3.4 Development Schedule and Cost Estimate

3.4.1 Development Schedule

(1) Development Steps

55. System development proceeds through the steps shown in Fig. II.3.11 and embodies the system in minute detail from the conceptual stage. This study is limited to give the basic design of the information system for the container handling through Laem Chabang Port and the ICD, with computerized operation activities, sub-system profile, and file profile, etc. After the basic design, further design should be carried out to develop a practical system.

56. Those designs consist of 1) output design, 2) input design, 3) file design, 4) master code design, and 5) process design. Based upon the detailed design, programs are prepared, and then the programs are tested from the points of both whether or not each one works as a single program and whether or not all the programs work altogether in proper relation. Finally the system is installed.

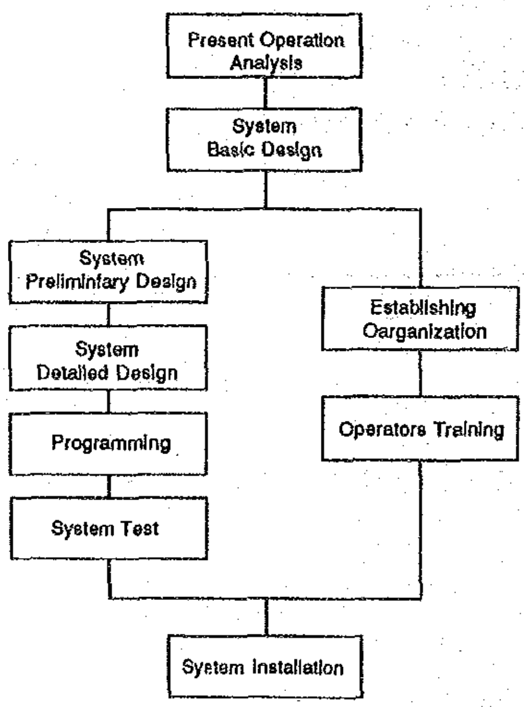


Fig. II.3.11 System Development Steps

(2) Development Schedule

57. The system development schedule of the ICD information system is as shown in Fig. II.3.12 considering the development steps mentioned above and that the period from the time of the lease contract between lessor and lessee to the starting time of the ICD operation is considered to be about one year.

58. The preliminary design needs at least two system engineers for four months, the detailed design a system engineer for three months, with a computer worker from the lessee as an assistant. The lessee's staff not only assists but also takes "on-the-job training," and is expected to become a system engineer for the system. Then he will be able to manage the whole system afterward.

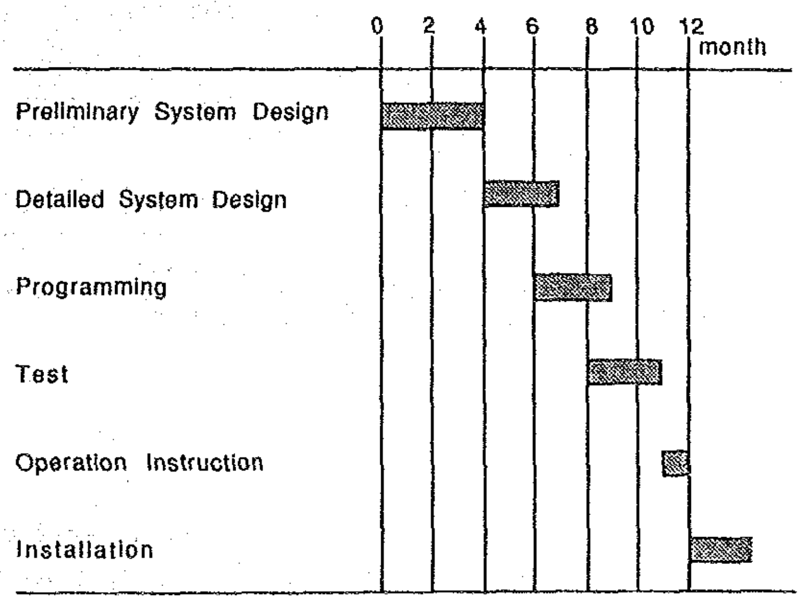


Fig. II.3.12 System Development Schedule

3.4.2 Cost Estimate

(1) The Computer Information System of the Marine Terminal and the ICD

59. From the system configuration in 3.3.2 (5), the cost for the system includes 1) hardware, 2) software, and 3) communication leased line, and is estimated in Table II.3.6. Application software development cost is estimated in Table II.3.5.

Table II.3.5 Application Development Cost Estimate

Development Step	Man-month		Total Cost (Baht)	Remarks
	System Engineer (50,000 ฿/m)	Programmer (40,000 ฿/m)		
Preliminary Design	8	-	400,000	2 SEs x 4 months
Detailed Design	3	-	150,000	1 SE x 3 months
Programming	-	24	960,000	8 PR x 3 months
Total			1,510,000	

Note : SE Stands for System engineer; PR Programmer

(2) Port Management Body

60. As mentioned in Section 3.2, a personal computer is sufficient for the P.M.B. operation. Each of the P.M.B. offices at Laem Chabang Port and the ICD are to set up a personal computer and a printer for their internal works. The cost for the personal computers and printers is shown in Table II.3.6.

Table II.3.6 Cost Estimate

Item	Unit	Unit Price (Baht)	Quant.	Amount (Baht) (A)	Ope/Main Cost (B/month) (A) x 0.3 %	Lease cost (B/month) (A) x 2.5 %
A. LCB Marine Terminal						
1. Hardware						
- Host (Mainframe)	Set	1,964,000	1	1,964,000	9,800	49,100
- Disk Unit	each	473,000	2	946,000	4,700	23,700
- MT Unit (system)	each	1,170,000	1	1,170,000	5,900	29,300
- MT rack	each	119,000	2	238,000	1,200	6,000
- FDD Unit	each	149,000	2	298,000	1,500	7,500
- Workstation (Display & Keyboard)	each	59,000	14	826,000	4,100	20,700
- Printer (host)	each	356,000	1	356,000	1,100	8,900
- Printer (workstation)	each	147,000	14	2,058,000	6,200	51,500
- Modem	each	29,000	1	29,000	100	700
- Sub-total				7,885,000	34,600	197,400
2. Software (Basic Software)	L.S	1,109,000	1	1,109,000	-	27,700
3. Application Software	L.S	1,510,000	1	1,510,000	-	-
Total (1 + 2 + 3)				10,504,000	34,600	225,100
B. ICD						
- Workstation	each	59,000	8	472,000	1,400	11,800
- Printer	each	147,000	8	1,176,000	3,500	29,400
- Modem	each	29,000	1	29,000	100	700
- Total				1,677,000	5,000	41,900
C. Leased Line Charge	line		1	-	24,000	24,000
D. Grand Total (A + B + C)				12,181,000	63,600	291,000
E. P.M.B.						
- Personal Computer	each	150,000	2	300,000	900	7,500
- Printer	each	147,000	2	294,000	900	7,400
Total				594,000	1,800	14,900

PART III INLAND CONTAINER DEPOT PLAN

CHAPTER 1 CARGO FORECAST

1.1 Socioeconomic Framework

1.1.1 National Economic and Social Development Plan

(1) Results of the Fifth Plan

1. Table III.1.1 shows the results of the main economic indicators during the fifth plan. The average economic growth was 4.4% per year, which was below the target of 6.6%. This was caused by low world economic growth, low growth of international trade, trade barriers, high real interest rates and falling prices for agricultural commodities.

(2) Sixth National Economic and Social Development Plan

2. In view of the problems and limitations on the one hand and the development opportunities in Thailand in the near future on the other, the Sixth Plan defines its major objectives as follows:

Economic: To maintain an average rate of growth at a level not below 5% in order to absorb the minimum of 3.9 million persons who will be entering the labour market. Growth should be accomplished in such a way that economic stability is strengthened and the economic problems that arose during the Fifth Plan period are solved.

Social: To develop the quality of life so that social development can progress, peace and justice be attained and development of the country as a whole supported. The national identity, culture and system of values will be maintained and the quality of life of the Thai people will be raised in both rural and urban areas.

3. Table III.1.2 shows the overall economic targets in the Sixth Plan.

Table III.1.1 Results of Main Economic Indicators During the Fifth Plan

	Fourth Plan (average) 1977–1981	1982	1983	1984	1985	1986	Fifth Plan trend (average)	Fifth Plan target (average)
1. Economic growth rate	7.1	4.1	5.8	5.6	3.2	3.5	4.4	6.6
(% per annum)								
- Agriculture	3.5	1.0	3.8	3.3	3.2	- 0.7	2.1	4.1
- Non-agriculture	8.5	5.2	6.5	6.3	3.2	4.7	5.2	-
- Industry	8.7	4.4	7.3	6.3	0.8	6.7	5.1	7.6
- Mining	10.1	- 4.2	- 0.4	22.7	10.8	1.4	6.1	16.5
- Natural gas/crude oil	-	328.8	45.1	56.4	53.7	2.6	97.3	-
- Electricity and water	11.7	6.7	8.8	10.1	10.2	6.9	8.5	-
- Construction	9.5	- 2.6	5.5	11.0	0.6	0.7	3.0	-
- Services	8.2	6.5	6.3	5.3	4.0	4.3	5.3	-
2. Growth rate								
(% per annum)								
- Consumption	6.3	2.6	7.2	5.0	3.2	2.4	4.1	5.3
- Private sector	5.5	2.5	8.3	5.0	2.9	2.6	4.3	4.8
- Public sector	10.2	3.1	2.2	4.8	4.8	1.5	3.3	7.9
- Investment	10.0	- 10.8	10.7	7.4	- 3.8	- 3.2	0.1	6.4
- Private sector	8.6	- 11.1	12.8	6.0	- 9.6	- 2.0	- 0.8	6.9
- Public sector	12.9	- 10.1	6.6	10.1	7.4	- 5.2	1.8	4.9
3. Inflation								
(% per annum)								
- Consumer price index	10.6	5.3	3.7	0.9	2.4	2.1	2.9	10.6
4. Balance of trade								
- Value (billion baht)	- 45.0	- 36.1	- 89.2	- 68.8	- 61.6	- 22.5	- 55.6	78.4
-Trade balance/GNP (%)	- 7.7	- 4.3	- 9.7	- 6.9	- 5.9	- 2.0	- 5.8	5.9
5. Current account balance								
- Value (billion baht)	- 37.4	- 23.1	- 66.1	- 49.5	- 41.9	- 0.7	- 36.0	53.0
- Current account/GNP (%)	- 6.4	- 2.7	- 7.2	- 5.0	- 4.0	0.1	3.8	- 4.1
6. Export of goods								
- Value growth rate (%)	20.0	4.7	- 7.7	19.6	10.5	14.8	8.4	22.3
- Volume growth rate (%)	10.3	12.7	- 8.9	20.6	7.8	9.3	8.3	11.3
- Value (billion baht)	108.4	157.2	145.1	173.5	191.7	220.0	177.5	309.4

	Fourth Plan (average) 1977-1981	1982	1983	1984	1985	1986	Fifth Plan trend (average)	Fifth Plan target (average)
7. Import of goods								
- Value growth rate (%)	24.8	- 10.5	21.2	3.4	4.5	- 4.3	2.9	18.1
- Volume growth rate (%)	12.6	- 12.7	28.4	2.7	- 4.6	0.8	2.9	7.3
- Value (billion baht)	153.4	193.3	234.3	242.3	253.3	242.5	233.1	387.8
8. Public finance (budget year, billion baht)								
- Government revenue	78.3	114.0	137.7	149.2	163.0	166.2	146.0	-
- Government expenditure	93.6	152.2	165.1	177.4	197.5	204.6	179.4	-
- Budget balance	- 15.3	- 38.2	- 27.4	- 28.2	- 34.5	- 38.4	- 33.3	-
- Cash balance	- 12.6	- 42.4	- 25.4	- 33.5	- 30.5	- 44.7	- 35.3	-
- Revenue/GNP (%)	14.2	13.5	14.9	15.0	15.6	15.1	14.8	-
Exchange rate (baht/US$)	-	22.9	22.99	23.60	27.12	26.5	24.62	-
GNP at current prices (million baht)	-	846,136.0	924,254.0	991,559.0	1,041,920.0	1,100,215.0	980,816.8	-

Source: The Sixth National Economic and Social Development Plan (NESDB)

Table III.1.2 Overall Economic Targets in the Sixth Plan

Category	Fifth Plan Actual trends (1982-1986)	Sixth Plan Targets (1987-1991)
1. Economic growth (%/yr at constant prices)		
1.1 Agriculture	2.1	2.9
1.2 Manufacturing	5.1	6.6
1.3 Mining	6.1	6.4
1.4 Natural gas (million cu ft/day)	320 1/	720 2/
1.5 GDP	4.4	5.0
2. Population growth rate (%)	1.7 1/	1.3 2/
. Municipal districts	(2.7)	(2.5)
. Santiary districts	(2.1)	(2.4)
. Villages	(1.4)	(0.8)
3. Inflation rate (%)	2.9	2.3
4. Per capita income (baht)	21.395 1/	27.783 2/

1/ in 1986
2/ in 1991
Source: The Sixth National Economic and Social Development Plan (NESDB)

1.1.2 Future Socioeconomic Framework

4. It is necessary to estimate the future economic situation in the hinterland in order to forecast the future cargo volume.

5. Though the estimated annual growth rate of GDP in the Sixth National Economic and Social Development Plan (1986-1991) is set at 5%, the actual growth rate of GDP was 7% in 1987 and 10.5% (estimated) in 1988. Then the Study Team estimates the annual growth rate as 6.5% during the period of the Sixth Plan. And after 1991, the Study Team adopts an annual growth rate of 5% based on the forecast of per capita GDP published by the Institute of Developing Economies in Tokyo and the growth rate of population. Table III.1.3 shows the future growth rate of the GDP assumed

by the Study Team.

Table III.1.3 Future Economic Growth Rate

Unit: %/year at constant prices

	1987-1991	1992-1996	1997-2001
Economic Growth of GDP	6.5	5.0	5.0

1.2 Cargo Volume Forecast

1.2.1 Methodology

6. The target year of this study is 1996 as a first stage and 2001 as a final stage. But to analyze the situation of Bangkok Port before the operation of Laem Chabang Port starts, the container volume in 1991 is also forecast.

7. Fig. III.1.1 shows the flow chart of the cargo forecast. Based on the analysis of the present cargo volume by commodity, export and import cargo volume is estimated by each commodity group individually considering the following factors:

(Export)

a) National Development Plan
b) Industrial Estates/Parks Development Plan
c) International Trade Agreements
d) Production Forecast by the Government
e) Annual Trends in recent 5-10 years, etc.

(Import)

a) Production Forecast in Thailand
b) Future Economic Factors (Population, GDP, etc.)
c) Consumption per Capita
d) Relation between Import Volume and Export Volume
e) Annual Trends in recent 5-10 years, etc.

This method is called the micro forecast.

8. On the other hand, a macro forecast which is a method to estimate the cargo volume using the relation between economic indices and cargo volume is conducted for the purpose of checking the volume estimated by the micro forecast.

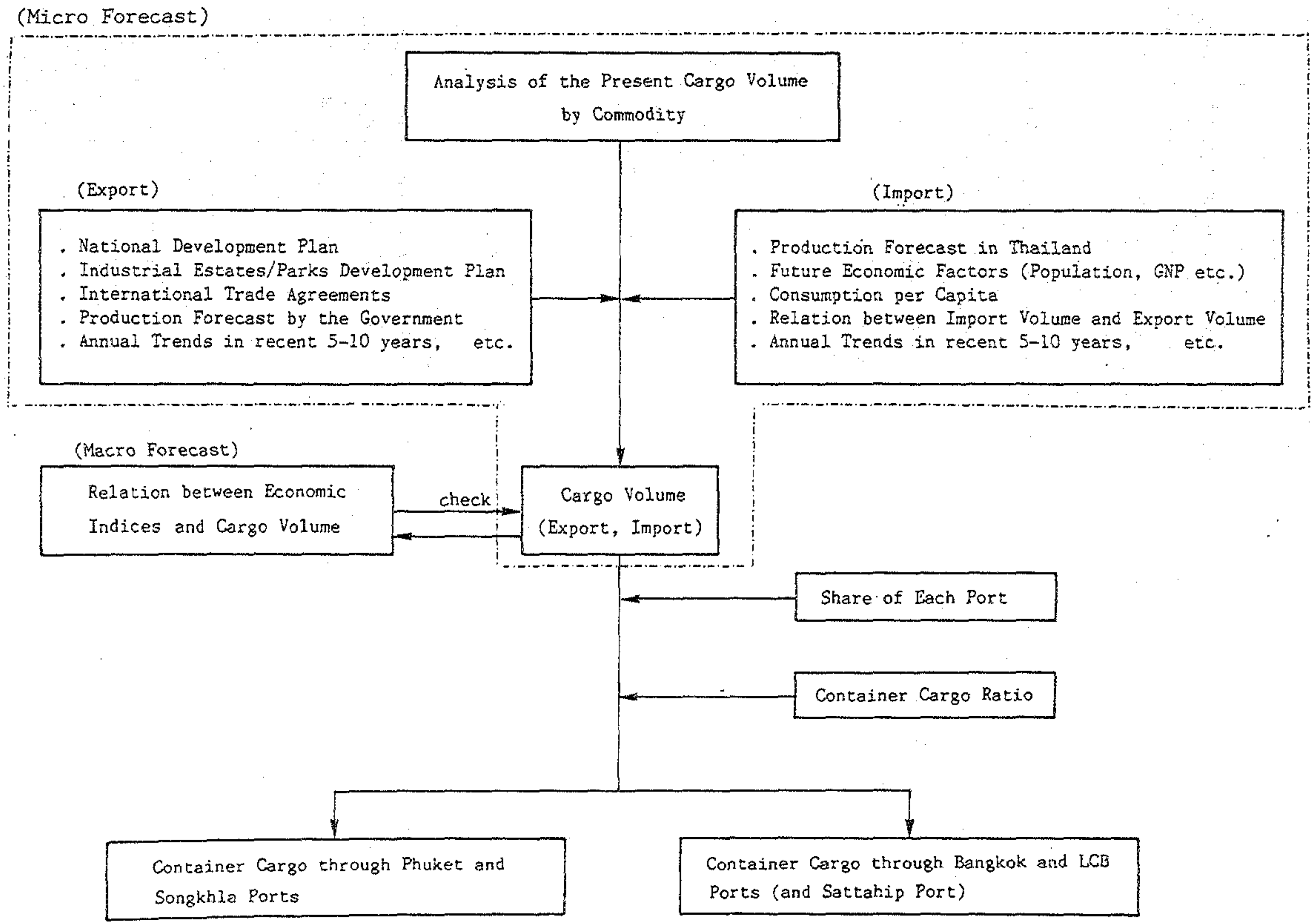


Fig. III.1.1 Flow Chart of the Cargo Forecast

1.2.2 Micro Forecast

(1) Selection of Major Commodity Groups

9. Considering the present cargo volume and trend by commodity, the study team selected the following major commodity groups for the micro forecast.

(Export)

Agricultural Products

(Rice, Maize, Tapioca, Sugar and molasses, Raw rubber, Others)

Wood Products

Marine Products

Mining Products

Industrial Products

(Import)

Iron & Steel

Chemical Products

Wood Products

Pulp and Paper

Fertilizer

Industrial Materials

Others

(2) Results of Micro Forecast

10. The micro forecast is conducted by the method explained above. The detailed process is described in Appendix 5. The results of the micro forecast, showing export and import cargo volumes by major commodity groups, are shown in Table III.1.4 and Table III.1.5.

Table III.1.4 Forecast by Major Commodity Groups (Export)

Unit: 1,000 tons

	1991	1996	2001
1. Agricultural Products	19,616	20,579	21,553
Rice	(4,210)	(4,600)	(5,010)
Maize	(3,660)	(3,920)	(4,210)
Tapioca	(6,550)	(6,550)	(6,550)
Sugar	(2,200)	(2,200)	(2,200)
Molasses	(830)	(830)	(830)
Raw rubber	(1,010)	(1,170)	(1,280)
Others	(1,156)	(1,309)	(1,473)
2. Wood Products	160	160	160
3. Marine Products	330	440	550
4. Mining Products	3,440	3,800	4,300
5. Industrial Products	5,720	8,260	10,140
Total	29,266	33,239	36,703

Table III.1.5 Forecast by Major Commodity Groups (Import)

Unit: 1,000 tons

	1991	1996	2001
1. Iron & Steel	3,150	4,070	5,130
2. Chemical Products	2,390	3,330	4,310
3. Wood Products	520	520	520
4. Pulp and Paper	700	910	1,090
5. Fertilizer	1,880	2,390	2,960
6. Industrial Materials	1,460	2,245	2,820
7. Others	1,920	2,050	2,180
Total	12,020	15,515	19,010

Note: Excluding imports of fuel oil and ships.

1.2.3 Check by Macro Forecast

11. The cargo volume estimated by the micro forecast should be checked by the macro forecast. But indicators linked to the export volume of agricultural products, wood products, marine products and mining products can not be identified because those volumes are limited by trade agreements and other factors. So the macro forecast is conducted only for the exports of industrial products and imports.

(1) Future GDP

12. The future GDP is estimated using the future growth rate of GDP set in 1.1 of this Chapter. On the other hand, the percentage of manufacturing in total GDP in 1991 is estimated as 26.4% using the target growth rate of total and sectoral GDP of manufacturing in the Sixth Plan (5% and 6.6% respectively).

13. However, considering the shift from secondary industry to tertiary industry such as the service sector, the share of manufacturing is assumed not to increase after 1991. Therefore, in this study, it is assumed that the percentage of manufacturing will not change after 1991. Table III.1.6 shows the past and estimated future GDP.

Table III.1.6 Past and Future GDP (at 1972 Prices)

Unit: Million Baht

Year	GDP	GDP of Manufacturing
1983	352,702	85,780 (24.3%)
1984	385,538	91,603 (23.8%)
1985	397,944	92,489 (23.2%)
1986	412,458	100,817 (24.4%)
1987 E	441,698	110,748 (25.1%)
1991	565,000	149,000 (26.4%)
1996	721,000	190,000 (26.4%)
2001	920,000	243,000 (26.4%)

E = Estimates
Source: Past GDP --- NESDB
Note : Future GDP is estimated by the study team

(2) Correlation between Cargo Volume and GDP

14. The correlation between cargo volume and GDP for 1983 through 1987 can be expressed by the following equations.

(Export volume of industrial products and GDP of manufacturing)

$V = -3{,}938.8 + 0.0634\ G \qquad (r = 0.993)$

V : Export volume of industrial products (1,000 tons)

G : GDP of manufacturing (Million Baht)

(Import volume and GDP)

$V = -564.6 + 0.0226\ G \qquad (r = 0.941)$

V : Import volume (1,000 tons)

G : GDP (Million Baht)

(3) Results of the Forecast

15. The results of the macro forecast are summarized in Table III.1.7. The export volume of industrial products in 1991 and 1996 and the import volume in each year are similar to the results of the micro forecast.

