MINISTRY OF INTERIOR
PROVINCIAL WATERWORKS AUTHORITY

FINAL REPORT
FOR
DEVELOPMENT PLAN AND FEASIBILITY STUDY
ON
PROVINCIAL WATER SUPPLY PROJECTS
IN
THE KINGDOM OF THAILAND

VOLUME V-B

APPENDICES
FOR

PATTAYA

JAPAN INTERNATIONAL COOPERATION AGENCY

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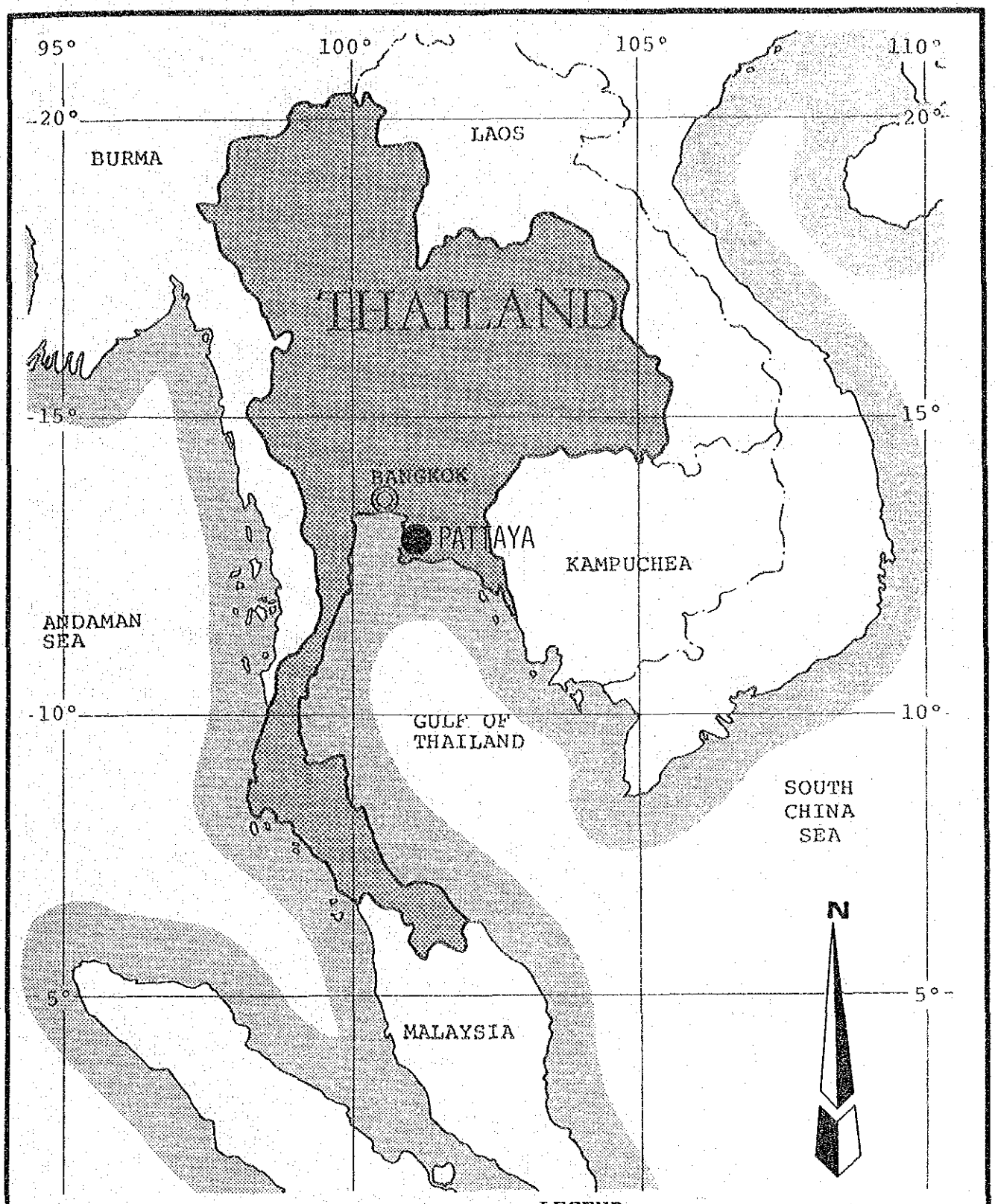
FOR

PATTAYA

MARCH 1987

JAPAN INTERNATIONAL COOPERATION AGENCY



LEGEND

● : PATTAYA CITY

◎ : CAPITAL CITY

SCALE 1 : 10,000,000

FIGURE	LOCATION MAP

JAPAN INTERNATIONAL COOPERATION AGENCY

APPENDICES

APPENDICES

APPENDIX 1

POPULATION FORECAST

APPENDIX 1

APPENDIX 1 POPULATION FORECAST

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APPENDIX 1 POPULATION FORECAST

1.1 General

This appendix forecasts the future total and served population in the study area for the Development Plan. The area, as defined in the scope of work, consists of three districts, Pattaya City, Ban Rong Po and Nong Preo Sanitary District. The estimated served population will be utilized as an input to the water demand projection to be dealt with in the Appendix 2 to this report.

Widely used five types of mathematical formulae were used in forecasting the total population. To determine the most appropriate coefficients in the formulae, population data in the past were fed and the least square method was employed. The population in future was calculated by the formulae, then.

1)	Arithmetical Progression	$Y = aX + b$
2)	Geometrical Progression	$Y = Y_o \times (1 + b)^X$
3)	Decreasing Rate of Increase	$Y = K - ab^X$
4)	Exponential	$Y = Y_o + aX^b$
5)	Logistic	$Y = K / (1 + e^{(a - bX)})$

Where, Y : Population Forecasted
Y_o : Population in Base Year
X : Year from Base Year
a, b, K : Coefficient

Appropriateness of population forecast by the above formulae was examined in comparison with the 2003 population calculated from Land Use Plan prepared by the DTCP.

Demographic and socio-economic features, such as recent tendency of migration and habitation in the area, future possibilities of industrial and commercial development etc. were discussed with the local officials. Materials related to them were provided and studied for evaluating the mathematical results.

In planning the future service area, the waterworks development program and the city's land use plan were studied and in forecasting the served population, the results of questionnaire survey were reflected.

In 1982, 60 % of Pattaya's water supply was consumed by tourists and the tourists' number, a most influential factor, was also forecasted for the future in this study.

1.2 Population Statistics

Available records of the population of Pattaya City, Ban Rong Po and Nong Preo Sanitary District are shown in Table-1.1. The recorded period differs for each of the three, however.

Pattaya's increase, about 2,000 persons per year or about 5 % of the preceding year, indicates that the city has been growing still, owing to tourism and related activities.

Ban Rong Po's increase of 100 to 130 persons per year in 1977 - 1981 is relatively low to the population of about 8,000. Nong Preo Sanitary District's population dropped by 500 persons in 1979 - 1980 and increased at 150 to 170 persons per year rate in 1980 - 1982.

Table-1.1 DATA OF PAST POPULATION

YEAR	Area		
	Pattaya	Ban Rong Po	Nong Preo S.D.
1975		6,489	
1976		7,396	
1977		7,494	
1978	29,726	7,633	
1979	31,777	7,761	5,710
1980	34,867	7,921	5,220
1981	36,507	8,019	5,390
1982	38,525		5,544
1983	40,475		
1984	42,009		

DATA SOURCES :

Pattaya : Institute of Population Studies, Chulalongkorn University

Rong Po : PWA Survey Report on Pattaya Waterworks, 1982

Nong Preo : - ditto -

1.3 Population Forecast

The results of population forecast for Pattaya City, Ban Rong Po and Nong Preo Sanitary District are shown on Figs-1.1, 1.2 and 1.3 respectively.

1.3.1 Pattaya City

Fig-1.1 shows five lines calculated by the before mentioned formulae.

The result from geometrical progression shows a sharp increase ratio of 5.9 % per year.

Three lines from arithmetical progression, exponential and logistic run similarly, reaching 75,000 to 76,000 in 2000 and 89,000 to 96,000 in 2010.

The decreasing rate of increase line shows a rather low growth, comparing the other lines mentioned above.

The result from arithmetical progression was selected because of the following reasons:

1) The past trend of population increase is similar to that of arithmetical progression.

2) The Land Use Plan shown in Table-1.2 forecasts 81,227 in 2003 which is very close to 81,000 in the same year calculated by the arithmetical progression formula.

Table-1.2 POPULATION FORECAST FROM FUTURE LAND USE IN 2003

CLASSIFICATION	AREA (ha)	POPULATION DENSITY (persons/ha)	POPULATION ESTIMATED
Low Density Residential	1,607	9	14,463
Medium "	241	52.5	12,653
High "	597	75	44,775
Industrial	1		
Recreational	110		
Educational	13	15	2,580
Religious	38		
Governmental	11		
Rural	2,252	3	6,756
Total	4,869		81,227

SOURCE : Future population densities and 2003 Land Use Plan from DTCP

1.3.2 Ban Rong Po

Fig-1.2 shows four lines calculated by the before mentioned formulae. As the decreasing rate of increase curve is found to be not applicable, it is not plotted.

The logistic curve runs low, apart from other three. Of those three, the arithmetic progression line extends at the lowest gradient.

As Ban Rong Po is a small town located along the Sukumvit Highway, the economy is supported seemingly by small size agriculture and fishery, serving tourists' cars and earning in Pattaya by various means.

The arithmetic progressing line showing a moderate increase was selected accordingly.

1.3.3 Nong Preo Sanitary District

Fig-1.3 shows four lines calculated by the before mentioned formulae except the decreased rate of increase.

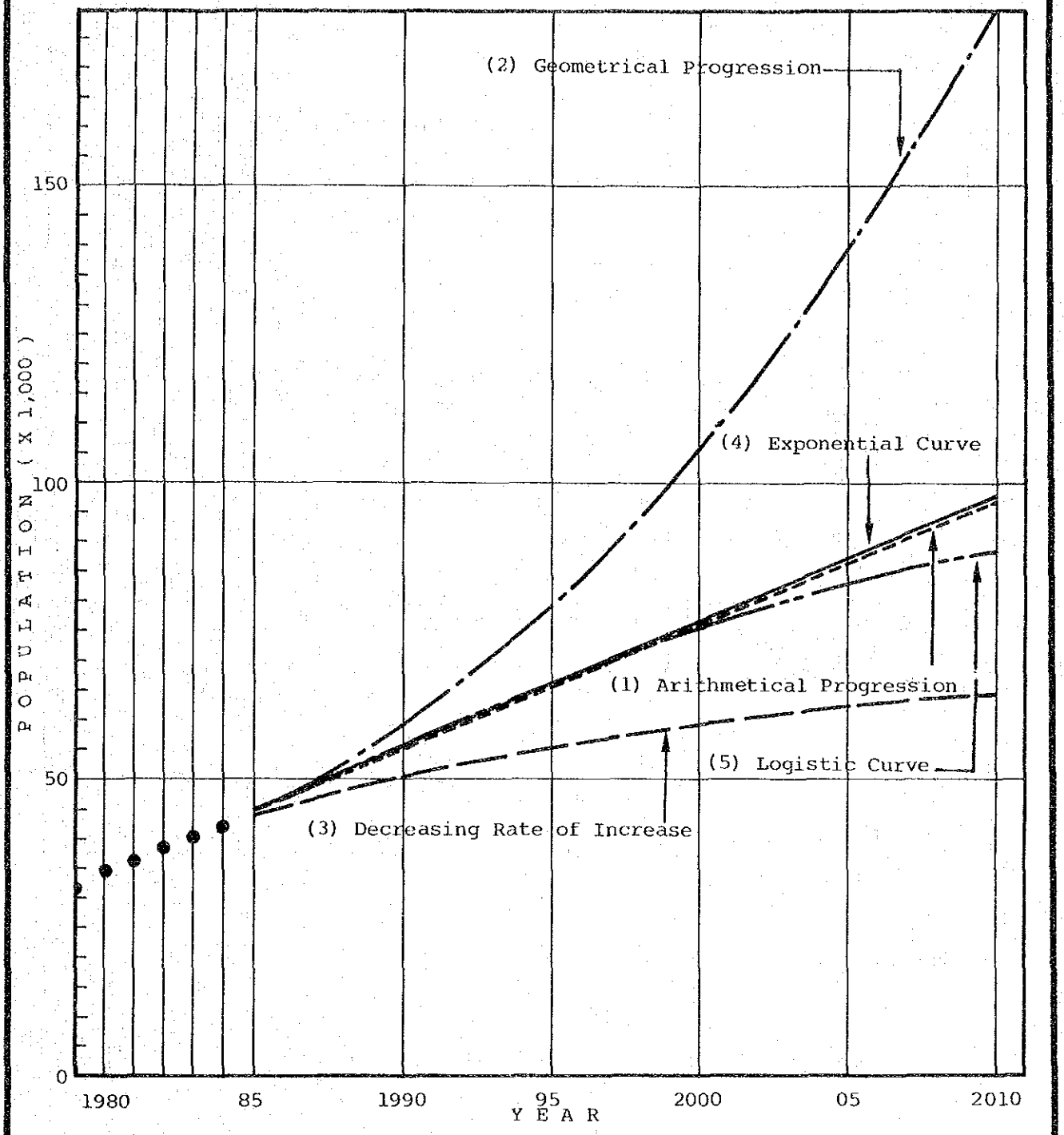
Two of the four, geometrical progression and arithmetical progression, similar in rising at a higher rate than the other two which runs almost flatly in identical manner.

Nong Preo is a small village located along the access road leading to the Pattaya - Na Klua Treatment Plant, branching off from the Sukumvit Highway. The economy is supported seemingly by small size agriculture and the workers commuting to and earning in Pattaya.

Considering the above, the logistic curve, lowest in the rate of increase was selected.

1.3.4 Total Population of Project Area

Summarizing 1.3.1 to 1.3.3, the total population of Pattaya City , Ban Rong Po and Nong Preo Sanitary District is shown in Table-1.3 and on Fig-1.4.



CASE	1985	1990	1995	2000	2005	2010
(1)	44,541	54,881	65,221	75,561	85,901	96,240
(2)	44,502	59,367	79,199	105,655	104,949	188,033
(3)	43,773	50,721	55,890	59,735	62,596	64,724
(4)	44,888	55,415	65,844	76,205	86,515	96,784
(5)	44,840	56,078	66,725	75,900	83,183	88,596

