4. POPULATION AND WATER DEMAND

4.1 Project Horizon

The study area is delineated as to coincide with the town planning area of DTCP. The area consists of the Municipality and a neighboring area on the north in Tambon Pasemas of Amphoe Su Ngai Golok as in Table 4-1-1 where urban development continued from the Municipality is seen. The target year of the DTCP town plan is 2006 which is five years before the target year of the study. However it is thought to be unnecessary to delineate a larger area for the study, because at present the DTCP town planning area has a lot of unurbanized area in its peripheries and is considered to be large enough to meet the urban development by 2011.

Table 4-1-1 Area of the Study Area

(Unit : sq.km (%))

Study area (DTCP town planning area)	25.63 (100.0)
Municipality	22.50 (87.8)
Outside Municipality (Tambon Pasemas)	3.13 (12.2)

4.2 Population

4.2.1 Historical Population

The population of the study area was 30,350 in 1986 as shown in Table 4-2-1.

Population of the Municipality has grown steadily at an average growth rate of 3.8% in 1980's.

4.2.2 Future Population

Future population was firstly calculated with the following five mathematical formulae:

A) Arithmetical progression $y = aX + b$

B) Geometrical progression $y = y0 \times (1 + b)^X$

C) Decreasing rate of increase $y = K - ab^X$

D) Exponential $y = y0 + aX^b$

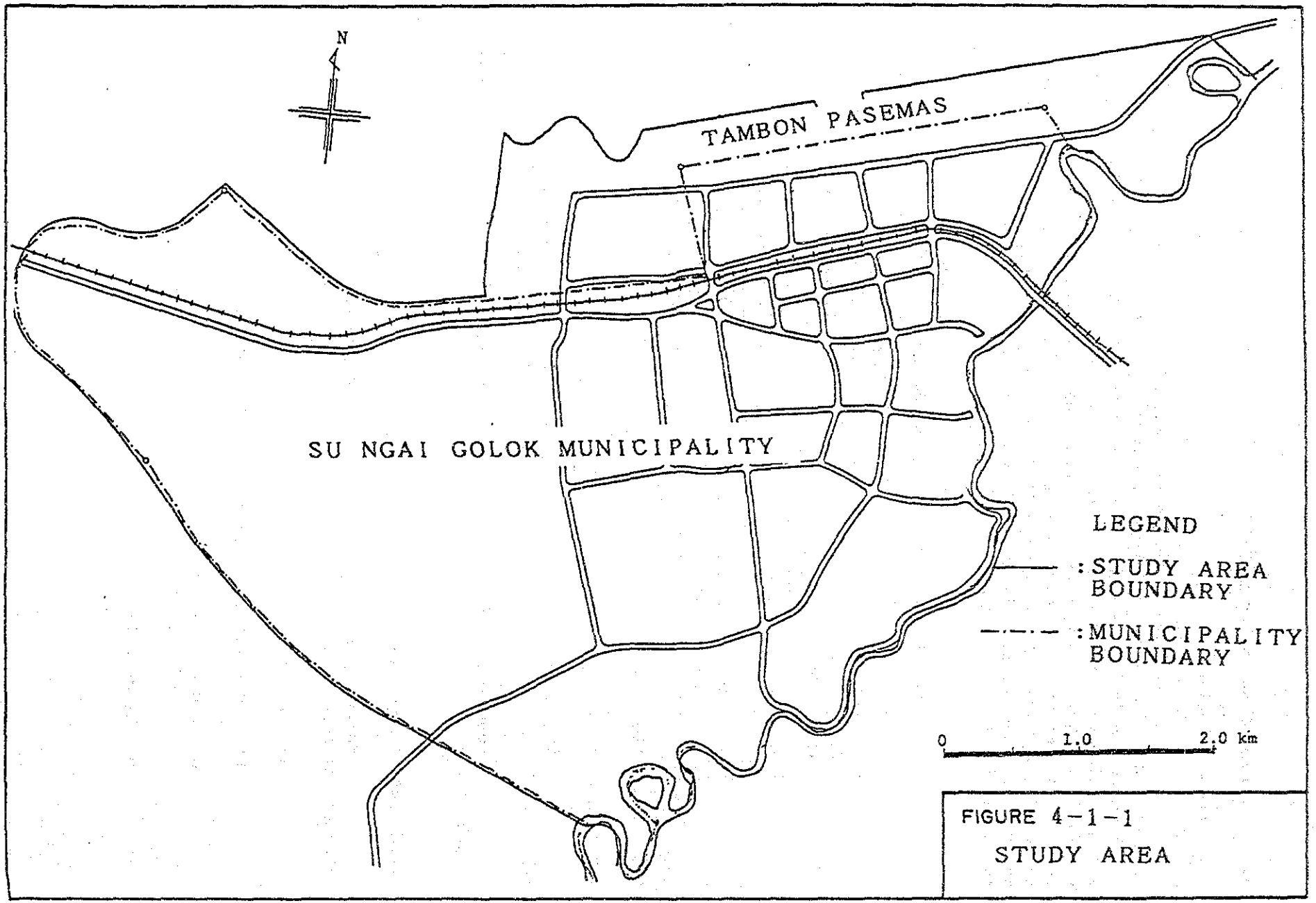


FIGURE 4-1-1
STUDY AREA

Table 4-2-1 Population Projection of Su Ngai Golok Study Area

Year	1980	1981	1982	1983	1984	1985	1986	1987	1991	1996	2001	2006	2011
Population of Su Ngai Golok Municipality													
Population	21,917	22,536	23,324	24,221	25,272	26,070	27,297	28,501	31,954	36,864	42,528	49,062	56,600
Natural Increase (%)		2.555	2.525	0.356	3.365	3.415	3.115	3.869					
Social Increase (%)		0.269	0.972	3.490	0.974	−0.257	1.592	0.542					
Growth Rate (%)		2.824	3.497	3.846	4.339	3.158	4.707	4.411					
Population of Su Ngai Golok Study Area (*)									34,258	39,522	45,594	52,599	60,681

Estimation of Population Distribution by Land Use Plan Zone

Zone		Area (sq.km)						
Zone 1	Low Density Residential Zone	5.77408	5,505	7,268	9,743	12,965	17,115	22,404
Zone 2	Medium Density Residential Zone	2.63808	11,737	12,660	13,865	15,073	16,257	17,385
Zone 3	High Density Resi./Commercial Zone	1.34208	11,089	12,258	13,757	15,327	16,940	18,566
Zone 4	Rural/Agricultural Zone	13.64552	1,734	1,790	1,875	1,950	2,012	2,057
Zone 5	Others	2.23024	283	280	280	279	275	269
Total		25.63	30,350	34,256	39,520	45,594	52,599	60,681

Note : (*) According to DTCP, study area's population was 30,350 and municipality's 28,309 in 1986.

E) Logistic $y = K / (1 + \exp(a - bX))$

Where,

y : Population forecasted

y0 : Population in the base year

X : Years from the base year

a, b, K : Coefficient

Aside from these mathematical models, the annual growth rate is also considered from the socioeconomic conditions of each target area. Therefore, mathematical models are used only for comparison.

