7	AG	
	50 tons	2	AG	
	149-165 tons	2	1 R	
Side Loader	35 tons	2	1 R	electric
Top Loader	35 tons	2	2 m R	
Shifter Container	30 tons	3	2 R	Rubber-type transtaine for 20'/40' container 2 plus 1 rows, 2 high
Fork Lift	5,000 lbs	56	21 D, 5 MR.1mR	
	7,000 lbs	263	2 D, 15 MR.24mR	
	10,000 lbs	36	r mR, 4 MR	
	10 tons	2	AG	Takatan
	30 tons	2	2 m R	
Trucks	5-7 tons	144	10 R, 3 H	6 wheels
Towing Tractor	8,000 lbs	19	8 R, 1 H	6 wheels
	12,000 lbs	10	1 R, 1 H	
Yard Hustler	30 tons	7	AG	6 wheels
Tractor Trailer	30 tons	7	2 H	10 wheels
Tractor for chassis	30 tons	8	2 H	
Fifth wheels	30 tons	7	AG	
Trailer	10 tons	21	AG	8 wheels (wooden floor)
	20 tons	4	4 R	12 wheels
	30 tons	10	4 R	
Full Trailer Van	5-7 tons	5	Ag	8 wheels
Full Trailer	10 tons	5	Ag	Iron floor
Chassis	30 tons	58	2 R	8 wheels
Jeep/Van		4	2 R	
Fuel Service Truck		1	AG	

*): R; Repair, mR; Minor Repair, MR; Major Repair, H; Overhaul, D; Disable, AG; All Good
Source: Cargo Handling Division, P.A.T.

(b) ETO

Type	Capacity	Q'ty	Remarks
Trucks	5 tons	350	6 wheels
	10 tons	150	10 wheels
Tractor for Trailer	20 tons	45	6 wheels
	30 tons	10	10 wheels
Trailer	low bed	5	for conventional/container cargo
	low buoy	15	for heavy cargo

Source: Office in the Bangkok Port, ETO.

Table II.1.3 TRAFFIC THROUGH KLONG TOEI PORT (P.A.T. WHARF)

(Unit: Thousand Ton)

Year	Import Cargo			Export Cargo	
	Klong Toei Wharf	Midstream Dolphins (Klong Toei)	Total	Klong Toei Wharf	Total
1974	2,454	223	2,677	235	2,912
1975	2,267	142	2,409	146	2,558
1976	2,981	198	3,179	373	3,552
1977	3,468	230	3,698	475	4,173
1978	3,395	575	3,970	723	4,693
1979	3,729	761	4,490	857	5,347
1980	3,586	518	4,104	1,017	5,121
1981	3,734	691	4,425	1,231	5,656
1982	3,378	862	4,240	1,438	5,678
1983	4,363	809	5,172	1,580	6,752

Source: Statistical Section, P.A.T.

Table II.1.4 CARGO TRAFFIC BY CARGO TYPE

(Unit: Thousand Ton)

Year	Import Cargo			Export Cargo			Grand Total
	Conven-tional	Container	Total	Conven-tional	Container	Total	
1976	2,777	204	2,981	200	172	372	3,353
1977	3,114	354	3,468	252	223	475	3,943
1978	2,814	581	3,395	255	468	723	4,118
1979	2,953	776	3,729	181	676	857	4,586
1980	2,747	839	3,586	122	895	1,017	4,603
1981	2,608	1,126	3,734	172	1,059	1,231	4,965
1982	2,271	1,107	3,378	282	1,156	1,438	4,816
1983	2,867	1,496	4,363	250	1,330	1,580	5,943

Note: Excluding Midstream Dolphins

Source: Statistical Section, P.A.T.

Table II.1.5 CONTAINER TRAFFIC THROUGH KLONG TOEI PORT

Year	Volume (Thousand Ton)			Container Box										
				Import				Export				Total		Grand Total (TEU)
	Import	Export	Total	Loaded BOX	Loaded TEU	Empty (TEU)	Total (TEU)	Loaded BOX	Loaded TEU	Empty (TEU)	Total (TEU)	Loaded (TEU)	Empty (TEU)	
1976	204	172	376	18,969	n.a.	n.a.	27,896	17,678	n.a.	n.a.	26,065	n.a.	n.a.	53,961
1977	354	223	577	26,533	37,445	433	37,378	23,996	30,218	4,778	34,996	67,663	5,211	72,374
1978	581	468	1,049	46,498	58,206	4,577	62,783	41,451	48,756	8,627	57,383	106,962	12,204	120,166
1979	776	676	1,452	60,714	76,491	6,467	82,958	59,338	60,940	11,347	81,287	146,431	17,314	164,245
1980	839	895	1,724	71,433	81,580	14,612	96,192	69,190	83,746	9,489	93,235	165,326	24,101	189,427
1981	1,126	1,059	2,185	90,567	106,142	13,760	119,902	91,800	104,915	16,679	121,594	211,057	30,439	241,496
1982	1,107	1,156	2,263	101,795	103,176	28,657	131,833	96,273	119,130	8,461	127,591	222,306	37,118	259,424
1983	1,496	1,330	2,826	103,161	134,624	17,566	152,190	105,386	135,204	17,130	152,334	269,828	34,696	304,524

Source: Statistical Section, P.A.T.

Table II.1.6 VESSELS ENTERING KLONG TOEI PORT

Year	Conven-tional Vessel	Combi-nation Vessel	Container Vessel	Total (Number)	Net Register Tonnage (Thousand Ton)
1976	1,084	316	160	1,560	5,342
1977	1,053	346	184	1,583	5,467
1978	998	527	316	1,841	5,998
1979	825	581	358	1,764	6,047
1980	668	577	453	1,698	5,912
1981	648	576	495	1,717	5,834
1982	683	452	602	1,737	5,467
1983	770	469	588	1,827	5,856

Note: Combination vessel is a ship to be loaded together conventional cargo and container cargo.

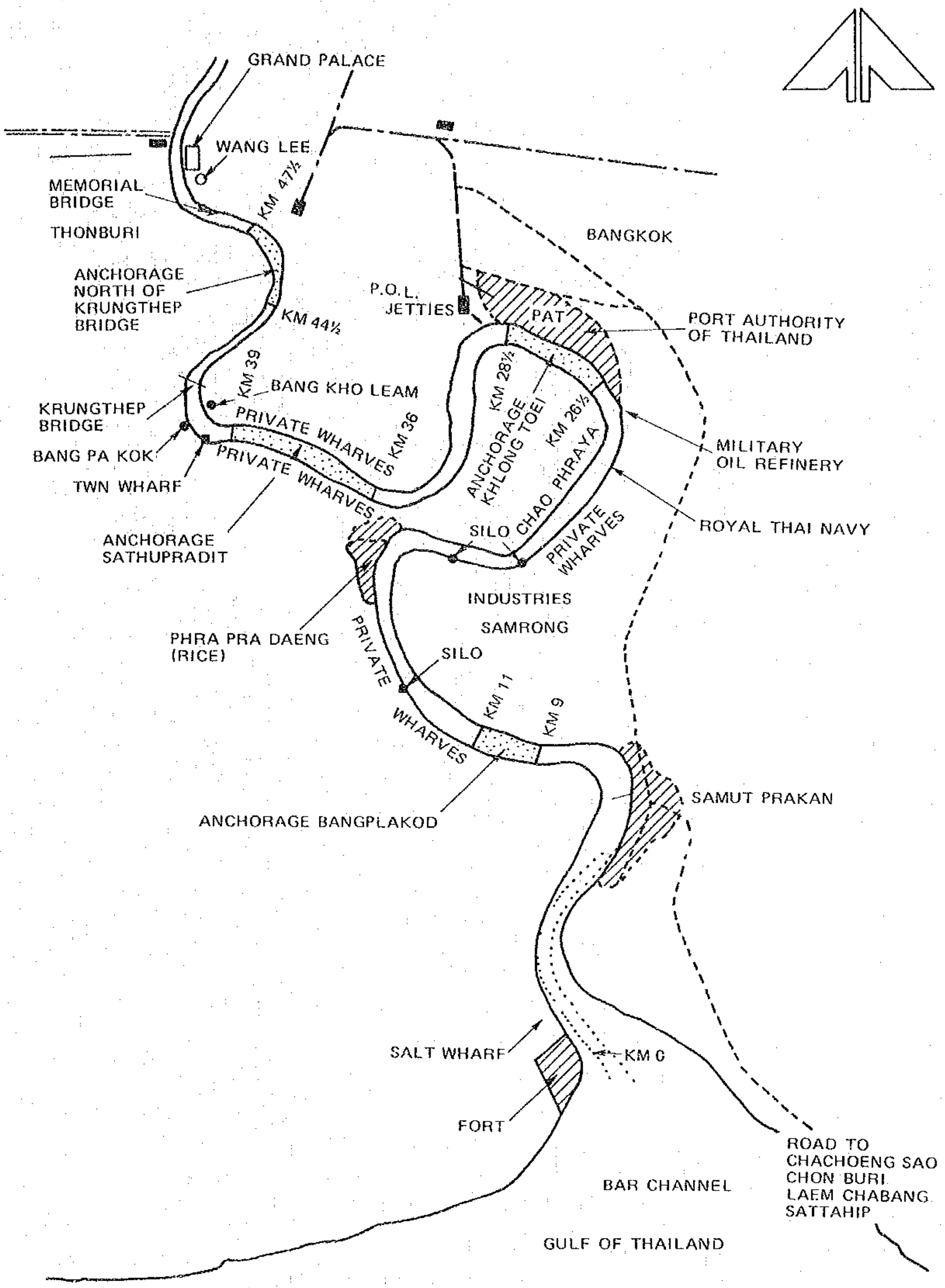
Source: Bangkok Port, P.A.T.

Table II.1.7 PAST STUDIES ON THE CAPACITY OF KLONG TOEI PORT

Deep Seaport Laem Chabang NEDECO (1978)	Sattahip Commercial Port Study (1980)
5.0 Million Tons	4.2 Million Tons
(West Quay 2.6 Million Tons (East Quay 2.4 "	(West Quay 3.0 Million Tons (East Quay 1.17 "
(Import Cargo 4 Million Tons (Export Cargo 1 "	

Master Plan Study of Sattahip Commercial Port, Thailand (Draft, 1982)	Eastern Seaboard Study Sector: Transport (1982)
5.0 Million Tons	7.6 - 8.3 Million Tons
(Container 3.0 Million Tons (Break Bulk 2.0 "	(Container: 3.2 Million Tons)

Bang Sue Container Freight Station (BKKTERM, 1983)
Container 3.2 Million Tons



LEGEND

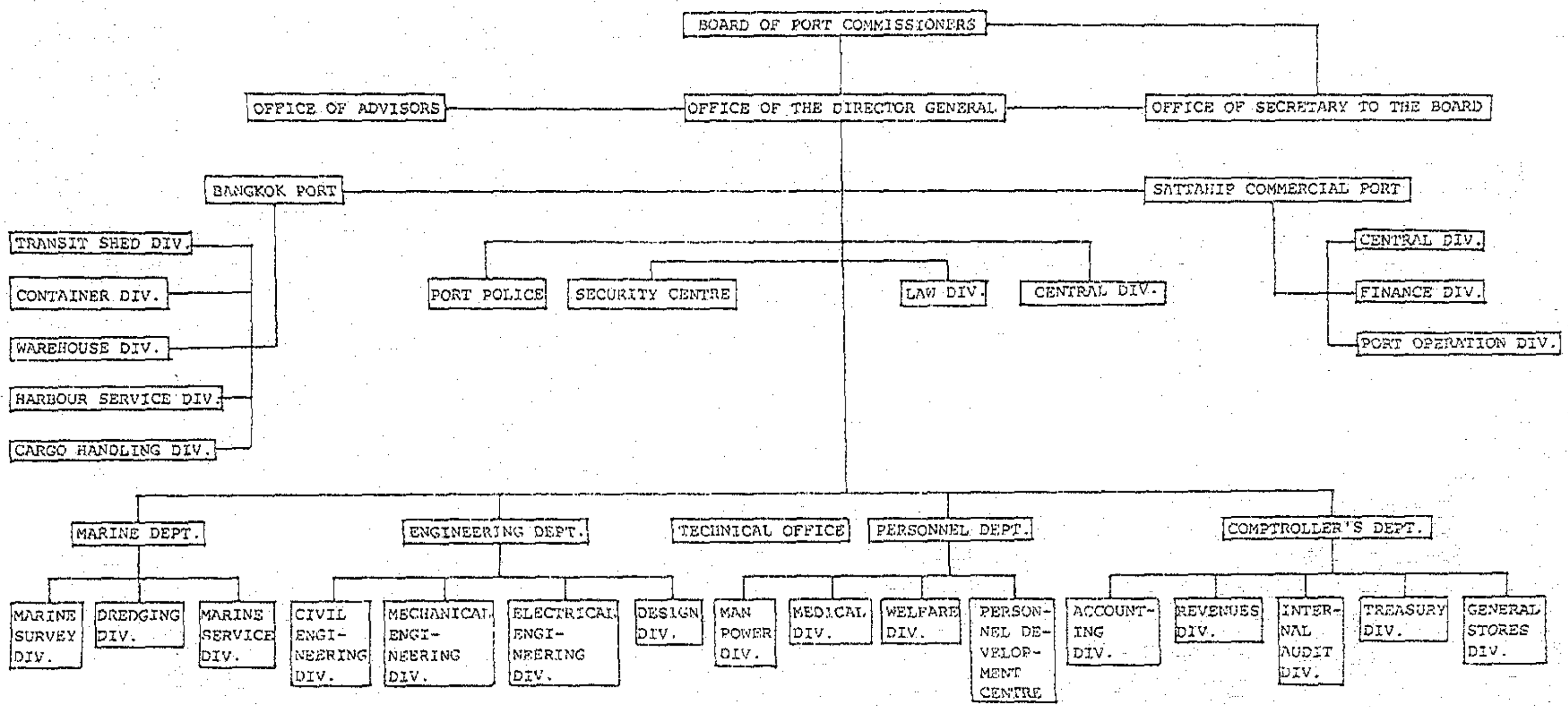
KINGDOM OF THAILAND
THE STUDY ON THE DEVELOPMENT PROJECT
OF LAEM CHABANG COASTAL AREA

JAPAN INTERNATIONAL COOPERATION ANGENCY

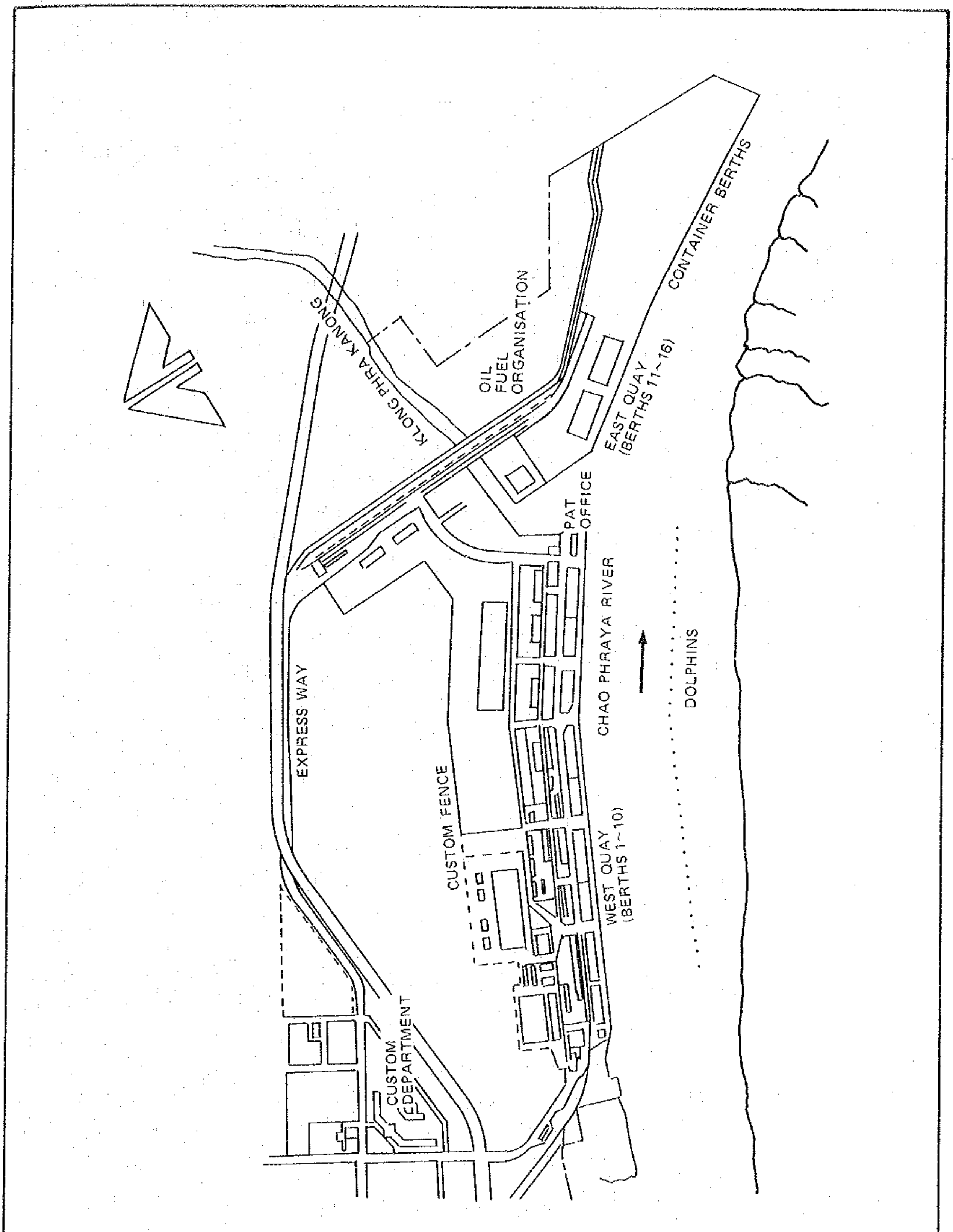
Fig. II.1.1

The Port of Bangkok

Fig. II.1.2 Port Authority of Thailand Organization Chart



Source: PAT



<table>
<tr><td rowspan="3">LEGEND</td><td>KINGDOM OF THAILAND
THE STUDY ON THE DEVELOPMENT PROJECT
OF LAEM CHABANG COASTAL AREA</td></tr>
<tr><td>JAPAN INTERNATIONAL COOPERATION ANGENCY</td></tr>
<tr><td>Fig. II.1.3
Klong Toei P.A.T. Wharf</td></tr>
</table>

2. EXISTING PORT ACTIVITIES ALONG THE EASTERN SEABOARD

Because of the afore-mentioned restrictions on the existing port facilities along the Chao Phraya River, the berthing facilities for large vessels have been constructed along the coast line of the Eastern Seaboard. (See Fig. II.2.1). In this report this wider area where cargo handling is carried out is referred to as the Bangkok Port Area. Import and export cargo going through the Bangkok Port Area, including Klong Toei Port, are shown in Table II.2.1.

2.1 Bangkok Port Area

1) Lighterage Facilities on the Bang Pa Kong River

These facilities are used mainly to transport tapioca, and to a smaller extent sugar and maize, which is carried to the deepwater anchorage at Ko Si Chang for loading onto ocean-going vessels. The lighters are usually self propelled steel barges with 100 - 300 ton cargo capacity.

2) Deepwater Anchorage at Ko Si Chang

This is a sheltered anchorage used for bulk carriers. Vessels of up to 120,000 - 150,000 DWT handle approximately 4.5 million tons of cargo per annum, mainly tapioca. It is equipped with four mechanical loading towers owned by Thai Bulk Services Ltd. (TBS). These towers are able to load ships at a rate of around 14,000 - 17,000 tons per day, and to handle about 3.0 - 3.5 million tons per annum.

The remainder of the traffic is loaded from lighters using ships' gear at the rate of about 7,000 tons per ship per day.

3) Tapioca Jetty at Siracha owned by Mah Boonkrong Dry & Silo Co., Ltd.

This has a throughput of around 1.2 million tons per annum, and storage capacity for 100,000 tons of tapioca. The 3 km long jetty was designed to accommodate 120,000 DWT. The loading rate is approximately 15,000 tons per day.

4) Oil Terminals at Siracha

The three refineries, TORC, ESSO and Summit, have terminals capable of receiving crude oil tankers of 120,000 DWT, 80,000 DWT and 50,000 DWT respectively. These are in the form of buoy moorings 1.0 - 2.0 km off-shore. Oil companies transport almost all of their products from the refinery by sea, using either small coastal tankers for distribution to Southern Thailand or barges of about 2,000 DWT for deliveries to the main depots in Bangkok.