FIGURE 1.1 POPULATION FORECAST OF PATTAYA

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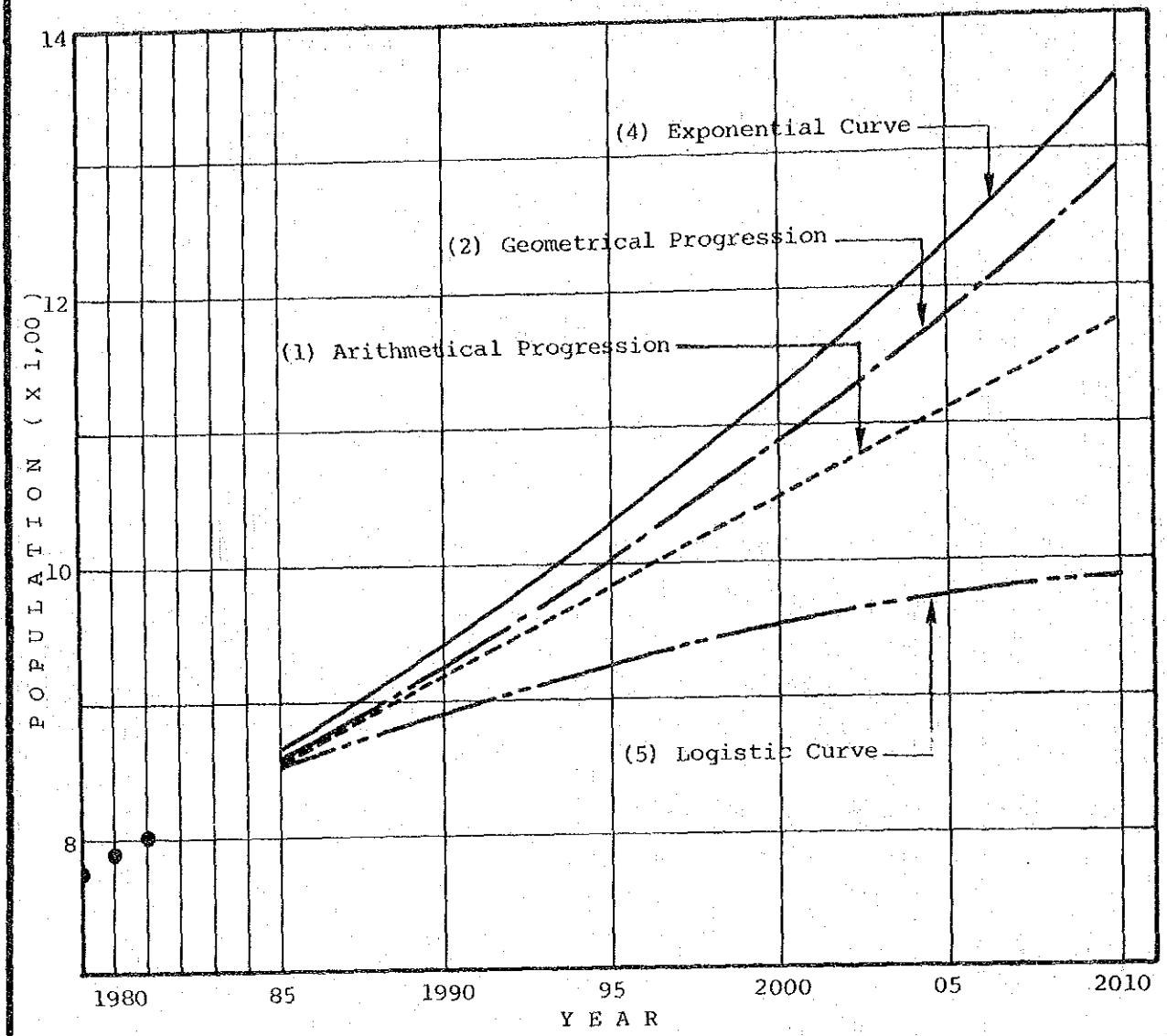
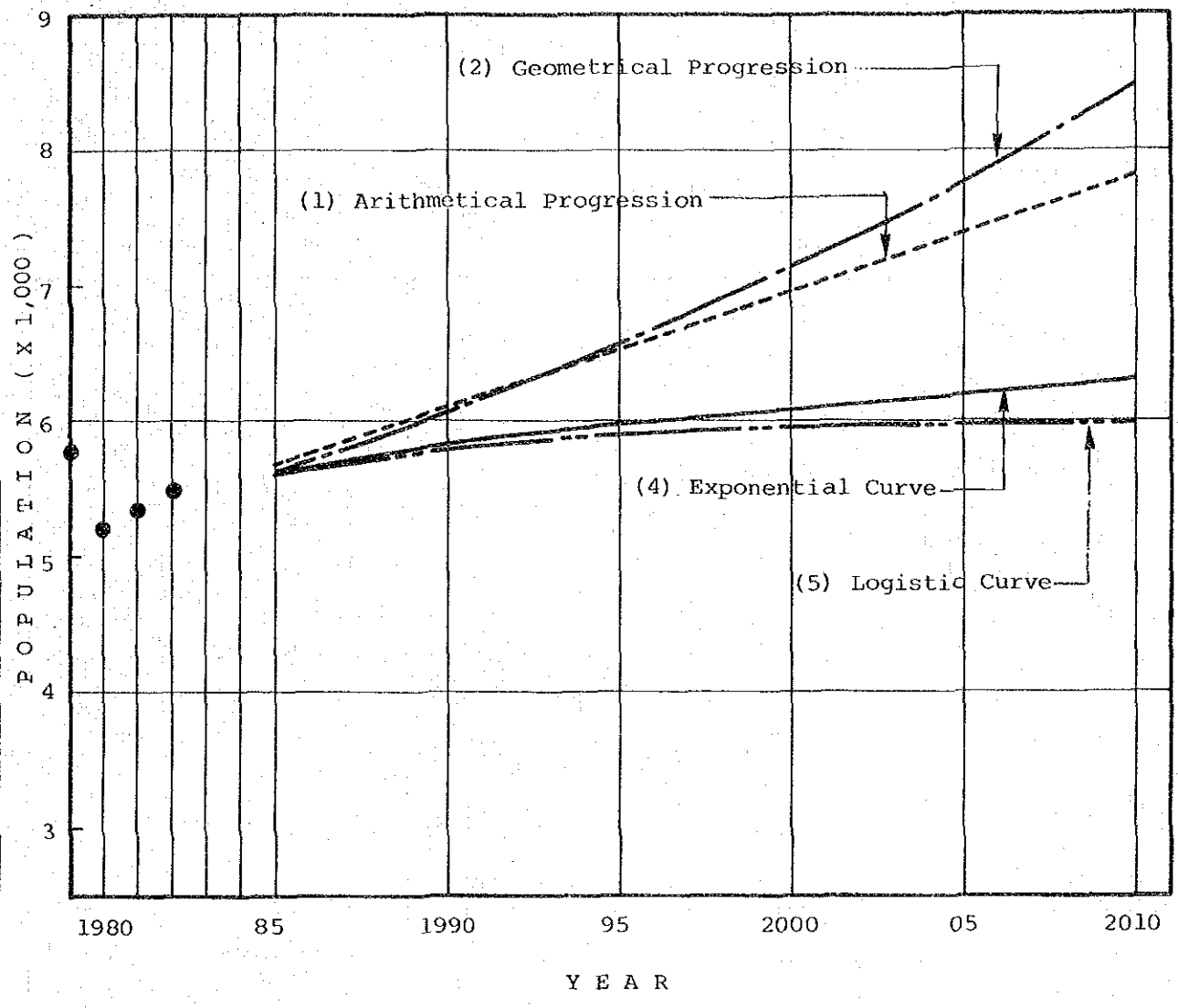


CASE	1985	1990	1995	2000	2005	2010
(1)	8,544	9,190	9,873	10,483	11,129	11,776
(2)	8,555	9,276	10,057	10,904	11,823	12,818
(3)	Decreasing Rate of Increase was not applied					
(4)	8,697	9,571	10,497	11,465	12,466	13,495
(5)	8,460	8,912	9,267	9,539	9,743	9,895

FIGURE	POPULATION FORECAST OF RONG PO
1.2	
JAPAN INTERNATIONAL COOPERATION AGENCY	



CASE	1985	1990	1995	2000	2005	2010
(1)	5,712	6,141	6,569	6,998	7,426	7,855
(2)	5,656	6,128	6,640	7,195	7,796	8,447
(3)	Decreasing Rate of Increase was not applied					
(4)	5,651	5,837	5,981	6,104	6,212	6,310
(5)	5,664	5,848	5,932	5,970	5,987	5,994

FIGURE 1.3	POPULATION FORECAST OF NONG PREO
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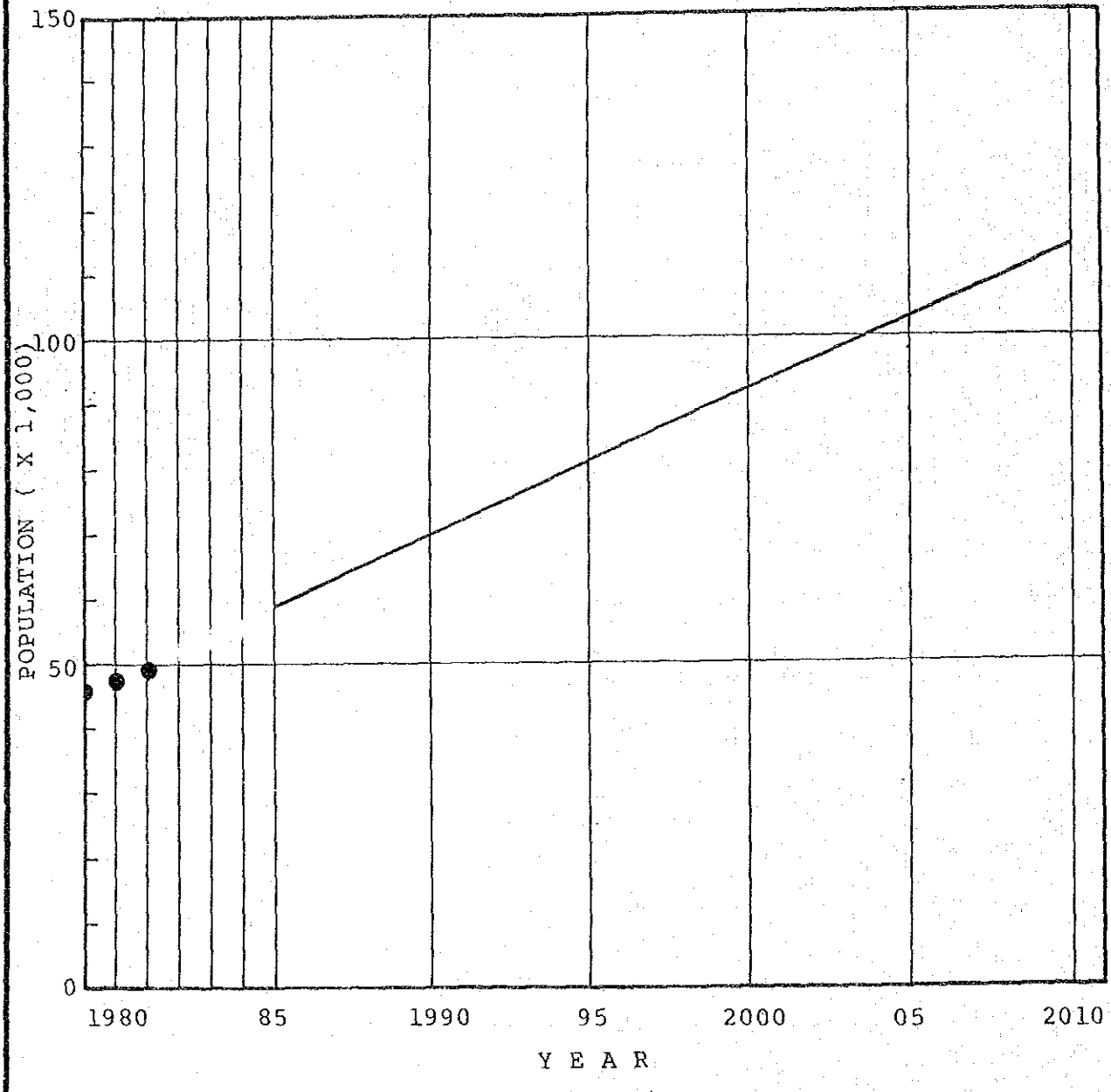

FIGURE	TOTAL POPULATION FORECAST OF PROJECT AREA
1.4	
JAPAN INTERNATIONAL COOPERATION AGENCY	

Table-1.3 TOTAL POPULATION OF PROJECT AREA

YEAR	AREA			
	PATTAYA	RONG PO	NONG PREO	TOTAL
1985	44,540	8,540	5,660	58,740
1990	54,880	9,190	5,850	69,920
1995	65,220	9,840	5,930	80,990
2000	75,560	10,480	5,970	92,010
2005	85,900	11,130	5,990	103,020
2010	96,240	11,780	5,990	114,010

The ratio of Pattaya's population to the total increase from 75.8 % in 1985 to 82.1 % in 2000 and 84.4 % in 2010.

1.4 Present and Future Service Area

The future service area was delineated based on the development program of the waterworks and the future land use plan prepared by DTCP. Size of the service area in 1985, 2000 and 2010 are shown in Table-1.4.

Table-1.4 SERVICE AREA

YEAR	SERVICE AREA (ha)
1985	1,330
2000	2,700
2010	3,100

Fig-1.5 shows the present service area of Pattaya Waterworks and the future expanded service area in 2000 and 2010.

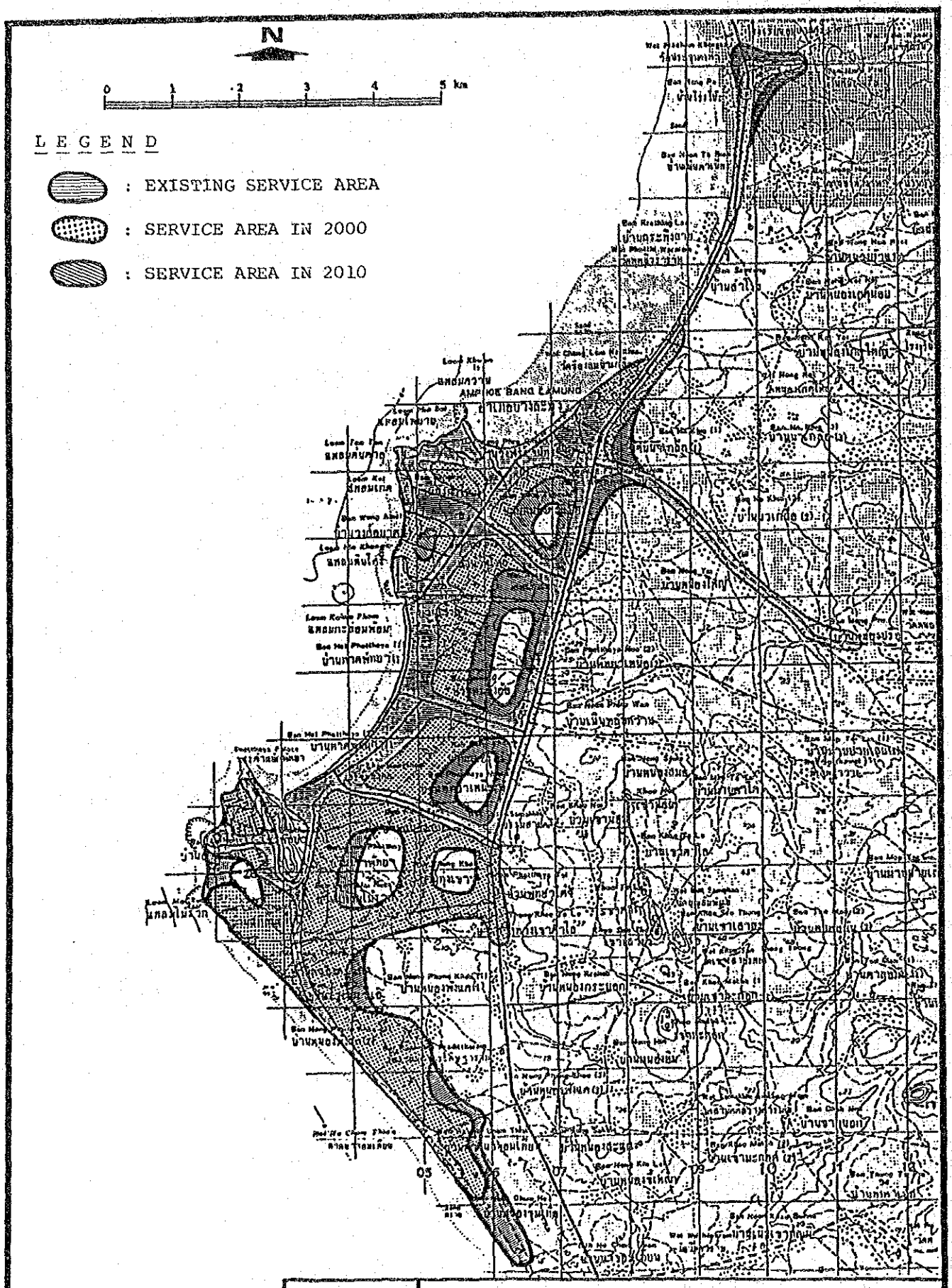

FIGURE 1.5 EXISTING AND FUTURE SERVICE AREA

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As shown on Fig-1.5, there are three directions to which the service area expands. The growing Na Klua area will expand northward and the central area along the beach, already fully developed and densely populated, eastward. Developers are looking for new resort area to the south, along the Jom Tien Beach. This area would be a new center of tourism in the future.

1.5 Service Ratio

The service ratio has been rapidly increasing in the Project Area. Especially, after commissioning of Pattaya-Na Klua Treatment Plant in 1981, the service ratio increased from 13 % to 22 % in one year.

As shown in Fig-1.6, the following four service ratios were forecasted.

Case 1

The curve of Case 1 followed the past trend.

Case 2

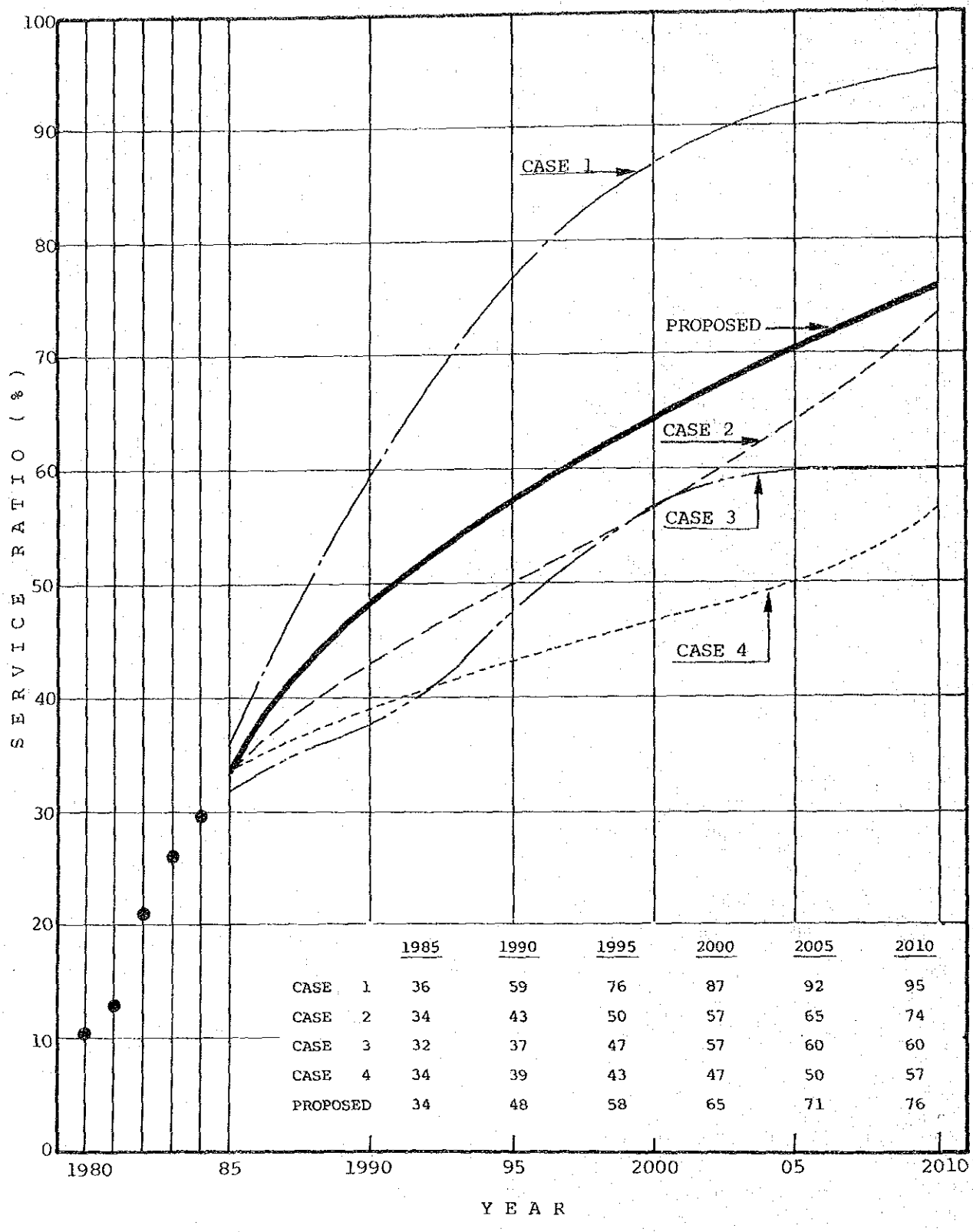
Case 2 was plotted, reflecting the results of the questionnaire survey.