In these years, the natural growth rate was higher than net in-migration rate. Considering that such rapid growth in recent years will not continue in the coming years till 2011, the growth rate is set at 2.9% which is 0.1% less than the growth rate set by DTCP.

Assuming the whole study area will grow at the same pace as the Municipality, the population of the study area is estimated at 60,700 in 2011.

Figure 4-2-1 shows the population projection of the Municipality for reference. In this figure, legends "A" to "E" correspond to the formulae and legend "T" shows the values adopted.

Presently the average family size is approximately six. According to the HOMES Research Report prepared in 1987 for the Seminar on Demographic and Economic Forecast for Thailand, the average household size of the nation in 2011 will be approximately 71% of the 1987 level. Following the decreasing trend, the average family size in 2011 is estimated at 4.1 and the number of families at 14,800 as in Table 4-2-2.

Due to the large share of houses for commercial use, the average population per house is less than the average family size. The number of houses is estimated at 18,700 in 2011.

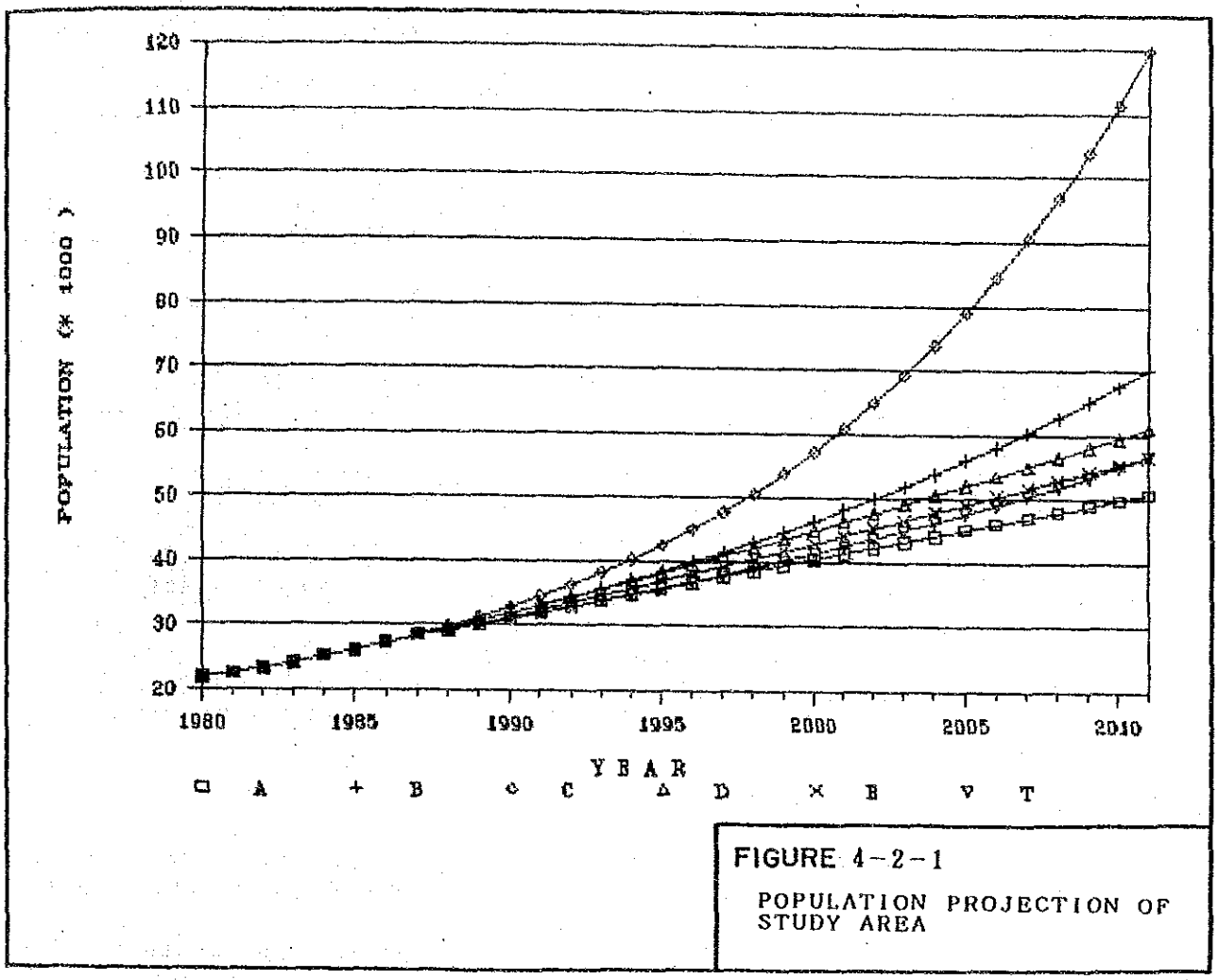


FIGURE 4-2-1

POPULATION PROJECTION OF STUDY AREA

Table 4-2-2 Number of Families and Houses

Municipality								
Year	1980	1981	1982	1983	1984	1985	1986	1987
Population	21917	22536	23324	24221	25272	26070	27297	28501
No. of Houses	4139	4433	4799	4173	5310	5551	5902	6261
House Size	5.30	5.08	4.86	5.80	4.76	4.70	4.63	4.55
Whole Nation								
Year		1985	1990	1995	2000	2005	2010	2015
Household Size		4.98	4.62	4.27	3.96	3.70	3.49	3.31
Year		1987	1991	1996	2001	2006	2011	
Household Size		4.84	4.55	4.21	3.91	3.66	3.45	
Index		1	0.94	0.87	0.81	0.76	0.71	
Su Ngai Golok								
Population		30556	34256	39520	45594	52599	60681	
Family Size		5.73	5.39	4.99	4.63	4.34	4.09	
No. of Families		5331	6353	7925	9844	12133	14824	
House Size		4.55	4.28	3.96	3.68	3.44	3.25	
No. of Houses		6712	7998	9977	12394	15275	18663	

4.2.3 Higher and Lower Growth Cases

In order to compare effects of the assumptions adopted in the method of estimation, higher and lower growth cases are shown in Table 4-2-3.

In the higher growth case, the annual population growth rate of the study area is 1% higher than the original case and in the lower growth case, the growth rate is 1% lower.

In the higher growth case, the population of the area is 30% more than the original case, while in the lower growth case, it is 20% less.

Table 4-2-3 Population Projection in Higher and Lower Growth Case

Year	1986	1991	1996	2001	2006	2011
Population	30350	34256	39520	45594	52599	60681
Higher Growth Case	30350	36748	44495	53876	65233	78986
Lower Growth Case	30350	33345	36635	40251	44222	48586

4.2.4 Population Distribution

The area can be roughly zoned into two halves: the northeastern half where most people reside including the central commercial district and the southwestern half consisting mostly of forests.

Future population is thought to be distributed reflecting the land use plan of DTCP, growing from the existing pattern.

Population distribution by the land use category expected in 2011 is shown in Table 4-2-1.

