SECTORAL REPORT V

UTILITY DEVELOPMENT PLAN

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1. WATER SUPPLY

1.1 Master Plan

1.1.1 Present Condition

Present water supply of the Study Area can be classified into two categories, namely public pipe-water supply by Ao Udom waterworks and private water supply of existing industries.

Ao Udom waterworks, which was established by the Ao Udom Sanitary District in 1970, is located in the east of the Study Area about 6 km away from the route 3. According to the "Feasibility Study for the Nong Kho-Laem Chabang Water Pipeline Project" (hereafter the "Pipeline Study"), the Ao Udom waterworks with the water treatment capacity of 1,200 m^3/day is supplying water to the population of approximately 4,300 which mainly inhabits in Ao Udom town area and along Route 3241 which runs north of the ESSO and Thai Oil Refinary as shown in Fig. V.1.1. Inhabitants at present residing in the area planned for port, industrial estate and urban development are not provided with public pipe water supply. They mainly use rain water or water from shallow dug-well for their domestic use.

There are several industries in the Study Area which possess their own water supply facilities. They are Thai Oil Refinery (TORC), ESSO Oil Refinery, Siracha Industrial Park Estate (SIPE) and the Siracha Sugar Factory (SSF). Present and future water consumption and water source of these industries is summarized below.

Industry	Water Use in 1982 ($10^6 m^3/yr$)	Future Water Use ($10^6 m^3/yr$)	Present Water Sources	Future Water Source
TORC	0.9	2.0/1	Bang Phra	Bang Phra
ESSO	0.8	1.5/2	Sea Water	Sea Water
SIPE	0.4	1.3/3	Groundwater & Stream	Nong Kho
SSF	0.8	0.8	Huai Yai River	Nong Kho
Total	2.9	5.6	-	-

/1 : From 1987
/2 : From 1985
/3 : From 1987

TORC gained an approval from the Royal Irrigation Department (RID) already on the withdrawal of $2.0 \times 10^6 m^3$ from the Bang Phra reservoir after 1987. ESSO which at present utilizes sea water has a plan to increase its production capacity by 1985. Resultant increase in water consumption will be satisfied by the expansion of desalination facilities. Siracha Industrial Park Estate currently depends on groundwater and stream flow for water source. In future water will be supplied both to SIPE and SSF by water pipeline now being planned to connect Nong Kho reservoir and the Laem Chabang Complex. Location of each industry is illustrated in Fig. V.1.1.

1.1.2 Previous Studies

The Pipeline Study was conducted by JICA during the period between August 1983 and March 1984 aiming at formulating an optimum development plan of the raw water pipeline connecting the Nong Kho reservoir constructed by RID in 1983 and the Laem Chabang Complex. Based on the water demand and supply balance study, analysis on route selection and an alternative analysis of the most economical phased development plan, the Pipeline Study proposes to construct the pipeline in two stages with gravity flow to satisfy water demand in the target year of 2001. Principal factors relevant to the present planning is summarized as follows.

1) Location of the receiving well is planned in the Pipeline Study to be in the new town area about 1.0 km away from the satellite station to the south. Its ground elevation is MSL + 35.0 m and H.W.L. of the receiving well is M.S.L. + 36.7 m. In the Pipeline Study, it is assumed that the filtration plant will be located next to the receiving well.

2) Principal features of the pipeline is summarized in the following table.

Description	Unit	1st State	2nd Stage
Commissioning Year	-	1988	1944
Transmission Quantity	$10^6 m^3$/yr	21.6	21.5
Length of Pipeline			
Nong Kho - Turnout/1	km	10.95	10.95
Turnout - Receiving well	km	3.49	3.49
Inside Diameter of Pipe			
Nong Kho - Turnout	mm	1,000	1,000
Turnout - R.W.	mm	900	900

/1 : Facility to withdraw water to Ao Udom waterworks.

Raw water demand of the development area as demarcated in Fig. V.1.2 has been estimated by the Pipeline Study to be 13.2 x $10^6 m^3$/day in 1991 and 32.1 x $10^6 m^3$/day in 2001. The plan for pipeline has been formulated on the basis of this water demand. In the Study, however, the water demand estimated by the Pipeline Study has been adjusted according to the industrial development plan and population projection conducted by the Study.

1.1.3 Water Demand

Future water demand is projected for the Laem Chabang development area, which includes Laem Chabang Complex and surrounding area expected to be urbanized as a result of the government-oriented development in the Complex, so that regional water balance is reviewed comparing water resources availability and projected future water demand.

Water demand in the Laem Chabang complex is composed of domestic, industrial and port water demand.

1) Domestic Water Demand

Water consumption is assumed to be 220 l per capita per day (lcd) in 2001, which is taken from the Pipeline Study. This figure is obtained on the basis that present consumption per capita for around 180 lcd in the Easten Seaboard area will grow at 1% per year as a result of upgrading of living standard. Projected water demand at consumers level (hereafter consumer demand) is as given below.

Area	Population	Water Demand (m^3/day)
New Town	120,000	26,400
Others/1	87,000 /1	19,100
Total	207,000	45,500

/1: - Natural growth : 73,000
- Ao Udom : 14,000

2) Industrial Water Demand

Industrial water demand is projected based on the net area and water consumption per net area of each type of industry planned to be introduced into the Laem Chabang Complex. Results is summarized below and water demand by each type of industry is given in the Table V.1.1.

Item	Water Demand (m^3/day)
EPZ	8,400
GIE	24,800
Total	33,200

It is assumed that water recycling technology will prevail in future in Thailand and reach the present level of Japan in the year 2001. Assumption is that around 80% and 50% of water consumed will be recycled.

3) Port Water Demand

Port water demand comprises two categories; one is for the use of workers in the port and the other is water use by ship. Unit water consumption is assumed to be 150 lcd and 170 m^3 per ship per day. Estimated port water demand is given below.

Item	Volume	Water Demand (m^3/day)
Worker	33,900 person	5,100
Ship	2,200 ships/year	1,000
Total	-	6,100

4) Total Water Demand for Development Area

Total Water demand for the development area in 2001 is summarized in the following table.

Area	Water Use	Per Day (m^3)	Per Year ($x10^6m^3$)
Laem Chabang Complex	Domestic	26,400	9.6 /1
	Industrial	33,200	10.0 /2
	Port	6,100	2.2 /1
Other	Domestic	19,100	7.0 /1
Total		84,800	28.8

/1: computed as 365 days per year

/2: computed as 300 working days per year

Total consumer water demand is projected at 28.8 x 10^6 m^3/year, which corresponds to 37.3 x 10^6m^3/year of the water to be supplied from the reservoir (hereafter called "Source Water Demand") assuming an unaccounted-for-water of 10% and 15% of the water produced at filtration plant between the reservoir and the receiving well and between the receiving well and consumer respectively.

Development plan of the raw water pipeline between the Nong Kho reservoir and the Laem Chabang Complex was formulated by the Pipeline Study to cope with the source water demand of 32.1 x $10^6 m^3$/year in 2001. It is planned that the Nong Kho reservoir will be supplied with raw water from the Nong Pla Lai reservoir in the Rayong River basin. Considering that there is still abundant water resources in the Rayong River basin, it is proposed that the raw water supply plan is amended to meet an additional water demand of 5.2 x $10^6 m^3$/year.

1.1.4 Water Supply Planning

Water supply system comprises distribution system and filtration plant and is basically to be planned for the Laem Chabang Complex as the planning area consisting of the New Town, industrial estate and port area in the development area. Plan for other development area is not included in the Study for the following two reasons.

(1) Situation of future urbanization is not clarified yet at this early stage of development.

(2) It is not economically and technically efficient to transmit filtrated water for about 10 km from the filtration plant to the north extremity of the development area.

In addition to the Laem Chabang Complex, Ao Udom town, which is at present receiving pipe water supply from the Ao Udom Water Works, is included in the planning area.

1) Filtration Plant

The filtration plant is planned based on the daily maximum volume as summarized below, including the planned filtration capacity of the Ao Udom Water Works which amounts to 4,000 m^3/day.

Water Use	Daily Mean	Daily Max /1	Hourly Max /2
Domestic	26,400	37,000	55,500
Industrial	33,200	46,500	69,800
Port	6,100	8,500	12,800
Ao Udom	4,000	5,600	8,400
Total	69,700	97,600	146,500

/1: Daily mean x 1.4

/2: Daily Max x 1.5

Filtration process is determined analyzing water quality. According to the quality investigation performed at the Nong Kho Dam by the Pipeline Study, turbidity is 39 degree and Fe component is 1.7 mg/l as shown in detail in the Table V.1.2. From this result rapid filtration process with chemical sedimentation is considered to be most appropriate for the project.

Since filtration plant is to be designed based on the raw water quality, a detail study of water quality is recommended to be conducted prior to the detailed design at the Nong Kho Dam at least for one year period to observe seasonal change.

Plan and Flow Sheet for filtration plant are shown in Fig. V.1.3 and Fig. V.1.4 respectively. Features of filtration plant facilities are shown in Table V.1.3.

2) Water Distribution System

Filtrated water is conveyed from the filtration plant to the distribution tower for water supply to high land area and to the distribution basin for low land area.

The distribution tower is to be installed at the location of G.L. + 55 m. Its capacity basically requires the volume for 8 hours of planned daily maximum amount plus comsumption for fire fighting. However, due to the difficulty of constructing large scale distribution tower, the volume is separated into the capacity of the distribution tower with one hour of planned daily maximum amount plus comsumption for fire fighting and the rest of seven hours amount, is kept in the clean water basin in the filtration plant.

The distribution basin is to be installed on the location of G.L. + 50 m and its capacity requires the volume for 8 hours of planned daily maximum amount plus comsumption for fire fighting.

Principal features of the distribution tower and the distribution basin are summarised as follows.

Item	Distribution Tower	Distribution basin
Capacity	1,000 m^3	27,000 m^3
G.L.E.	M.S.L + 55.0 m	M.S.L + 50.0 m
H.W.L	M.S.L + 78.0 m	M.S.L + 50.0 m
L.W.L	M.S.L + 75.0 m	M.S.L + 47.0 m
Water Supply Population	57,600 /1	62,400/1 + 33,900/2

/1: Water supply population at housing estate

/2: Workers at port

note; Capacity of distribution basin for low land area comprises the volume for industrial area and for ships.

Distribution pipe is designed at planned hourly maximum amount plus consumption for fire fighting. Computation of pipe network for the distribution pipe is carried out on the basis that polyvinyl chloride be adopted for the range between 100 and 150 mm in diameter and ductile pipe for more than 200 mm in diameter. Layout of water supply system is shown in Fig. V.1.5.

1.2 Short-term Development

1.2.1 Water Demand

Water demand for the target year of 1991 is estimated according to the same methodology as applied for the master plan.

1) Domestic Water Demand

Domestic water demand is estimated with 200 lcd as consumption per capita for the population of the New Town and other urban are as follows.

Item	Population (persons)	Water demand (m^3/d)
N.T.	24000	4800
Others	40900 /1	8200
Total	64900	13000

/1:		
	Population outside the New Town	8100 persons
	Natural growth	18800 "
	Existing Ao Udom	14000 "
	Total	40900 persons

2) Industrial Water Demand

Industrial water demand is estimated on the assumption that types of industries and their composition are same as the Master Plan. Water recycling is assumed to be prevailing to the extent of around 50% of the level in 2001, which is around 25% and 40% for EPZ and GIE respectively. Projected industrial water demand is summarized below.

- GIE /1 : 19,500 m^3/day
- EPZ /2 : 3,800 m^3/day
= Total : 23,300 m^3/day

/1: 110 m^3/ha x 3 (Water to be supplied is 60% of the consumption for production conpared with 20% in Master Plan) x 141 ha x 0.42 (Area in operation)

/2: 99 m^3/ha x 1.5 (75% to 50% in Master Plan) x 46 ha x 0.55 (Area in operation)

3) Port Water Demand

Unit water consumption is assumed to be 150 lcd per worker per day and 170 m^3 per ship per day. Projected port water demand is summarized as below.

	No. of Water & Ship	Water Demand (m^3/day)
Workes	Wharf: 3600 persons	500
	Business & commercial area: 7200 persons	1100
Ship	770 ships/year	400
Total		2000

During the field survey, it was informed by PAT that water demand of the Laem Chabang port may be around 1.2 x 10^6 m^3 per year or 3,300 m^3 per day in 1991. In the present study the figure obtained above are applied for consistency in planning. PAT figure, however, is also applicable through further analysis.

4) Total Water Demand

Total water demand in the short-term plan for the target year 1991 is tabulated below:

Item	Water use	Perday (m^3)	Per year ($x10^6 m^3$)
Laem Chabang	Domestic /1	4800	1.8
Complex	Industrial /2	23300	7.0
	Port /1	2000	0.7
Others	Domestic /1	8200	3.0
Total	-	38300	12.5

/1: Calculated as 365 days a year

/2: Calculated as 300 working days a year

Total consumer water demand is estimated to be 12.5 x 10^6 m^3 per year for the Laem Chabang development area. This corresponds to 16.2 x 10^6 m^3/year of source water demand. In addition to the present planning of the water supply system, it is necessary to assess the overall water supply and demand balance for the area as tentatively conducted in the Appendix V.1.

1.2.2 Water Supply Planning

As already described in the Master Plan, the Laem Chabang Complex is devided into high land distribution area and low land distribution area.

Ground elevation within the proper area of The S.T.P extends from M.S.L +30.0m to +3.0m and totally included in low land distribution area.

The amount of maximum daily and hourly water supply from distribution basin is shown in the following table. Water demand in other area is not included for the same reasons explained in the Master Plan.

Unit: m^3/d

Item	Daily Mean	Daily Maximum /1	Hourly Maximum /2
domestic	4800	6700	10100
industrial	23300	32600	48900
port	900	1300	2000
business	1100	1500	2300
Total	30100	42100	63300

/1: Dialy Mean x 1.4

/2: Daily Maximum x 1.5

1) Filtration Plant

Water demand in the short-term corresponds to about 40% of water demand of the Master Plan. Filtration plant in the Master Plan is composed of 2 sets of facilities. Filtration plant in the short-term is planned to be with one set of facilities. Principal features of filtration plant facilities is shown in Table V.1.4.

2) Water Distribution System

Distribution facilities consist of distribution basin and distribution pipes. Capacity of the distribution basin is planned as 14500 m^3 equivalent to 8 hours value of daily maximum water supply plus fire flow. Distribution pipes are planned according to the layout and diameter which are studied in the Master Plan. Proposed layout plan for water supply system is shown in Fig. V.1.6.

Table V.1.1 INDUSTRIAL WATER DEMAND FOR MASTER PLAN

Type of Industry	Area (ha)	Unit Water Consumption (m^3/ha)	Water Demand (m^3)
EPZ			
Food	1.6	211.0	338
Textile mill products	9.6	147.2	1,413
Apparel and finished products	14.4	68.9	992
Furniture and fixture	3.2	28.5	91
Paper products	2.4	47.0	113
Chemical and allied products	1.6	306.5	490
Rubber products	2.4	195.8	470
Leather products	2.4	49.4	119
Ceramic, stone and clay products	2.4	64.0	154
Non-ferrous metals	3.2	125.0	400
Fabricated metal products	3.2	38.0	122
General machinery	4.0	66.0	264
Electrical machinery	20.0	110.7	2,214
Transport equipment	5.6	146.0	818
Precision instruments and machinery	2.4	118.0	283
Others	6.0	16.4	98
Sub-Total	84.4	-	8,379
GIE			
Food	6.9	377.7	2,606
Textile mill products	2.3	177.0	407
Lumber and wood products	4.6	35.3	162
Chemical and allied products	10.4	275.7	2,867
Rubber products	5.8	198.5	1,151
Leather products	1.2	147.0	176
Ceramic, stone and clay products	13.8	136.0	1,877
Iron and steel	13.8	110.0	1,518
Nonferrous metals	10.4	197.1	2,050
Fabricated metal products	20.7	69.2	1,432
General Machinery	11.5	62.4	718
Electrical Machinery	34.5	118.6	4,091
Transport equipment	87.4	64.6	5,646
Others	2.3	60.0	138
Sub-Total	225.6	-	24,839
Total	310.0	-	33,218

Table V.1.2 RESULTS OF WATER QUALITY ANALYSIS

Water Sample	Nong Kho Dam
Date of Sampling	Nov. 23, '83
Physical Analysis	
True color in Pt units	16
Odour	Unobjectionable
Turbidity in Silica units	39
pH Value	6.9
EC at 25°C (micromhos/cm)	95
Chemical Analysis	
Total Solids	124
Suspended solids	25
Dissolved solids	99
Total hardness (CaCO3)	68
Carbonate hardness (CaCO3)	44
Non-carbonate hardness (CaCO3)	24
Nitrogen (total)	1.0
Nitrogen (organic)	0.72
Nitrogen (ammonia)	0.28
Nitrate, expressed as notrogen	Nil
Nitrite, expressed as nitrogen	0.01
Total alkalinity	44
Total acidity	15
Phosphorus (phosphate)	0.25
Chloride	-
Iron (Fe)	1.7
Chlomium (Cr)	0.004
Zinc (Zn)	0.28
Magnesium (Mg)	2.8
Sulfate (SO4)	Nil
Fluoride (F)	-
Dissolved oxygen (DO)	0.90
Chemical oxygen demand (COD)	68
Biochemical oxygen demand (BOD at 20°C)	6.0
Biological Analysis	
Bacterial Count per ml	9,300
Bacterial Coli. Group per 100 ml	7,900
E. Coli. per 100 ml	1,300

Table V.1.3 FEATURES OF FILTRATION PLANT FACILITIES FOR MASTER PLAN

Item	Contents
Planning quantity	97,600 x 1.1 = 108000 m^3
1. Mixing Basin	= 54000 m^3 x 2 sets W L H 3.6m x 3.6m x 3.0m x 2 system x 2 sets
2. Flocculation Basin	W L H 7.0m x 9.0m x 3.0m x 8 system x 2 sets
3. Chemical Sedimentation Basin	W L H 7.0m x 45.0m x 3.5m x 8 system x 2 sets overflow weir W L 3.5m x 7.0m x 8 system x 2 sets
4. Rapid Sand Filtration	W L 7.0m x 9.0m x 8 system x 2 sets
5. Clean Water Basin	High land area (7 hr.) 57600 person x 0.22 m^3/lcd x 1.4 x 7/24 = 5200 m^3 Low land area (1 hr.) (97600 - 57600 x 0.22 x 1.4) x 1/24 = 3300 m^3 Total: 5200 + 3300 = 8500 m^3
6. Pumping Station	Capacity = 15 min 97600 m^3/d - (24 x 60) x 15 = 1000 m^3
7. Lagoon and Waste Water Pond	1 set
8. Distribution Tower	V = 1000 m^3
9. Distribution Basin	V = 26000 m^3 + 400 m^3 W L H 35.0m x 70.0m x 3.0m x 4 Basin

Table V.1.4 PRINCIPAL FEATURES OF FILTRATION PLANT FACILITIES FOR SHORT-TERM PLAN

Item	Contents
Planning quantity	42,100 x 1.1 = 46000 m^3
1. Mixing Basin	W L H 3.6m x 3.6m x 3.0m x 10 system
2. Flocculation Basin	W L H 7.0m x 9.0m x 3.0m x 8 system
3. Chemical Sedimentation Basin	W L H 7.0m x 45.0m x 3.5m x 8 system overflow weir W L 3.5m x 7.0m x 8 system
4. Rapid Sand Filtration	W L 7.0m x 9.0m x 8 system
5. Clean Water Basin	Capacity = 1 hr. 38800 x 1/24 + 400 = 2200 m^3 W L H 20.0m x 35.0m x 3.0m x 1 Basin
6. Pumping Station	1000 m^3
7. Lagoon and Waste Water Pond	1 set
8. Distribution Basin	Capacity = 14,000m^3 + 400m^3 = 14,500m^3 W L H 35.0m x 70.0m x 3.0m x 2 Basin

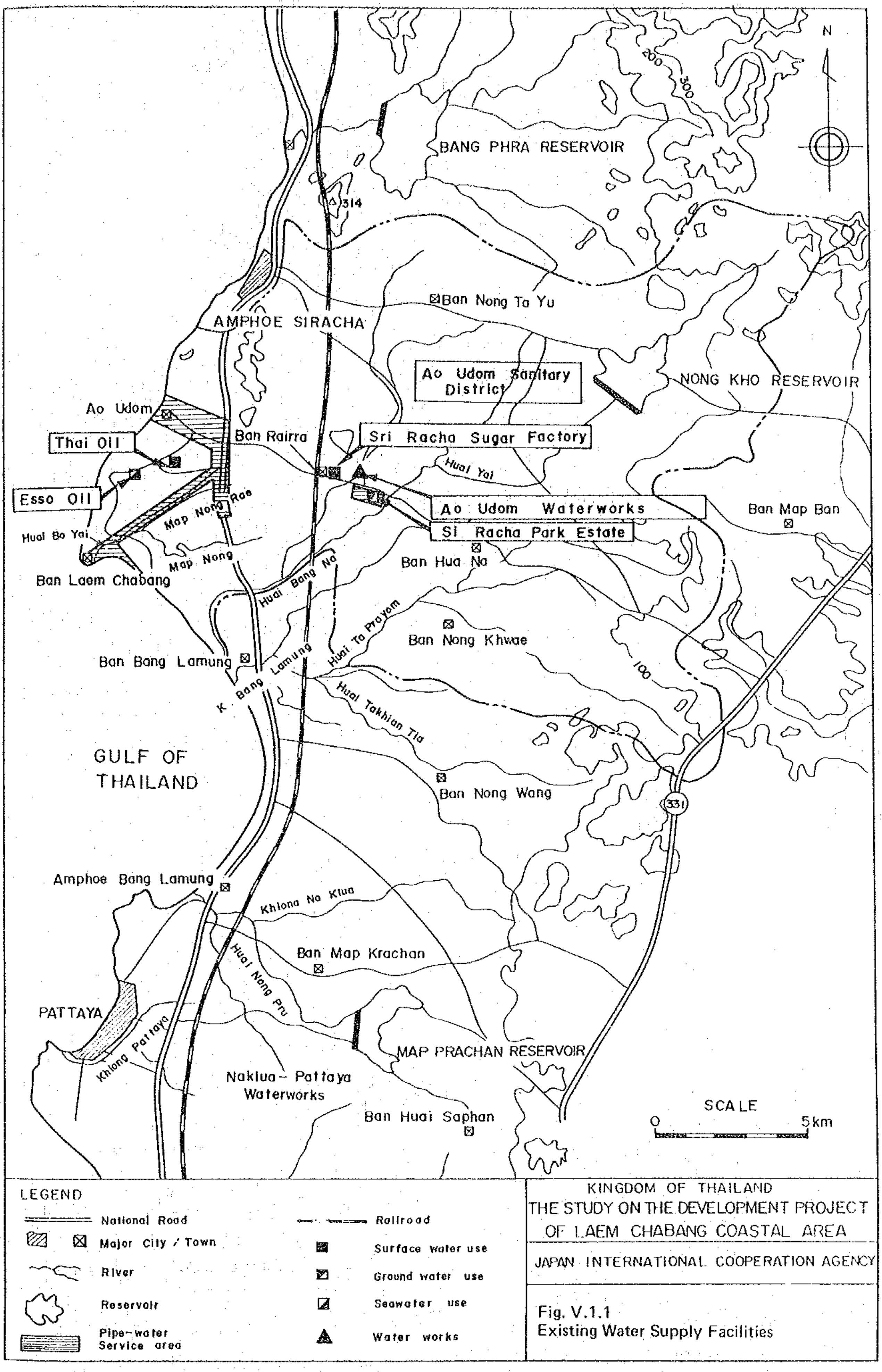
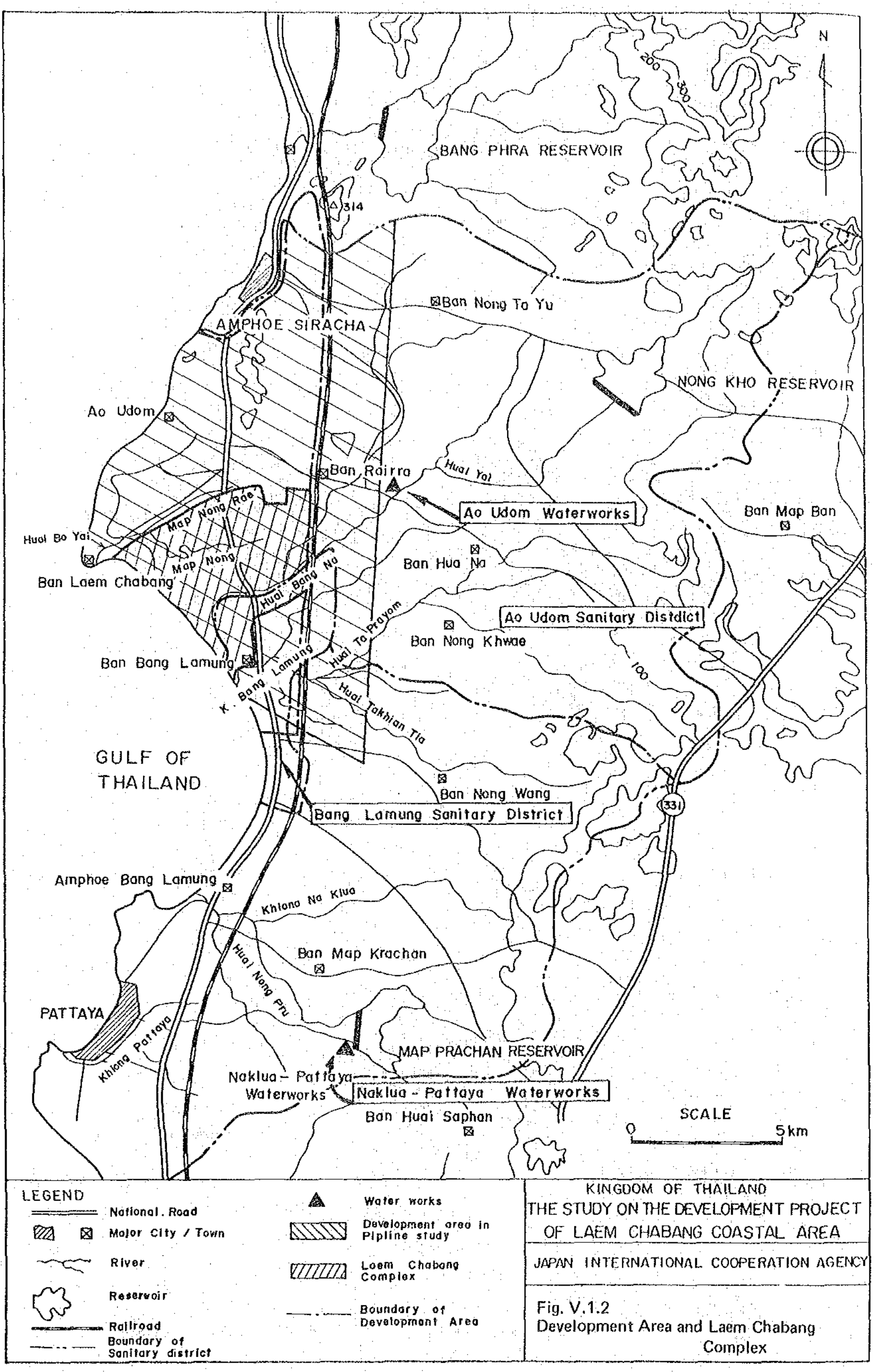


Fig. V.1.1
Existing Water Supply Facilities



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

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Fig. V.1.2
Development Area and Laem Chabang Complex