16. However, the export volume of industrial products in 2001 under the macro forecast is a little larger than under the micro forecast. This difference may come from the structural change of manufacturing in Thailand. This means that the correlation between the export volume of industrial products and the GDP of the manufacturing sector is changing due to the shift from low value-added to high value-added products. So the study team accepts the micro forecast as correct.

Table III.1.7 Results of the Macro Forecast

Unit: 1,000 tons

		Macro Forecast	(Micro Forecast)
Export Volume of Industrial Products	1991	5,510	(5,720)
	1996	8,110	(8,260)
	2001	11,470	(10,140)
Import Volume	1991	12,190	(12,020)
	1996	15,710	(15,515)
	2001	20,200	(19,010)

1.2.4 Container Cargo Forecast

(1) Share of Each Port

17. Before executing the forecast of the container cargo by each port, it is necessary to divide the total national cargo among the ports.

1) Bangkok Zone

18. Based on the actual share of the Bangkok Port against the national total and the future production forecast, the future share of the Bangkok Zone (Bangkok, Laem Chabang and Sattahip Port) is estimated as shown in Table III.1.8.

Table III.1.8 Share of the Bangkok Zone

(Bangkok Zone = Bangkok + Laem Chabang + Sattahip)

	1991	1996	2001
(Export)			
Agricultural Products			
Rice	99 %	99 %	99 %
Maize	90	90	90
Tapioca	100	100	100
Sugar and Molasses	100	100	100
Raw rubber	8	11	14
Others	90	90	90
Wood Products	60	60	60
Marine Products	60	60	60
Mining Products	31	29	28
Industrial Products	92	92	92
(Import)			
Iron & Steel	100 %	100 %	100 %
Chemical Products	91	91	91
Wood Products	70	70	70
Pulp and Paper	100	99	99
Fertilizer	100	100	100
Industrial Materials	93	93	93
Others	91	91	91

2) Songkhla & Phuket

19. Deep seaports at Songkhla and Phuket, which are under construction at present, will open in the near future. So a large volume of raw rubber produced in the south region and industrial products will be loaded at Songkhla and Phuket. Table III.1.9 shows the cargo volume forecast of Songkhla and Phuket.

Table III.1.9 Cargo Volume Forecast of Songkhla and Phuket

Unit: 1,000 tons

		1991	1996	2001
Songkhla	Raw Rubber	740	830	880
	Industrial Products	20	81	102
	Total	760	911	982
Phuket	Raw Rubber	190	210	220

(2) Container Ratio Analysis

20. Fig. III.1.2 shows the flow chart of the container ratio analysis. Based on the interviews with exporters, importers and shipping companies, present and future container ratios are estimated by commodity, and checked by the actual total container volume and the annual trend of the total container ratio. The estimated container ratios by commodity are shown in Table III.1.10.

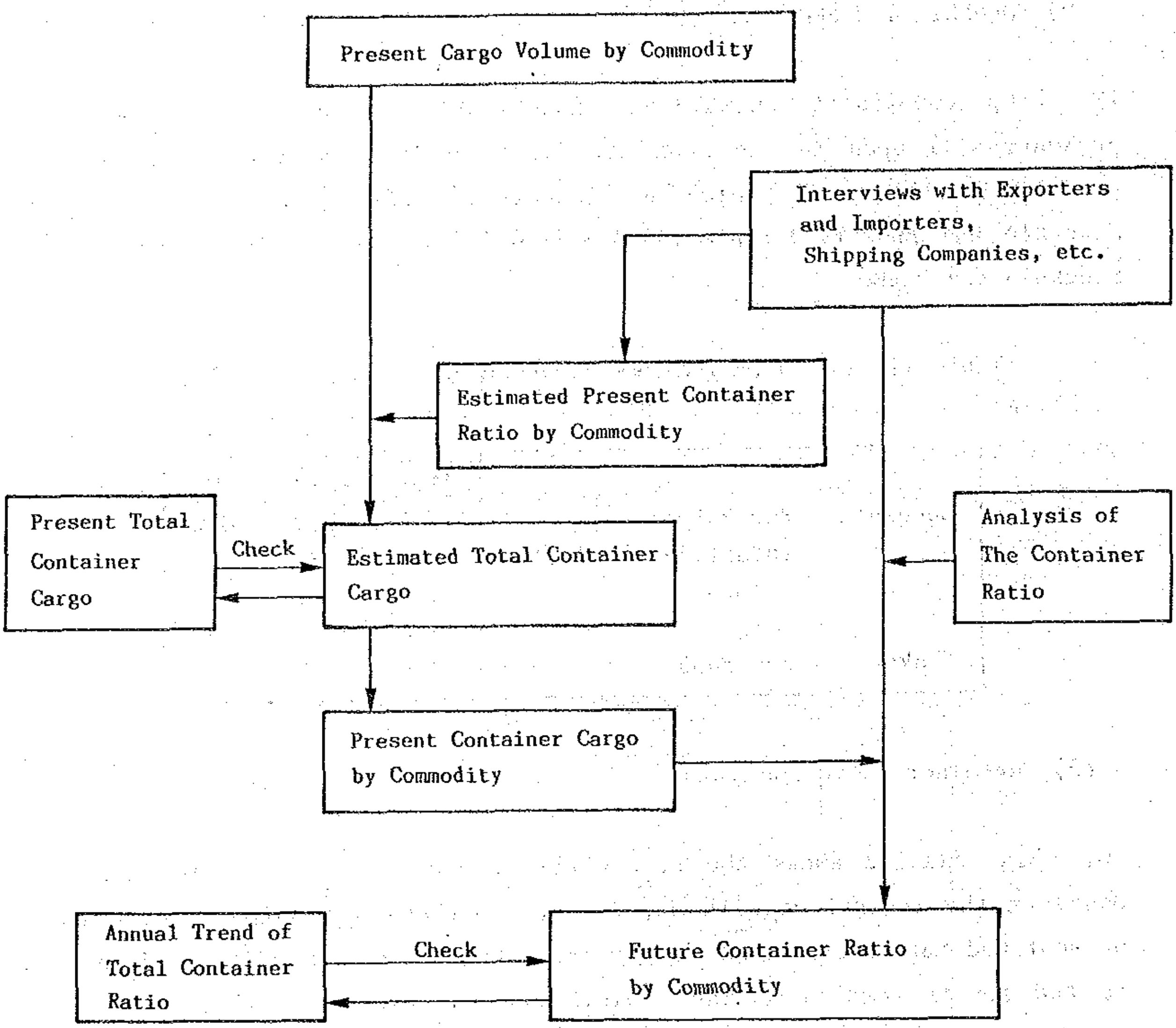


Fig. III.1.2 Flow Chart of Container Ratio Analysis

Table III.1.10 Container Ratio by Commodity

	1991	1996	2001
(Export)			
Agricultural Products			
Rice	2 %	2 %	2 %
Maize	-	-	-
Tapioca	2	2	2
Sugar and Molasses	-	-	-
Raw rubber	90	95	100
Others	84	87	90
Wood Products	100	100	100
Marine Products	85	90	90
Mining Products	6	6	6
Industrial Products	88	89	90
(Import)			
Iron & Steel	10 %	15 %	20 %
Chemical Products	51	70	80
Wood Products	40	60	80
Pulp and Paper	54	66	75
Fertilizer	-	-	-
Industrial Materials	48	52	56
Others	57	68	73

Source: Estimate by the Study Team

(3) Container Cargo Volume in Thailand

21. Using the share of each port and the container ratios estimated above, the future container cargo volume in Thailand is forecast as shown in Table III.1.11. The total estimated container volume in Thailand is 10.6 million tons in 1991, 15.5 million tons in 1996 and 19.8 million tons in 2001.

Table III.1.11 Container Cargo Volume in Thailand

Unit: 1,000 tons

		1991	1996	2001
Bangkok Zone	Export	6,108	8,568	10,455
	Import	3,617	5,910	8,185
	Total	9,725	14,478	18,640
Songkhla & Phuket	Export	855	1,062	1,192
	Import	-	-	-
	Total	855	1,062	1,192
Total	Export	6,963	9,630	11,647
	Import	3,617	5,910	8,185
	Total	10,580	15,540	19,832

Note 1: Bangkok Zone = Bangkok + Laem Chabang + Sattahip
Note 2: Import container cargo at Songkhla and Phuket would be negligible.

22. Considering that the export volume exceeds the import volume in Thailand, the future container handling is calculated as follows:

$$N = \frac{Vexp}{W} \times 2$$

N : Container handling (TEUs/year)
Vexp: Container export volume (tons/year)
W : Cargo weight per loaded 20 ft container (tons/TEU)

23. The average weight of container cargo is set as 12 tons/TEU based on the actual data. But 17 tons/TEU is used for raw rubber handling at Songkhla and Phuket Port. Using these cargo weights and the export volume estimated above, the future container handling is calculated to be 1.12 million TEUs in 1991, 1.56 million TEUs in 1996 and 1.89 million TEUs in 2001.

24. On the bother hand, container boxes may be manufactured in Thailand to cope with the shortage of container boxes because of the imbalance of exports and imports. Assuming that the number of manufactured containers

is 30,000 TEUs/year in 1991 and 70,000 TEUs/year in 1996 and 2001, the future container handling in Thailand is estimated to be 1.09 million TEUs in 1991, 1.49 million TEUs in 1996 and 1.82 million TEUs in 2001 as shown in Table III.1.12.

Table III.1.12 Container Handling in Thailand

Unit: 1,000 TEUs

	1991	1996	2001
Bangkok Zone	988	1,358	1,673
Songkhla & Phuket	101	129	145
Total	1,089	1,487	1,818

Note : Bangkok Zone = Bangkok + Laem Chabang + Sattahip

1.3 Origin and Destination (O/D) Analysis

1.3.1 Methodology

25. In this section, the Origin and Destination (O/D) of the container cargo handled at Bangkok Zone (Bangkok, Laem Chabang and Sattahip Port), which is examined in section 1.2 of this Chapter, is estimated.

26. Fig. III.1.3 shows the flow chart of the O/D analysis. Based on the interview survey of exporters and importers, the present O/D of container cargo is estimated considering the following factors:

a) Number of Factories by Region
b) Regional Economic Activities
c) Main Production Areas
d) Location of Warehouses, Silos
e) Industrial Estates/Parks
f) Relations between Export and Import, etc.

27. The number of surveys and responses are as follows:

Type of Firms	No. of Surveys	No. of Responses
Exporter	485	350
Importer	236	184
BOI Listed Firms	98	38
Total	819	572 (70%)

28. Using the estimated present O/D, the future O/D of container cargo is estimated considering the industrial and agricultural development plan.

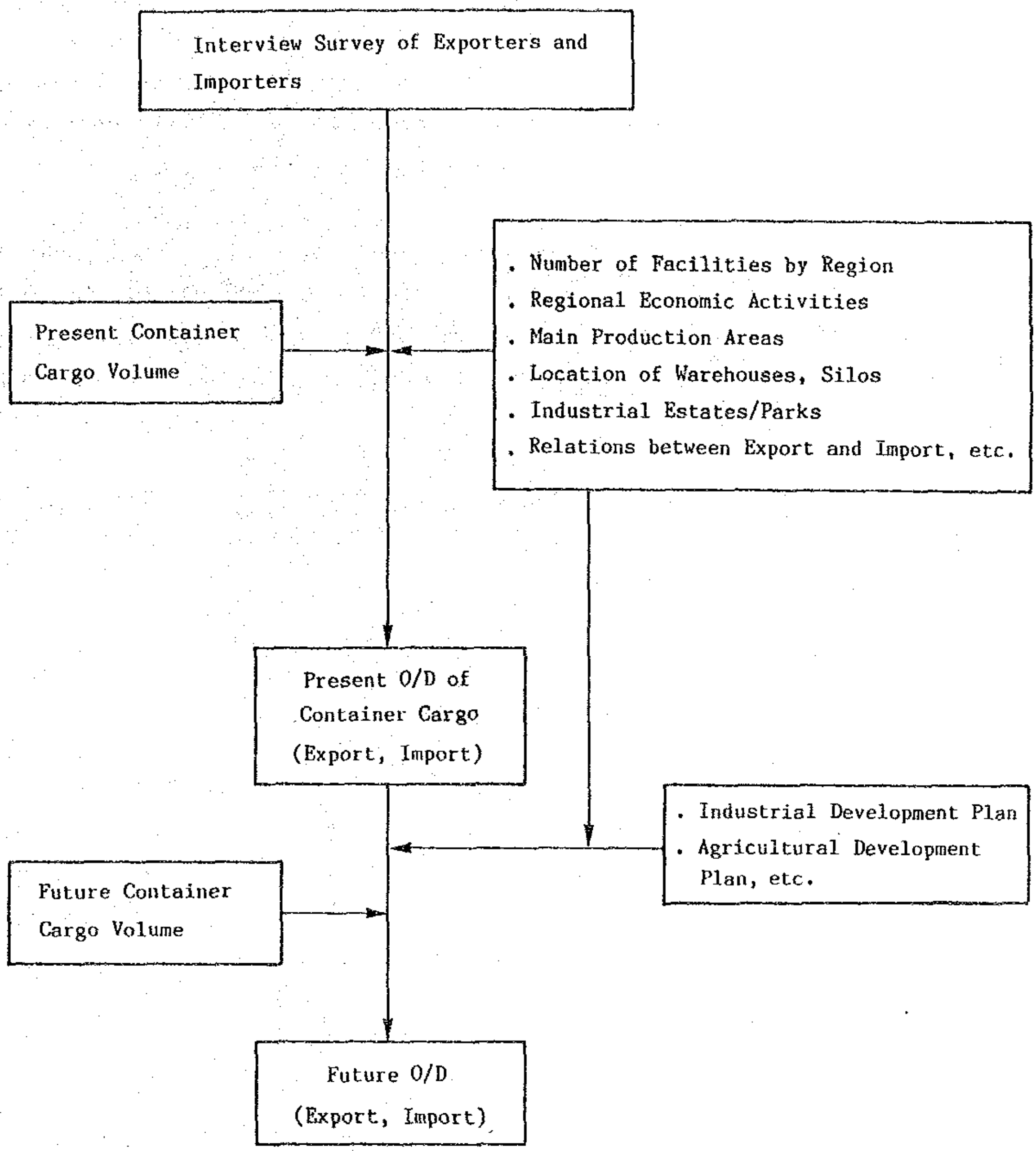


Fig. III.1.3 Flow Chart of the O/D Analysis

1.3.2 Results of the Present and Future O/D

29. Fig. III.1.4 and Fig. III.1.5 show a zone area map and zone blocks for the O/D analysis. The results of the present and future O/D by those areas and blocks are shown in Table III.1.13 and Fig. III.1.6.

30. As for exports, due to the restrictions on industrial development in the BMA, the share of BMA will decrease from 26% in 1987 to 16% in 2001. On the other hand, the share of the Central and Eastern areas will increse from 35% in 1987 to 52% in 2001 and from 8% in 1987 to 15% in 2001, respectively.

31. As for imports, the share of BMA will increse from 54% in 1987 to 57% in 2001.

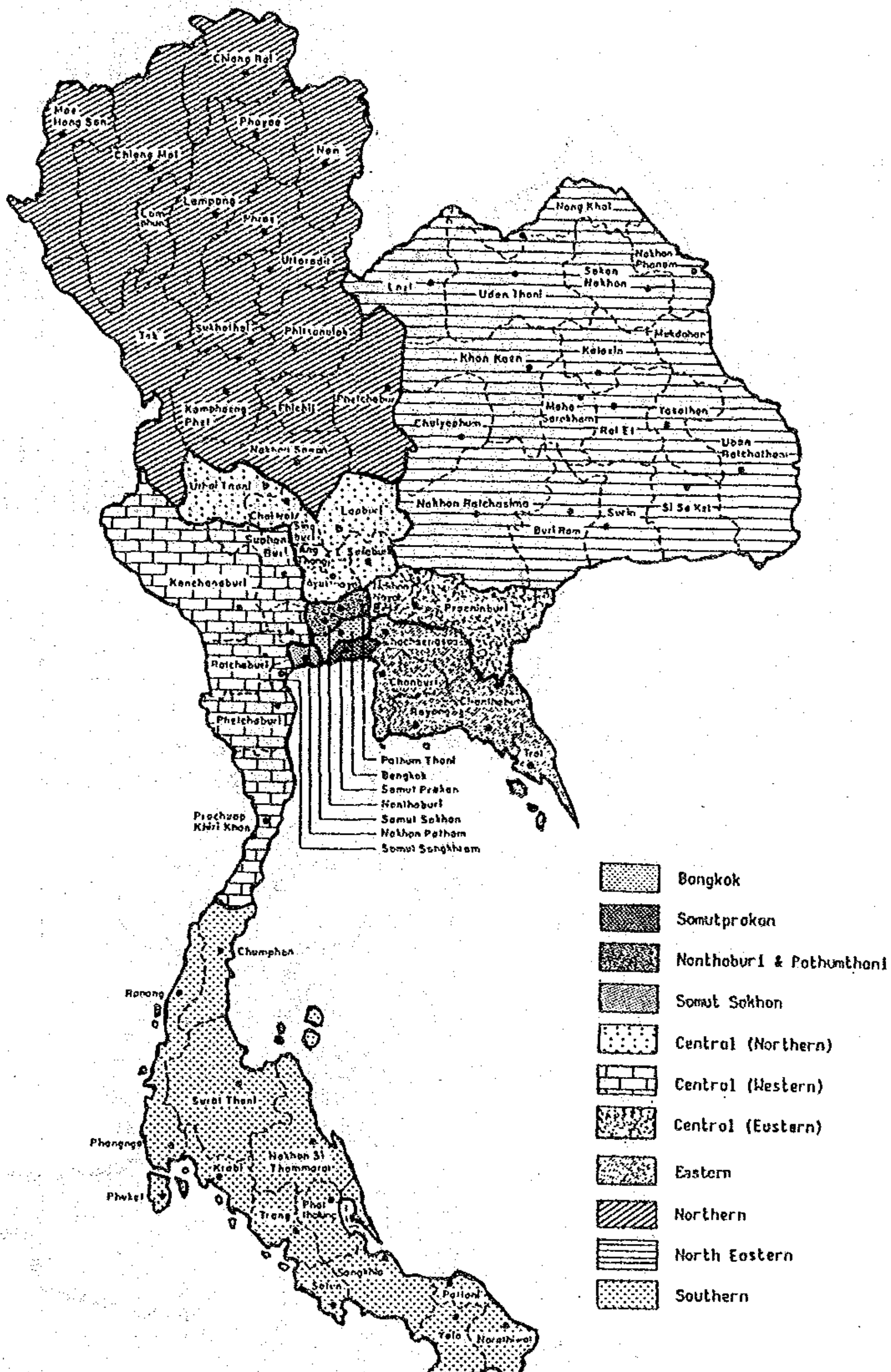


Fig. III.1.4 Zone Area Map

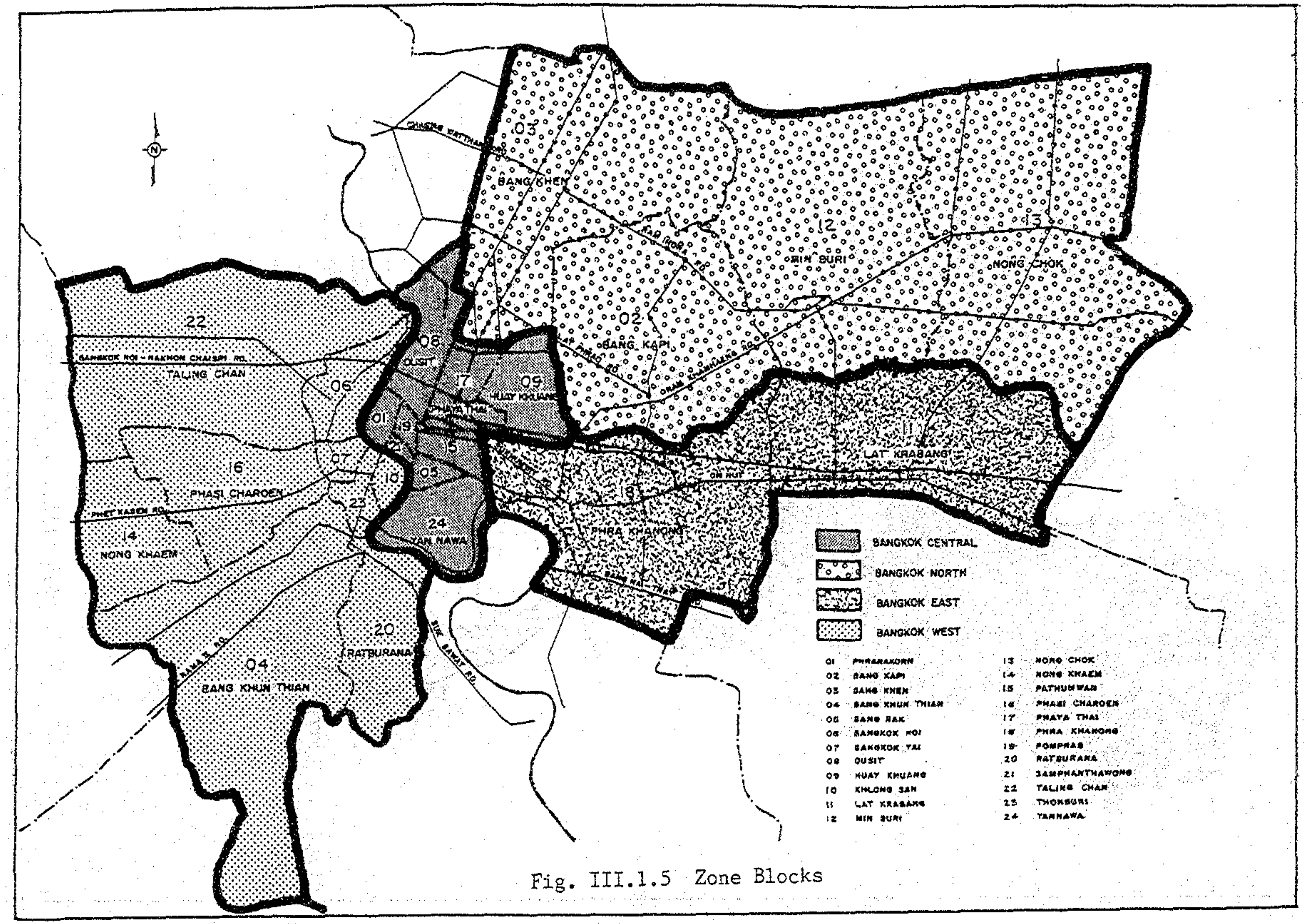


Fig. III.1.5 Zone Blocks

Table III.1.13 O/D of Container Cargo Handled at Bangkok Zone
(Bangkok Zone = Bangkok + Laem Chabang + Sattahip)