The population density of the town planning area is estimated to grow from the present level of 11.8 persons/ha (1.9 persons/rai) to 23.7 persons/ha (3.8 persons/rai). Residential zones will considerably increase the population density. The density of the low density residential zones designated by the land use plan is estimated at approximately 39 persons/ha (6 persons/rai) in 2011, that of the medium density residential zones at approximately 66 persons/ha (11 persons/rai), and that of the high density residential/commercial zones at approximately 140 persons/ha (22 persons/rai). The population density of the rural/agricultural zones will remain low.

4.3 Service Area and Served Population

4.3.1 Service Area

The present service area of the Su Ngai Golok Waterworks consists of the Municipality of Su Ngai Golok and the area behind the railway station where some governmental offices are located.

For the expansion of the services area in the future, taken into account are the DTCP's development plan and the PWA's development strategy. Consideration is made with future land use, population growth and tourism prospect.

The area was classified into three categories according to the DTCP's plan: (1) the high density area, (2) the medium density area, and (3) the low density area. The population and service ratio are predicted by this classification.

The extent of the service area in years 2001 and 2011 are as shown in Figure 4-3-1.

4.3.2 Served Population

(1) Past and Present Served Population

Past and present served population was estimated from the number of connections and the number of members per household. Prior to this, the number of connections for domestic use is calculated from the number of connections in the past, and the ratio of the connections for domestic use against the total connections. As the ratio of residential users is 0.913 (see Table 4-4-3), this ratio is applied to each year's number of connections to calculate the number of connections for domestic use.

Table 4-3-1 shows the result of estimation of served population in each year.

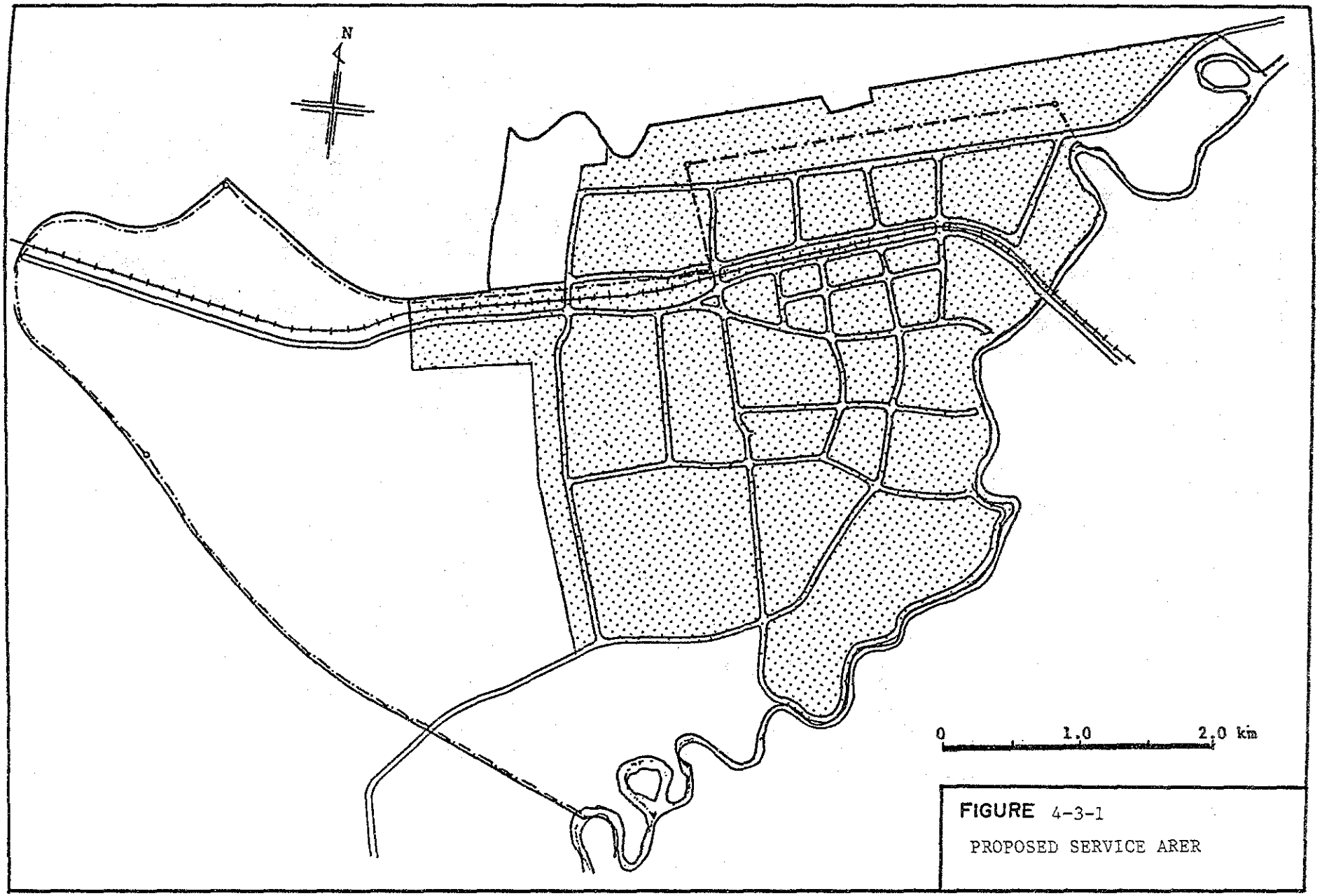


FIGURE 4-3-1

PROPOSED SERVICE ARER

Table 4-3-1 Estimation of Served Population

Year	No. of Conn. (a)	No. of Conn. for Domestic Use (b)	Pop./ No. of Houses (c)	Pop. Served (d)
1980	1,531	1,427	5.30	7,563
1981	1,595	1,487	5.08	7,554
1982	1,712	1,596	4.96	7,916
1983	1,926	1,795	5.81	10,429
1984	2,072	1,931	4.76	9,192
1985	2,253	2,100	4.70	9,870
1986	2,366	2,205	4.59	10,121
1987	2,550	2,377	4.55	10,815

(b) = (a) x 0.932
(c) from Table 4-2-2

(2) Service Ratio

Service ratio is given as shown in Table 4-3-2

Table 4-3-2 Estimation of Service Ratio

Year	Pop. in Service Area	Pop. Served	Service Ratio (%)
1980	21,917	7,563	34.51
1981	22,536	7,554	33.52
1982	23,324	7,916	33.94
1983	24,221	10,429	43.06
1984	25,272	9,192	36.37
1985	26,070	9,870	37.86
1986	27,297	10,121	37.08
1987	28,501	10,815	37.95

(3) Future Service Ratio Forecasting

The future service ratio by area are scheduled considering the present service ratio, development strategy for water supply and land use plan, and are summarized as shown in Table 4-3-3.

Table 4-3-3 Future Service Ratio

(Unit : %)

Year	High Density Area	Medium Density Area	Low Density Area
1991	70	20	-
1996	75	33	15
2001	80	45	25
2006	85	58	40
2011	90	70	50

(4) Future Served Population

Future served populations are calculated by area using the future service ratios and projected population therein as shown in Table 4-3-4.