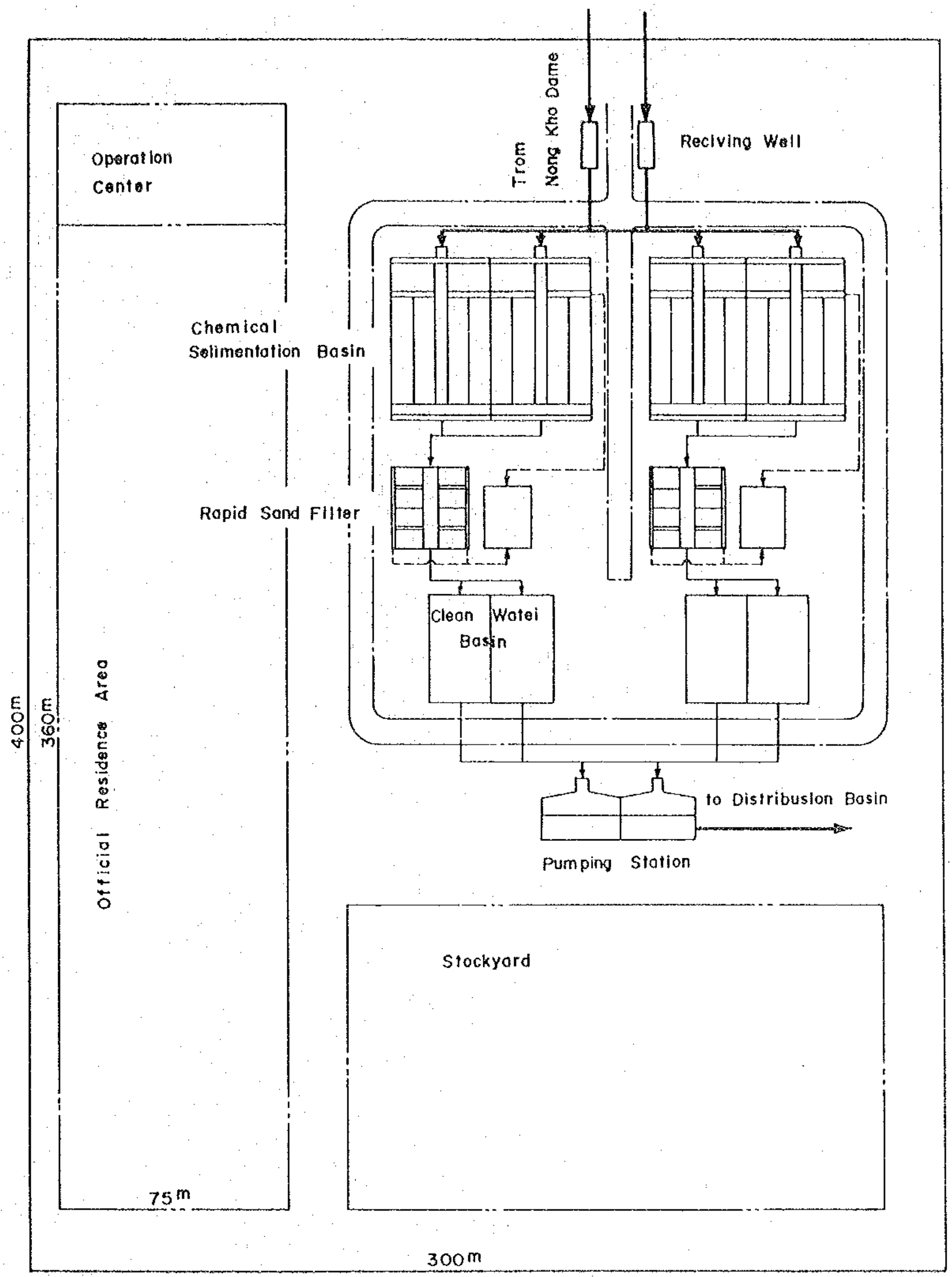

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Fig. V.1.3
Plan for Filtration Plant

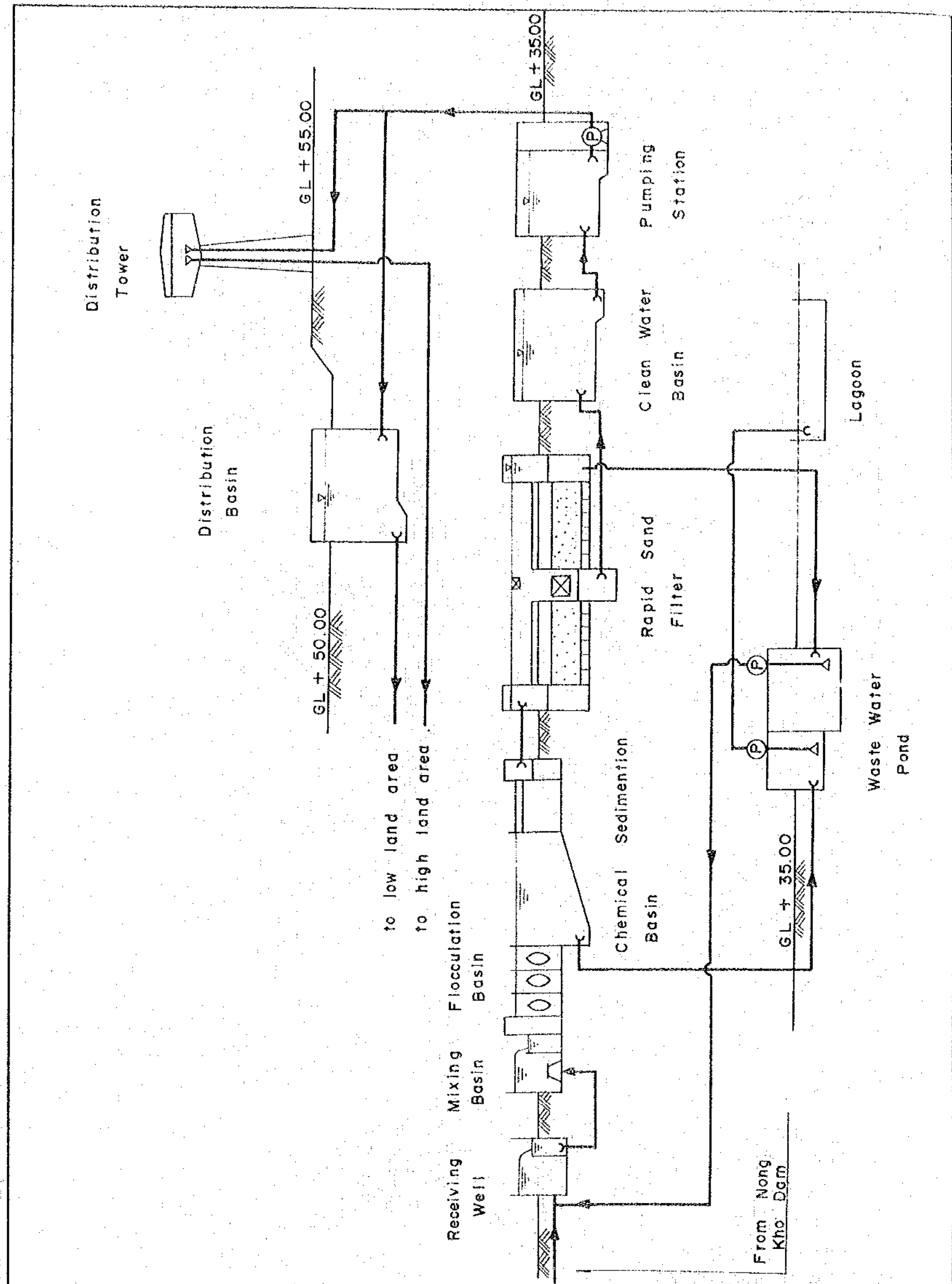

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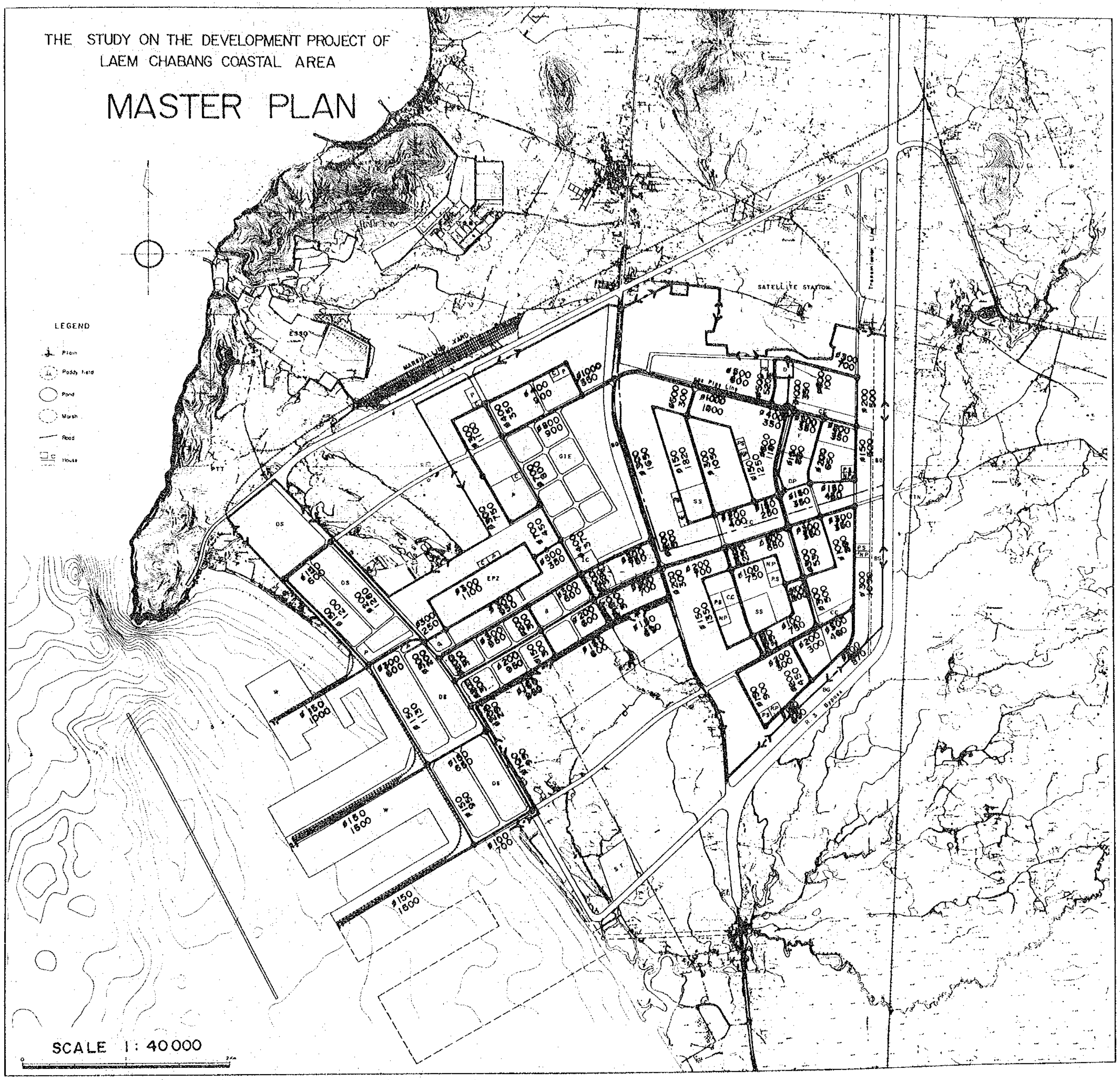
Fig. V.1.4
Flow Sheet of Filtration Plant



LEGEND

—<-->—	Boundary of Project Area
---- - ----	Boundary of Zone
ø 200	Diameter (mm)
1000	Length (m)
[D]	Distribution Basin

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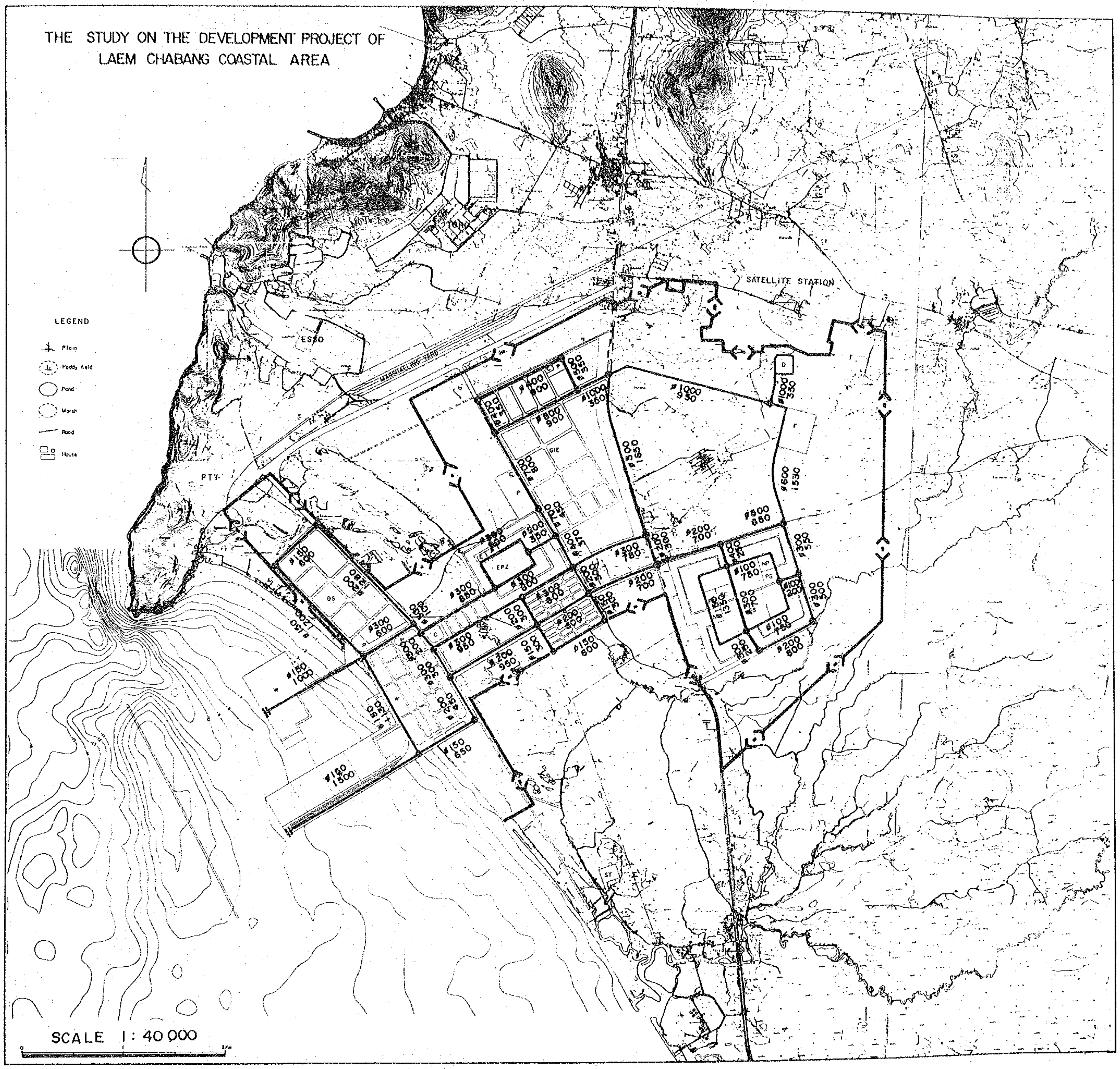
Fig. V.1.5
Proposed Layout Plan for Water Supply
System for Master Plan



LEGEND

—‹–›—	Boundary of Project Area	
—·—	Boundary of Zone	
ø 200	Diameter	(mm)
1000	Length	(m)
[D]	Distribution Basin	

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Fig. V.1.6
Proposed Layout Plan for Water Supply System for Short-Term

2. SEWERAGE SYSTEM

2.1 Master Plan

2.1.1 Present Condition

Environmental condition of rivers and seashore in the Laem Chabang area is comparatively favorable with scarce pollution sources, such as high population density and much industrial activity. At the site of underpassing the railroad in the upstream of Klong Huai Bang Na, odor of wastewater, which is probably from the Siracha Industrial Park Estate (SIPE) is recognized. This is, however, limited to this point and there is no serious environmental impact on the project area.

2.1.2 Sewage Quantity and Quality

Quantity and quality of sewage in the year 2001 is analyzed for sewage from domestic, industrial and port use.

1) Sewage Quantity

Sewage quantity is assumed to be 90% of water consumption, with reference to the data of Japan and Malaysia, except the quantity for ship use. Infiltration of ground water into sewer pipe due to cracks on the pipes and defect of the joint should be considered in the planning. Quantity of infiltration varies largely depending on conditions of constructing the pipes and the amount of groundwater at each site. It is reported that in some cases the volume of infiltration amounts to the equal level as sewage or more. In the present study, 20% in addition to maximum daily volume is adopted for infiltration in consideration of past records in Japan.

Projected sewage quantity is as presented below.

(Unit: m^3/day)

Source	Mean Daily	Max Daily	Max Hourly	Ground Water
Domestic	23,800	33,300	50,000	6,700
E P Z	7,600	10,600	15,900	2,100
G I P	22,300	31,200	46,800	6,200
Port	4,600	6,400	9,600	1,300
Total	58,300	81,500	122,300	16,300

2) Sewage Quality

An average sewage quality of domestic and industrial sewage is summarized as follows and presented in Table V.2.1. and V.2.2.

(Unit: mg/l)

BOD	COD	SS	T-N	T-P
180	110	190	30	4

note: values of BOD, COD, SS are 20% higher than the results of computation

3) Effluent Quality Standards

The effluent quality standards for the industrial sewage is prepared by the Industrial Works Department (IWD) as shown in Table V.2.3. This standard is applied to the industrial sewage directly pouring into public water-course.

In this project, sewage treatment plant is designed based on IWD Standards. Industrial sewage generally contains heavy metals and harmful substances which have effect on such sewarage facilities as sewer pipe and treatment plant. To minimize this effect, industries of the estate are required to give primary treatment to the sewage generated in their factories to the degree required by responsible agency (probably IEAT). Effluent quality standards of Lat Krabang and Bang Poo industrial estate issued by IEAT as well as of Japan are shown in Table V.2.4.

2.1.3 Sewerage System Plan

1) Sewerage System

Two alternatives are considered for sewerage system; the comprehensive system which treats sewage from the industrial estate, new town and port collectively and the separate system by which treatment plants are constructed within each of the above three areas. The Study Team proposes the comprehensive system for the Laem Chabang Complex for the following reasons.

- Construction cost is lower.
- Construction sites of treatment plants are limited by land use plan.
- No industry which discharges hazardous sewage is planned to be located in the industrial estate and there will be no need for exclusive treatment of industrial sewage.
- Operation and maintenance cost is lower.
- Fluctuation in sewage volume will be lessened.
- Operation and maintenance will be easier.

Location of the treatment plant is proposed at the southern tip of the port area, which will not cause any eutrophication or hinder future expansion of development activities.

The Study Team carried out the preliminary comparison of the two systems in terms of construction cost. Results are shown in Appendix V-2.

2) Sewers

Cross section of sewer pipe is determined in consideration of hourly maximum wastewater plus infiltration of groundwater and unknown water such as stormwater. Applied design criteria are as follows.

(i) Flow Friction Formula

The Manning formula is adopted for design of sewers. Coefficient of roughness is taken at 0.013.

(ii) Minimum and maximum velocity

Minimum velocity required to prevent sedimentation of substances in wastewater, shall be 0.6 m/s and maximum velocity to protect the pipe from erosion shall be 3.0 m/s.

(iii) Depth of Sewers

The depth of earth covering is planned between 1.0 m ad 5 m except for special situations in consideration of maintenance and construction cost.

(iv) Materials of Pipes

Considering the availability of materials in Thailand, vitrified clay pipes with 300 mm or less in diameter and centrifugal reinforced concrete pipe with 350 mm or more in diameter are adopted for the purpose of protection against erosion due to the velocity and also due to acid and alkaline.

(v) Booster Pump Station

At the location with earth covering for more than 5.0 m, booster pump station shall be installed and submersible pump is adopted herein.

Layout of sewarage system is shown in Fig. V.2.1.

3) Sewage Treatment Plant

Effluent quality of the three treatment processes of the standard biological treatment is summarised as follows based on the data in Japan.

(mg/l)

Item	Quality of Sewage	Effluent Quality		
		Aerated Lagoon	Standard Activated Sludge	Oxidation Ditch
BOD	180	40	20	
COD	110	40	30	
SS	190	40	20	
T-N	30	25		15
T-P	4	3		

COD, N and P are known as the typical cause of environmental pollution on the sea area. Therefore, diffusion densities at 5.0 km and 10 km offshore distance shown in Fig. V.2.2 are roughly computed by Joseph-Sendner formula and its results are summarized below. Detailed description on the computation is given in the Appendix V.3.

(unit: mg/l)

Distance from the coast	COD	T-N	T-P
5 km	1.2	0.4	0.03
10 km	1.1	0.3	0.02

According to the results of computation, typical biological treatment such as aerated lagoon, oxdation ditch and standard activated sludge are able to dillute effluent water to a sufficient degree. For reference, Environmental Standard (C Standard) in Japan is presented as follows:

(unit: mg/l)

Item	Value of standard
COD	3
T-N	1
T-P	0.1

note: T-N, T-P are Environmental Standard for lakes and marshes

4) Selection of Treatment Process

Sewage treatment process is devided into the following categories, (i) primary treatment with sedimentation, (ii) secondary treatment with biological treatment and (iii) further advanced treatment to obtain highly treated water, for instance, by removing N and P. In recent years, various types of advanced treatments have been developed for the purpose of removal of N and P as a countermeasure against eutrophication in effluent area.

Standard biological treatment as formerly mentioned basically belongs to the secondary treatment which can easily remove N and P and is therefore, selected as the treatment process in this project.

As already mentioned, there are three kinds of treatment methods; aerated lagoon, standard activated sludge and oxidation ditch. Flow-sheet and plan are shown in Fig. V.2.3 and V.2.4. General design criteria and cost comparisons are given in Table V.2.5 and Table V.2.6 respectively.

Aerated lagoon types among these can be operated with low cost and are often adopted in the tropical areas, but it requires large plottage and its stability of treatment is inferior to other two processes.

Standard activated sludge process is the most popular in Japan, but well trained engineer is necessary for the operation.

Oxidation ditch process has been in spotlight in recent years as it removes N with easy operation. Though the construction and operation cost of this process is higher than aerated lagoon process, it would be a reasonable investment taking into accont the stability of N removal. Furthermore, P is also able to be removed by chemical dosing. Consequently, oxidation ditch process is adopted in this project.

5) Design Capacity of Sewage Treatment Plant

The daily amount of water consumption varies with various factors such as season, working hour of industry, commercial functions etc. through a year. Daily mean, daily maximum and maximum hourly rate of sewage volume are defined as follows:

Daily mean (m^3/day)	Daily average volume through a year (obtained by dividing total annual volume by number of days in a year.)
Daily maximum (m^3/day)	Daily volume in a day with maximum volume through a year.
Maximum hourly (m^3/day) ...	Daily volume converted from maximum hourly sewage through a year.

Design of treatment plant had been made with the rate of daily mean several decades ago in Japan. In recent years, however, maximum daily rate has been adopted in order to treat sewage steadily. In case that the treatment plant is designed with the rate of daily mean, detention period will become short and steady treatment cannot be expected for the sewage amounting to daily maximum. It is also better to apply daily maximum rate to minimize the contamination of effluent water area. In the present study, therefore, the rate of maximum daily is adopted as design sewage volume which is assumed to be 1.4 times of daily mean.

2.2 Short-term Development

2.2.1 Quantity and Quality of Sewage

1) Quantity of Sewage

Quantity of sewage, as is mentioned in the Master Plan, is assumed to correspond to the total of 90% of water demand plus 20% of daily maximum sewage for the infiltration of ground water. Sewage amount is as follows.

Unit: m^3/d

	Mean Daily	Max Daily	Max Hourly	Ground Water
N. T	4,300	6,000	9,000	1,200
Industrial Estate	21,000	29,400	44,100	5,900
Business	1,000	1,400	2,100	300
Wharf	800	1,100	1,700	200
Total	27,100	37,900	56,900	7,600

2) Quality of Sewage

Sewage quality of domestic, port, E.P.Z and G.I.E is estimated as below.

Item	Sewage Quantity	Sewage Quality				
		BOD	COD	SS	T-N	T-P
N.T	4300	200	108	200	48	7.2
Wharf	800	200	108	200	48	7.2
Business	1000	200	108	200	48	7.2
E P Z	3400	60	40	80	7	0.2
G I E	17600	120	80	140	15	0.3

Sewage quality from all these origins is estimated based upon above conditions as shown in the following table. Detail computation is summarized in Table V.2.7.

Unit: mg/l

BOD	COD	SS	T-N	T-P
160	100	170	21	2

Note: Values of BOD, COD, SS are 20% higher than the results of computation.

2.2.2 Sewerage System Plan

1) Sewers

Sewers in the short-term plan are planned with the diameter applied in the long-term plan. It is considered more reasonable to plan with large diameter from the viewpoint of development efficiency, though it reduces velocity of sewage to some extent. Layout plan for sewarage system by The Short-Term Plan is shown in Fig. V.2.5.

2) Wastewater Treatment Plant

Oxdation ditch process is applied also for the short-tem plan.

In consideration of treatment volume, 4 systems out of 10 systems in the long-term shall be constructed in the short-term plan. Features of the sewage treatment plant facilities are shown in Table V.2.8. Flow sheet is shown in Fig. V.2.6.

Table V.2.1 AVERAGE SEWAGE QUALITY FOR MASTER PLAN

Type of Industry	Water demand (m3)	BOD		COD		SS		T-N		T-P	
		Concen. (mg/l)	Load (kg)	Concen. (mg/l)	Load (kg)	Concen. (mg/l)	Load (kg)	Concen. (mg/l)	Load (kg)	Concen. (mg/l)	Load (kg)
Domestic	23,800	200	4,760	108	2,570	200	4,760	48	1,142	7.2	171.4
E P Z	7,600	60	456	40	304	80	608	7	53.2	0.2	1.5
G I E	22,300	120	2,676	80	1,784	140	3,122	15	334.5	0.3	6.7
Port	4,600	200	920	108	496.8	200	920	48	220.8	7.2	33.1
Total	58,300	-	3,812	-	5,154.8	-	9,410	-	1,750.5	-	212.7
Ave.	-	151	-	88	-	161	-	30	-	3.6	-

Table V.2.2(1/2) ESTIMATION OF INDUSTRIAL SEWAGE QUALITY FOR MASTER PLAN (GIE)

Type of Industry	Water demand (m3)	BOD		COD		SS		T-N		T-P	
		Concen. (mg/l)	Load (kg)	Concen. (mg/l)	Load (kg)	Concen. (mg/l)	Load (kg)	Concen. (mg/l)	Load (kg)	Concen. (mg/l)	Load (kg)
Food	2606	500	1303.0	300	718.8	360	938.2	100	260.6	2	5.2
Textile	407	40	16.3	30	12.2	70	28.5	1	0.4	0.1	0.1
Lumber Processing and Furniture	162	10	1.6	10	1.6	40	6.5	1	0.2	-	-
Chemical	2867	420	1204.1	210	602.1	110	315.4	33	94.6	1	2.9
Rubber	1151	10	11.5	20	23.0	50	57.6	1	1.2	-	-
Chamois-leather	176	10	1.8	10	1.8	20	3.5	2	0.4	-	-
Pottery	1877	10	18.8	50	93.9	200	375.4	-	-	-	-
Steel Industry	1518	60	91.1	20	30.4	200	303.6	-	-	-	-
Nonferrous Metals	2050	50	102.5	10	20.5	30	61.5	-	-	-	-
Metals	1432	10	14.3	20	28.6	100	143.2	-	-	-	-
General Machine	718	10	7.2	10	7.2	100	71.8	-	-	-	-
Electrical Machine	4091	10	40.9	30	122.7	100	409.1	-	-	-	-
Transport Machine	5646	10	56.5	20	112.9	100	564.6	-	-	-	-
Others	138	10	1.4	20	2.8	100	13.8	-	-	-	-
Total	24839	-	2871.0	-	1841.5	-	3292.7	-	357.4	-	8.2
Average	-	116	-	74	-	133	-	14.4		0.3	

Table V.2.2(2/2) ESTIMATION OF INDUSTRIAL SEWAGE QUALITY FOR MASTER PLAN (EPZ)

Type of Industry	Water demand (m3)	BOD		COD		SS		T-N		T-P	
		Concen. (mg/l)	Load (kg)	Concen. (mg/l)	Load (kg)	Concen. (mg/l)	Load (kg)	Concen. (mg/l)	Load (kg)	Concen. (mg/l)	Load (kg)
Food	338	500	169.0	140	47.3	220	74.4	100	33.8	2	0.7
Textile	1413	10	14.1	10	14.1	30	42.4	1	1.4	0.1	0.1
Artificial Fiber Processing	992	10	9.9	10	9.9	30	29.8	1	1.0	0.1	0.1
Lumber Processing and Furniture	91	10	0.9	10	0.9	40	3.6	1	0.1	-	-
Paper Craft	113	100	11.3	100	11.3	40	4.5	1	0.1	-	-
Chemical	490	420	205.8	210	102.9	110	53.9	33	16.2	1	0.5
Rubber	470	10	4.7	20	9.4	50	23.5	1	0.5	-	-
Chamois-leather	119	10	1.2	10	1.2	20	2.4	2	0.2	-	-
Pottery	154	10	1.5	50	7.7	200	30.8	-	-	-	-
Nonferrous Metals	400	50	20.0	10	4.0	30	12.0	-	-	-	-
Metals	122	10	1.2	20	2.4	100	12.2	-	-	-	-
General Machine	264	10	2.6	10	2.6	100	26.4	-	-	-	-
Electrical Machine	2214	10	22.1	30	66.4	100	221.4	-	-	-	-
Transport Machine	818	10	8.2	20	16.4	100	81.8	-	-	-	-
Precision	283	10	2.8	10	2.8	100	28.3	-	-	-	-
Others	98	10	1.0	10	1.0	100	9.8	-	-	-	-
Total	8379	-	476.3	-	300.3	-	657.2	-	53.3	-	1.4
Average	-	57	-	36	-	78	-	6.4		0.2	