Unit : 1,000 tons, (%)

Area	1987						1996						2001					
	Export	%	Import	%	Total	%	Export	%	Import	%	Total	%	Export	%	Import	%	Total	%
BMA																		
Bangkok West	400	(11)	353	(15)	753	(12)	464	(5)	677	(11)	1141	(8)	491	(5)	933	(11)	1424	(8)
Bangkok East	170	(4)	147	(6)	317	(5)	491	(6)	418	(7)	909	(6)	575	(5)	586	(7)	1161	(6)
Bangkok North	133	(3)	81	(3)	214	(3)	235	(3)	242	(4)	477	(3)	266	(3)	345	(4)	611	(3)
Bangkok Central	300	(8)	691	(30)	991	(17)	349	(4)	2047	(35)	2396	(17)	364	(3)	2836	(35)	3200	(17)
Sub-Total	1003	(26)	1272	(54)	2275	(37)	1539	(18)	3384	(57)	4923	(34)	1696	(16)	4700	(57)	6396	(34)
Central																		
Samutprakan	480	(12)	192	(8)	672	(11)	1335	(16)	722	(12)	2057	(14)	1681	(16)	1038	(13)	2719	(15)
Nonthaburi & Pathumthani	152	(4)	104	(4)	256	(4)	1041	(12)	232	(4)	1273	(9)	1226	(12)	331	(4)	1557	(8)
Samut Sakhon	136	(3)	72	(3)	208	(3)	580	(7)	145	(2)	727	(5)	743	(7)	182	(2)	925	(5)
Central North	235	(6)	51	(2)	286	(5)	754	(9)	158	(3)	912	(6)	924	(9)	240	(3)	1164	(6)
Central West	169	(4)	88	(4)	257	(4)	206	(2)	198	(3)	404	(3)	263	(3)	270	(3)	533	(3)
Central East	177	(6)	15	(2)	192	(3)	435	(5)	27	(0)	462	(3)	554	(5)	34	(0)	588	(3)
Sub-Total	1349	(35)	522	(23)	1871	(30)	4351	(51)	1482	(24)	5833	(40)	5391	(52)	2095	(25)	7486	(40)
Eastern	313	(8)	58	(3)	371	(6)	1190	(14)	119	(2)	1309	(9)	1559	(15)	159	(2)	1718	(9)
Northern	365	(9)	135	(6)	500	(8)	721	(8)	266	(5)	987	(7)	866	(8)	356	(5)	1222	(7)
Northeastern	253	(6)	239	(10)	492	(8)	354	(4)	451	(8)	805	(6)	439	(4)	600	(7)	1039	(6)
Southern	616	(16)	93	(4)	709	(11)	413	(5)	208	(4)	621	(4)	504	(5)	275	(4)	779	(4)
Total	3899	(100)	2319	(100)	6218	(100)	8568	(100)	5910	(100)	14478	(100)	10455	(100)	8185	(100)	18640	(100)

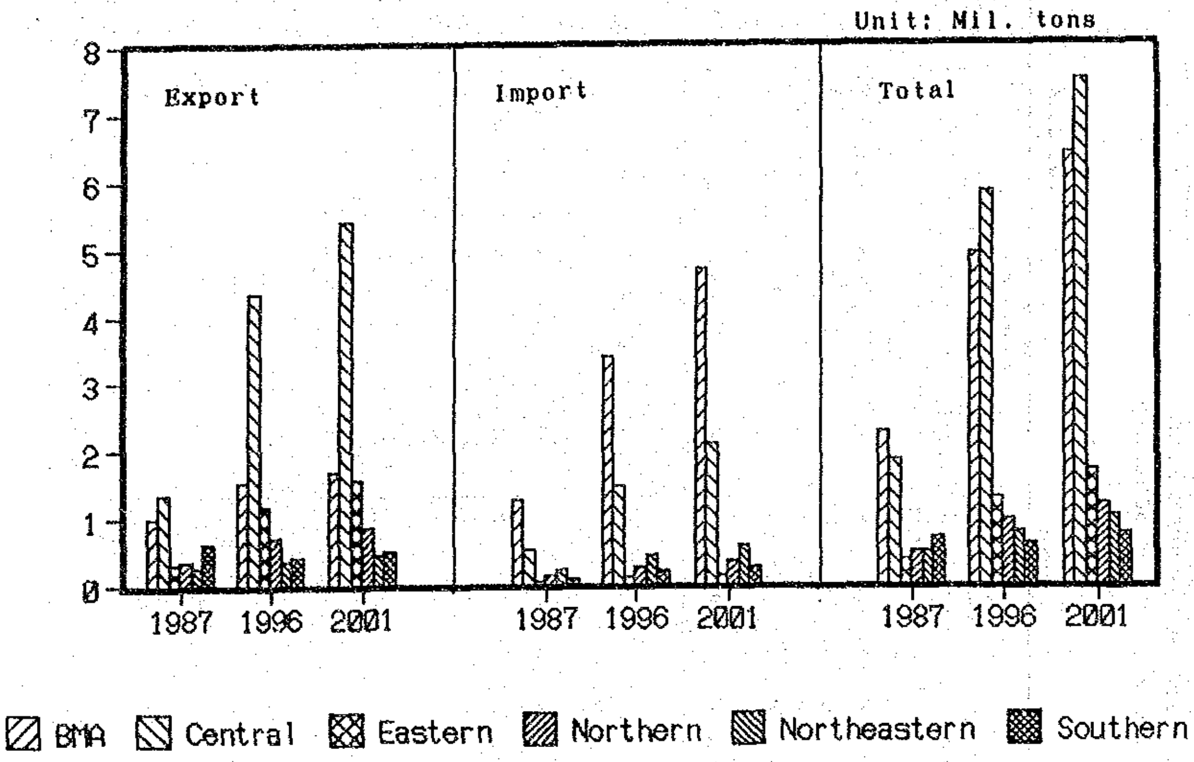


Fig. III.1.6 O/D of Container Cargo Handled at Bangkok Zone

1.4 Cargo Volume of Bangkok Port and Laem Chabang Port

1.4.1 Evaluation of the Container Handling Capacity at Bangkok Port

(1) Presuppositions for the Evaluation

32. The evaluation criteria to determine the container handling capacity at Bangkok Port consist of two fields, 1) the yard capacity and 2) the berth occupancy, which mainly depends on the handling capacity of the gantry cranes. And the capacity is evaluated at two levels, 1) the normal capacity which will occur after the Laem Chabang Port operation starts, and 2) an exceptional capacity which will serve as a temporary countermeasure before the Laem Chabang Port operation starts. The evaluation is carried out preliminarily under the following presuppositions.

1) Facilities

a) Outside container yards to be set up by the private sector will be utilized.
b) The container yard at Klong Toei Wharves will be expanded.
c) The sheds at East Quay, which are obstacles to effective container handling, will be demolished.
d) The container handling capacity of the gantry cranes is the same as at other main ports.

2) Management & Operation

a) PAT totally controls the terminal operation.
b) The operation hours for loading and unloading are 24 hours a day.
c) The yard allocation for each activity, such as stacking and passage, should be strictly controlled.
d) The apron area will not be used as a container stacking yard.
e) Container transportation between the marshalling yard and quay side will be carried out smoothly, and container marshalling will be executed utilizing the marshalling yard.
f) Stuffing and unstuffing in the port area will be carried out at CFSs.

3) Others

a) The ratio of loaded containers carried to and from the outside of the port will increase.

b) Bonded transport between outside container yards and the port area will be admitted by the Customs Department.

c) The fare rates of ETO for trailer chassis will be at the same level as private sector rates.

(2) Capacity of the Container Yards

1) Container Stacking Capacity in Container Yards

33. In analyzing the container stacking capacity in the container yards, the Study Team considers not only the capacity at Klong Toei Wharves but also the capacity at outside container yards which are to be built and operated by the private sector. The estimated container handling volumes at both types of yards are as follows:

Outside Container yards	:	200,000 TEUs/year
Klong Toei Wharves		
. Normal Capacity	:	270,000 "
. Exceptional Capacity	:	350,000 "

2) Container Handling Capacity through Bangkok Port

(a) Before the Laem Chabang Port Operation Starts

34. The container handling volume through the port should be counted as twice the yard volume, because each container box is handled two times at quay side: once when unloading from a vessel and again when loading on to a vessel. On the basis of the yard capacity, the study team estimates the container handling capacity as follows:

a) Normal Capacity

Klong Toei Wharves	:	540,000 TEUs/year
Outside Container Yards	:	400,000 "
Total		940,000 "

b) Exceptional Capacity

Klong Toei Wharves	:	700,000 TEUs/year
Outside Container Yards	:	400,000 "
Total		1,100,000 "

(b) After the Laem Chabang Port Operation Starts

35. After container handling at Laem Chabang Port starts, the container cargo which will be stuffed or unstuffed at outside container yards is assumed to pass through both Bangkok Port and Laem Chabang Port. The Study Team supposes that half of the container cargo stuffed or unstuffed at outside container yards would pass through each port, and the utilization of the container yard at Klong Toei Wharves would be normalized.
Then the yard capacity for Bangkok Port is estimated as follows:

Klong Toei Wharves	:	540,000 TEUs/year
Outside Container Yards	:	200,000 "
Total		740,000 "

(3) Capacity of the Berths at East Quay of Bangkok Port

1) Premises of the Analysis

36. The capacity of the berths is evaluated on the basis of the berth occupancy and the waiting vessels. Each factor for the analysis is assumed as follows:

Number of berths	:	6 berths
Number of gantry-cranes	:	6 units (1 unit/berth)
Container movement	:	20 moves/hour crane
Share of 40' container boxes	:	36 % (= 1.36 TEU/move)
Berthing and reberthing time	:	2 hours
Rest time (for meals)	:	1 hour in every 8 hours

37. On the basis of the above factors, the berth occupation time for different handling volumes of arriving vessels is calculated as follows:

Handling volume per vessel		Berth occupation time	Share
300 TEU	:	14.0 hours	(15%)
500	:	22.4	(30)
700	:	30.7	(30)
900	:	39.1	(15)
1,100	:	47.4	(10)

2) Evaluation of the Berth Capacity

38. The result of the simulation for berth occupancy and waiting vessels is presented in Fig. III.1.7. The figure shows that the ratio of waiting vessels increases sharply if the berth occupancy exceeds 63-64 percent.

39. On the other hand, though the berth occupancy of East Quay and the waiting time were stable in 1987, they have increased sharply in 1988. The berth occupancy in 1987 fluctuated between 57 to 72 percent, and the average was 62.5 percent through the year. And it is said that the severe congestion which Bangkok Port suffers in 1988 did not occur in 1987.

40. Therefore the Study Team estimates appropriate berth occupancy would be at most 63-64 percent. But before the container handling at Laem Chabang Port starts, some congestion will be inevitable. The Study Team adopts a berth occupancy of 74 percent as an exceptional level, that is a temporary countermeasure until the operations begin at Laem Chabang Port. At this level some 25 percent of the arriving vessels, that is almost the same ratio of waiting vessels as in January and February of 1988, will wait for berths.

Table III.1.14 Berth Occupancy and Waiting Vessels at East Quay of Bangkok Port

	1987			1988			
	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.
Calling Vessels	91	93	102	94	100	102	95
Berth Occupancy (%)	68	72	62	79	74	76	81
Waiting Vessels	15	12	11	25	22	46	61
Ratio of Waiting Vessels (%)	16.5	12.9	10.8	26.6	22.0	45.1	64.2
Average Waiting Time of Waiting Vessels (hours)	11.6	9.1	6.2	10.8	11.8	19.9	25.3

Source: PAT

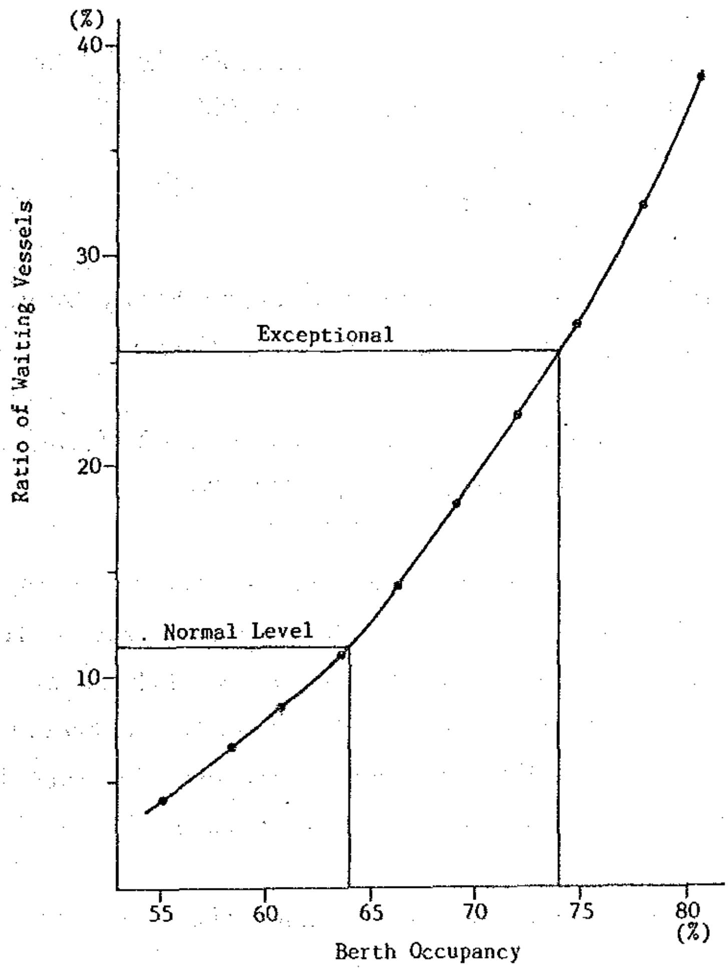


Fig. III.1.7 Result of the Simulation, Relation between Berth Occupancy and Ratio of Waiting Vessels

3) Capacity of the Berths

41. The relation between the berth occupancy and the container throughput at East Quay is presented in the following formula:

$Y = 11.1X + 14.8$ X: Berth occupancy : %
Y: Container cargo : 1,000 TEUs

Note: This formula is available in the range of berth occupancy 55-80%.

42. In this calculation, effective working days in a year are assumed to be 345 days excluding 5 days of holidays and 15 days for maintenance and repair of each gantry crane.
Then the capacity of East Quay is calculated as follows:

Normal Capacity	:	720,000 TEUs/year
Exceptional Capacity	:	840,000 "

(4) Evaluation of the Capacity

43. Considering the above two results, the Study Team estimates the container handling capacity at East Quay as follows:

Exceptional Capacity	:	840,000 TEUs/year
Normal Capacity	:	720,000 "

44. As the estimated container volume through the ports in Bangkok Zone is 988 thousand TEUs, in 1991, about 150 thousand TEUs would overflow the container handling capacity at East Quay of Bangkok Port. To handle this overflow volume it will be desirable to utilize temporarily Sattahip Port which is projected to handle containers now, and the West Quay of Bangkok Port where combo-type vessels handle containers now.

1.4.2 Future Cargo Volume at Laem Chabang Port

45. Based on the result of the future O/D and the container handling capacity at Bangkok Port, the future cargo volume at Laem Chabang Port is estimated as shown in Table III.1.15.

46. Containr cargo volume handled at Laem Chabang Port, which is calculated by deducting the capacity of Bangkok Port from the total container volume of Bangkok Zone, is 6.8 million tons in 1996 and 10.6 million tons in 2001 and the corresponding TEUs are 638 thousand TEUs and 953 thousand TEUs.

47. As for tapioca exports, it is assumed that 50% of the cargo from the Eastern and Central East areas will be loaded at Laem Chabang Port considering that the other 50% will be loaded at Ko Sichang and Sattahip Port.

Table III.1.15 Future Cargo Volume at Laem Chabang Port

Unit: 1,000 tons
(1,000 TEUs)

	1996			2001		
	Export	Import	Total	Export	Import	Total
Containers	4,030	2,780	6,810 (638)	5,950	4,660	10,610 (953)
Break Bulk	50	280	330	70	330	400
Tapioca	1,270	-	1,270	1,270	-	1,270
Sugar	590	-	590	590	-	590
Molasses	230	-	230	230	-	230
Total	6,170	3,060	9,230	8,110	4,990	13,100

1.5 Container Cargo through the ICD

1.5.1 Presuppositions for the Estimation

48. Container cargo volume through the ICD was estimated considering the following conditions:

(1) The container cargo through the ICD would be loaded or unloaded at Laem Chabang Port.

(2) The LCL container cargoes are handled at the ICD

(3) But considering the present situation that FCL cargoes in addition to LCL cargoes are also being stuffed and unstuffed at the Bangkok Port area, some part of the FCL cargoes to/from the Bangkok Metropolitan Area were assumed to also be handled at the ICD. It is difficult to precisely determine the availability of stuffing/unstuffing areas at shippers'/ consignees' own sites.

Based on the results of the interview survey with exporters and importers, the ratios of stuffing and unstuffing at the port area and the ICD are estimated to be 60% of container cargo for export and 50% for import.

(4) Considering the relative location between the O/D of container cargo, Laem Chabang Port and the ICD, the following container cargoes are assumed to be directly transported by road, coastal shipping or railway to/from Laem Chabang Port.

1) Cargoes to/from the Central (East), Eastern and Southern areas and half of the cargoes to/from the Samut Prakan area.

2) Railway cargoes

The share of railway cargo volume is estimated considering the present share of railway transportation and the plan of railway construction in the Northeastern Area. The shares of railway are estimated to be 1% for the Central (North and West), 4% for the Northern and Northeastern Areas and 25% for the Southern area.

(5) The container handling capacity of Bangkok port would be 720,000 TEUs/year.

1.5.2 Container Cargo Volume through the ICD

(1) O/D of LCL and FCL Cargo

49. Based on the result of the O/D analysis, the O/Ds of LCL cargoes are estimated by the ratios of LCL cargo by commodity. Here based on the interview survey with exporters and importers, the ratios of LCL cargo are estimated by each commodity considering the lot size and style of container cargos. The maximum weight of the lot of LCL cargo is considered to be 10 tons and 6 tons for light weight cargo.

50. The results of the estimation are shown in Table III.1.16. LCL cargo volumes are 1.4 million tons and 1.7 million tons in 1996 and 2001. The share of LCL cargoes is about 10% in both years. Remaining cargoes are FCL cargo and the volumes are 13.1 million tons and 16.9 million tons in 1996 and 2001.

(2) Container Cargo Volume through the ICD

51. Based on the O/D of LCL and FCL cargo, container cargo volume through the ICD is estimated by LCL and FCL cargo as follows.

1) LCL Cargo Volume

52. LCL cargo volume through the ICD is calculated by multiplying the share of Laem Chabang Port (shown in Appendix 6) to the O/D of LCL cargo except the Central (East), Eastern and Southern Areas, and half of the cargoes to/from the Samut Prakan district and the railway cargoes.

2) FCL Cargo Volume

53. With regard to FCL Cargo, assuming the FCL cargoes to/from the Bangkok Metropolitan Area except industrial estates are handled at the ICD, the container cargo volume is calculated by multiplying the ratios of

stuffing/unstuffing and the share of Laem Chabang Port mentioned above.

54. The results of the calculation are shown in Table III.1.17. Total cargo volumes are 1.3 million tons and 2.1 million tons in 1996 and 2001, and the share of the Bangkok Metropolitan Area is over 80% in both years.

Table III.1.16 O/D of Container Cargo

(Unit: 1,000 tons)

Year	LCL/FCL	Bangkok	Central						Eastern	Northern	Northeastern	Southern	Total
			Samut Prakan	Nonthaburi Pathumtani	Samut Sakhon	North	West	East					
1996	LCL	406	205	210	81	108	32	28	124	101	54	60	1,409
	FCL	4,517	1,852	1,063	644	804	372	434	1,185	886	751	561	13,069
	Total	4,923	2,057	1,273	725	912	404	462	1,309	987	805	621	14,478
2001	LCL	470	268	257	102	136	39	37	167	122	63	74	1,735
	FCL	5,926	2,451	1,300	823	1,028	494	551	1,551	1,100	976	705	16,905
	Total	6,396	2,719	1,557	925	1,164	533	588	1,718	1,222	1,039	779	18,640

Table III.1.7 Cargo Volume through the ICD

Total

(Unit:tons)

Year	LCL/FCL	Bangkok	Central	Northern	Northeastern	Total
1996	LCL	160,100	192,600	35,100	20,900	408,700
	FCL	878,600	---	---	---	878,600
	Total	1,038,700	192,600	35,100	20,900	1,287,300
	(Share)	(80 %)	(15 %)	(3 %)	(2 %)	(100 %)
2001	LCL	237,900	317,000	55,600	31,000	641,500
	FCL	1,462,400	--	--	--	1,462,400
	Total	1,700,300	317,000	55,600	31,000	2,103,900
	(Share)	(81 %)	(15 %)	(3 %)	(1 %)	(100 %)

Export

(Unit:tons)

Year	LCL/FCL	Bangkok	Central	Northern	Northeastern	Total
1996	LCL	78,400	157,400	28,300	8,400	272,500
	FCL	188,700	---	--	---	188,700
	Total	267,100	157,400	28,300	8,400	461,200
	(Share)	(58 %)	(34 %)	(6 %)	(2 %)	(100 %)
2001	LCL	114,900	259,500	45,500	13,500	433,400
	FCL	272,600	--	--	--	272,600
	Total	387,500	259,500	45,500	13,500	706,000
	(Share)	(55 %)	(37 %)	(6 %)	(2 %)	(100 %)

Import

(Unit:tons)

Year	LCL/FCL	Bangkok	Central	Northern	Northeastern	Total
1996	LCL	81,700	35,200	6,800	12,500	136,200
	FCL	689,900	--	--	---	689,900
	Total	771,600	35,200	6,800	12,500	826,100
	(Share)	(93 %)	(4 %)	(1 %)	(2 %)	(100 %)
2001	LCL	123,000	57,500	10,100	17,500	208,100
	FCL	1,189,800	--	--	---	1,189,800
	Total	1,312,800	57,500	10,100	17,500	1,397,900
	(Share)	(94 %)	(4 %)	(1 %)	(1 %)	(100 %)

1.5.3 Traffic Volume by Mode

(1) Traffic Volume between the ICD and the O/D

55. Container cargoes would be transported by 6-wheel trucks and 10-wheel trucks. The traffic volume is estimated by the following formula;

$$Q = C/W * \beta/365 * \gamma * (1 + \delta)/\varepsilon \qquad \text{(vehicles/day)}$$

C	: cargo volume (tons/year)	
W	: capacity tonnage of trucks	10 tons/vehicle for FCL 5 tons/vehicle for LCL
β	: monthly fluctuation	1.1
γ	: daily fluctuation	1.4
δ	: ratio of related vehicles	0.5
ε	: ratio of loaded vehicles	0.6

Here, W is estimated by the lots of LCL and FCL cargo, β is estimated by the record of container handling at Klong Toei wharves in 1987 and is based on the result of the traffic O/D survey being carried out by JICA, "Road Development Study in The Central Region, 1988."