An apparent correlation existed between the service ratio and the income level of the people surveyed. In future, as the income level grows the service ratio will increase. The curve was made on an assumed growth rate of 8 % per year, highest in the past.

CASE 3

Case 3 was plotted, partly reflecting the results of the questionnaire survey.

The curve was made based on the following assumptions:



	1985	1990	1995	2000	2005	2010
CASE 1	36	59	76	87	92	95
CASE 2	34	43	50	57	65	74
CASE 3	32	37	47	57	60	60
CASE 4	34	39	43	47	50	57
PROPOSED	34	48	58	65	71	76

FIGURE 1.6 ESTIMATION OF SERVICE RATIO

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1) Of the presently unserved people, the willingness for the public service was 58 %. All of the willing people will be supplied before 2010, at a presumed pace.

2) Of the incremental population in future, 58 % will be supplied by the service immedeately responding to the increase.

CASE 4

Case 4 was plotted in the same way as in Case 2, at an assumed growth rate of 4.5 %, lowest in the past.

The above four cases are characterized as bellow:

Case 1 prepared on the basis of the past trend shows a high rate of increase. As the trend in 1981 - 1984 is attributable to the rapid rectification of suppressed condition in the preceding years after the commissioning of Pattaya-Na Klua Treatment Plant, Case 1 overstates the future pattern of increase.

Case 2 and 4, made on the basis of the income level solely, are limited in usefulness, because other factors also affects the service ratio. They cannot be used without modification.

Case 3, made on the basis of the present willingness, is also limited in usefulness, as the willingness may change in future. Especially in Pattaya, where the availability of other supply sources is very low while water demands are pushed by rapid urbanization, the dependence on the public supply will grow stronger as years go.

After considering the above conditions of the four curves, a new curve is proposed, as shown in Fig-1.6. It has been made on the expectations that the willingness would grow stronger and the regional economy would raise the income level rather rapidly.

1.6 Served Population

In Table-1.5 the future total population, service ratio and served population are listed and in Fig-1.7, the population, total and served, are plotted. Calculation was made based on the total population in Table-1.3 and the service ratio in Fig-1.6.

Table-1.5 FUTURE SERVICE RATIO AND SERVED POPULATION

YEAR	TOTAL POPULATION	SERVICE RATIO	SERVED POPULATION
1985	58,750	34	19,980
1990	69,920	48	33,560
1995	80,990	58	46,970
2000	92,010	65	59,810
2005	103,020	71	73,140
2010	114,010	76	86,650

1.7 Tourist Number Forecast

In view of the character of the City as a leading center of tourism, the forecast of tourists number is dealt with in this section and the result will be used in forecasting water demands in Appendix 2.

In view of the character of the City as a leading center of conducted early in 1970's were reviewed. They predicted that the City would receive 800,000 tourists in 1986, while the tourism statistics registered no more than 600,000 tourists as an yearly figure up to the year 1983 and the number has shown a stagnant tendency since then (see Table-2.6 of Appendix 2).

In forecasting the tourists number, a similar mathematical method as applied to the population projection was employed. The results of employing the four formulae are shown in Fig-1.8, together with past record.

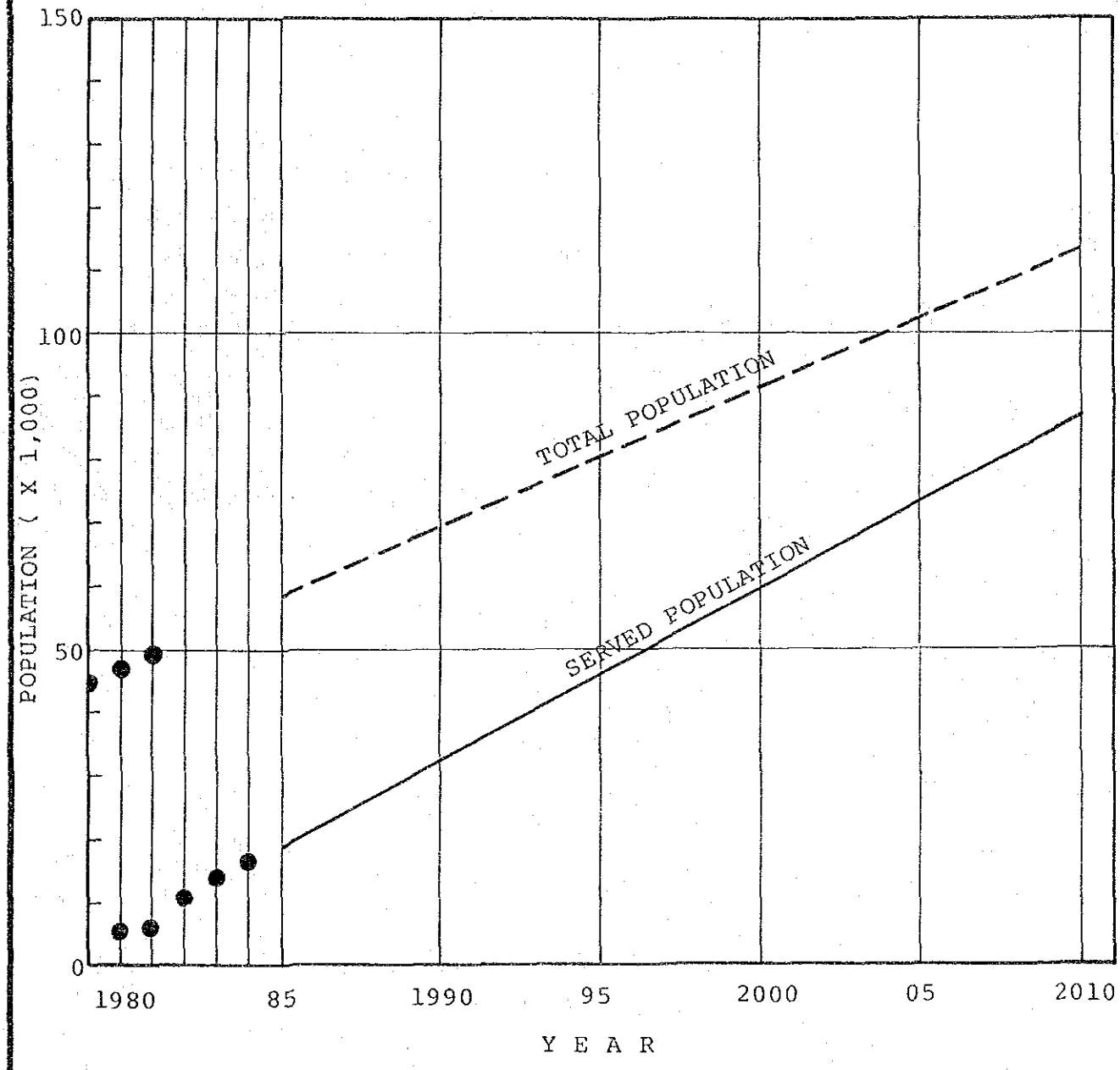

FIGURE	SERVED POPULATION FORECAST
1.7	

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When the recent years' stagnant tendency is considered, the arithmetical and geometrical progression curves showing too high growth in future are unreasonable. The other curves, the exponential and logistic, are left for examination therefore.

Of the two, the logistic curve seems to be more realistic than the exponential because the rate of growth is slower in the near future.

Many other resorts have also been promoted for tourism development in the recent years, helped much by the improvement of transportation facilities. Besides, Pattaya is limited in the land space. Even if its dominance in the coming years is kept stable, the high growth rate in the past will not be expected possibly.

The number of tourists per annum calculated by the logistic formulae is shown in Table-1.6.

The number per annum shall be converted to the number per day, as it is needed in calculating the water demand by tourism.

In 1981, 1982 and 1983, the average length of stay was 4.8, 4.7 and 4.0 days respectively, indicating a tendency of decreasing (see 2.3.3 of Appendix 2). In the talks with TAT, however, the agency predicted that four days would be appropriate for the future forecast and the estimation was made accordingly.

Fig-1.9 shows the average length of stay of tourists at the popular tourist spots in Thailand from 1981 to 1983.

Table-1.6 concludes the average number of tourists a day in the every fifth year from 1985 to 2010.

Table-1.6 FORECAST OF TOURISTS IN PATTAYA

YEAR	ANNUAL TOURISTS (persons)	AVERAGE LENGTH OF STAY (days)	ANNUAL TOTAL STAY (man-days)	AVERAGE DAILY TOURISTS (persons/day)
1985	734,686	4	2,938,744	8,050
1990	961,816	4	3,847,264	10,540
1995	1,090,924	4	4,363,696	11,960
2000	1,150,018	4	4,600,072	12,600
2005	1,174,370	4	4,697,480	12,870
2010	1,183,968	4	4,735,872	12,980

NOTE : (ANNUAL TOTAL STAY) = (ANNUAL TOURISTS) X
(AVERAGE LENGTH OF STAY)

(AVERAGE DAILY TOURISTS) = (ANNUAL TOTAL STAY)/365

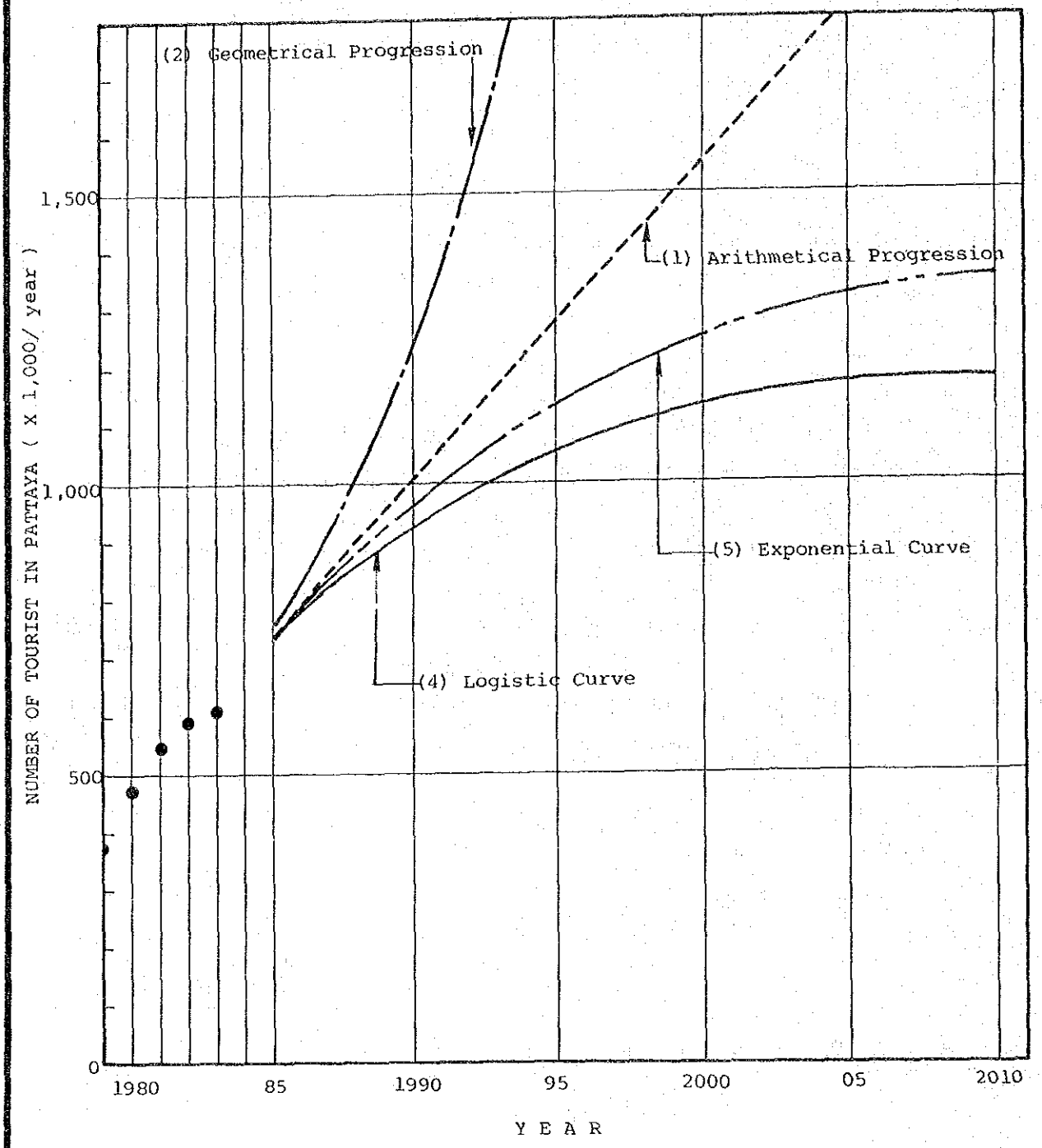

FIGURE	FORECAST OF THE NUMBER OF TOURIST
1.8	
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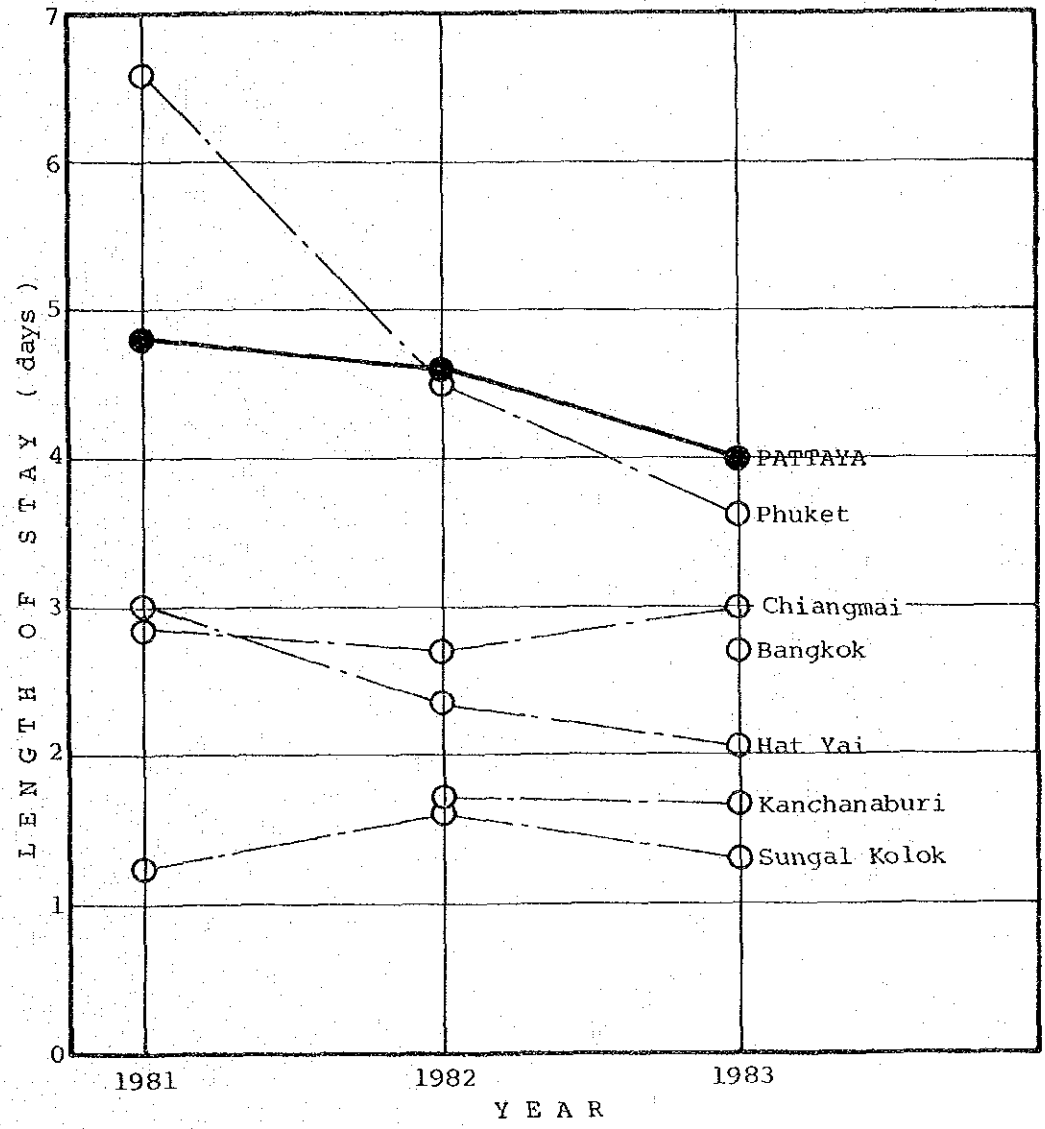

FIGURE	AVERAGE LENGTH OF STAY
1.9	
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APPENDIX 2

FUTURE WATER DEMAND

APPENDIX 2

APPENDIX 2 FUTURE WATER DEMAND

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APPENDIX 2 FUTURE WATER DEMAND

2.1 Introduction

In this Appendix, the water demands in the planned service area are forecasted for the Development Plan based on the analysis of records provided by PWA and the served population in future studied in Appendix 1 to this report.