Table V.2.3 EFFLUENT QUALITY STANDARD FOR DISCHARGE TO WATER-COURCE

Unit : mg/l

Item	Japan	Thailand
BOD (5 days 20°C)	av. 120 max. 160	av. 20 max. 60
SS (Suspended solids)	av. 150 max. 200	min. 30 max.150
PH	5.8-8.6	5-9
HS (Sulphides)	-	11
HCN (Cyanide)	1	0.2
Oil and Grease	5 mineral 30 biotic	0.5
Tar	-	none
Formaldehyde	-	1
Phenols and Cresols	5	1
Cl (Free Chlorine)	-	1
Zn (Zinc)	5	5
Cr (Chromium)	2	0.5
Cu (Copper)	3	1
As (arsenic)	0.5	0.25
Cd (Cadmium)	0.1	0.03
Pd (Lead)	1	0.2
Ba, Ni (Barium, Nickel)	-	1
PCB	-	-
Tw (Water Temperature)	45°C	40°C
Org.-P (Organic Phosphor)	1	none
Hg (Mercury)	none	0.005
R-Hg (Alkyl Mercury)	none	-
D.S. (Disolved Solids)	-	2000
Se (Selenium)	-	0.02

Source : Ministry of Industry

Table V.2.4 EFFLUENT QUALITY STANDARD FOR DISCHARGE INTO SEWERAGE SYSTEM

Unit:mg/l

Item	Japan	Lat Krabang	Ban Poo
BOD (5 days 20°C)	<600	av. 900 max. 1000	<1000
SS (Suspended solids)	<600	<500	<500
PH	5-9	6-9	4-11
HS (Sulphides)	-	<1	<1
HCN (Cyanide)	<1	<0.2	<0.2
Oil and Grease	<5 <30	none	none
Tar	-	none	none
Formaldehyde	-	<1	<1
Phoenols and Cresols	<5	<1	<1
Cl (Free Chlorine)	-	<1	<1
Zn (Zinc)	<5	<1	<1
Cr (Chromium)	<2	<1	<1
Cu (Copper)	<3	<1	<1
As (Arsenic)	<0.5	<1	<1
Cd (Cadmium)	<0.1	-	-
Pd (Lead)	<1	<1	<1
Ba, Ni (Barium, Nickel)	-	Ni<1	Ni<1
PCB	<0.003	-	-
Tw (Water Temperature)	<45°C	<45°C	<45°C
Org.-P (Organic Phosphor)	<0.005	-	-
Hg (Mercury)	none	<0.005	<0.005
R-Hg (Alkyl Mercury)	none	-	-
D.S. (Disolved Solids)	-	-	-
Se (Selenium)	-	-	-

Source : IEAT

Table V.2.5 DESIGN CRITERIA FOR TREATMENT PROCESS

Treatment Process	Design Conditions	
1. Aerated Lagoon		
Aerated Lagoon	Surface BOD Load	= 1500 kg/ha/D
	Depth	= 4 m
Maturation Pond	Detention Time	= 3 Day
	Depth	= 2 m
2. Standard Activated Sludge		
Primary Settling Tank	Surface Load	= 40 m^3/m^2.D
	Detention Time	= 1.5 Hr.
	Depth	= 2.5 m R.C.
Aeration Tank	BOD. SS Load	= 0.3 kg BOD/SS kg.D
	Detention Time	= 6 Hr.
	Depth	= 5 m R.C.
Final Settling Tank	Surface Load	= 25 m^3/m^2.D
	Detention Time	= 2.5 Hr.
	Depth	= 3 m R.C.
Chlorination Tank	Detention Time	= 15 Min.
	Depth	= 2 m R.C.
Sludge Treatment	Dewater	
3. Oxidation Ditch		
Oxidation Ditch	BOD.SS Load	= 0.05 kg/BOD/SS kg.D
	Detention Time	= 24 Hr.
	Depth	= 4 m R.C.
Final Settling Tank	Surface Load	= 15 m^3/m^2.D
	Depth	= 2.5 m R.C.
Chlorination Tank	Detention Time	= 15 Min.
	Depth	= 2 m R.C.
Sludge Treatment	Dewater	

Note: R.C. = Reinforced Concrete Structure

Table V.2.6 COMPARISON OF TREATMENT PROCESS

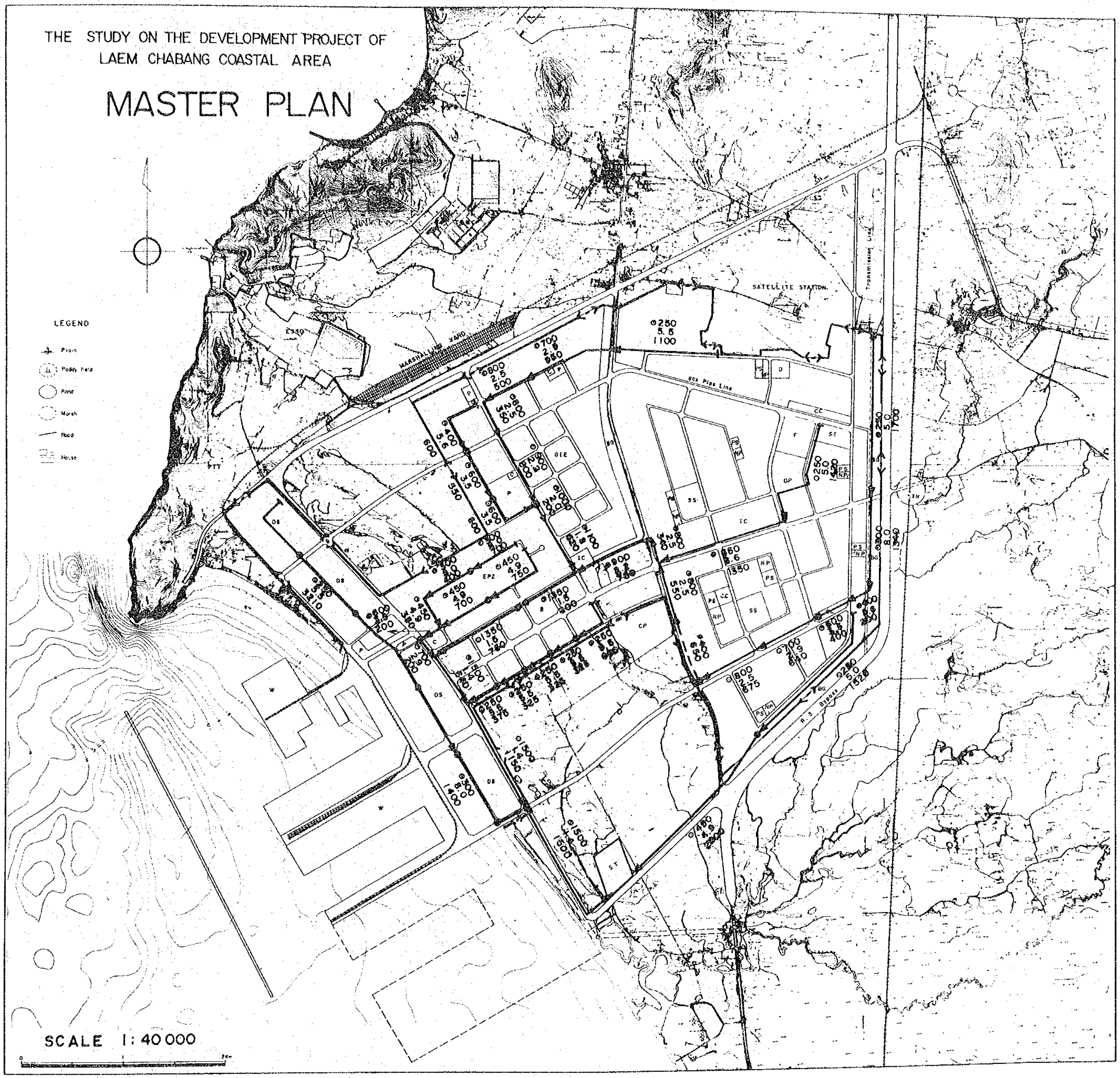
Item	Aerated Lagoon	Standard Activated Sludge	Oxidation Ditch
Construction Cost (x 10^6 ฿)	377	845	637.6
Operation Cost (x 10^6 ฿)	15	42.7	38.7
Required Plant Area (ha)	34.8	4.0	6.5
Maintenance	Easy	Need Expert Control	Easy
Stability of Treatment	Unstable	Stable	Stable
Sludge Treatment	No dewater	Dewater	Dewater

Table V.2.7 AVERAGE SEWAGE QUALITY FOR SHORT-TERM PLAN

	Filthy water quality (m^3/d)	BOD		COD		SS		T-N		T-P	
		Concen. (mg/l)	Load (kg)	Concen. (mg/l)	Load (kg)	Concen. (mg/l)	Load (kg)	Concen. (mg/l)	Load (kg)	Concen. (mg/l)	Load (kg)
N.T	4300	200	860.0	108	464.4	200	860.0	48	206.4	7.2	31.0
E P Z	3400	60	204.0	40	136.0	80	272.0	7	23.8	0.2	0.7
G I E	17600	120	2112.0	80	1408.0	140	2464.0	15	264.0	0.3	5.3
Business	1000	200	200.0	108	108.0	200	200.0	48	48.0	7.2	7.2
Wharf	800	200	160.0	108	86.4	200	160.0	48	38.4	7.2	5.8
Total	21700	-	3536.0	-	2202.8	-	3956.0	-	580.6	-	50.0
Ave.	-	130	-	80	-	145	-	21.4	-	2.0	-

Table V.2.8 PRINCIPAL FEATURES OF TREATMENT PLANT FACILITIES FOR SHORT-TERM PLAN

Item	Contents
Planning quantity	Max Daily 45,500 m^3/d Max Hourly 64,500 m^3/d
1. Degritting Tank	W L H 3.8m x 10.0m x 0.7m x 1 Basin Pump pint W L H 8.0m x 20.0m x 4m x 1 Basin
2. Oxidation Ditch	W L H 12.0m x 105.0m x 4m x 2 Basin x 4 stage
3. Settling Tank	ø H 30.0m x 2.5m x 4 Basin
4. Chlorination Tank	W L H 20.0m x 13.0m x 2.0m x 1 Basin
5. Sludge Thickener	ø H 6.0m x 5.0m x 1 Basin
6. Dehydrator	1 set



LEGEND

—(·)—	Boundary of Project Area
●	Pumping Station
ST	Treatment Plant
——→	Trunk Sewer
– – →	Force Main
⊙600	Diameter (mm)
3.5	Slope (‰)
400	Length (m)

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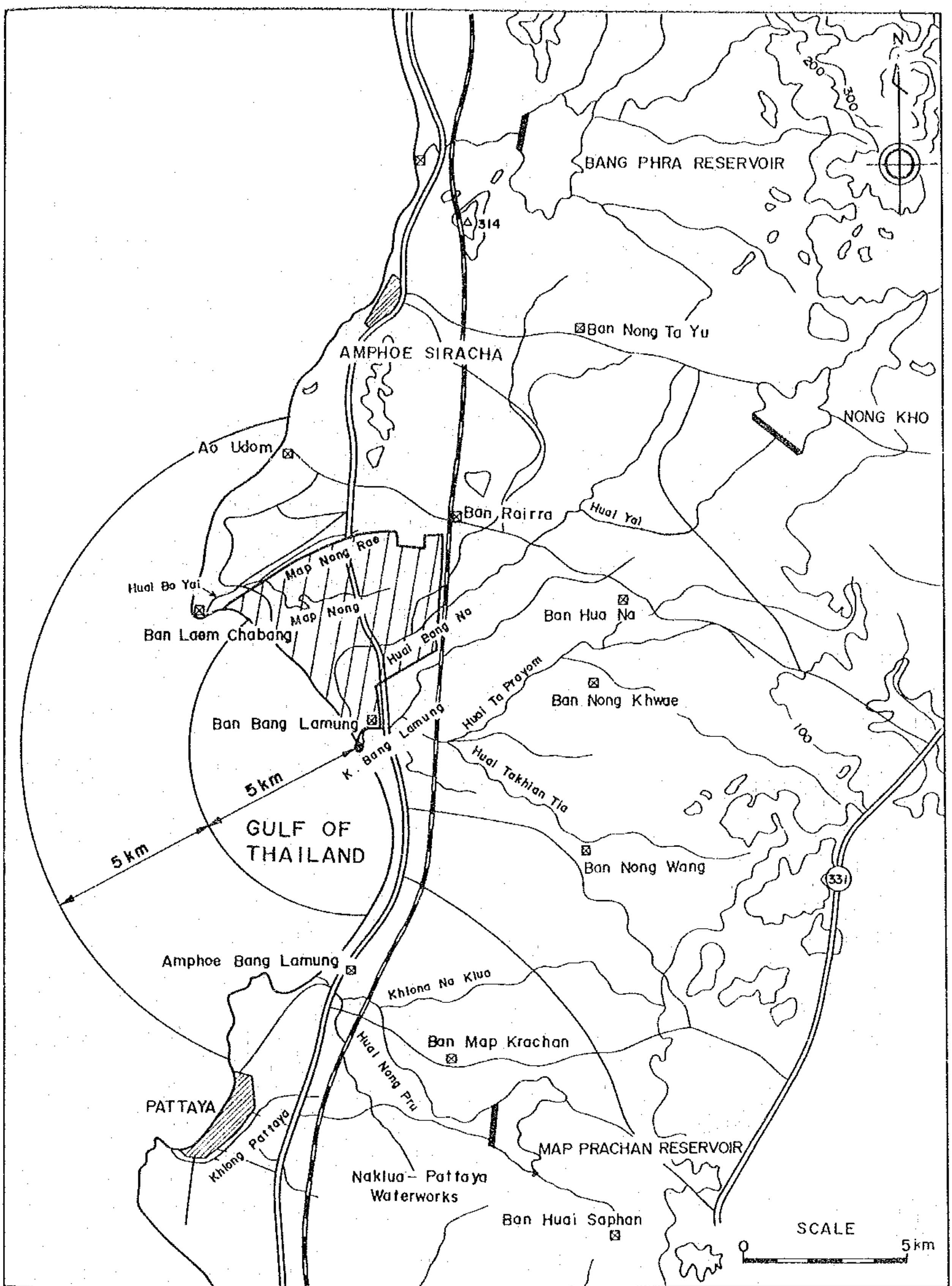
Fig. V.2.1
Proposed Layout Plan for Sewerage System (Master Plan)



LEGEND

- National Road
- Major City / Town
- River
- Reservoir
- Railroad
- Laem Chabang Complex

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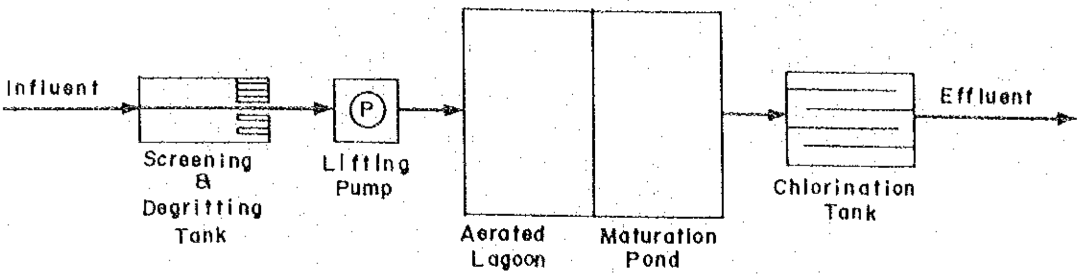
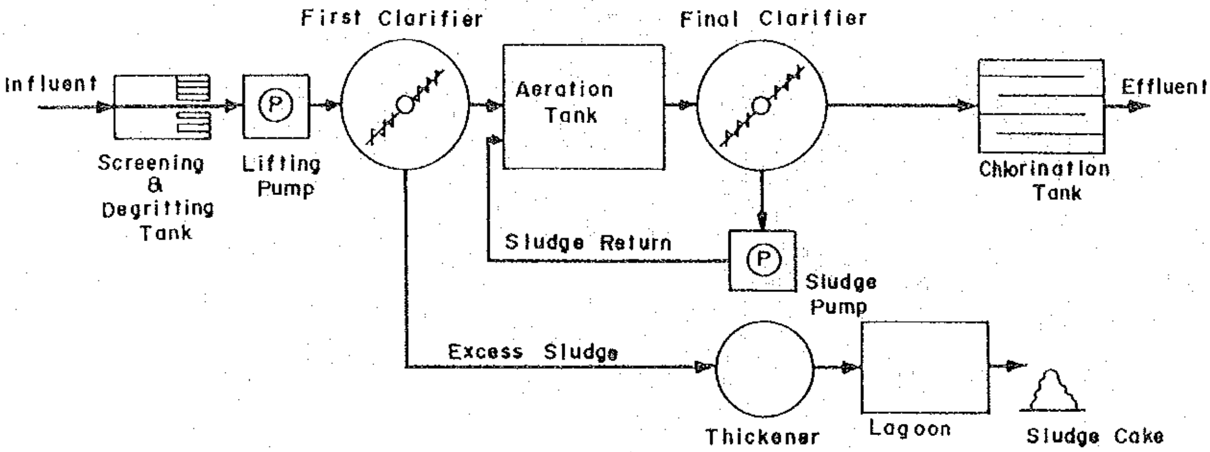
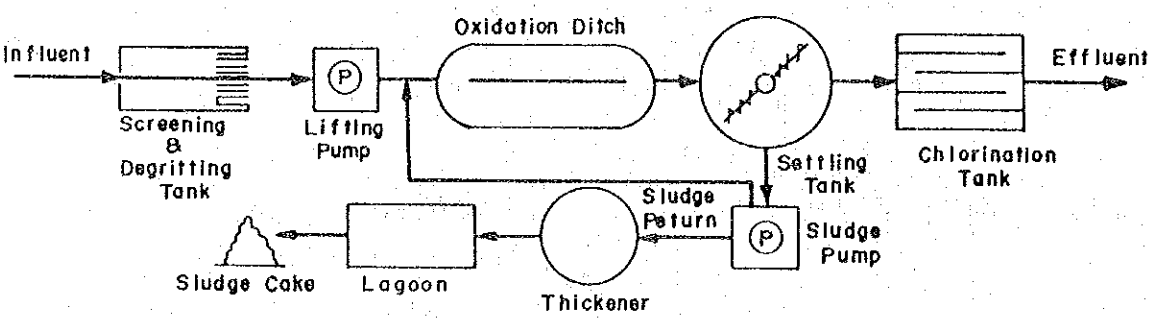
Fig. V.2.2
Computation of Dilution on Sea Area



(Aerated Lagoon)



(Standard Activated Sludge)



(Oxidation Ditch)

LEGEND

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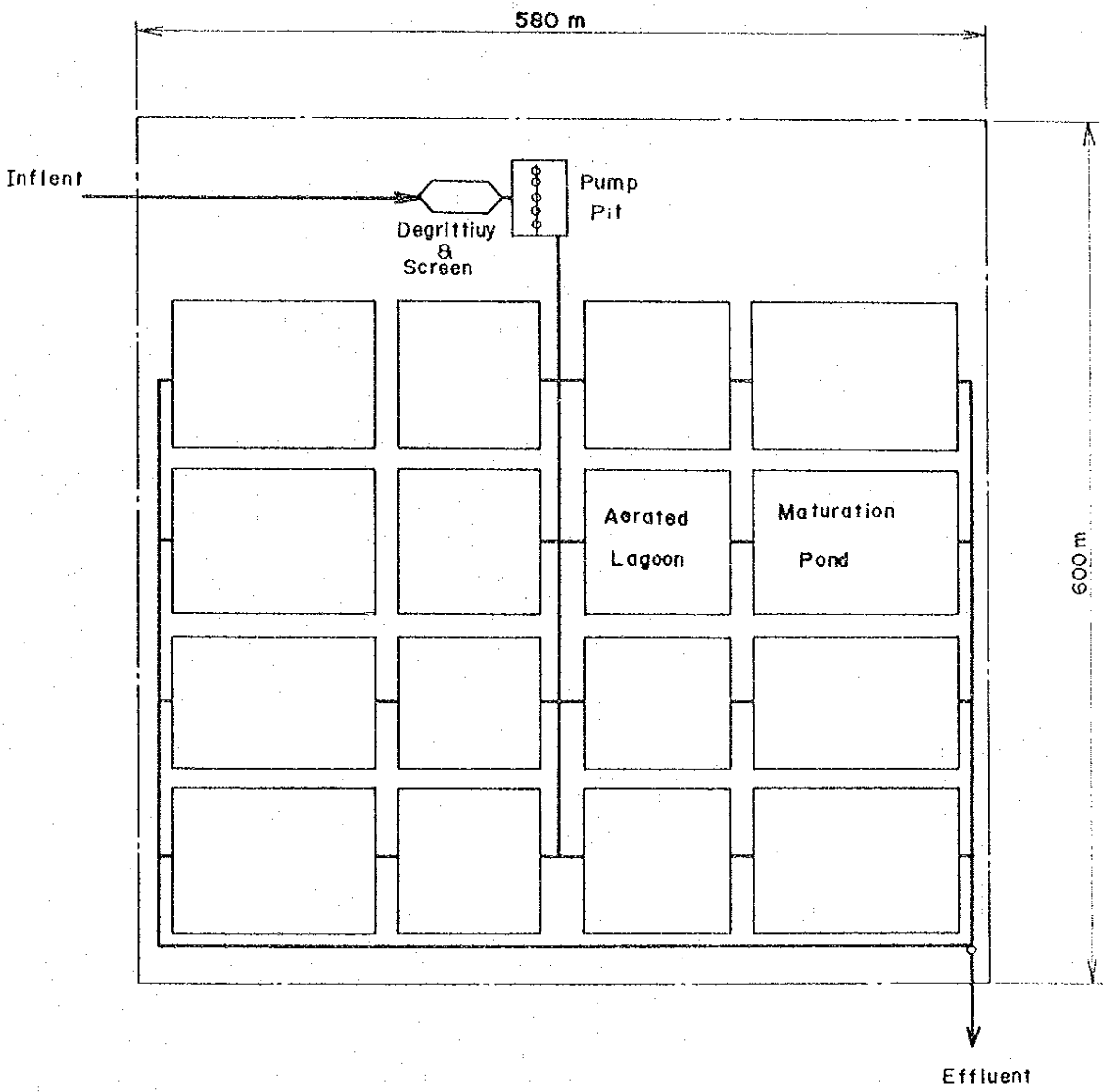
Fig. V.2.3
Flow Sheets of Sewage Treatment Plants



LEGEND

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Fig. V.2.4 (1/3)
Plan for Treatment Plant
(Aerated Lageon)

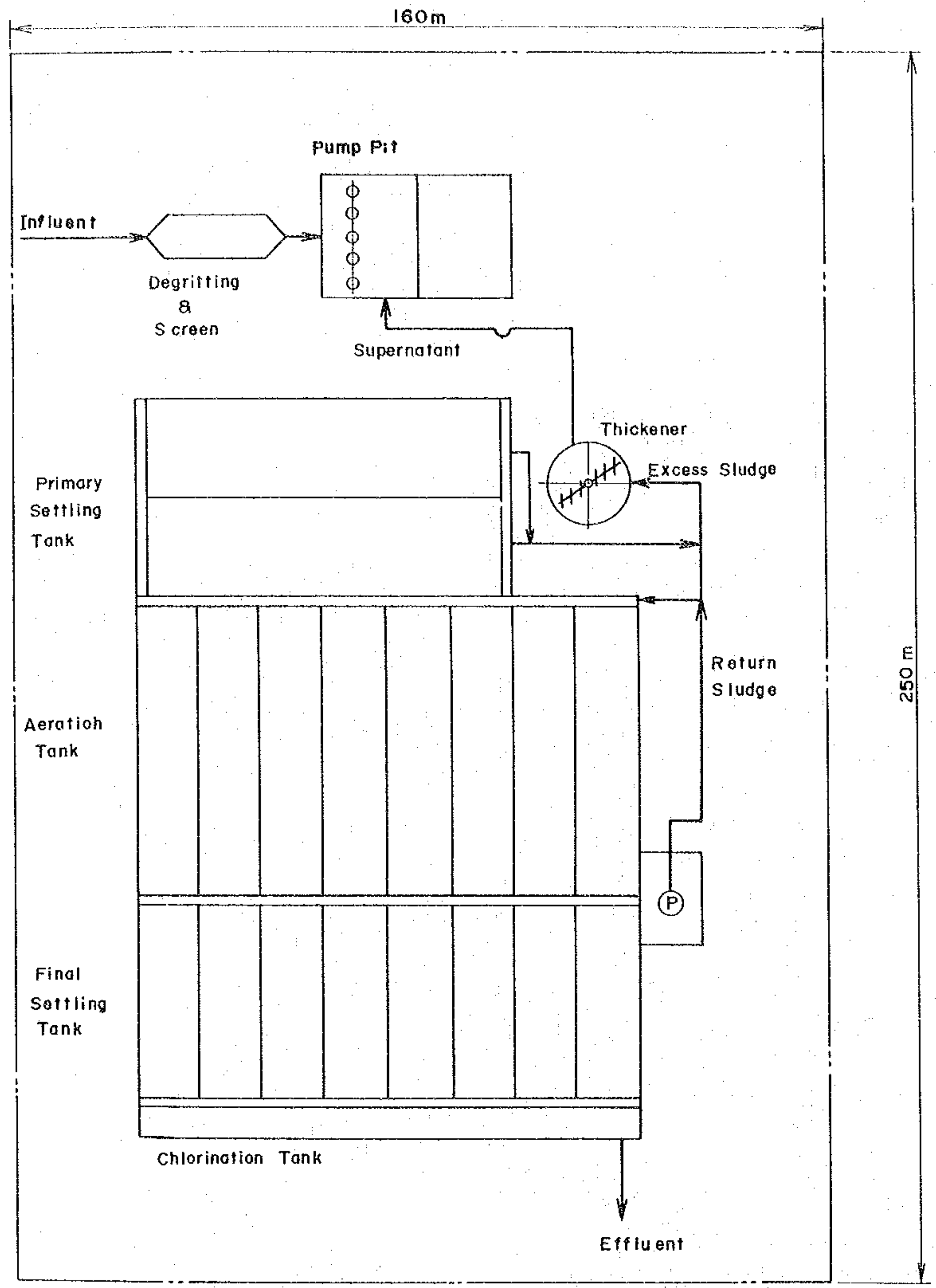

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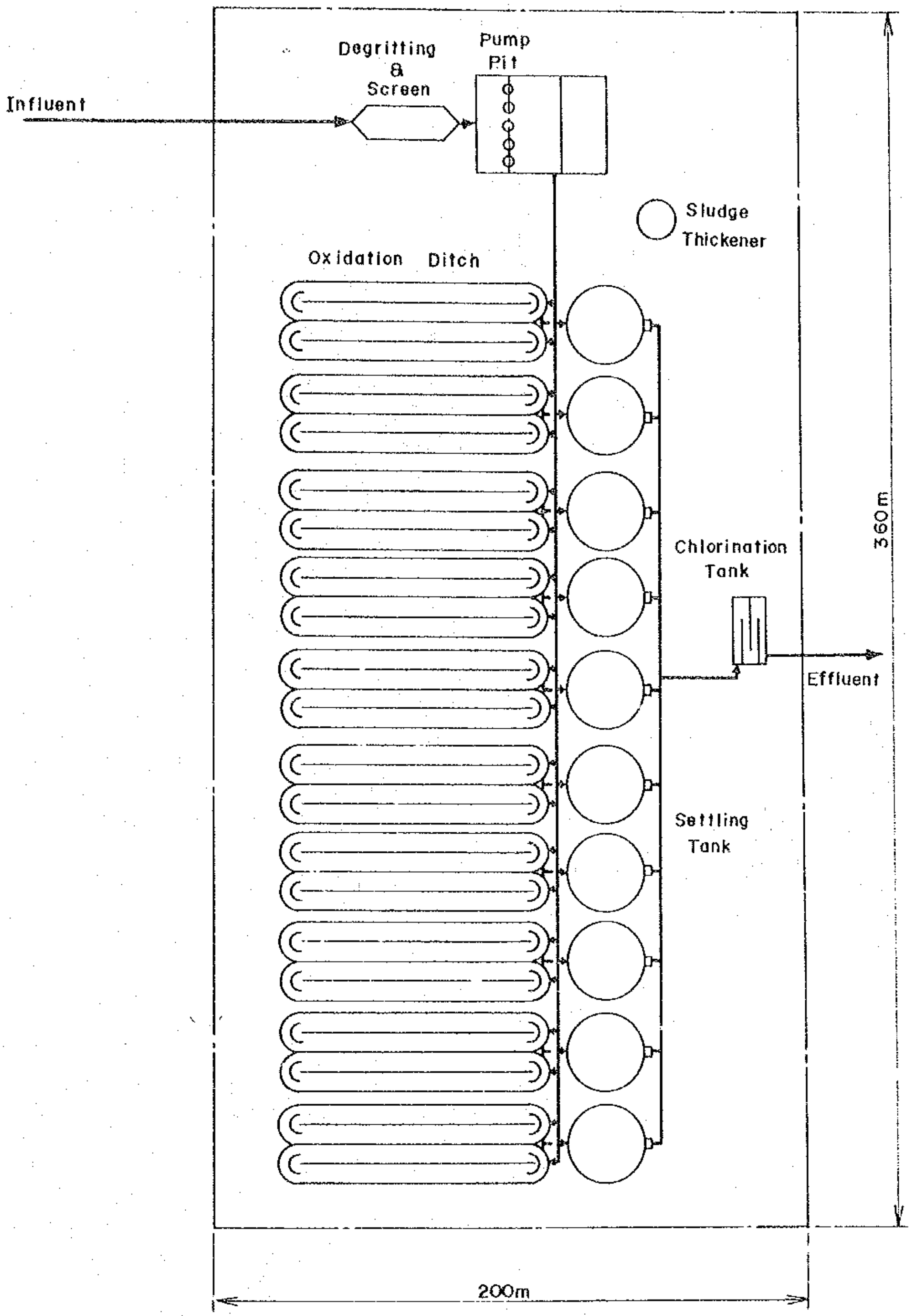
Fig. V.2.4 (2/3)
Plan for Treatment Plant
(Standard Activated Sludge)