56. The results of the estimation are shown in Table III.1.18. The daily traffic volumes are estimated to be 1,790 vehicles per day and 2,890 vehicles per day in 1996 and 2001, respectively.

Table III.1.18 Traffic Volume between ICD and O/D

<1996>

Origin/ Destination	Cargo Volume (tons/year)	Daily Traffic Volume (vehicles/day)		
		Truck	R/V	Total
B M A	1,038,700	850	420	1,270
Central	192,600	270	140	410
Northern	35,100	50	20	70
Northeastern	20,900	30	10	40
Total	1,287,300	1,200	590	1,790

<2001>

Origin/ Destination	Cargo Volume (tons/year)	Daily Traffic Volume (vehicles/day)		
		Truck	R/V	Total
B M A	1,700,300	1,360	680	2,040
Central	317,000	450	220	670
Northern	55,600	80	40	120
Northeastern	31,000	40	20	60
Total	2,103,900	1,930	960	2,890

Note: Cargo volume and daily traffic volume are total of export and import
R/V: Related Vehicles

(2) Traffic Volume between the ICD and Laem Chabang Port

57. Considering that the container transportation between the ICD and Laem Chabang Port is to be executed by shuttle service, transportation by railway should also be considered because of its high security, under the condition that the cost of transportation is comparable with that by trailers.

58. In the case of transportation by railway, the container handling time is longer than that by trailers, so cargoes which do not need to be carried

quickly would be carried by railway. The cutoff time at the ICD would be about 4 days prior to ship departure considering the handling time. Referring to the result of the survey in Japan (the ratio of the container cargo carried into container yards 4 days before the cutoff time is estimated to be 35%), the share of railways was assumed to be 35% for exports. With regard to imports, the same volume as for exports would transported, fully utilizing the shuttle service.

59. The results of the calculation are shown in Table III.1.19. The daily traffic volume is 420 vehicles per day in 1996 and 710 vehicles per day in 2001.

60. With regard to railways, assuming the ALSTOM type locomotive (the tractive weight is 1,280 tons) would be used, it is estimated that 28 freight cars can be carried by train and the train length is 410m. Considering that the shortest sidetrack between Laem Chabang Port and around Lat krabang is 498m, trains up to this length can be operated. The container cargo volumes by railway are 13,400 TEUs and 20,600 TEUs for both export and import in 1996 and 2001, respectively. Conidering the fluctuation, it will be neccesary to operate two round trips a day between the ICD and Laem Chabang Port.

Table III.1.19 Traffic Volume between the ICD and LCB Port

(1996)

Mode	Cargo Volume (TEUs/year)			Daily Traffic Volume (vehicles/day)			Round-trips /day
	Export	Import	Total	Trailer	R/V	Total	
Road	25,000	55,500	80,500	280	140	420	
Railway	13,400	13,400	26,800				2

(2001)

Mode	Cargo Volume (TEUs/year)			Daily Traffic Volume (vehicles/day)			Round-trips /day
	Export	Import	Total	Trailer	R/V	Total	
Road	38,200	95,900	134,100	470	240	710	
Railway	20,600	20,600	41,200				2

Note: Cargo volume, daily traffic volume and number of trains are total of export and import.
R/V : Related Vehicles

1.6 Influence on the Present Development Plan of Laem Chabang Port

1.6.1 Cargo Throughput

61. The present development plan of Laem Chabang Port is based on the cargo forecast in the Detailed Design Study carried out in 1986. In the Detailed Design Study, the container cargo through Laem Chabang Port is forecast as follows:

Year	Bangkok	Laem Chabang	Total
1995	450,000	400,000	850,000 TEUs
2000	470,000	550,000	1,020,000 TEUs

62. On the other hand, the Study Team estimates the container cargo as follows:

Year	Bangkok	Laem Chabang	Songkhla & Phuket	Total
1996	720,000	638,000	129,000	1,487,000 TEUs
2001	720,000	953,000	145,000	1,818,000 TEUs

63. The main reason why the volume of the Detailed Design estimate is low is that this forecast was based on the trend of the container cargo up to 1985, but actual volume increased sharply from 1986.

64. As for the volume of other cargoes there is not so much difference between the present forecast and the Detailed Design forecast as shown in Table III.1.20.

Table III.1.20 Comparison between Two Forecasts

Unit: 1,000 tons

	Present Study		Detailed Design	
	1996	2001	1995	2000
Break Bulk	330	400	320	380
Tapioca	1,270	1,270	1,300	1,300
Sugar	590	590	550	650
Molasses	230	230	230	250

1.6.2 Influence on the Present Plan

(1) General Influence

65. On the basis of the cargo forecast and the proposed cargo handling system using the ICD, it might be better to review the present plan. The main points to be reviewed at Laem Chabang Port would be as follows:

1) Container handling capacity of the container berths
2) Number of container berths in the target year
3) Necessity of the multipurpose berth
4) Capacity of the facilities such as the CFS
5) Container handling system between the container yard and the railway terminal
6) Layout of the railway terminal behind the container terminal

(2) Required Number of Container Handling Berths in Laem Chabang Port

66. The ICDs should be operated by integrated operators which are also responsible for handling at the marine terminals and inland transportation. It is necessary to estimate the required number of berths in the target years of the Study assuming that each marine terminal would be operated by a different operator.

67. Under the Laem Chabang Port Construction Contract which was signed in October 1987, two container berths and one break-bulk berth for international general cargo handling are scheduled to be completed by September 1991. The plan is based upon the Detailed Design Report in which the container cargo volume in 1995 and 2000 are estimated at around 4.0 million tons (400 thousand TEUs) and 5.5 million tons (550 thousand TEUs).

68. On the other hand, in this study the container cargo volume is estimated as 6.8 million tons (638 thousand TEUs) in 1996 and 10.6 million tons (953 thousand TEUs) in 2001 considering recent changes in actual economic growth and the rapid increase of container cargo. Therefore, the required number of container handling berths at Laem Chabang Port is estimated by the study team based on this cargo forecast.

69. As for the handling capacity of one container terminal, it is assumed as 160,000 TEUs per year considering the effects of the ICD which could contribute to reducing the storage period of container boxes at the marine terminal in Laem Chabang Port. Using the capacity and container handling volume estimated in this study, the required number of container handling berths at Laem Chabang Port is estimated as 4 berths in 1996 and 6 berths in 2001.

CHAPTER 2 SELECTION OF THE APPROPRIATE AREA FOR THE ICD

2.1 Examined Areas

1. It is commonly recognized that one of the main objects of container transport is door to door service, which means that the most ideal point for stuffing and unstuffing is the factory or warehouse of the shipper or consignee. But it is impossible to realize door to door service for all container cargo. Then it is desirable to locate the stuffing and unstuffing point as close to the main O/D point of the cargo as possible.

2. From the O/D survey in our study, it is estimated that more than 80 percent of the container cargo which would be stuffed or unstuffed at the ICD moves to or from the BMA.
Therefore the Study Team examined the BMA and its surrounding areas for appropriate ICD sites. The area examined in the study is divided into four zones, namely, the Bangkok Central Area, the Bangkok Eastern Area, the Bangkok Western Area and the Bangkok Northern Area.

2.2 Main Criteria

3. The main criteria used to evaluate each area as a possible ICD site are as follows:

2.2.1 Relation between ICD Site and O/D of the Container Cargo

4. From the O/D survey of the forecast container cargo which would be handled at the ICD, it is supposed that the central area within BMA would have the largest share followed by the western area and the eastern area, and the northern area would have the smallest share.

Table III.2.1 O/D of the Container Cargo through the ICD

Unit: 1,000 tons, (%)

	BMA					Other areas	Total
	West	East	North	Central	Sub-Total		
1996	251 (19.5)	157 (12.2)	92 (7.1)	539 (41.9)	1,039 (80.7)	248 (19.3)	1,287 (100)
2001	397 (18.9)	258 (12.3)	152 (7.2)	893 (42.4)	1,700 (80.8)	404 (19.2)	2,104 (100)

5. As for the industrial estates and parks, they are located in the Bangkok Eastern and Northern areas and in the Changwats of Samut Prakan and Pathum Tani now, and new industrial estates and parks are planned to be established mainly in the same areas in the Central region.

6. Furthermore, the cargo volume which would be stuffed or unstuffed at the ICD should also be considered, because it is not recommendable to establish many ICD sites at the initial stage of the Laem Chabang Port operation.
The management body of the ICD should be the same as the port management body of Laem Chabang Port, and the operator of the ICD should be the same as the terminal operators at Laem Chabang Port. These means that the ICD should be considered as a part of Laem Chabang Port.

2.2.2 Accessibility to the Transportation Network between the ICD Site and Laem Chabang Port

7. The container transportation between the ICD and Laem Chabang Port must depend on the land transportation network which consists of the road network and the railway network. So the accessibility of the ICD to these transportation networks is also one of the important factors to evaluate each area.

(1) Road Network

8. As for the road network, it is necessary to take into consideration primarily the present network and secondarily the future network, because it generally takes a long time to complete new roads, and the ICD should begin operations simultaneously with the start of container handling at Laem Chabang Port.

1) Present Road Network

9. The main roads which connect the BMA and Laem Chabang Port consist of Route 34 (Bang-Na Trat) and Route 304, and the connecting roads running from north to south are Route 3119 and Route 3256. The Bangkok Eastern area is the most convenient area to access these roads.

2) Future Network

10. As for future road development plans in the BMA and the Central region which will connect to Laem Chabang Port, the following projects are planned;

(a) Outer Ring Road
(b) Extension of Dindang Road to Lat Krabang
(c) New Highway between Lat Krabang and Bang Pakong

Roads (b) and (c) are intended to connect at Lat Krabang. To utilize these new roads for container transportation between ICD and Laem Chabang Port, the Bangkok Eastern area is the most convenient zone.

(2) Railway

11. Only the eastern line connects the BMA and Laem Chabang Port, but it crosses many main roads in the Bangkok Central area, which contributes to the road congestion problem in Bangkok. The overpass plan of the railway in Bangkok has been studied by JICA, but its implementation has yet to be decided.

12. So to avoid further impact on road traffic from the container transport by railway it is desirable that the ICD be located in the Bangkok Eastern area.

2.2.3 Container Traffic

13. The road container transportation between the Port and the ICD will be carried out by trailer trucks, and regular trucks will be used for the

cargo transportation between the ICD and the O/D of the container cargo. So it is also important to consider the present and future traffic conditions, such as i) traffic congestion, ii) regulations on the movement of heavy vehicles and iii) the need to pass through the Bangkok Central area, which is already heavily congested, to connect with Laem Chabang Port. Considering the above conditions, Bangkok Eastern area would present the least problems.

2.2.4 Land Use

14. Concerning the land use, the main factors to be considered are i) present land use ii) ease for future expansion, namely, sufficient land space, iii) regulations on land use and iv) land cost.
Present land use in each area is mainly agricultural except for the Bangkok Central area where urbanized use predominates. As it is necessary to ensure a sufficient area for the future expansion at the first stage, and as it is also desirable that cargo distribution facilities be located around the ICD for the effective use of the ICD, then it is difficult to secure sufficient space in an urbanized area.

15. As for regulation of land use, the General Plan is being prepared now. According to the draft of the General Plan of BMA, the construction of warehouses is permitted only in a restricted area, where many warehouses are located presently, mainly along the Chao Phraya River.
But from the viewpoint of location considering the cargo distribution facilities, warehouses should also be located in the areas surrounding the zone where the main cargoes are concentrated. Therefore it is also necessary to allocate some areas for cargo distribution facilities such as sheds and warehouses in the suburbs of BMA, where the traffic is not yet so congested and the land transportation network is well connected.
As for the ICD, the Study Team considers that the ICD is a part of the port facilities. But to operate the ICD effectively, it is desirable that private sector firms also locate their cargo distribution facilities such as sheds and warehouses near the ICD.

16. Land prices, which are one of the factors to decide the project cost, are increasing recently in Bangkok, the Central Region and the Eastern

Region.

2.3 Evaluation of the Examined Areas

17. The Study Team evaluates each area by each of the criteria mentioned above, as follows. Each of the criteria are weighted equally, as they are all important.

Good condition	:	◎ --- Point: 1
Normal condition	:	○ --- Point: 0
Poor condition	:	△ --- Point: -1

18. According to the above assumptions, each area is evaluated as shown in Table III.2.2. Consequently the Study Team recommends that the Bangkok Eastern area would be the most appropriate area for the ICD.

Table III.2.2 Comparison of the Four Areas

Evaluation Criteria	BKK Cent.	BKK East	BKK West	BKK North
ICD Site and O/D of Cargo				
(1) O/D of the Container Cargo	◎	○	○	△
(2) Location of Industrial Estates/Parks	△	◎	△	○
(3) Sufficient Cargo Volume	○	◎	△	△
Accessibility to Transportation Network				
(1) Road				
1) Present Network (Rt. 34, Rt. 304, Rt. 3119, Rt. 3256)	○	◎	△	○
2) Future Network (Outer Ring Rd., Dindang Rd. New Highway (Lat Krabang-Bang Pakong))	△	◎	○	○
(2) Railway: Eastern Line	○	◎	△	○
Traffic Condition				
(1) Traffic Congestion	△	◎	◎	○
(2) Regulations on the Traffic of Heavy Vehicles	△	◎	◎	◎
(3) Need to Pass through the Center of the BMA	△	◎	△	○
Land Use				
(1) Present Land Use	△	◎	◎	◎
(2) Ease for Future Expansion	△	◎	◎	◎
(3) Regulations on Land Use	△	○	○	○
(4) Land Cost	△	○	◎	○
Evaluation	-8	10	0	1

Note 1) ◎: Good Condition ------ Point: 1
○: Normal Condition ----- Point: 0
△: Poor Condition ------ Point: -1

Note 2) BKK: Bangkok

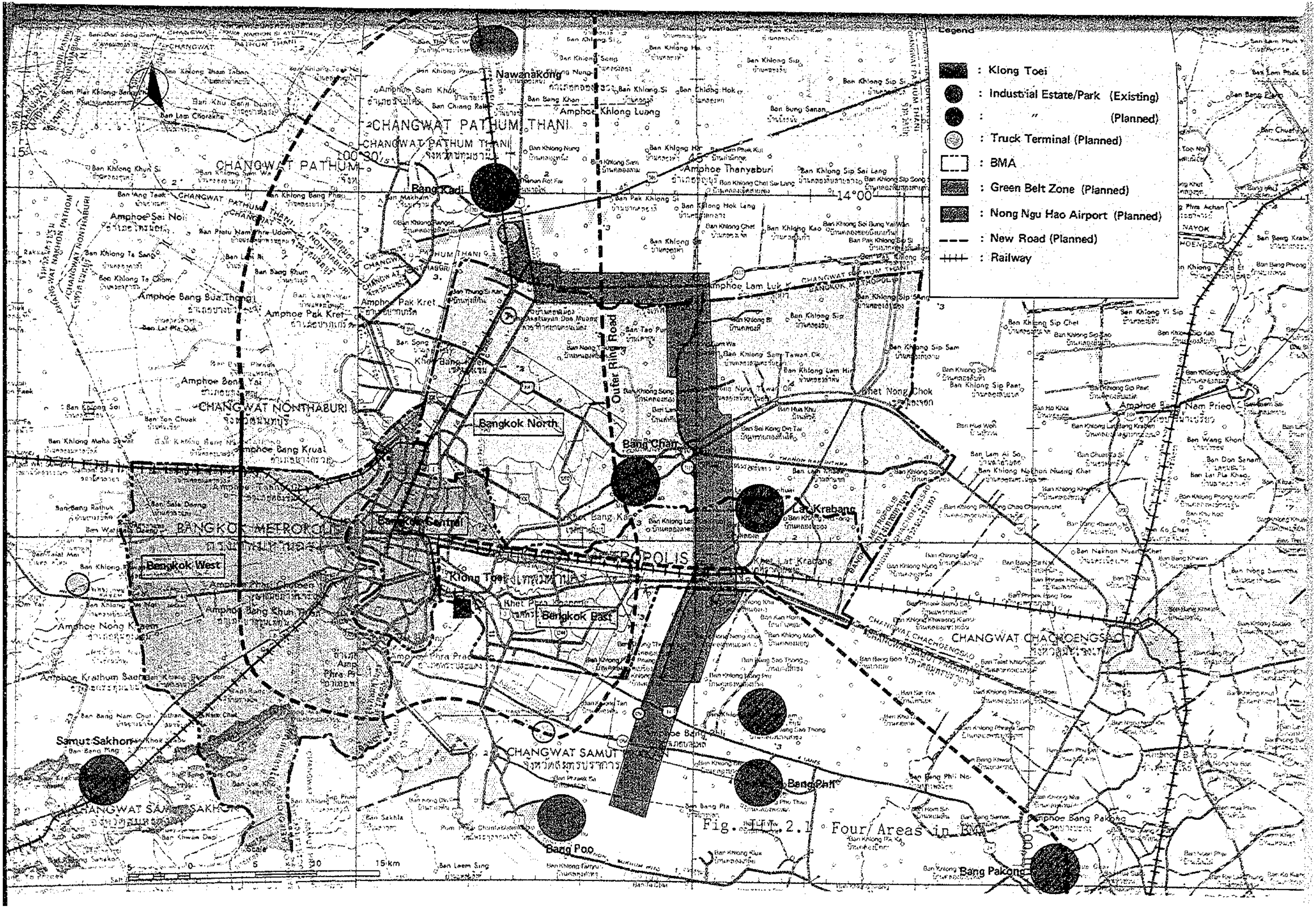


Fig. III.2.1 Four Areas in BMA

CHAPTER 3 NATURAL CONDITIONS

3.1 Natural Conditions of the Proposed Area

3.1.1 Project Area

1. The proposed project area is in the Lat Krabang area between Laem Chabang Port and Bangkok as shown in Fig. III.3.1.

3.1.2 Topography

2. The topography of Thailand is characterized by a low-level ground formation interlaced with many waterways. The natural ground elevations in the study area are in the order of 0.2 meters to 1.5 meters with a maximum of about 2.0 meters above mean sea level as shown in Fig. III.3.2.

3. Most of the roads, highways and railways in the area have been constructed on low embankments consisting of topsoil scooped from road side trenches within the right of way, which in turn serve as canals or ditches after the completion of roads and railways. In some places, natural levees can be observed with low-lying marshy areas behind them. In addition to these topographic characteristics, there are many artificial ponds which are the remains of past diggings.

4. The rainfall run-off water is drained through natural streams or khlongs to the Chao Phraya River. However, water accumulates and forms marshes in some low-lying areas.