In section 2.2, available data regarding water consumption are described to clarify the present situation in Pattaya. Section 2.3 describes the process and methodology applied in forecasting the water consumption together with the results of projection. After adding up the categorized water consumptions, the total water consumption including the unaccounted for water is summarized. Estimated in section 2.4 are the maximum-day and average-day water demands.

To be noted here is that the tourists visiting Pattaya are consuming about 60 % of the piped water now. The tourism water consumption will be studied in Subsection 2.3.3, considering the future development of tourism industry.

2.2 Records of Water Consumption

The water consumption records collected during the site survey relate to the total water production and water sales in 1978 up to 1984 on the yearly basis, as given in Fig-2.1 and Table-2.1.

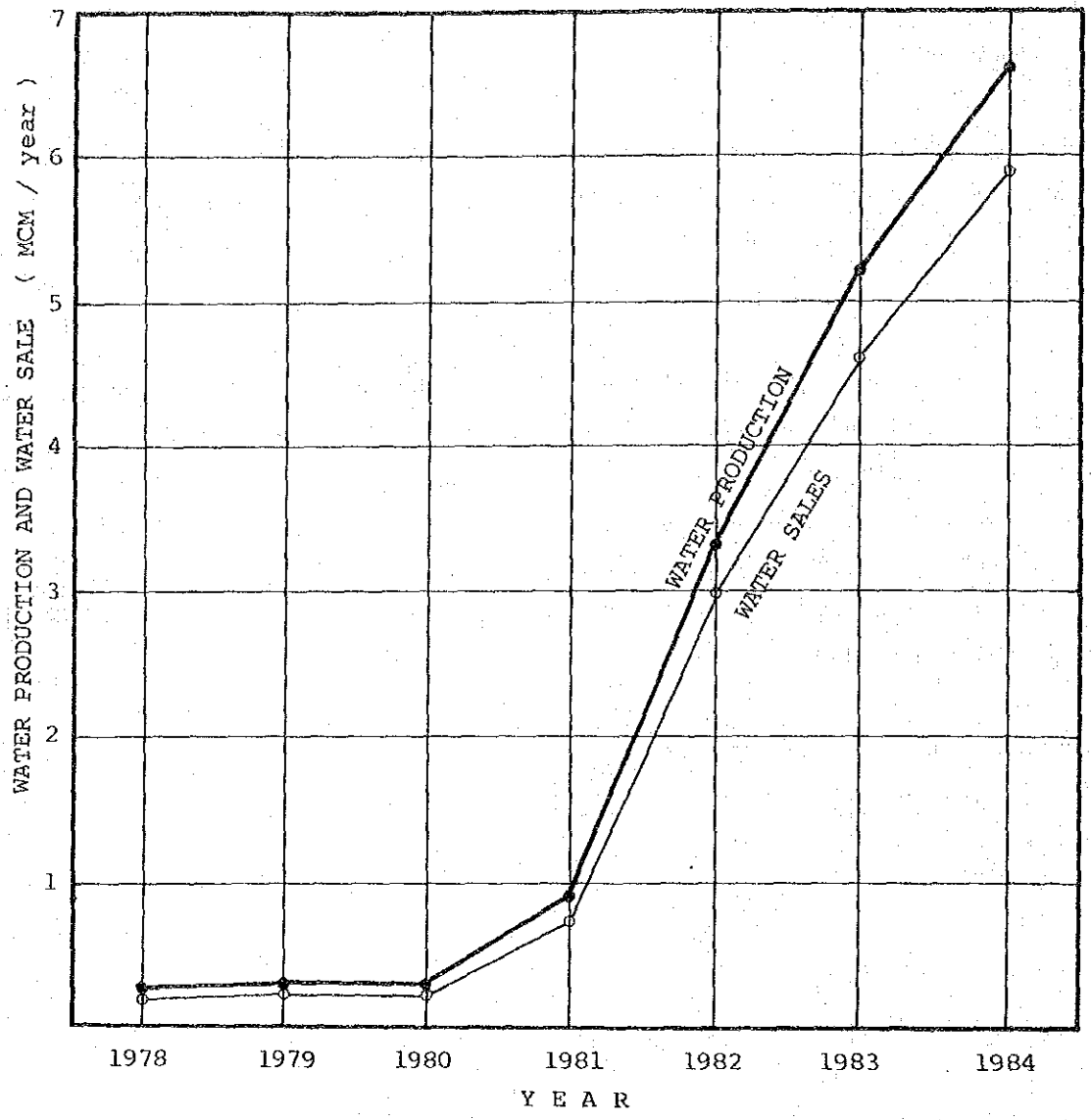

FIGURE	PAST RECORD OF WATER PRODUCTION AND WATER SALES
2.1	

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Table-2.1 WATER PRODUCTION AND WATER SALES

YEAR	WATER PRODUCTION (cu m/year)	WATER SALES (cu m/year)	NUMBER OF CONNECTION	CONSUMPTION PER CONNECTION (cu m/month)
1978	258,745	193,956	798	243
1979	301,689	205,148	886	232
1980	294,282	260,544	966	270
1981	915,515	733,487	1,342	547
1982	3,327,949	2,978,433	2,571	1,158
1983	5,199,565	4,573,615	3,683	1,242
1984	6,590,375	5,909,651	4,239	1,394

DATA SOURCE : PWA

As seen in Fig-2.1, the water production and water sales suddenly increased in 1982 when Pattaya-Na Klua treatment plant started its operation. The monthly water consumption per connection also doubled simultaneously due to increase of relatively large consumers. It was informed by officials of the Waterworks that most of the modernized hotels in Pattaya had changed their water source from the quantitatively and qualitatively poor ground-water to the reliable and stable piped water.

Other available data are the 1982 water consumption records grouped into consumer categories as provided in Table-2.2. This breakdown of water consumption, as detailed in "PWA Survey Report on Pattaya Waterworks in 1982", was derived from the analysis of actual records of meter-reading.

Table-2.2 BREAKDOWN OF THE WATER CONSUMPTION

CATEGORY	WATER CONSUMPTION (cu m/month)	(%)
Government Office	3,463	1.4
Hospital	2,379	1.0
School	792	0.3
Temple	660	0.3
Industry	3,678	1.5
Domestic	34,748	14.0
Commercial	57,349	23.1
Hotel	145,089	58.4
Total	248,203	100.0

SOURCE : PWA Survey Report on Pattaya Water-works in 1982

The above table clearly explains the characteristic of Pattaya. The consumption by hotels and commercial businesses is accounted for more than 80% of the total water consumption. On the other hand, the consumption by institutions like government office, hospital, school, temple and the industry is a mere 4.5%.

2.3 Future Water Consumption

2.3.1 Domestic Water Consumption

In this Subsection, the per capita consumption is estimated for the future and the domestic water consumption is forecasted by the estimated consumption and the served population projected in Appendix 1.

As described in the foregoing section, reliable data on the domestic consumption are only of the 1982 survey report prepared by PWA. Table-2.2 tells that the domestic water consumption is accounted for 14% of the total in 1982. Assuming that this ratio was constant in 1983 and 1984 after the start-up of Pattaya-Na Klua treatment plant, the domestic water consumptions was estimated as shown in Table-2.3.

Table-2.3 PAST DOMESTIC WATER CONSUMPTION AND PER CAPITA CONSUMPTION

YEAR	SERVED POPULATION	TOTAL WATER SALES (cu m/year)	DOMESTIC WATER CONSUMPTION (cu m/day)	PER CAPITA CONSUMPTION (lpcd)
1982	11,055	2,976,481	1,142	103.3
1983	14,209	4,573,615	1,754	123.5
1984	16,685	5,909,651	2,267	135.9

(DOMESTIC WATER CONSUMPTION) = (TOTAL WATER SALES) /365 X 0.14

(PER CAPITA CONSUMPTION) = (WATER CONSUMPTION) / (SERVED POPULATION) X 1,000

SOURCE : Served Population and Total Water Sales from PWA

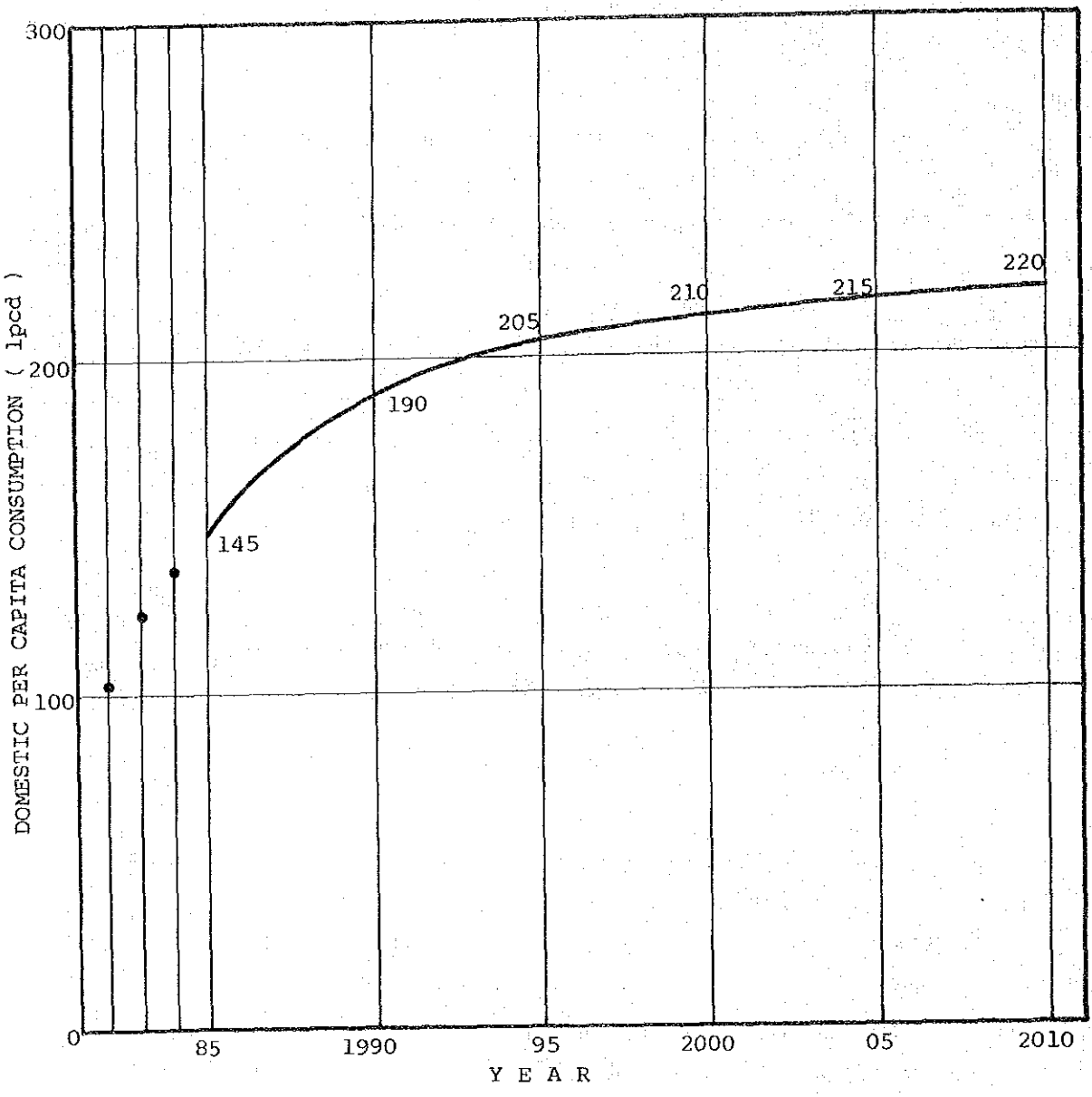

FIGURE	FORECAST OF FUTURE PER CAPITA CONSUMPTION
2.2	

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The estimated per capita consumption for 1984 is 136 lpcd, slightly smaller than that was recorded at the Metropolitan Waterworks system in Bangkok. Considering the socio-economic features of Pattaya and the living standard, a logistic curve which comes up to a level-off point of 220 lpcd in 2010 was selected. The result of estimation by the formula is illustrated in Fig 2.2 and Table-2.4 shows the domestic water consumption in the every fifth year up to 2010.

Table-2.4 DOMESTIC WATER CONSUMPTION

YEAR	SERVED POPULATION	PER CAPITA CONSUMPTION (lpcd)	DOMESTIC WATER CONSUMPTION (cu m/day)
1985	19,980	148	2,956
1990	33,560	190	6,377
1995	46,970	205	9,630
2000	59,810	210	12,559
2005	73,140	215	15,726
2010	86,650	220	19,062

2.3.2 Public Water Consumption

The public water consumption includes water consumptions by such institutions as government offices, hospitals, schools and temples.

As it is seen in Table-2.2, the percentages of the public water consumption and the domestic water consumption are 3 % and 14 % of the total respectively, making the public/domestic ratio 21:100.

In forecasting the future situation however, 27:100 ratio is applied instead of 21:100, because the facilities of the public institutions, such as hospitals and schools, are planned for improvement according to the Municipal Office's information.

Table-2.5 shows the public water consumption in the every fifth year from 1985 to 2010.

Table-2.5 PUBLIC WATER CONSUMPTION

YEAR	DOMESTIC WATER CONSUMPTION (cu m/day)	PUBLIC WATER CONSUMPTION (cu m/day)
1985	2,960	800
1990	6,380	1,720
1995	9,630	2,600
2000	12,560	3,390
2005	15,730	4,250
2010	19,060	5,150

2.3.3 Tourism Water Consumption

The tourism water consumption is defined as the water required by hotels and other accommodations. The tourism water consumption is estimated by multiplying the per capita consumption by the tourists number.

Table-2.6 shows the data of accommodation establishments and number of tourists in Pattaya, provided by PWA.

Table-2.6 ACCOMMODATION ESTABLISHMENTS AND NUMBER OF TOURIST

YEAR	NUMBER OF HOTEL ROOMS	AVERAGE OCCUPANCY RATE (%)	NUMBER OF TOURIST (person/year)	AVERAGE LENGTH STAY (days)
1981	6,582	54.74	505,804	4.81
1982	7,642	53.23	599,535	4.73
1983	8,647	48.18	593,554	3.99

SOURCE : TAT

The per capita consumption of tourists are calculated in the following way:

Water consumption of hotel (Table-2.2) = 145,089 cu m/month
= 4,836 cu m/day
Number of tourist per year (Table-2.6) = 599,535 persons
Average length of stay (Table-2.6) = 4.73 days
Number of tourist per day = (599,535 x 4.73) / 365
= 7,769 persons/day

Per capita consumption = 4,836 / 7,769
= 622 lpcd

It was learned, during the field investigation that some hotels in Pattaya are using groundwater especially for gardening, washing and laundering to supplement the piped water supply. Also learned was that they prefer the piped water to the groundwater because of the latter's poor yield and high chloride contents.

To look into the per capita consumption, further, the records of other municipalities characterized similarly to Pattaya were collected for comparison, and it was concluded that the actual per capita consumption might be in the range of 850 to 900 lpcd instead of 622 lpcd as calculated before. 875 lpcd in 1990 and 900 lpcd from 1995 to 2010 were decided to be used in the future forecast.

The tourism water consumption, shown below in Table-2.7, is calculated by the per capita consumption and the number of tourists quoted from Table-1.6 of Appendix 1.

Table-2.7 TOURISM WATER CONSUMPTION

YEAR	NUMBER OF TOURIST/DAY	CONSUMPTION PER TOURIST (l/day)	TOURISM WATER CONSUMPTION
1985	8,051	875	7,040
1990	10,540	875	9,220
1995	11,955	900	10,800
2000	12,603	900	11,340
2005	12,870	900	11,580
2010	12,975	900	11,700

2.3.4 Commercial Water Consumption

The commercial category defined herein includes the consumption of private businesses such as restaurants, bars, shops and bazaars. The consumption is thought to be related to the tourism water consumption closely, because commercial activities in Pattaya are mostly the services for tourists. In Table-2.2 the consumption was about 40 % of the tourism consumption and 37 % was used, as a constant, in projecting the future commercial water consumption.

Table-2.8 shows the results.

Table-2.8 COMMERCIAL WATER CONSUMPTION

YEAR	TOURISM WATER CONSUMPTION (cu m/day)	COMMERCIAL WATER CONSUMPTION (cu m/day)	COMMERCIAL/ TOURISM RATIO (%)
1985	2,610	7,040	37
1990	3,410	9,220	37
1995	4,000	10,800	37
2000	4,200	11,340	37
2005	4,290	11,580	37
2010	4,330	11,700	37

2.3.5 Industrial Water Consumption

The economy of the city will continue to depend largely upon tourism and the city has no long-term industrial development program at present. Hence, the industrial water consumption will stay at the present size.

2.3.6 Total Water Consumption

Table-2.9 shows the total and the categorized water consumptions and Table-2.10 lists the percentages corresponding Table-2.9's components.

Table-2.9 TOTAL WATER CONSUMPTION IN QUANTITY

WATER CONSUMPTION	WATER CONSUMPTION (cu m/day)					
CATEGORY	1985	1990	1995	2000	2005	2010
Domestic	2,960	6,380	9,630	12,560	15,730	19,060
Public	800	1,720	2,600	3,390	4,250	5,150
Tourism	7,040	9,220	10,800	11,340	11,580	11,700
Commercial	2,610	3,410	4,000	4,200	4,290	4,330
Industry	400	400	400	400	400	400
Total	13,810	21,130	27,430	31,890	36,250	40,640

Table-2.10 TOTAL WATER CONSUMPTION IN PERCENTAGE

WATER CONSUMPTION	WATER CONSUMPTION (%)					
CATEGORY	1985	1990	1995	2000	2005	2010
Domestic	21.4	30.2	35.1	39.4	43.4	46.9
Public	5.8	8.1	9.5	10.6	11.7	12.7
Tourism	51.0	43.6	39.4	35.6	31.9	28.8
Commercial	18.9	16.1	14.6	13.2	11.8	10.7
Industry	2.9	2.0	1.4	1.2	1.2	0.9
Total	100.0	100.0	100.0	100.0	100.0	100.0

2.4 Average Day and Maximum Day Water Demands

The average day and maximum day water demands under the heading are defined as the required output of production including unaccounted-for water. The maximum day demand is calculated by multiplying the average day consumption by the peak factor selected properly.