5) Ao Udom Tapioca Jetty

This is a small lighterage jetty built for the transportation of tapioca to the anchorage at Ko Si Chang.

6) Liquified Petroleum Gas Jetty

This jetty extends about 1.2 km in a northeasterly direction from the shore immediately to the north of Laem Chabang and can receive LPG tankers of 100,000 DWT. It also has berths for two 2,000 DWT barges for domestic distribution of LPG. The LPG will be brought by pipeline from the gas separation plant at Map Ta Phut.

2.2 Sattahip Commercial Port

This facility was originally constructed by the U.S. Navy for military purposes but was converted into a commercial port and placed under the control of Port Authority of Thailand (P.A.T.) in 1979.

1) Existing Facilities

- West Quay	540 m long	3 Berths	10.1 m draft
- North Quay	350 m long	2 Berths	8.7 m draft

2) Port Activities

(1) Towage

Two tugboats and two rope handling boats are quick to help cargo vessels calling at the port.

(2) Utilization

The records of cargo traffic in the few past years are shown in Table II.2.2 while Table II.2.3 shows the past records of the number of ships calling at the Sattahip Commercial Port.

Currently, the Marketing Organization of Farmers (MOF) is building a maize export terminal at the Port.

2.3 Map Ta Phut Port

Map Ta Phut Port is planned as an industrial port, to support a heavy-chemical industrial complex in its hinterland. The necessary port facilities will be constructed prior to the activation of industries in the Map Ta Phut Industrial Complex. Facilities for handling non-industrial cargoes will also be provided. According to the previous study, projected cargo volume and berth requirement are as shown in Table II.2.4 and II.2.5.

Adjacent to the Map Ta Phut area, to the east of Rayong, the Rayong ethylene jetty has been built by Thai Petrochemical Industries Ltd. It is a structure designed to import about 130,000 tons of bulk liquid ethylene per year. This will be moved by pipeline to a directly adjacent plant.

Allotment of bulk cargoes to ports on the Eastern Seaboard are summarized as follows:

	Bangkok Port	Anchorage of Ko Sichang Island	Private Jetties of Siracha	Sattahip Port	Map Ta Phut Port	Laem Chabang Port
Agri-Products						
Maize	o	o		o		
Rice	o					
Cassava, Tapioca		o	o	o	o	o
Raw Sugar, Molasses	o					
Mineral Products						
Crude Oil, Petro Products			o			
Rock Salt					o	
Potash Ore					o	

2.4 Railway Network

1) The Eastern Line

(1) Existing Line

The existing railway system in the northern areas of the Eastern Seaboard is called the Eastern Line. The line from Bangkok extends eastward for 60 km to Chachoengsao, and then further northward to Prachanburi and on to Cambodia. This railway travels 225 km from Bangkok to Cambodia.

The Eastern Line is a single track and the average traffic between Chachengsao and Bangkok is 11 runs/eastward per day.

(2) Chachoengsao - Sattahip Rail Link

A new railway, stretching 143 km from Chachoengsao to Sattahip, is set for completion in 1984. (Fig. II.2.2)

The outline of the plan is as follows:

- Single track
- 9 Stations
- Design speed : 100 km/h
- Maximum axle load : 20 t

Spur Line to Laem Chabang

The spur line has been designed by the SRT and the proposed right of way area has already been purchased by the SRT and P.A.T.

2) Railway Traffic Volume

Based on the modal split discussed before, the railway cargo and the train traffic were estimated as follows:

Railway Cargo and Train Traffic

	Origin	2001		1991	
		Cargo Volume	Trains per Day	Cargo Volume	Trains per Day
Container	Laem Chabang - Bangkok	1.9(MT)	6.2	0.7(MT)	2.4*
Container	Bangkok - Laem Chabang	1.9	6.2	0.7	2.4**
Break Bulk	Laem Chabang - Bangkok	0.27	1.5	0.05	0.27
Tapioca	North East - Laem Chabant	0.90	5.0	0.9	5.0
		5.0(MT)	Laem Chabang Siracha 7.7 Siracha Laem Chabang 11.2	2.35(MT)	Laem Chabang Siracha 2.7 Siracha Laem Chabang 7.4

Note: *: 1,000 t payload unit train 640 m
**: 600 t payload non unit train 380 m

3) Spur Line Alignment

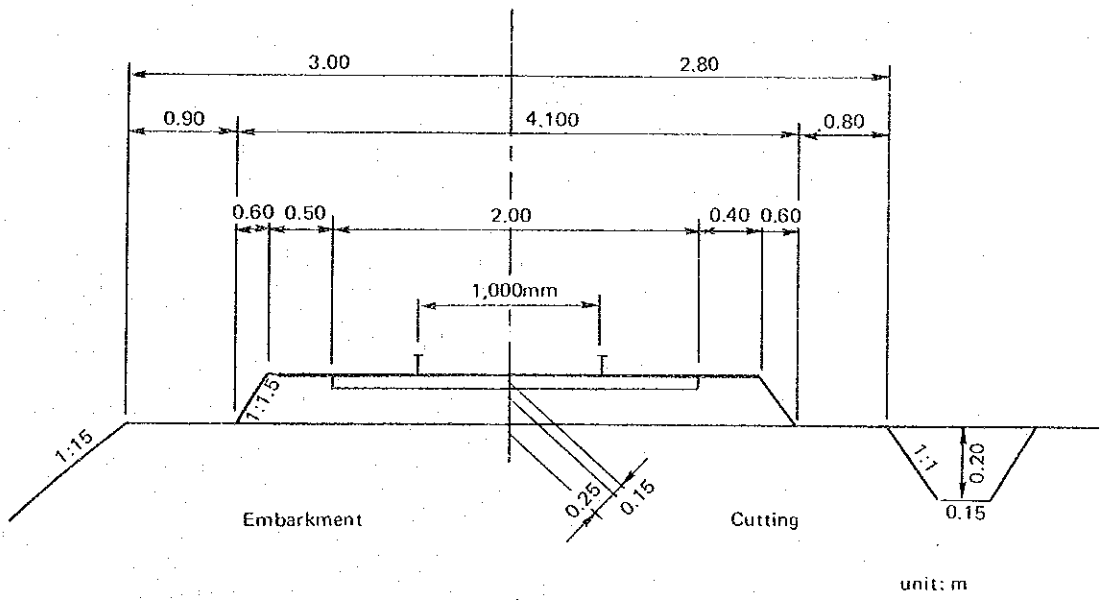
The junction station is located at about 2 km south of Siracha Station. The spur line will branch out to the west, run beneath highway, and enter the P.A.T. area along its northern boundary.

Around seven kilometers from the branch point, at the flat terrain, the marshalling yard will be located. The spur wi-l go straight toward the Cape of Laem Chabang then turn to the left as it nears the shore, running southward through the port project area.

In case of the pier type layout this spur will reach the pier within 2 km after it turns south. The railway is to be extended to the tapioca berth, container berths and break bulk berth. (Fig. II.2.3)

4) Standard Track Structure

The track structure is assumed to be the same as that of the Chachoengsao - Sattahip line. The outline is shown in the following.



The Standard Track Structure

Weight of rail	:	80 lb/yd
Type of fastening	:	Elastic fastening
Sleeper type	:	PS concrete or concrete
Spacing	:	60 cm
Min depth of ballast below sleeper	:	25 cm
Maximum train speed allowed	:	100 km/hr

5) Construction Cost of the Railway Spur

The construction cost of the proposed spur line was roughly estimated as follows, based on the similar studies in the Eastern Seaboard area. The costs which arise in the main line due to the extention of this spur are not included, but the cost to underpass the Route 3 is counted in.

Track structure (12 km)	58.44
Bridge 1	2.31
Bridge 1 (highway)	12.1
Marshalling yard	10.0
Communication	2.0
Lighting facilities	3.0
Station	0.8
Sub-total:	88.65
Investigation and engineering	8.87
Physical contingency	13.3
Total:	110.8 MB

The railway cost in case of the island type layout was assumed to be the same except the connecting bridge.

The cost of a bridge between the island and the sea shore without contingency and etc.:

$$350 \text{ m} \times 4 \text{ m} \times 14{,}500 \text{ B/M}^2 = 20.3 \text{ (MB)}$$

The railway total cost for the island type:

$$110.8 + 25.4 = 136.2 \text{ MB}$$

Table II.2.1 IMPORT AND EXPORT CARGOES BY COMMODITIES PASSED THROUGH BANGKOK PORT AREA

(Unit : Thousand Ton)

	1978		1979		1980		1981	
	Import	Export	Import	Export	Import	Export	Import	Export
Total	17,131	13,446	19,626	12,956	18,231	13,137	16,806	15,672
	(100)	(100)	(100)	(100)	(100)	(100)	(100)	(100)
Edible Vegetable	9	6,232	8	4,044	10	5,118	8	5,926
(Tapioca Pellets, Mung Beans)		(46)		(31)		(39)		(38)
Cereal	108	3,592	151	4,780	203	4,905	192	5,668
(Maize, Rice, Grain Sorghum Milo, Wheat)	(1)	(27)	(1)	(37)	(1)	(37)	(1)	(36)
Product of Milling Industry	33	295	42	195	33	315	32	385
(Flour of Maize, Tapioca, Rice, Wheat)		(2)		(2)		(2)		(3)
Sugar and Confectionery	-	1,768	-	1,812	108	698	-	1,559
(Raw Sugar, Molasses)		(13)		(14)		(5)		(10)
Waste from Food Industry	99	120	76	272	176	205	156	214
(Fish Meal, Bean and Seed Cake)	(1)	(1)		(2)	(1)	(2)	(1)	(1)
Salt Sulphor Earth Cement	410	424	1,192	591	1,020	645	245	635
(Sea Salt, Unground Barium Sulpate Natural, Gypsum Crude, Asbestos, Sulphur Refind and unrefind)	(2)	(3)	(6)	(5)	(6)	(5)	(2)	(4)
Mineral Fuel Oil Wax	11,333	6	11,090	16	11,746	2	10,742	12
(Petroleum & Shale Oils Crude)	(66)		(57)		(64)		(64)	
Inorganic Chemical	234	10	318	7	273	7	275	8
(Carbon Black, Sulphuric Acid, Aluminum and Sodium Hydroxide Solid)	(1)		(2)		(2)		(2)	
Organic Chemical	253	5	337	-	286	-	335	-
(Styrene, Vinyl Chloride, Ethylene Giycol)	(1)		(2)		(2)		(2)	
Fertilizer	732	-	861	-	694	2	765	-
(Ammonium Sulphate, Mixed Fertilizers Containing Nitrogen etc.)	(4)		(4)		(4)		(5)	
Artificial Resin & Plastic	184	10	237	14	140	18	214	22
(Polythylene in Primary Forms etc.)	(1)		(1)				(1)	
Wood & Article	335	60	670	53	233	37	295	42
(Sawn Lumber, Logs)	(2)		(3)		(1)		(2)	
Paper Making Material	197	-	280	-	235	-	249	-
(Waste Paper for Use in Paper Making)	(1)		(1)		(1)		(1)	
Iron and Steel	2,042	37	3,103	51	1,728	107	1,880	70
(Scrap & Waste of Iron and Steel Coil, Plate & Sheet)	(12)		(16)		(10)	(1)	(11)	
Boiler Machinery	168	3	186	5	182	8	205	7
	(1)		(1)		(1)		(1)	
Vehicle	179	2	159	7	156	5	196	3
(Tractors, Parts, Forklift)	(1)		(1)		(1)		(1)	
Others	815	882	916	1,109	1,008	1,065	1,017	1,121
	(5)	(8)	(5)	(9)	(6)	(9)	(6)	(8)

( ) is percentage.

Source: MOC - Transport Management Information System
: Department of Customs - Foreign Trade Statistics of Thailand

Table II.2.2 CARGO VOLUME AT THE SATTAHIP COMMERCIAL PORT, BY COMMODITY

(Unit: Metric ton)

Item	1980	1981	1982	1983
Import Cargo				
Pipe line	153,497	27,767	8,480	26,120
Mild steel bars, rails, pipes, roads, etc.	137,192	7,420	-	9,262
Electricity machinery and equipment	4,706	11,906	12,920	13,103
Machinery products	1,750	3,949	461	11,320
Chemical products	4,256	4,958	957	8,303
Machinery and equipment for oil exploration work	44	6,545	6,236	14,067
Military equipment	5,277	492	15	-
Petroleum equipment	8,065	6,436	15,496	17,456
Miscellaneous	15,057	330	221	6,959
Sub-total:	329,844	69,803	44,786	106,590
Export Cargo				
Tapioca	170,866	234,502	263,413	232,159
Miscallaneous	-	791	-	-
Sub-total:	170,866	235,293	263,413	232,159
Domestic Transit Cargo				
Pipe line	-	65,633	17,236	26,831
Minerals	-	4,400	5,763	19,854
Oil	-	13,600	4,956	686
Chemical products	-	8,686	12,102	29,349
Cement	-	5,278	10,587	16,385
Food stuff	-	446	-	15
Miscellaneous	448,990	896	2,704	4,970
Sub-total	448,990	98,939	53,348	98,090
Total	949,700	404,235	361,547	436,839

Source: Sattahip Commercial Port

Table II.2.3 SHIP CALLS AT THE SATTAHIP COMMERCIAL PORT

Year	Number of Vessels through Cannel		Vessel	
	No.	No. of Call	No.	No. of Call
1980	337	773	95	99
1981	418	834	95	110
1982	521	884	93	111
1983	390	681	145	162

Source: Sattahip Commercial Port.

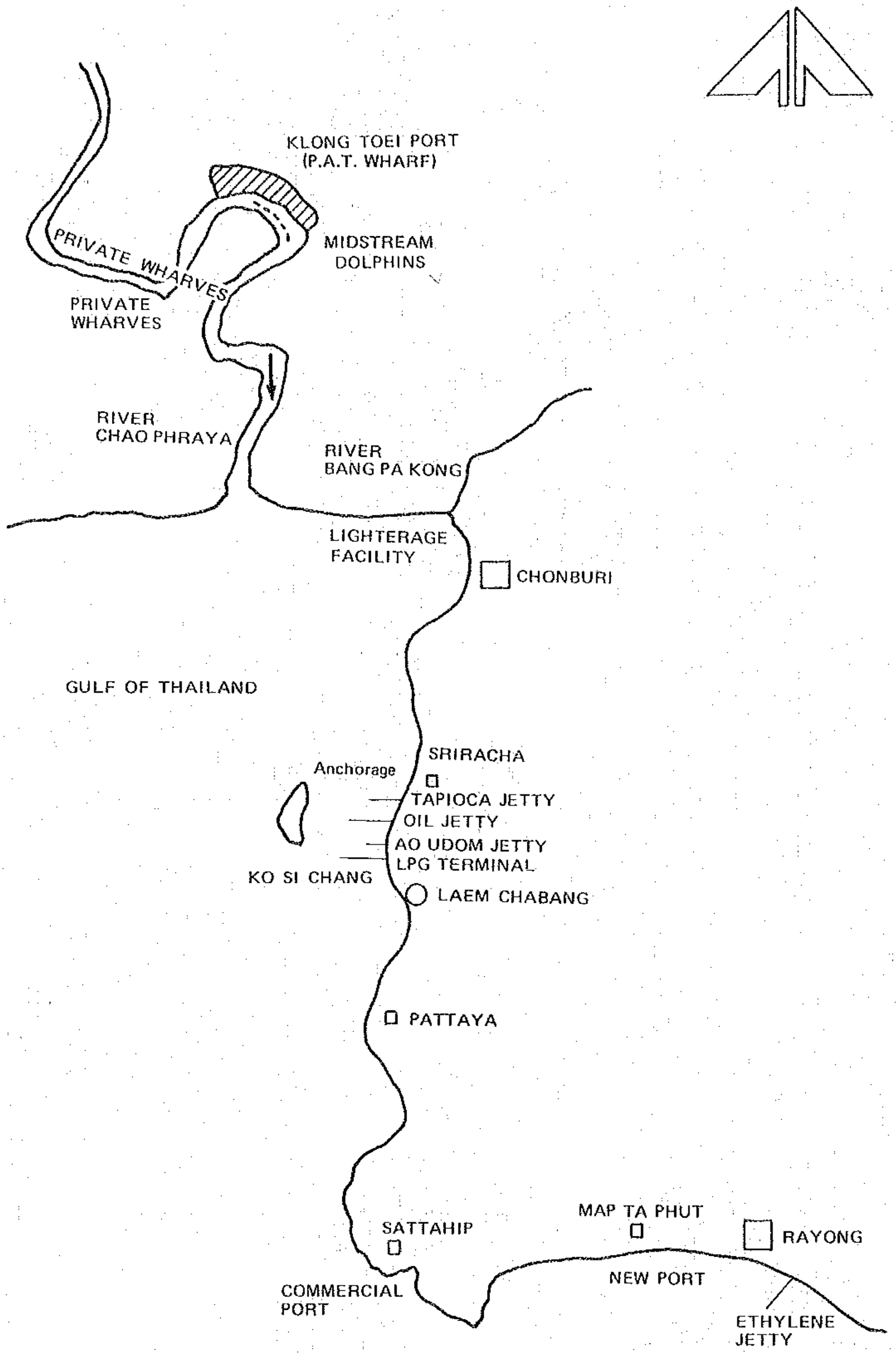
Table II.2.4 CARGO HANDLING VOLUMES AT MAP TA PHUT PORT IN 2000

Item	Foreign		Domestic		Total
	Export	Import	Export	Import	
Fertilizer Complex	300	1,814.7	890	-	3,004.7
Soda Ash Plant	480	-	560	-	1,040
Petrochemical Complex	-	-	243	-	243
Iron and Steel Complex	-	10,635	5,559	-	16,194
Public Terminal Area	1,130	70	434	889	2,523
Total	1,890	12,519.7	7,686	889	22,984.7

Table II.2.5 REQUIREMENT FOR MOORING FACILITIES

Item		Ship Size (DWT)	Quay Depth (m)	Berth Length (m)	Necessary No. of Berth	Total Length (m)	Berth Occupancy Rate (%)
Fertilizer	Domestic	3,000	-6.5	105	5	525	50
	Foreign	60,000	-14.0	280	1	280	46
Soda Ash	Domestic	3,000	-6.5	105	3	315	54
	Foreign	60,000	-14.0	280	1	280	17
Petrochemical	Domestic (Resin)	3,000	-6.5	105	1	105	16
	Domestic (Liquid)	3,000	-6.5	105	1	105	53
Iron and Steel	Domestic	3,000	-6.5	105	17	1,785	78
	Foreign	100,000	-18.0	330	2	660	53
Public Terminal	Domestic (Bulk, Bag, etc.)	3,000	-6.5	105	12	1,260	-
	Domestic (Liquid)	3,000	-6.5	105	1	105	54
	Foreign	150,000 60,000	-14.0	330	1	330	24
Total					45	5,750	

Source: The Study on the Development Project of the Industrial Port on the Eastern Seaboard by JICA, 1983