LEGEND

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Fig. V.2.4 (3/3)
Plan for Treatment Plant
(Oxidation Ditch)

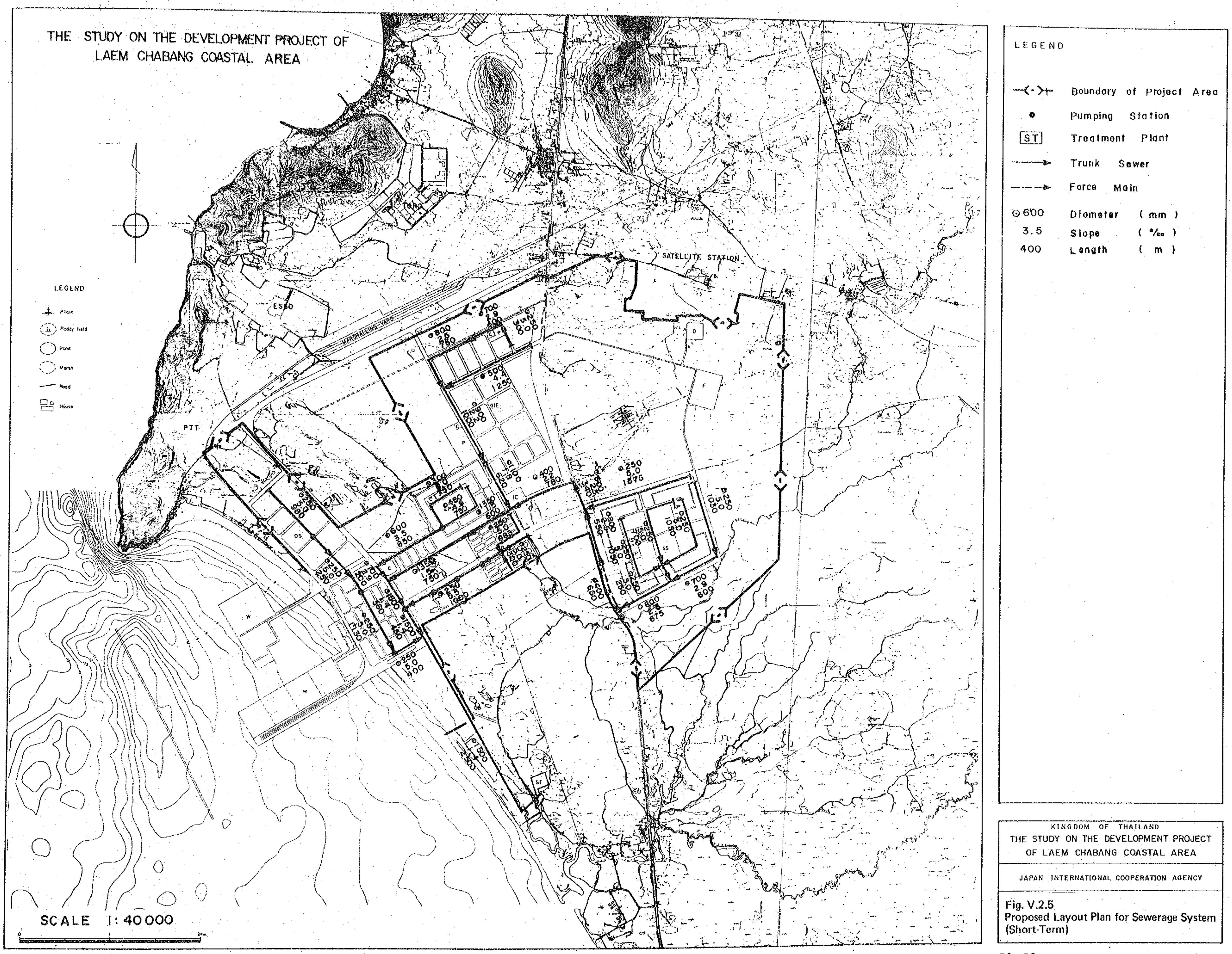

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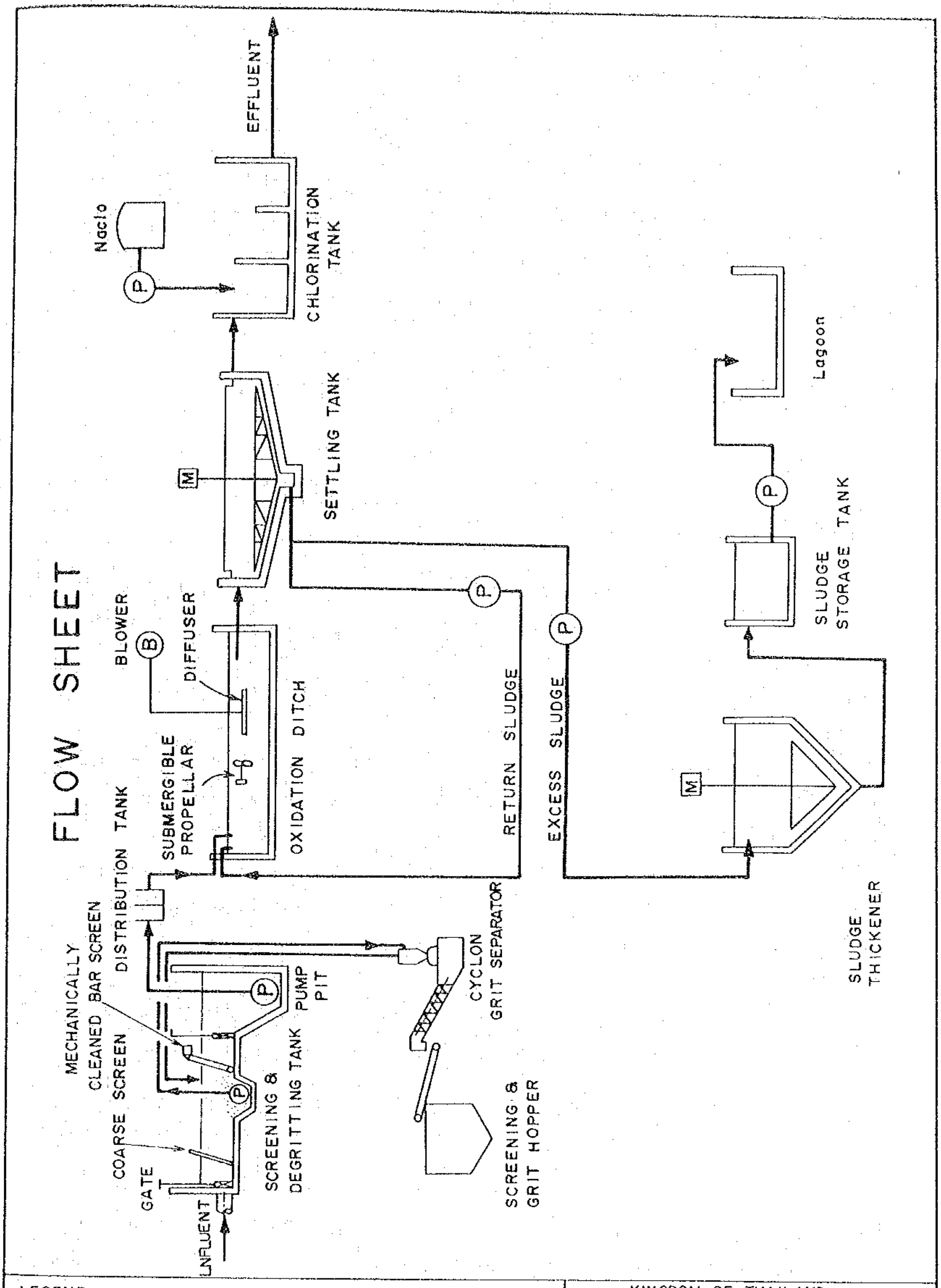
Fig. V.2.5
Proposed Layout Plan for Sewerage System (Short-Term)



LEGEND	KINGDOM OF THAILAND THE STUDY ON THE DEVELOPMENT PROJECT OF LAEM CHABANG COASTAL AREA
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	Fig. V.2.6 Flow Sheet for Oxidation Ditch Process

3. DRAINAGE SYSTEM

3.1 Master Plan

3.1.1 Physical Characteristics of Project Area

1) Present Condition

Existing main channels, Khlong Huai Bo Yai and Khlong Huai Bang Na run through the project area consisting of the New Town, industrial estate and port area as shown in Fig. V.3.1.

Khlong Huai Bo Yai with the total length of 5,800 m originates in the vicinity of the satellite station located east of the Route 3 and flows into the project area. An approximately 1,500 ha out of total catchment area of 2,700 ha is considered to be within the project area.

Khlong Huai Bo Yai branches off at the point of 1,300 m upstream from the estuary and leads to Khlong Map Nong Rai and Khlong Map Nong stretching to the east and crossing the Route 3. As for the underpassing of the route 3, box culvert of 7.5m-wide, and 1.8m-high, is installed for K. Map Nong Rai. Concrete pipe with 1.5m in diameter is installed for K. Map Nong.

On the other hand, K. Huai Bang Na with the total length of 19,500 m originates at the Nong Kho Dam site covering about 9,800 ha of catchment area. Catchment area in the project area is approximately 8,600 ha out of total 9,800 ha.

K. Huai Bang Na underpasses the route 3 at the 4,000m upstream from the estuary and 30m-span bridge is installed there. Furthermore, it underpasses the railroad at 2,600m upstream from the route 3 through box culvert with 7.5m-wide and 1.35m-high.

Stormwater discharge mentioned above would probably cause immersion in the downstream within the Project Area unless appropriate drainage facilities are provided. According to the hydraulic computation of the existing drains, facilities at the location of four underpassing of the route 3 are almost unable to discharge the stormwater runoff. The design of drainage facilities should be performed taking into consideration the situation of catchments area mentioned above.

3.1.2 Design Consideration

1) Design Storm Recurrence Intervals

Storm drains should be designed to carry discharge from the maximum stormwater expected at a given location. However, the actual design of the discharge facilities should be made on the basis of an average frequency of rainfall occurence with due consideration of reasonable investment for implementation.

The determination of return period is so difficult that the present method which is generally accepted has been applied taking into consideration of past experience in projects.

For the present design, 5-year return period is considered to be reasonable according to similar examples in Thailand and other countries. The following table shows the comparison of storm reccurrence interval and rainfall intensity applied in Thailand and other countries.

Item	Storm Recurrence (year)	Rainfall Intensity (mm/h)
Eastern Suburban Bangkok	5	76
Map Ta Put	5	63
Summut Sakhon	10	90
Kelang (Malaysia)	2 (Residencial Area)	66
Kuala Lumpur (Malaysia)	5 (Industrial Area)	78
Average of Japan	5 - 7	50 - 70

2) Sea Level Used for Design

The lowest ground elevation except the alongside the route 3 ranges from MSL+2.0m to +3.0m in the port and industrial area. Hence, design water elevation at the outlet should be determined as MSL +1.75m (H.H.W) in order to prevent the low land from flooding.

3) Rainfall Intensity and Runoff Formula

Two rainfall gausing stations are installed around the Study Area at Srirancha and Bang Lamung. However, since the data in short duration of rainfall which is actually necessary for determination of the rainfall intensity is not available, formula applied by the Map Ta Phuts Study which is based on the records of Chon Buri Gausing Station is adopted for the Study as below.

$$I = \frac{6,000}{t+35}$$

Where, I: Rainfall intensity (mm/h)

t: Time of concentration (min)

t: $t_1 + t_2$

t_1: Inlet-time (mini)

t_2: Time of flow in drain (mini)

Stormrunoff is coputed using above formula and "Rational Formula" which is widely used in current practice as follows:

$$Q = 1/360 \times C \times A \times I$$

Where, Q: Peak discharge of return period T-year (m^3/sec)
A: Catchment area (ha)
C: Runoff Coefficient
I: Rainfall intensity (mm/h)

4) Runoff Coefficient

Runoff coefficients to be used for designing are determined, taking into account the various types of ground surface of the Project Area. The recommended coefficients for the Area by type of land use are as follows:

Land Use	Runoff Coefficient
Residencial Area	0.70
Commercial Area	0.90
Industrial Area	0.65
Port Area	0.90
Open Space	0.30
Mountainous Area	0.50

5) Time of Concentration

The concept of time of concentration is used for estimation of peak discharge derived from the rainfall duration relationship curve for the given frequency.

The time of concentration, which is calculated according to the formula in the Study as below, consists of the inlet time of runoff flow over the ground surface to the nearest drain plus the time of flow in the drain from the most remote inlet to the point under consideration, as expressed in the following equation:

$$t = t_1 + t_2$$

Where, t: time of concentration (mini)

t_1: inlet time (mini)

t_2: time of flow in the drain (mini)

Inlet time is estimated to be 10 minutes on the basis of the situation in the area concerned. The time of flow in the drain is estimated to be 1.5/sec according to the hydraulic properties of the individual channels.

Meanwhile, time of concentration runoff flow over the ground surface is computed using 30 min/2km^2 for inlet time (t_1) and Rziha Formula for time of flow in the drain (t^2).

Rziha Formula

$$V = 72 \times (H/L)^{0.6} \quad (km/h)$$

Where, V: Velocity

H: Difference of hight between upstream and downstream

L: Length of drain

6) Flow Friction Formula

For the hydraulic design of open channels, Manning formula is applied as expressed below:

$$V = 1/n \times R^{2/3} \times I^{1/2}$$

Where, V: Velocity (m/sec)

n: Roughness Coefficient

R: Hydraulic radius (m)

I: Gradient

The value of "n" is determined according to the type of drain as defined below:

Concrete Drain Cast-In-Place	n = 0.015
Precast	n = 0.013
Wet Masonry Drain	n = 0.025
Earth Drain	n = 0.030

7) Velocity of Flow

To prevent deposition of grit and sand in storm drains, the velocity of flow should not be lower than 0.6 meter per secod in any type of drain.

Care should also be given to maximum velocity of flow to prevent erosion of drains. The recommended minimum and maximum velocities for various types of drain are summarized below:

Design Velocity by Type of Drain

Type of Drain	Design Velocity (m/sec)	
	Minimum	Maximum
Concrete Drain	0.6	3.0
Masonry Drain	0.6	2.5
Earth Drain	0.6	1.0

3.1.3 Planning of Drainage Facilities

Stormwater discharge system is classified into open channel system and closed conduit sytem. In this project area, except residential area, ground elevation is relatively low, in M.S.L. +2.0m to +3.0m, resulting in an increase of construction cost for the closed conduit system due to the installation of pump stations. Open channel system is generally said to be reasonable for the low land.

In general, closed conduit system is higher in construction cost compared with open channel system. For this verification, a certain area of the New Town is selected as shown in Fig. V.3.2 and rate of discharge for the closed conduit system and open channel system are calculated for comparison as presented in Table V.3.1. According to the results of the calculation, construction cost of closed conduit system is about 4 times higher than the open channel system. Open channel system shall be adopted in the study.

The selection of the route for trunk drains of stormwater is basically in accordance with the existing drain routes, while in some parts, routes are shifted from the existing ones within the framework of the land use plan. The plan for trunk drain is shown in Fig. V.3.3. Outlet of stormwater discharge is selected to be at the northern extremity and southern extremity of the project area, taking into consideration the deposition of sand into the port area.

Rainfall intensity in this project area is determined to be 5 year return period, refering to the such cases as in the Floor Protection Project of Bangkok Municipality.

Peak discharges of North Main and South Main are computed to be 70 m^3/sec and 194 m^3/sec respectively.

For reference, rate of discharge at the South main canal is calculated with 25 year return period. It is revealed, as a result, that peak dischange in this case is two times larger than the 5 year return period and more than 100 m is required for the width of channel.

3.2 Short-term Development

Following items are indentified in The Long-Term Plan.

(1) In the selection of distribution system, open channel system is preferable to closed conduit system.

(2) 5 year return period is reasonable for the project of stormwater trunk sewer.

(3) Proposed water elevation of the outlet as well as the one at the port shall be M.S.L +1.75 m.

(4) As far as the ground elevation of the project area is maintained at M.S.L +3.0m, there will be no effect of sea water with M.S.L +1.75m.

However, the bottom gradient of the channels is planned to be kept with the range from 0.2% (1/5000) to 0.5% (1/2000), so that the water velocity in the channel partially comes to approximately 0.5 m/sec.

The short-term plan is planned under these conditions and with the capacity set in the Master Plan. The layout plan for the drainage system for the short-term plan is shown in Fig. V.3.4.

Table V.3.1 (1/3) CONSTRUCTION COST OF CONDUIT SYSTEMS

(1) CLOSED CONDUIT SYSTEM

No	Size	Length (m)	Unit Cost (฿/m)	Cost (฿)
1	H1100	530	3,570	1,892,100
2	H1000	200	3,240	648,000
3	B1500x1500	500	10,030	5,015,000
4	H1500	450	5,410	2,434,500
5	B1700x1700	750	12,540	9,405,000
6	H1500	700	5,410	3,787,000
7	H1500	1050	5,410	5,680,500
8	B2600x2600	250	20,380	5,095,000
9	H1200	600	3,890	2,334,000
10	B3000x3000	750	27,180	20,385,000
11	H1500	1000	5,410	5,410,000
12	B3000x3000	40	27,180	1,087,000
13	H1500	650	5,410	3,516,500
14	H1500	550	5,410	2,975,500
15	B1700x1700	300	12,540	3,762,000
16	H1000	500	3,240	1,620,000
17	B2100x2100	400	14,080	5,632,000
18	H800	300	2,380	714,000
Manhole		95 x 10,000 ฿/NO=		950,000
Total:				82,343,100

Note: H: concret pipe
B: box culvert

Table V.3.1 (2/3) CONSTRUCTION COST OF CONDUIT SYSTEMS

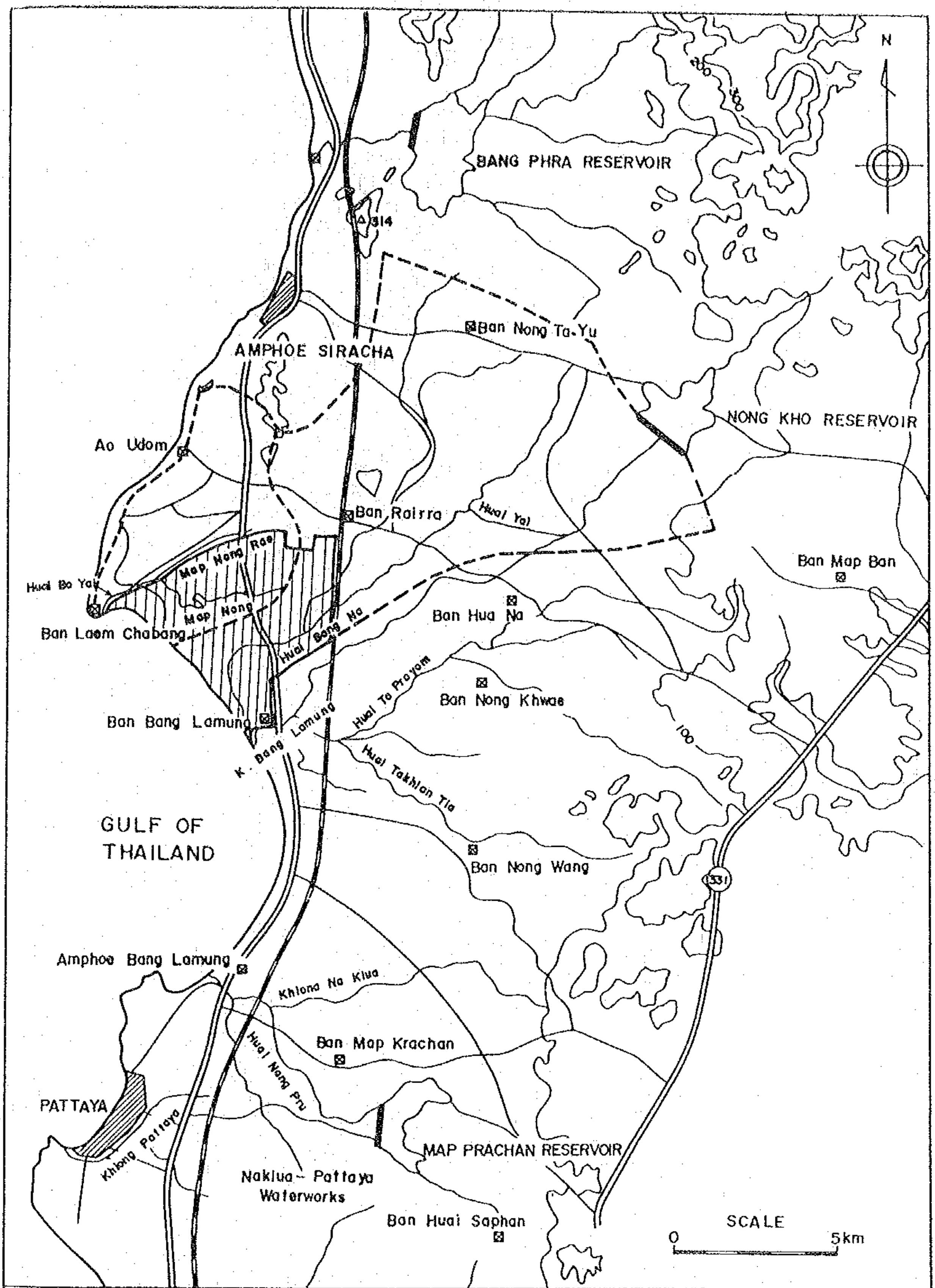
(2) OPEN CONDUIT SYSTEM (1/2) (Unit: ฿)

No	Size	Length (m)	Unit Cost (฿/m)	Cost (฿)
1	T 1.4/0.7 x 0.7	530	790	481,700
2	T 1.8/0.9 x 0.9	500	1030	515,000
3	T 1.4/0.7 x 0.7	650	790	513,500
4	T 1.2/0.6 x 0.6	530	680	360,400
5	T 1.8/0.9 x 0.9	25	1030	25,750
6	T 1.0/0.5 x 0.5	200	50	114,000
7	T 2.2/1.1 x 1.1	1100	1270	1,397,000
8	T 1.8/0.9 x 0.9	1200	1030	1,236,000
9	T 1.8/0.9 x 0.9	1000	1030	1,030,000
10	T 2.6/1.3 x 1.3	25	1520	38,000
11	T 1.4/0.7 x 0.7	750	790	592,500
12	T 2.8/1.4 x 1.4	250	1650	412,500
13	T 8/5 x 1.5	25	6100	152,500
14	T 1.6/0.8 x 0.8	1050	910	955,500
15	T 1.6/0.8 x 0.8	700	910	637,000
16	T 2.2/1.1 x 1.1	25	1270	31,750
17	T 1.8/0.9 x 0.9	1050	1030	1,081,500
18	T 2.6/1.3 x 1.3	250	1520	380,000
19	T 10/7 x 1.5	750	6350	4,762,500
20	T 2.2/1.1 x 1.1	1000	1270	1,270,000
21	T 10/7 x 1.5	40	6350	254,000
22	T 1.6/0.8 x 0.8	650	910	591,500
23	T 1.4/0.7 x 0.7	550	790	434,500
24	T 1.8/0.9 x 0.9	25	1030	25,750

Table V.3.1 (3/3) CONSTRUCTION COST OF CONDUIT SYSTEMS

(2) OPEN CONDUIT SYSTEM (2/2) (Unit: ฿)

No	Size	Length (m)	Unit Cost (฿/m)	Cost (฿)
25	$T\frac{1.0}{0.5} \times 0.5$	250	570	142,500
26	$T\frac{1.8}{0.9} \times 0.9$	300	1030	309,000
27	$T\frac{1.6}{0.8} \times 0.8$	300	910	273,000
28	$T\frac{1.6}{0.8} \times 0.8$	25	910	22,750
29	$T\frac{1.6}{0.8} \times 0.8$	300	910	273,000
30	$T\frac{1.6}{0.8} \times 0.8$	200	910	182,000
31	$T\frac{2.2}{1.1} \times 1.1$	400	1270	508,000
32	$T\frac{1.4}{0.7} \times 0.7$	300	790	237,000
33	$T\frac{2.4}{1.2} \times 1.2$	40	1390	55,600
34	$T\frac{1.6}{0.8} \times 0.8$	650	910	591,500
35	$T\frac{1.6}{0.8} \times 0.8$	700	910	637,000
Total:				20,461,200



LEGEND

- National Road
- Major City / Town
- River
- Reservoir
- Railroad
- Laem Chabang Complex
- Boundary of Drainage Basin

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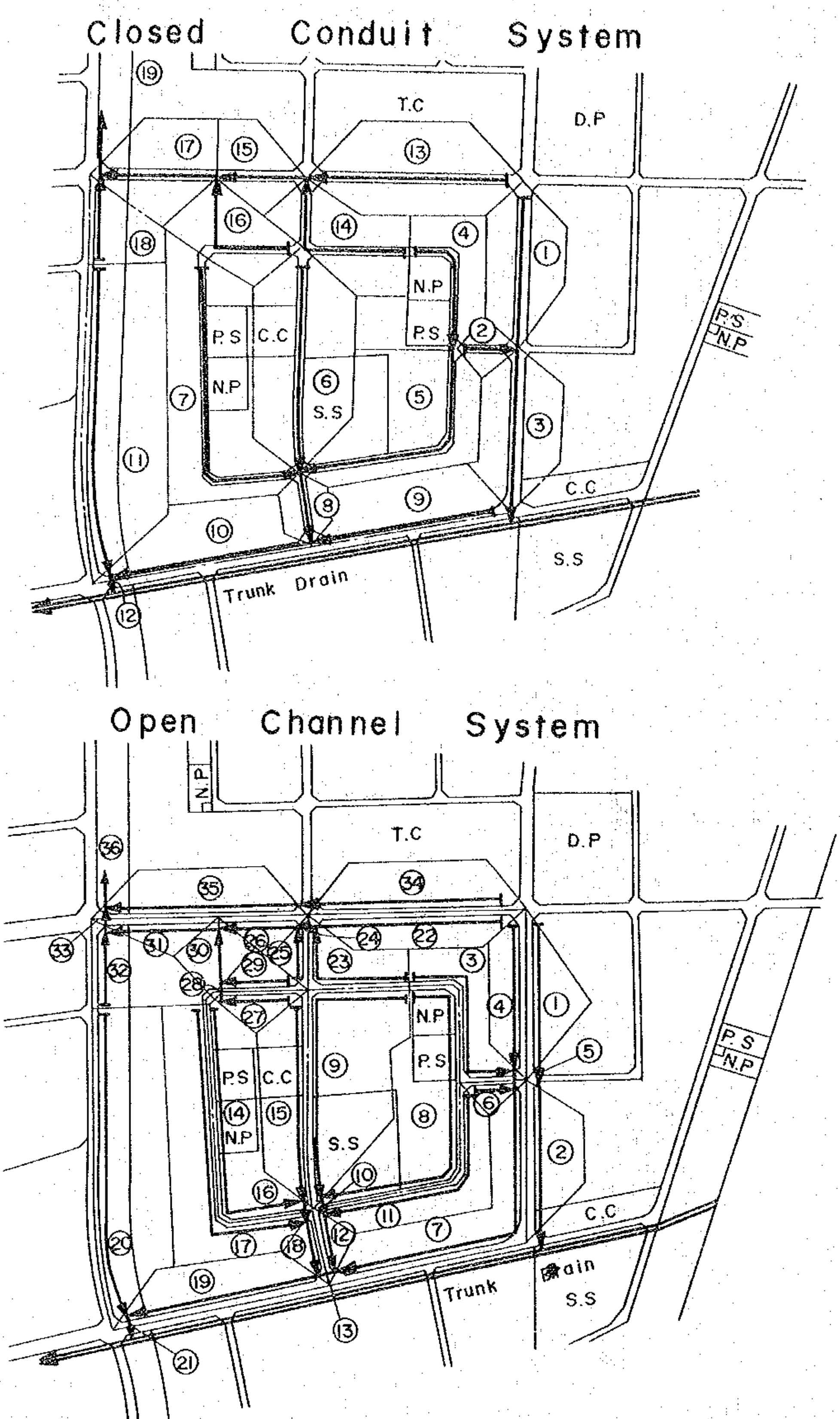
Fig. V.3.1
Existing Main Drain and Drainage Basin