2.4.1 Unaccounted-for Water and Average Day Water Demand

The unaccounted-for water ratio has been very low in the project area, because, as shown in Table-2.11, it was 10.5, 12.0 and 10.3 % in 1982, 1983 and 1984 respectively.

These low ratios are caused by the fact that distribution networks were built rather in recent years. To maintain the good condition in future, the Pattaya Waterworks are recommended to take care for leakage reduction. The ratio employed in the forecast is a constant 15% throughout the project period.

Table-2.11 UNACCOUNTED-FOR WATER RATIO

YEAR	WATER PRODUCTION (cu m/year)	WATER SALES (cu m/year)	UNACCOUNTED - FOR RATIO (%)
1978	258,745	193,956	25.0
1979	301,689	205,148	32.0
1980	294,282	260,544	11.5
1981	915,515	733,487	19.9
1982	3,327,949	2,978,433	10.5
1983	5,199,565	4,573,615	12.0
1984	6,590,375	5,909,651	10.3

SOURCE : PWA

2.4.2 Peak Factor and Maximum Day Water Demand

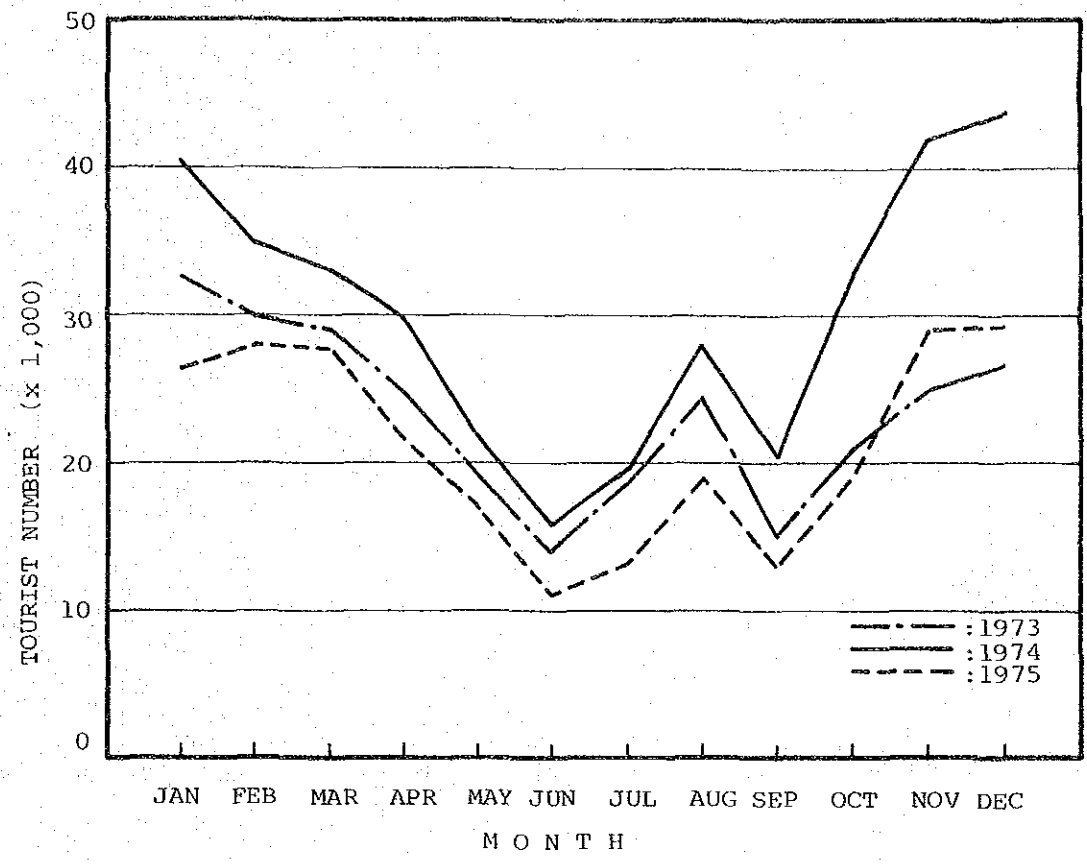
The peak factor defined as the ratio of maximum day demand to the average day demand was determined for two categories of water consumption: the tourism water consumption and others. The peak factor for the tourism water consumption was assumed as 1.4 on the data of monthly fluctuation of tourists' number referring to the report of "Pattaya Tourism Develpment" by JICA and Tourist Organization of Thailand as shown in Fig-2.3. As for the

other consumptions, a peak factor of 1.25 was used on the basis of comparable data in Ubon.

Table-2.12 and Fig-2.4 show the average day water demand and maximum day water demand.

Table-2.12 AVERAGE DAY AND MAXIMUM DAY WATER DEMAND

WATER DEMAND	WATER DEMAND (cu m/day)					
	1985	1990	1995	2000	2005	2010
AVERAGE DAY	16,241	24,863	32,270	37,510	42,640	47,810
MAXIMUM DAY	21,544	32,706	42,240	48,900	55,340	61,830



YEAR	1973	1974	1975
JAN	32,569	40,500	26,293
FEB	29,923	34,671	27,867
MAR	28,983	35,433	27,559
APR	24,646	29,729	21,370
MAY	19,056	21,794	17,312
JUN	14,014	15,902	11,241
JUL	18,459	19,533	13,239
AUG	24,562	27,961	18,629
SEP	14,834	20,278	12,954
OCT	20,841	32,455	19,192
NOV	24,806	41,964	29,111
DEC	26,585	43,595	29,299
TOTAL	279,278	363,815	254,066
AVERAGE	23,273	30,318	21,172
P.F.	1.40	1.44	1.38

P.F. : PEAK FACTOR

Notice: 1973's and 1974's data were collected from 19 major hotels in Pattaya, and 1975's from 7 hotels.

Data Source: Tourist Organization of Thailand (TOT)

FIGURE 2.3	MONTHLY FLUCTUATION OF TOURIST NUMBER IN PATTAYA

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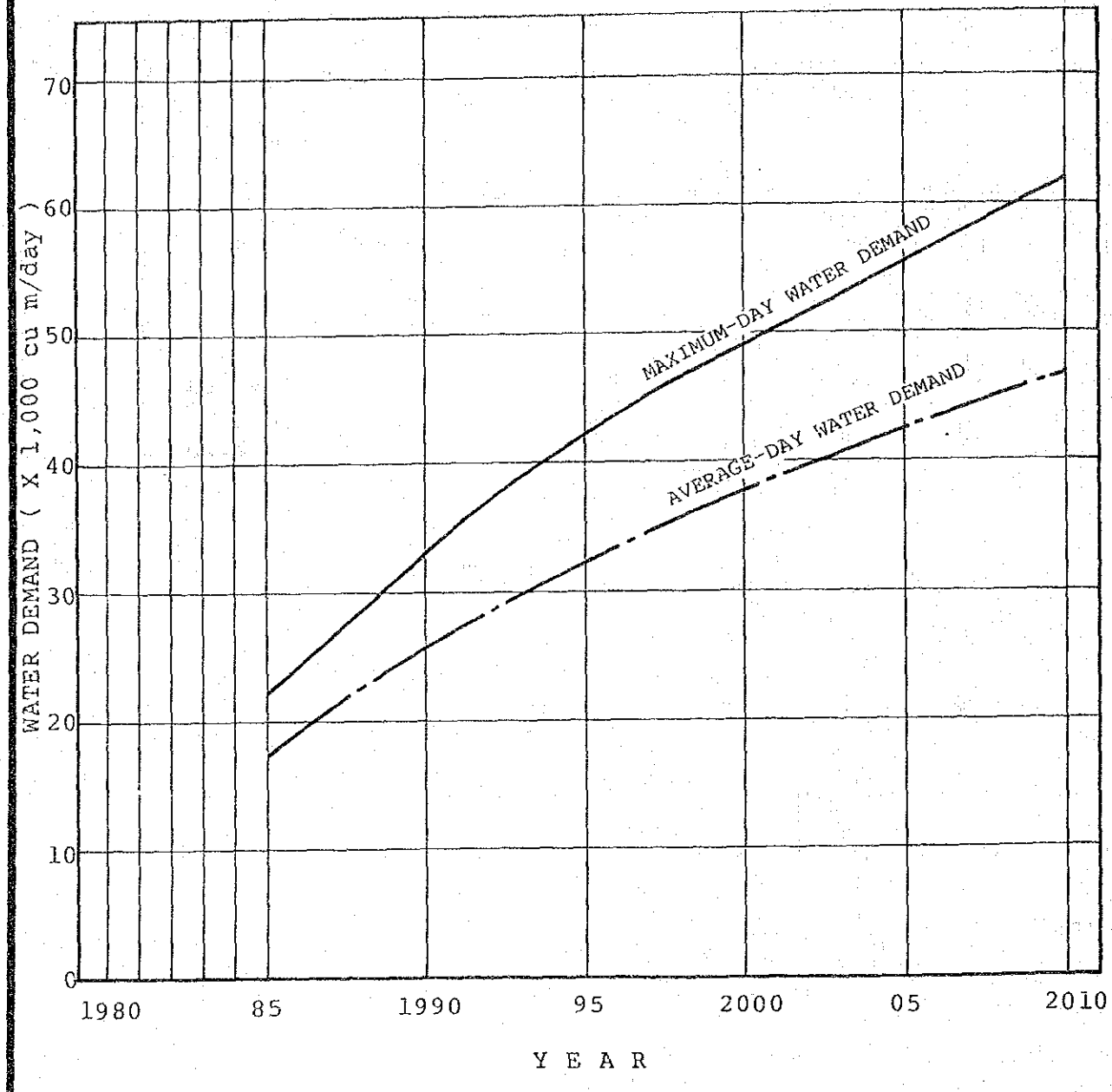

FIGURE	ESTIMATED FUTURE AVERAGE-DAY WATER DEMAND AND MAXIMUM-DAY WATER DEMAND
2.4	

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APPENDIX 3

STUDY ON WATER SOURCE

APPENDIX 3

APPENDIX 3 STUDY ON WATER SOURCE

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APPENDIX 3 STUDY ON WATER SOURCE

3.1 Introduction

This Appendix aims to review and summarize the water resources conditions and development program for Pattaya.

The study on water resource was carried out during the periods, from December 16, 1985 to February 13, 1986 and from June 1 to August 31, 1986, to prepare the Development Plan and Feasibility Study on Provincial Water Supply Projects. The water resources discussed in this Appendix are those located in Pattaya, Laem Chabang and its surrounding area.

From the viewpoints of climatic, geographical, topographical, hydrological and hydrogeological conditions, the availability of water resources and possibility of developing them to meet the planned future demand have been studied in detail, as seen in the following chapters and sections. Attention has been paid on the groundwater development as well as on the surface water development.

As qualitative assessment of water resources is as important as quantitative one, Appendix 4, studying exclusively the water quality in the area has been prepared by the team. In this report, the relevant matters are referred to and quoted from it.

3.2 Location and Topography

Pattaya City, Chonburi Province, is situated on the east coast of Gulf of Thailand in the Eastern Region of the country. It is about 100 km southeast of Bangkok.

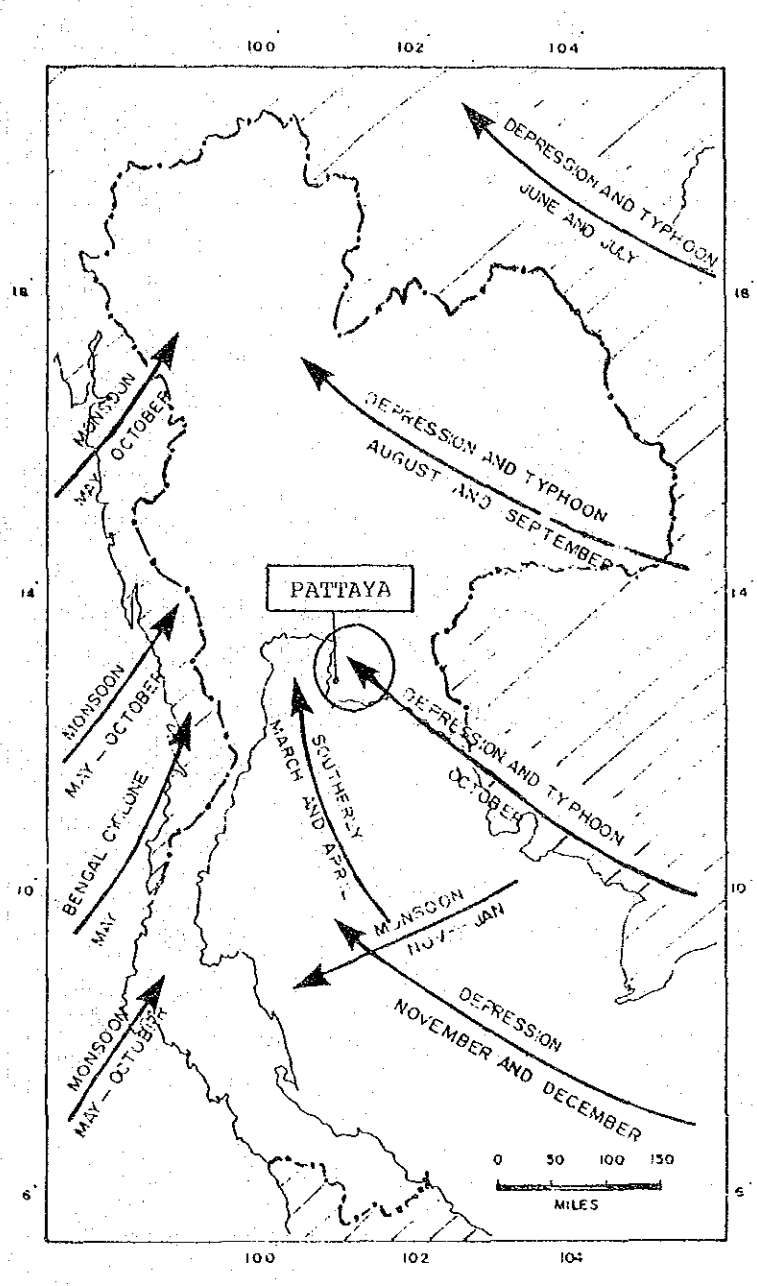
Narrow flat land extending along the coastline and low hills undulating toward the sea characterize the topography of Pattaya. The flat area lies at MSL (mean sea level) of 5 m or less, while the hills elevation varies from 20 to 100 m MSL.

3.3 Climate

The climate is tropical and monsoon-influenced. There are two distinct seasons in the year.

The dry season from November to February is influenced by the north--easterly monsoon of the Northern Hemisphere winter. While, the south-westerly monsoon, usually extending from May to October, causes the rainy season. Heavy rainfalls in the area are, however, affected more by the depression which originates in the South China Sea. (Fig-3.1)

Although no climatological observation station is in Pattaya, the data of Chonburi observatory and Bang Lamung are useful to represent the climate. According to them, the mean annual rainfall is about 1,310 mm, of which more than 80 % occurs during the rainy season. The mean temperature is 27.9 C. The pan evaporation is slightly higher than the annual rainfall, being 1,590 mm per year. (Table-3.1)



MAP OF THAILAND AND AIR STREAMS DOMINATING THE CLIMATIC CONDITION

DATA : AIT 1973

FIGURE	MONSOON, DEPRESSION, CYCLONE AND TYPHOON
3.1	

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Table-3.1 SUMMARY OF CLIMATOLOGICAL DATA

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Data Source
Air Temperature (°C)														(1)
Mean	25.9	27.4	28.8	29.6	29.3	28.9	28.6	28.3	27.8	27.4	26.6	25.8	27.9	
Mean Max.	31.5	32.2	33.3	34.2	33.4	32.6	32.0	31.7	31.5	31.6	31.4	31.5	32.2	
Mean Min.	20.2	22.5	24.3	25.5	25.5	25.5	25.1	25.0	24.5	23.8	22.1	20.4	23.7	
Extreme Max.	37.5	37.6	37.8	38.4	38.2	37.1	35.9	35.8	35.5	35.9	36.2	36.7	38.4	
Extreme Min.	9.9	16.5	17.5	20.4	21.2	21.0	20.5	20.9	20.6	17.9	14.2	12.0	9.9	
Relative Humidity (%)														(1)
Mean	68.0	72.0	72.0	73.0	76.0	75.0	76.0	77.0	81.0	81.0	74.0	67.0	74.0	
Mean Max.	85.0	87.8	87.5	87.4	88.6	87.7	88.6	89.6	92.3	92.6	88.6	84.4	88.3	
Mean Min.	51.2	55.5	56.1	56.2	60.4	61.3	62.4	63.4	66.6	65.4	55.9	48.6	58.6	
Extreme Min.	20.0	22.0	19.0	26.0	32.0	42.0	43.0	43.0	46.0	32.0	24.0	22.0	19.0	
Wind Velocity (km/hr)														(1)
Mean	10.8	12.1	12.2	11.5	10.0	11.9	11.1	10.9	8.9	8.5	10.9	11.3	10.9	
Cloudiness (Oktas)														(1)
Mean	3.4	3.7	3.8	4.5	6.0	6.5	6.6	6.8	6.6	5.6	4.3	3.5	5.1	
P an Evaporation (mm)														(2)
Mean	111.4	112.1	145.6	160.6	158.9	144.9	144.6	136.3	116.9	126.4	116.9	117.9	1592.5	
Rainfall (mm)														(3)
Mean	12.1	22.1	32.6	76.8	155.6	136.1	152.7	165.6	291.0	206.5	56.5	6.3	1313.9	
Mean rainy days	1.6	3.3	4.5	7.8	14.7	14.7	17.0	19.0	20.1	17.2	6.5	1.4	127.8	