LEGEND

KINGDOM OF THAILAND
THE STUDY ON THE DEVELOPMENT PROJECT
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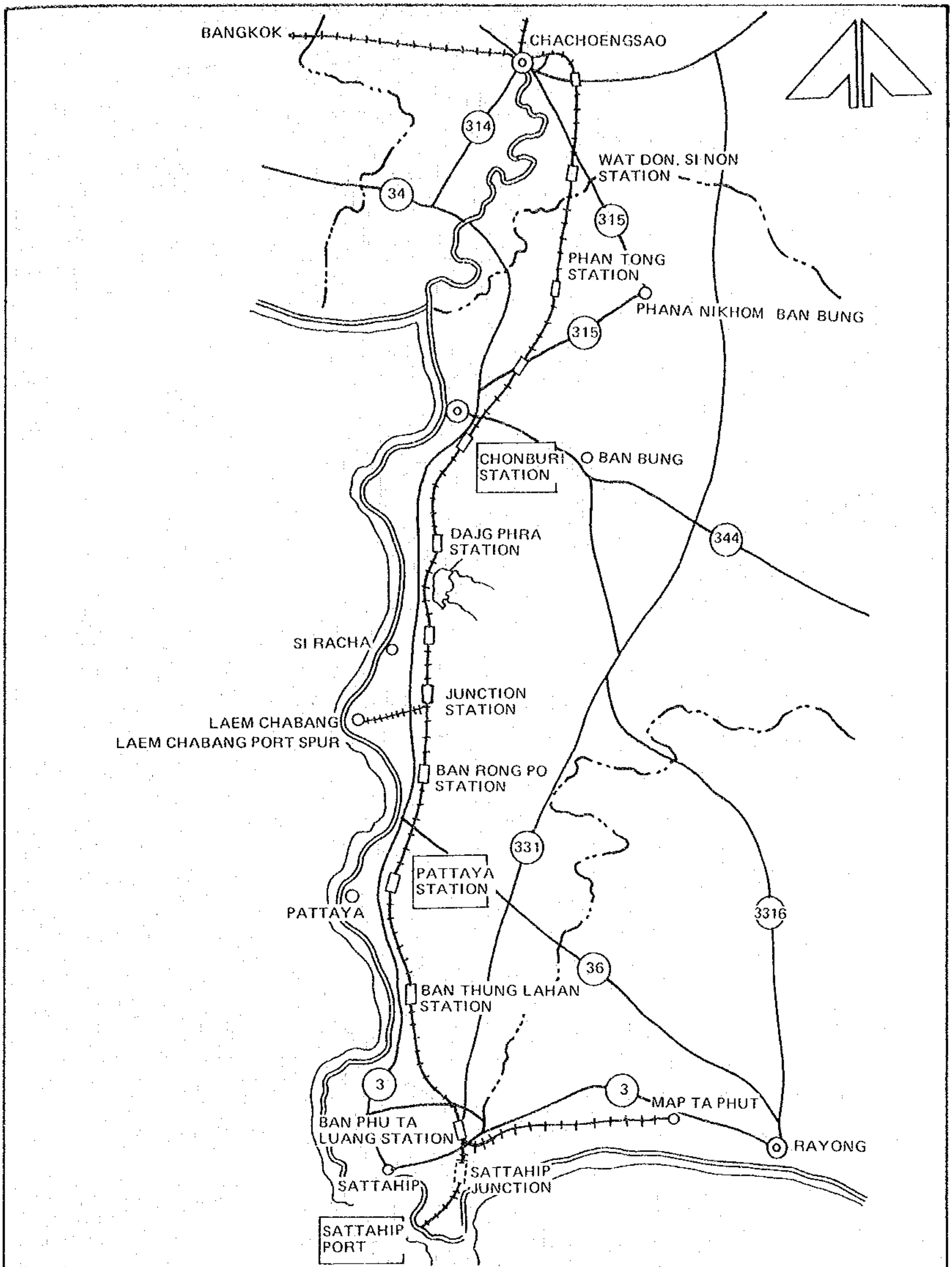
JAPAN INTERNATIONAL COOPERATION ANGENCY

Fig. II.2.1
Map of Bangkok Port Area and Eastern Seaboard Ports



LEGEND

Railway

KINGDOM OF THAILAND
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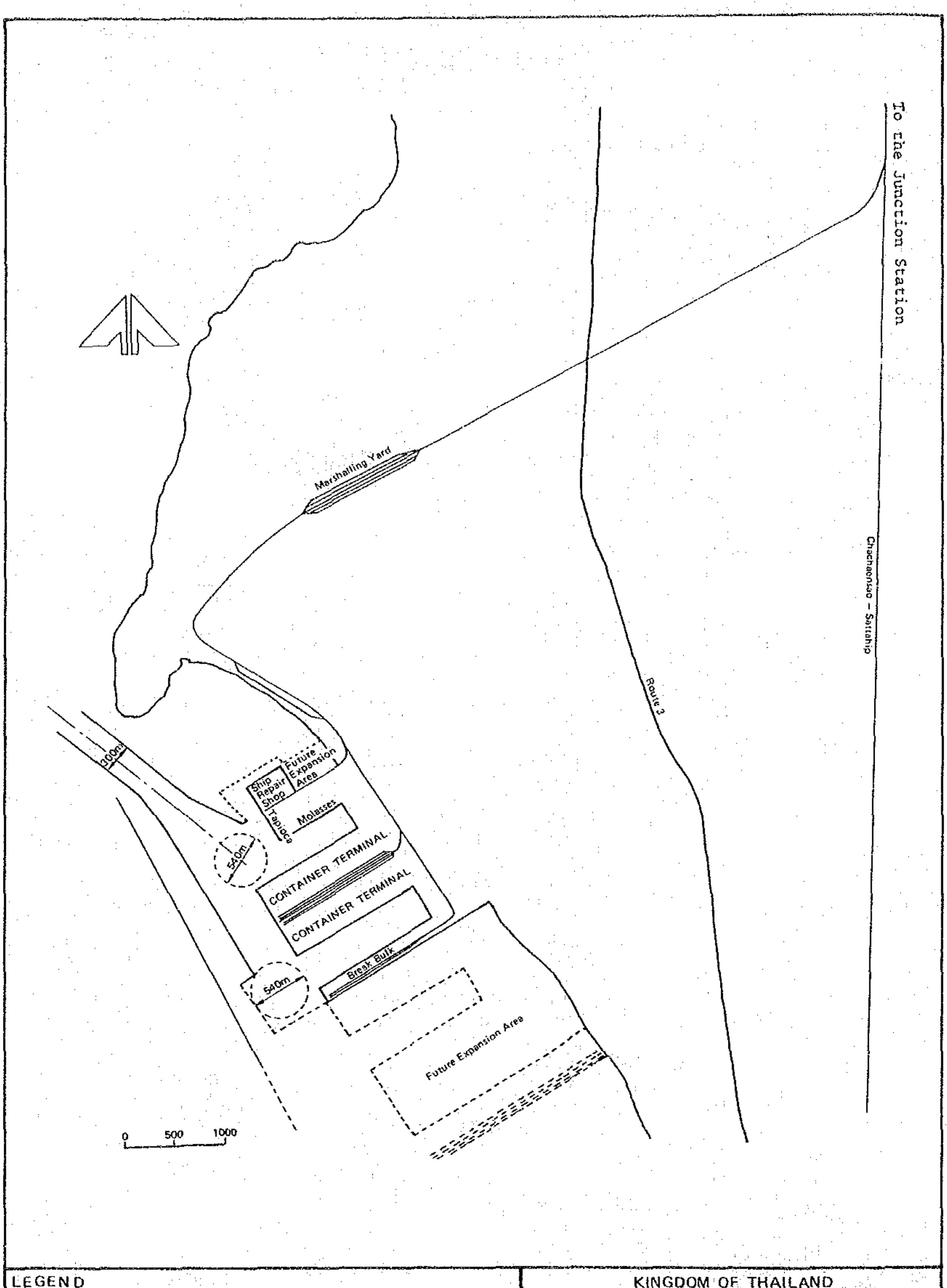
OF LAEM CHABANG COASTAL AREA

JAPAN INTERNATIONAL COOPERATION ANGENCY

Fig. II.2.2
Railway (Chachoengsao-Sattahip)



LEGEND

KINGDOM OF THAILAND
THE STUDY ON THE DEVELOPMENT PROJECT
OF LAEM CHABANG COASTAL AREA

JAPAN INTERNATIONAL COOPERATION ANGENCY

Fig. II.2.3
Spur Line Alignment

3. PORT CARGO FORECAST

3.1 Container and Break-Bulk Cargo Forecast

1) Methodology

The traffic forecast for the future cargo volumes at Klong Toei and Laem Chabang Ports have been made using two methods:

- a correlation analysis between the cargo volume and the GDP based on data for the years 1974 through 1982 (High Projection).
- a time series analysis of imports and exports for the years 1974 through 1983 (Low Projection).

In the "The National Economic and Social Development Plan" by the Thai Government, during the Fifth Five Year Plan starting in 1981 and ending in 1986, an average GDP growth rate of 6.6 percent per annum was forecast. The actual growth rate during this period has been slightly less than the expected rate.

Although the economy of the free world is recovering, the expected growth rate of 6.6 percent per annum may be difficult to achieve. In this report, we assumed a rather conservative average growth rate of 6.0 percent per annum up to the target year of 2001.

The past and future annual gross domestic products of Thailand are shown in Table II.3.1. The volume of port cargo passing through P.A.T. wharves has increased in line with the economic development of Thailand as shown in Table II.3.2.

Based on the data shown in Table II.3.2 the correlations between the port cargo volume handled at the P.A.T.'s wharves and the gross domestic product and between cargo volume and the calendar years for 1974 through 1983 can be expressed by Appendix II-2 and II-3.

Based on the above-mentioned two analysis which showed a quite high correlation, the future cargo volume handled at Klong Toei and Laem Chabang Ports was estimated as summarized in Table II.3.3 and as illustrated in Fig. II.3.1.

Several studies have been made on the cargo forecast of Bangkok Port in Appendix II-4.

2) Container Traffic

Container traffic forecasts for Klong Toei and Laem Chabang Ports were estimated by correlation analysis between cargo volume and GDP (High Projection), and by trend-line analysis based on data for the years 1976 through 1983 (Low Projection).

The container cargo volumes handled at PAT wharves are shown in Table II.3.4. The volume of containerized imports was nearly equal to the export container cargo.

The formulas for the correlations between the container cargo volume and GDP, or calender year can be obtained by Appendix II-2-3.

The figures for the cargo volume and GDP, and calender year show a very strong correlation.

The containerization rates for the years from 1976 through 1983 are shown in Table II.3.5. Refering to the trend that the containerization of exports was nearly 90% at Klong Toei Port in 1980, the export traffic using Klong Toei and Laem Chabang Ports in the future is assumed to be 90% containerized.

The volume of containerized imports handled at Klong Toei Port in 1983 was 34% of all imports.

According to the correlationship with GDP, import container cargo is estimated to reach about 50% of all import traffic in 2001. In 1983, MOC adopted 45 - 50% as the estimated import containerization rate. MOC also assumed that the volume of containerized import cargo is the same as that of containerized export cargo (Feasibility Study of the Development of the Port of Laem Chabang Louis Berger International, January L983).

In this forecast, therefore, it was assumed that import traffic at Klong Toei and Laem Chabang Ports would be about 50% of all import cargo.

3) Break Bulk Cargo

It is assumed that break bulk cargo volume is found by subtracting the container volume from the total cargo volume handled at Klong Toei and Laem Chabang Ports.

4) Container and Break Bulk Cargo Volumes handled at Laem Chabang Port

It was assumed that cargo volume at Laem Chabang Port can be calculated by deducting capacity of Klong Toei Port from the combined traffic forecast of Klong Toei and Laem Chabang Ports. Based on this assumption, container and break bulk cargo volume at Laem Chabang Port was projected as shown in Table II.3.6.

3.2 Agri-Bulk Cargo Forecast

Main agricultural bulk exports which would benefit significantly from the development of Laem Chabang Port are as follows: tapioca, sugar and molasses. Although maize, rice and minor agri-bulk cargoes may use Laem Chabang Port, maize will likely be handled at Sattahip Port because the Marketing Organization of Farmers (MOF) is currently building a maize export terminal at Sattahip, with a storage capacity of 20,000 tons. Some rice and minor agri-bulk export cargoes are unlikely to use large vessels because of the nature of overseas markets and the structure of the trade. They may be continued to be handled at Bangkok Port.

3.2.1 Tapioca (Cassava)

1) Tapioca, like rice, is one of the most important Thai agricultural products. Although output varies by year, the recent annual production amounts about 18 million tons. Tapioca is produced mainly in Northeastern and Central Thailand. The major producing areas include Nakhon Ratchasima and Khon Kaen in the Northeast, and Chon Buri, Rayong and Chachchoengsao along the Eastern Seaboards as shown in Table II.3.7 and illustrated in Fig. II.3.2.

Tapioca exports have increased from 0.2 million tons per annum in 1960 to 7.9 million tons per annum in 1982 as shown in Table II.3.8. More than 90% of these exports are to Western Europe.

Tapioca undergoes the following processing sequence: Cassava roots are converted into pellets at nearby processing plans and they are then transported to a tapioca storage facility by trucks, and exported as bulk cargo.

The typical sequence is as follows:

Producing Area —(Trucks)— Processing Plant —(Trucks)— Jetty —— Ships (cargo handling at port) 1

Pellets

Processing Plant —(Trucks)— Lighter Terminal —— Ships (offshore cargo handling) 2

Jetty based cargo handling in case 1 is performed by the Mah Boonkrong Drying & Silo Co., Ltd. in the Siracha Area, where handling capacity is said to be more than 1.2 million tons a year. Offshore cargo handling in case 2 is conducted at the anchorage off Ko Si Chang, using four loading towers and the ships' own equipment. Cargo handling at this anchorage is quite important as the ship size used in transporting goods to European ports is, at present, increasing towards the 100,000 - 160,000 DWT range. Many lighter terminals have been constructed in Bang Pa In and Bang Pa Kong.

2) The Estimation of Export Tapioca Products

Export of Tapioca is presently under spontaneous control, whereby the government advises major exporters to limit their exports according to foreign demand or foreign import quotas. However, it is more efficient to implement limits by limiting production and covering excess land to other uses, as has been indicated in the 5th National Economic and Social Development Plan. Along the Eastern Seaboard in particular, a switch from cassava to rubber is being planned.

Nevertheless, in view of the above restrictions, on the opportunities for developing alternative markets and increasing worldwide demand, it appears likely that exports will remain in general at present levels. In this study, the future volume of tapioca production for export is estimated using two methods; in one it is assumed that production will remain at present levels (low projection), in the other annual growth rate is adopted as shown in Table II.3.9. (high projection)

The results of these estimates are shown in Table II.3.6.

On the other hand, a Government policy on tapioca handling facilities at Laem Chabang Port was established by the Ministry of Communications. So in this forecast, it was assumed that export of tapioca products handled at Laem Chabang Port would be 4.5 million tons in order to replace the offshore towers from which the tapioca is presently loaded.

3.2.2 Sugar/Molasses

1) Thailand produces about 25 million tons of sugarcane annually. Sugarcane is mainly produced in the western provinces such as Kanchanaburi and Suphan Buri, and the two provinces of Chon Buri and Rayong along the Eastern Seaboard as shown in Table II.3.10 illustrated in Fig. II.3.3.

Export of Sugar during the last five years has fluctuated between 0.5 and 2.2 million tons as shown in Table II.3.11. Sugar exports are highly dependent on weather conditions.

Four big customers, the USSR, China, Japan and the U.S.A., together accounted for about 80% of all exports in 1982.

2) Export of molasses is generally related to those of sugar, but are subject to a number of additional constraints. Because molasses is a by-product of sugar refining and has limited uses, it is a much lower value commodity and is traded more competitively.

Export of molasses has varied from 0.5 to 0.9 million tons per annum in the last five years, as shown in Table II.3.12, except 1980, when there was especially a bad weather year for the Thai sugar crop.

3) Future Sugar and Molasses Exports

The traffic forecast for future exports of sugar and molasses has been made by using trend line analysis based on data for the years 1960 through 1982 (excluding 1980) (low projection), and also by multiplying the export volume of sugar and molasses in 1982 by the growth rate of sugar exports as shown in Table II.3.9 (high projection).

Future sugar and molasses export is obtained by substracting cargoes handled at private wharves in 1982 at Bangkok Port Area, assuming the present cargo volume in private wharves is equal to their handling capacity.

3.2.3 The Port Cargo Volume generated by the Industrial Estate

The origin and destination of port cargoes going to and from the proposed Laem Chabang industrial estate in 2000 were calculated as follows:

(Unit: Thousand Ton)

Item	Origin	Destination	Total
Export Processing Zone (EPZ)	165	180	345
General Industrial Estate (GIE)	536	824	1,360

It is assumed that those port cargoes which relate with EPZ are already counted into the projected container and breakbulk cargo discussed in 3.1.

3.3 Cargo Volume Handled at Laem Chabang Port in 2001

The Traffic Forecast for Laem Chabang Port in AD 2001 is summarized as Table II.3.6.

Crude oil and petroleum products are not included in this port cargo forecast.

3.4 Cargo Volume Handled at Laem Chabang Port in 1991

Table II.3.13 shows the traffic forecast for Laem Chabang Port in AD 1991.

Table II.3.1 THAILAND'S GROSS DOMESTIC PRODUCTS

(in 1972 prices)

Year	GDP (Billing Baht)	Growth Rate (%)
1981	311	6.1
1982	324	4.2
1983	344	6.0
1991	548	6.0
2000	926	6.0

Source: 1981 - 1982 NESDB
1983 - 2000 Assumption of the JICA Study Team

Table II.3.2 PORT CARGO VOLUMES AND GROSS DOMESTIC PRODUCTS

Year	GDP (Billing B 1972 Prices)	Import Cargo	Export Cargo	Total (Thousand Ton)
1974	190	2,677	235	2,912
1975	204	2,409	146	2,555
1976	223	3,179	373	3,552
1977	237	3,698	475	4,173
1978	261	3,970	723	4,693
1979	277	4,490	857	5,347
1980	293	4,104	1,017	5,121
1981	311	4,425	1,231	5,656
1982	324	4,239	1,438	5,677
1983	-	5,172	1,580	6,752

Source: Statistical Section, PAT
NESDB

Table II.3.3 ESTIMATED CARGO VOLUMES AT KLONG TOEI AND LAEM CHABANG (INCLUDING CONTAINER CARGO)

(Unit: Thousand Ton)

Item	1983	1991	2000
I. High Projection (GDP 6%)	-	11,360	20,412
II. Low Projection (Time Trend)	6,752	9,981	13,827

Table II.3.4 GDP AND CONTAINER CARGO VOLUMES HANDLED AT P.A.T. WHARF

Year	GDP (Billing Ø 1972 Prices)	Import Cargo	Export Cargo	Total (Thousand Ton)
1976	223	204	172	376
1977	237	354	223	577
1978	261	581	468	1,049
1979	277	776	676	1,452
1980	293	839	895	1,734
1981	311	1,126	1,059	2,185
1982	324	1,107	1,156	2,263
1983	-	1,496	1,330	2,826

Source: Statistical Section, PAT
NESDB

Table II.3.5 THE TREND IN THE CONTAINERIZATION RATE

(Unit: %)

Year	Import Cargo (Excluding Midstream)	Export Cargo	Total
1976	6.9	46.3	10.6
1977	10.2	47.0	13.8
1978	17.4	64.7	22.4
1979	20.8	78.9	27.2
1980	23.4	88.0	33.9
1981	30.2	86.0	38.6
1982	32.8	80.3	39.9
1983	34.3	84.2	41.9

Table II.3.6 PROJECTED TRAFFIC IN YEAR 2001

	Total Volume in Bangkok and Laem Chabang Ports		Capacity of Bangkok Port	Potential Demand of Laem Chabang Port
Container	Total	8.1 - 13.1	3.0	5.1 - 10.1
	Import	4.2 - 6.8		(7.6)
	Export	3.9 - 6.3		
Break Bulk	Total	5.7 - 7.3	4.5	1.2 - 2.8
	Import	5.3 - 6.6		(2.0)
	Export	0.4 - 0.7		
Break Bulk	Domestic	0.86		0.86
Tapioca	Export	7.9 - 8.4		4.5
Sugar	Export	3.1 - 4.0	2.2	0.9 - 1.8
				(1.4)
Molasses	Export	1.1 - 1.7	0.9	0.2 - 0.8
				(0.5)
Total		26.7 - 35.3		12.9 - 20.8 (16.8)

Brackets refer to medium projections.

Table II.3.7 CASSAVA: PRODUCTION BY PROVINCE

(Unit: Thousand Ton)

Province	1976		1977		1978		1979		1980		1981		1982	
		%		%		%		%		%		%		%
NOng Khai	97	-	461	4	709	4	483	4	858	5	825	5	681	4
Udon Thai	365	4	57	-	819	5	530	5	789	5	680	4	472	3
Kalasin	426	4	451	4	873	5	578	5	771	5	925	5	635	4
Khon Kaen	280	3	577	5	828	5	521	5	728	4	970	5	972	5
Maha Sarakham	180	2	299	3	545	3	442	4	465	3	257	1	524	3
Buri Ram	582	6	641	5	780	5	310	3	670	4	379	2	268	2
Chaiyaphum	460	4	585	5	727	4	449	4	562	3	529	3	570	3
Nakhon Ratchasima	1,712	17	2,328	20	3,333	21	2,868	26	3,870	23	4,115	23	4,773	27
Chacheongsao	528	5	462	4	542	3	482	4	674	4	1,219	7	1,055	6
Prachin Buri	656	6	597	5	687	4	560	5	789	5	743	4	734	4
Chon Buri	1,306	13	1,287	11	1,421	9	847	8	1,708	10	1,488	8	1,578	9
Rayong	1,696	17	1,438	12	1,894	12	1,150	10	1,503	9	1,591	9	1,866	10
Chanthaburi	159	2	453	4	727	4	296	3	582	4	625	4	376	2
Others	1,783	17	2,204	18	2,473	16	1,585	14	2,571	16	3,398	20	3,284	18
Tttal	10,230	100	11,840	100	16,358	100	11,101	100	16,540	100	17,744	100	17,788	100

Source: Ministry of Agriculture and Cooperate

Table II.3.8 EXPORT OF TAPIOCA PRODUCTS

Year	Export Volume (Thousand Ton)
1960	270
1970	1,327
1975	2,385
1976	3,721
1977	3,954
1978	6,288
1979	3,961
1980	5,218
1981	6,266
1982	7,916

Source: Agricultural Statistics of Thailand Custom Department

Table II.3.9 ANNUAL GROWTH RATE OF EXPORT GOODS

Item	1982 - 1986 (% per year)
Rice (volume)	2.9
Maize (volume)	3.0
Rubber (volume)	7.0
Tapioca (volume)	0.3
Sugar (volume)	3.4
Tin (volume)	2.7
Other goods (volume)	14.0
Total goods (value)	20.1
" (volume)	9.8

Source: NESDB, Long-term Prospect for Economic Development 1980 - 90.