Table 4-3-4 Future Served Population

Year	Population in Service Area				Average Service Ratio (%)
	High Dens. Area	Med. Dens. Area	Low Dens. Area	Total	
1991	8,581 (12,258)	2,532 (12,660)	0 (7,268)	11,113 (32,186)	34.5
1996	10,318 (13,757)	4,575 (13,865)	1,461 (9,743)	16,354 (37,365)	43.8
2001	12,262 (15,327)	6,783 (15,073)	3,241 (12,965)	22,286 43,365)	51.4
2006	14,399 (16,940)	9,429 (16,257)	6,846 (17,115)	30,674 (50,312)	61.0
2011	16,709 (18,566)	12,170 (17,385)	11,202 (22,404)	40,081 (58,355)	68.7

Upper : Served population in the service area
Lower : Total population in the service area

(5) Prediction of Number of Tourists

In predicting the number of tourists, a similar mathematical method was employed as applied in the population projection. The result of the prediction by four formulae are shown in Figure 4-3-2 as well as the past record.

Considering the recent year's stagnant tendency, the arithmetic (A) and geometrical (B) progressions showing too high growth seem to be unrealistic. The exponential curve (D) seems also unrealistic since it show that the number of tourists in the future would decrease.

From these analysis, the logistic curve (E) was eventually taken for the prediction because of its characteristic of the stable but not too high growth. This trend may suit the condition of the tourism in Su Ngai Golok that the most of tourists are coming from Malaysia depending on the economical situation in Malaysia, and that its number may be rather stable compared to the other tourism spots such as Pattaya or Phuket.

From the prediction of the number of tourists based on the logistic formula and their average length of stay, characteristics of tourists are concluded as shown in Table 4-3-5.

Table 4-3-5 Number of Tourists

Year	Annual Tourist Number (pers.) (a)	Average Length of Stay (days) (b)	Annual Total Stay (man-day) (c)	Average Daily Tourists (pers./d) (d)
1982	149,815	1.59	238,206	653
1983	250,399	1.27	318,007	871
1984	273,576	1.59	434,986	1,188
1985	227,465	1.47	334,374	916
1986	238,917	1.34	320,149	877
1991	305,400	1.4	427,560	1,171
1996	330,500	1.4	462,700	1,268
2001	341,800	1.4	478,520	1,311
2006	346,600	1.4	485,240	1,329
2011	348,600	1.4	488,040	1,337

(c) = (a) x (b)
(d) = (c) / 365

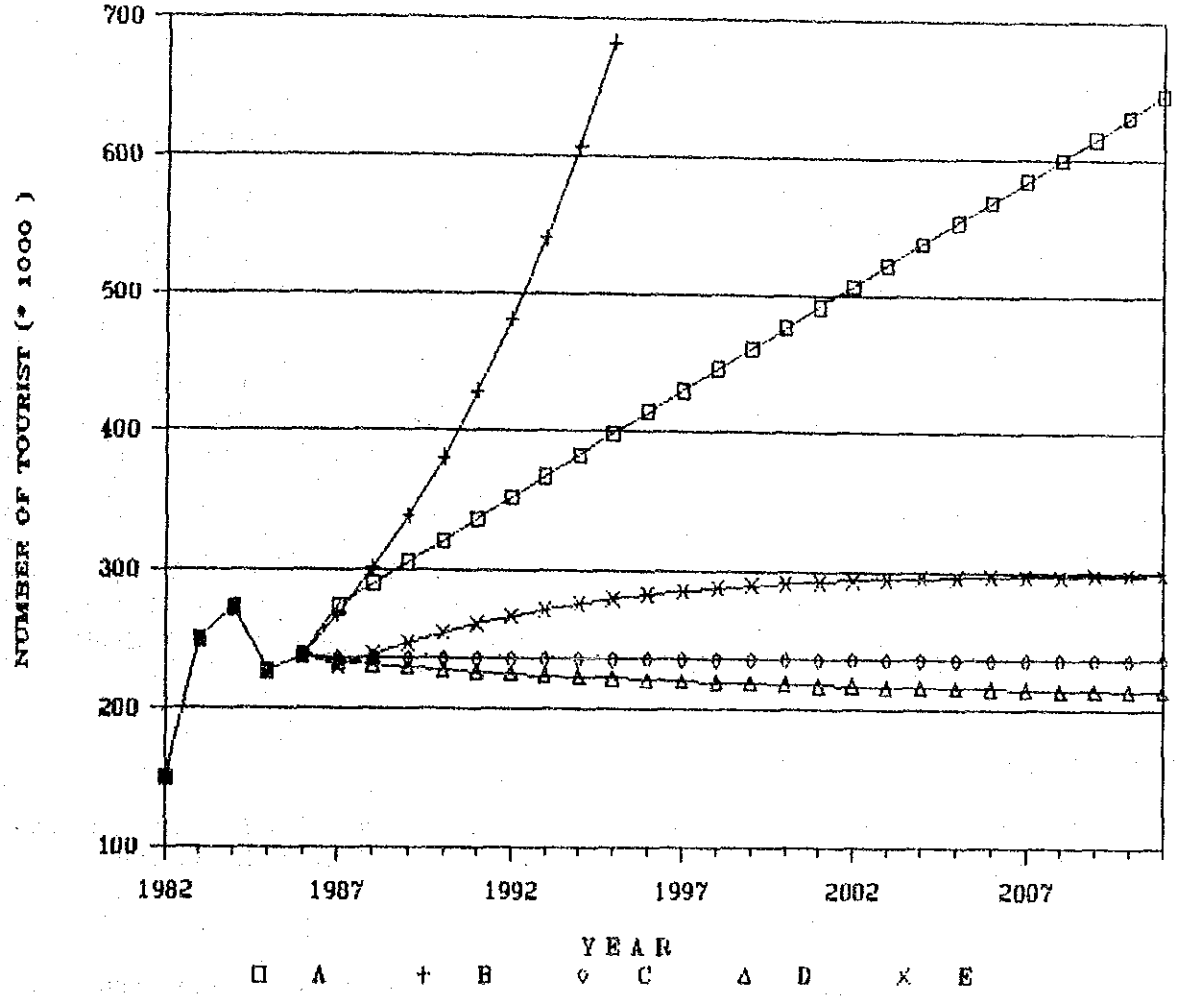


FIGURE 4-3-2

NUMBER OF TOURISTS IN FUTURE

4.4 WATER DEMAND

4.4.1 Historical Water Consumption

(1) Water Production and Sales

The annual water production and sales from 1980 to 1987 are shown in Table 4-4-1 and Figure 4-4-1.