Source :

(1) Climatological Data of Thailand, 30-Year Period (1951 - 1980),MD
(2) RID stations at Bang Phra Damsite (1968 - 1980) and Chon Buri Station (1981 - 1984)
(3) MD station at A. Muang Chon Buri, Period 1952 - 1984

DATA : PWD, 1985

3.4 Hydrology

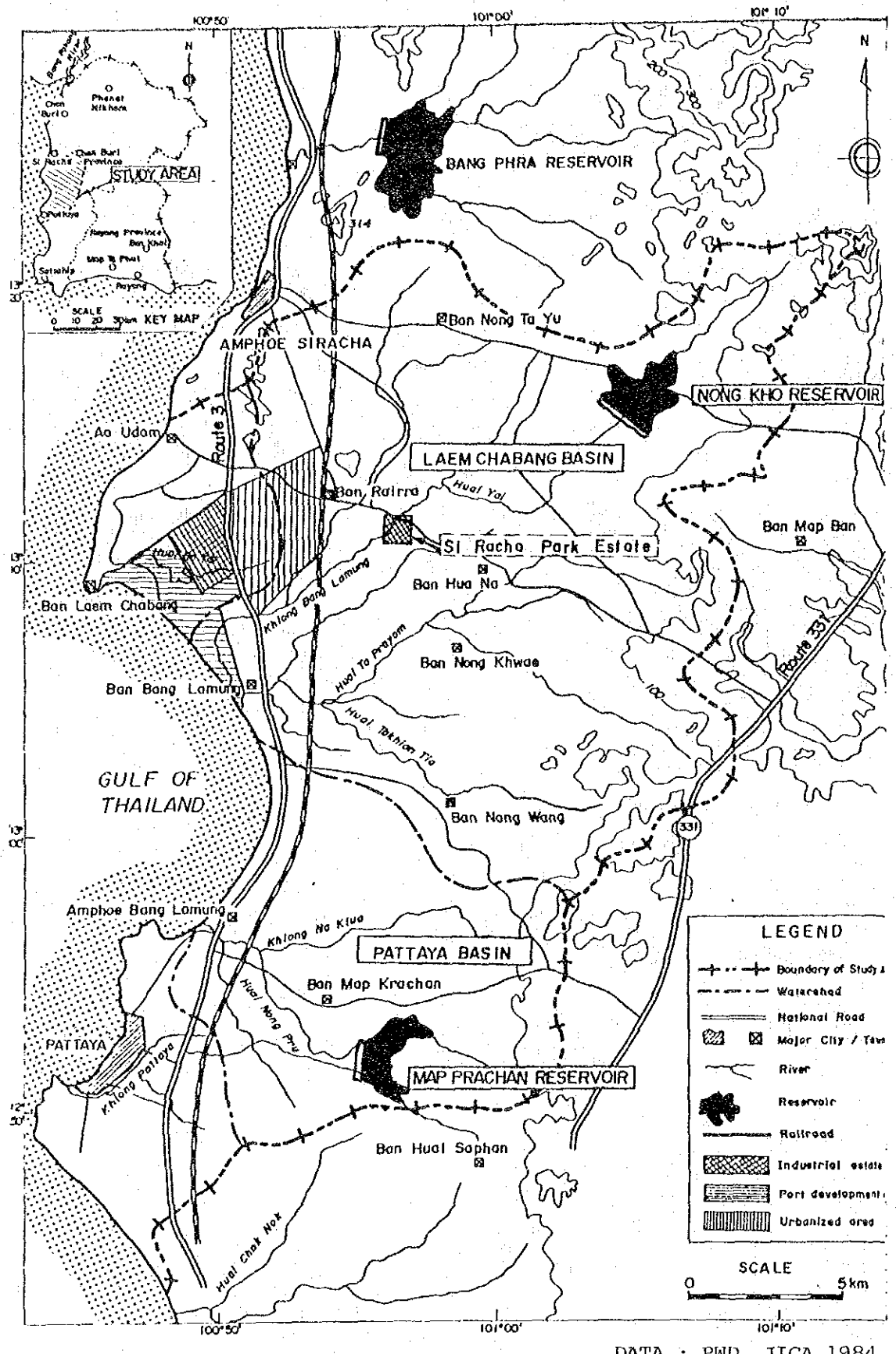
In the Pattaya-Laem Chabang area, there are two basins, namely the Pattaya Basin and Laem Chabang Basin.

The Pattaya Basin, covering an area of 154.7 sq km drainage area, consists of the Huai Nong Pru River basin of 103 sq km, the Khlong Pattaya River basin of 20.3 sq km and the Mab Phawa River basin of 31.4 sq km. The Laem Chabang Basin covers 333.4 sq km gross area, consisting of the Huai Bo Yai River basin of 32.4 sq km and the Khlong Bang Lamung River basin of 301 sq km. (Fig-3.2)

The catchment area and flow of the mentioned rivers are limited, and no stationary gauging station has been established in the area. The Nong Kho dam was constructed on the Khlong Nong Kho river, a tributary of the Khlong Bang Lamung river, by RID in 1983 and the Mab Prachan dam was constructed astride the Mab Prachan and Mab Tao Kiat rivers, tributaries of the Huai Nong Pru river, by RID also in 1979. Both dams are multiple - purpose, that is,for water supply, irrigation and flood control.

The Mab Prachan reservoir is presently used for the exclusive purpose to supply water to Pattaya. The dam is located about 8 km east of Pattaya City, having a gross storage capacity of 14.8 MCM. The Nong Kho reservoir was built to supply water to the Laem Chabang Complex and Pattaya. The reservoir has a gross storage capacity of 26.6 MCM. Major features of the two reservoirs are shown in Table 3.2.

The water balance of the Pattaya Basin and the Laem Chabang Basin was studied in the Feasibility Study of the Nong Kho - Laem Chabang Water Pipeline Project, by JICA in March 1984.



DATA : PWD, JICA 1984

FIGURE	PATTAYA & LAEM CHABANG RIVER BASIN
3.2	

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The water balance of the two basin is summarized as below:

UNIT: MCM

Year	1986	1991	1996	2001
Laem Chabang Basin				
Supply by Nong Kho dam	13.9	13.9	13.9	13.9
Water requirement	8.3	16.9	25.8	36.3
Balance	+5.6	-3.0	-11.9	-22.4
Pattaya Basin				
Supply by Mab Prachan dam	9.8	9.8	9.8	9.8
Water requirement	11.5	10.3	14.6	18.8
Balance	-1.7	-0.5	-4.8	-9.0

Source: Feasibility Study of the Nong Kho Laem Chabang Water Pipeline Project, JICA, 1984.

From the above, serious shortage of water in the two basin areas is predictable and no prospect of improving the situation is foreseen for Pattaya's shortage.

Conceivably, water will have to be diverted from other basins and the required amount, calculated from the above, will be 3.5 MCM in 1991, 16.7 MCM in 1996 and 31.4 MCM in 2001.

Table-3.2 MAJOR FEATURES OF RESERVOIRS

Description		Nong Kho	Mab Prachan
1. Hydrology			
Name of river		Khlong Nong Kho	Huai Nong Pru
Catchment area	km^2	59	37.9
Average annual inflow	10^6 m^3/yr	24.7	14.5
2. Reservoir			
Gross storage capacity	10^6 m^3	26.6	14.8
Surcharge capacity	10^6 m^3	7.0	2.2
Active storage capacity	10^6 m^3	18.8	14.0
Dead storage capacity	10^6 m^3	2.3	0.8
Flood water level	El. m	66.5	45.7
High water level	El. m	65.6	45.0
Low water level	El. m	58.9	36.0
Reservoir surface area at H.W.L.	km2	4.7	2.8
Type		Earth fill	Earth fill
Height	m	17.0	17.0
Crest elevation	El. m	68.0	47.0
Crest length	m	1,985	2,060
3. Year of Completion		1983	1979

Data Source: RID
PWD, 1985

3.5 Re-evaluation of Present Water Sources of Pattaya

The Pattaya waterworks now depends on an only water source which is the Mab Prachan reservoir constructed in 1979 and maintained by Royal Irrigation Department (RID). Developing surface water further in Pattaya Basin is not prospective, as the catchment area and rivers flow are limited. Regarding groundwater, the potentiality is not high hydrogeologically and the groundwater in the narrow plain is brackish. Possibility of using it for the public supply is low.

The basic solution for long-term water source development plan will be diverting water from other basins, as mentioned before. Since the supply capacity of the Mab Prachan reservoir is closing to the limit, re-evaluating the present water sources to utilize them to the maximum will be made hereunder.

3.5.1 Draft Rate of Mab Prachan Reservoir

Fig-3.3 illustrates the monthly fluctuation, in the consecutive years from 1979 to 1986, of storage and water level of the Mab Prachan Reservoir. Filling of the reservoir started in 1979 and in the middle of 1981 it was filled up. Since then, the lowest storage recorded at 7.4 MCM in July 1985 was the most critical situation in the recent years.

Figs-3.4 and 3.5 illustrate the present reservoir topography and the reservoir area-storage curve respectively.

The volume of storage at the high water level (HWL) of 45.0 m MSL and the lower water level (LWL) of 36.0 m MSL are 14.8 MCM and 0.8 MCM, respectively. As the Pattaya waterworks intake level is positioned at 39.0 m MSL, the dead storage of water supply is 3.25 MCM. RID plans to raise the height of spillway to 45.5 m MSL to increase the reservoir capacity to 16.5 MCM after 1989. The major features of the Mab Prachan Reservoir are summarized in Table-3.3

As of 1986, 24,000 cu m/day (8.8 MCM/year) is the rated production capacity of the Pattaya-Na Klua treatment Plant.

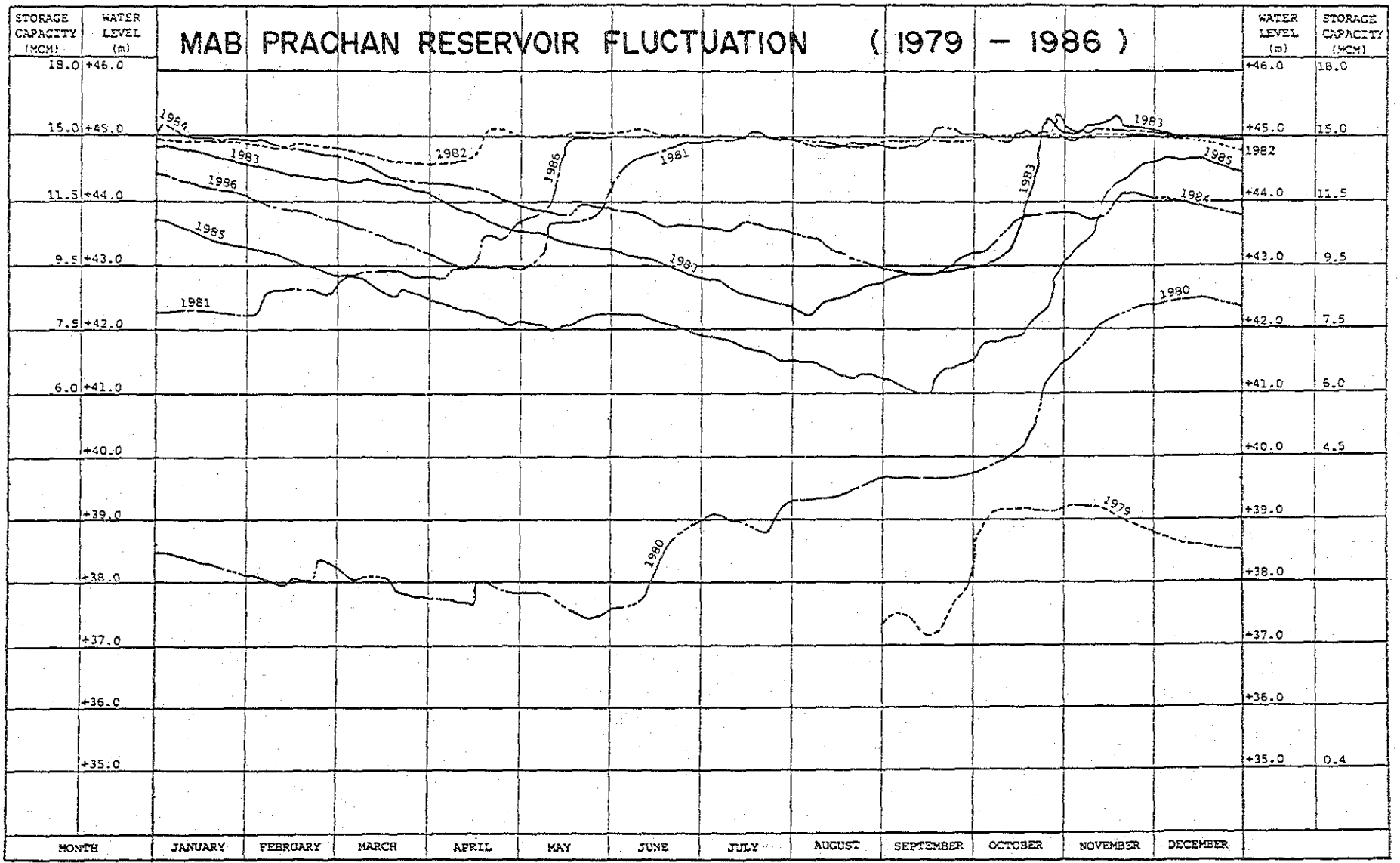

FIGURE	MAB PRACHAN RESERVOIR FLUCTUATION (1979-1986)
3.3	
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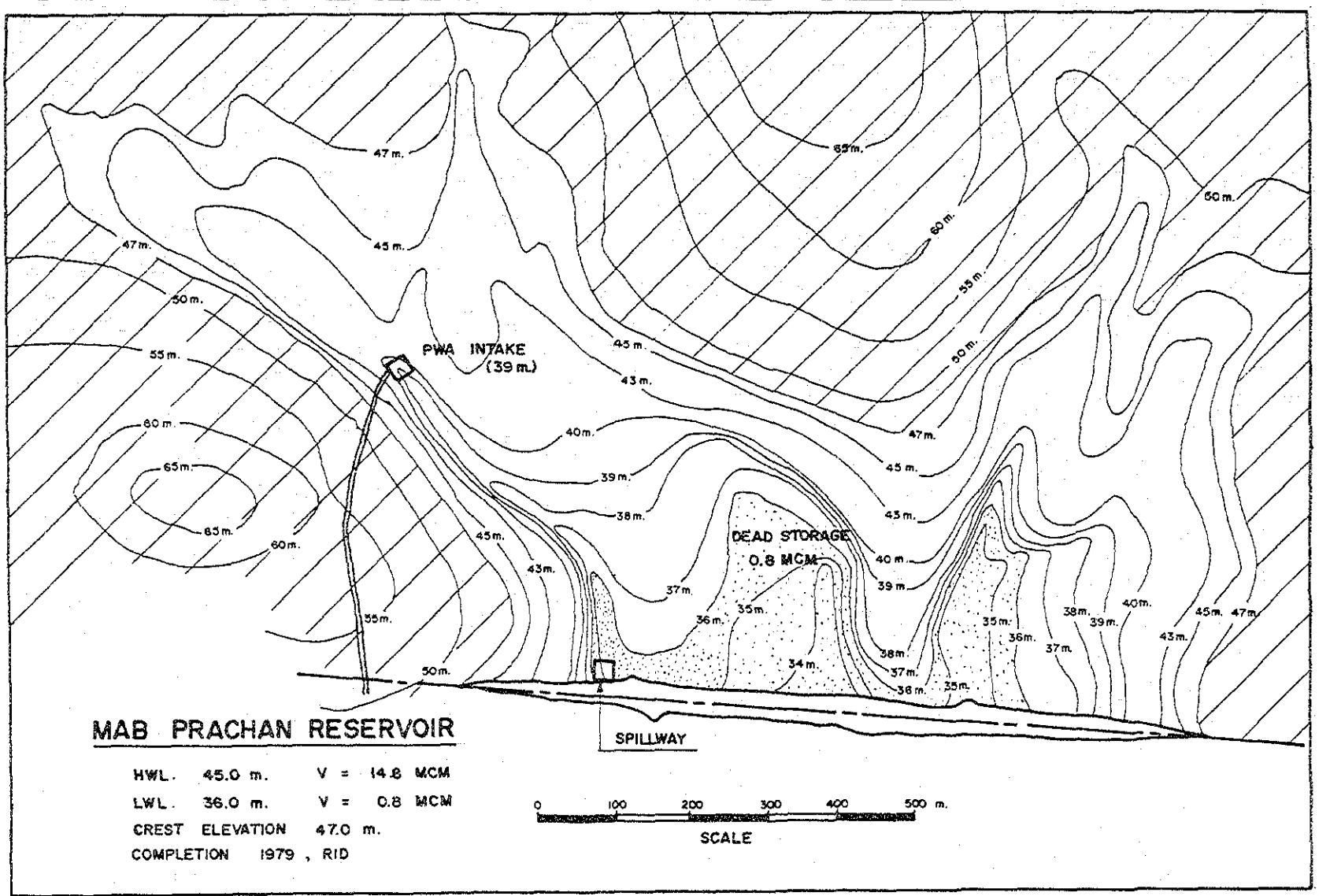