Table II.3.10 SUGARCANE: PRODUCTION BY PROVINCE

(Unit: Thousand Ton)

Province	1976		1977		1978		1979		1980		1981		1982	
		%		%		%		%		%		%		%
Udon Thani	1,280	5	729	4	931	5	971	8	1,214	6	1,694	6	2,619	11
Kamphaeng Phet	1,467	6	854	4	735	4	914	7	1,168	6	1,640	5	1,708	7
Nakhon Pathod	1,980	8	1,401	7	1,098	5	380	4	1,418	7	1,904	6	1,189	5
Suphan Buri	2,809	11	2,199	12	3,090	15	1,906	15	2,272	11	4,066	13	2,847	12
Kanchanaburi	6,309	24	5,390	28	5,428	26	2,156	17	5,103	26	8,027	27	4,842	20
Prachuap Khiri Khan	2,236	9	1,096	6	917	4	580	4	633	3	761	3	1,004	4
Ratchaburi	3,711	14	1,095	6	2,232	11	1,140	9	1,667	8	2,876	10	1,880	7
Chon Buri	2,649	10	2,796	15	2,301	11	1,669	13	2,112	11	2,820	9	2,188	9
Rayong	558	2	933	5	917	4	588	4	1,150	6	1,634	5	1,013	4
Other	3,095	11	2,448	13	2,912	15	2,423	19	3,117	16	4,778	16	5,117	21
Total	26,094	100	18,941	100	20,561	100	12,827	100	19,854	100	30,200	100	24,407	100

Source: Agricultural Statistics of Thailand

Table II.3.11 EXPORT SUGAR VOLUME

Year	Volume (Thousand Ton)
1960	6
1970	56
1974	436
1975	595
1976	1,124
1977	1,655
1978	1,040
1979	1,190
1980	452
1981	1,119
1982	2,201

Source: Agricultural Statistics of Thailand
Custom Department

Table II.3.12 MOLASSES EXPORTS

Year	Volume (Thousand Ton)
1974	500
1975	500
1976	722
1977	953
1978	742
1979	629
1980	245
1981	454
1982	912

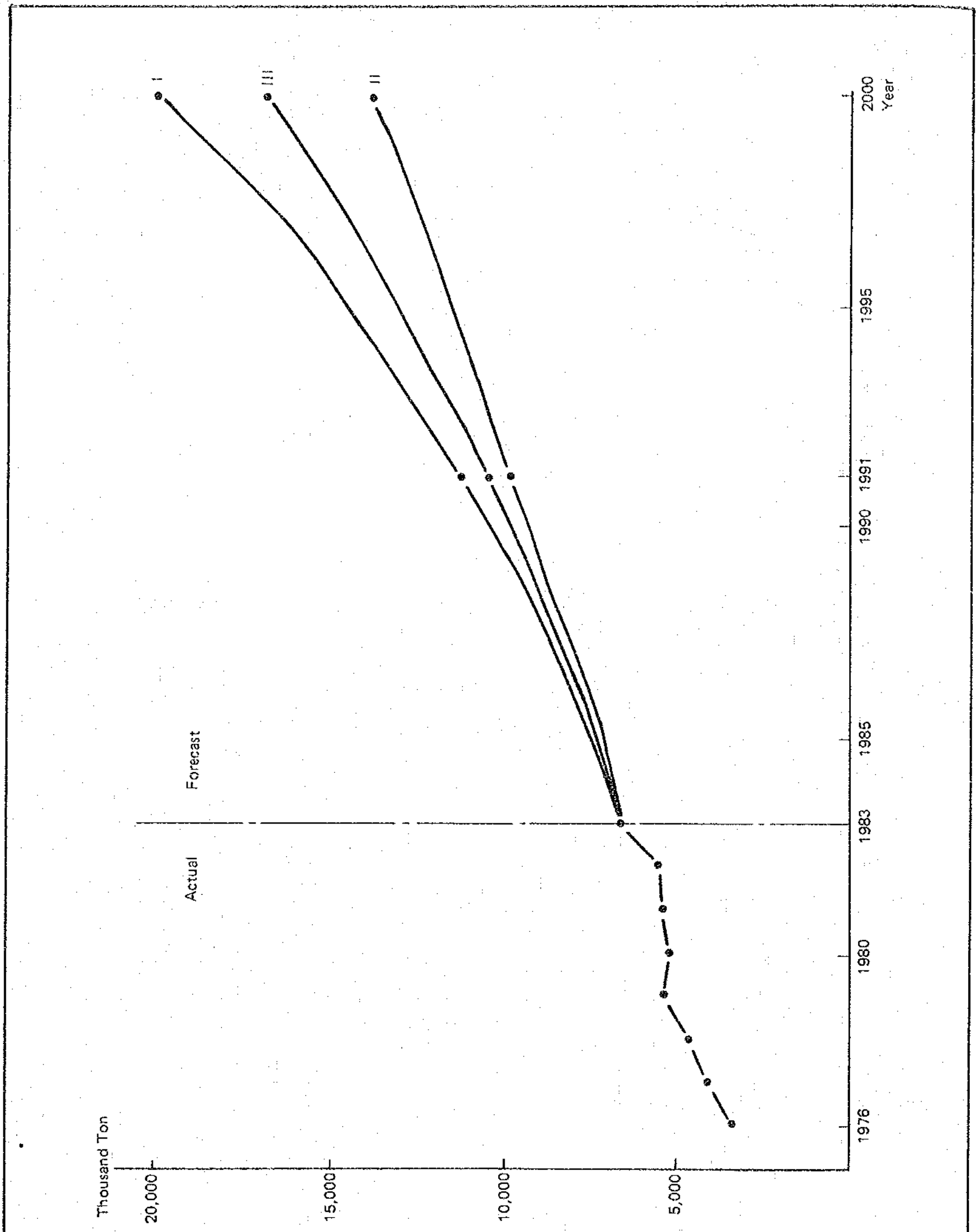
Source: Agricultural Statistics of Thailand
Custom Department

Table II.3.13 PROJECTED TRAFFIC IN YEAR 1991

(Unit: Million Ton)

	Total Volume in Bangkok and Laem Chabang Ports	Capacity of Bangkok Port	Potential Demand of Laem Chabang Port
Container			
Total	5.3 - 6.3	3.0	2.3 - 3.3
Import	2.7 - 3.1		(2.8)
Export	2.6 - 32.		
Break Bulk			
Total	4.7 - 5.0	4.5	0.2 - 0.5
Import	4.4 - 4.7		(0.4)
Export	0.3 - 0.3		
Break Bulk			
Domestic Shipping	0.23	-	0.23
Tapioca			
Export	7.9 - 8.1	-	4.5
Sugar			
Export	2.3 - 3.0	2.2	0.0 - 0.7
			(0.4)
Molasses			
Export	0.9 - 1.2	0.9	0.0 - 0.3
			(0.2)
Total	21.3 - 23.8		7.3 - 9.5 (8.5)

Brackets refer to medium projections.



LEGEND

I High Projection
II Low Projection
III Medium Projection

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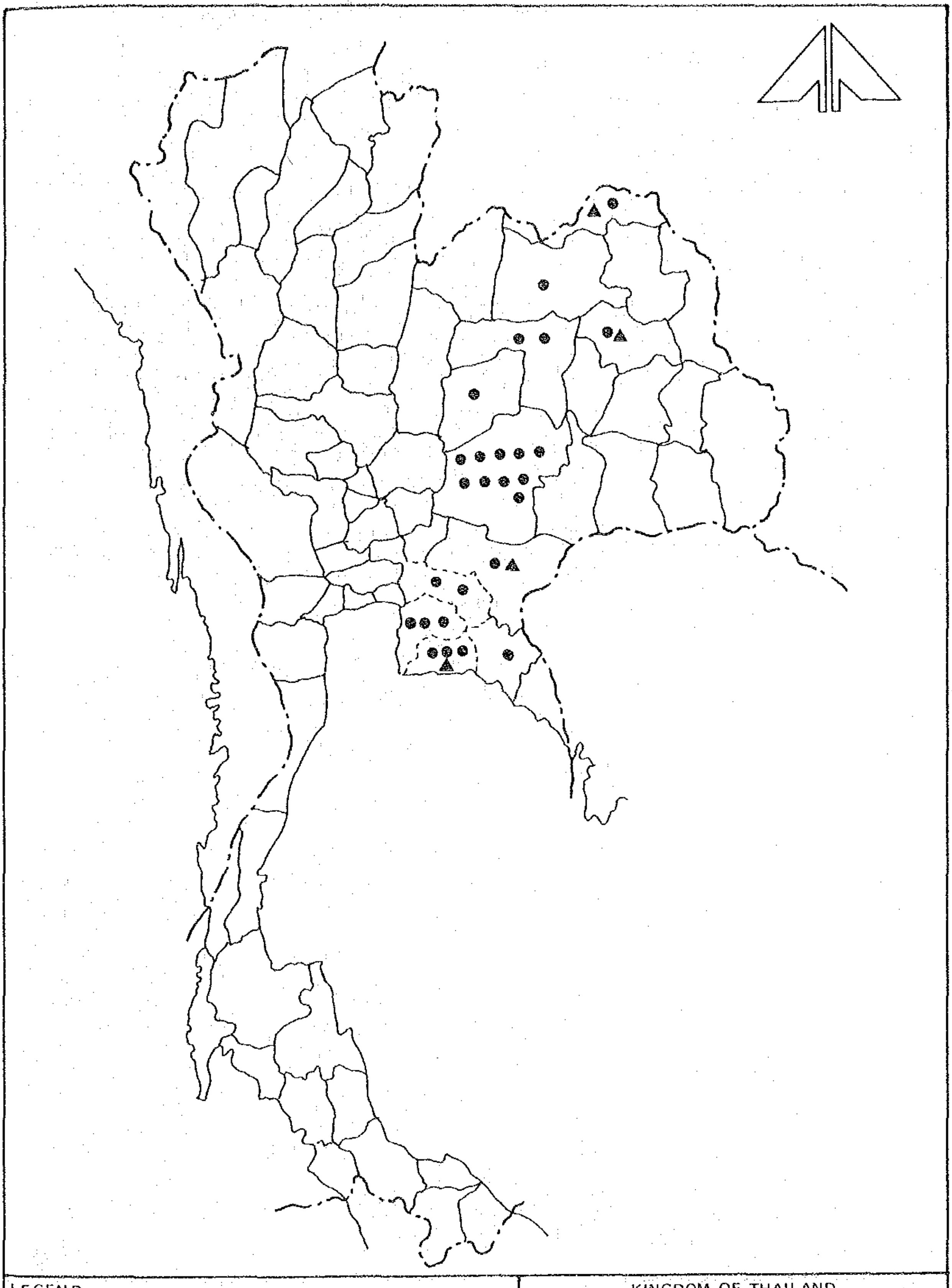
Fig. II.3.1
Forecast of General Cargo Volume at Klong Toei and Laem Chabang Ports



LEGEND

● 500,000 Ton

▲ 250,000 Ton

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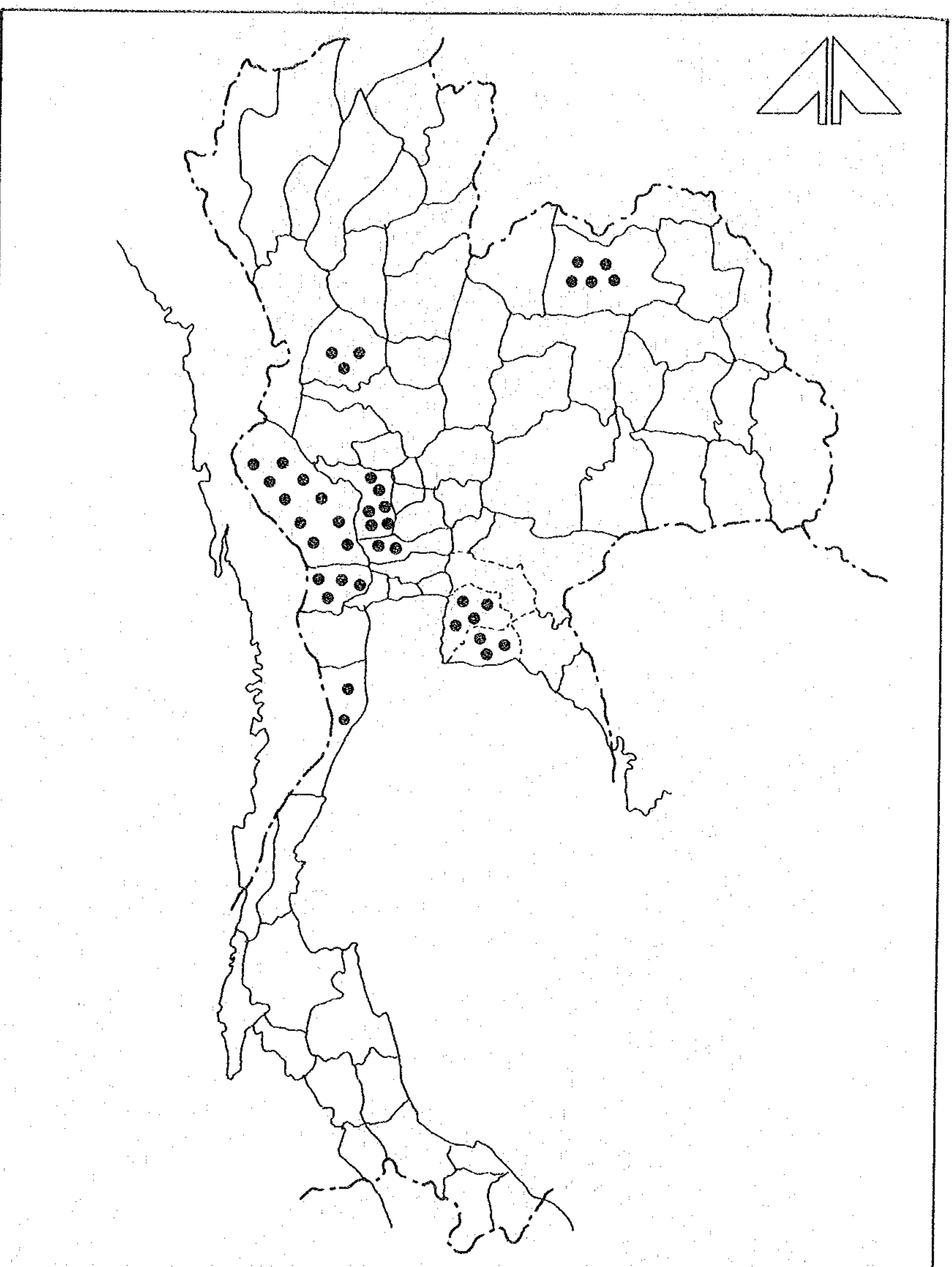
Fig. II.3.2 Cassava: Main Production Area (1982)



LEGEND

● 500,000 Ton

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Fig. II.3.3 Sugar Cane: Main Production Area (1982)

4. NATURAL CONDITION OF LAEM CHABANG

4.1 Tpography

The Study Area is characterized by undulating hilly topography. The proposed port area is facing the Gulf of Thailand and the most of the area lie below El. 4 m. The area of the industrial estate is located adjacent to the proposed port area in the west of Route 3. Its altitude ranges between El. 2 m and El. 30 m. The elevation of the urban development area proposed to be located at the opposite side of the industrial estate varies from El. 15 m to El. 55 m.

4.2 Climate

The climate over the Study Area is tropical and monsoonal. There are two distinct seasons in a year. Dry season with the northeast monsoon lasts from November to April, while season with the southwest monsoon extends from May to October.

Air temperature is 27.9°C on the average. Its diurnal and annual variations are about 2°C and 9°C respectively. Mean relative humidity ranges from 66% in December to 80% in September. Diurnal variation of relative humidity is 30 - 35% for the dry season and 25 - 31% for the wet season. The average annual rainfall is about 1,300 mm, of which more than 80% occurs during the wet season. The amount of evaporation is slightly less than annual rainfall, being 1,100 mm per year.

4.3 Geology

Geological map covering the whole area planned for the Laem Chabang Complex was prepared by Land Development Department (LDD). (Refer to Progress Report, 2-9, March 1984) As a whole, geological characteristics of the area is considered to be good for foundation. Most of the area is characterized by loamy sand texture except the area along the boundary between the industrial estate and port area of which soil is clayey. For this area, detailed geological survey may be required at the implementation stage of the Project.

4.4 Offshore Conditions

The 3 km wide strip along the existing shoreline is generally flat, sloping gently southwards until it meets a swampy area surrounding the Huai Yai River mouth located about 7 km south of the cape of Laem Chabang.

The sea bottom slope is also gentle except the area just south of Laem Chabang cape, where -13m below LLW contour line comes in close to the cape and therefore, the ocean going vessels can access the area without much dredging. The coast line runs in an arc from Cape Laem Chabang at one and Cape Laem Khwan at the other.

The catchment area of the Huai Yai River which constitutes the southern boundary of P.A.T.'s estate is of considerable width and causes the shallow contour lines to protrude near the river mouth revealing apperently the flow of soil from upstream and its accumulation near the seashore. In view of these features, this Huai Yai River is deemed to be probably the southern limit of the Laem Chabang Port development.

A shoal lying at a depth of -3.5 m LLW extends southwards offshore from the Cape of Laem Chabang. The substratum is geotechnically sound and reliable. A natural channel exists between the cape and the shoal.

In general, the surface layer is an alluvial soil underlaid by in-situ weathered granite with an N value over 30. Below this, fresh granite rock is found at a depth of 40 - 50 m. The in-situ weathered granite seems to be decomposed enough to be dredged by the cutter suction dredger. There is no fresh rock above -20 - -30m LLW which can not be dredged by the cutter suction dredger.

A reduction of the cost of breakwater construction as well as that of the initial dredging may be attained by utilizing this topographically advantageous characteristic, i.e. using the shoal as the breakwater foundation and the natural channel as part of the fairway.

By constructing the breakwater on the shoal, the tidal current across the fairway might be intensified at the proposed harbour entrance. But according to the NEDECO's study the effect of this on the ship navigation is negligible.

The winds are generally weak and the design wave has a height of approximately 2 m and moves from S to SW. The wave period is less than 4 seconds. The tidal current was observed by NEDECO and the magnitude of the maximum current is of the order of 1 - 1.5 knots which will not have a serious effect on maneuvering ships.

5. PORT PLANNING

5.1 Berth Requirements

5.1.1 Maximum Ship Size and Berth Dimensions

The maximum size of vessels for various commodities will practically decide the dimensions of the port's entrance channel and basin. The water depth alongside the berth and the length of the berth will also be decided by the ship's dimensions. Based on examples of maritime transport in East Asia and previous studies, the ship size was assumed as tabulated below.