Table 4-4-1 Annual Water Production and Sales

Year	Water Production (cu.m/y)	Water Sales (cu.m/y)	No. of Conn.	Consump. per Conn. (cu.m/d)
1980	928,880	730,376	1,531	1.303
1981	1,076,460	807,851	1,595	1.427
1982	1,123,816	833,094	1,712	1.371
1983	1,357,506	951,165	1,926	1.391
1984	1,613,456	1,071,329	2,072	1.413
1985	1,527,501	1,081,895	2,253	1.353
1986	1,374,478	1,158,101	2,366	1.379
1987	1,461,269	1,266,207	2,550	1.399

(2) Classification of Consumption

PWA Survey Reports from 1985 to 1987 show the consumption by categorized major consumer as listed in Table 4-4-2. Table 4-4-3 shows the average share of each group after being regrouped into six groups for convenience of estimating future water demand.

4.4.2 Future Water Consumption

The six categories of consumption iisted in Table 4-4-3 are forecasted separately for the future, as they are different in nature.

(1) Domestic Water Consumption

Table 4-4-3 shows that the average domestic water consumption is accounted to be 48.8% of the total consumption. Assuming that this ratio has been constant from 1980 to 1987, the domestic water consumption is calculated as shown in Table 4-4-4.

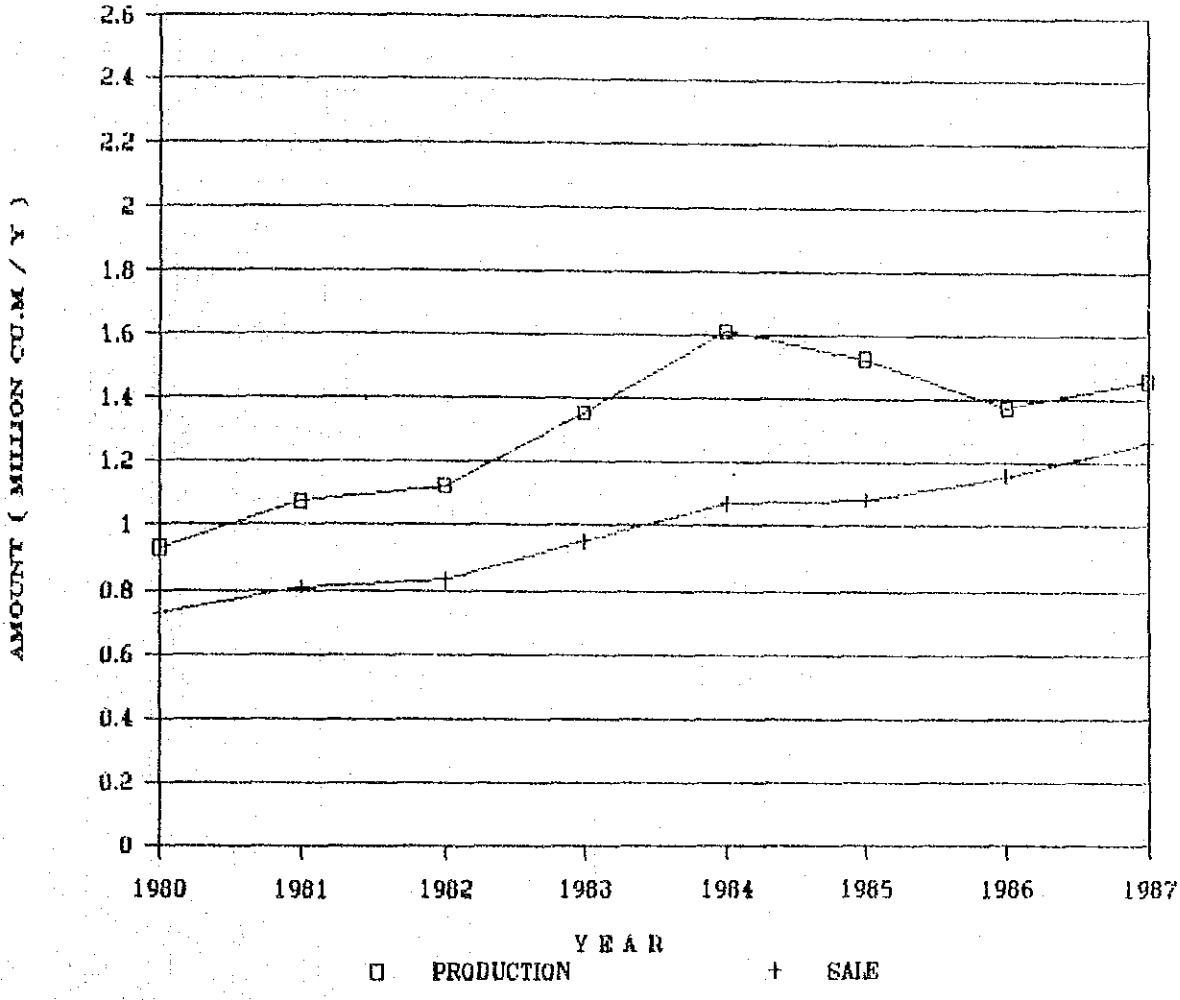


FIGURE 4-4-1

WATER PRODUCTION/SALE
SU NGAI GOLOK

Table 4-4-2 Major Consumers by Category

Code	Category	1985		1986		1987		Total		Average		Share	
		No. of Conn.	Consump.	No. of Conn.	Consump.	No. of Conn.	Consump.	No. of Conn.	Consump.	No. of Conn.	Consump.	No. of Conn.	Consump.
1	Residential	49	3291	46	2731	46	3191	141	9213	47	3071	1.91	3.16
2	Residential(Rental)	28	4348	32	4650	32	4743	92	13741	30.7	4580	1.25	4.71
3	Commercial	34	2390	32	1825	32	1920	98	6135	32.7	2045	1.33	2.1
4	Restaurant	9	1468	7	1172	7	1209	23	3849	7.7	1283	0.31	1.32
5	Government Agency	14	5208	14	5315	14	5734	42	16257	14	5419	0.57	5.57
6	School	10	1710	10	1781	10	1637	30	5128	10	1709	0.41	1.76
7	Temple	3	216	1	69	1	64	5	349	1.7	116	0.07	0.12
8	Bangalow	0	0	0	0	0	0	0	0	0	0	0	0
9	Industrial	6	675	5	629	5	900	16	2204	5.3	735	0.22	0.76
10	Hotel	44	22801	48	26890	48	30021	140	79712	46.7	26571	1.9	27.32
11	Hospital	2	4110	2	5069	1	6202	5	15381	1.7	5127	0.07	5.27
12	Service	0	0	0	0	0	0	0	0	0	0	0	0
13	Others	17	3312	16	1481	17	1815	50	6608	16.7	2203	0.68	2.27
	Sub-total	216	49529	213	51612	213	57436	642	158577	214	52859	8.71	54.36
	Percentage	9.39	53.39	8.79	55.2	8.04	54.46	8.71	54.36				
14	Other than Major Consumer	2085	43242	2210	41887	2437	48030	6732	133159	2244	44386	91.29	45.64
	Sub-total	2085	43242	2210	41887	2437	48030	6732	133159	2244	44386	91.29	45.64
	Percentage	90.61	46.61	91.21	44.8	91.96	45.54	91.29	45.64				
	Total	2301	92771	2423	93499	2650	105466	7374	291736	2458	97245		
	Percentage	100	100	100	100	100	100	100	100			100	100