FIGURE	MAB PRACHAN RESERVOIR
3.4	

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MAB PRACHAN RESERVOIR AREA-STORAGE CAPACITY CURVES

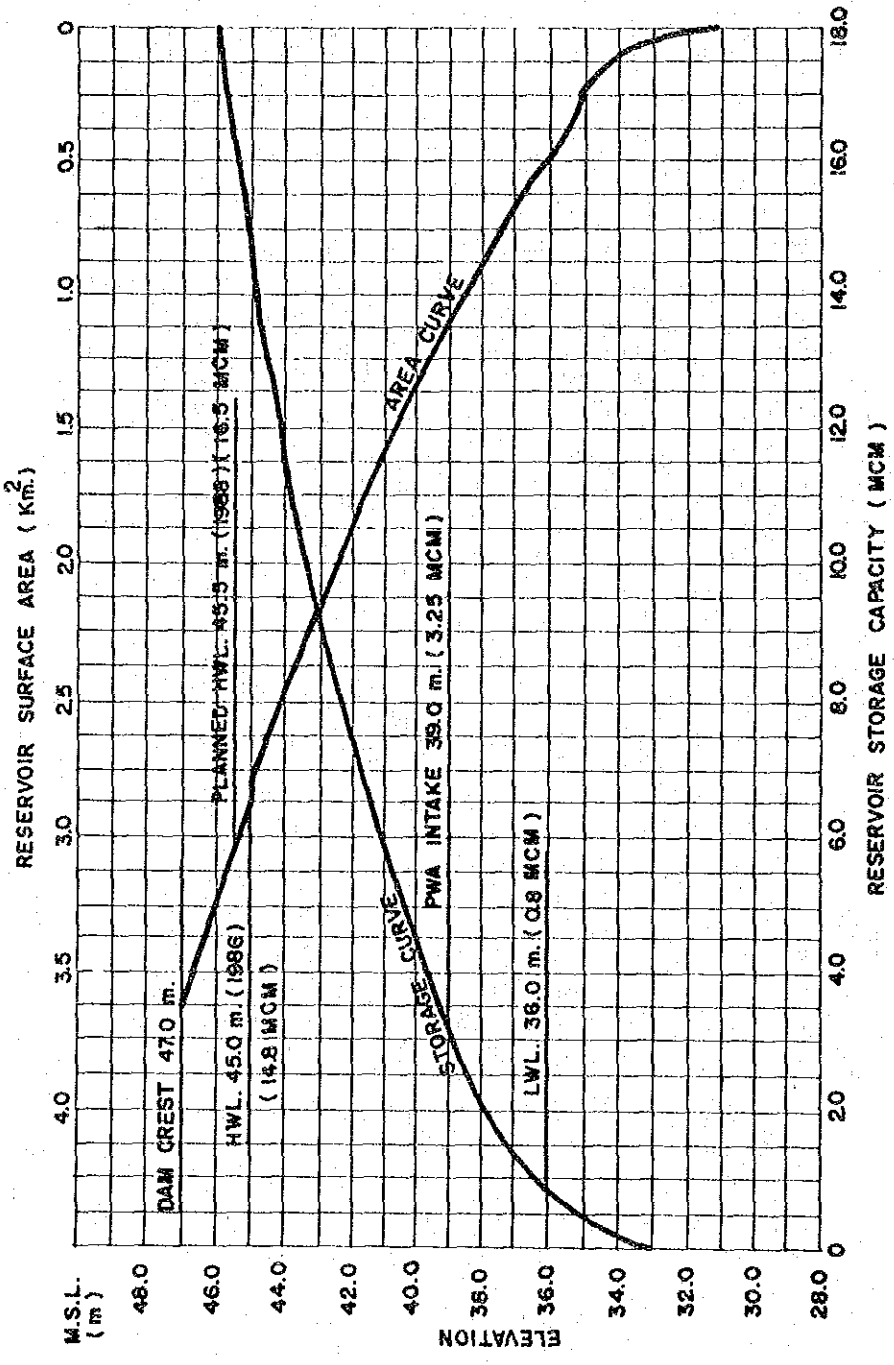

FIGURE	MAB PRACHAN RESERVOIR AREA-STORAGE CAPACITY CURVES
3.5	

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To find the maximum supply capacity, or the net draft rate of the reservoir, a study was made, using the runoff model of the Bang Phra dam site for 17 years, from 1968 to 1984, and the operation record of the Mab Prachan Reservoir for 8 years, from 1979 to 1986. The used hydrological data of the Bang Phra dam site are shown in Table-3.4 to Table-3.6. The rainfall data of both Bang Phra and Mab Prachan areas in 1968 to 1986 are shown in Fig-3.6 and Table-3.7.

Regarding the Mab Prachan reservoir site, sufficient hydrological data was not available and the Bang Phra's well-prepared data were simulated for the use in the Mab Prachan's case.

The Bang Phra's data, monthly rainfall in Table-3.4, monthly evaporation in Table-3.5 and monthly runoff in Table-3.6, were studied at first to find the runoff characteristic at the site. Then, comparing the rainfall data of the two sites in Table-3.7 and Fig-3.6, the runoff characteristic at the Mab Prachan Reservoir site was determined.

Table-3.8 shows the result of the simulation. With the catchment area of 37.9 sq km and the rainfall condition in 1968 to 1984, the runoff at the Mab Prachan Reservoir site was estimated at 16.08 MCM/year, as the 17 years' average. The lowest in the period was 4.10 MCM/year in 1977.

Fig-3.7 shows the mass curve analysis of the Mab Prachan Reservoir, resulted from Table-3.8.

Table-3.3 MAJOR FEATURES OF MAB PRACHAN RESERVOIR

DESCRIPTION	UNIT	TECHNICAL DATA	
1. Year of Completion		1979	1989
2. Hydrology			
Name of River		Huai Nong Pru	Huai Nong Pru
Catchment Area	sq km	37.9	37.9
Average Annual Inflow	MCM	16.08	16.08
3. Reservoir			
Active Storage Capacity	MCM	14.0	15.7
Gross Storage Capacity	MCM	14.8	16.5
Flood Water Level	El. m	45.7	45.7
High Water Level	El. m	45.0	45.5
Low Water Level	El. m	36.0	36.0
Reservoir Surface Area at HWL	sq km	2.8	3.06
4. Dam			
Type		Earthfill	Earthfill
Height	m	17.0	17.0
Crest	El m	47.0	47.0
Crest Length	m	2,000	2,000

Source: PWA and RID

Table-3.4 MONTHLY RAINFALL AT BANG PHRA DAM SITE

(unit : mm)

Water Year	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Annual
1968	151.4	165.1	215.3	48.6	154.9	197.1	202.5	39.8	1.9	120.9	0.0	106.4	1,404
1969	40.4	247.5	23.1	69.7	178.3	347.7	111.8	11.8	0.0	4.9	50.8	35.7	1,122
1970	112.2	159.9	226.6	64.8	146.2	220.6	225.8	81.2	141.4	0.0	30.8	34.3	1,444
1971	197.2	205.2	106.2	95.6	288.6	276.9	139.1	14.4	4.8	0.0	24.0	55.1	1,407
1972	91.6	18.6	134.1	59.6	63.8	318.9	145.0	171.2	13.0	5.4	1.8	76.0	1,099
1973	4.6	152.1	97.3	94.0	179.5	230.0	155.8	47.6	11.9	12.3	0.0	81.4	1,067
1974	189.6	148.0	45.4	94.3	155.5	203.6	600.3	62.7	1.5	62.9	13.9	14.7	1,592
1975	75.0	130.6	39.7	97.1	246.7	248.9	109.6	50.7	0.0	0.0	80.9	59.5	1,139
1976	83.6	118.4	83.1	132.4	226.4	397.9	380.7	43.7	1.3	7.7	32.3	19.8	1,527
1977	105.0	190.9	110.8	80.3	57.6	203.5	200.3	26.4	0.0	15.8	171.7	0.0	1,162
1978	128.4	188.3	164.9	290.8	61.9	315.8	118.4	0.0	0.0	0.0	0.0	0.0	1,269
1979	162.9	44.4	104.7	90.1	100.8	308.9	37.0	0.0	0.0	0.0	102.3	39.1	990
1980	129.8	112.4	238.1	191.6	99.5	295.4	202.4	53.7	0.0	9.4	40.5	102.7	1,476
1981	341.4	252.3	64.4	157.2	57.9	316.5	193.9	75.0	0.0	0.0	31.8	121.7	1,612
1982	63.4	115.2	184.9	201.3	51.5	156.4	215.1	93.6	38.0	0.0	0.0	49.4	1,169
1983	43.7	133.6	46.3	125.2	333.7	125.4	295.7	111.4	11.1	0.0	57.9	31.5	1,316
1984	33.3	77.4	83.9	47.2	87.4	186.9	87.4	186.9	0.0	28.3	65.2	16.9	901
Average	114.6	144.7	115.8	114.1	146.5	255.9	201.2	62.9	13.2	15.7	41.4	49.7	1,276

Source : RID
PWD, 1985

Table-3.5 MONTHLY EVAPORATION AT BANG PHRA DAM SITE

(unit : mm)

Water Year	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Annual
1968	117.7	127.5	141.3	139.6	135.0	91.7	93.4	96.2	100.3	82.6	79.0	108.3	1,313
1969	130.7	129.5	113.5	93.5	82.0	(84.4)	98.3	87.4	88.7	(104.0)	83.3	(116.1)	1,211
1970	113.5	(120.9)	(97.4)	105.3	83.9	77.2	(74.4)	85.9	70.1	58.8	73.1	93.4	1,054
1971	112.6	101.2	99.2	91.0	90.8	87.7	80.7	76.4	89.6	57.5	76.5	101.1	1,064
1972	101.4	147.7	102.8	112.8	(107.0)	(69.4)	(96.7)	(81.3)	72.8	80.0	81.8	97.3	1,151
1973	(127.9)	93.0	85.3	88.8	107.6	(72.9)	(93.5)	66.6	64.3	(54.6)	65.0	(82.3)	1,001
1974	(93.8)	(88.0)	90.0	91.5	78.0	(85.6)	(83.9)	78.5	77.1	63.1	85.3	104.3	1,019
1975	109.3	(92.5)	89.1	88.9	(83.3)	(77.0)	96.8	107.9	62.4	57.3	(70.8)	(99.1)	1,034
1976	(111.7)	(95.9)	(119.8)	(112.4)	95.9	(98.9)	(78.3)	(50.6)	96.0	101.8	75.2	(86.5)	1,123
1977	(102.5)	101.1	108.5	91.5	88.2	74.7	(83.2)	75.7	88.3	78.5	55.2	90.6	1,038
1978	(95.8)	(96.1)	89.8	(81.1)	80.6	(73.7)	95.1	93.4	84.9	75.0	80.2	115.8	1,062
1979	(100.2)	118.2	82.9	86.7	85.5	(61.7)	102.5	99.3	76.8	77.4	79.3	107.2	1,078
1980	(123.2)	133.6	(98.0)	(112.7)	103.4	(96.5)	(90.9)	74.0	77.5	74.2	70.3	98.6	1,153
1981	113.6	103.4	107.5	108.1	97.4	93.6	92.0	68.8	89.2	92.2	88.5	188.5	1,143
1982	118.0	113.5	102.9	112.1	94.5	76.0	85.6	82.4	90.5	95.7	93.6	120.5	1,185
1983	131.5	119.6	95.7	108.3	104.1	81.2	70.6	73.8	78.3	87.0	86.4	112.1	1,149
1984	107.4	108.3	99.3	95.9	104.7	88.8	89.4	92.6	96.2	86.3	91.0	110.5	1,170
Average	112.4	111.2	101.4	101.2	95.4	81.8	88.5	81.8	82.5	78.0	78.5	101.9	1,115

Source : RID, PWD, 1985

Note : (1) Values in parenthesis are adjusted.

(2) Values from Jan. 1981 onward are obtained from A. Muang Chon Buri Station.

(3) Pan coefficient is assumed to be 0.70.

Table-3.6 MONTHLY RUN-OFF AT BANG PHRA DAM SITE

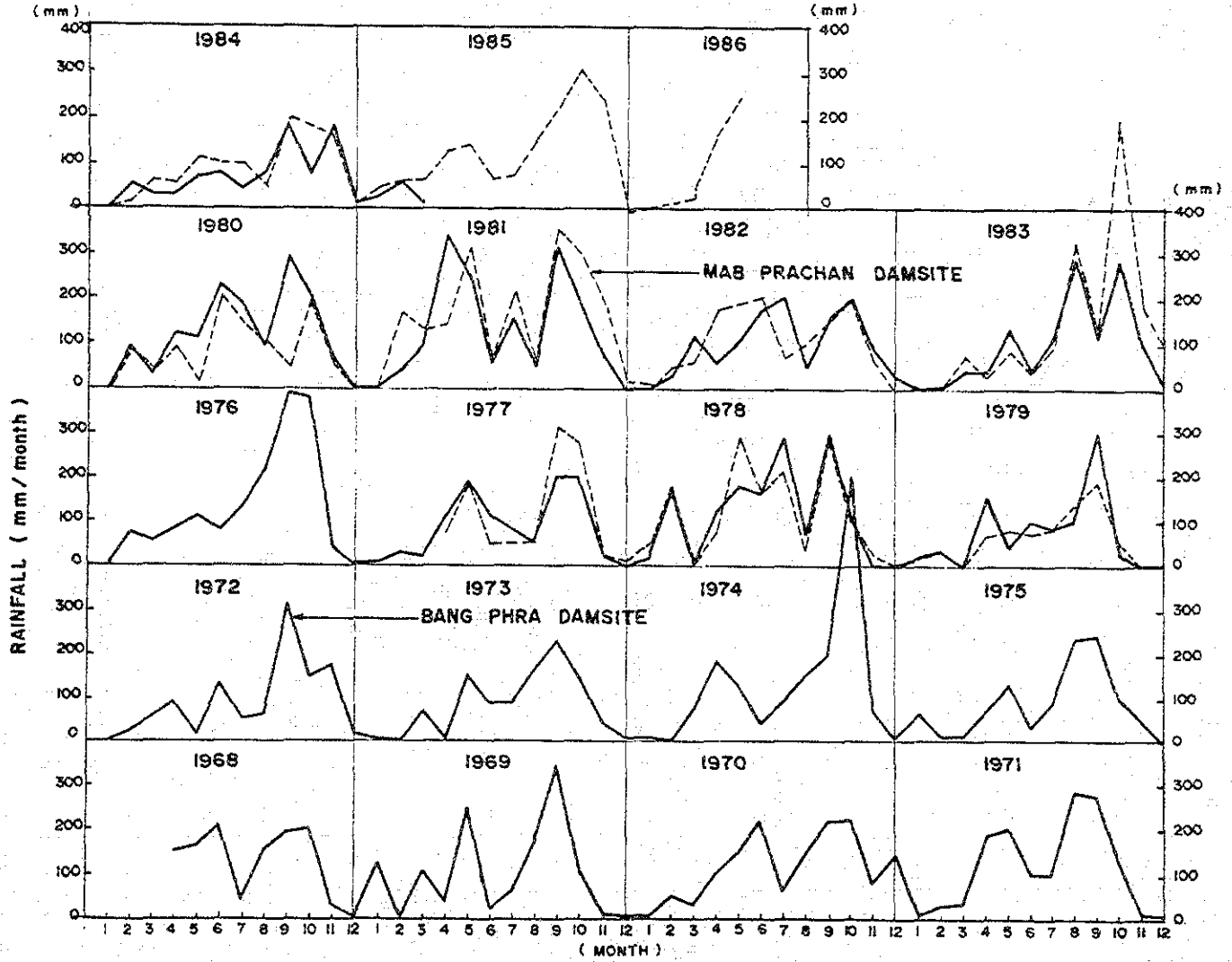
(unit : m^3/s)

Water Year	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Mean
1968	0.74	1.43	1.77	0.54	0.86	3.30	7.31	1.62	0.35	0.59	0.16	0.45	1.60
1969	0.40	0.96	1.52	0.22	1.49	12.26	5.25	1.38	0.21	0.20	0.23	0.16	2.02
1970	0.58	0.65	1.91	0.75	0.57	1.24	5.95	0.52	2.77	0.29	0.40	0.17	1.33
1971	0.99	1.96	2.38	0.99	3.74	11.57	9.16	1.57	0.34	0.05	0.26	0.15	2.76
1972	0.71	0.05	0.16	0.13	0.07	5.46	8.05	5.69	1.78	0.31	0.20	0.40	1.92
1973	0.09	0.45	0.42	0.22	1.32	3.01	5.50	0.54	0.18	0.14	0.15	0.27	1.03
1974	1.31	1.29	0.26	0.23	0.68	2.60	13.92	2.15	0.60	1.06	0.59	0.51	2.12
1975	0.96	0.48	0.10	0.41	1.04	3.60	2.83	1.99	0.38	0.20	0.51	0.26	1.06
1976	0.40	0.36	0.29	0.34	0.93	8.04	4.49	2.62	0.43	0.31	0.30	0.13	1.55
1977	0.56	0.33	0.45	0.23	0.28	0.40	1.35	0.17	0.08	0.03	0.84	0.14	0.40
1978	0.50	1.90	2.31	3.87	0.94	3.49	2.13	0.66	0.04	0.10	0.51	0.07	1.38
1979	0.42	0.21	0.87	0.53	0.70	1.46	0.76	0.19	0.02	0.04	0.14	0.10	0.45
1980	0.93	0.12	1.82	1.42	1.00	3.41	5.24	1.22	0.22	0.13	0.50	0.45	1.37
1981	3.56	2.92	0.98	0.94	0.75	3.98	2.00	1.78	0.46	0.27	0.09	0.43	1.51
1982	0.88	0.81	1.44	1.74	0.46	1.36	2.38	2.14	0.70	0.00	0.11	1.38	1.12
1983	0.14	0.61	0.23	1.21	5.13	5.91	13.32	8.74	2.15	1.42	0.75	0.29	3.33
1984	0.65	2.86	1.60	0.34	2.09	2.50	3.56	3.84	0.00	0.00	0.00	0.00	1.46
Average	0.81	1.02	1.09	0.83	1.30	4.33	5.48	2.17	0.63	0.30	0.34	0.32	1.55