Maximum Ship Size and Berth Dimension

	Dead Weight Ton DWT	Hold Volume	Ship Dimensions (m)			Average Cargo per Ship	Berth (m)	
			L	W	D		Length	Depth
Container (2000 TEU)	33,000	-	269.8	32.2	12.0	500-600 TEU/ship	300	13.0
Break Bulk	40,000 30,000	- -	217 199	28.3 26.1	11.9 11.0	4,000 t/ship	260 240	13.0 12.0
Tapioca	142,000 DWT	160,000 m^3 (Bulk density 0.6 t/m^3)	284.2	45.6	D=165 (D=11.5)	80,000 Weight/ton	340	13.0
Sugar	25,000 DWT	26,000 m^3 (0.84 $t/m3$)	190	15	D=10.5	20,000 Weight/ton	235	11.5
Molasses	25,000 DWT	26,000 m^3	190	25	D=10.5	20,000 Weight/ton	225	11.5

5.1.2 Berth Requirements in Year 2001

Based on the estimated cargo traffic and the assumed ship sizes, the berth requirements in the Year 2001 were tentatively estimated as follows:

Berth Requirements in 2001

Commodities	Traffic Demand (Million ton)	Average Load/ Unload per Ship	Ship Size (DWT)	No. of Ship Calls per Annum	Handling Speed	Berth Time (hours/ship)	No. of Berths	
Container Cargo	7.5	500 TEU	33,000 (2,000 TEU)	1,500	20 (TEU/H x) 2	12.5 (15.5 including idle time)	7	*$\rho = 0.40$
Break Bulk (Foreign)	2.0	3,000 t	40,000- 15,000	677	-	(-13m) 260m x 2B (-10m) 185m x 5B	7	**
Break Bulk (Domestic)	0.86	-	1,500	-	-	-	(1,100m)	***
Tapioca	4.5	80,000 t	142,000	56.2	1,000 t/h	80	1	$\rho = 0.52-0.6$
Sugar	1.36	20,000 t	20,000	68	1,000 t/h	20		
Molasses	0.5	20,000 t	20,000	25	500 t/h	40	1	$\rho = 0.27-0.35$

Note: *: 1 TEU = 10t. Two gentry cranes are to be installed in each berth. An average throughput is about 1.2 million tons per annum.

**: 1,400t per meter per annum based on the throughput at conventional berths and Klong Toeis and other ports.

***: 800t per meter per annum.

The number of container berths was calculated based on the throughput performance experienced in the Port of Kobe, Japan. The average throughput is assumed to be about 1.2 million tons per berth which can be attained with two container gantry cranes installed at each berth.

5.1.3 Cargo Flow between the Port and its Hinterland

There is no reliable information about or estimation of the cargo flow between the port and origins/destinations in its hinterlands.

In order to design the necessary infrastructure for the secondary transport from the Port, including a railway, the road system within the port, and lighterage wharves, the transport demand modal split was assumed as follows:

(Unit: %)

Cargo Type	Truck	Rail	Barge
Container	50	50	-
Break bulk	75	15	10
Tapioca	50	20	30
Sugar	100	-	-
Molasses	100	-	-

These figures were assumed based upon the consideration described below:

1) According to the cargo flow statistics for 1977, about 72% of the total cargo tonnage was carried by trucks, 16% by inland waterway barges, 9% by rail and 3% by coastal shipping.

   Although the cost per unit ton carried by rail becomes lower than that carried by trucks when the hauling distance exceeds 150 km, railway transport will not be competitive even for distances over 200 km, because of the inevitable transshipment from railway wagons to trucks at the station. (Fig. II.5.1)

2) The Bang Sue railway container station has been planned by the SRT in order to transport container from Laem Chabang to Bangkok and vice versa.

3) At present, more than 50% of the cargoes handled at P.A.T. facilities are transshipped between ocean going vessels and lighters. In particular, import cargoes are carried from P.A.T. berths by lighter and distributed to the private berths along the Chao Phraya River owned by the factories and shipping agents. New factories tend to be built at the industrial estates which are located in the outer fringe of the Bangkok Metropolitan Area or in the areas along the roads radiating outward from the central part of Bangkok. As a result of this shift of factory away from the Chao Phraya terrace, lighterage transport may become less predominant and other transport means will be selected instead. Thus the use of lighters as secondary cargo transport may not be so intensive in Laem Chabang as in the present Klong Toei, but still in year 2000 considerable amounts will be transported by lighters for which the distance between Bangkok and Laem Chabang is only 90 km instead of 120 km by trucks.

4) Container transportation: There remains a lot of uncertainty concerning railway transport. Some liner staff members believe that using trucks to carry cargo door to door is the most effective and reliable method for containers. It is not clear at this stage whether the railways will be operated efficiently enough to offset the disadvantage of the inevitable transshipment to/from the truck transport.

Hauling distance of container boxes and other relevant data are summarized in Appendix II-4(B).

In this study the existence of these two competitive transportation methods is assumed as it will enable competition between them and also insure transportation in the case of an accident on either one route. This decision needs to be reviewed after observing the actual performance in the initial state of operation. Lighter transport was discarded since the container cargo is generally sensitive to uncertainty in the travel time.

5) Break Bulk: Trucks are apparently major means of transportation, while some heavy and bulky cargo such as large plant machinery and steel prefers water way transport. Railways become competitive only when the commodities need to be transported to cities far from Laem Chabang Port.

6) Tapioca: The main origins of tapioca cargo are located in the North-eastern Region and the Eastern Seaboard area. (Fig. II.3.2)

The tapioca originating from the latter will continue to be carried by truck. Transport of tapioca from the Northeastern Region may change from truck to railway if the railway connection between Bang Pha Chi and Klong Sip Kao is constructed to enable the long distance railway traffic to by-pass the metropolitan area. The lighterage transport from the existing tapioca terminals along the Chao Praya River and the Ban Pakong River will continue to be significant until the investment in these terminals is exhaused.

7) Molasses/Sugar: These commodities are to be transported by truck. (Fig. II.3.3)

The amount of port cargo carried by these transportation modes is consequently calculated as shown below.

(Unit: Million ton)

Commodity	Package Format	Imp./Exp.	Origin	Destination	Volume	Truck	Rail	Barge
Container	Van	Exp.	Whole Thailand	Port	3.8	1.9	1.9	-
		Imp.	Port	Mainly Bangkok	3.8	1.9	1.9	-
Break Bulk		Exp.	Whole Thailand	Port	0.2	0.15	0.03	0.02
		Imp.	Port	Mainly Bangkok	1.8	1.35	0.27	0.18
		Domestic	Port	Industrial estate	0.86	0.86	-	-
Tapioca	Dry Bulk	Exp.	North East	Port	4.5	2.25	0.9	1.35
Sugar	Bulk/ Bag	Exp.	Eastern Seaboard	Port	1.4	1.4	-	-
Molasses	Liquid Bulk	Exp.	Eastern Seaboard	Port	0.5	0.5	-	-
Total					16.8	10.31	5.0	1.55

5.2 Land Use of the Area along the Shore Line

5.2.1 Land Requirement for Port Activity

As the guideline for planning the urban area in relation to the port activity, land requirement was estimated based on the port throughput.

The distribution and storage area was estimated by summing up the more detailed land use which is required to be planned near the pier area. Review of business/commercial area was also done based on the higher density of population.

The general land requirement and the review of distribution storage area and business/commercial area are described as below.

1) The Land Requirement Estimate based on the Port Throughput

The land requirement is roughly calculated based on the relationship between the cargo throughput and the area of the land used for the port activities. Samples were taken from the existing commercial ports in Japan and Klong Toei Port. (Fig. II.5.2)

Judging from the seashore length between the Cape and the Hui Yai River Mouth the maximum throughput of the Laem Chabang Port is estimated as the order of 50 million tons. This volume will be attained in about AD 2020 assuming 6% increase of GDP after 2001 AD.

The breakdown of the required land was also estimated based on the constitutent ratio in the Port of Kobe.

The definition of the pier back-up area, urban area, and recreational area is given below. The land requirement for AD 2001 was also estimated based on the assumed throughput of 16 MT per annum. The rough estimate of the land requirement was decided by taking into consideration the reclaimed land for harbour and the Cape of Laem Chabang. The latter area is not easy to utilize for any other purposes than a park.

(1) AD 2020

Item	Pier Backup Area	Urban Function Area	Recreational	Road	Rail	Reserve	Total
Estimation from the throughput	461.1	371.4	50.3	170.8	32	94.4	1,180
Planned area excluding reclamation	160 *1	271.4	190 *2	170	32	94	1,017

Note: Definition of Various Areas

Pier Back-up Area: cargo sorting area, passenger terminal area, storage area, area for welfare facilities for port workers, and area for site offices for port related public and private services.

Urban Function Area: residential area for workers in the port and business area.

commercial/business area.

area for other urban-related facilities.

Recreational Area: park and green area.

*1 reclamation: approximately 300 ha

*2 Laem Chabang Cape (140 ha) is reserved for an observation platform.

(2) AD 2001

Item	Pier Backup Area	Urban Function Area	Recre-ational	Road	Rail	Reserve	Total
Estimation from the throughput	152.1	122.5	16.6	56.4	10.6	31	289.4
Planned area exclud-ing reclamation	160*	130	170	57	10	31	558

Note: * includes reserve for future distribution and storage area.
reclamation: approximately 200 ha

(3) AD 1991

Item	Pier Backup Area	Urban Function Area	Recre-ational	Road	Rail	Reserve	Total
Estimation from the throughput	92.2	74.3	10.6	34.2	6.4	18.8	236
Planned area exclud-ing reclamation	100	80	170	34	6	20	410

reclamation: approximately 100 ha

2) The Area for Distribution and Storage

The pier back-up area consists of cargo sorting area and distribution/ storage area.

The area for distribution and storage was estimated by a different method from one described above in order to confirm the result for 1991.

By summing up the various land use requirement in the waterfront and distribution and storage area, the necessary area to be provided in commercial distribution area is estimated to be about 60 ha. The breakdown is shown in the following table.

Since other unknown land requirements may occur in future and the estimation is mainly based on examples in Japan, an allowance for such factors needs to be considered. Therefore, it is proposed to secure at least 80 ha as the distribution/storage (D/S) area. The D/S area in the Master Plan remains unchanged until further information is obtained from the observation on the activities in this area after the start of operation. (Refer to Fig. II.5.10)

(Unit: ha)

Item	Distribution and Storage Area	Wharf Area
1) Container terminal	-	31.5
2) Open storage for container	-	28.4
3) Space for container storage	40	-
4) Site office for government organizations	4	-
5) Site office for private companies	6	-
6) Truck terminal	10	-
7) Warehouse area	-	18.5
8) Open storage for domestic shipping	-	15
9) Rail and road space	-	23
Total	60	116.4

- Open space for container storage and extra container freight station operated by independent stevedoring companies

  In total, a 100 ha is necessary for container operation of three container berths, which include marshalling yards, container freight stations, empty van pools and extra container freight stations operated by independent stevedoring companies. This area requirement was obtained based on the area requirement in Honmoku wharf area of Yokohama Port. Because about 60 ha was reserved for container in the reclaimed area as shown in the figure, another 40 ha is necessary within a commercial distribution area.

- Site office of the authorities responsible for the port operation

Minimum 4 ha will be needed for immigration, customs, quarantine, police, harbour dept. etc.

Site office for private companies which will supply various kinds of service in the port; 6 ha for stevedore, longshore, shipping agent service, tally and measuring chandlering, customs brokerage, tug, ship cleaning, etc.

- Truck Terminals

Cargo volume handled at truck terminals in a commercial distribution area is assumed to be 860,000 t per year. 40 percent of container cargo transport by trucks and almost all of break bulk cargo are assumed to be handled in truck terminals in this area.

Container by truck : 1,400,000 x 0.4 = 560,000 t/year
Break bulk cargo by truck: 300,000 x 1.0 = 300,000 t/year

Assuming three hundred days per year and 50% peak ratio, cargo volume handled per day is estimated at 4,300 t/days.

$$860{,}000 \text{ t} \times \frac{1}{300} \times 1.5 = 4{,}300 \text{ t/days}$$

The total area necessary for truck terminals is estimated to be 10 ha using the result of the truck terminal study in Bangkok area.

$$4{,}300 \text{ t} \times 24.65 \text{ m}^2/\text{t} = 10 \text{ ha}$$

3) Port Back-up Area: Business and Commercial Area

The business and commercial area was reduced to 72 ha in the master plan and 36 ha in the short term development plan assuming a high density of employment. This area is to be mainly used for buildings and facilities as follows:

(1) Government offices (customs, immigration, quarantine, harbour department, port authority, etc.)

(2) Offices of import/export business firms

(3) Offices of steam ship lines, shipping agents, stevedore and longshore companies

(4) Banks and insurance offices mainly for shipping and port business

(5) Companies to supply fuel, food and other material to ships (ship chandler)

(6) Restaurants, hospitals and parks mainly for port workers

(7) Exhibition hall for the international trade including museum, civil auditorium hall

(8) Banks for general public

(9) Commercial center consisting of department stores, supermarkets and restaurants

Under the Land Expropriation Law, the following facilities can not be built within the Port Authority owned land.

(1) Municipal hall

(2) Hotel

(3) Amusement facilities for mariners such as movie theaters and game centers

(4) Consulate

(5) Other facilities which is not directly related to port activities

5.2.2 Space Demand of the Water Front by Other Activities

In contemplating the utilization of the shoreline in the study area, the potential demand on the water front from other activities has to be taken into account. These are fishery, ship repairing industries and recreation space near the sea shore.

1) Fishery

At present, approximately 40 fishing boats stay along the south eastern shoreline of Laem Chabang Cape. They are less than 10 meters long and navigable only in calm sheltered areas. The population of this fishery village seems to be not more than 300.

Although it will take quite some time until the ocean going vessels' traffic becomes so intensified that the interferance with the small fishing boats endangers the ship's navigation, in the long term it is desirable to shift the fishery harbor to some other place. The MOC is planning to switch the fishery village to the left bank of the Huai Yai River, which is outside of the P.A.T. area.

For the time being it is not clear whether a basin for the fishing boats will be required or not. In this study it is assumed that neither the basin nor any other kind of facilities of the fishing boats needs to be constructed within the study area.

It is not known whether people in this fishery village want to continue fishing or not. If they don't, the problem is to find out new jobs in this area for the fishermen, which might be easily attained because of the newly created jobs as a result of this development.

If they insist to continue fishing, some measures have to be considered.

The troubles which may arise if the fishing village continues to exist adjacent to the port are as follows:

(1) The traffic of fishery boats will interfere with navigation of big vessels calling on this port.

(2) A slum area might arise near this fishery village and illegal activities such as drug traffic, smuggling and pilferage might be performed in this area.

The relocation of the whole village is one counter measure against those disadvantages. But other counter measures were also considered as another possible alternatives in case it is difficult to shift the whole village.

(1) Strict observation of navigational regulations within the harbour area.

The fishery boat can navigate very shallow area and it is very easy to maneuver a fishing boat compared with big vessels.

(2) Encouragement to switch jobs especially for young fishermen and employment of the fishermen's children to the jobs generated in this area.

With this process the fishermen here may disappear within one or two decades.

(3) In order to preclude a slum, public houses should be given to even unskilled labourers working in the port and the adjacent factories.

The minimum wages rate needs to be applied to all kinds of labourers and insurance or guarantee has to be given to the port workers who can not find jobs due to the fluctuation of the port handling activities.

It was not recommended to shift the village to the river mouth of the Huai Yai River by the following reasons:

(1) It might be difficult to keep the water depth and calmness which are required for the fishery harbour.

(2) Another relocation may become necessary to reserve a port back-up area if the port is expanded in future.

2) Ship Repair/Building Yard

The Thai Government is inviting private companies to establish a ship repair and building facility in the Eastern Seaboard. The selected company will be given various kinds of financial support and privileges from the government. The final determination of the location of this factory and the dimension of the plant will be made by the private sector. As present, the Government believes that Laem Chabang is the appropriate site for this factory and that it should have the capacity to repair/serve 6,000 GT ship with the possibility of expanding the capacity to 20,000 GT in the future.

It was also stated that it is not likely in the foreseeable futures that any ship machinery factory producing things such as ship engines or boilers will be established in this area. The dimension of the plot required by this shipbuilding complex is 200,000 m^2 for repair and building yard.

The minimum water depth required is 5 meters below LLW and an 11 m water depth is recommended in front of the dock. The turning basin needs to be larger than a 500 m diameter circle. A breakwater will not necessary if the significant wave height is around 2.0 m.

The space for a further expansion was not reserved adjacent to the planned site provided that the related/supporting industries for the ship repair factory are to be located in the general industrial estate utilizing the vast reserved area in the estate.

The proposed location for the repair facilities was confirmed as most suitable on the basis that this location enables to reserve the natural beach and to minimize the initial investment for infrastructures by sharing this cost with other port users.

3) The Seashore North of the Port

The natural seashore between the cape and the port is reserved to convert the beach area into a park which will function, together with the landscape headland, as a welcome point for mariners visiting this country. This park will also be utilized as an observation platform for common people to see activities in the modern port and ship repair/building facilities.

5.3 Port Layout

5.3.1 Boundaries of the Area

The P.A.T. owns the land along shoreline from the Cape of Laem Chabang to the Huai Yai River mouth. Parts of the eastern boundary adjoin Route 3 and the land owned by IEAT. The total area is about 1,100 ha, of which more than 90 percent has already been purchased.

The SRT has already decided on the alignment of the spur line from the Chachoengsao - Sattahip line to Laem Chabang and has purchased the land along the route from the junction point to the P.A.T.'s tract.

The IEAT has purchased most of the area of about 450 ha which is delineated by the P.A.T.'s property line and Route 3.

To the north of the P.A.T.'s land, three petroleum entities, namely ESSO, TORC and PTT, have oil refineries and LPG storage facilities. A mooring jetty is planned north of Cape Laem Chabang to handle these kinds of liquid bulk cargoes.

It was assumed that the boundaries of the land owned by Government agencies can be adjusted to some extent if it is necessary and desirable for the development of this area.

Along the shoreline near the Cape of Laem Chabang, there are restaurants serving tourists and a temple for the local residents. It was assumed and confirmed by the Royal Thai Government officials that it is not difficult to shift these somewhere outside the port area in order to construct the port.

5.3.2 Water Front Demand

The water front demands in the port area can be divided into groups according to their purposes as follows:

Group	Depth (LLW)	Water Front Length	Allowable Wave Height
∘ Ship building and repair yard	(-5 m minimum) (-11 m desirable)	400 m	2.0 m*
∘ Agri-bulk export terminal	(-13 m) (-12 m)	340 m 225 m	1.8 m** 1.2 m**
∘ Container terminal	(-13 m)	2,100 m	0.75 m**
∘ Break bulk terminal	(-10 m - -13 m)	1,445 m	0.75 m**
∘ Quaywalls for domestic shipping	(-5 m)	1,100 m	0.3 m
∘ Basin for auxiliary port ships	(-3m, -5m)	-	0.3 m
(Such as tugs, pilotboats, water and bunker oil supply boats, lift barges and dredgers)			

Note: *: The ship building facilities will not require a sheltered area if the wave height is less than 2 m, but the bulk carriers in the agri-bulk terminal are more sensitive to wave action.

**: (NEDECO Study 1978)

5.3.3 Principles of the Port Layout

1) The entrance channel is dredged from the northern part taking advantage of a natural trench. Its effective width needs to be equal to or greater than the maximum ship length.

2) The shoal which exists 2 km off the shoreline should be utilized as the break water foundation as much as possible.

The breakwater length was decided so as to protect the berth basin against waves intruding from the WNW, W and SW. (Appendix II-6).

3) Within the shielded area a straight line waterway longer than 5 L is secured between the harbour entrance and the container berth, where L is the length of container vessels.

4) The basin is large enough to allow ships to be turned by tugboats.

5) The agribulk berth and ship repair berth need not interact with the container and break bulk wharves. On the contrary, as tapioca dust may cause trouble for the mechanical equipment at the public wharves, the agri-bulk berth had better be located to the leeward side of the port. (Refer go Appendix II-7 and II-8)

6) According to the sensitivity of the handling operations to wave action, the tapioca berth and ship repair yard are arranged near the harbour entrance and the container wharves are located in the inner harbour.

7) Some of the break bulk berths are designed so that they can be converted to container berths in the future.

8) The Area for Domestic Shipping

In order to preclude the unnecessary customs formalities for domestic shipping, an area for domestic shipping was clearly separated from the foreign shipping area, which was confined within the customs fence.

9) Space for a Future Agri-bulk Terminal

Although it was not confirmed by the cargo forcast in this study, the P.A.T. believes that another agri-bulk terminal will be required at Laem Chabang after AD 2001. The existing agri-bulk handling facilities in the Bangkok and the Eastern Seaboard will get obsolete within twenty years and the renewal will have to be made.

The Laem Chabang Port will possibly become the most favorable site for agri-bulk export if the connection line between Bang Pha Chi and Klong Sip Kao is constructed enabling direct traffic from the Northeastern region to this port. The space for future agri-bulk terminal was, therefore, reserved in the port layout.