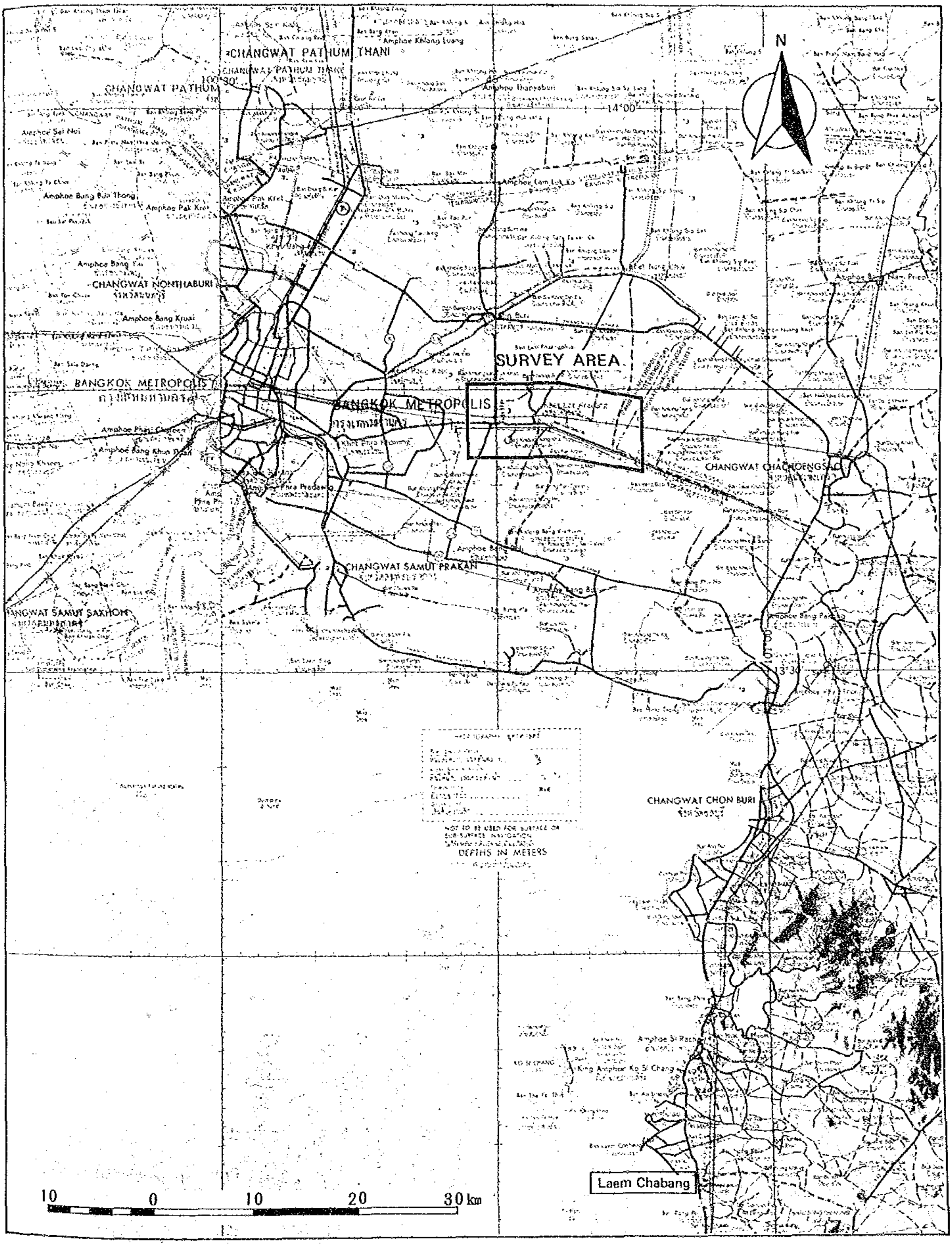


Fig. III.3.1 Survey Area

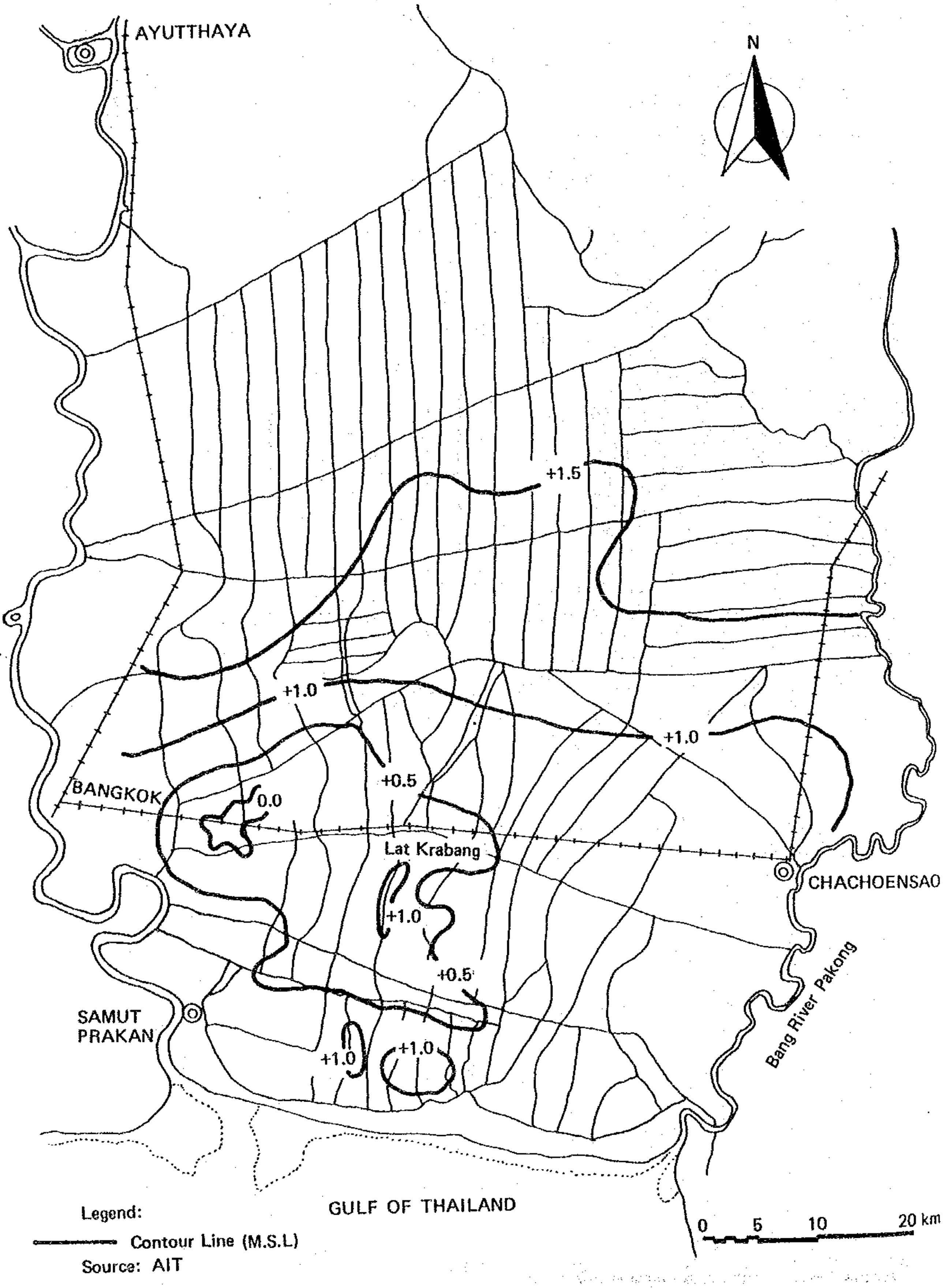


Fig. III.3.2 Ground Elevation in the Eastern Bangkok Plain

3.1.3 Meteorological Conditions

(1) Climate Zone

5. Fig. III.3.3 shows the climate zones in Thailand which is classified into three zones.

Aw; Dry Tropical Scrub and Thorn Forest

Am; Tropical Monsoon Forest

Af; Tropical Rain Forest

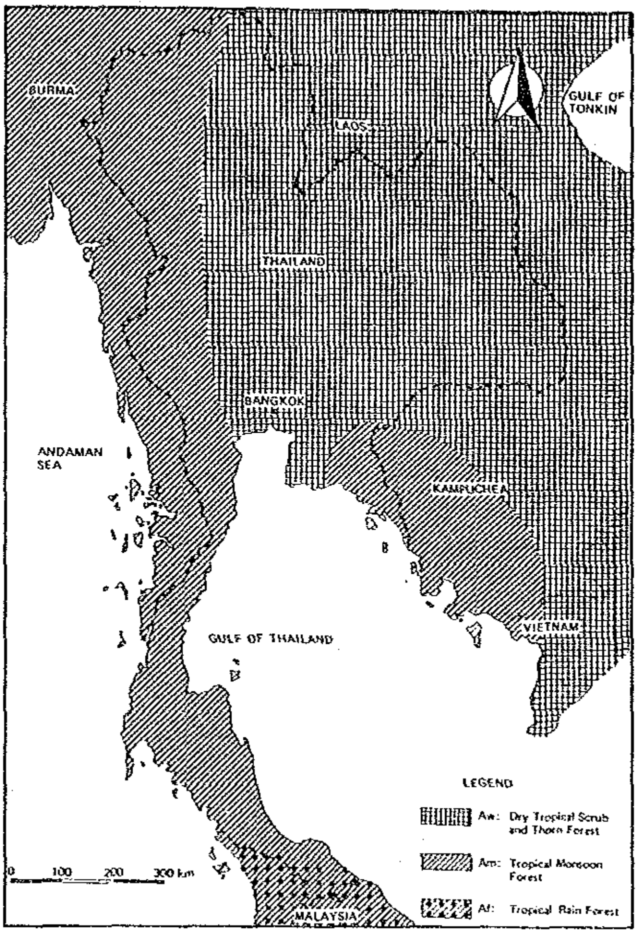


Fig. III.3.3 Climate Zones in Thailand

6. Bangkok belongs to the tropical wet climate zone. This zone covers major areas of Thailand in the Central, Northern and Eastern Regions, and has a wet season and a dry season. The dry season occupies much of the year and rain falls seasonally in the wet season. The climate of Thailand is governed mainly by monsoons. Three well-defined seasons arise as a consequence of the prevailing winds. Climatological data for Bangkok Metropolis during 1956 to 1985 is shown in Table III.3.1.

Table III.3.1 Climatological Data in Bangkok (1956 -1985)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Temperature (°C)													
Mean	25.6	27.2	28.6	29.6	29.3	28.7	28.1	27.9	27.6	27.5	26.7	25.5	27.7
Mean Max.	31.9	32.8	33.9	34.9	34.2	33.1	32.6	32.4	32.4	31.8	31.5	31.4	32.7
Mean Min.	20.6	23.1	24.8	25.9	25.6	25.3	24.9	24.8	24.5	24.3	23.0	20.9	24.0
Ext. Max.	33.7	36.6	39.8	40.0	39.5	37.7	37.8	36.3	36.0	35.3	35.1	35.2	40.0
Ext. Min.	11.5	14.9	16.5	19.9	21.1	21.7	22.2	21.2	21.6	18.3	14.2	10.5	10.5
Relative Humidity (%)													
Mean	72.1	75.7	76.0	76.0	78.4	78.5	79.3	80.2	82.8	82.2	77.5	72.5	77.6
Mean Max.	90.6	92.2	91.6	90.7	92.2	91.5	91.8	93.2	94.8	94.3	92.5	90.0	92.1
Mean Min.	48.6	53.4	55.2	55.8	60.1	62.3	63.5	63.9	66.0	65.6	59.4	52.1	58.8
Ext. Min.	27.0	17.0	23.0	28.0	30.0	38.0	43.0	47.0	49.0	36.0	36.0	31.0	17.0
Rainfall (mm)													
Mean	9.3	29.1	26.2	66.4	189.9	156.1	158.7	204.6	339.4	239.3	48.3	9.7	1477.0
Mean rainy days	1.3	2.9	3.0	6.4	15.7	16.7	18.1	20.6	21.5	17.0	5.9	1.3	130.4
Greatest in 24 hr.	39.3	73.0	88.4	89.7	124.7	167.3	108.6	97.8	153.7	123.2	81.2	32.0	167.3
Day/Year	31/61	11/64	30/82	29/57	15/65	13/79	28/76	26/71	23/68	5/69	2/69	8/72	13/79

Source: Meteorological Department

(2) Seasons

7. Thailand has three seasons; rainy season, dry season and hot season. The following outlines the three seasons and Table III.3.2 shows annual temperature and humidity. The temperature through the year does not vary largely from season to season.

Table III.3.2 Mean Temperature and Humidity

	Temperature			Humidity		
	Max °C	Min °C	Max-Min°C	Max %	Min %	Max-Min %
Month	31.4-34.9	20.6-25.9	7.5-11.1	90.0-94.8	48.6-66.0	28.8-41.4
Year	32.7	24.0	8.7	92.1	58.8	33.3

1) Rainy Season

8. The rainy season is from mid-May to September when air streams flows from the southwest. The rainfall during the rainy season in Bangkok presents some regularities. In general, it starts raining the late afternoon or in the evening with strong showers usually coupled with thunderstorms.

2) Dry (Cool) Season

9. Air streams flow from the northeast during the months from November to February.

3) Hot Season

10. Thailand has the hottest and most humid season for three months from March to May due to the reduction of the influence of the northeast monsoon in this season.

(3) Rainfall

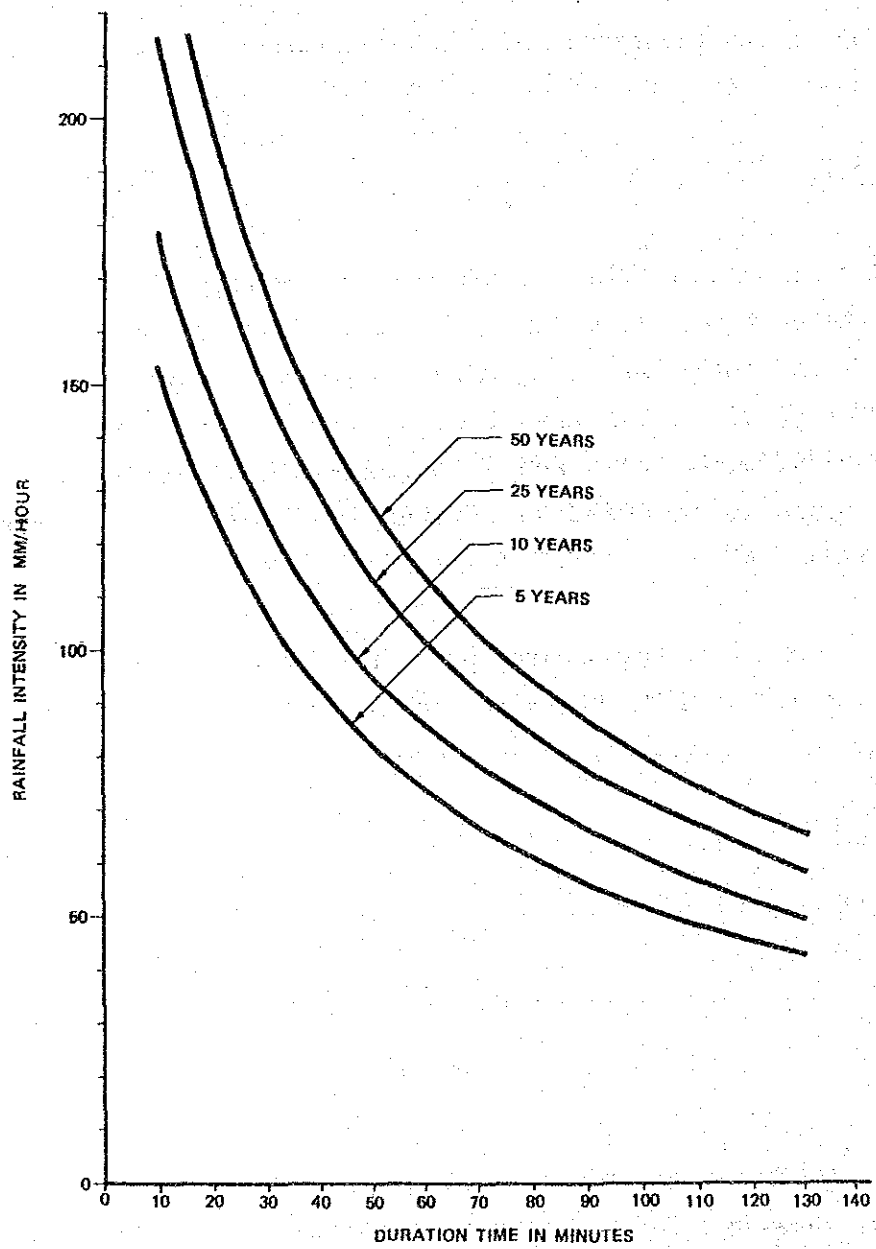
11. Annual mean rainfall in Bangkok is 1,477mm with 130.4 rainy days per year. In the half year from May to October, rainfall totals 1,288mm, which is 87.2% of the total annual rainfall, and rainy days total 109.6 days, which is 84% of the total annual rainy days. September is the wettest month with 339.4mm of rain and 21.5 rainy days. The maximum rainfall within 24 hours is recorded as 167.3mm in June followed by 153.7mm in September.

12. The rain record of the project area from 1956 to 1971 is shown in Table III.3.3. The rainfall is characterized by high intensity, short duration storms as shown in Fig. III.3.4.

Table III.3.3 Mean Rainfall and Rainfall Days at Lat Krabang (1956 - 1971)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Rainfall mm	7.5	23.9	12.7	75.6	191.3	154.2	165.6	216.3	293.7	193.9	37.2	14.5	1386.4
Rainy days	0.3	1.4	0.6	3.8	10.0	8.6	10.1	11.8	15.3	9.1	2.4	0.7	74.1

Source: Meteorological Department



Source: Department of Highways

Fig. III.3.4 Intensity - Duration - Frequency Curve in Bangkok Metropolis

3.1.4 Floods

13. The Chao Phraya basin, a vast alluvial plain called the Bangkok Plain, was developed through soil sedimentation and deposition by the Chao Phraya River.

14. The Bangkok Plain is dissected by numerous canals and drainage courses which irrigate and drain the vast area developed for rice cultivation. Land gradients are extremely flat in the delta region and the area is covered with an impermeable and deep layer of clay. The altitudes of the lowest and highest lands do not differ by more than about one meter and the mean land elevation in the Bangkok Metropolitan area is 1.5 meters above the mean sea level.

15. Therefore, at the end of the rainy season, the rainfall and the high water of the Chao Phraya River cause floods frequently about 50cm above the surface of the land. Remarkable floods in the Greater Bangkok area occurred in 1983 is shown in Table III.3.4.

Table III.3.4 Monthly Rainfall in 1983

unit: mm

Station	Don Muang	Bangkhen	Bangkok	Bang Na	Bang Kapi	Minburi
Jan.	0	0	0.3	0	0	0
Feb.	0	0	0	0	0	0
Mar.	0	5.5	29.0	46.2	0	0
Apr.	0	0	0	0	0	0
May	198.6	172.8	47.7	35.4	124.1	208.3
Jun.	135.3	169.2	161.4	112.3	107.0	134.4
Jul.	160.5	185.6	230.2	104.8	157.3	157.5
Aug.	414.3	515.7	574.5	556.7	510.6	304.8
Sep.	237.2	430.5	453.8	293.4	335.2	320.1
Oct.	267.0	350.7	487.7	325.7	out of order	205.7
Nov.	44.2	160.7	131.8	128.8	251.1	85.8
Dec.	15.0	14.9	13.6	0	0	0
Annual	1,522	2,006	2,130	1,603	1,564	1,417

Source: Meteorological Department

16. The inside Green Belt and the Khlongs Song Tong Nun basin are used to prevent floods.

3.1.5 Underground Water

17. In the upper 200m of the deposits, six separate confined aquifers have been identified at depths of approximately 35, 65, 85, 115, 150 and 200 m.

18. The aquifers at 85m and 150m are the most heavily used at the present time. These aquifers consist of poorly sorted mixtures of fine sand, coarse sand and gravel, and are of great areal extent having an average thickness of about 20m.

3.1.6 Earthquakes

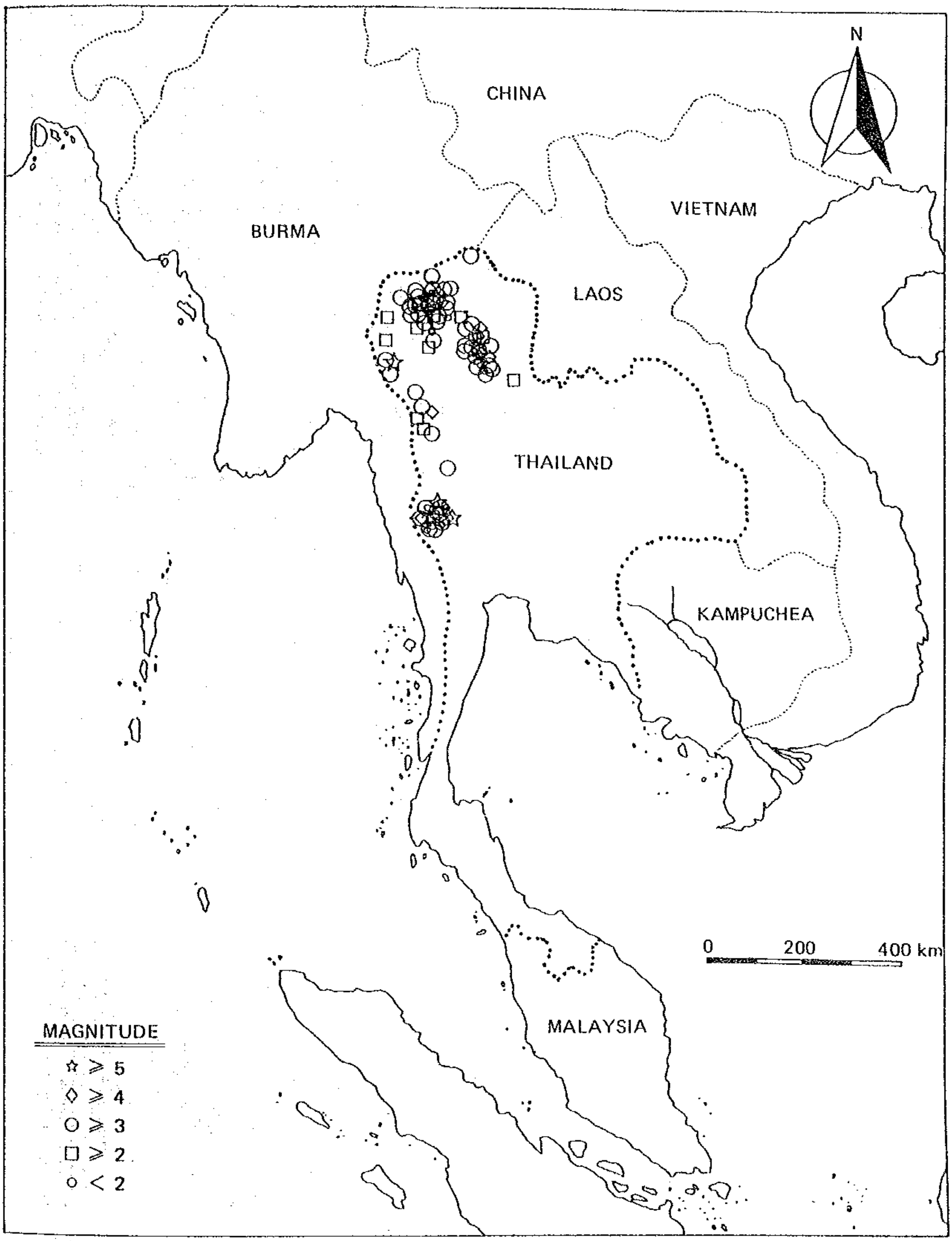
19. Seismic areas concentrate in the mountainous areas of northern and western Thailand, mainly in Tanen Taunggyi district as shown in Fig. III.3.5. The magnitude of the earthquakes ranges mostly between M2 and M4. The earthquakes of those magnitudes comprise 98% of all earthquakes, as shown in Table III.3.5. and Fig. III.3.6.

Table III.3.5 Magnitude Distribution of Thailand (1975-1987)

Magnitude (M)	M<2	M≧2	M≧3	M≧4	M≧5
Percentage %	1	38	50	10	1

Source: Meteorological Department

20. Big earthquakes have never been recorded around Bangkok including the ICD area. Earthquakes have only slightly influenced the area in the past years. Due to this, the load of earthquakes is not a major consideration in the design of structures.