River System : Huai Sukhrip DATA : RID, PWD, 1985

Catchment Area : 123 km^2

RAINFALL OF MAB PRACHAN AND BANG PHRA DAMSITES , 1968 - 1986



DATA , RID , 1986

FIGURE	RAINFALL OF MAB PRACHAN
3.6	AND BANG PHRA DAMSITES, 1968-1986
JAPAN INTERNATIONAL COOPERATION AGENCY	

Table-3.7 RAINFALLS OF MAB PRCAHN AND BANG PHRA DAM SITE

units : mm

YEAR		Apl	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	March	Total
1977	A	79.7	187.0	44.6	54.3	53.9	316.9	270.1	22.3	14.7	49.9	161.8	0.0	1,255.2
	B	105.0	190.9	110.8	80.3	57.6	203.5	200.3	26.4	0.0	15.8	171.7	0.0	1,162.3
1978	A	74.7	284.8	174.7	219.3	30.3	283.4	118.8	27.1	0.0	21.1	32.9	0.0	1,267.1
	B	128.4	188.3	164.9	290.8	61.9	315.8	118.4	0.0	0.0	0.0	0.0	0.0	1,268.5
1979	A	69.4	83.2	71.3	82.6	135.6	191.0	60.3	0.0	0.0	0.0	96.2	49.0	838.6
	B	169.2	44.4	104.7	90.1	100.8	308.9	37.0	0.0	0.0	0.0	102.3	39.1	996.5
1980	A	93.0	18.0	205.7	145.4	106.7	49.6	205.8	65.7	0.0	0.0	164.7	136.6	1,191.2
	B	129.8	112.4	238.1	191.6	99.5	295.4	202.4	53.7	0.0	9.4	40.5	102.7	1,475.5
1981	A	142.2	319.6	51.8	216.2	62.2	359.5	304.8	194.9	0.0	0.0	50.1	64.2	1,765.5
	B	341.4	252.3	64.4	157.2	57.9	316.5	193.9	75.0	0.0	0.0	31.8	121.7	1,612.1
1982	A	186.4	193.6	208.3	72.4	101.9	159.6	190.0	68.6	2.7	0.0	0.0	78.8	1,262.3
	B	63.4	115.2	184.9	201.3	51.5	156.4	215.1	93.6	38.0	0.0	0.0	49.4	1,168.8
1983	A	33.9	80.3	43.3	98.1	326.3	143.0	614.7	197.8	104.9	0.0	10.3	60.9	1,713.5
	B	43.7	133.6	46.3	125.2	333.7	125.4	295.7	111.4	11.1	0.0	57.9	31.5	1,315.5
1984	A	57.3	118.3	106.1	101.8	64.1	222.0	180.3	168.4	0.0	48.1	64.0	64.8	1,195.2
	B	33.3	77.4	83.9	47.2	87.4	186.9	87.4	186.9	0.0	28.3	65.2	16.9	900.8
Average	A	92.1	160.6	113.2	123.8	110.1	215.6	243.1	93.1	15.3	14.9	72.5	56.8	1,311.1
	B	126.8	139.3	124.8	148.0	106.3	238.6	168.8	68.4	6.1	6.7	58.7	45.2	1,237.5
Coefficient (A/B)		0.726	1.153	0.908	0.836	1.036	0.904	1.440	1.362	2.491	2.226	1.236	1.257	1.059

Note : A = Mab Prachan Damsite
B = Bang Phra Damsite

Table-3.8 MONTHLY RUN-OFF AT MAB PRACHAN DAMSITE

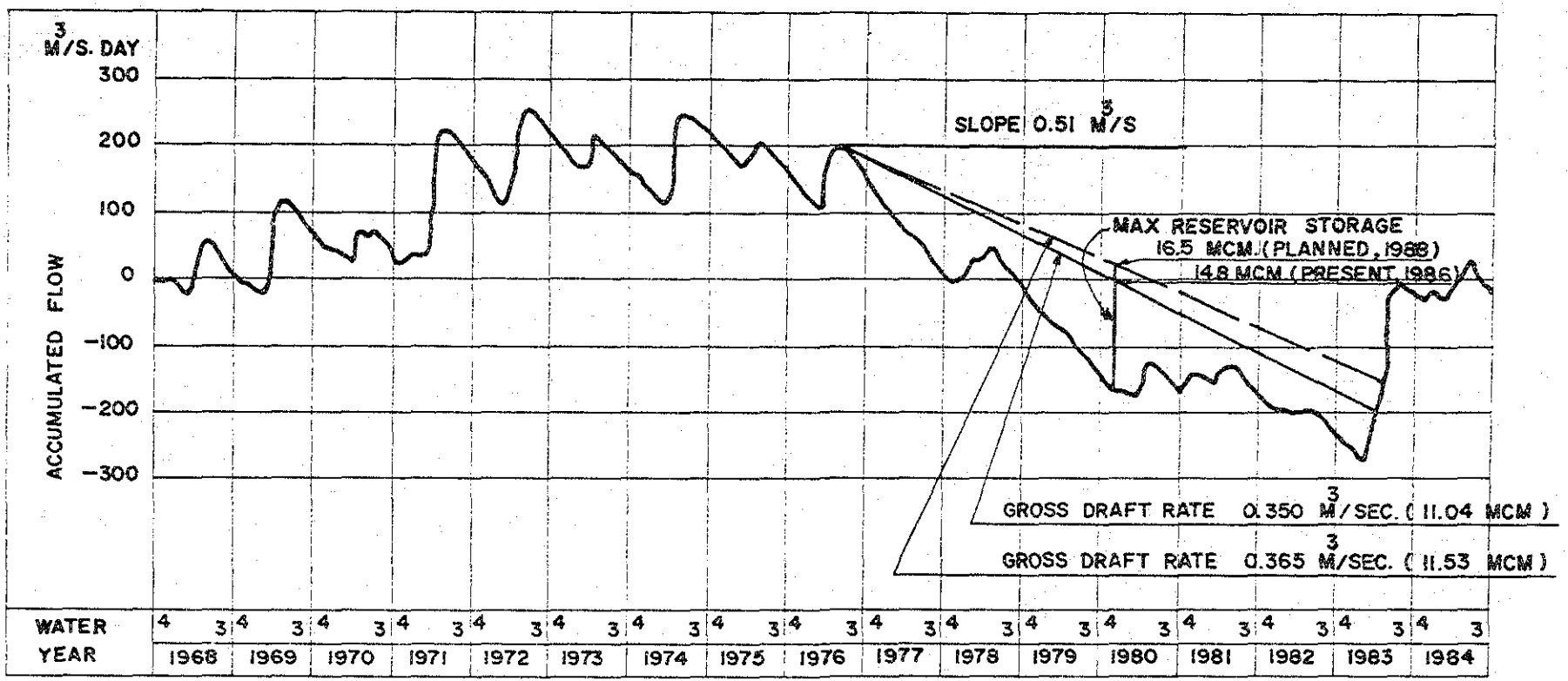
(unit: cu m/s)

Water Year	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Mean	Total(MCM)
1968	0.24	0.47	0.58	0.18	0.28	1.08	2.39	0.53	0.12	0.19	0.05	0.15	0.52	16.40
1969	0.13	0.32	0.50	0.07	0.49	4.01	1.72	0.46	0.06	0.06	0.07	0.05	0.66	20.81
1970	0.19	0.21	0.63	0.24	0.18	0.40	1.94	0.17	0.90	0.10	0.13	0.05	0.43	13.56
1971	0.32	0.64	0.77	0.33	1.22	3.78	2.99	0.51	0.11	0.01	0.08	0.05	0.90	28.38
1972	0.23	0.01	0.05	0.04	0.02	1.78	2.63	1.86	0.58	0.11	0.06	0.13	0.63	19.87
1973	0.03	0.15	0.14	0.07	0.43	0.99	1.80	0.18	0.05	0.04	0.05	0.08	0.33	10.41
1974	0.43	0.42	0.08	0.07	0.22	0.85	4.55	0.70	0.20	0.35	0.19	0.17	0.69	21.76
1975	0.31	0.16	0.03	0.14	0.34	1.18	0.92	0.65	0.13	0.06	0.17	0.08	0.35	11.04
1976	0.13	0.12	0.10	0.11	0.31	2.63	1.46	0.86	0.14	0.11	0.10	0.04	0.51	16.08
1977	0.18	0.11	0.15	0.07	0.10	0.13	0.45	0.05	0.02	0.01	0.28	0.04	0.13	4.10
1978	0.16	0.61	0.75	1.26	0.31	1.13	0.70	0.21	0.01	0.03	0.17	0.02	0.45	14.19
1979	0.14	0.06	0.29	0.17	0.22	0.48	0.24	0.06	0.01	0.01	0.04	0.03	0.15	4.73
1980	0.31	0.04	0.59	0.47	0.33	1.11	1.72	0.39	0.07	0.04	0.16	0.15	0.45	14.19
1981	1.17	0.95	0.32	0.31	0.24	1.30	0.66	0.58	0.15	0.08	0.03	0.14	0.49	15.45
1982	0.29	0.27	0.47	0.56	0.15	0.45	0.77	0.70	0.23	0	0.03	0.46	0.37	11.67
1983	0.04	0.20	0.07	0.39	1.67	1.93	4.35	2.85	0.70	0.47	0.24	0.10	1.08	34.06
1984	0.21	0.93	0.52	0.11	0.68	0.82	1.17	1.25	0	0	0	0	0.47	14.82
Mean	0.27	0.33	0.36	0.27	0.42	1.41	1.79	0.71	0.20	0.10	0.11	0.10	0.51	16.08

Catchment Area 37.9 sq Km

DATA: Based on Bang Phra Run-off Model (1968-1984),RID

MASS CURVE OF MAB PRACHAN RESERVOIR



DATA : BANG PHRA RUN OFF MODEL , 1968 – 1984 , RID
MODIFIED MAB PRACHAN RUN OFF MODEL , 1968 – 1984

FIGURE	MASS CURVE OF MAB PRACHAN RESERVOIR
3.7	
JAPAN INTERNATIONAL COOPERATION AGENCY	

As it was described and shown in Table-3.3 previously, the storage capacity is planned to be increased in 1989. Then, the reservoir's operating conditions will be changed, compared below:

	1986	1989
Max (Gross) Storage, MCM:	14.8	16.5
Gross Draft, MCM/year :	11.04	11.53
Reservoir Loss, MCM/year:	1.92	1.92
Net Draft, MCM/year :	9.12	9.61

The Maximum (gross) draft is shown in Fig-3.7. The reservoir loss includes leakage, seepage and evaporation. The net draft is calculated by deducting the reservoir loss from the gross draft. The planned storage increase is effective in that 0.49 MCM/year increase of the net draft.

The net draft cannot be allocated to the exclusive use of PWA, as private industries and river maintenance want their shares also.

The estimated demand is a constant 0.9 MCM/year for the industries and 0.9 MCM/year for the river maintenance.

When both demands, 1.8 MCM/year altogether, are deducted from the net draft, the PWA's share will be 7.32 MCM/year in 1986 and 7.81 MCM/year in 1989. If the river maintenance part is spared for the water supply use, it will be 8.22 and 8.71 MCM/year respectively in 1986 and 1989.

The 7.32 MCM/year will be able to manage the Pattaya's water demand in 1987, but after 1988, if similar conditions as in the 17 years' period happen, shortage of water in drought years will occur probably.

3.5.2 Groundwater Potential

Groundwater available in Pattaya area comes mainly from the Alluvial flood plain, small valleys and terrace deposit area. In the eastern part of the hilly area, there crops out the mass of granite and gneisses rocks which is the hydrogeological basement, except for eroded decomposed zones, cracks and faults zones. It results in the low productivity of aquifer in the area, as the existing wells data show.

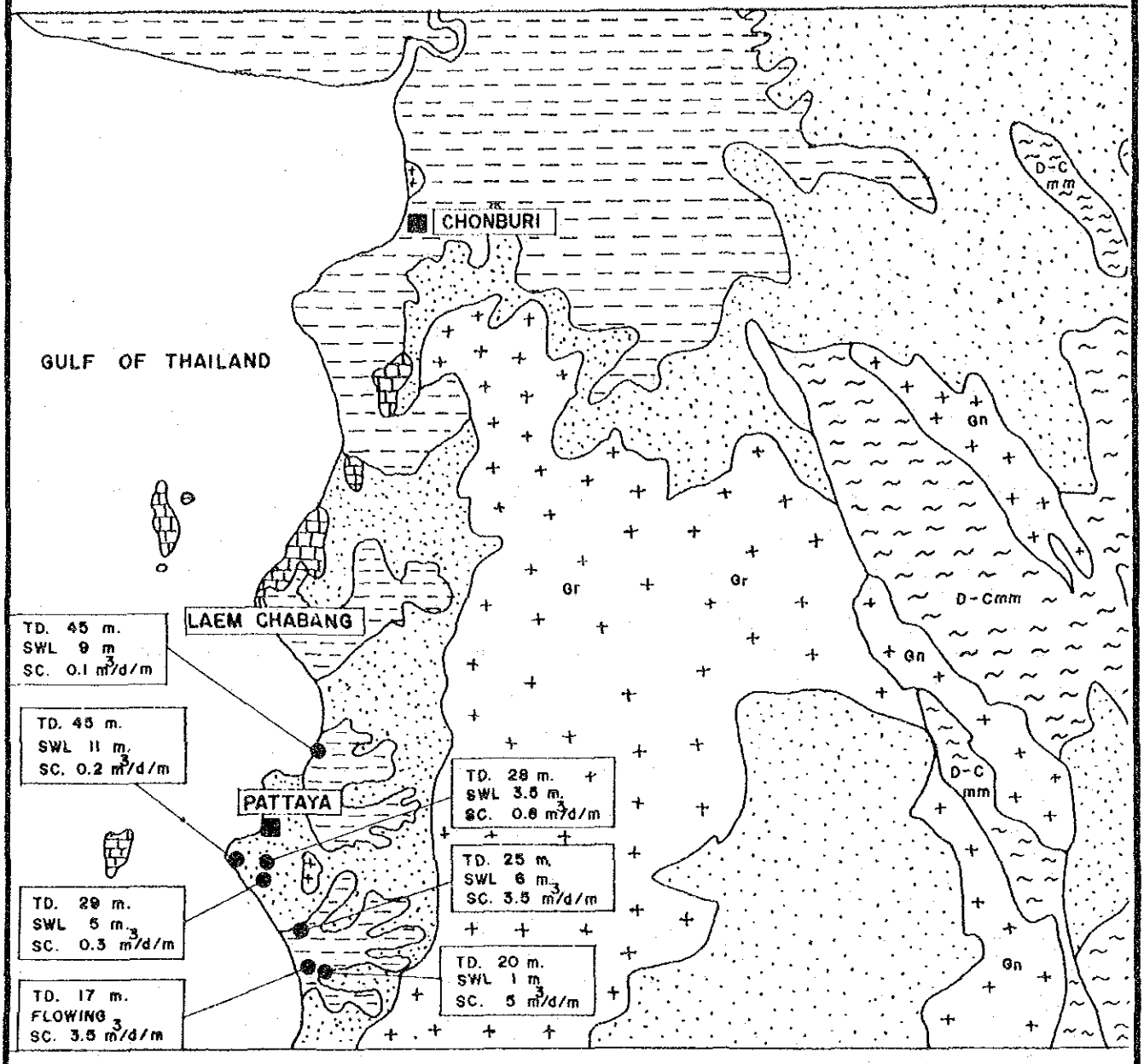
Fig-3.8 summarizes the hydrogeological conditions indicating groundwater availability in the area, based on the published map by DMR, 1973 - 1978 and 1983, and other relevant information.

Most of the deep wells are about 17 to 45 m deep and the static water level ranges from 1 to 11 m, despite some flowing wells. However, the specific capacity (Discharge (cu m/day)/Draw-down (m)) is quite low, ranging from 0.1 to 3.5 cu m/d/m. The locally confined aquifers consisting of silty sand, sandy clay and rare gravely sands have poor hydraulic characteristics, it is reported.

The potentiality of developing groundwater in the area is to be concluded from the facts that the aquifer is less productive, yielding only from 100 to 300 cu m/d per well and that the water contains salinity.

Because of the low productivity and high concentration of chloride, the groundwater is not recommendable for the use of the Pattaya waterworks' supply, even though the private sectors, large and small, are using.

HYDROGEOLOGICAL MAP OF PATTAYA



HYDROGEOLOGICAL POTENTIAL

0 10 20 30 Km.
SCALE

ALLUVIAL DEPOSITS (THICKNESS 50 – 100 m.)
100 – 300 m³/d/well (SOMETIMES BRAKISH WATER)

COLLUVIUM TALLUS , PIEDMONT DEPOSITS (THICKNESS 30 – 50 m)
100 m³/d/well

CARBONATE / LIMESTONE AQUIFER
100 – 300 m³/d/well

METAMORPHIC ROCKS (LESS POTENTIAL)

GRANITIC AND GNEISSC ROCKS (LESS POTENTIAL)

TD = TOTAL DEPTH
SWL = STASTIC WATER LEVEL
SC = SPECIFIC CAPACITY

DATA : DMR , 1978 , 1983

FIGURE	HYDROGEOLOGICAL MAP OF PATTAYA
3.8	

JAPAN INTERNATIONAL COOPERATION AGENCY