LEGEND

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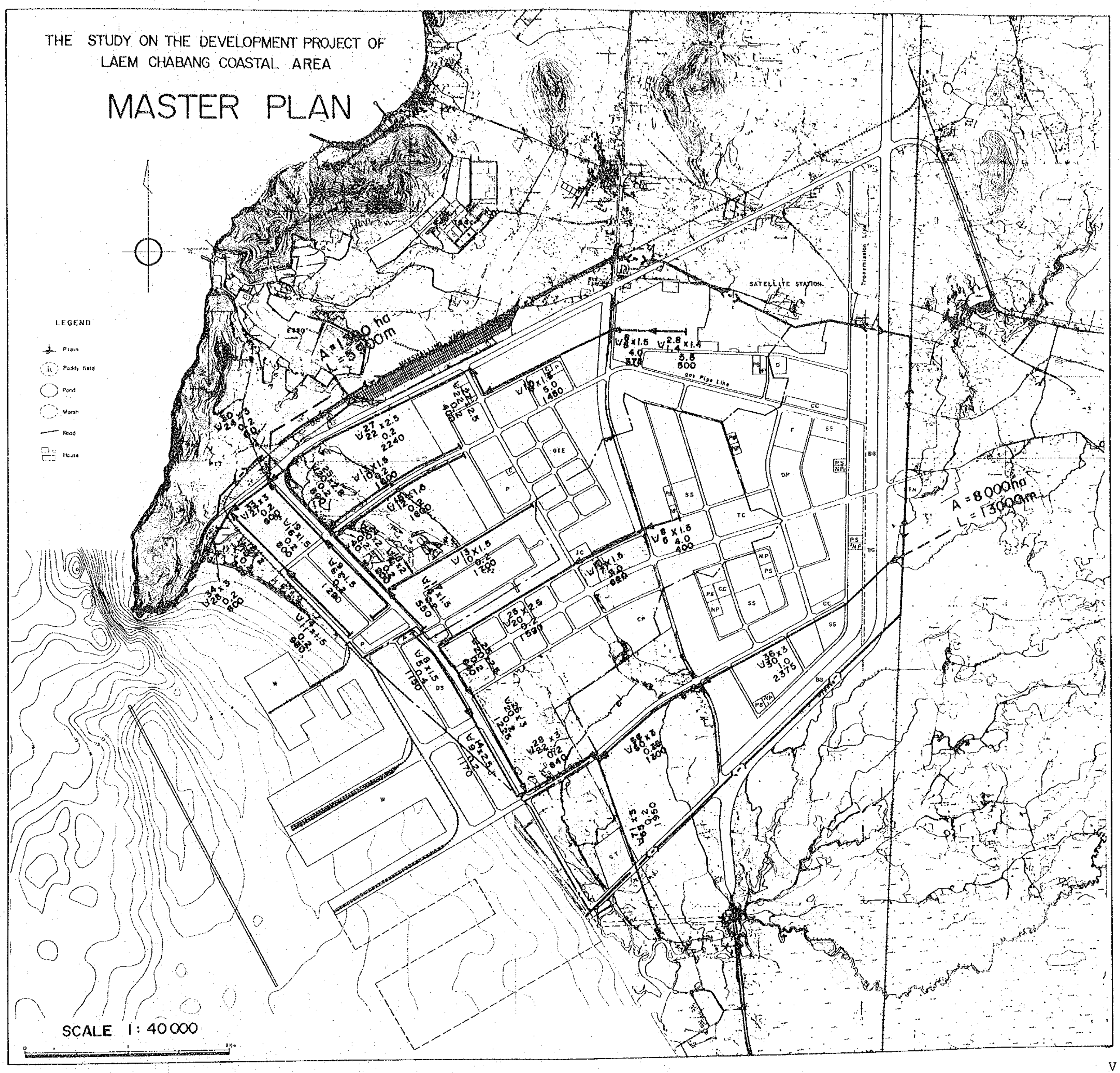
Fig. V.3.2
Alternative of Drainage System



LEGEND

—‹-›—	Boundary of Project Area
— - —	Boundary of Catchment
———→	Trunk Drain
$\nabla^{14.0}_{10.0}$x2.0	Shapeand Size (m)
0.5	Slope
500	Length

Where

Upper Wdidth	14.0m
Bottom Width	10.0m
Depth	2.0m

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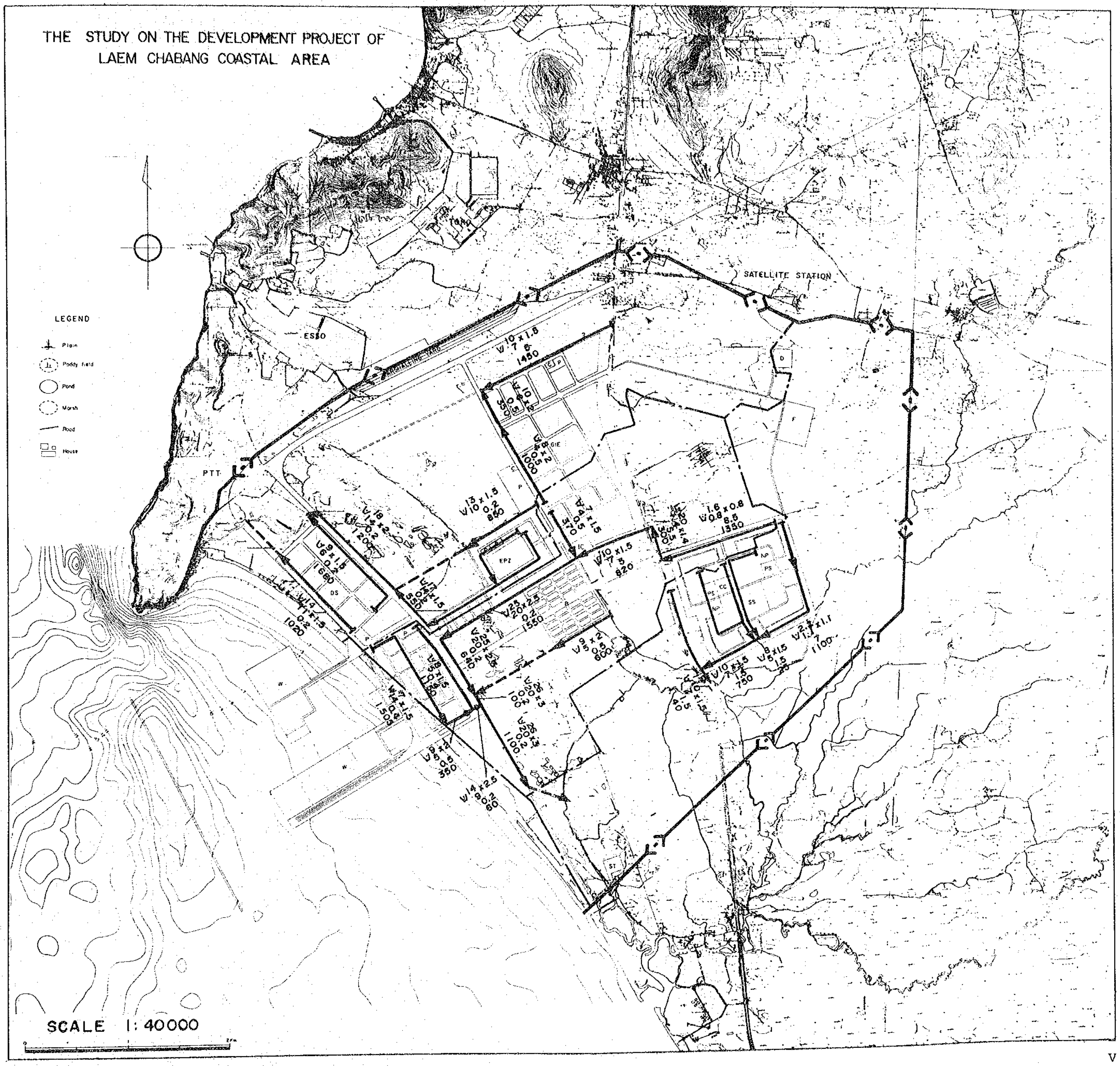
Fig. V.3.3
General Plan of Proposed Drainage System
(Master Plan)



LEGEND

—‹·›—	Boundary of Project Area
— - —	Boundary of Catchment
———	Trunk Drain
$\nabla\frac{14.0}{10.0}\times 2.0$	Shape and Size (m)
0.5	Slope
500	Length

Where

Upper Width	14.0m
Bottom Width	10.0m
Depth	2.0m

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Fig. V.3.4
General Plan of Proposed Drainage System
(Short-Term)

4. SOLID WASTE DISPOSAL

4.1 Present Condition

Municipal and Amphoe offices of Siracha are at present responsible for operation of the solid waste disposal respectively.

Solid waste tip of Siracha Municipality is located at approximately 2.5 km east from the railroad with the area of 100 ha. On the otherhand, Amphoe Siracha office utilizes the land of PAT located in the north of ESSO, but is required to find out the new solid waste tip in near future. Service area and the location of the tip of Siracha Municipality and Amphoe Siracha is presented in Fig. V.4.1. They serve for about 50,000 population that consists of 45% of the total Amphoe Siracha population with 109,000 in 1981. Collection of solid waste is carried out by means of three lorries in Siracha Municipality.

4.2 Solid Waste Quantities

Solid waste Quantities will be about 115,800 tons per year in the Laem Chabang Complex at full development and 32,000 tons/year for the short-term development as shown below.

Area	Short-Term Development	Full Development of Master plan
		(tons/year)
Industrial Estate	19,000	67,800
Port Area (including Business Area)	5,800	13,000
New Town	7,200	35,000
Total	32,000	115,800

Note: See Table V.4.1. for detail

Accumulated tonnage of solid waste from 1987 to full development year will be about 867,000 tons that corresponds to the 1,450,000 m^3 with the specific gravity of 0.3 tons/m^3 and the compaction factor 50%. For short term development project of 1987 to 1991, total volume of solid waste will be around 210,000 m^3 requiring solid waste tip with 10 ha with 2 m depth. (See Table V.4.2)

The industrial estate generates sludge and mineral wastes mainly. Solid waste from the port is made of chip, paper and flour, and the new town generate garbage, paper and plastics. Volume of industrial wastes by kinds is given in Table V.4.3. and V.4.4.

4.3 Disposal System

4.3.1 Disposal Method

Landfilling is the suitable method of solid waste disposal in the Laem Chabang Complex at least until 2001 for the following reasons.

(1) A lot of farm land or forest with low land price are available for the solid waste tip around the Laem Chabang Complex.

(2) Incineration can not be introduced to the Complex depend on some reasons as follows:

(a) Construction cost and maintenance cost would be high.

(b) Solid waste from the complex would not be suitable for the incineration because of physical composition of the solid wastes (Inflammable materials such as paper would amount little.)

(c) Air pollution would occur.

From the viewpoint of an efficiency of the system, industrial waste, port waste and the garbage from new town must be disposed at the one tip.

Scrapped material with poisonous ingredient is not acceptable to the tip and must be disposed by each factory by their own responsibility.

4.3.2 Location of Solid Waste Tip

Following two alternatives can be proposed for the location of solid waste tip as shown in Fig. V.4.2.

Tip A: The tip of Siracha Municipality that has the area of 100 ha at 10 km north from Laem Chabang Complex can be utilized with joint work. Otherwise farm land can be purchased as the new tip next to Siracha municipality's tip.

Tip B: Reserved area near sewage treatment plant in the port area of the Laem Chabang Complex could be utilized as the tip. Tip Site of landfilling can be utilized as the park or truck terminal in future.

A comparison of the two alternatives is shown in the following table.

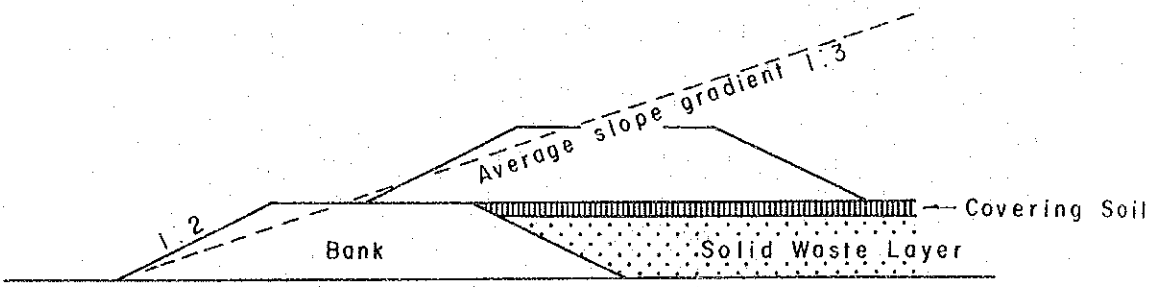
Item	A tip	B tip
(1) Accessibility	10 km from the north edge of the industrial estate by surface trip	Located in the port area
(2) Down Stream	Located along upstream of Huai Yai river with lots of residences on down stream	Located near the river month without residences on downstream
(3) Land acquision	About ฿7.3 x 10^6 (146 Rai with 6 m depth x ฿50,000/ Rai) be needed for land acquision	Already purchased by PAT
(4) Environmental impact	Smell or insect damage are not regarded to be social problem based on the thin population density	Some measures for the smell or insect are required because of the proximity to the business and commercial area.
(5) Capacity	No limitation on additional land acquisition	About 600,000 m^3 in the port area

Provided that an optimum countermeasure such as enough soil covering to the offensive smell and insect damage be taken, tip B would be attractive at the beginning of development of the Laem Chabang Complex. However, tip A is required to be developed in the future after the full disposal of tip B.

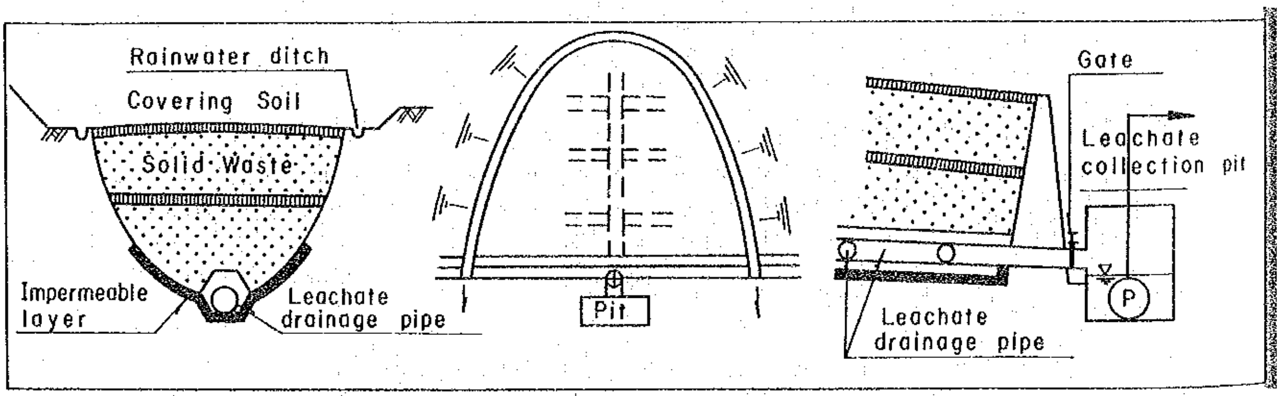
4.3.3 Land Fill Plan

In case of a site where landfill is newly started, a pre-embankment landfill method should be adopted. In this method, scheduled landfill area is enclosed by the previously-constructed embankment and solid waste is placed inside the embankment.

Model shape of embankment section (Average shape gradient 1:3)



For the purpose of avoiding emvironmental pollution, drainage pipes, leachate collection pit and impermeable layer are needed to be constructed shown as below.



Source: Text for Japan-USA Solid Waste Conference by M. Hanajima

Fig. V.4.3 shows the typical section of the Solid waste tip.

4) Collection System

Solid Waste from the port area and the new town will be collected by the authority in charge of Laem Chabang Complex development. Industrial solid waste must be transported by each factory to the solid waste tip.

Number of garbage trucks for collection of solid waste is estimated as below.

Area	Short-Term Development	Full Development of master plan
Port area	3	7
New Town	4	18
Total	7	25

(See Table V.4.5 for detail)

Altogether twenty five garbage trucks are to serve the port area and new town with 8 m^3 non-compactor truck (2.2 tons) at full development and seven garbage trucks for short term development for the Laem Chabang Complex.

Table V.4.1 SOLID WASTE GENERATION TONNAGE

Item	Short Term Development	Full Development of Master Plan
Industrial Estate	19,000 tons/year	67,800 tons/1/year
(EPZ)	(4,500)/2	(13,500)
(GIE)	(14,500)	(54,300)
Port (Wharf)	8.3 m tons x 0.5 ton/3/1,000 tons (cargo volume) = 4,200 tons/year	16 m tons x 0.5 ton/3/1,000 tons (cargo volume) = 8,000 tons/year
Port (Back up area)	11,000 employee/4 x 400 g/person/3 x 365 days = 1,600 tons/year	34,000/4 employee x 400 g/person x 365 days = 5,000 tons/year
New Town	24,800 persons x 800 g/persons/5 x 365 days = 7,200 tons/year	120,000 persons x 800 g/persons/5 x 365 days = 35,000 tons/year
Total	32,000 tons/year	115,800 tons/year

Note:
- /1: See Table V.2.3
- /2: EPZ: $13,500 \times \frac{400 \text{ Rai}}{700 \text{ Rai}} \times 58\%$ (Operation Ratio) = 4,500 tons/year

  GIE: $54,300 \times \frac{1,400 \text{ Rai}}{2,100 \text{ Rai}} \times 40\%$ (Operation Ratio) = 14,500 tons/year
- /3: Japanese example
- /4: Direct and multiplier employee in port wharf, distribution and business area.
- /5: 800 g/cap. day includes not household waste but related waste as market waste in New Town based on the examples in BMA from "The Bangkok Solid Waste Management Study, Sept. 1982, JICA".

Table V.4.2 ACCUMULATED VOLUME OF SOLID WASTE IN LAEM CHABANG COMPLEX

Item	To Short Term Development (1991)	To Full Development of Master Plan
Solid Waste Generation Tonnage	32,000 tons/year	115,800 tons/year
Solid Waste Generation Tonnage during 1987-1981 or 1987-2001	32,000 x 4 years = 128,000 tons	(32,000+115,800)/2 x 10 years + 128,000 = 867,000 tons
Volume of Solid Waste (m^3)	128,000 ÷ 0.3 tons/m^3 = 427,000 m^3	867,000 ÷ 0.3 tons/m^3 = 2,890,000 m^3
Volume based on Compaction Factor of 50% (m^3)	427,000 x 0.5 = 210,000 m^3	2,890,000 x 0.5 = 1,450,000 m^3

TABLE V.4.3 VOLUME OF INDUSTRIAL WASTES

(Unit: tons/year)

1) GIE

	Cinder	Sludge	Oil Sludge	Acidic Wastes	Alka-line Wastes	Plast-ic Wastes	Paper Wastes	Wood Wastes	Textile Wastes	Residue of Animals and Plants	Rubber Wastes	Metal Wastes	Glass & Ceramic Wastes	Mine-ral Wastes	Building Material Wastes	Dusts	Pretre-ated Wastes	Others	Total	Landfill-ing Ratio	Landfill-ing Volume
Mean	6187.4	27350.5	78.8	1261.1	157.6	630.6	472.9	433.5	39.4	78.8	78.8	78.8	2049.3	34207.9	5872.1	2995.2	0.0	8512.6	90485.4	88.8	80351.0
19	53.5	1017.7	4.0	2.0	0.0	23.8	21.8	7.9	0.0	110.9	0.0	2.0	2.0	0.0	37.6	0.0	0.0	27.7	1310.8	88.1	1154.8
20	2.0	54.5	0.0	0.0	0.0	1.4	1.0	0.2	3.5	0.0	0.0	0.0	0.6	0.0	0.8	0.6	0.2	0.4	65.1	70.6	45.9
21	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0
22	47.3	3.4	0.0	0.0	0.0	0.0	0.0	11.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.8	0.0	0.2	75.3	85.7	64.6
23	1.5	20.0	0.0	0.0	0.0	7.6	0.2	8.8	0.5	0.0	0.0	0.2	1.7	15.4	2.2	0.0	0.0	0.2	58.8	100.0	58.8
24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	84.9	0.0
25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	83.3	0.0
26	22.9	2997.3	5.3	88.0	22.9	59.8	15.8	3.5	5.3	3.5	5.3	1.8	19.4	42.2	378.4	22.9	0.0	140.8	3836.8	87.2	3345.7
27	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	83.4	0.0
28	9.4	26.4	2.6	0.0	0.0	136.5	7.7	4.3	10.2	0.0	94.7	0.9	1.7	0.0	0.0	3.4	0.0	54.6	351.4	82.4	289.6
29	0.0	348.2	0.0	0.0	0.0	0.9	0.2	0.2	28.9	1.1	7.3	0.4	0.0	0.0	0.0	0.6	0.0	25.7	413.4	80.0	330.7
30	7.0	3930.0	4.0	9.0	53.0	14.0	7.0	7.0	0.0	0.0	0.0	2.0	411.0	74.0	268.0	59.0	0.0	116.0	4962.0	97.9	4857.8
31	15.9	1107.3	7.1	35.3	0.0	1.8	8.8	1.8	1.8	0.0	0.0	3.5	506.8	12271.9	1681.2	490.9	0.0	770.0	16902.4	92.0	15550.2
32	12.4	14322.6	8.8	903.4	0.0	37.1	3.5	3.5	0.0	0.0	3.5	3.5	15.9	2910.1	411.9	447.3	0.0	7961.3	27045.1	83.3	22528.6
33	3.1	421.3	3.1	106.9	0.0	15.3	27.5	3.1	0.0	0.0	0.0	3.1	3.1	152.7	58.0	42.7	0.0	152.7	1001.4	79.1	792.1
34	4.9	29.4	3.3	0.0	0.0	9.8	3.3	3.3	0.0	0.0	0.0	6.5	6.5	356.0	18.0	14.7	0.0	58.8	516.0	89.5	461.8
35	16.2	291.9	16.2	527.1	16.2	170.3	73.0	32.4	0.0	0.0	0.0	8.1	64.9	170.3	56.8	0.0	0.0	40.5	1492.1	53.7	801.2
36	65.4	588.3	32.7	16.3	32.7	163.4	114.4	49.0	16.3	0.0	16.3	49.0	65.4	1977.3	261.5	457.5	0.0	326.8	4216.0	93.7	3950.4
37	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	71.4	0.0
38	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
39	4.8	11.6	1.0	0.0	0.0	48.9	10.6	3.2	0.6	0.3	0.6	0.0	1.6	0.0	10.6	0.6	0.0	6.1	101.1	81.3	82.2
18–39	266.1	25169.9	87.9	1688.0	124.8	690.5	294.8	139.9	67.2	115.8	127.8	81.1	1100.5	17969.9	3185.0	1553.2	0.2	9681.8	62347.7	0.0	54314.4

2) EPZ

	Cinder	Sludge	Oil Sludge	Acidic Wastes	Alka-line Wastes	Plast-ic Wastes	Paper Wastes	Wood Wastes	Textile Wastes	Residue of Animals and Plants	Rubber Wastes	Metal Wastes	Glass & Ceramic Wastes	Mine-ral Wastes	Building Material Wastes	Dusts	Pretre-ated Wastes	Others	Total	Landfill-ing Ratio	Landfill-ing Volume
Mean	2329.9	10299.0	29.7	474.9	59.4	237.4	178.1	163.2	14.8	29.7	29.7	29.7	771.7	12881.1	2211.2	1127.8	0.0	3205.4	34072.6	88.8	30256.5
19	9.2	174.8	0.7	0.3	0.0	4.1	3.7	1.4	0.0	19.0	0.0	0.3	0.3	0.0	6.5	0.0	0.0	4.8	225.1	88.1	198.3
20	10.4	289.1	0.0	0.0	0.0	7.3	5.2	1.0	18.7	0.0	0.0	0.0	3.1	0.0	4.2	3.1	1.0	2.1	345.3	70.6	243.8
21	2.8	28.0	0.0	0.0	0.0	11.2	64.4	0.0	145.6	0.0	75.6	0.0	0.0	0.0	0.0	0.0	0.0	2.8	330.4	100.0	330.4
22	32.1	2.3	0.0	0.0	0.0	0.0	0.0	7.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.7	0.0	0.1	51.2	85.7	43.8
23	1.0	13.9	0.0	0.0	0.0	5.3	0.2	6.1	0.3	0.0	0.0	0.2	1.2	10.7	1.5	0.0	0.0	0.2	41.0	100.0	41.0
24	61.5	2411.9	0.0	0.0	0.0	53.8	121.7	190.5	3.4	0.0	0.0	1.7	0.0	3.4	15.5	0.4	0.0	188.3	3052.1	84.9	2591.3
25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	83.3	0.0
26	3.3	425.8	0.8	12.5	3.3	8.5	2.3	0.5	0.8	0.5	0.8	0.3	2.8	6.0	53.8	3.3	0.0	20.0	545.0	87.2	475.2
27	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	83.4	0.0
28	3.9	10.8	1.1	0.0	0.0	56.0	3.1	1.8	4.2	0.0	38.9	0.4	0.7	0.0	0.0	1.4	0.0	22.4	144.2	82.4	118.8
29	0.0	757.6	0.0	0.0	0.0	1.9	0.5	0.5	63.0	2.4	16.0	0.9	0.0	0.0	0.0	1.4	0.0	55.9	899.6	80.0	719.7
30	1.0	550.2	0.6	1.3	7.4	2.0	1.0	1.0	0.0	0.0	0.0	0.3	57.5	10.4	37.5	8.3	0.0	16.2	694.7	97.9	680.1
31	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	92.0	0.0
32	3.8	4374.5	2.7	275.9	0.0	11.3	1.1	1.1	0.0	0.0	1.1	1.1	4.9	888.8	125.8	136.6	0.0	2431.6	8260.4	83.3	6880.9
33	0.3	40.0	0.3	10.2	0.0	1.5	2.6	0.3	0.0	0.0	0.0	0.3	0.3	14.5	5.5	4.1	0.0	14.5	95.1	79.1	75.2
34	1.6	9.7	1.1	0.0	0.0	3.2	1.1	1.1	0.0	0.0	0.0	2.2	2.2	117.7	5.9	4.9	0.0	19.4	170.6	89.5	152.7
35	10.9	196.9	10.9	355.6	10.9	114.9	49.2	21.9	0.0	0.0	0.0	5.5	43.8	114.9	38.3	0.0	0.0	27.4	1006.5	53.7	540.5
36	4.7	42.5	2.4	1.2	2.4	11.8	8.3	3.5	1.2	0.0	1.2	3.5	4.7	142.8	18.9	33.0	0.0	23.6	304.4	93.7	285.3
37	3.1	37.2	0.6	0.0	0.0	18.0	9.3	1.2	0.0	0.0	0.0	0.6	5.6	19.8	0.6	0.6	2.5	5.6	104.8	71.4	74.8
38	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
39	1.7	4.0	0.3	0.0	0.0	16.7	3.6	1.1	0.2	0.1	0.2	0.0	0.6	0.0	3.6	0.2	0.0	2.1	34.5	81.3	28.1
18–39	151.2	9369.3	21.4	656.9	24.0	327.3	277.2	240.8	237.4	22.0	133.7	17.2	127.6	1329.1	317.6	206.0	3.5	2837.0	16304.9	0.0	13479.8