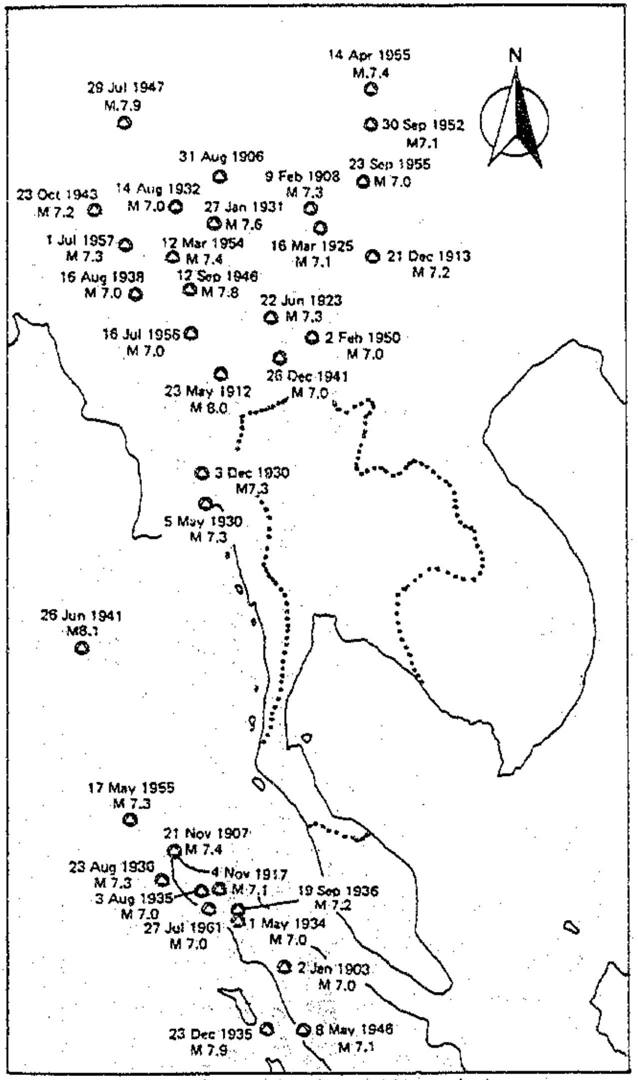


Source: Meteorological Department (1975 ~ 1987)

Fig. III.3.5 Epicentral Distribution Thailand

Distribution of Earthquake

Source: Meterological Department

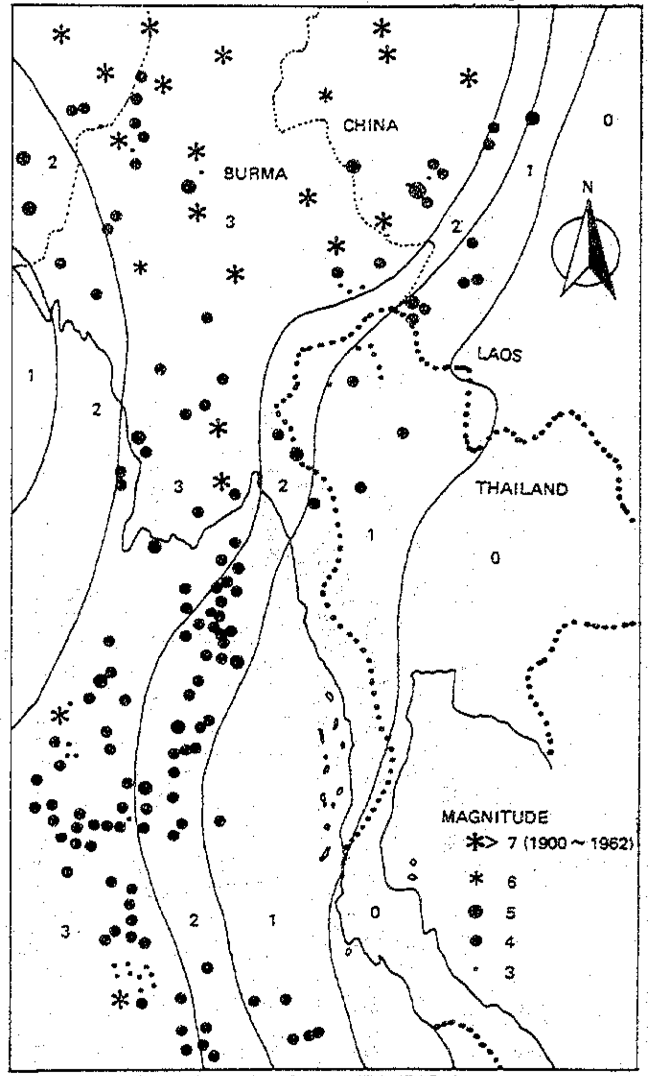


Distribution of earthquake epicentres with magnitude greater than or eqqal to 7 during the period 1900 ~ 1962

A Seismic Probability Map for Thailand

Distribution of Earthquake Epicentre 1975 ~ 1981

Source: Meteorological Department.



EARTHQUAKE PROBABILITY LEGEND

Zone 0 — No damage   Zone 2 — Moderate damage

Zone 1 — Minor damage   Zone 3 — Major damage

Fig. III.3.6 Distribution of Earthquakes

3.1.7 Subsurface Conditions

21. The soil profile in Bangkok can generally be divided into four strata described as follows:

i) A weathered crust of 2 ± 1m, usually composed of mottled gray-brown clay having cracks due to alternate cycles of wetting and drying. The water table is at El 1.0 to 1.5m above the mean sea level.

ii) Very soft to medium dark gray clay, referred to as the soft Bangkok clay, which usually extends to El-12.0 ± 2m.

iii) Stiff to hard, gray and yellow brown clay of variable thickness.

iv) Dense sand and gravel strata, with some sandy clay, that occur alternately at El-22.0 ±2m to an indeterminate depth of at least 300m.

Their typical properties are shown in Table III.3.6

Table III.3.6 Typical Physical Properties of Bangkok Clay

Item	Soft Bangkok Clay Layers (1) and (2)	Stiff Bangkok Clay Layer (3)
Color	Dark gray	Mottled brown and gray
Consistency	Very soft to Medium	Stiff
Natural Water Content	50-88 (60-70)	20-30
Liquid Limit	55-95 (75)	53-65 (59)
Plastic Limit	23-33 (28)	21-24 (23)
Plasticity Index	20-60 (47)	32-42 (37)
Liquidity Index	0.7-1.0(0.85)	0.1
% Finer than 2μ	40	44
Activity	0.6-1.1(0.8)	0.83
Soluble Sale Content(g/liter)	1.5-15 (2.5-10)	5.6
Organic Matter(%)	1-5 (3)	0.8
Specific Gravity	2.65-2.75(2.70)	2.74
Wet Density:		
(t/m^3) Above 2±1m depth	1.65-1.80(1.74)	-
Below 2±1m depth	1.45-1.75(1.65)	-
Dry Density	0.84-1.13(1.13)	1.61
Void Ratio	1.4 -2.2	(less than 1)
Sensitivity	3-7 (5)	1.3
Main Reference	Ladd, et al(1971)	Nelson, et al(1970)

Note: Numbers in parentheses indicate representative values.

3.2 Soil Conditions

3.2.1 Outline of the Soil Investigation

22. The purpose of the soil investigation is to obtain basic data for the design and construction of the ICD.

23. The soil investigations were carried out at the Soi Patana Chonnabot area of the north part of Lat Krabang Railway station and at the Ruam Patana Road area of the south part of Eastern Railway.

24. The Study Team planned the field work and laboratory tests: boring, standard penetration test with sampling, thin-walled tube sampling, and laboratory tests including CBR test. Bore holes were drilled at two locations. The field work and laboratory tests were actually executed by the local consultants during August and September in 1988.

3.2.2 Survey Results

(1) Soil Types Encountered

25. The following four types of soil were observed by the boring survey. Figs. III.3.7 and III.3.8 illustrate the four strata at the two survey points.

1) Weathered Clay Top Stratum

26. The uppermost stratum of 0.5 to 1.5 meters is gray-brown clay, organic soil including humus and forming a weathered "dry crust" and a partial fill of various materials. The underground water levels in bore holes are 0.5m (East area) and 0.2-0.4 meters (West area).

2) Soft Bangkok Clay

27. Very soft to medium dark gray silty clays with occasional shell bits, decayed wood and very fine sand, reaching depths generally between 15.0 to 20.0 meters, recent and highly compressible.

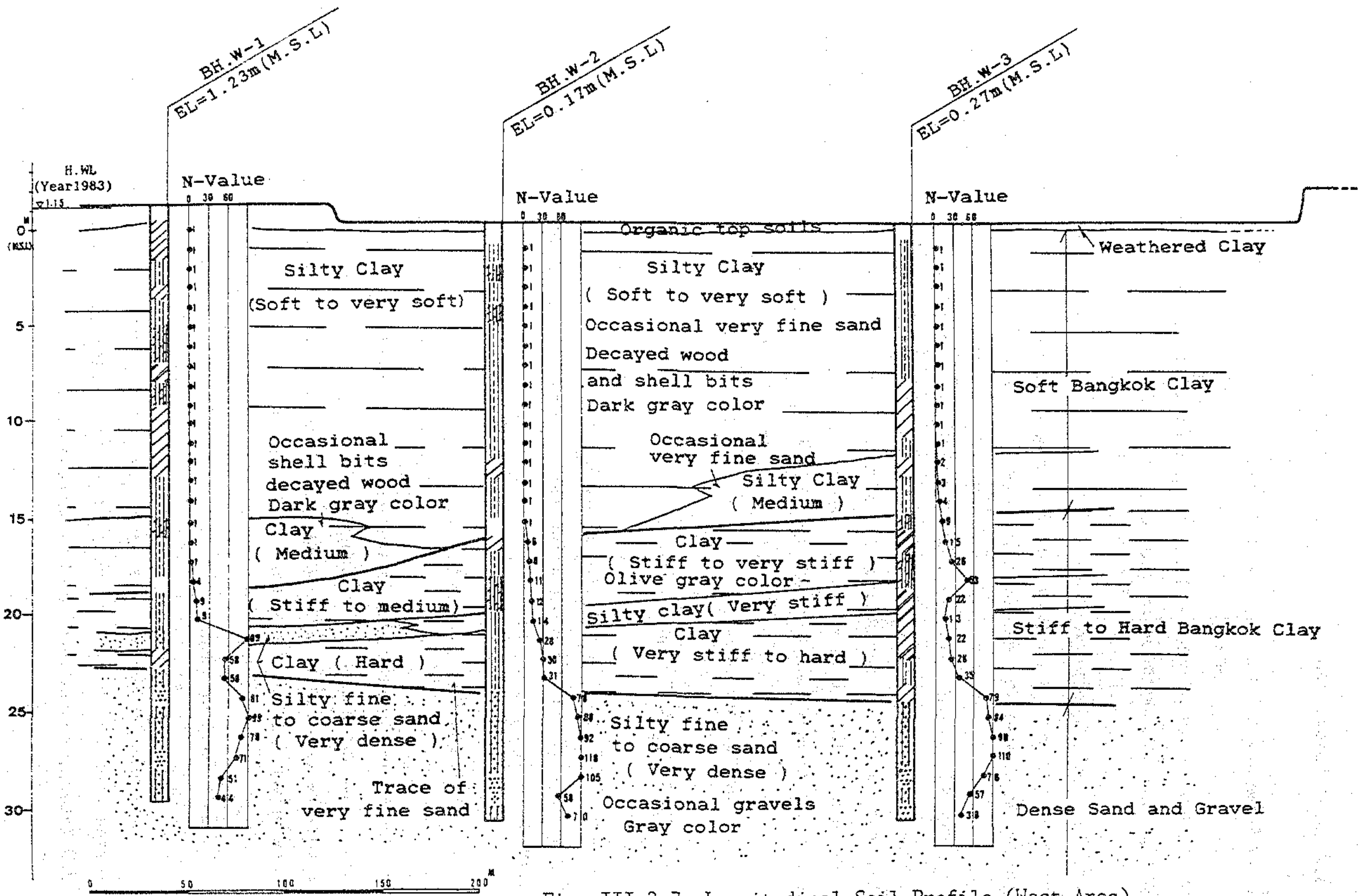


Fig. III.3.7 Longitudinal Soil Profile (West Area)

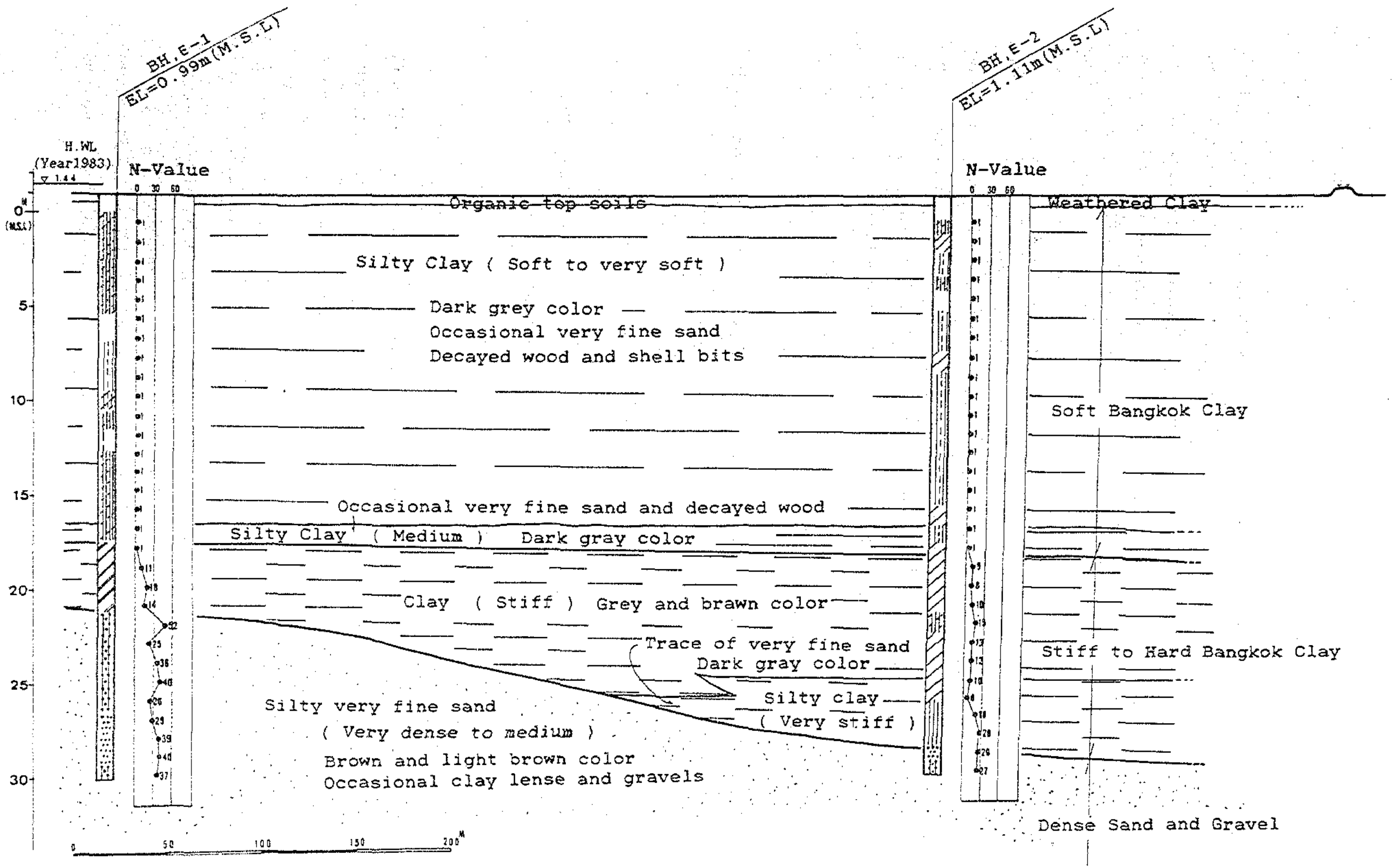


Fig. III.3.8 Longitudinal Soil Profile (East Area)

3) Stiff to Hard Bangkok Clay

28. Stiff to hard gray and brown clay lie underneath the soft Bangkok clay. The depth of this formation is generally between 15.0 to 29.0 meters and the thickness is 4.0 to 10.0 meters. There was a thin substratum of very dense dark gray silty and very fine to coarse sand in the middle of this stratum around the area of Borehole No.1 at the East area site.

4) Dense Sand and Gravel

29. The dense sand stratum is dark gray to light brown silty and very fine sand. The depth of this formation is generally between 21.8 meters in the East area and 23.8 meters in the west area. The N-values range from 25 to 40 and to more than 50 in the East and West areas, respectively.

(2) Soil Test Results

30. Table III.3.7 summarizes the values obtained from the laboratory works, which characterize each of the abovementioned four strata.

3.2.3 Considerations for the ICD Construction

31. The survey results have important implications for the ICD construction; one is about embankment, the other about piling.

(1) Allowable Pile Load Capacity

32. The ultimate load capacity of the precast concrete piles where the pile tops are 1 meter below the existing ground surface is shown in Table III.3.8.

(2) Embankment

33. The Bangkok clay is normally considered sensitive clay with a consistency of "very soft to soft" and with a high compressibility and a high rate of consolidation. This clay appears to be slightly over-consolidated throughout the depth and the "critical load" due to this

Table III.3.7 Soil Test Results from Laboratory

Soils Properties \ Serata		Soft Bangkok Clay	Stiff Bangkok Clay	Dense Sand	Dense Sand & Gravel
Depth m		15.0 ~ 20.0	15.0 ~ 29.0	22.0 ~ 23.0	21.8
Color		Dark gray	Gray & Brown	Dark gray	Dark gray
Consistency		Very Soft Medium	Stiff to Hard	Dense	Dense
Field test	N-value	0 ~ 1	6 ~ 79	89	25 ~ 118
	average	1	20.2	89	62
Classification	Visual Classification	CL - CH	CL - CH	SP	SM - SP
	Unified Classification	CH	CH - CH	SP	SP
Atterberg Limits	Liquied Limit %	29.44 ~ 66.79	23.46 ~ 74.00	-	-
	average	46.20	44.22	-	-
	Plasitc Limit %	17.02 ~ 40.75	14.95 ~ 45.04	NP	NP
	average	30.74	26.45	NP	NP
	Plasticity Index %	5.82 ~ 35.37	7.02 ~ 37.47	-	-
	average	15.33	20.06	-	-
	Liquidity Index %	28.10 ~ 1,545.32	0.46 ~ 143.59	-	-
	average	435.63	46.49	-	-
Specific Gravity		2.60 ~ 2.78	2.59 ~ 2.78	2.62	2.55 ~ 2.78
average		2.69	2.69	2.62	2.69
Natural State	Water Content %	30.01 ~ 132.05	14.67 ~ 98.42	21.42	11.58 ~ 24.51
	average	87.40	36.62	21.42	19.10
	Bulk Density g/cm³	1.34 ~ 1.93	1.83 ~ 2.21	2.23	1.89 ~ 2.29
	average	1.55	2.02	2.23	2.12
	Void Ratio	0.778 ~ 3.588	1.786 ~ 0.447	0.424	0.287 ~ 0.797
	average	1.873	0.803	0.424	0.514
Strength Parameters	Uc g/cm²	0.080 ~ 1.780	0.860 ~ 4.920	-	-
	average	0.404	2.119	-	-
	Ps t/m²	1.590 ~ 3.980	-	-	-
	average	2.461	-	-	-
	Up kg/cm²	0.25 ~ 1.00	0.750 ~ 4.500	-	-
	average	0.367	2.574	-	-
	C t/m²	-	-	-	0
	average	-	-	-	0
	ϕ °	-	-	-	33.5 ~ 34.5
	average	-	-	-	34.0
Chemical Analysis	pH	8.3	8.0 ~ 8.4	-	7.6 ~ 7.9
	average	8.3	8.2	-	7.75
	SO_4 ppm	95.0 ~ 130.0	9.5 ~ 15.0	-	14.6 ~ 28.0
	average	112.5	12.25	-	21.3
	Cl ppm	13.0 ~ 18.0	1.5 ~ 2.0	-	1.8 ~ 4.0
	average	15.5	1.75	-	2.9
C B R		1.90 ~ 1.96			
average		1.93			
Coefficient of Permeability cm/sec		0.0007 ~ 0.3147	x 10.E - 06		

Uc: Unconfined Compressive Strength
Up: Penefrometer Test
C,ϕ: Direct shear Test
CL,CH: Silts and Clays
SP,SM: Sand and Sandy soils

Table III.3.8 Allowable Pile Load Capacity

Area	Boring No	Pile tip elevation	Pile length	Type I.30				Type I.35				Type I.40			
				Perimeter 120cm				Perimeter 140cm				Perimeter 160cm			
				Tip area 660cm²				Tip area 880cm²				Tip area 1240cm²			
		m	m	Qu t	Qn t	Qa t	Qa't	Qu t	Qn t	Qa t	Qa't	Qu t	Qn t	Qa t	Qa't
West	1	23.0	22.0	106.03	19.10	34.01	42.41	140.37	22.29	46.34	56.15	190.87	25.47	65.14	76.35
		24.0	23.0	92.38		28.55	36.95	111.37		34.74	44.55	133.83		42.33	53.53
		25.0	24.0	120.72		39.88	48.29	159.00		53.79	63.60	213.73		74.28	85.49
	2	23.0	22.0	100.41	28.43	27.65	40.16	118.58	33.17	32.84	47.43	138.59	37.90	38.76	55.44
		24.0	23.0	119.73		35.38	47.89	146.57		44.03	58.63	180.39		55.48	72.16
		25.0	24.0	152.79		48.61	61.12	198.34		64.74	79.34	262.93		88.99	105.17
	3	22.0	21.0	111.06	22.90	39.64	49.72	131.56	26.71	47.14	58.90	154.58	30.53	55.79	69.22
		23.0	22.0	124.29		45.18	55.26	107.24		53.69	65.45	173.04		63.46	76.89
		24.0	23.0	138.14		54.05	64.13	163.62		67.16	78.91	192.22		84.32	97.75
East	1	22.0	21.0	93.67	15.64	30.59	37.47	114.01	18.25	37.58	45.60	139.24	20.85	46.52	55.69
		23.0	22.0	107.61		36.16	43.04	135.52		46.18	54.21	173.35		60.17	69.34
		24.0	23.0	107.48		36.11	42.99	134.40		45.73	53.76	169.62		58.67	67.85
	2	23.0	22.0	94.69	17.32	30.26	37.88	111.48	20.20	35.70	44.59	129.54	23.09	41.66	51.81
		24.0	23.0	100.63		32.63	40.25	118.27		38.42	47.31	137.01		44.65	54.80
		29.0	28.0	-		-	-	170.87		59.46	68.85	199.22		69.53	79.69

Qu : Ultimate load bearing of the pile
Qn : Negative skin friction
Qa : Allowable pile load capacity (The factor of safety is 2.5)
Qa': Allowable pile load capacity (Without negative skin friction)

effect is of great engineering significance in terms of stability and settlement problems.