10) Container Terminal (See APPENDIX II-10)

(1) The width of space for railway track and road behind container terminals was decided to be 100 m allowing for queues of trucks which are usually observed before arrival of ships in container terminals.

(2) The necessity of RO/RO ramp way is not concrete enough to plan this facility in the layout. The suitable site is the eastern end of the break bulk berth in case an actual necessity occurs. The decision is left to further consideration in future possibly after the commencement of operation of Laem Chabang Port.

(3) The number of gantry crane necessary for the short term plan was decided to be 5 allowing for one spare. Without maintenance and breakdown 4 unit would be enough for the short term plan stage.

11) In principle, an attempt is made to balance the reclamation and dredging volumes as much as possible.

12) The layout for the short term development plan is designed to be compact to minimize the initial investment for the breakwater and the harbour basin.

5.3.4 Port Layout

The previous studies proposed three different port layouts (Figs. II.5.3, II.5.4, II.5.5) Although the number of berths and the size of maximum ships are different, the general configurations are quite similar.

In all cases, the breakwater is to be constructed on the shoal and the existing natural channel between the cape and the shoal is utilized to minimize the initial investment. Therefore, not so different port layout seems to exist as an alternative in the Master Plan.

In order to investigate the possibility of completely different port layouts the excavated type and the island type were studied.

The advantages of the excavated type as shown in Fig. II.5.6 are:

- reduction of breakwater construction cost
- completely shielded basin
- relatively simple fairway alignment without frequent turnings of big angle at the harbour entrance.

The disadvantages are:

- back-up area will be squeezed between the Route 3 and the excavated waterway
- possible increase of dredging cost
- road connection between wharves in not easy
- congestion within the inland waterway
- lack of flexibility compared with other layouts

The excavated type was excluded from further consideration.

In the Interim Report, two port layouts were studied; pier type and island type. (Figs. II.5.7 and II.5.8)

The pier type is not much different from the layout proposed by NEDECO in the 1978 report except for the exclusion of the deep water berths for the heavy industries. The access channel alignment and the pier head line direction are very similar to the original layout.

The island type is studied mainly because it preserves favorable natural environment along the existing shoreline and ensures the port's customs area from smuggling and pilferage. Since the waterway behind the island will be utilized as part of a park along the seashore and the access to the customs area is limited, this port does not cause any mixed land use, eliminating the congestion and confusion arising from it, as happens at Klong Toei Port.

Major disadvantages of the island type include:

- When the inland area has been intensively developed and densely populated, it may be hard to keep the water in the channel clean.
- An additional connecting bridge to the island might be necessary in a long-term development plan, not to handle traffic but to serve as a back-up in case of an accident. This implies a further cost increase.

The result of discussion on the comparison of two types of layout is summarized as shown in the following table. Based on these consideration the pier type was chosen as the most suitable layout.

Comparison between Pier and Island Type

	Pier Type	Island Type
Construction cost		xx 8% expensive than pier type in master plan stage. 20% expensive in rough estimation in short term.
Calmness within the harbour		x Since the turning basin near the entrance is surrounded by berths, the energy disperse of the incident wave is less than the pier type.
The compactness of layout in the short term		x The concave shape rivet lines is exposed to the SW wave in the short term plan, implying the cost increase for the wave proteceon.
The accessibility to the natural water side	x Only the shore line in the northern portion can be accessible for the citizen.	o The waterway will be utilized as the park for the citizen x The waterway has to be dredged about 2 - 3 m depth from the existing bottom to keep the water in the trench. xx The water may possibly be hard to be kept clean if the land area is intensively utilized.
The relation with the city behind	x The interfence between the business and port area may occur. The mixing up of the land use may occur.	o The additional land can be obtained easily if the waterway is reclaimed.
The security of the port area		o The access to the port area is completely controlled.
Connecting bridge		x The additional bridge may be necessary for security.

Note: xx: disadvantage, x: slightly disadvantage, o: advantage

After discussion with the P.A.T. and MOC, it was agreed to revise the port layout in some minor points, which include the space for the future agri-bulk terminal and the secession of domestic cargo wharf from the customs area.

The final master plan was shown in Fig. II.5.9)

5.3.5 Short Term Development

1) Cargo Traffic Forecast in 1991

Cargo volume to be handled at Laem Chabang Port in 1991, the target year of the short term development, is summarized in Table II.3.13.

2) Berth Requirements in 1991

Corresponding to the above-estimated cargo traffic, the berth requirement in 1991 is planned as in the following table.

Berth Requirements in the Year 1991

Commodities	Traffic Demand (Million ton)	Available Load/ Unload per Ship	Ship Size (DWT)	No. of Ship Calls per Annum	Handling Speed	Berth Time (hours/ship)	No. of Berths	
Container Cargo	2.8	500 TEU	33,000	564	20 (TEU/H) x 2	12.5 (15.5 including idle time)	3	*$\rho = 0.27$
Break Bulk	0.4	3,000 t	40,000 -15,000	117	-	(-13m) 260m	1	**
Domestic Shipping	0.23	-	1,500	-	-	-	(280m)	***
Tapioca	4.5	80,000 t	142,000	57	1,000 t/h	80	1	$\rho = 0.52-0.6$
Sugar	0.4	20,000 t	25,000	23	1,000 t/h	20	1	$\rho = 0.1-0.13$
Molasses	0.2	20,000 t	25,000	9	500 t/h	40		

Note: *: 1 TEU = 10 t. 4 gantry cranes are to be installed for three berths. An average throughput is about 1.2 million tons per annum.

**: 1,400 t per meter per annum based on the throughput at the conventional berths of Klong Toei and other ports.

***: 800 t per meter per annum.

3) Cargo Flow between the Port and its Hinterland by Mode

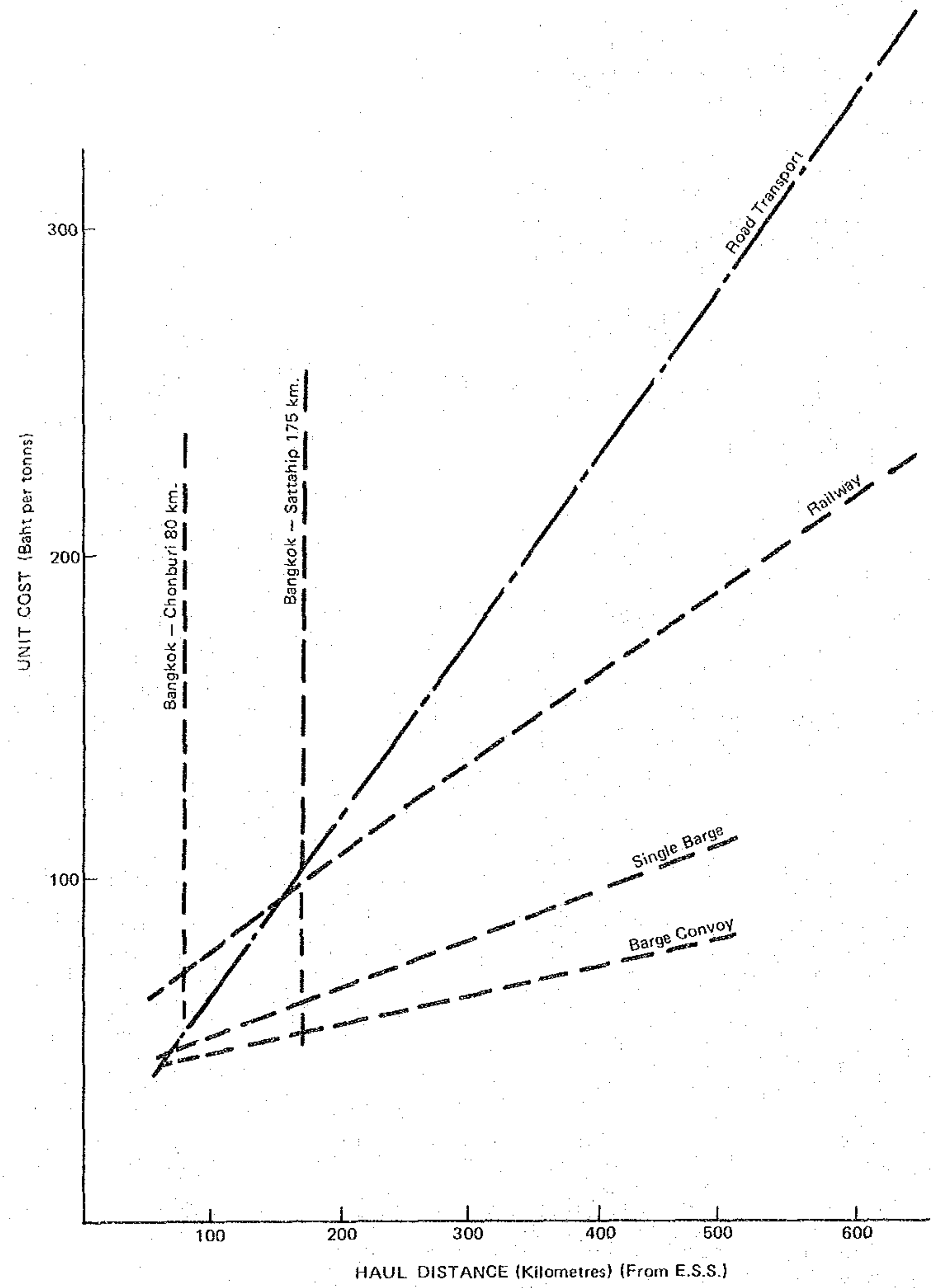
The volume of cargo transported by each transport mode was estimated as summarized below:

(Unit: Million ton)

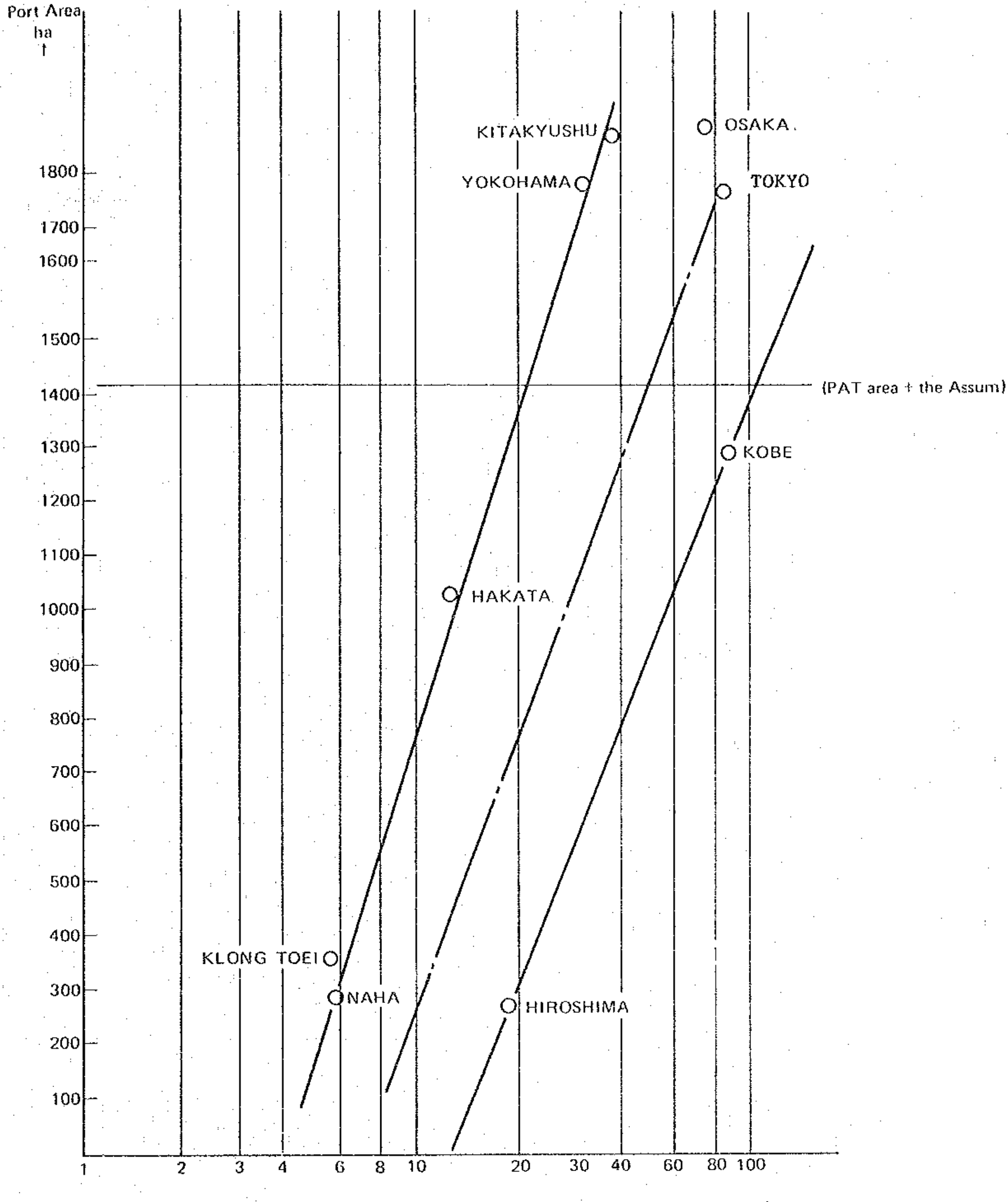
Commodity	Package Format	Imp./Exp.	Origin	Desti-nation	Volume	Truck	Rail	Barge
Container	Van	Ex.	Whole Thai	Port	1.4	0.7	0.7	-
		Im.		Main Bangkok	1.4	0.7	0.7	-
Break Bulk		Ex.	Whole Thai	Port	0.04	0.04	-	-
		Im.	Port	Mainly Bangkok	0.36	0.27	0.05	0.04
Break Bulk		Domestic	POrt	Industrial Estate	0.2	0.2		
Tapioca	Dry Bulk	Ex.	North East	Port	4.5	2.25	0.9	1.35
Sugar	Bulk/ Bag	Ex.	Eastern Seaboard	Port	0.4	0.4		
Molasses	Liquid Bulk	Ex.	Eastern Seaboard	Port	0.2	0.2		
Total					8.5	4.7	2.4	1.4

4) Port Layout

The layout for the short term development plan is shown in Fig. II.5.10.



LEGEND	KINGDOM OF THAILAND THE STUDY ON THE DEVELOPMENT PROJECT OF LAEM CHABANG COASTAL AREA
	JAPAN INTERNATIONAL COOPERATION ANGENCY
	Fig. II.5.1 Unit Freight Cost



LEGEND	KINGDOM OF THAILAND THE STUDY ON THE DEVELOPMENT PROJECT OF LAEM CHABANG COASTAL AREA
The industrial area was excluded from whole port area.	JAPAN INTERNATIONAL COOPERATION ANGENCY
	Fig. II.5.2 Cargo Volume vs Port Area

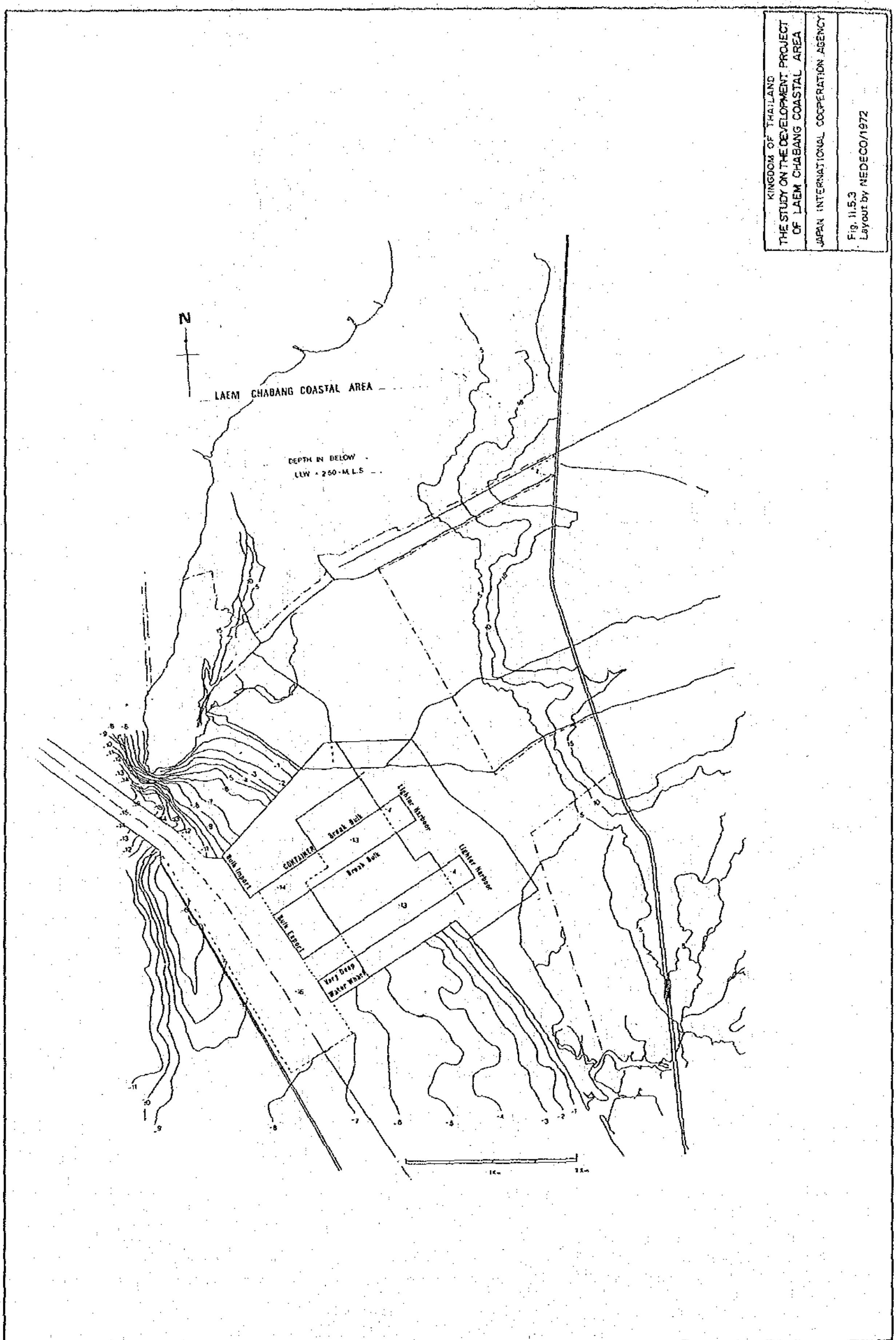
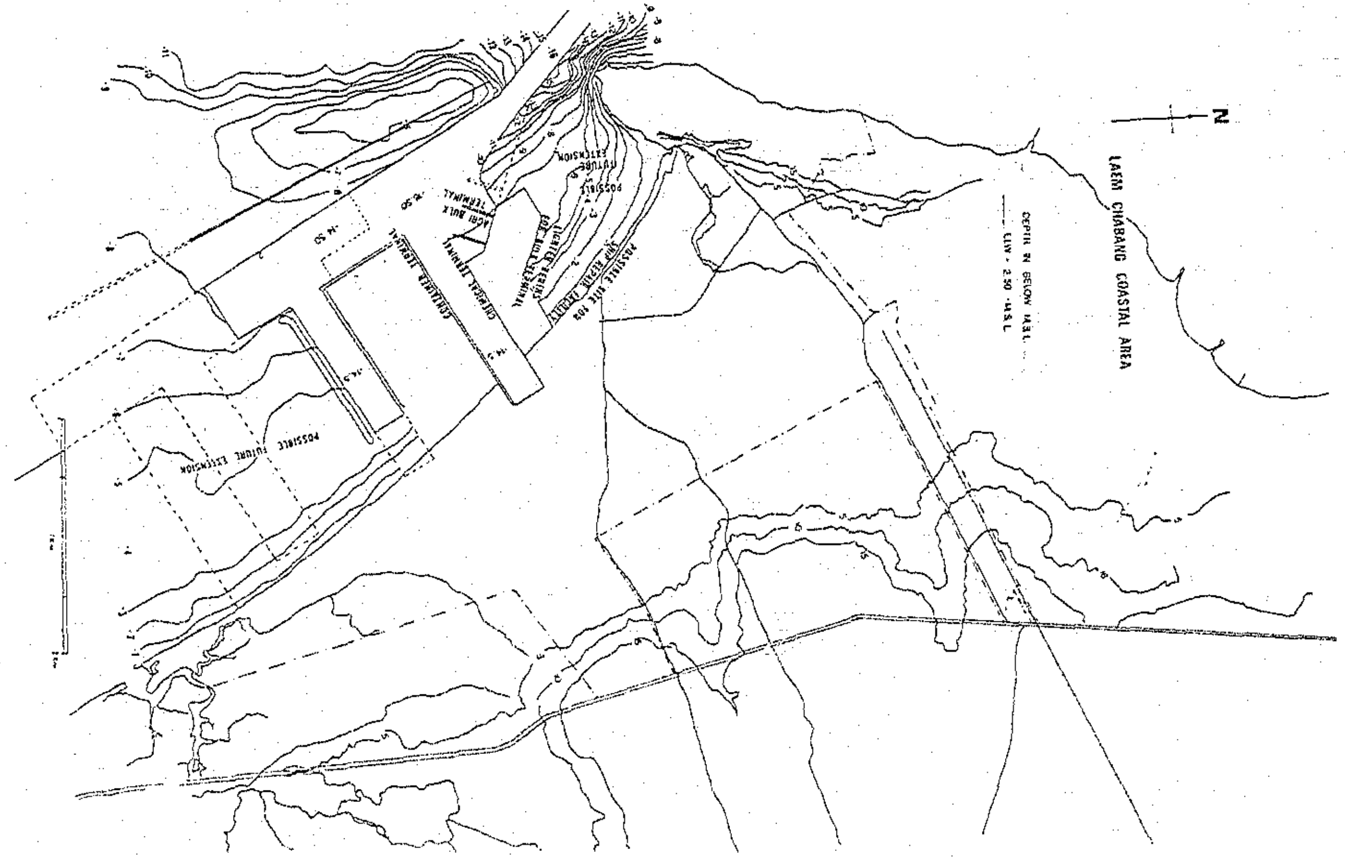