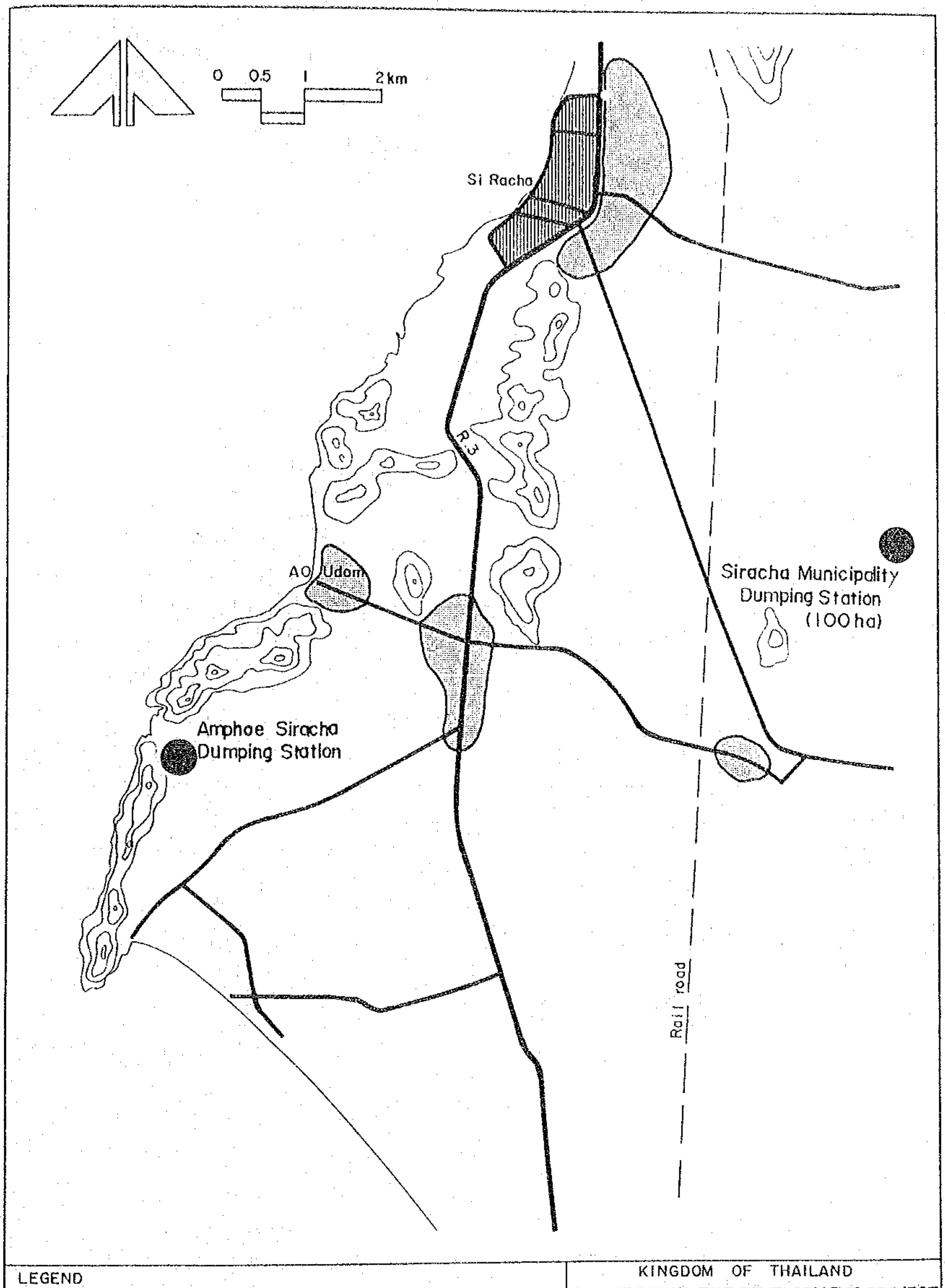
Table V.4.4 UNIT VOLUME OF INDUSTRIAL WASTES

(unit: Tons/1 Billion YEN)

	Cinder	Sludge	Oil Sludge	Acidic Wastes	Alka -line Wastes	Plast -ic Wastes	Paper Wastes	Wood Wastes	Textile Wastes	Residue of Animals and Plants	Rubber Wastes	Metal Wastes	Glass & Ceramic Wastes	Mine -ral Wastes	Building Material Wastes	Dusts	Pretre -ated Wastes	Others	Total
Mean	15.7	69.4	0.2	3.2	0.4	1.6	1.2	1.1	0.1	0.2	0.2	0.2	5.2	86.8	14.9	7.6	0.0	21.6	229.6
19	2.7	51.4	0.2	0.1	0.0	1.2	1.1	0.4	0.0	5.6	0.0	0.1	0.1	0.0	1.9	0.0	0.0	1.4	66.2
20	1.0	27.8	0.0	0.0	0.0	0.7	0.5	0.1	1.8	0.0	0.0	0.0	0.3	0.0	0.4	0.3	0.1	0.2	33.2
21	0.1	1.0	0.0	0.0	0.0	0.4	2.3	0.0	5.2	0.0	2.7	0.0	0.0	0.0	0.0	0.0	0.0	0.1	11.8
22	29.2	2.1	0.0	0.0	0.0	0.0	0.0	7.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.9	0.0	0.1	46.5
23	0.6	8.2	0.0	0.0	0.0	3.1	0.1	3.6	0.2	0.0	0.0	0.1	0.7	6.3	0.9	0.0	0.0	0.1	24.1
24	14.3	560.9	0.0	0.0	0.0	12.5	28.3	44.3	0.8	0.0	0.0	0.4	0.0	0.8	3.6	0.1	0.0	43.8	709.8
25	0.0	2.3	0.0	0.0	0.1	1.5	1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	5.7
26	1.3	170.3	0.3	5.0	1.3	3.4	0.9	0.2	0.3	0.2	0.3	0.1	1.1	2.4	21.5	1.3	0.0	8.0	218.0
27	0.1	3.5	0.2	0.0	1.6	0.1	0.0	0.0	0.0	0.0	0.0	0.0	12.1	0.1	4.9	0.3	0.0	0.1	23.1
28	1.1	3.1	0.3	0.0	0.0	16.0	0.9	0.5	1.2	0.0	11.1	0.1	0.2	0.0	0.0	0.4	0.0	6.4	41.2
29	0.0	161.2	0.0	0.0	0.0	0.4	0.1	0.1	13.4	0.5	3.4	0.2	0.0	0.0	0.0	0.3	0.0	11.9	191.4
30	0.7	393.0	0.4	0.9	5.3	1.4	0.7	0.7	0.0	0.0	0.0	0.2	41.1	7.4	26.8	5.9	0.0	11.6	496.2
31	0.9	62.7	0.4	2.0	0.0	0.1	0.5	0.1	0.1	0.0	0.0	0.2	28.7	694.9	95.2	27.8	0.0	43.6	957.1
32	0.7	810.1	0.5	51.1	0.0	2.1	0.2	0.2	0.0	0.0	0.2	0.2	0.9	164.6	23.3	25.3	0.0	450.3	1529.7
33	0.1	13.8	0.1	3.5	0.0	0.5	0.9	0.1	0.0	0.0	0.0	0.1	0.1	5.0	1.9	1.4	0.0	5.0	32.8
34	0.3	1.8	0.2	0.0	0.0	0.6	0.2	0.2	0.0	0.0	0.0	0.4	0.4	21.8	1.1	0.9	0.0	3.6	31.6
35	0.2	3.6	0.2	6.5	0.2	2.1	0.9	0.4	0.0	0.0	0.0	0.1	0.8	2.1	0.7	0.0	0.0	0.5	18.4
36	0.4	3.6	0.2	0.1	0.2	1.0	0.7	0.3	0.1	0.0	0.1	0.3	0.4	12.1	1.6	2.8	0.0	2.0	25.8
37	0.5	6.0	0.1	0.0	0.0	2.9	1.5	0.2	0.0	0.0	0.0	0.1	0.9	3.2	0.1	0.1	0.4	0.9	16.9
38	0.0	7.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.9
39	1.5	3.6	0.3	0.0	0.0	15.2	3.3	1.0	0.2	0.1	0.2	0.0	0.5	0.0	3.3	0.2	0.0	1.9	31.4

Table V.4.5 NUMBER OF GARBAGE TRUCKS FOR COLLECTION OF SOLID WASTE

Item	Short Term			Full Development		
	Port Area	New Town	Total	Port Area	New Town	Total
1) Solid Waste Tonnage (tons/year)	5,800	7,200	13,000	13,200	35,000	48,200
2) 8 m^3 Noncompactor Truck Capacity (tons/vehicle)	2.2	2.2	2.2	2.2	2.2	2.2
3) Working Days per Year	298	298	298	298	298	298
4) Total Truck Service Times per Day (vehicle.time/day) 1) ÷ 2) ÷ 3)	9	11	20	20	54	73
5) Service Times per Day	3	3	3	3	3	3
6) Number of Needed Vehicles 4) ÷ 5)	3	4	7	7	18	25



LEGEND

- Dumping Station
- Siracha Municipality Service Area
- Amphoe Siracha Service Area

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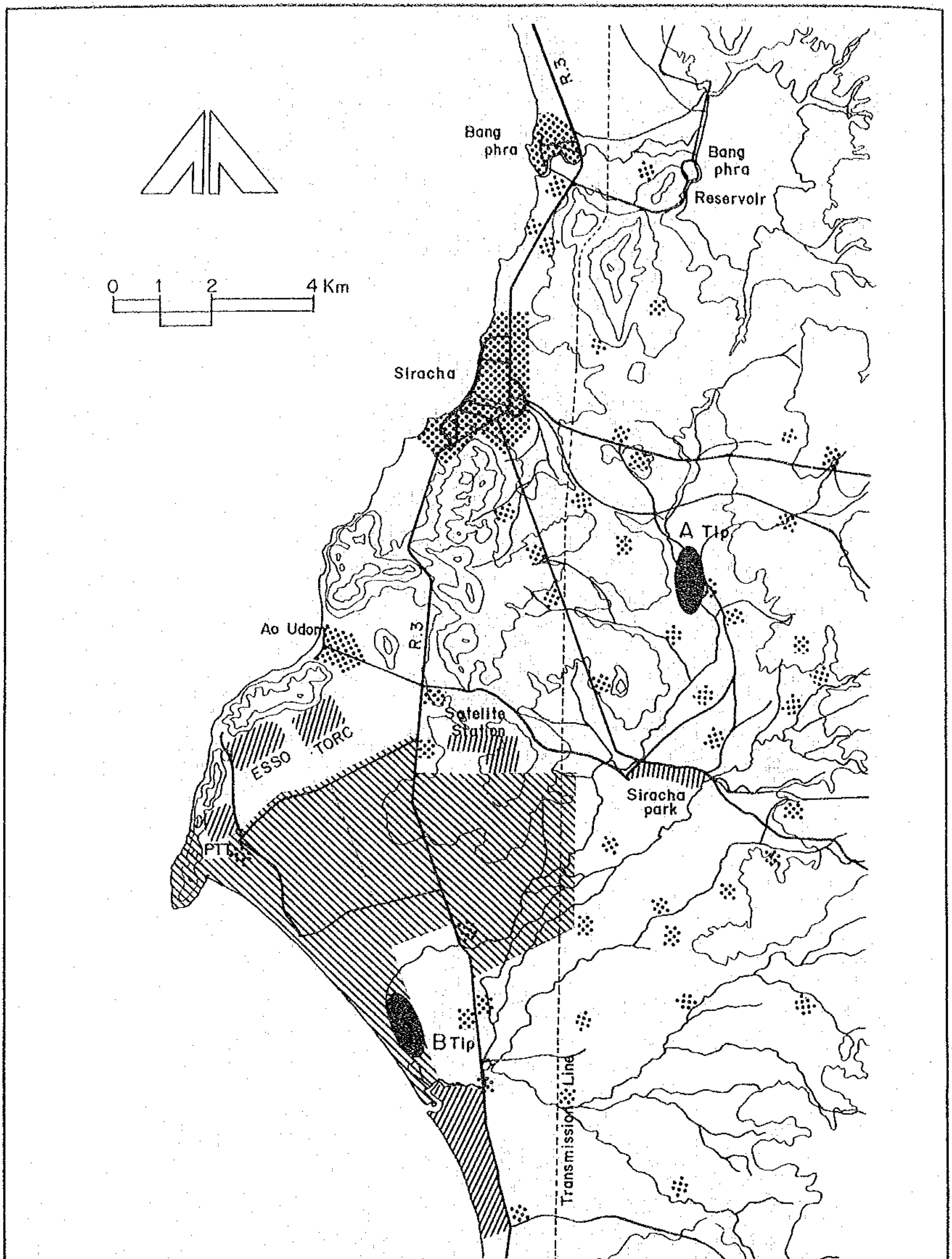
Fig. V.4.1
Existing Condition of Solid Waste Disposal System



LEGEND

Laem Chabang Complex

Existing Residence

Solid Waste Tip

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Fig. V.4.2
Proposed Site for Solid Waste Tip

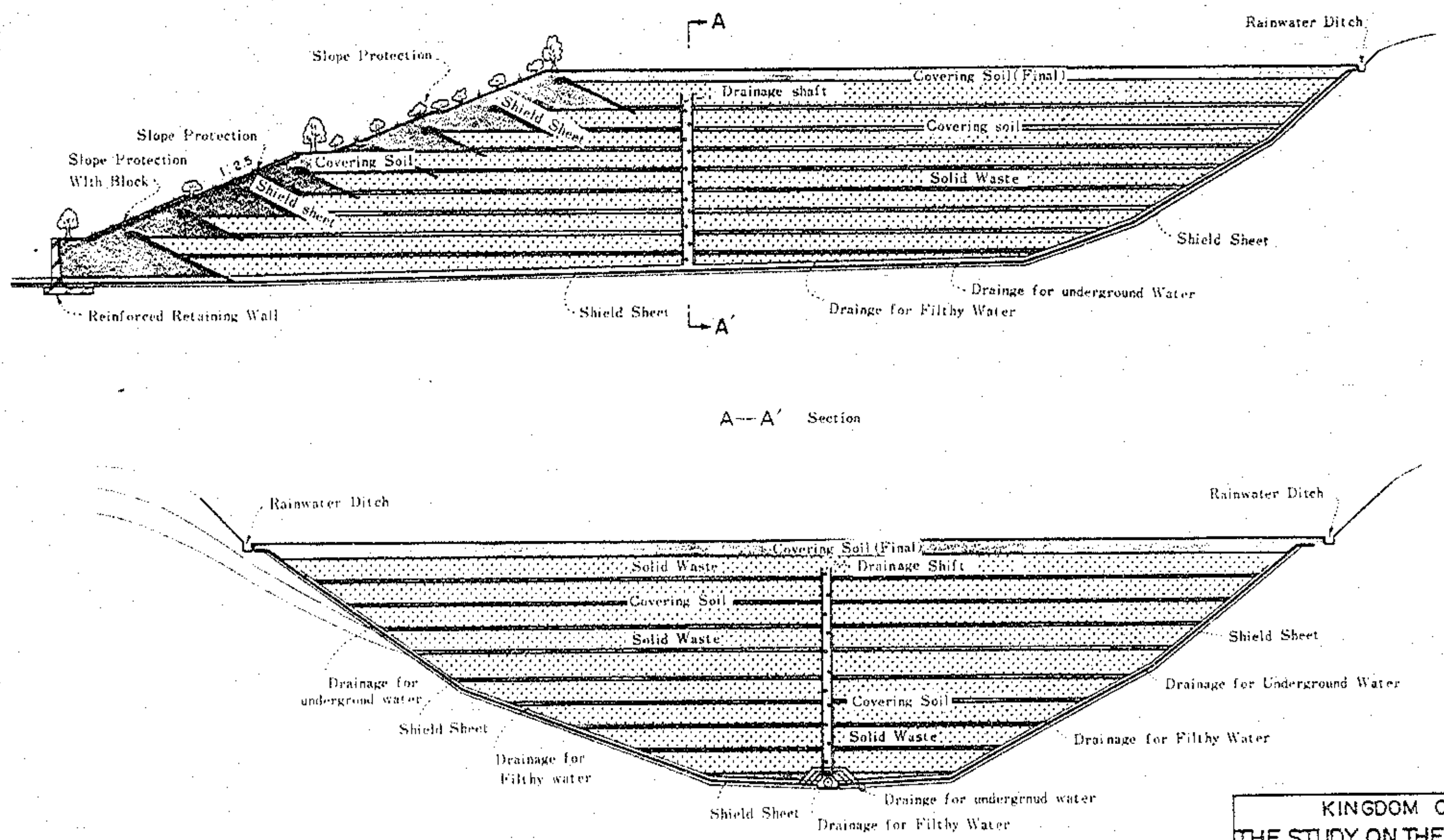

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Fig. V.4.3
Typical Section of Solid Waste Disposal

5. POWER

5.1. Master Plan

5.1.1 Present Condition and Development Plan

In Thailand, there are several government organizations concerned with generation, transmission and distribution of electricity. The Electricity Generating Authority of Thailand (EGAT) is in charge of the generation and transmission of electricity. Metropolitan Electricity Authority (MEA) and Provincial Electricity Authority (PEA) are for the distribution of electricity to consumer, the former for the Bangkok Metropolitan area and the latter mainly for provincial areas.

The principal generating plants for the Laem Chabang complex at present are one thermal power plant of the South Bangkok and two thermal power plants of Bang Pa Kong in Chachongsao province as shown in Table V.5.1.

115 kV transmission line is at present installed from the South Bangkok power plant to the Siracha substation (S/S) which is located approximately 1.5 km east from Siracha downtown and to the Ao Phai S/S situated approximately 4 km east from Ban Ao Udom as shown in Fig. V.5.1 and V.5.2. 230 kV transmission line comes from the Ban Pa Kong power plants to the Ao Phai substation.

Ao Phai thermal plants are scheduled to be constructed during 1991-1995 on the coastal area of Amphoe Siracha. Rayong No. 2 S/S, which is now under construction, will be connected with the Ao Phai S/S by 230 kV transmission line in future for the power supply to the Map Ta Phut Industrial Complex. New Ao Phai No. 2 S/S and transmission line are scheduled to be constructed following the completion of the Ao Phai power plants as shown in Table V.5.2.

The standard voltage for transmissin in the EGAT system are 230, 115 and 69 kV at a frequency of 50 Herz. The voltage is reduced to 22 kV by EGAT for the local high voltage distribution system by PEA and consumers can apply for either a high voltage of 22 kV or a low voltage of 220 v or 220/380 v.

For the Laem Chabang complex, the power generation capacity is considered enough upon the completion of large scale project of power plants being planned by EGAT. A substation in the development area and transmission line from the Ao Phai S/S will, however, need be installed.

The right of way of transmission line is 25 m and 40 m for 115 kV T.L and 230 kV T.L respectively.

5.1.2 Power Demand

Power demand of the new town, industrial estate and port area is estimated to amount to 188.6 MW at full development. The calculation are made according to the following steps.

1) New Town

In the residential area, power demand was estimated assuming 1.2 kW as a consumption per dwelling units in NHA's existing housing estate. In the town center area, 900 kW/ha is assumed as power demand per effective floor area which is set from number of employees. Calculation was made as follows:

(1) Residential area

26,100 units x 1.2 kW/unit = 31,300 kW

(2) Town Center

Area	Employee	Assumed Effective/1 Floor Area (ha)	Power Demand (kW)
Community Center	9,696	7.76	7,000
Neighborhood Shopping Center	2,200	1.76	1,600
Education Facility	1,620	1.30	1,200
Water Filtration Plant and Other	-	-	700
Total			10,500

/1: Computed as 8 m^2/employee

As a result, total power demand in the New Town is estimated to be 41,800 kW.

2) Industrial Estate

Power demand in EPZ, GIE and Industrial Center was estimated as below based on the net area and power density of each kind of industry which are taken from statistical value in Japan. Its detail is shown on Table V.5.3.

Area	Power Demand (kW)
EPZ	18,600
GIE	77,200
Industrial Center and Other	200
Total	96,000

3) Port Area

Port power demand comprises three categories; for port facility area, for distribution and storage area, and for the business and commercial area. The power demand for port facility area was estimated from data obtained through a survey of Tokyo and Yokohama port in Japan. Projected power demand is presented in detail in Table V.5.4.

Area	Power Demand (kW)
Port Facility	25,400
Distribution and Storage	8,200
Business and Commercial	17,200
Total	50,800

4) Total Power Demand

Total power demand for the development area at full scale is summarized as below.

Power Demand Area	Power Demand (KW)
New Town	41,800
Industrial Estate	96,000
Port	50,800
Total:	188,600

5.1.3. Power Supply Plan

In order to supply electric power to the new town, industrial estate, and port in the Laem Chabang Complex, construction of power supply system including 115 kV transmission lines, 115/22 kV substations, 22 kV distribution lines and 380-220 V lines are needed.

In planning the power line system as shown in Fig.V.5.3. , the followings are taken into consideration.

(1) As total power demand in the Laem Chabang Complex was estimated to increase significantly to 188.6 MW in 2001, two new 115/22 kV substations are planned to be located within the development area.

(2) 115 kV transmission line is a double circuit giving priority to high quality.

(3) Capacity of each substation is decided with diversity factor as follows.

Area	Power Demand (MW)	Diversity factor	Capacity (MVA)
New Town	41.8	1.19	35
Industrial Estate	96.0	1.21	79
Port	50.8	1.15	44
Total:	188.6	1.19	158

Therefore, both substation capacity is decided to two bank of 40 MVA.

(4) The electricity will be supplied from two new substations to each load center by 22 kV distribution lines, except the point at which lines cross major roads, where overhead lines are planned to be installed.

(5) For the residential area, 22 kV/220-380 V pole mounting transformers will be supplied by PEA for domestic use.

For the industrial estate and port area, electricity will be supplied to each consumers from points on the road, at 22 kV at owners expense.

Principal features of each facility of the power supply system are summarized as follows.

1) Transmission Line

Item	Ao Phai Laem Chabang-1	Ao Phai Laem Chabang-2
Voltage (kV)	115	115
No. of circuit	2	2
Type of Tower	Double-circuit steel	Double-circuit steel
Conductor size (MCM)	477	477
Line capacity (MVA/circuit)	100	100
Line route	Refer to Fig. V.5.3.	

2) Substation

Item	Laem Chabang-1	Laem Chabang-2
Capacity (MVA)	80	80
Transformer	3-phase 115/22 kV OA/FA 30/40 MVA 2 sets	3-phase 115/22 kV OA/FA 30/40 MVA 2 sets
115 kV incoming lines (No.)	2	2
22 kV feeders (No.)	8	8
Substation land area (m^2)	16,000	16,000
Location	Refer to Fig. V.5.3.	
Switching diagram	Refer to Fig. V.5.4.	

3) Distribution Line

Item	New Town	Industrial Estate	Port
Voltage (KV)	22	22	22
Max. line capacity (A)	300	300	300
Type of wire	Insulated HDCC / Insulated ACSR		
Wire size (Sq.mm)	60/120		
Type of pole	Concrete pole		

5.2. Short-term Development Plan

5.2.1 Power Demand

Power demand in Laem Chabang Complex is estimated at 88.5 MW in 1991. Power demand of the New Town, Industrial estate and port area are given as below:

Power Demand Area	Power Demand (MW)
New Town	9.1
Industrial Estate	58.6
Port	20.8
Total	88.5

The calculation was made under the same consideration as the long term plan according to the following steps.

1) New Town

(1) Residential area

No. of dwelling unit x 1.2 KW/dwelling unit

Therefore,

5,133 x 1.2 = 6,200 KW

(2) Town center

No. of employee x 8 m^2/employee x 10^{-4} x 900 KW/ha

Therefore,

Community Center : 2,424 x 8 x 10^{-4} x 900 = 1,700 KW

Neiborhood Shopping Center : 550 x 8 x 10^{-4} x 900 = 400 KW

Education facility : 405 x 8 x 10^{-4} x 900 = 300 KW

(3) Water filtration plant and other : 500 KW

(4) New town power demand : 9,100 KW

2) Industrial Estate

(1) Factories

$$\text{Long term power demand (KW)} \times \frac{\text{Short term net area (ha)}}{\text{Long term net area (ha)}}$$

Therefore,

$$\text{EPZ} : 18,600 \times \frac{46.1}{84.4} = 10,200 \text{ KW}$$

$$\text{GIE} : 77,200 \times \frac{141.1}{225.6} = 48,300 \text{ KW}$$

(2) Industrial Center

No. of employee x 8 m^2/employee x 10^{-4} x 900 KW/ha

Therefore,

$112 \times 8 \times 10^{-4} \times 900 = 80$ KW

(3) Other : 20 KW

(4) Industrial estate power demand : 58,600 KW

3) Port Area

(1) Port facility area

Container berth :	3 Berth x 3,000 KW/berth =	9,000 KW
Break bulk berth :	1 Berth x 200 KW/berth =	200 KW
Agri-bulk berth :	2 Berth x 1,500 KW/berth =	3,000 KW

(2) Distribution and storage area

Employee x 8 m^2/employee x 10^{-4} x 900 KW/ha

Therefore,

$3,636 \times 8 \times 10^{-4} \times 900 = 2,600$ KW

(3) Business and commercial area

$7,177 \times 8 \times 10^{-4} \times 900 = 5,200$ KW

(4) Swerage treatment plant and other : 800 KW

(5) Port area power demand : 20,800 KW

5.2.2 Power Supply Plan

As a result of study on short term power demand, approximately 66 % of total power demand in Laem Chabang Complex will be concentrated in the industrial estate, and the other demand are alloted to 24 % in the port area and 10 % in the new town.

Therefore, location of new substation is selected within northern side of industrial estate which is near to power load center and planned as Leam Chaban-2 in long term plan.

Consequently, power line system is as show in Fig. V.5.5. Principal features of each facility of the power supply system are summarized as follows.

1) Transmission Line

Voltage	:	115 KV
No. of circuit	:	2
Type of tower	:	Double circuit steel tower
Conductor size	:	477 MCM
Line capacity	:	100 MVA/circuit
Line route	:	Refer to Fig. V.5.5.

2) Laem Chabang-2 Substation

Substation capacity	:	80 MVA
Main transformer	:	3 phase, 115/22 KV, 40 MVA x 2 sets
115 KV incoming line	:	2
22 KV feader	:	8
Substation land area	:	16,000 m^2 (10 rai)

3) Distribution Line

Voltage	:	22 KV
Max. line capacity	:	300 A
Type of wire	:	Insulated HDCC/Insulated ACSR
Wire size	:	60/120 Sq.mm
Type of pole	:	Concrete pole
No. of Line	:	4 (Industrial estate), 2 (Port area) 1 (New town), 1 (Spare)

Table V.5.1. GENERATING PLANTS FOR LAEM CHABANG COMPLEX

Plants	Fuel Type	Unit No.	Rating (MW)	Total (MW)	In-Service Date
South Bangkok	Fuel Oil	1	200.0		Dec. 18, 1970
		2	200.0		Nov. 16, 1971
	Fuel Oil/Gas	3	300.0		Jun. 11, 1974
		4	300.0		Sep. 22, 1975
		5	300.0	1,300.0	Nov. 11, 1977
	Diesel Oil/Gas	1	25.0		Mar. 25, 1981
		2	25.0		Apr. 1, 1981
		4	25.0	75.0	Mar. 25, 1981
Ban Pakong (Block I)	Diesel Oil/Gas	1	60.0		Mar. 11, 1980
		2	60.0		Mar. 1, 1980
		3	60.0		Jun. 6, 1981
		4	60.0	240.0	Aug. 22, 1981
Ban Pakong (Block II)	Diesel Oil/Gas	1	60.0		Jan. 8, 1981
		2	60.0		Dec. 21, 1981
		3	60.0		Feb. 9, 1982
		4	60.0	240.0	Apr. 16, 1982
Ban Pakong Steam Turbine	Combined-Cycle	1	120.0		Mar. 20, 1983
		2	120.0	240.0	July 1983
Ban Pakong Thermal	Oil/Gas	1	550.0		Sept. 1983
		2	550.0	1,100.0	August 1984
Sub-Total				3,195.0	
Ao Phi Thermal	Coal	1	600.0		October 1991
		2	600.0		October 1993
		3	600.0	1,800.0	October 1995
Ao Phai	Diesel Oil	1	15.0	15.0	Apr. 13, 1969
Sub-Total				1,815.0	
Total				5,010.0	

Source: EGAT Power Development Plan (1982 - 1996)

Table V.5.2 TRANSMISSION EXPANSION PROGRAMME

	Length in km	Number of Circuit	Voltage kV	Conductor Size MCM	Commissioning Date
Ao Phai S/S - Rayong 2 S/S	54	2	230	1,272	1983
Ao Phai 2 S/S - Ao Phai S/S	3	2	230	1,272	1993

Source: EGAT Power Development Plan (1982 - 1996)

Table V.5.3(1/2) INDUSTRIAL ESTATE POWER DEMAND (EPZ)

Type of Demand	Net Area (ha)	Power Density/1 (kW/ha)	Power Demand (kW)
Food	1.6	410	656
Textile and Clothes	24.0	170	4,080
Wood	1.6	100	160
Furniture and Pulp	4.0	140	560
Chemical	1.6	190	304
Rubber	2.4	440	1,056
Leather	2.4	130	312
Electric appliance	32.8	270	8,856
Automobile	8.0	230	1,840
Other	6.0	130	780
Total:	84.4	220.4	18,604

/1 : Based on the statistical value in Japan.