34. Settlement rates of embankments differ according to the load of the embankment on the existing ground, which is calculated based on the materials and thickness of the embankment.

35. The Bangkok clay has extremely low strength and high compressibility and the presence of thin lenses of silt and sand in the soft Bangkok Clay complicates the settlement rates considerably. Therefore, for forecasting settlement and its rate for the soft Bangkok clay, it is much safer to make use of empirical, observed time-settlement relationships on a similar subsurface condition with similar loading than to estimate by the results of the laboratory tests. Otherwise, a test embankment of the same height as the original embankment should be constructed at a study area as soon as possible, and settlement plates, piezometers and surface stakes should be installed beneath and around the test embankment, and field measurements should be taken regularly in order to obtain empirical data.

36. Lateritic soils and river sand are often used for embankment construction in the Bangkok area. It is recommended that the materials for embankment be selected based upon the results of sufficient investigations.

CHAPTER 4 OPERATION IN THE ICD

4.1 Operation

4.1.1 Main Operation System in the ICD

1. The efficiency of operation and the quality of the service are governed by the container handling system and the types and quantities of equipment assembled in each ICD. Container handling systems are classified by the handling equipment used such as the chassis system, the straddle carrier system, the transtainer system and the top lifter system, all of which are used in marine container terminals. A comparison of container handling systems is shown in Table III.4.1. This is intended only as a general guideline.

2. Under the chassis system, each container is placed on a chassis and stored in the container yard. This system requires a large land area and a large number of chassis since containers are stored in a single tier. In the three other systems, containers are stacked in the container yard in tiers -- 3 tiers maximum using a straddle carrier or top lifter, and normally 4 tiers using a transtainer -- which enables the efficient use of land area. Considering the flexibility in handling, the straddle carrier system is an excellent operational system. However, many skilled operators and a high level of maintenance are required. The initial investment for this system as well as for the transtainer system is larger than that for the top lifter system. The top lifter, which is popular in Bangkok, is developed from the forklift truck and is used for handling in a comparatively small area.

3. The total container volume of each ICD is estimated at about 29,000 TEUs per year. Judging from this volume and the above examination (although the adoption of each system shall be left to each ICD operator), the top lifter system is the most appropriate, in combination with a chassis feed.

Table III.4.1 Comparison of Container Handling Systems

Area of Comparison	Chassis	Straddle Carrier	Tire-Mounted Transtainer	Top Lifter
1. Land Utilization	Very Poor	Good	Very Good	Good
2. Initial Investment including Equipment	Large	Medium	Large	Small
3. Heavy Pavement	Not Required	Required	Required(Partial)	Required
4. Mobility and Flexibility	Very Large	Large	Small	Large
5. Container Shifting	No	Medium	Large	Medium
6. Number of Skilled Laborers	Small	Large	Medium	Small
7. Maintenance Cost	Low	High	Low	Medium
8. Container Damage	Low	High	Low	Low
9. Safety of Operation	High	Low	Medium	Medium

4.1.2 Operation

4. The following is an outline of the operation system for export containers. The reverse operation is applicable for import containers.

(1) Small-lot export cargoes (LCL) and some large-lot export cargoes (FCL) of shippers which do not have sufficient facilities for stuffing cargo into containers are brought to the CFS by trucks arranged by the shipper.

(2) A CFS clerk issues a receipt to the truck driver after checking the name of the ship which will carry the cargo, the name of the shipping company, the destination, the cargo mark, the number of packages, the weight and measurement, the apparent condition of the cargo and whether customs procedures have been completed or not.

(3) Loose cargoes are unloaded onto the pallets of the CFS separately by each cargo mark according to the directions of the CFS clerk, and are shifted to the storage space within the CFS by forklift.

(4) An empty container is moved from a separate storage area in the yard to the container side of the CFS by a yard tractor according to the instructions of the shipping company, and then the export cargoes are stuffed into the empty container.

(5) The loaded container is moved by a yard tractor to the container stacking yard according to the yard plan prepared by the yard planner.

(6) When an empty road trailer, arranged for by the ICD operator or the container terminal operator, arrives at the gate office, the gate clerk directs the tractor driver to the container stacking position. The yard controller also directs the operator of the top lifter to proceed to the container stacking position by VHF radio.

(7) The top lifter then transfers the container from the storage slot to the road trailer, which is waiting at a specified bay in the vehicle traffic zone. The road trailer returns to the gate office, where the

container is inspected for the seal, apparent damage, etc., and then goes out.

(8) As for railway transportation, before a train arrives, the top lifter transfers containers from the storage slots in the stacking yard to yard chassis, according to the loading work sequence list prepared by the yard planner. The yard tractor then brings the containers to the container marshalling yard at the side of the railway. When the train arrives, the top lifter loads the containers onto the designated slots on the train.

4.2 Organization and Personnel

4.2.1 ICD Office

5. Following is a short explanation of the duties of each section of the ICD office.

(1) Administration Section

1) Administration of the ICD properties and expenditures, including labor costs and the flow of general administration funds. Other general affairs.
2) Dealing with all claims which are concerned with injuries, facilities, equipment, containers, cargoes, vehicles, etc.
3) Issuing invoices for all charges for the ICD operations. Collecting payments.

(2) Business Section

1) Preparation and issuing of necessary documents for import/export containers and cargoes.
2) Arrangements for customs inspections.

(3) Operational Section

1) Planning of loading/unloading to and from trains. Container marshalling in the container yard. Shifting within the container yard. Arrangements of trains and road trailers.
2) Planning of cargo operations such as delivery/receiving, storage, stuffing and unstuffing within the CFS.
3) Arrangement of necessary equipment and operators, and of other workers.
4) Controlling yard operations from the control center in the office. Controlling road trailers in the container yard.
5) Clerical work of container delivery and receiving documents at the gate office. Inspection of the exterior condition of loaded containers and damage inspection of empty containers.
6) Inventory control of empty containers, and the documentation of their

delivery.

(4) Maintenance Section

1) Maintenance of the ICD equipment and facilities. Maintenance, checking and repair of electrical equipment for refrigerated containers and handling equipment (top lifters, forklifts, etc.).
2) Inspection of damaged and dirty containers which are returned to the gate office for repair, and inventory control of repair materials.

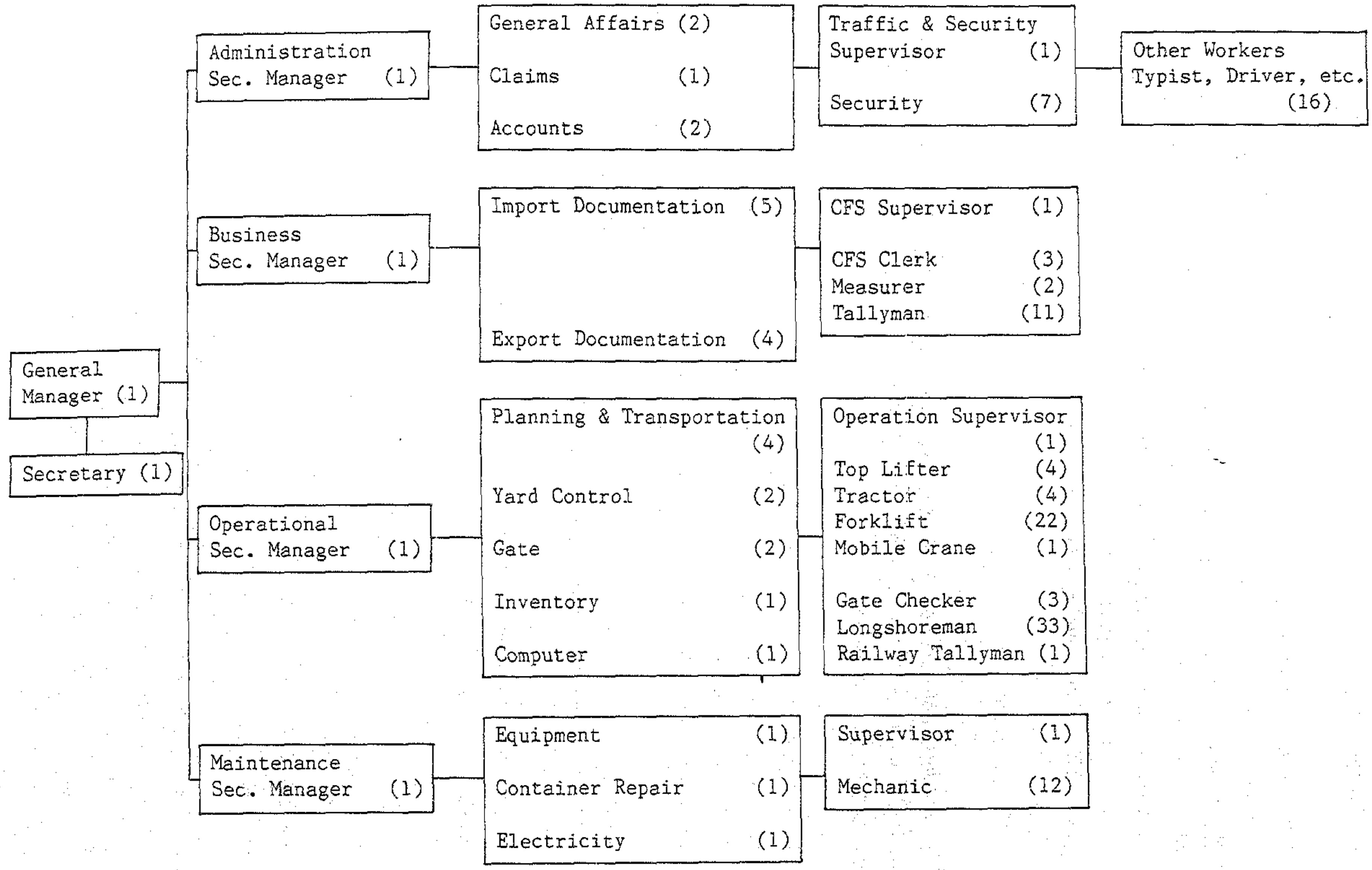
4.2.2 Organization

6. The numbers and functions of personnel which will be required to effectively carry out the ICD operations depend on various factors. The major conditions are considered as follows:

(1) Delivery/receiving of containers and cargoes to and from the ICD is basically limited to a daytime shift (8 hours). However, a flexible response should be made at the request of the marine terminal operator, the shipping company and the shipper/consignee.

(2) A computer system will be introduced in conjunction with the those of the marine terminal and the shipping companies.

7. A sample organization chart and the number of personnel for the ICD in 1996 is shown in Fig. III.4.1.



Total 156 men

Fig. III.4.1 Organization Chart of each ICD

4.3 Necessary Equipment for the ICD Operation

8. The type and quantity of equipment are estimated considering the top lifter system as mentioned avobe.

9. The following is a description of the role of each piece of container and cargo handling equipment.

(1) Top lifter (35-ton) with telescopic spreader

This machine is used to transfer or shift containers, as the spreader attached to the mast of the forklift grasps the container from above and lifts it up or down. Top lifters are mainly used in the container stacking yard for loaded containers and in the container marshalling yard near the side of the railway.

(2) Top lifter (10-ton) with telescopic side spreader

This is used to hoist and shift containers, supporting the sidewalk of the container with the front of the forklift. The side spreader attached to the mast of the forklift grasps the container at two longitudinal corner fittings. Top lifters (10-ton) are exclusively used for empty containers at the separate yard area and in the container repair area.

(3) Yard tractor and yard chassis

The yard tractor, which is a tractive unit and is usually unlicensed, hauls the yard chassis exclusively used for containers. The yard tractors and chassis are used to transfer containers between the container yard, the CFS and trains. The yard chassis can carry one forty-foot container or two twenty-foot containers.

(4) Mobile crane (20-ton)

The mobile cranes are used to pick up containers that have fallen down due to misoperation, etc., and can also be used for the handling of bulky cargoes and containers.

(5) Forklift (6-ton)

Forklifts (6-ton) are used for bulky or heavy cargoes that are handled at the CFS.

(6) Forklift (2-ton, 3-ton)
2-ton forklifts are mainly used at the CFS to stuff/unstuff loose cargoes to and from containers. On the other hand, 3-ton forklifts are used to shift cargoes between containers and the storage space of the CFS, and to deliver/receive cargoes to and from consignees/shippers. They are also used for auxiliary purposes as well.

(7) Weighbridge (50-ton)
A weighbridge scale is installed under the gate lane for delivering export containers and receiving import containers. The total weight of each vehicle and container that passes is indicated on the meter in the gate office.

(8) Wireless phone (VHF)
This is used for the yard controller in the control center to supervise the operators and drivers of container handling equipment in the ICD, and to instruct them about container shift plans and railway-side operation plans.

10. The necessary equipment for each ICD in 1996 is listed in Table III.4.2.

Table III.4.2 Equipment Necessary for each ICD

Item		Number
Top Lifter	(35-ton)	4
"	(10-ton)	1
Yard Tractor		5
Yard Chassis		36
Mobile Crane	(20-ton)	1
Forklift	(6-ton)	2
"	(3-ton)	14
"	(2-ton)	13
Weighbridge	(50-ton)	2
Wireless Phone	(VHF)	15
Small Equipment (Sling, Pallet, etc.,-- Set)		1
Mini Truck	(2-ton)	1
Messenger Car		1

CHAPTER 5 LAYOUT PLAN OF THE LAT KRABANG INLAND CONTAINER DEPOT

5.1 Scale of the ICD

5.1.1 Cargo Volume

1. As estimated in the cargo forecast in Chapter 1 of this Part, the cargo volume which would be stuffed or unstuffed at the Lat Krabang ICD would be as follows:

	Import	Export	Total
1996	826,000	461,000	1,287,000 tons
2001	1,398,000	706,000	2,104,000 tons

The number of containers corresponding to the above cargo volume is estimated by each transportation mode as shown in Table III.5.1.

Table III.5.1 Container Volume by Each Transportation Mode Between the ICD and Laem Chabang Port

Unit:TEUs

	1996			2001		
	Export	Import	Total	Export	Import	Total
Road	25,000	55,500	80,500	38,200	95,900	134,100
Railway	13,400	13,400	26,800	20,600	20,600	41,200
Total	38,400	68,900	107,300	58,800	116,500	175,300

5.1.2 Number of ICDs

2. In this study we suppose that each ICD corresponding to each marine terminal at Laem Chabang Port will be located at the Latkrababang ICD. From the cargo volume forecast the container cargo which will be handled at Laem Chabang Port will be 638 thousand TEUs in 1996 and 953 thousand TEUs in 2001. On the other hand, assuming that the container handling capacity would be 160 thousand TEUs per berth with the ICD, the required number of container handling berths at Laem Chabang Port will be 4 in 1996 and 6 in 2001.

3. Therefore, there would be 4 marine terminals at the Laem Chabang Port and 4 ICDs at the Lat Krabang ICD in 1996, and 6 marine terminals and 6 ICDs in 2001. Consequently, the volume of container cargo in each ICD will be 29,200 TEUs per year, 9,800 TEUs for export and 19,400 TEUs for import.

5.1.3 Facilities in each ICD

(1) Container Freight Station

4. The required space of the CFS is calculated by the following formula.

$$A = \frac{Q_c \cdot \beta}{W \cdot \alpha \cdot R}$$

A: required space of the CFS (m^2)

Q_c: container cargo volume (tons/year)

W: storage capacity (tons/m^2) = 2 tons/m^2

α: utilization factor of floor space for cargo storage = 0.70

R: cargo turnover = 52 times/year

β: required space ratio for storage of machines and tools = 1.1

Container volume is estimated as 1,287 thousand tons in 1996 and 2,104 thousand tons in 2001. Then the required space of the CFS will be

$$A\ (1996) = \frac{1,287,000 \times 1.1}{2 \times 0.70 \times 52} = 19,500\ m^2$$

$$A\ (2001) = \frac{2,104,000 \times 1.1}{2 \times 0.70 \times 52} = 31,800\ m^2$$

5. As the depth of a CFS is usually about 40 meters, the necessary frontage of the CFS will be 490 meters in 1996 and 795 meters in 2001. Considering the frontage lengths and the existing scale of most CFS facilities, the number of CFS buildings will be 4 with a frontage of 130 meters and a depth of 40 meters in 1996, and 6 of the same scale in 2001,

which means that each ICD will have one CFS. Each CFS will have 32 bays with a frontage of 3.75 meters per bay.

(2) Container Yard

1) Reefer Containers

6. At each ICD 700 TEUs of reefer container cargoes would be stuffed and 300 TEUs would be unstuffed per year. So the necessary number of reefer plugs is calculated as follows.

$$N_P = \frac{Q_R \cdot \alpha \cdot D}{365}$$

N_P: required number of plugs
Q_R: reefer container cargo volume (TEUs)
α : peak ratio = 2.0
D : dwell time = 3 days

Then the required number of plugs will be:

$$Np = \frac{1{,}000 \times 2.0 \times 3}{365} = 16$$

7. But the seasonal fluctuation of the reefer cargo would be high, and it is absolutely necessary to provide sufficient reefer plugs for the reefer cargo. And both 20 foot containers and 40 foot containers are used for reefer cargo. Each ICD should have 20 plugs, 10 plugs for 20 foot container and 10 plugs for 40 foot containers. The containers would be stacked in layers of 2; consequently 10 ground spaces will be sufficient.

2) Dry Cargo Container

8. There will be 9,100 TEUs of export cargo stuffed and 19,100 TEUs of import cargo unstuffed per year at each ICD. The required space for containers is calculated as follows:

$$A_D = \frac{Q_D \cdot \alpha \cdot D}{365 \cdot H_D}$$

A_D : required ground space (TEUs)

Q_D : dry container cargo volume (TEUs)

α : peak ratio = 1.1 (seasonal fluctuation)

D : dwell time = 3 days

H_D : stacking height = 1.5

Then the required number of spaces will be;

$$A_D = \frac{(19,100 + 9,100) \times 1.1 \times 3}{365 \times 1.5} = 170 \text{ spaces}$$

3) Empty Container Boxes

9. The total number of empty boxes per ICD per year will be 19,400 TEUs. The required number of spaces for stacking is calculated in the same way as for the above dry cargo containers. But the dwell time will be 6 days and the average stacking height will increase to 3 layers.
So, the required number of spaces will be

$$A_E = \frac{19,400 \times 1.1 \times 6}{365 \times 3} = 117 \text{ spaces.}$$

4) Container Yard Space

10. The container handling machines at the Lat Krabang ICD are assumed to be top-lifters. Then the required stacking space per TEU will be about 75 square meters. Consequently, the required area of the container yard will be

$$Ac = 75 \times (10 + 170 + 117) = 22,000 \text{ m}^2$$

(3) Space for Parking of Yard Chassis

11. In each ICD 36 yard chassis will be used for container handling. Then parking space for 20 chassis will be required in each yard. The necessary area is about 1,400 square meters.

(4) Space for Railway Transportation

12. The required yard space for container handling for railway transportation is a width of about 25 meters from the edge of the rail.

(5) Gates

13. The number of gates is calculated by the maximum gate throughput of the container boxes. It requires about 2-3 minutes to pass through a gate per box. So considering the container volume per ICD, each ICD will require three lanes, one in bound, one out bound and one additional gate.

(6) Office

14. For operators, customs officers and other related persons, each ICD will have an office building adjacent to the CFS. The monitoring of the container handling will be carried out from the top of each office building.

(7) Maintenance and Repair Shop

15. The maintenance and repair shop is designated only for light repair at the ICD. The floor space is 32m x 20m.

(8) Parking Space

16. Parking space for trucks, passenger cars and motorcycles will also be provided at each ICD.

(9) Other facilities

17. The following facilities are also considered;
- Container washing area
- Fuel station for container handling machines

5.1.4 Administration Zone

18. There will be a main office, overtime cargo warehouse, electric sub-station, water supply, septic tank and other facilities in the administration zone.

(1) Main Office

19. The following agencies will have branch offices inside the main office building at the Lat Krabang ICD.

1) Port Management Body
2) Customs Department
3) State Railways of Thailand
4) Terminal Operators' Association
5) Police

The total floor space will be about 1,200 square meters.

(2) Overtime Cargo Warehouse

20. Some imported cargoes will sometimes remain at the CFS without customs clearance longer than the allowable period. Such cargoes should be transferred to the overtime cargo warehouse under the control of the Customs. And if the goods are not cleared within two months they are liable to forfeiture upon 15 days notice. We estimate that the cargoes which remain more than 15 days at the CFS will be transferred to the overtime warehouse and that their average storage period there will be 30 days.
The ratio of the above cargo volume is estimated at 3 percent of the imported container cargo at the first stage. As this ratio is expected to

decrease, the floor space for this purpose in the master plan is 1.5 times the space in the first stage, though the imported cargo volume in 2001 is estimated to be 1.7 times the volume in 1996.

21. Then the required space of the warehouse is:

$$A = \frac{Q_c \cdot D_o}{365 \cdot W \cdot \alpha}$$

A	:	required space(m^2)
Q_o	:	cargo volume = 24,800 tons in 1996
D_o	:	dwell time = 30 days
W	:	storage capacity = 1.5 tons/m^2
α	:	utilization factor of floor space = 0.65

Then the required space is 2,100sq. meters for the first stage plan and 3,200sq. meters for the master plan.

5.1.5 Spur Line

22. The Lat Krabang ICD will be connected to the Eastern Line of the State Railways for the transportation of container cargo between the ICD and Laem Chabang Port. The items to be considered for the spur line are as follows:

1) The capacity of the locomotives of SRT
2) The effective length of the railroad at the stations between Lat Krabang and Laem Chabang
3) The weight of the locomotives, wagons and containers.
4) The length of the locomotives and wagons.
5) The radius of the spur line (at least 300 meters).

The dimensions of the locomotives and wagons and the effective length of the railroad are as follows:

Locomotives : ALSTOM - Type, Length = 16.3m
Weight = 82.5 tons
Tractive weight = 1,280 tons

Freight Wagons : Length = 13.7 m
Weight = 14.4 tons
Loading capacity = 41.6 tons

Effective length of the railroad : 500 m

23. Considering the above capacity and the average container weight of 15 tons per TEU, the length of one freight train will be about 400 - 450 meters. So the required length for the spur line will be 500 meters which is the same length as the effective length of the railroad stations on the Eastern Line.

5.2 Layout Plan

24. The basic concepts of the layout plan are as follows:

(1) Smooth connection of the spur line to the Eastern Line.

(2) Smooth cargo handling at the ICDs
- between the gate and the container yard.
- between the railway and the container yard.
- between the container yard and the CFS.

(3) Smooth connections between each ICD and the main office.