Fig. II.5.3
Layout by NEDECO/1972



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THE STUDY ON THE DEVELOPMENT PROJECT OF LAEM CHABANG COASTAL AREA

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. II.5.4
Layout by NEDECO/1978

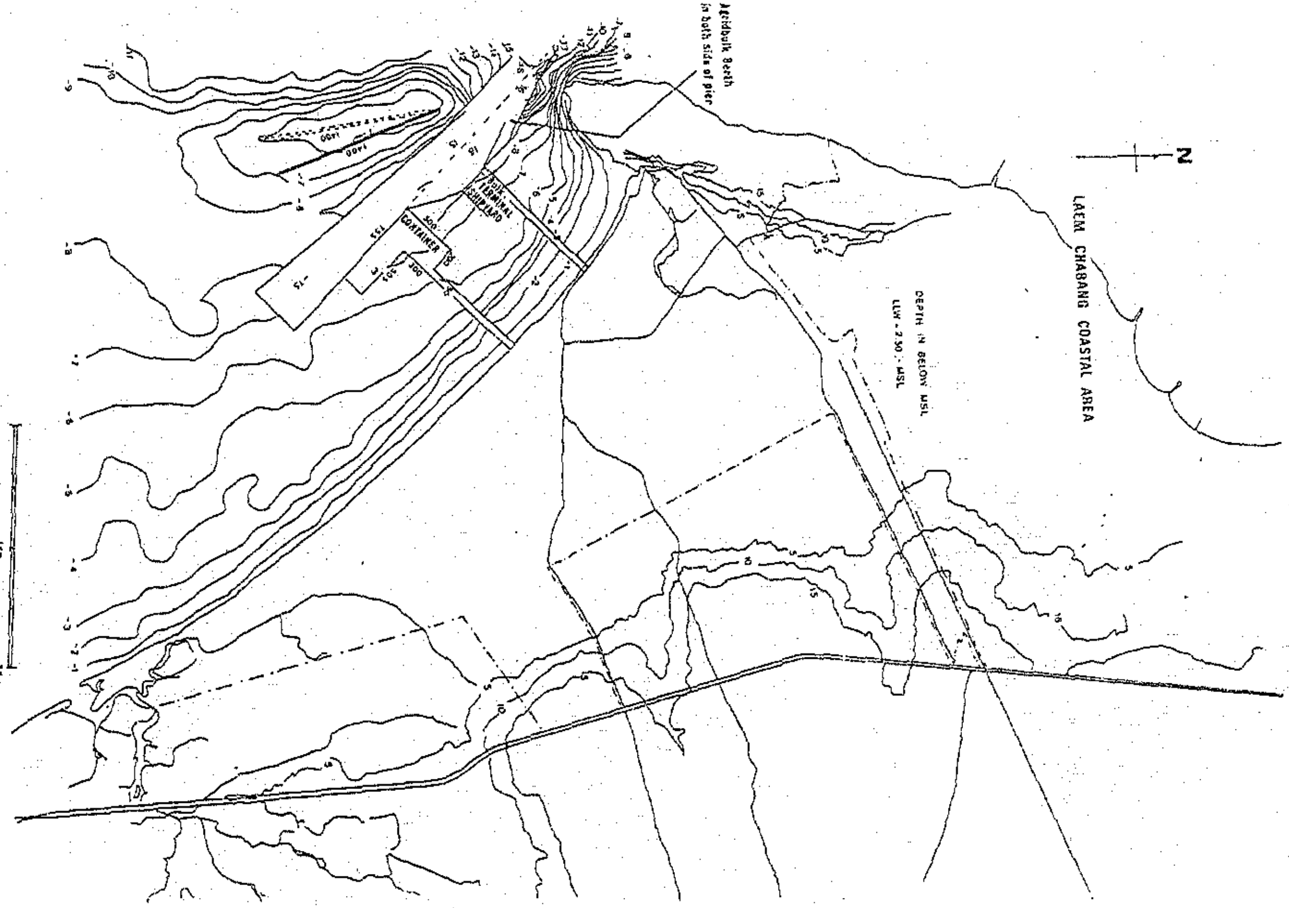

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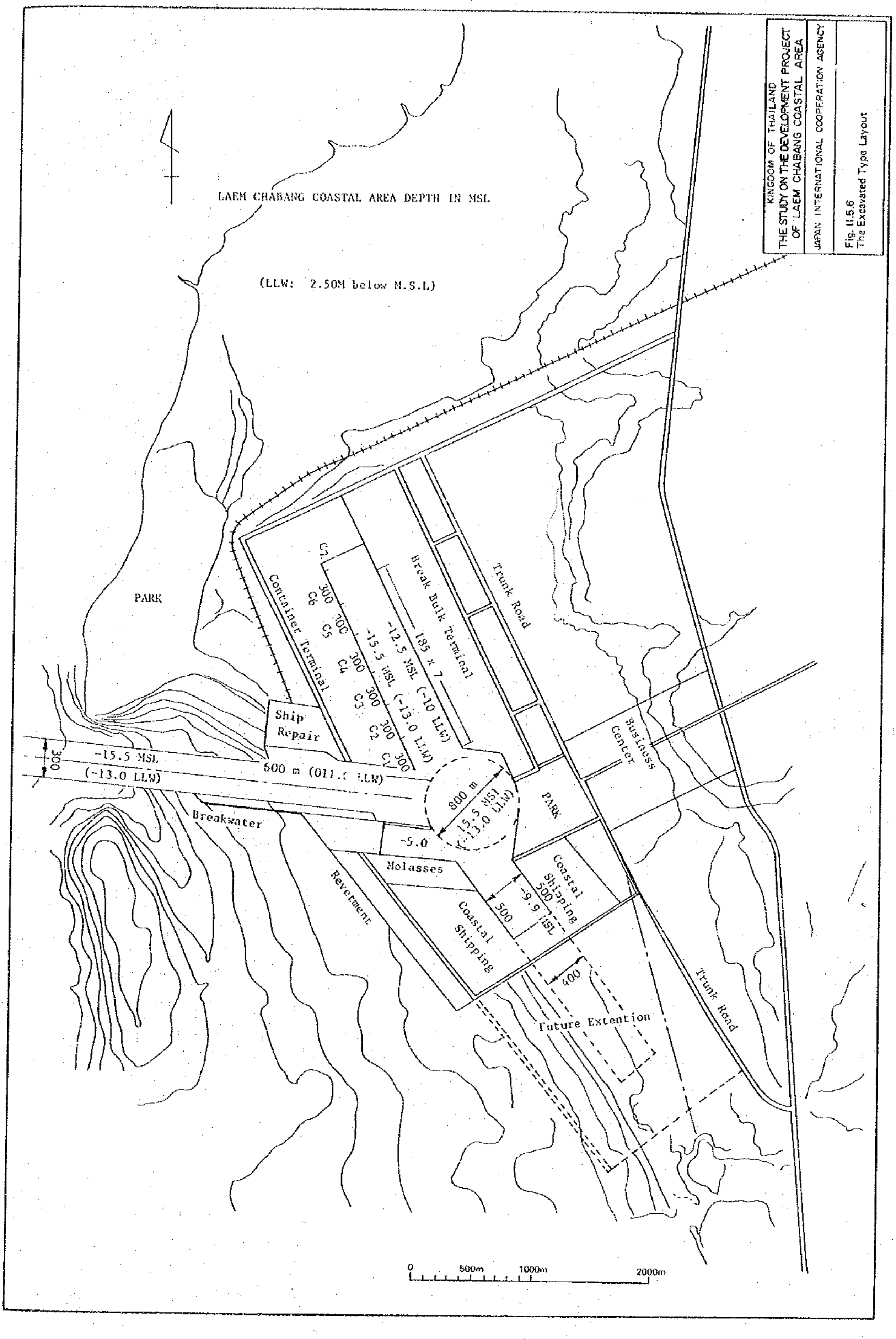
Fig. II.5.5
Layout by Louisberger 1983



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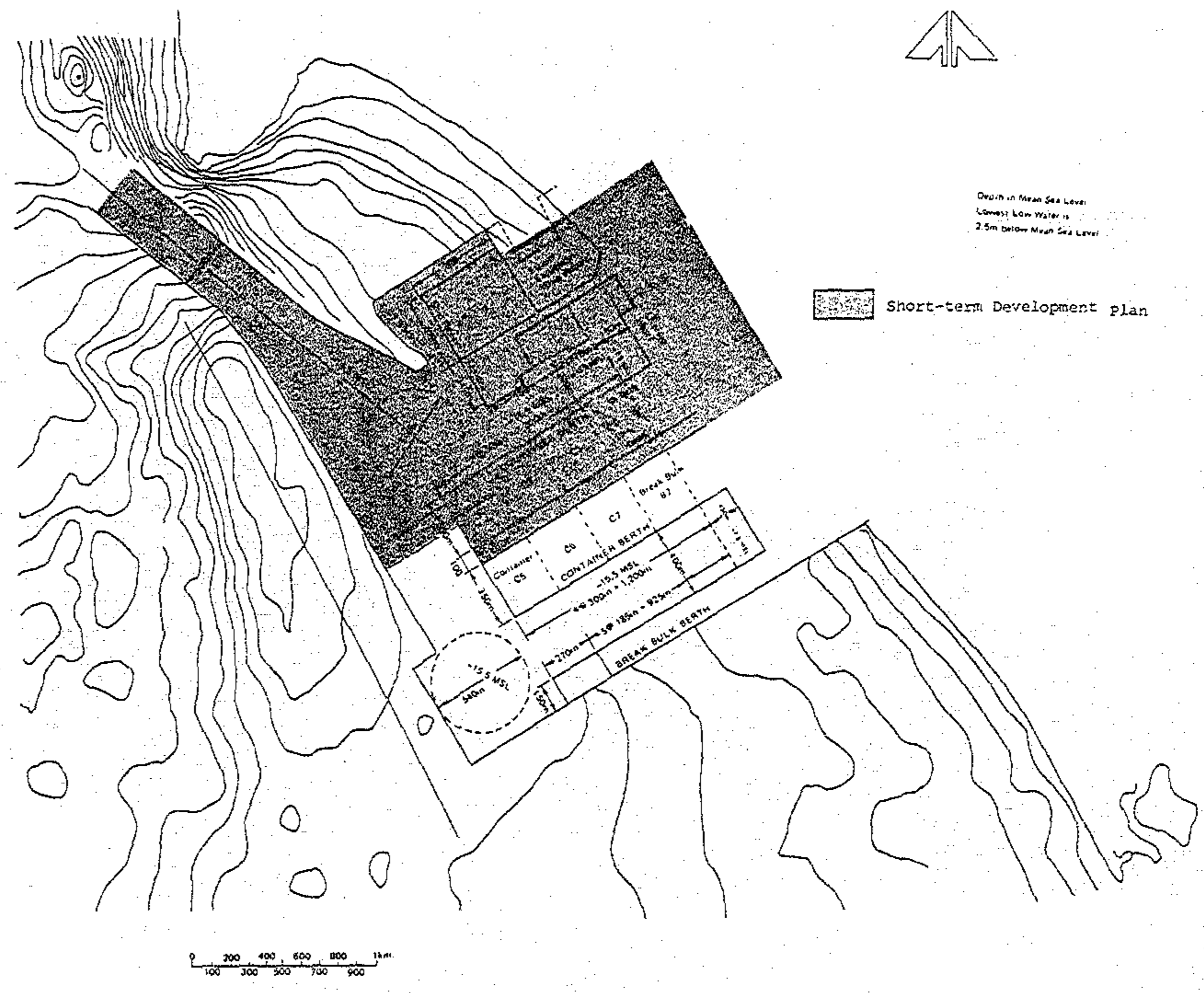
THE STUDY ON THE DEVELOPMENT PROJECT OF LAEM CHABANG COASTAL AREA
JAPAN INTERNATIONAL COOPERATION AGENCY
Fig. II.5.6
The Excavated Type Layout



See Fig.II.5.9

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THE STUDY ON THE DEVELOPMENT PROJECT OF LAEM CHABANG COASTAL AREA

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Fig. II.5.7
Master Plan (Pier Type)

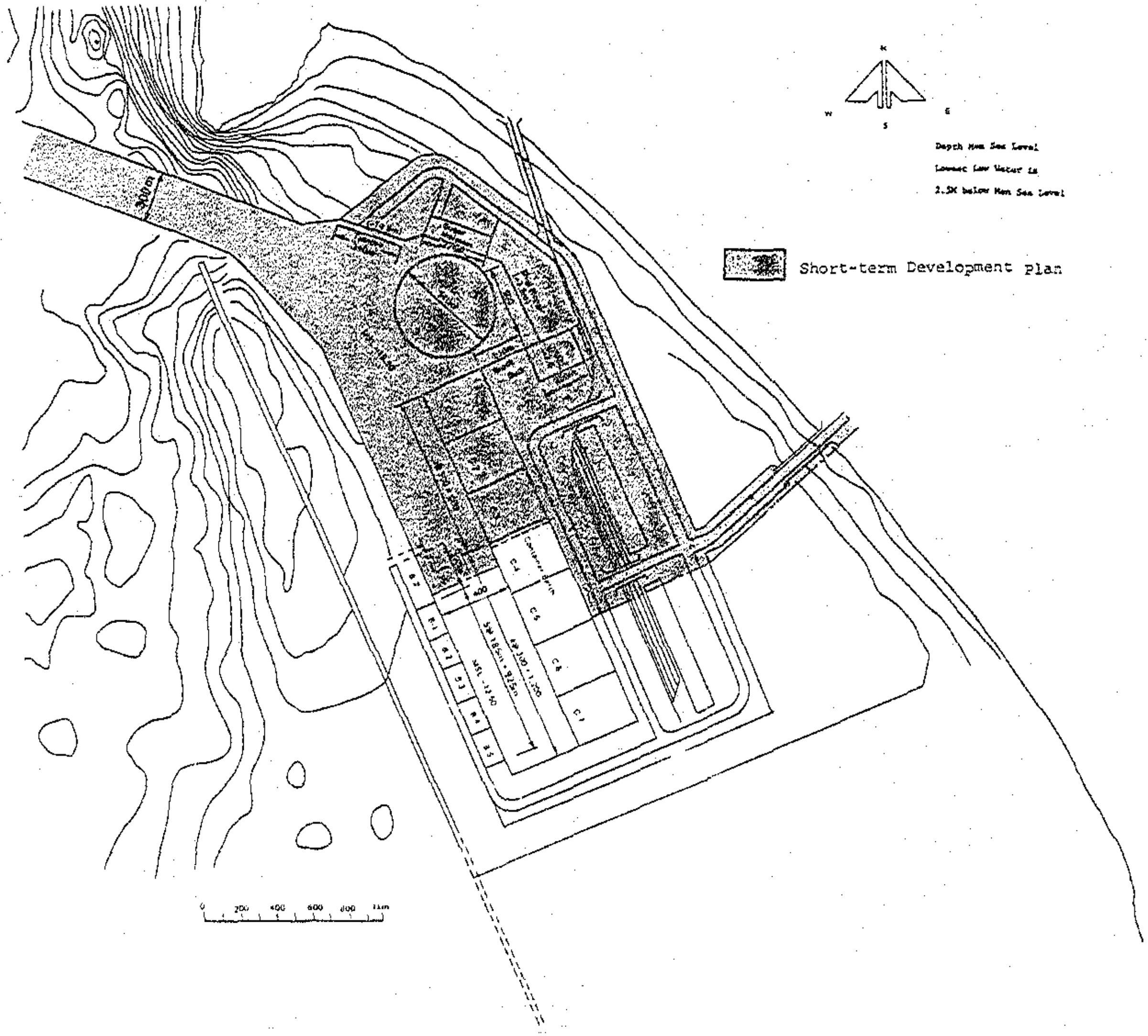

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Fig. II.5.8
Master Plan (Island Type)