Table V.5.3(2/2) INDUSTRIAL ESTATE POWER DEMAND (GIE)

Type of Demand	Net Area (ha)	Power Density/1 (kW/ha)	Power Demand (kW)
Food	6.9	470	3,243
Textile and Clothes	2.3	200	460
Wood	2.3	140	322
Furniture and Pulp	2.3	110	253
Chemical	10.4	200	2,080
Rubber	5.8	500	2,900
Leather	1.2	160	192
Concrete	13.8	470	6,486
Iron and Steel	13.8	480	6,624
Nonferrous metal	10.4	620	6,448
Metal good	20.7	220	4,554
Machinery	11.5	200	2,300
Electric appliance	34.5	350	12,075
Automobile	87.4	330	28,842
Other	2.3	170	391
Total:	225.6	342.1	77,170

/1 : Based on the statistical value in Japan.

Table V.5.4 (1/3) PORT POWER DEMAND

(1) Power Demand in Port Facility Area

Type of Berth	Number of Berth	Power Density/1 (KW/Berth)	Power Demand (KW)
Container Berth	7	3,000	21,000
Break Bulk Berth	7	200	1,400
Agri Bulk Berth	2	1,500	3,000
Total			25,400

/1: Data obtained through a survey of Tokyo and Yokohama port in Japan.

Table V.5.4 (2/3) PORT POWER DEMAND

(2) Power Demand in Distribution and Storage Area

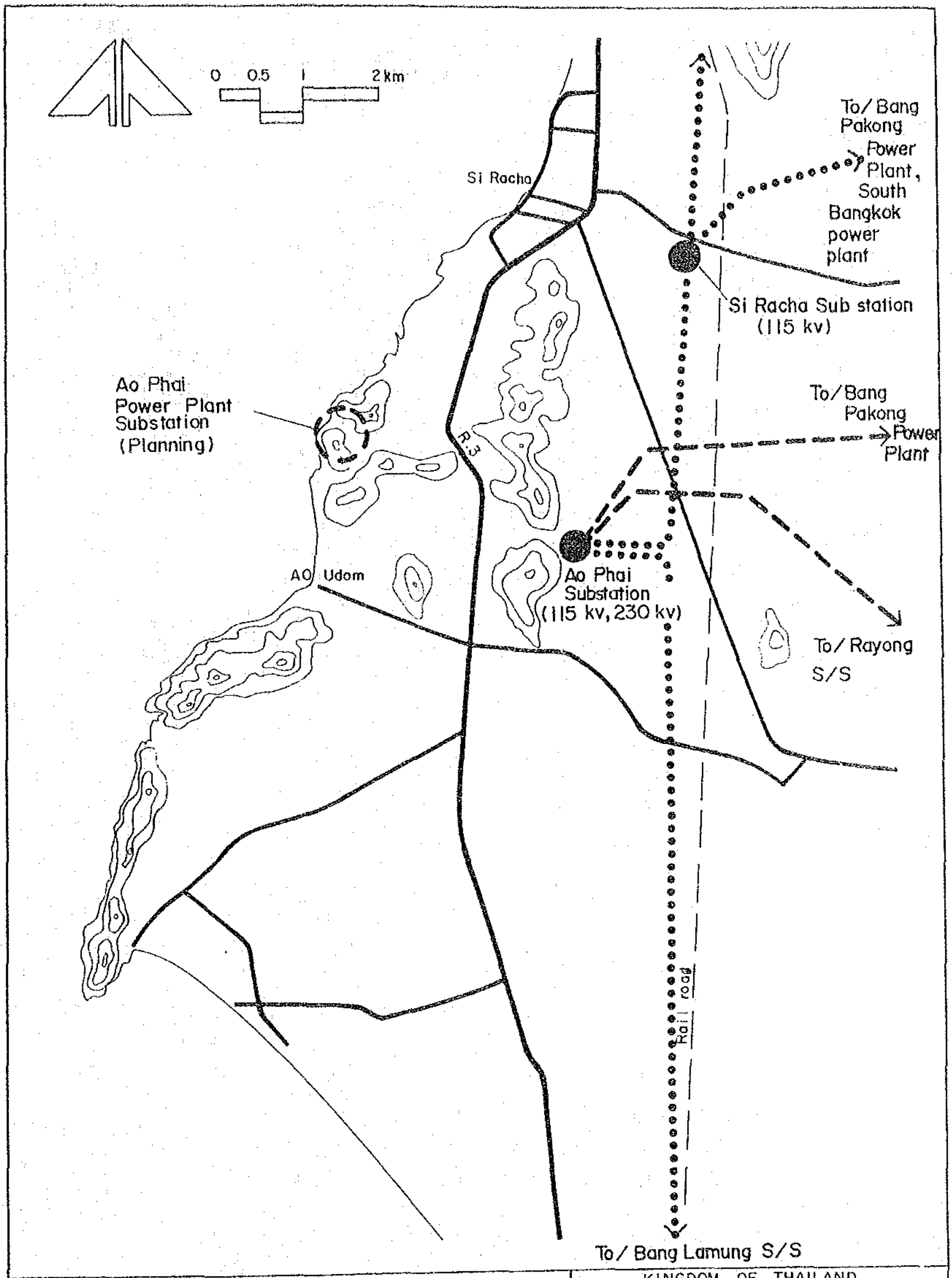
Type of Area	Employee	Net Area/1 (ha)	Power Density (KW/ha)	Power Demand (KW)
Distribution and Storage	11,400	9.1	900	8,200

/1: Computed as $8m^2$ per one employee.

Table V.5.4 (3/3) PORT POWER DEMAND

(3) Power Demand in Business and Commercial Area

Type of Area	Employee	Net Area (ha)	Power Density (KW/ha)	Power Demand (KW)
Business and Commercial	22,500	18.0	900	16,200
Sewerage Treatment Plant and other	-	-	-	1,000
Total				17,200



LEGEND

Right of Way of 115 KV Transmission Line: 25m

Ao Phai Power Plant planned to be constructed in 1993

230KV Transmission Line

115 KV Transmission Line

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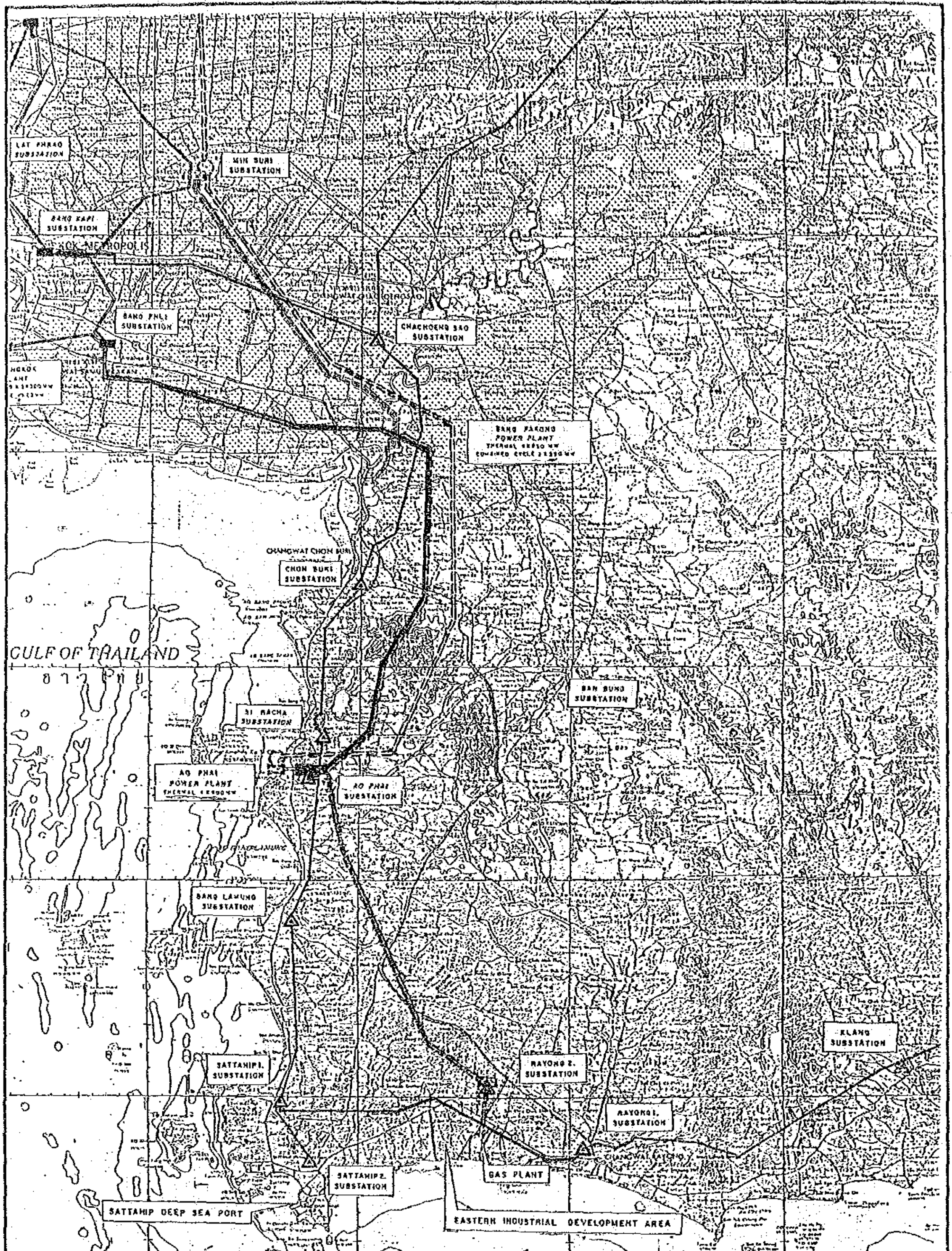
Fig. V.5.1
Present and Proposed Power Supply System



LEGEND

EXISTING	UNDER CONSTRUCTION	FUTURE	
▲	△	△	115KV SUBSTATION
▬	▭	▭	230KV SUBSTATION
⬡	⬡	⬡	500KV SUBSTATION

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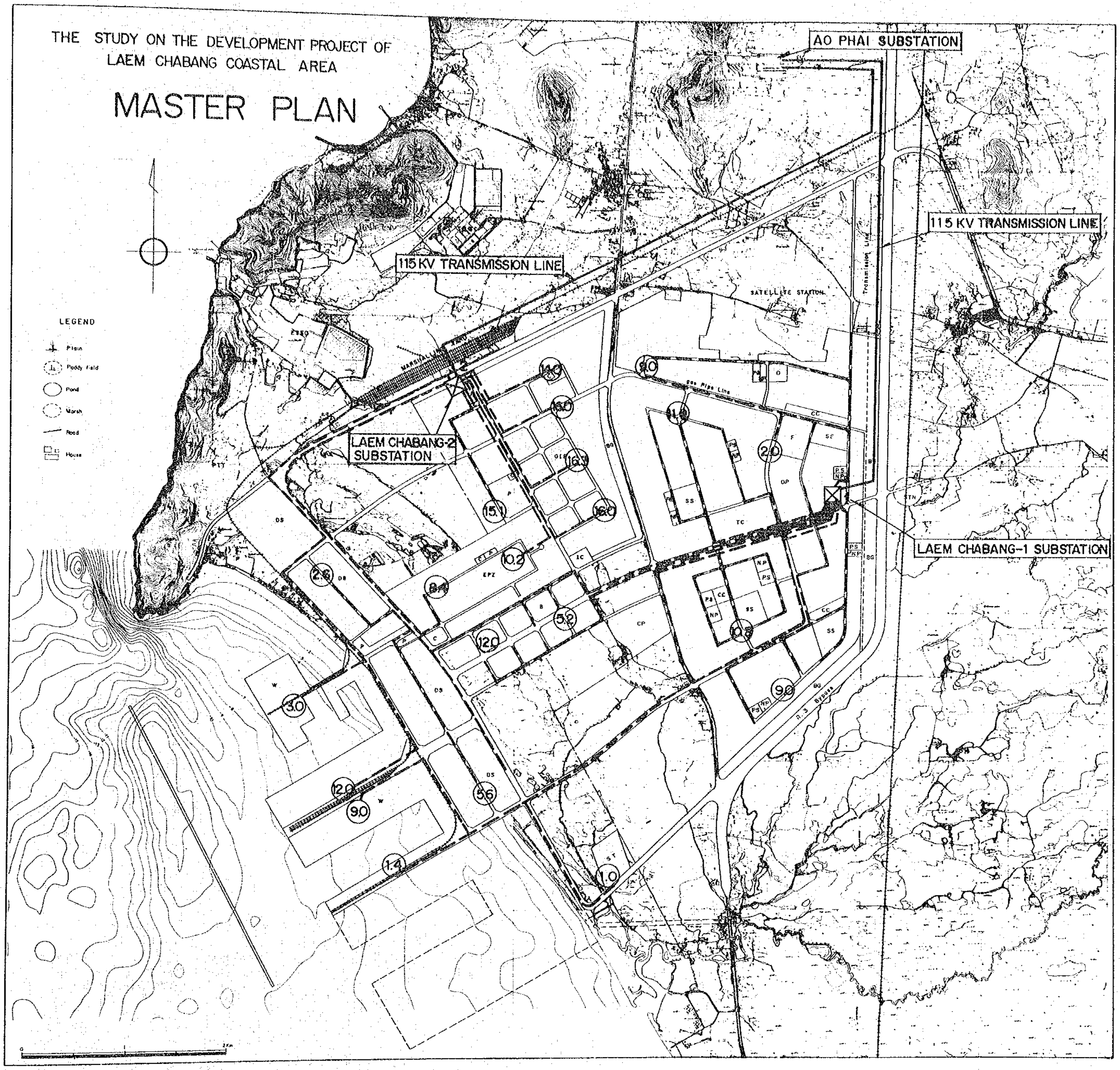
Fig. V.5.2
EGAT's Power Supply System in Eastern Seaboard



LEGEND

115 KV TRANSMISSION LINE

VOLTAGE	: 115 KV
NO. OF CIRCUIT	: 2
TYPE OF TOWER	: 2-CCT STEEL
CONDUCTOR SIZE	: 477 MCM
LINE CAPACITY	: 100 MVA/CCT

22 KV DISTRIBUTION LINE

VOLTAGE	: 22 KV
MAX. LINE CAPACITY	: 300 A
KIND OF WIRE	: INSULATED ACSR
WIRE SIZE	: 120 SQMM
TYPE OF POLE	: CONCRETE

⊠1 LAEM CHABANG-1 SUBSTATION

SUBSTATION CAPACITY : 80 MVA
MAIN TRANSFORMER :
3 PHASE, 115 / 22 KV
40 MVA x 2 SETS
115 KV INCOMING LINE : 2
22 KV FEEDER : 8
(Including One Spare)

⊠2 LAEM CHABANG-2 SUBSTATION

SUBSTATION CAPACITY : 80 MVA
MAIN TRANSFORMER :
3 PHASE, 115 / 22 KV
40 MVA x 2 SETS
115 KV INCOMING LINE : 2
22 KV FEEDER : 8

Note :

Figures in circle indicate the power demand (MW) within each area.

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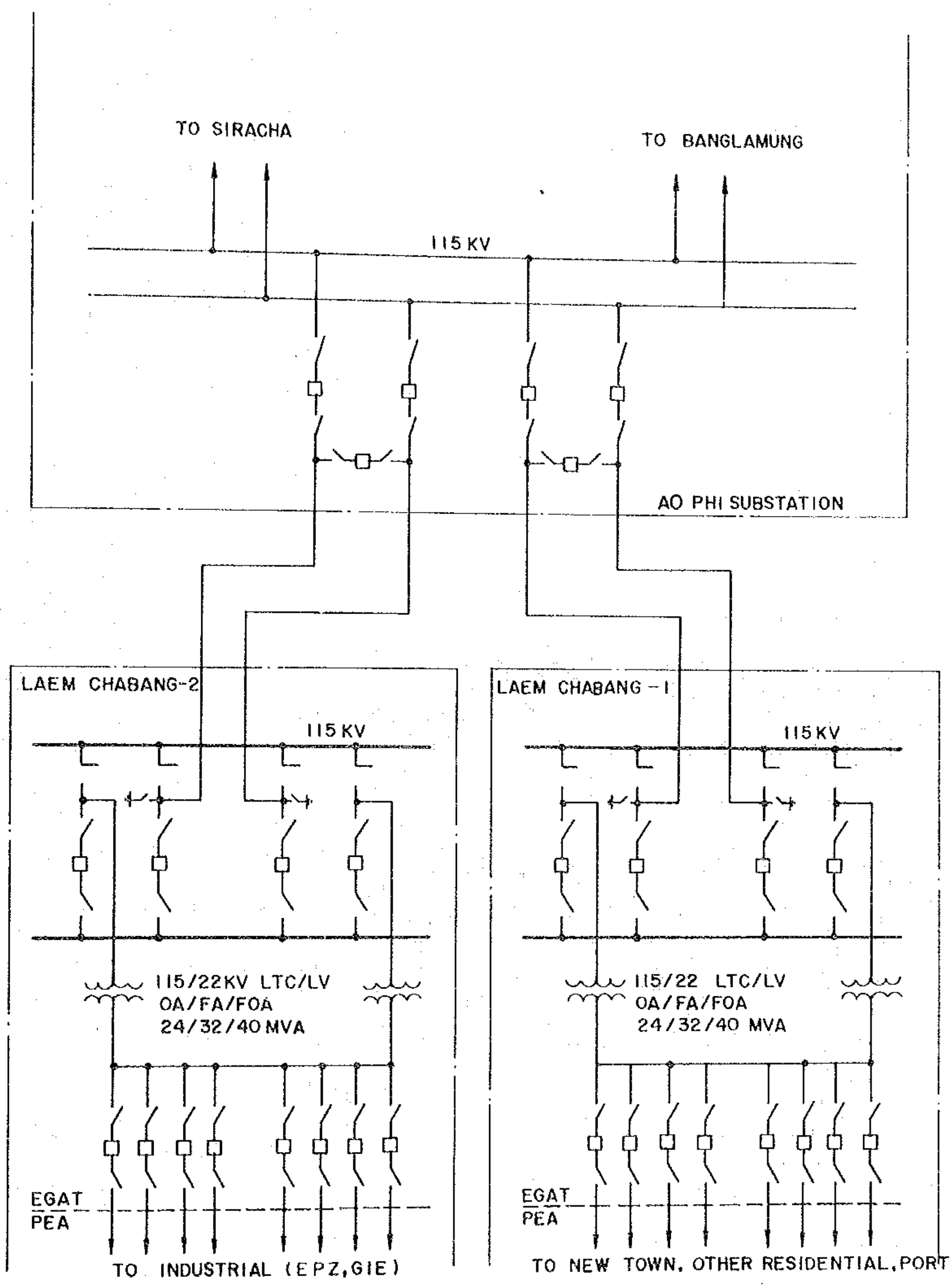
Fig. V.5.3
Power Supply System in Master Plan



LEGEND

- DISCONNECTING SWITCH, NORMALLY CLOSE
- – DO – , NORMALLY OPEN
- POWER CIRCUIT BREAKER
- TWO WINDING TRANSFORMER
- HIGH SPEED GOUNDING SWITCH

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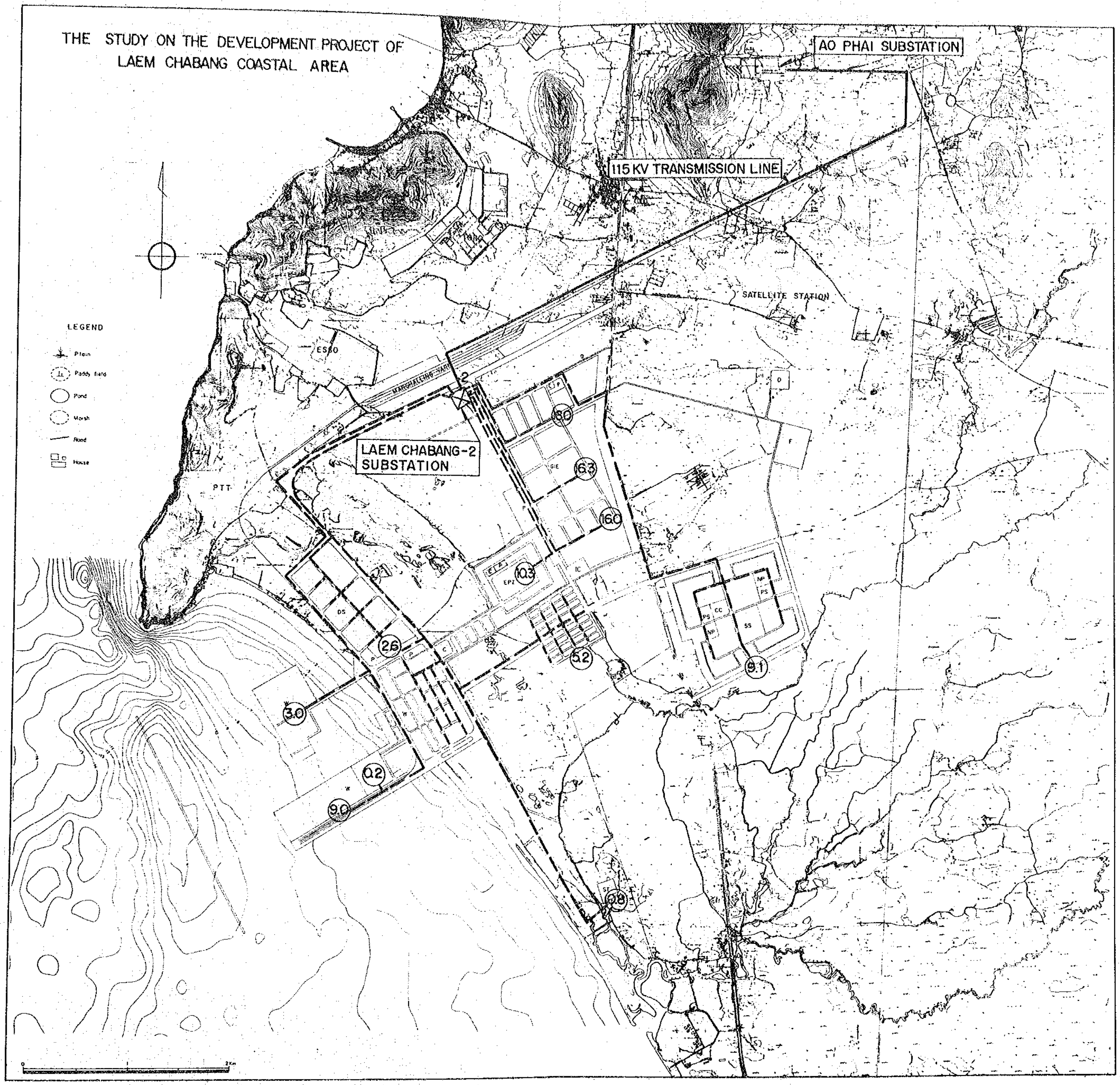
Fig. V.5.4
Planned Laem Chabang Substation Switching Diagram



LEGEND

115 KV TRANSMISSION LINE

VOLTAGE	: 115 KV
NO. OF CIRCUIT	: 2
TYPE OF TOWER	: 2-CCT STEEL
CONDUCTOR SIZE	: 477 MCM
LINE CAPACITY	: 100 MVA/CCT

22 KV DISTRIBUTION LINE

VOLTAGE	: 22 KV
MAX. LINE CAPACITY	: 300 A
KIND OF WIRE	: INSULATED ACSR
WIRE SIZE	: 120 SQMM
TYPE OF POLE	: CONCRETE

☒2 LAEM CHABANG-2 SUBSTATION

SUBSTATION CAPACITY : 80 MVA
MAIN TRANSFORMER :
3 PHASE, 115/22 KV
40 MVA x 2 SETS
115 KV INCOMING LINE : 2
22 KV FEEDER : 8

Note :

Figures in circle indicate the power demand (MW) within each area.

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Fig. V.5.5
Power Supply System in Short-Term Plan

6. TELECOMMUNICATION

6.1 Master Plan

6.1.1 Present Condition and Development Plan

1) Telephone

During the 5-year period from 1978 to 1982, automatic telephone facilities in the Kingdom of Thailand increased at a rate of approximately 9% annually. As a result, automatic telephone facilities which numbered 409,470 in 1978 increased to as many as 576,361 units in 1982. At the same time, the telephone automatization ratio which was 99% in 1978 reached 100% in 1981.

At present, the Telephone Organization of Tahiland (TOT) is in charge of a fully automatic telephone system providing about 900,000 local exchange lines connected to 270 local telephone exchanges.

TOT is now promoting a large scale programme aiming at increasing the total number of exchange lines to approximately 1,800,000 by the year 1988. This programme is formally called the "Economic Development Plan 1984 - 1988 of TOT" which is based on and constitutes an integral part of the "Fifth National Economic Development 1982 - 1986 for the whole Kingdom".

As of 1988, the number of main telephone station per 100 inhabitants can be expected as approximately 3.36 or more.

The Kingdom of Thailand is divided into the five telecommunication areas as follows and shown in Fig.V.6.1.

Metropolitan area	- 02
Central area	- 03
North-Eastern area	- 04
Northern area	- 05
Southern area	- 07

Each telecommunication area mentioned above is called a tertiary area. A tertiary area, except the Metropolitan area, is divided into several secondary areas.

The name of centers of the primary area in the "038" area code are Chonburi, Chachoengsao and Rayong. The existing telephone exchanges in the Chonburi Secondary Center Area is shown in Fig. V.6.2 .

All telephone exchanges mentioned above have long distance subscriber trunk dialling (S.T.D.). The existing long-distance telephone transmission system is shown in Fig. V.6.3.

2) Telex

The Kingdom of Thailand is divided into four telex service parts, the Central, North-Eastern, Northern and Southern parts. Fig. V.6.4 shows the present telex network for the whole Thailand.

The existing telex service operated by the Communications Authority of Thailand (CAT) has approximately 3,500 subscribers throughout the Kingdom. Automatic connections are possible between those subscribers accommodated in the telex network that interconnects main cities in the country.

The existing exchange within the Eastern Seaboard is the Pattaya zone exchange with 250 lines and Chachoengsao, Chonburi, Siracha, Rayong and Chanthaburi line concentrator. Fig. V.6.5. shows "Telex Network in Pattaya Zone Exchange". Generally, each concentrator is able to serve the subscriber's area within a 10-15 Km radius.

Under the Fifth Plan, telex services is planned to be extended to all provinces in Thailand.

6.1.2 Telephone and Telex Demand

1) Telephone

Telephone demand in the Laem Chabang Complex is calculated at 15,000 lines at long term (2001) from number of dwelling, shop in town center, factory and employee in port area.

The calculation are made according to the following steps.

(1) New Town

Number of telephone for the New Town is estimated as follows.

(i) Residential Area

Group of Dwelling	No. of Dwelling	No. of Telephone	Installation Ratio (%)
High income	2,610	2,610	100
Middle income	16,970	5,091	30
Low income	6,520	163	2.5
Total	26,100	7,846	30.1

(ii) Town Center

Categories of Shop	No. of Shop	No. of Telephone	Installation Ratio (%)
Community Center	788	630	80
Neighbourhood shopping	440	220	50
Education facility	44	44	100
Total	1,272	894	70.3

(iii) Total Telephone Demand in New Town : 8,740

(2) Industrial Estate

Number of telephone including PABX extension telephones is as follows:

Item	No. of Factory	No. of Telephone per Factory	No. of Telephone
E P Z			
16-32 Rai	3	10	30
8 - 2 Rai	47	8	376
Standard factory	40	4	160
Sub-Total	90		566
G I E			
460 Rai	1	26	26
46 Rai	2	12	24
8 - 2 Rai	89	8	712
Sub-Total	92		762
Industrial center			
EPZ center	1	10	10
Estate Center	1	10	10
Sub-center	3	4	12
Gaurd gate	1	4	4
Sub-total	6		36
Total	188	-	1,364

(3) Port Area

Number of telephone demand for port area and port related area will be considered as follows:

Number of employee x 0.1 (No. of Tel./employee)

Item	No. of Employee	No. of Telephone
Port facility, Distribution and storage area	11,400	1,140
Business and commercial area	22,500	2,250
Total		3,390

(4) Number of Public Booths

In general, number of public booths required is estimated to be 2% of the number of telephone. There will be, therefore, a requirement for 270 public booths.

(5) Total Number of Telephone and Lines to be installed are as follows.

New Town	:	8,740
Industrial Estate	:	1,364
Port Area	:	3,390
Sub-total	:	13,494
Public Booths	:	270
Total Telephone Demand	:	13,764
Number of lines installed	:	15,000

2) Telex Demand

Telex demand is strong especially among firms and factories in Thailand. In provincial area, telex is installed being limited only to some of government related offices, hotel, bank and firms and factories.

The short term prospect is that the demand will continue to grow at the current average annual growth rate of 20%. From the long term view-point, the demand for telex service is prospected to be replaced by the demand for new service such as data communication and facsimile service as already observed in the developed countries. However, even during the initial stage of proliferation of such new services, the demand for telex service will continue to make steady growth.