Table 4-4-3 Water Consumption by Category (after Re-grouping)

Code	Category	1985		1986		1987		Total		Average		Share	
		No. of Conn.	Consump.	No. of Conn.	Consump.	No. of Conn.	Consump.	No. of Conn.	Consump.	No. of Conn.	Consump.	No. of Conn.	Consump.
	Domestic												
1	Residential	49	3291	46	2731	46	3191	141	9213	47	3071	1.91	3.16
14	Other than Major Consumer	2085	43242	2210	41887	2437	48030	6732	133159	2244	44386	91.29	45.64
	Sub-total	2134	46533	2256	44618	2483	51221	6873	142372	2291	47457	93.21	48.8
	Institutional												
5	Government Agency	14	5208	14	5315	14	5734	42	16257	14	5419	0.57	5.57
6	School	10	1710	10	1781	10	1637	30	5128	10	1709	0.41	1.76
7	Temple	3	216	1	69	1	64	5	349	1.7	116	0.07	0.12
11	Hospital	2	4110	2	5069	1	6202	5	15381	1.7	5127	0.07	5.27
	Sub-total	29	11244	27	12234	26	13637	82	37115	27.3	12372	1.11	12.72
	Commercial												
3	Commercial	34	2390	32	1825	32	1920	98	6135	32.7	2045	1.33	2.1
4	Restaurant	9	1468	7	1172	7	1209	23	3849	7.7	1283	0.31	1.32
	Sub-total	43	3858	39	2997	39	3129	121	9984	40.3	3328	1.64	3.42
	Hotel												
8	Bangalow	0	0	0	0	0	0	0	0	0	0	0	0
10	Hotel	44	22801	48	26890	48	30021	140	79712	46.7	26571	1.9	27.32
	Sub-total	44	22801	48	26890	48	30021	140	79712	46.7	26571	1.9	27.32
	Industrial												
9	Industrial	6	675	5	629	5	900	16	2204	5.3	735	0.22	0.76
	Sub-total	6	675	5	629	5	900	16	2204	5.3	735	0.22	0.76
	Others												
2	Residential(Rental)	28	4348	32	4650	32	4743	92	13741	30.7	4580	1.25	4.71
12	Service	0	0	0	0	0	0	0	0	0	0	0	0
13	Others	17	3312	16	1481	17	1815	50	6608	16.7	2203	0.68	2.27
	Sub-total	45	7660	48	6131	49	6558	142	20349	47.3	6783	1.93	6.98
	Total	2301	92771	2423	93499	2650	105466	7374	291736	2458	97245	100.01	100

Table 4-4-4 Domestic Water Consumption

Year	Water Sales			Pop. Served	Per Capita Consump.
	Total (cu.m/y) (a)	Total (cu.m/d) (b)	Domestic (cu.m/d) (c)	(d)	(e)
1980	730,376	1,996	974	7,563	129
1981	807,851	2,213	1,080	7,554	143
1982	833,094	2,282	1,114	7,916	141
1983	951,165	2,606	1,272	10,429	122
1984	1,071,329	2,927	1,428	9,192	155
1985	1,081,895	2,964	1,446	9,870	147
1986	1,158,101	3,173	1,548	10,121	153
1987	1,266,207	3,469	1,693	10,815	157

(c) = (b) x 0.488

The estimated per capita consumption for 1991 is 170 lpcd in the high density area. Considering the socioeconomic feature of Su Ngai Golok and living standard, an arithmetical progression curve which comes up to 210 lpcd in 2011 is selected.

For the medium and low density areas the per capita consumption in 2011 is assumed to be 140 lpcd and 100 lpcd, respectively.

Table 4-4-5 summarizes the unit water consumption for domestic use in the future.

Table 4-4-5 Future Unit Water Consumption

(Unit : lpcd)

Year	High Density Area	Medium Density Area	Low Density Area
1991	170	115	-
1996	180	121	85
2001	190	128	90
2006	200	134	95
2011	210	140	100

Table 4-4-6 shows the domestic water consumption in every five years to 2011.

Table 4-4-6 Future Domestic Water Consumption

(Unit : cu.m/d)

Year	High Density Area	Medium Density Area	Low Density Area	Total
1991	1,459	291	-	1,750
1996	1,857	554	124	2,535
2001	2,330	868	292	3,490
2006	2,880	1,263	650	4,793
2011	3,509	1,704	1,120	6,333

(2) Governmental/Institutional Water Consumption

The governmental/institutional water consumption includes the consumption of such institutions as governmental offices, hospitals, schools and temples.

Water consumption of each institution is predicted separately as they are different in nature.

(a) Governmental Office

It is assumed that the activities of governmental facilities correlate the population in the service area where these facilities are governing. For example, the staff of the police department will be increased as the population grows up.

Considering this concept, future water consumption of the governmental facilities is predicted from the ratio to the population in the service area of each year. Present data gives the following figures for the water consumption of governmental offices.

Average consumption of governmental office (1985-87)

$Q = 5,419$ cu.m/mo

Total population in the service area (1987)

$p = 28,501$

Average daily consumption of governmental office expressed by per population is:

$q = Q/p = 5,419 / 30 / 28,501 = 6.3$ lpcd

For future unit consumption for governmental use, 6 lpcd is adopted.

(b) School

Prediction of water consumption of school is made by assuming the number of students from the proportion of that against the total population. Record shows that this ratio is about 6.7. The per student consumption calculated from the present data is applied to the future prediction. The per student consumption is given as below:

Average consumption of school (1985-87)

$Q = 1,709$ cu.m/mo

Number of students (1987)

n = 4,554

Average daily consumption of school expressed by per school is:

q = Q/n = 1,709 / 30 / 4,554 = 12.5 lpcd

Considering this value, future unit consumption is set to be 20 lpcd, constantly through years.

(c) Hospital

Most of hospitals in the study area are equipped with their own water sources, mainly deep wells, as well as treatment facilities. This fact makes it difficult to identify the unit consumption and the actual total consumption of hospitals.

In Su Ngai Golok, counted in major consumers in the category of hospital is only one in 1987, which shows a big amount of consumption (6,202 cu.m/mo or 207 cu.m/d). This figure is rather high compared to the other categories of big consumers.

Regarding the statistical data of the number of beds against population, the "Population and Health" report of TDRI shows the following historical data with predictions in 1991 and 2006.

Table 4-4-7 Ratio of Population to Hospital Bed

(Unit : pop./bed)

Year	Whole Kingdom	MBA	Provincial Area
1980	805.85	341.48	955.66
1981	801.35	361.22	952.75
1982	793.46	365.63	934.51
1983	761	376	888
1984	749	354	879
1985	748	336	882
1986	744	354	862
1991			(700)
2006			(600)

The ratio of population to bed in the whole province was 842.89 in 1985, while there is 215 beds in Su Ngai Golok for an amphoe population of 46,042 in 1986, which is equivalent to 214.14 pop./bed rather lower than a national target of 600 pop./bed in 2006. Su Ngai Golok is in good medical condition and no additional bed is expected until 2011.

A unit water consumption per bed is assumed at 1.5 cu.m/d/bed through years.