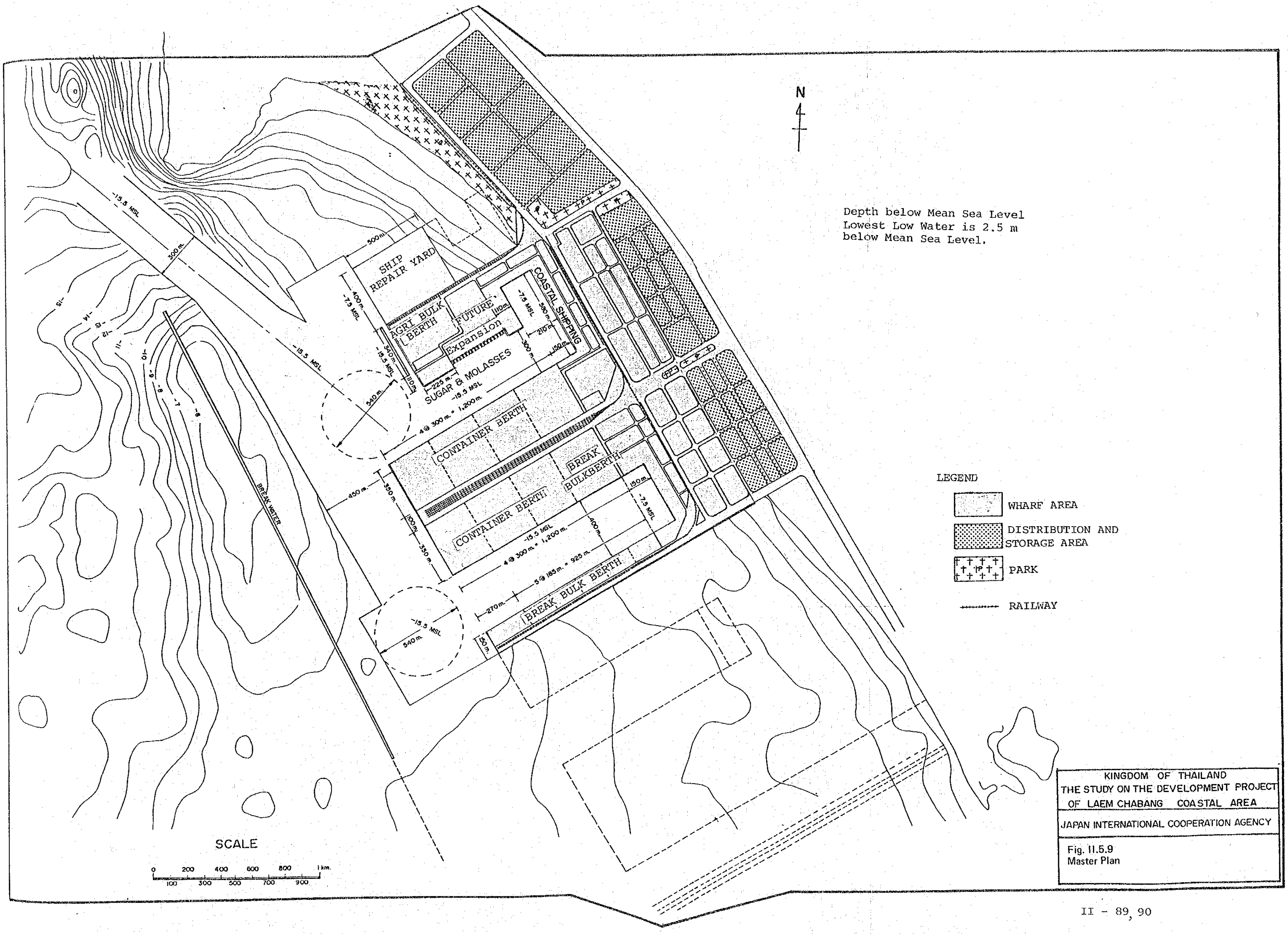

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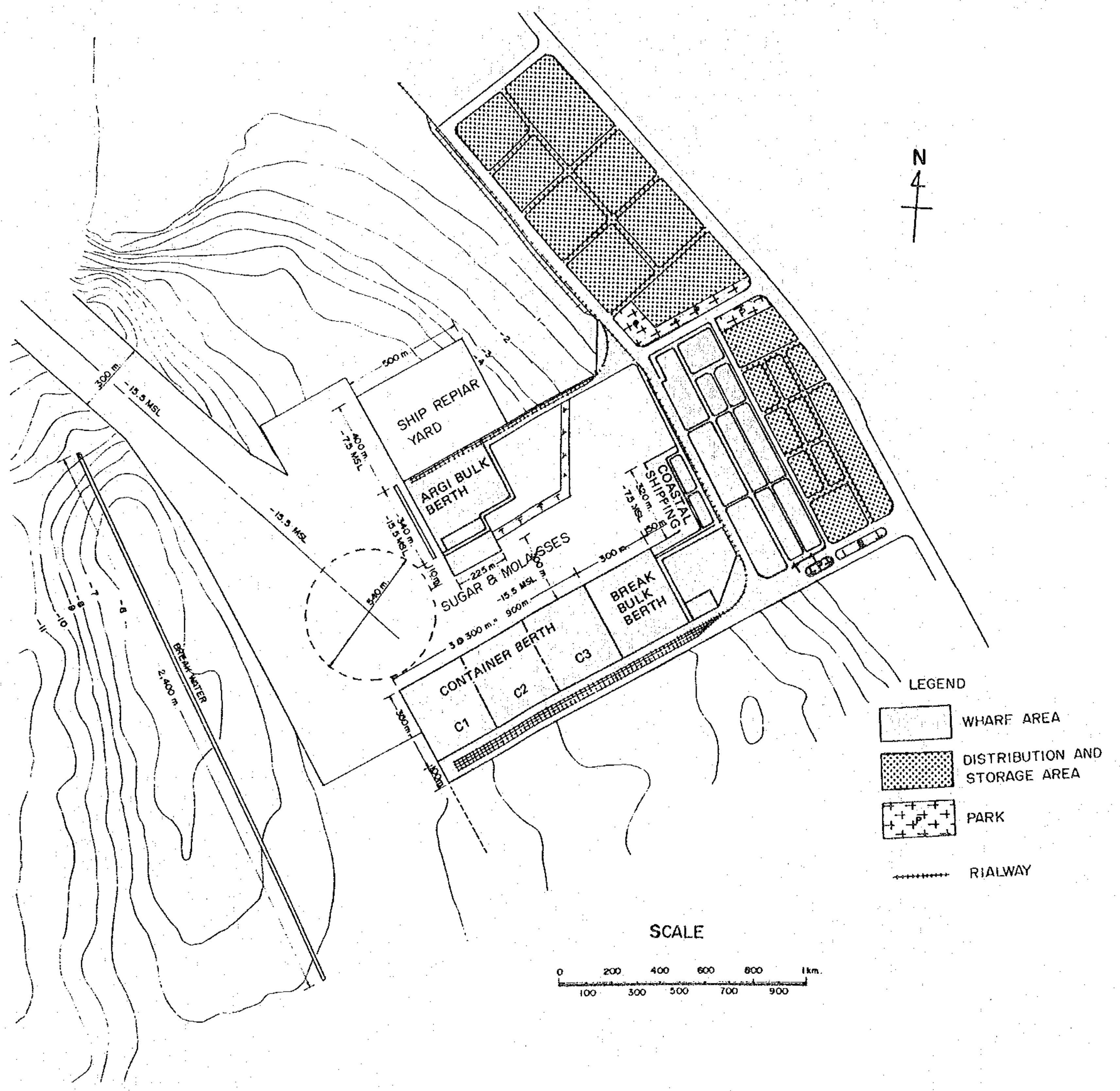
Fig. II.5.9
Master Plan



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THE STUDY ON THE DEVELOPMENT PROJECT OF LAEM CHABANG COASTAL AREA

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Fig. II.5.10
Short Term Development Plan

6. DESIGN OF PORT FACILITIES

6.1 Design Conditions

6.1.1 Design Criteria

The results of the previous surveys on marine, meteorological and geological conditions at Laem Chabang Site are included in the 1972 NEDECO Report. The Study Team carefully reviewed and studied the report and has concluded that most of them are trustworthy and good enough to use for designing the facilities for the deep-sea port of Laem Chabang.

The following is a summary of design conditions, mostly derived from NEDECO's report and supplemented by the experience in Japan.

Tide level	:	H.H.W. = MSL + 1.75 m	
		L.L.W. = MSL - 2.25 m	
Design wave height	:	Direction W - SW	
		H = 2.3 m	
		T = 6.0 sec	
Seismic coefficient	:	Null	
Ship size	:	Tapioca	142,000 DWT
		Sugar/Molasses	25,000 DWT
		General cargo	15,000 DWT
		"	40,000 DWT
		Container	33,000 DWT

Maximum draught :

MSL-15.5 m for tapioca, container and general cargo (40,000 DWT)
MSL-14.5 m for sugar and molasses
MSL-12.5 m for general cargo (15,000 DWT)

Top of apron : MSL + 3.0 m

Surcharge load on quay;

4 t/m^2 for container
3 t/m^2 for carriers except container

Berthing velocity :

0.15 m/sec for 15,000 DWT general cargo and sugar/molasses carrier

0.10 m/sec for container and 40,000 DWT general cargo

6.1.2 Marine Conditions

Meteorological conditions at Laem Cabang are not particularly serious or austere, as the proposed port site is situated along the inner part of the Bay of Bangkok. The shallow depth and small width of this bay gives natural and ideal shelter to the proposed port area protecting it against the direct influences of the ocean.

1) Tide Level

After studying NEDECO's report, it was judged that the following two tide levels are reasonable for use in designing the port facilities:

H.H.W = MSL + 1.75 m (frequency: once in 5 years)

L.L.W = MSL - 2.25 m (frequency: once a year)

Besides, a lower level (LLW = MSL - 2.50) is taken into account in the stability calculations for the various facilities and this is expected to occur once ten years.

2) Current

The monthly average current velocities are about 0.4 m/sec in March and September and about 0.5 m/sec during July through December. The tidal current velocities may occasionally reach 0.7 m/sec during June, November, December and January.

3) Wind

The climate is of the northern hemisphere monsoon type: The winds blow from north, north-east and east during November through February and from east, south-east and south during March, April and May. Highly changeable south-west winds blow during May through September.

The winds are generally weak (monthly averages are from 1 to 4 m/sec and the daily maximum is 3 to 4 m/sec).

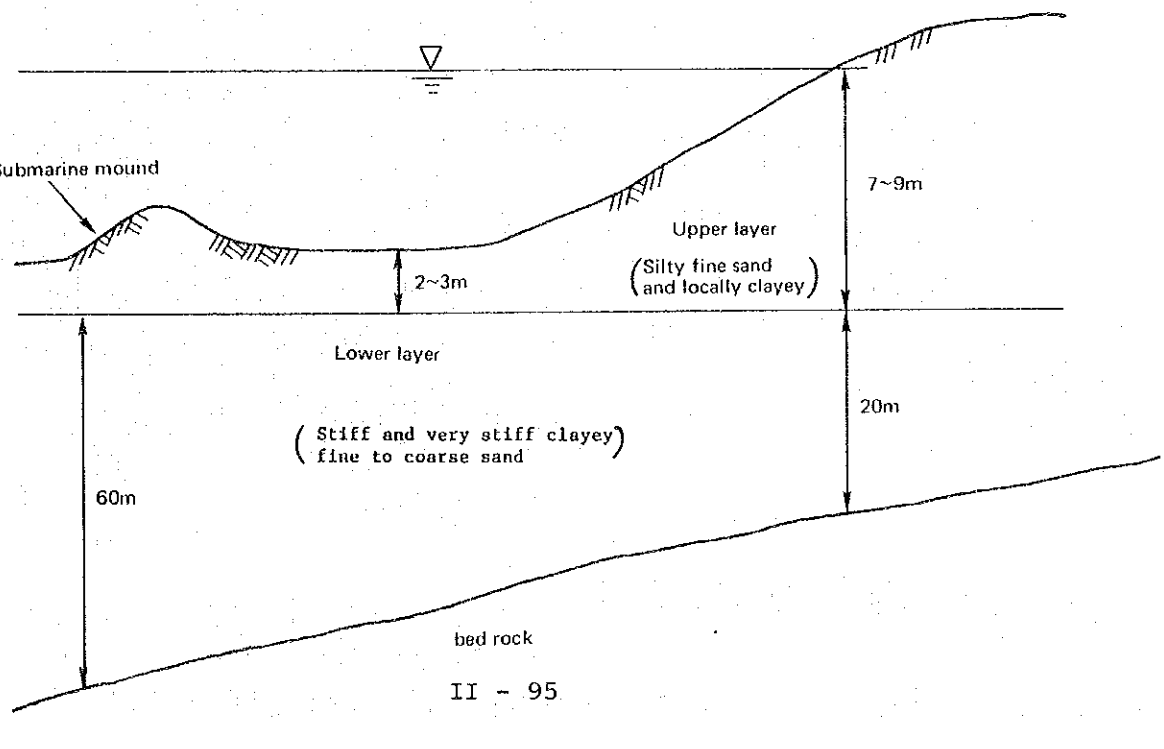
4) Waves

The waves at the site are observed not to be high. The following are the major factors affecting the fact:

- Most of the waves are generated by local winds in the Bay of Bangkok.
- Typhoons or tropical storms get weaker and lose their force on their way to central Thailand after passing over the mainland and ranges in the Indo - China countries.
- The shallow depth of the Bay prevents swells from coming as far as the Laem Chabang area.
- The islands such as Kosi Chang off the coast of Laem Chabang give natural protection to the new port site shielding it from the S.W. and N.W. waves.

6.1.3 Subsoil Conditions

Most of the port facilities will be built on or in the following strata.



The two layers illustrated above have the characteristics listed below:

(1) Upper layer

- the thickness, depth and composition of the sediment, vary
- the sediment composition ranges from soft clay to fine to coarse sand with shell fragments

(2) Lower layer

- weathered rock consisting of slightly clayey to clayey fine to coarse sand with local gravel
- strongest weathering in the top part of the layer
- unweathered rock exists 20 meters below the sea-level of ground level

According to the NEDECO's Report (1972), there exists soft silty clay just between the Cape of Laem Chabang and the offshore sand bank. This type of soil is quite unsuitable for filling purposes, because it has very weak shear strength after filling it to the reclamation area in unconsolidated area. Therefore designers and engineers will have to take account of how to deal with this poor material in the stage of the detailed engineering.

Some additional soil investigations will be needed before the commencement of the detailed design. And the results may be, more or less, different from those shown in the NEDECO's report. So designers and engineers will have to check and review carefully the two results to prepare a reasonable detailed design.

6.2 Study of the Main Facilities

6.2.1 Berthing Structures

In deciding the type of berthing structures both in the master plan and in the short term development plan, the following conditions/restrictions should be carefully considered:

(1) Soil conditions and the water depth

(2) Influence of waves

(3) Shipsize, types of vessels and cargo types

(4) Construction method, cost, and schedule

Considering natural conditions and the layout of port facilities, the following types of berthing structures will be studied for comparison in this section. (Refer to Comparison of Berthing Structures)

(1) Pile jetty

(2) Pile jetty & L-shaped bulkhead

(3) Sheet pipe pile type

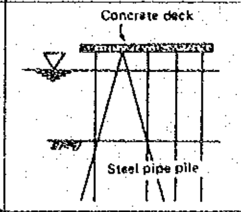
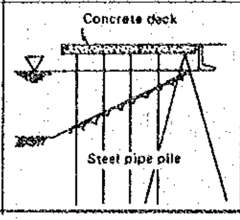
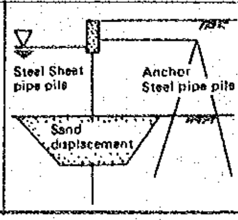
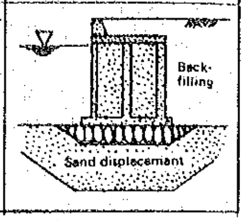
(4) Gravity type

The sheet pipe pile type costs a lot and has bad effects on wave reflection. This type requires backfilling work as soon as possible after the anchor plate (foundation) is completed and the high-strength steel tie-rods are properly arranged and set. Because the bulkhead of sheet piles is very unstable or vulnerable during construction work and, therefore, is easily broken by highwaves before backfilling is completed.

When the subsoil is poor, sheet pile quaywalls with a relieving platform are desirable. But this type of quaywall needs complex construction processes and, therefore, requires a considerably long period of construction work.

As for wave reflection, both the pile jetty and pile jetty & L-shaped bulkhead are superior when compared with other two types, sheet pipe pile type and gravity type.

Comparison of Berthing Structures

Type of wharf	Pile Jetty + L-shaped Bulkhead	Pile type	Sheet pipe pile type	Gravity type (Caisson)
Conceptual figure				

Considering reliable subsoil conditions, the Study Team has adopted the following types of structures.

- Gravity type for the container, break bulk and sugar/molasses wharves
- Pile jetty and L-shaped bulkhead for the agribulk terminal

Typical cross sections of various facilities are shown in Figs. II.6.3, II.6.4 and II.6.5.

6.3 Construction Method and Cost Estimate

6.3.1 General

The construction method and cost estimate in this study are prepared on the following considerations. In construction planning, construction materials, equipment and labors are supposed to be produred in Laem Chabang and Bangkok as much as possible in order to achieve an economical construction cost and to ensure efficiency in the implementation of the construction program.

1) Natural Conditions

A port's construction schedule and cost are affected by natural conditions such as rainfall and the sea conditions at the site. In the case of the Bay of Bangkok, the natural conditions are favorable for port construction work throughout the year.

2) Construction Materials

Some of the construction materials, such as wood, sand, stone, cement and reinforcing bars can be procured in Laem Chabang. However, steel pipe piles, rubber fenders, bollards and some of the steel products will have to be imported from abroad because they are not produced in Thailand.

A lot of rock/stone materials will have to be used for the construction work of the breakwater, revetment, backfilling and rubble mound. Some types of rock are not good materials for the protective facilities. They are siltstones, sandstones, shales, etc. Rock of good properties must be provided for the breakwater and revetment. The materials for backfilling and rubble mound shown in Fig. II.6.4 are used just for reference and, therefore, cheaper and more durable materials should be chosen at the detailed design.

3) Construction Equipment

The onshore construction equipment, such as crawler cranes, buldozers, payloaders and dump trucks are available in Laem Chabang. Offshore equipment, such as pile driving barges, tug boats, flat barges are mobilized from Bangkok. But heavy-duty working vessels such as floating cranes and floating docks will have to be mobilized from abroad.

4) Labor Force

Most kinds of workers are easily employed in Laem Chabang. However, some of the engineers are not available in Thailand.

6.3.2 Construction Schemes for Major Items

In either case of the two port layouts, pier type and island type, almost same construction work items are included, such as dredging and reclamation, construction of breakwater and revetment, prefabricating and placing of caisson quay walls (concrete), and construction of roads and the railway, etc.

1) Detached Pier

(1) Steel pipe piles

Steel pipe piles are produced abroad as single units of the design length, and are painted with tar-epoxy having thickness of 0.3 mm in abroad.

Thickness of steel pipe pile is calculated in the following way. Out of a total span of 50 years, the cathodic protection lasts for a period of 20 years, thus as protection for the remaining 30 years, an extra thickness of about 10 mm is added to that needed for structural reasons.

(2) Pile driving

Pile driving is executed by a piling barge equipped with a diesel pile hammer of 3.2 tons in ram weight. It is assumed that three piles are driven in a day. The piling barge requires supporting equipment, such as a tug boat, a flat barge and an anchor boat.

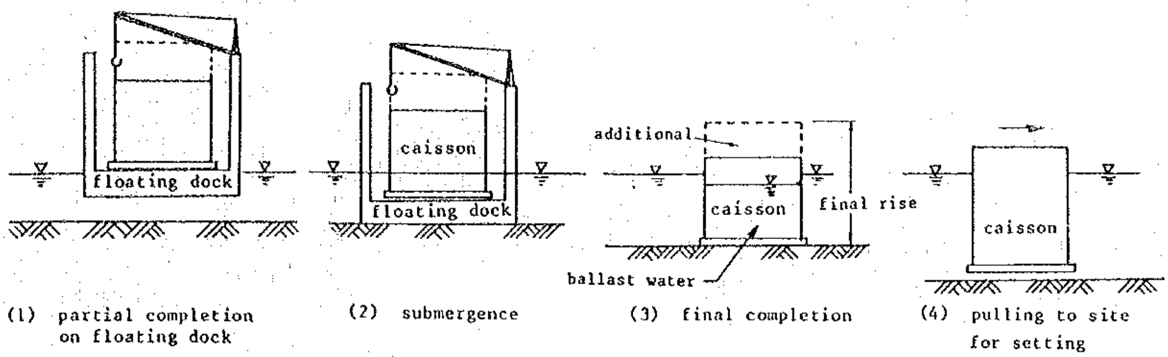
2) Caisson Construction

In this feasibility study, the Study Team suggests to use concrete caisson for some of the mooring facilities in Laem Chabang Port. A prefabricating yard/dry dock will be suitable for constructing and launching caissons. But the caissons weigh averagely 2,000 t per piece and it will be required to prepare a wide onshore construction yard with a heavily founded basement or slipway. Besides, extra dredging works have to be called for to launch caissons from the prefabricating yard into water. Therefore, these construction methods will involve considerable investments if they plan to build the structures in the above-mentioned ways.

The Study Team wants to suggest to make the best use of a floating dock/a temporarily built dry dock, which will probably minimize the equipment investment cost necessary for prefabricating caissons.

Caissons will be partly completed on a floating dock or in a temporary dry dock and they will be submerged for final completion height.

Following shows the conceptual procedures of caisson construction using a floating dock.



3) Dredging

The dredging wi-l be executed by crawler crane with a backet, mounted on a flat barge. Dredged materials will be dumped by hopper barges outside the Bay.

4) Buildings

Buildings will be built in the backup area. These are of steel frame structures and reinforced structures.

5) Roads

Roads will be newly constructed and the existing parts widened. The road will be paved by concrete with a thickness of 25 cm over a base course 30 cm in thickness.

6.3.3 Construction Schedule

The detailed construction schedule is shown in Table II.6.1. In this schedule, the additional soil investigations and detailed design will be concluded within the first months of following which the tender, evaluation, and award will be executed by the end of the year.

Actual construction work will commence at the beginning of 1986, and will be concluded in 24 months.

6.4 Cost Estimate

The construction cost estimate is given in the following breakdown table by individual items. This estimate includes direct/indirect costs, engineering service fee and physical contingency.

The cost estimate was made under the following conditions.

(1) Price is expressed in Baht as of Aug. 1984.

(2) Duties for imported construction materials, equipment and plants are not included in the cost.

(3) Engineering service fee includes the cost for natural condition surveys (meteorological, geological, etc.), the detailed engineering study and supervision.

(4) Twenty percent of the total cost is applied as physical contingencies.

(5) The scope of cost estimate is shown in the Fig. II.6.6. The cost estimate includes the construction cost of such infrastructures as wave protective facilities, mooring facilities, road, pavement, rail track, etc. The relocation cost of the fishermen's village at Laem Chabang is not included in this cost estimate.

(6) Cost impact caused by inflation is not included.

Construction cost for the long-term is summarized as follows and its breakdown is shown, in Table II.6.2 through II.6.3.

(in million Baht)

Item	Total
1. Public Facilities and Wharves	11,725
2. Private Facilities and Wharves	1,325
a. Agribulk Wharf	725
b. Sugar and Molasses Wharf	334
c. Ship Repair Yard	266
Total	13,050