Number of telex terminal demand in the industrial estate and port area is assumed for the minimum case as follows:

Area	Number of Telex Terminal
EPZ	25
GIE	9
Industrial Center	2
Port, Distribution and Storage Area	18
Business and Commercial Area	10
Total	64

3) Telecommunication System Plan

(1) Automatic Telephone Switching System

TOT realize that electronic exchange controlled by storaged program, the degital type (SPC Degital), is internationally accepted as the most modern system.

Most countries adopt this SPC Digital system instead of the Cross Bar system and other systems because it facilitates telephone network utilization and has flexibility for future extension of services and network.

Accordingly, TOT will introduce this SPC Digital system to supply the telephone service for the proposed development complex under the following conditions:

Number of lines:

Initial Capacity	:	3,000 lines
(to meet with the telephone demand of 1991)		
Capacity as of 2001	:	15,000 lines
Ultimate Capacity	:	20,000 lines

(2) Telex Exchange System

Present telex network of CAT is shown on Fig. V.6.4. Automatic connection can be established between any two lines terminating at five telex exchanges, i.e. Bangkok, Pattaya, Lampang, Nakhon Ratchasima and Hat Yai.

A double 16 lines for short term (1991) and fourfold 16 lines concentrator exchange will be installed by CAT in new post office located within business and commercial area.

And this concentrator exchange will connect the existing Pattaya Zone exchange as well as the existing Chonburi, Siracha, Rayong and other concentrator exchange.

(3) Subscriber's (Local) Cable System

The engineering and installation work of subscriber's cable system in Complex will be carried out by TOT based on the TOT technical criteria for local cable system.

(4) Exchange Location Plan

The exchange location will be determined to be within the business and commercial area in the Laem Chabang Complex. The following land for the telephone exchange and the post office need to be prepared by PAT.

For telephone exchange : 3,200 m^2 (2.0 Rai) required by TOT

For post office : 16,000 m^2 (10.0 Rai) required by CAT

6.2 Short-term Development

6.2.1 Telephone Demand

Telephone demand in Laem Chabang Complex is estimated as 3,000 lines at short term (1991). Each telephone demand and number of lines installed for New town, Industrial estate, port area and public booths are given as follows:

Telephone Demand Area	Number of Telephone
New Town	1,270
Industrial Estate	808
Port	541
Public Booths	52
Total	2,671
Number of Telephone Lines installed :	3,000 lines

The calculation was made under the same consideration as long term case as below.

1) New Town

(1) Residential area

Group of Dwelling	No. of Dwelling	No. of Telephone	Installation Ratio (%)
High income	510	510	100
Middle income	3,363	504	15
Low income	1,260	32	2.5
Total	5,133	1,046	20.4

(2) Town Center

Categories of Shop	No. of Shop	No. of Telephone	Installation Ratio (%)
Community	197	158	80
Neighborhood	110	55	50
Education facility	11	11	100
Total	318	224	70

(3) Total Telephone Demand in New Town : 1,270

2) Industrial Estate

Kind of Factory	No. of Factory	No. of Telephone per Factory	No. of Telephone
(1) EPZ			
16-32 Rai	3	10	30
8 - 2 Rai	22	8	176
Standard factory	20	4	80
Sub-total:	45		286
(2) GIE			
460 Rai	1	26	26
46 Rai	2	12	24
8-2 Rai	55	8	440
Sub-total:	58		490
(3) Industrial Center			
EPZ center	1	10	10
Estate center	1	10	10
Sub-center	2	4	8
Gaurd center	1	4	4
Sub-total	5		32
(4) Total Telephone Demand in Industrial Estate : 808			

3) Port Area

Area	No. of Employee	No. of Telephone per Employee	No. of Telephone
Port facility, Distribution and storage area	3,636	0.05	182
Business and commercial area	7,177	0.05	359
Total	10,813	0.05	541

4) Number of Public Booth

No. of telephone x 0.02 = 2.619 x 0.02 = 52

5) Total Number of Telephone and Lines installed

New Town	1,270
Industrial Estate	808
Port Area	541
Sub-total	2,619
Public Booths	52
Total Telephone Demand	2,671
Number of lines installed	3,000

6.2.2 Telex Demand

Telex demand in industrial estate and port area for short term is estimated as follows:

Area	Number of Telex Terminal
Industrial Estate	
EPZ	10
GIE	6
Industrial Center	2
Port Area	
Distribution and Storage	9
Business and Commercial	5
Total	32

6.2.3 Telecommunication System Plan

As mentioned in Master Plan, telecommunication system plan for the short term is summerized as follows:

1) Automatic Telephone Switching System

For telephone demand in Laem Chabang Complex, new local exchange will be established by TOT in the development area. The exchanger is connected with Chonbri secondary center to be incorporated into existing long-distance telephone transmission system.

The exchanger will be SPC digital type with the capacity as follow:

Initial capacity (Up to 1991)	:	3,000 lines
Capacity as of 2001	:	15,000 lines
Ultimate capacity	:	20,000 lines

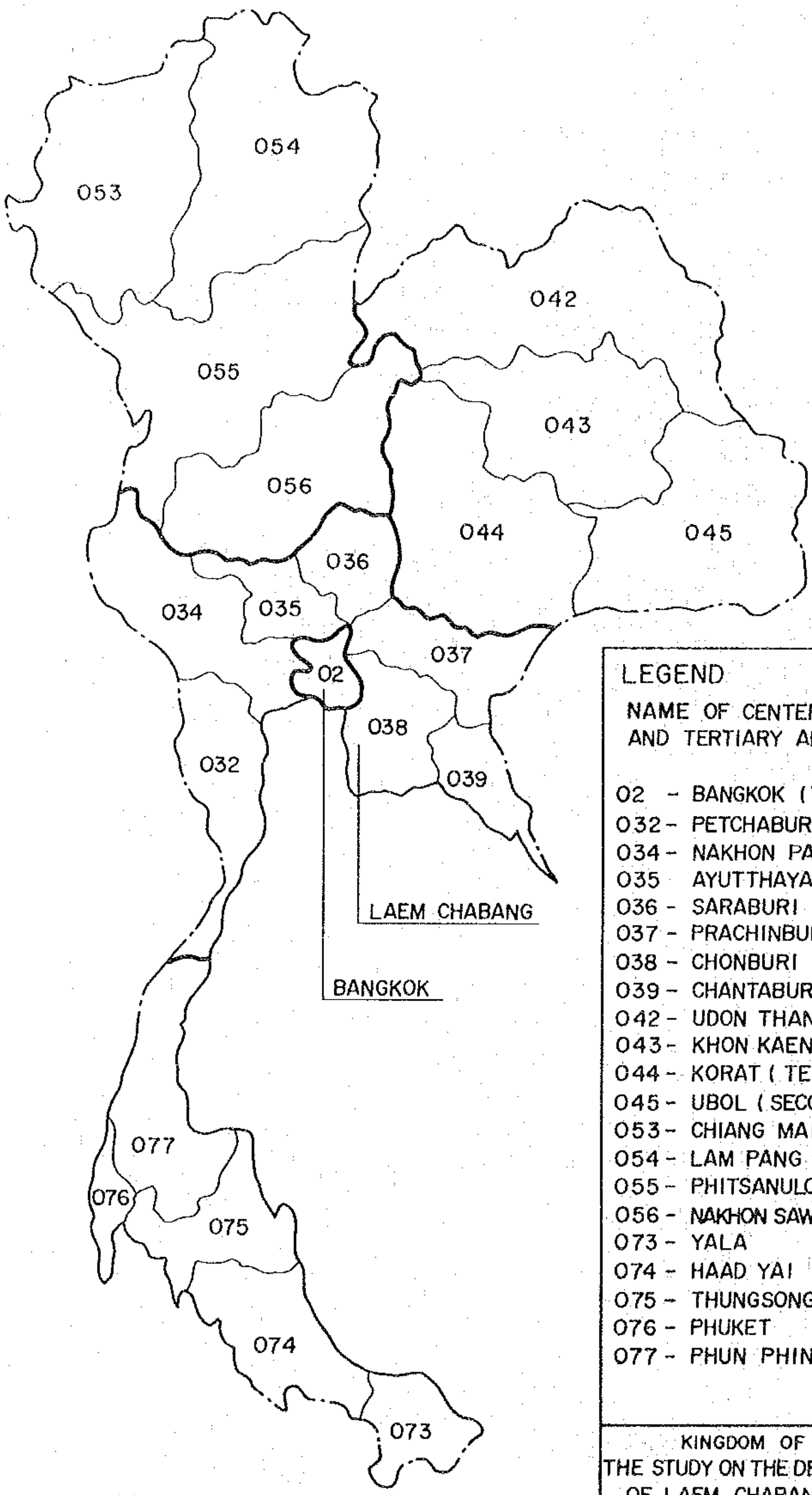
2) Telex Exchange System

A double 16 line telex concentrator will be installed by CAT in new post office located in Business and Commercial area.

And this concentrator exchange is connected with the existing Pattaya zone exchange.

3) Local Cable System

The engineering and installation work of subscriber's cable system in the development area will be carried out by TOT based on the TOT technical criteria for local cable system.



LEGEND

NAME OF CENTERS OF SECONDARY AND TERTIARY AREAS ARE AS FOLLOWS:

02 -	BANGKOK (TERTIARY CENTER)	
032 -	PETCHABURI (SECONDARY CENTER)	
034 -	NAKHON PATHON	(- Do -)
035	AYUTTHAYA	(- Do -)
036 -	SARABURI	(- Do -)
037 -	PRACHINBURI	(- Do -)
038 -	CHONBURI	(- Do -)
039 -	CHANTABURI	(- Do -)
042 -	UDON THANI	(- Do -)
043 -	KHON KAEN	(- Do -)
044 -	KORAT (TERTIARY CENTER)	
045 -	UBOL (SECONDARY CENTER)	
053 -	CHIANG MAI	(- Do -)
054 -	LAM PANG	(- Do -)
055 -	PHITSANULOK (TERTIARY CENTER)	
056 -	NAKHON SAWAN (SECONDARY CENTER)	
073 -	YALA	(- Do -)
074 -	HAAD YAI	(- Do -)
075 -	THUNGSONG	(- Do -)
076 -	PHUKET	(- Do -)
077 -	PHUN PHIN (TERIARY CENTER)	

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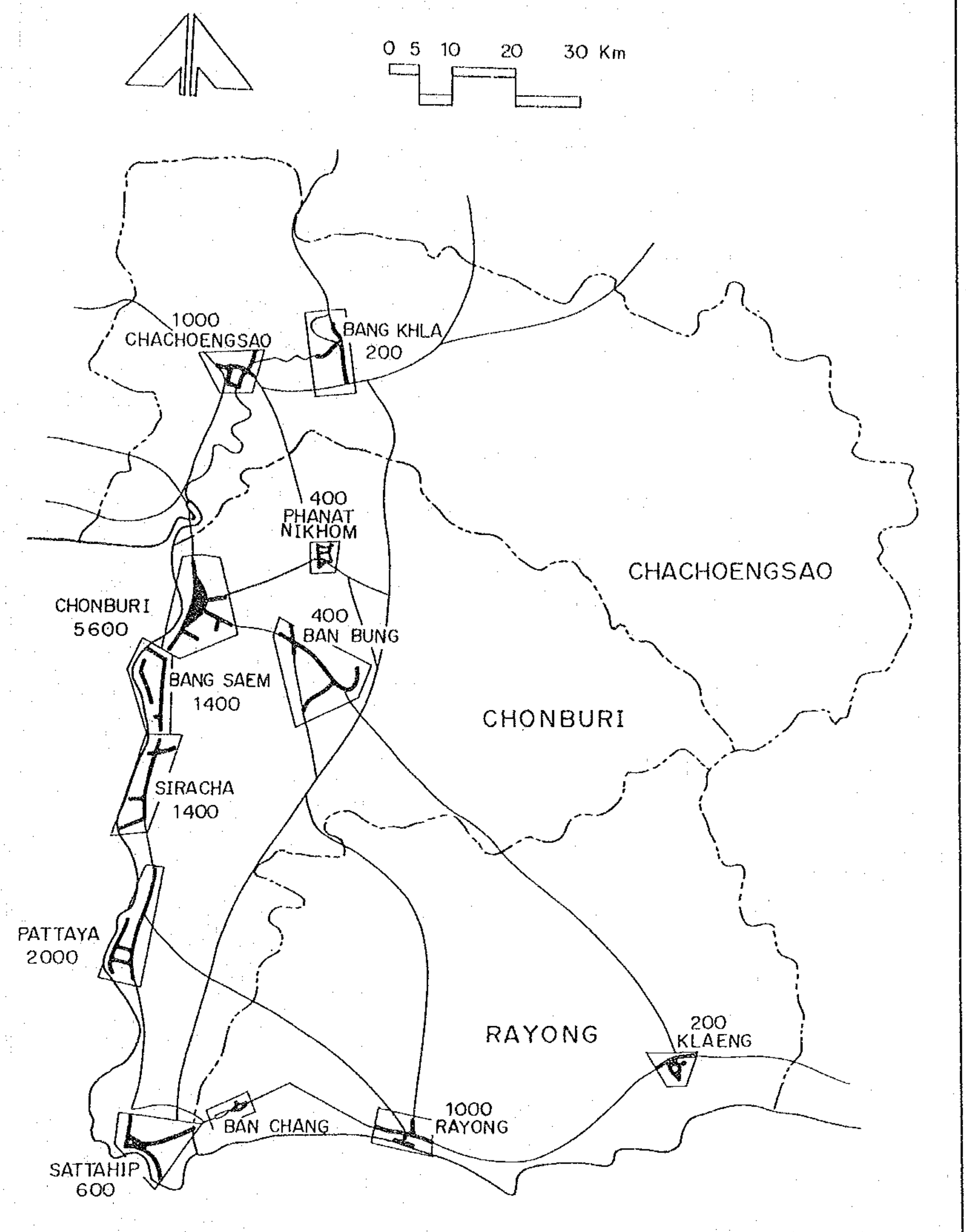
Fig. V.6.1
Telephone Area Code Number



LEGEND

Location of Telephone Exchange

Major Road Network

Provincial Boundary

Note ; Figures indicate number of switching lines.

Source ; Ess

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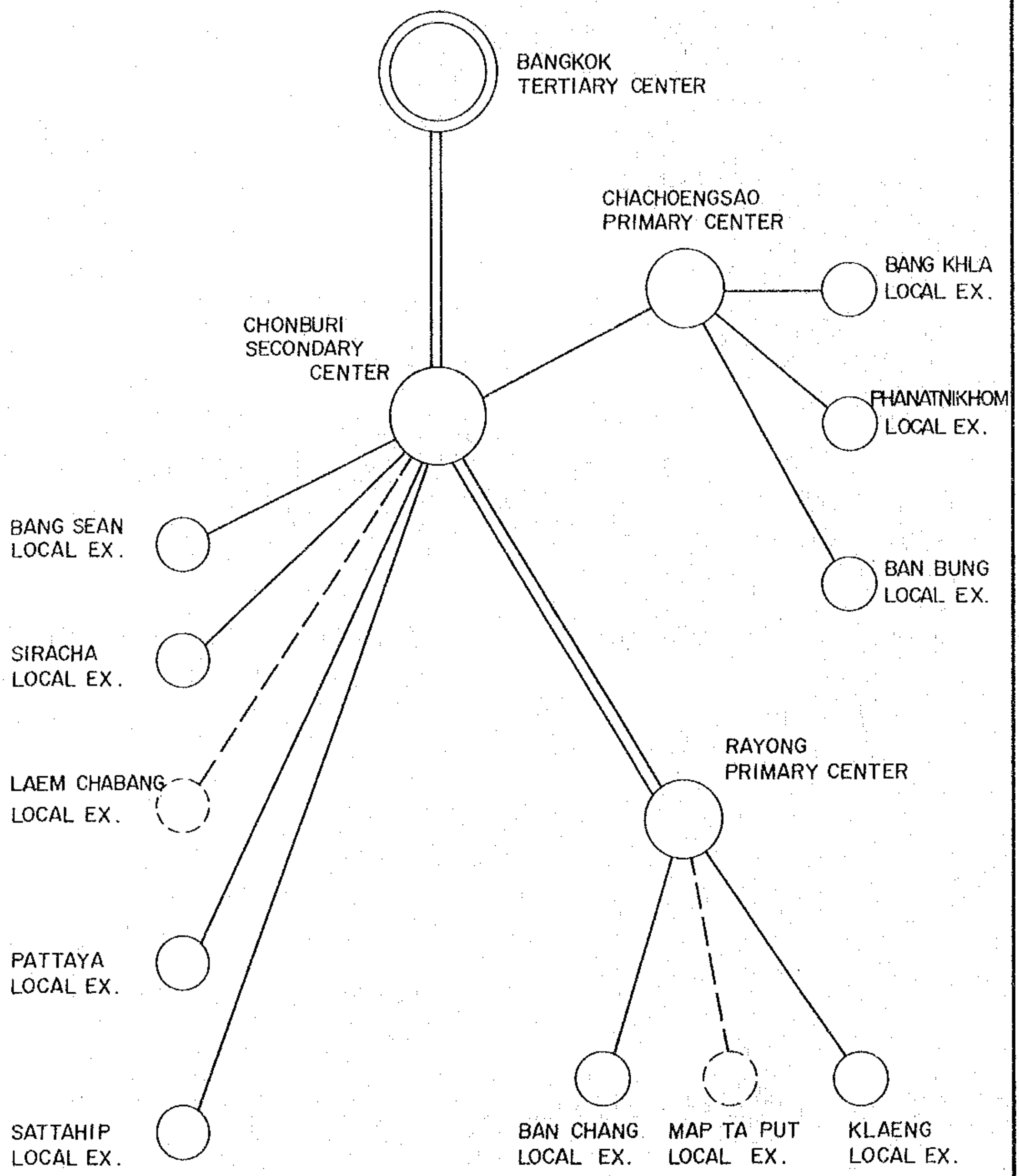
Fig. V.6.2
Present Telephone Exchange



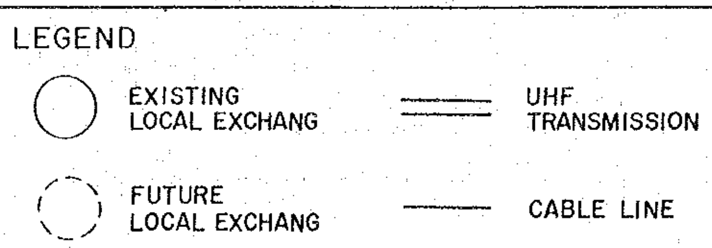


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Fig. V.6.3
Existing Long-Distance Telephone
Transmission Line

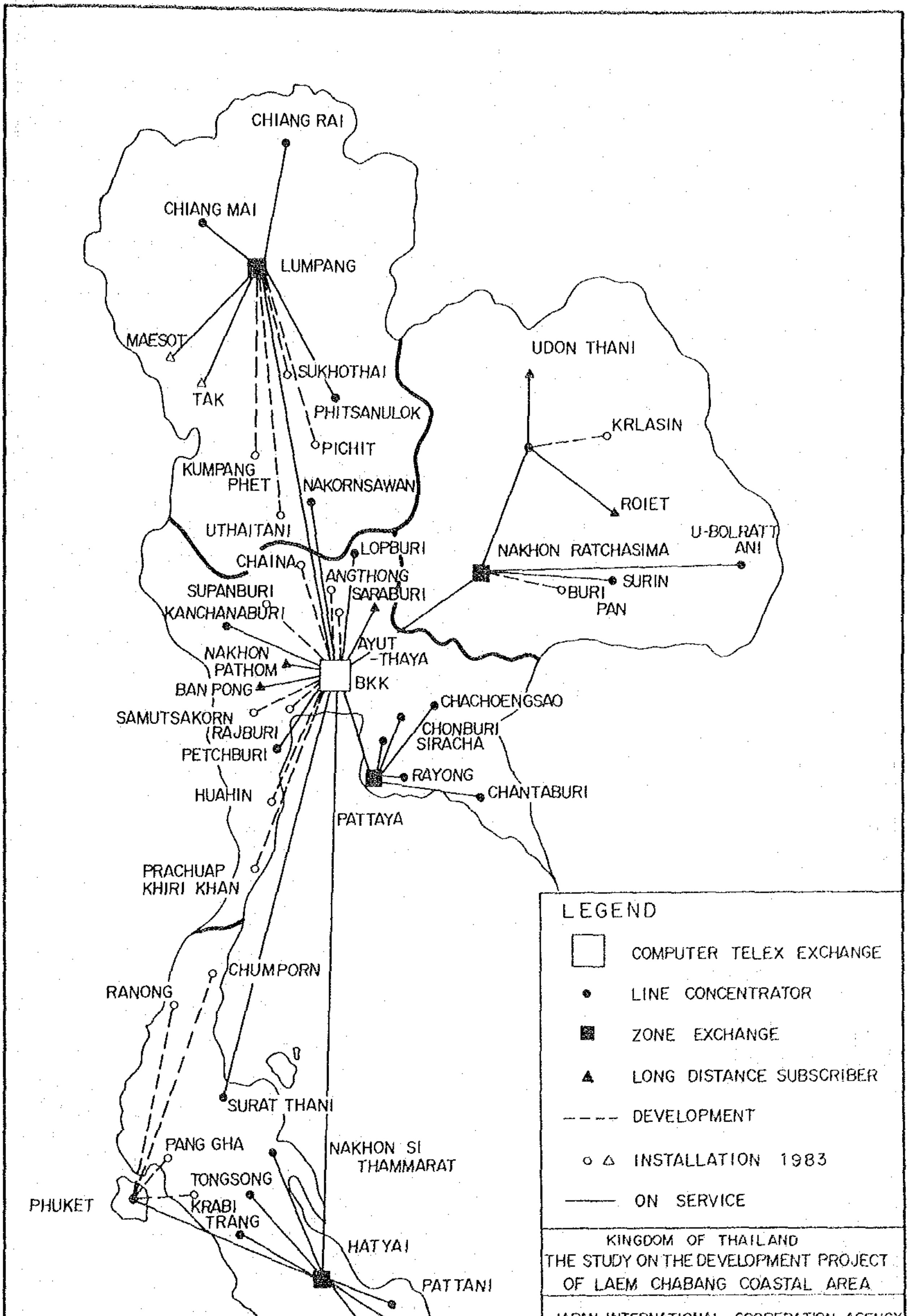
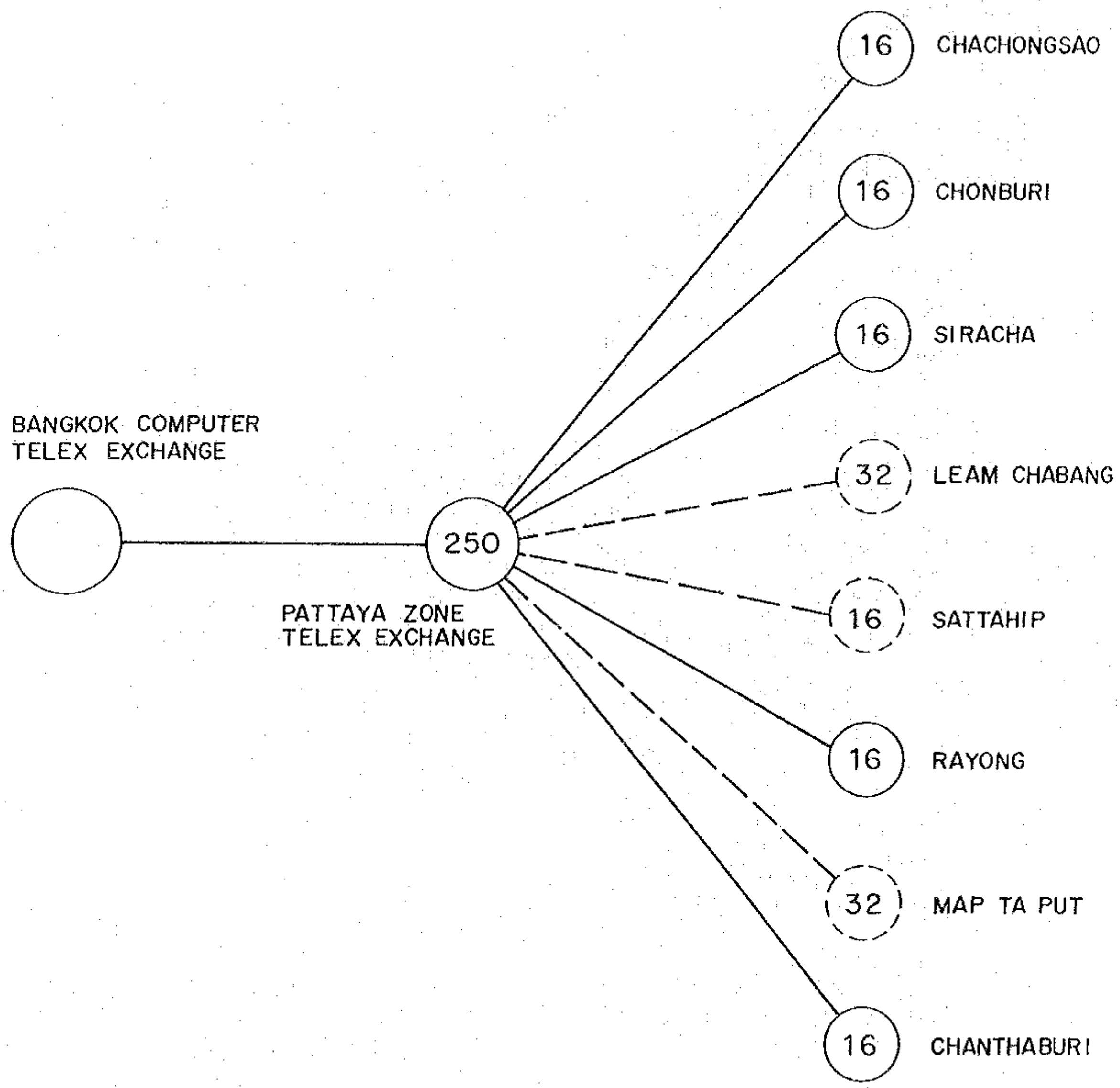


Fig. V.6.4
Present Telex Network



LEGEND

EXISTING LINE CONCENTRATOR

NEW LINE CONCENTRATOR IN NEAR FUTURE

NOTE : FIGURES INDICATE THE NUMBER OF TELEX TERMINALS

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

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. V.6.5
Telex Network in Pattaya Zone Exchange

7. LAND PREPARATION PLAN

7.1 Earth Work Volume

Fig. V.7.1 shows the topographical conditions of the Leam Chabang Area.

In the New Town area, little earth work will be needed except the small area around some rivers. It is with gentle slope with approximately 3% that is suitable for the gradient of the road in New town.

On the other hand, a large amount of earth work is needed in the port area and a part of the industrial estate to avoid flooding by high tide waves and heavy rain. Design land height is determined based on the drainage system design and it is needed to embank the low area up to E.L. 3m ∿ 4m that spreads in the port area as shown in Fig. V.7.2.

Earth Work Volume (Banking Volume) is Estimated as below.

(Unit: m^3)

	(1) Short-Term	(2) Master Plan	(2)-(1)
(1) Industrial Estate	740,000	2,800,000	2,060,000
(2) Port Area	1,860,000	2,800,000	940,000
- Port Wharf	(300,000)	(440,000)	110,000
- Distribution & Storage	(1,120,000)	(1,800,000)	680,000
- Business & Commercial	(410,000)	(560,000)	150,000
(3) Total	2,600,000	5,600,000	3,000,000

Materials for embankment can be supplied from three alternative site. One is the hilly area in the port area that holds the about 4 million m^3 earth volume that comes from the uper area higher than EL 3m ∿ 4m. Second is the sea bed that supply unlimited earth volume. Last is the mountain near Laem Chabang that has big amount of earth volume.

The earth from dredging work will cost 60฿/m^3 that is three times costly than the cost of the earth in the port area because of the utilization of large construction equipments. The earth from the mountain will be double of the port area material because the cost for conveyance will be higher. The earth volume in the port area will be short for the full development of Master Plan.

As a conclusion, we recommend that for the short-term development the earth in the port area must be utilized for the embankment considering of its economical advantage, paying particular attention to the preservation of the vegetation, and at the full development of master plan, adjacent mountain must be chosen as the source of embankment materials.

Fig. V.7.3 shows the earthwork volume.

7.2 Geological Analysis

According to the geological maps (Fig. 2.2.7) and the land investigation of the study area, some soft spot seems to be spreaded around the boundary of the IEAT and PAT purchased land.

In this soft soil spot, apart of EPZ and/or business, commercial area is planed to be constructed for the short-team development.

For the purpose of confirmation about the thickness of soft foundation, two soil borings were performed with Standard Penetration Tests. (Fig. V.7.4). The result of the soil boring shows that soft soil has under 5m thickness which can be easily improved to be firm foundation by compaction of banking soil or bearing pile for some buildings can be shorten to minimize construction cost. Though it is needed some additional soil borings to ensure the detail data for detail design, it can be said that there is no crucial trouble for the construction of industrial estate or port hinterland.