(d) Summary of Governmental/Institutional Consumption

The total of governmental/institutional consumption are summarized as shown in Table 4-4-8.

Table 4-4-8 Summary of Governmental Consumption

Year	1985-1987	1991	1996	2001	2006	2011
1. Government						
o per pop. consump. (lpcd)	6.3	6	6	6	6	6
o pop. in service area	28,501	32,186	37,365	43,365	50,312	58,355
o consump. (cu.m/d)	181	193	224	260	302	350
2. School						
o per student consump. (lpcd)	12.5	20	20	20	20	20
o no. of students	4,554	4,804	5,577	6,472	7,509	8,710
o consump. (cu.m/d)	49	96	112	129	150	174
3. Hospital						
o per bed consump. (cu.m/d/bed)	6.9*	1.5	1.5	1.5	1.5	1.5
o no. of beds	30	215	215	215	215	215
o consump. (cu.m/d)	207*	323	323	323	323	323
Total consumption (cu.m/d)	437	612	659	712	775	847

*1987 data

(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 number of tourists.

In Su Ngai Golok, most hotels are served by the municipal water supply system. Water consumption of hotels in the past is calculated from the past consumption data as shown below.

	1985	1986
Average No. of Tourists (pers./d) (from Table 4-3-5)	916	877
Consump. (cu.m/mo) (from Table 4-4-3)	22,801	26,890
Per Capita Consump. (lpcd)	830	1,022

These figures are higher than the past record of Pattaya (622 lpcd in 1982) and the planned per capita consumption of Chiang Mai (700 lpcd in 1987 Report). However, 850 lpcd is adopted fixed until 2011 in this study considering:

- that some hotels were found using ground water for gardening, washing and laundry to supplement tap water, therefore actual consumption may be higher than recorded;$and
- that hotels in Pattaya are now suffering from water shortage.

The total consumption by tourists is, therefore calculated from the number of tourists and per capita consumption as shown below:

Table 4-4-9 Tourist Consumption

Year	No. of Tourist (pers./d)	Per Capita Consump. (lpcd)	Total Consump. (cu.m/d)
1991	1,171	850	995
1996	1,268	850	1,078
2001	1,311	850	1,114
2006	1,329	850	1,130
2011	1,337	850	1,136

(4) Commercial Water Consumption

Commercial water consumption is defined to be the consumption by private businesses such as shops, restaurants, bars and markets. Consumption derived from the commercial activities in Su Ngai Golok is regarded to be closely related to the tourism activities since businesses in Su Ngai Golok are mostly relying on the tourism.

From the 1985-1987 data, ratios in annual water consumption for tourism (hotel) and commercial uses were 27.32% and 3.42%, respectively, in other word the commercial consumption is 13% of the tourism one. It is assumed that this ratio will be stable in the future.

Table 4-4-10 Commercial Consumption

(Unit : cu.m/d)

Year	Tourism (a)	Commercial (b)
1991	995	129
1996	1,078	140
2001	1,114	145
2006	1,130	147
2011	1,136	148

(b) = (a) x 0.13

(5) Industrial Water Consumption

Presently, industrial water consumption is 1.2% to the total of domestic and governmental/institutional consumptions. The nature of the economic activity of the town is considered to be nearly same as the present situation although the Municipality has a long-term industrial development program. Type of industries will therefore be assumed to be non-water use type (i.e., wooden, rubber, etc.).

Industrial water consumption in the future is determined from the fixed proportion of 1.2% against the total of domestic and institutional consumptions.

(6) Others

Category of water consumption included in the item of "Others" has shares of 1.9% in the number of connections and 7.0% in the amount of consumption. This category includes water consumption for rental houses, entertainment and others.

As well as the industrial consumption, it is assumed that this category's consumption relates to the total of domestic and governmental/institutional consumptions. Therefore, the average ratio of "others" to the above consumption from 1985 to 1987 which was 11.3% is applied for future consumption prediction.

Table 4-4-11 Industrial and Other Consumption

(Unit : cu.m/d)

Year	Domestic & Institutional (a)	Industrial (b)	Other (c)
1991	2,362	28	267
1996	3,194	38	361
2001	4,202	50	475
2006	5,568	67	629
2011	7,180	86	811

(b) = (a) x 0.012
(c) = (a) x 0.113

(8) Unaccounted-for Water Ratio

Unaccounted-for water ratio of the Su Ngai Golok Waterworks shows rather low value from 1980 to 1987 except for 1983 to 1985 as shown in Table 4-4-12.

This ratio is supposed to be maintained low by implementing the daily maintenance works such as replacement of old pipes, leakage detection and replacement of water meters with more sensitive and anti-reverse rotation type.

Table 4-4-12 Unaccounted-for Water Ratio

Year	Water Production (cu.m/y)	Water Sales (cu.m/y)	Unaccounted-for Water Ratio (%)
1980	928,880	730,376	21.37
1981	1,076,460	307,851	24.95
1982	1,123,816	833,094	25.87
1983	1,357,506	951,165	29.93
1984	1,613,456	1,071,329	33.60
1985	1,527,501	1,081,895	29.17
1986	1,374,478	1,158,101	15.74
1987	1,461,269	1,266,207	13.35

Considering the past record, the future ratio is set at 13% constant through years.

4.4.3 Future Water Demand

(1) Peak Factor

The data from January 1987 to December 1988 was studied. The results of analysis on the peak factor are summarized in Table 4-4-13.

Table 4-4-13 Summary of Peak Factor

Item	1987			1988		
	Demand (cu.m/d)	Factor	Date	Demand (cu.m/d)	Factor	Date
Daily Max.	5,181	1.320	Dec. 31	5,274	1.299	Apr. 21
Monthly Max.	4,183	1.066	Nov.	4,335	1.068	Apr.
Daily Ave.	3,924	1		4,060	1	
Monthly Max.	3,435	0.875	Jan.	4,834	0.944	Jan.
Daily Min.	430	0.110	Dec. 29	2,925	0.720	Feb. 2

The status of water supply is stable throughout the year. A value of 1.30 is adopted for the peak factor.

(2) Future Water Demand

Future water demand is calculated from the water consumption, unaccounted-for water ratio and peak factor.

Table 4-4-14 shows the daily average and maximum water demands.

Table 4-4-14 Future Water Demand

(Unit : cu.m/d)

Category	1987	1991	1996	2001	2006	2011
Domestic	1,652	1,750	2,535	3,490	4,793	6,333
Gov't/Inst'l	447	612	659	712	775	847
Tourism	98	995	1078	1,114	1,130	1,136
Commercial	128	129	140	145	147	148
Industrial	27	28	38	50	67	86
Others	248	267	361	475	629	811
Sub-Total	**3,489**	**3,781**	**4,811**	**5,986**	**7,541**	**9,361**
Unaccounted-for Water Ratio (%)	13	13	13	13	13	13
Unaccounted-for Water	521	565	719	894	1,127	1,399
Daily Average	**4,010**	**4,346**	**5,530**	**6,880**	**8,668**	**10,760**
Peak Factor		1.30	1.30	1.30	1.30	1.30
Daily Maximum		**5,650**	**7,189**	**8,944**	**11,268**	**13,988**

5. DESIGN CRITERIA

5.1 Intake

Intake Capacity = 110 percent of the daily maximum demand

5.2 Treatment and Pipe Design

Design criteria for the design of the treatment system and pipeline was established on the basis of the various design standards having been employed in Thailand or other countries, and with consideration on the conditions of the project site and raw water quality to be taken from Su Ngai River.