(4) Some reserved area

25. Based on the above concepts, each ICD requires 36 rai (230 m x 250 m). The ICDs, administration zone, access road and spur line are allotted as shown in Fig III.5.1 as a master plan and as shown in Fig III.5.2 as a first stage plan. The detailed layouts of each facility within each ICD and in the administration zone are shown in Fig III.5.3 and Fig III.5.4.

The required land area is 296 rai (47.4 ha) for the master plan and 200 rai (32.0 ha) for the first stage plan.

5.3 Development Plan Around the ICD

26. The Study Team considers that the Lat Krabang ICD is a part of Laem Chabang Port, and the port can not be operated effectively without the ICD. In general, port related facilities, such as warehouses and cargo distribution centers, are located near port areas and operated by private sector firms.

27. Then it is desirable that such facilities also be located around the ICD so that the users of the ICD can utilize it more effectively. The area around the ICD will be the most suitable area for such facilities from the viewpoint of the O/D of the container cargo and the overall transportation network.

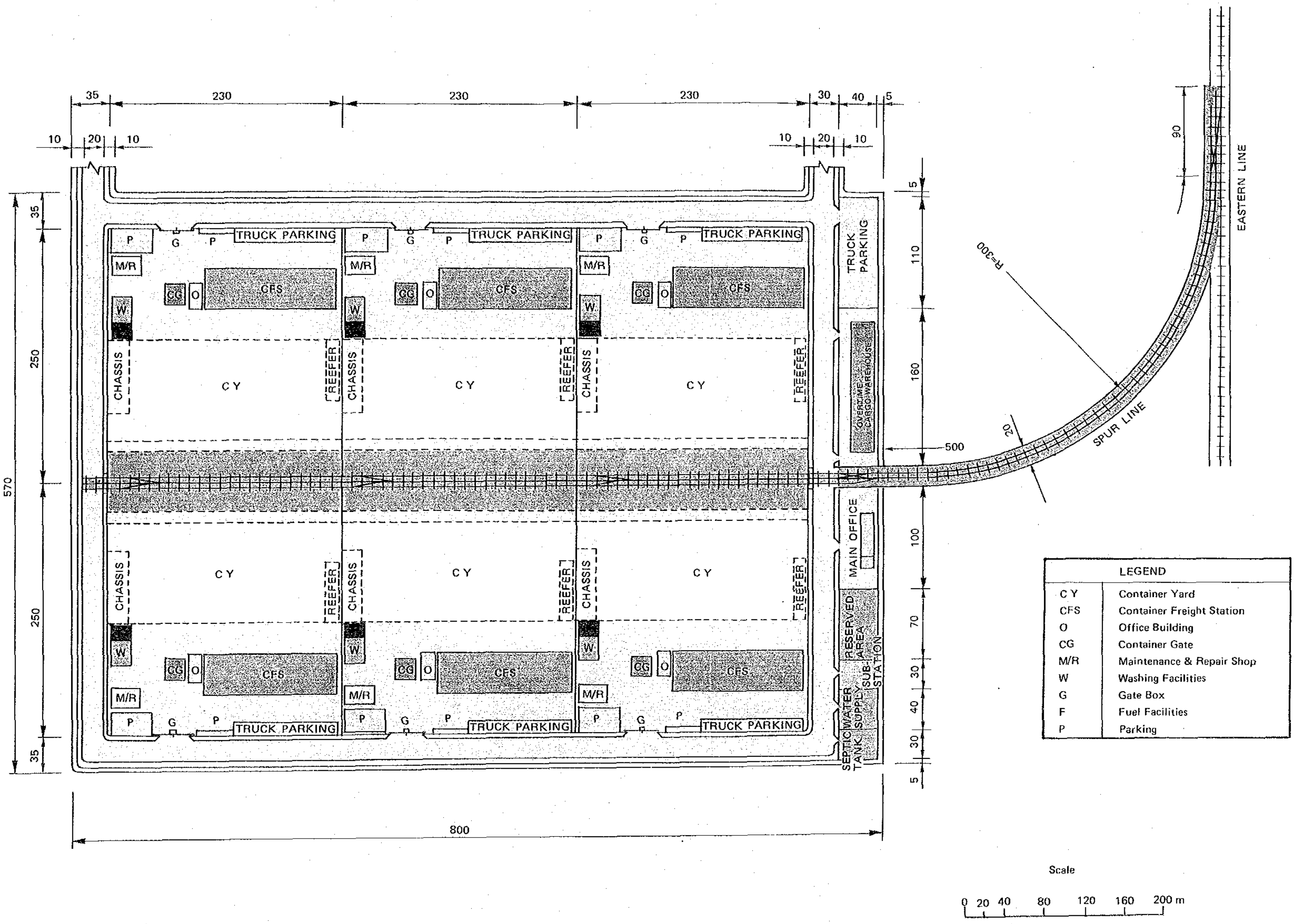


Fig. III.5.1 Layout of the Lat Krabang Inland Container Depot, Master Plan (2001)

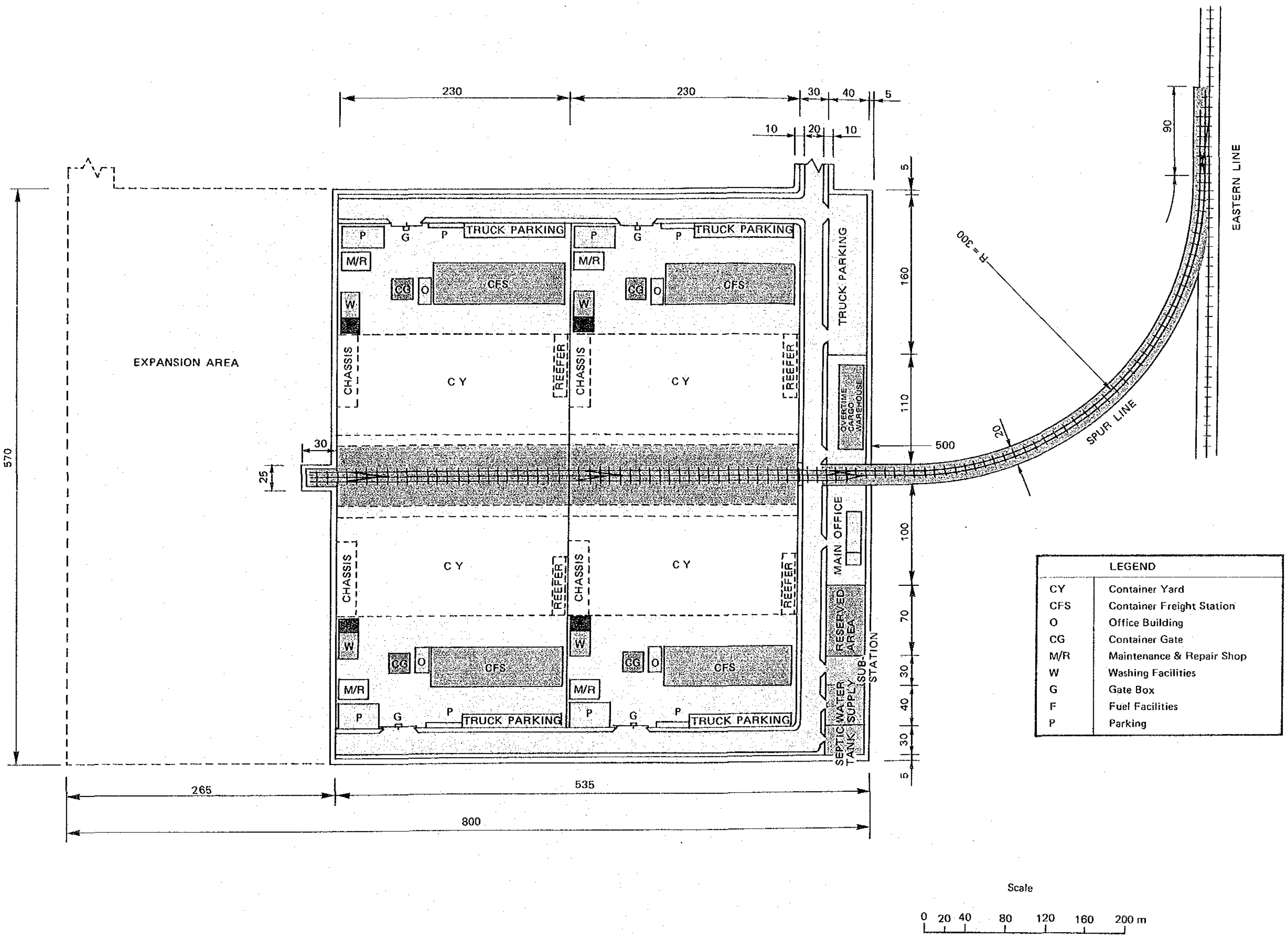


Fig. III.5.2 Layout of the Lat Krabang Inland Container Depot, First Stage Plan (1996)

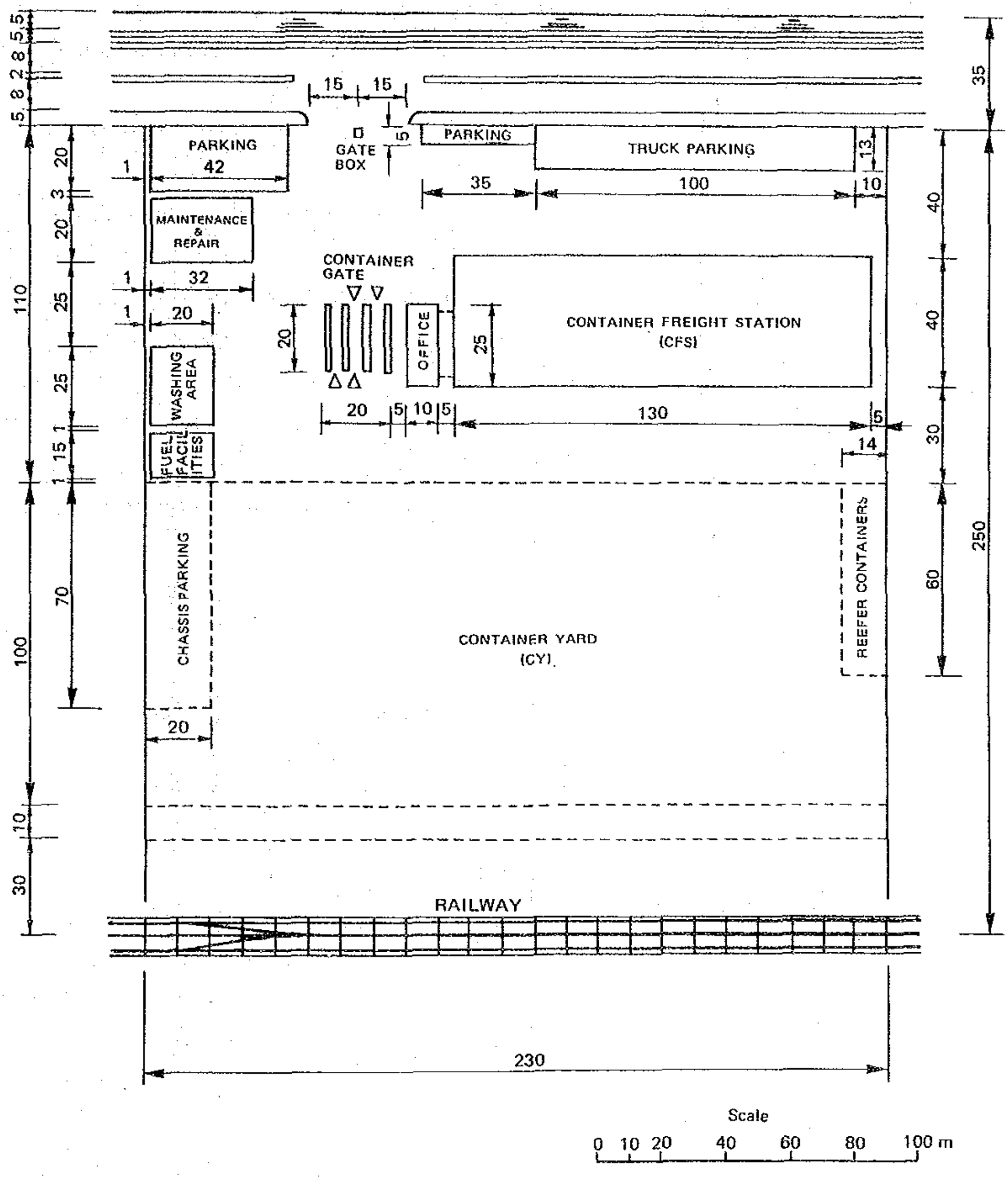


Fig. III.5.3 Layout of Each ICD at the Lat Krabang Inland Container Depot

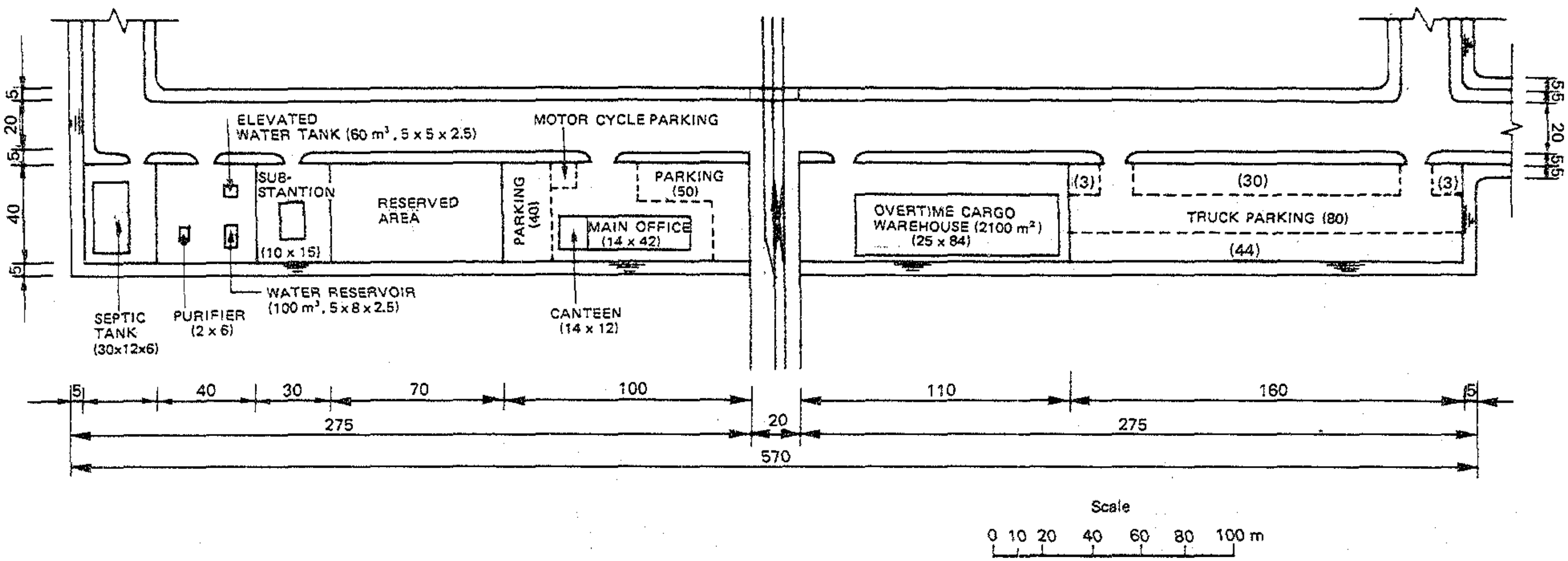


Fig. III.5.4 Layout of the Administration Zone at the Lat Krabang Inland Container Depot (First stage Plan)

CHAPTER 6 PRELIMINARY ENGINEERING DESIGN

6.1 Presuppositions for Preliminary Design

6.1.1 Site Constraints

1. There are no major constraints for the site planning. The proposed site and its surrounding area are cultivated fields with no significant structures. Therefore, the area and configuration of the site required by the site planning of the ICD can be sufficiently secured. It should be noted that the existing site level is lower than the flood protection level (2.0m above M.S.L).

6.1.2 Geological Conditions

2. Results from exploratory drillings at the site reveal the following soil profile.

i) Silty clay (Stratum A) appears directly below the organic top soils and extends to a depth between 15 m to 20 m below the existing ground surface.

ii) Clay (Stratum B) is encountered beneath Stratum A and extends to a depth between 21 m and 29 m below the ground surface.

iii) Silty very fine sand (Stratum C) is located beneath Stratum B and extends to the end of the boreholes at a depth of 30 m below ground surface.

6.1.3 Existing Utilities

(1) Water Supply

3. There are presently no water pipelines, and none are planned for the proposed site and its surrounding area. In general, there are three water sources: deep well, klong and river. However, it is suggested by the Public Work Department of BMA that deep wells should be avoided considering

the influence of over-pumping, i.e., salinity and ground subsidence. Therefore, the klongs would be considered as a possible water source for the proposed facility.

4. The quality of supplied water should meet the Thai Standard for Drinking Water, established by Thai Industrial Standard Institute, Ministry of Industry as shown in Table III.6.1.

(2) Sewage Discharge

5. Sewage disposal systems for individual facilities in the Bangkok Metropolitan Area and its surrounding area are generally septic tanks. The effluent quality of wastewater should meet the standard set by the Industrial Works Department, Ministry of Industry as shown in Table III.6.2.

(3) Electric Power Supply

6. According to the distribution diagram prepared by Metropolitan Electricity Authority, electric power supply is available in the vinicity of the proposed site.

7. Existing electric power supply in Bangkok Metropolis is as follows:

High Tension : 230 kv, 115 kv, 69 kv, 24 kv
Low Voltage : 400 /230 V

Table III.6.1 Thai Standard for Drinking Water (TIS 275-2521)

Particular	Unit	Maximum Acceptable Concentration	Maximum Allowable Concentration
Physical Characteristics			
Colour	Platinum-Cobalt	5	15
Taste		Unobjectionable	Unobjectionable
Odour		Unobjectionable	Unobjectionalbe
Turbidity	Silica	5	20
pH		6.5-8.5	not over 9.2
Chemical Characteristics			
Total Soilds	mg/dm^3	500	1,500
Iron (Fe)	"	0.5	1.0
Manganese (Mn)	"	0.3	0.5
Iron and manganeses (Fe & Mn)	"	0.5	1.0
Copper (Cu)	"	1.0	1.5
Zinc (Zn)	"	5.0	15
Calcium (Ca)	"	75	200
Magnesium (Mg)	"	50	150
Sulphate (SO_4)	"	200	250
Chloride (Cl)	"	250	600
Fluoride (F)	"	0.7	1.0
Nitrate (NO_3)	"	45	45
Alcyl Benzyl Sulfonates (ABS)	"	0.5	1.0
Phenolic Substances (as phenol)	"	0.001	0.002
Toxic Substances			
Mercury (Hg)	"	0.001	
Lead (Pb)	"	0.05	
Arsenic (As)	"	0.05	
Selenium (Se)	"	0.01	
Chromium (Cr hexavalent)	"	0.05	
Cyanide (CN)	"	0.2	
Cadmium (Cd)	"	0.01	
Barium (Ba)	"	1.0	
Biological Characteristics			
Standard Plate Count	$Coloni/cm^3$	500	
M P N	Coliform organism/ $100\ cm^3$	less than 2.2	
E. Coli		none	

Table III.6.2 Thai Industrial Standard for Effluent Waste
Refer: Ministrial Regulations No. 12 (1982)

B O D (5 days 20°C)	avg.	20 mg/1
	max.	60 mg/1
Suspended solids	avg.	30 mg/1
	max.	150 mg/1
Dissolved solids	max.	2,000 mg/1
Salinity	max.	2,000 mg/1
pH value		between 5 and 9
Permanganate value	max.	60 mg/1
Sulphide (as H_2S)	max.	1 mg/1
Cyanide (as HCN)	max.	0.2 mg/1
Zinc	max.	5 mg/1
Chromium	max.	0.5 mg/1
Arsenic	max.	0.25 mg/1
Copper	max.	1 mg/1
Mercury	max.	0.005 mg/1
Cadmium	max.	0.03 mg/1
Barium	max.	1 mg/1
Selenium	max.	0.02 mg/1
Lead	max.	0.2 mg/1
Nickel	max.	0.2 mg/1
Manganese	max.	5 mg/1
Tar		none
Oil & Grease	max.	5 mg/1
Formaldehyde	max.	1 mg/1
Phenols & Cresols	max.	1 mg/1
Free Chlorine	max.	1 mg/1
Insecticide		none
Radioactive substance		none

6.2 Preliminary Design of Facilities

6.2.1 Frame of Design

8. The required manpower and equipment considering the proposed cargo throughput, operation system and organization in the ICD area as follows.

Table III.6.3 Required Equipment and Machines in each ICD

Equipment/Machine	(tons)	Number	Remark
Top Lifter	(35)	4	Spare 1
	(10)	1	
Forklift	(6)	2	
	(3)	14	Spare 3
	(2)	13	Spare 3
Yard Tractor		5	Spare 1
Yard Chassis		36	Spare 2
Mobile Crane	(20)	1	
Small Equipment (Slings, Spreaders, Pallets, etc.)		1	Set
Weighbridge	(50)	2	
Wireless Phone		15	Spare 1
Mini Truck	(2)	1	
Messenger Car		1	

Table III.6.4 Main Office Staff

Section	Number (persons)	
	1996	2001
Port Management	5	5
Customs	50	70
Railway	5	5
ICD Operation	6	9
Others	14	21
Total	80	110

Table III.6.5 ICD Personnel

Section	Charge	Number of Persons	Section Total Persons
General	General Manager	1	
	Secretary	1	2
Administration	Manager	1	
	General Affairs	2	
	Claims	1	
	Accounts	2	
	Traffic & Security Supervisor	1	
	Security	7	
	Other Workers	16	30
Business	Manager	1	
	Import Documentation	5	
	Export Documentation	4	
	Shed Supervisor	1	
	Shed Clerk	3	
	Measurer	2	
	Tallyman	11	27
Operation	Manager	1	
	Planning & Transportation	4	
	Yard Control	2	
	Gate	2	
	Inventory	1	
	Computer	1	
	Operation Supervisor	1	
	Top Lifter	4	
	Tractor	4	
	Forklift	22	
	Mobile Crane	1	
	Gate Checker	3	
	Longshoreman	33	
	Railway Tallyman	1	80
Maintenance	Manager	1	
	Equipment	1	
	Container Repair	1	
	Electricity	1	
	Supervisor	1	
	Mechanic	12	17
Total			156

Besides the above personnel, 20 customs officers will work in the ICD.