The design criteria is summarized in the followings:

(1) Water Loss

Intake Loss : 10 %

Treatment Loss : 8 % of production capacity for filter washing and in-plant use.

(2) Pipeline

Formula for Flow Rate Calculation :

Hazen-William's Formula, C = 110

C-value for pipes are usually defined as 130 for new pipes. For planning purpose, 110 is adopted considering miscellaneous loss in line at valves, bends etc.

Velocity : Maximum 3.0 m/s

Minimum 0.3 m/s

Pipe Material: Material should be decided considering pressure, soil condition, pipe profile, etc. However, material is generally selected in accordance with the principle below:

Steel Pipe:for diameter 400 mm or larger

A/C Pipe: for diameter 300 mm or smaller

(3) Treatment Plant Facilities

a. Receiving Well

Retention Time	:	1.5 min

b. Mixing Tank

Type of mixing	:	Hydraulic
Mixing time (min)	:	1 - 5
Intensity, G (1/sec)	:	500 - 1,000

c. Flocculation

Type of mixing	:	Hydraulic
Stage	:	3 or more
Intensity, G (1/sec)	:	10 - 75
Flocculation time (min)	:	20 - 40

d. Sedimentation Basin

Type of sedimentation	:	by Gravity
Type of basin	:	Rectangular Horizontal flow
Flow velocity (cm/min)	:	less than 40
Retention time (hour)	:	3 - 5
Effective depth (m)	:	3 - 4
Length/Width ratio	:	3 - 8
Sludge removal	:	by manual

e. Filter

Type of filtration	:	Rapid sand filtration Gravity down flow
Surface loading (m/d)	:	120 - 150
Filter media		
type	:	Single media
depth (cm)	:	60 - 70
effective size (mm)	:	0.45 - 0.70
Underdrain		
gravel layer	:	100- 150 mm x 4 layers
underdrain type	:	Bored pipe
Surface washing		
type	:	fixed nozzle
jet pressure(kg/cm2)	:	1.5 - 2.0
washing time (min)	:	4 - 6
rate (m3/m2/min)	:	0.2
Backwashing		
rate (m3/m2/min)	:	0.6 or larger
washing time (min)	:	5 - 10

f. Clear Water Reservoir

Retention time (hour)	:	8.0
Depth (m)	:	3 - 6

g. Chemical feeding

Alum		
coagulant	:	Solid aluminum sulfate
mixing	:	Batch mixing
dosage rate	:	5 - 10
Lime (as necessarily)		
objective	:	pH control for coagulation
chemical type	:	Slaked lime (Ca(OH)2)

h. Chlorination

Chemical type	:	Chlorine gas

Minimum storage	:	1 month
Type of injector	:	Vacuum type injector
Dosage rate (ppm)	:	2.0

i. Instrumentation

General concept

Centralized operation not to be introduced;

Operation to be manual control

Flows to be measured	:	Raw and treated water
Levels to be measured	:	Clear water reservoir
Weights to be measured	:	Chlorine gas cylinder
Head to be measured	:	Filter loss

(4) Distribution Facilities

a. Service pressure

Minimum pressure (kg/cm2): 1.0 (for hourly maximum flow)

6. BASIS OF COST ESTIMATES

6.1 Construction Cost

(1) General

Construction cost of facilities to be built is calculated with prices in 1989 on the basis of the various unit costs.

The construction cost is calculated by different items in the manner as described below:

a. Pipelines : by linear meter for
- o Transmission pipes
- o Distribution pipes

b. Water Treatment Plant : by facilities for
- o Receiving well
- o Sedimentation basin
- o Sand filter
- o Clear water reservoir
- o Elevated tank
- o Pumping house
- o Chemical house
- o Mechanical works
- o Electrical works
- o Miscellaneous

These costs are separated in Foreign and Local Cost portion with the percentage by item as shown below:

Work Item	Foreign Currency	Local Currency
Pipeline	(%)	(%)
A/C pipes	30	70
Steel pipes	80	20
Structural/Architectural	30	70
Mechanical Works	80	20
Electrical Works	80	20
Land Acquisition	0	100

(2) Pipeline Construction

Pipelines are firstly separated into two major groups: (i) transmission pipeline for either raw water or clear water, but not for distribution, and (ii) distribution pipeline.

Unit costs for construction of transmission pipeline are calculated by linear meter, consisting of the material, $transportation (two cases as more than 800 km, or smaller) and installation costs. Cost for fittings are assumed as 10 and 15 percent of pipe material cost for asbestos cement and steel pipes, respectively. These ratios are set smaller compared to that of the distribution pipes because of the simplicity in the pipeline components.

Unit costs of distribution pipeline are calculated in the same manner as that for the transmission pipeline. The ratios for fittings are set as 25 and 35 percent of the pipe material cost for asbestos cement and steel pipes, respectively.

(3) Treatment Plant

Cost for the treatment plant is calculated by the unit cost by facility of plant component of various capacity which has been used by PWA for planning purpose. Each cost is updated to meet the increased construction cost in 1989.

Unit costs for facilities, which are not included in the PWA's unit cost list, are calculated assuming the unit costs for the major items as follows:

- o Concrete works by concrete volume, including related works as reinforcement (assuming 100 kg/cu m of concrete), forming, scaffolding, supporting.
- o Earth works by soil volume for excavation and fill
- o Architectural works by unit area of building
- o Concrete piles by each pile, including material, transportation and driving cost

(4) Mechanical Works

Costs for the plant facilities included in the mechanical works are calculated on the basis of the number of unit of each equipment such as pump, flocculator, sludge remover, or chemical and chlorination dosage equipment. Additional percentage is assumed for the miscellaneous items as pipings and fittings.

(5) Electrical Works

Cost for the electrical works substantially varies depending on the instrumentation system. The records in$the construction of the advanced water supply system shows it would share as much as 40 percent of the total construction cost if the sophisticated computer control system is employed. Employing the more simple system could reduce this cost much.

The system to be recommended in this study should be the simple one as described in the Design Criteria so that the cost for the system could be lowered. It is practical and common way to assume that the cost of the electrical works closely related to the cost of the mechanical works. In this study, the cost is therefore, calculated by percentage of the mechanical works.

(6) Land Cost

The unit land cost is assumed to be 1,000,000 Baht per Rai (1,600 sq m).

The details of the unit cost are shown in the Appendix A-6-1.

6.2 Operation and Maintenance Cost

(1) General

Operation and maintenance cost is calculated on the basis of the price and rate in 1989, and consists of the following factors:

- o Energy Cost
- o Chemical Cost
- o Manning Cost
- o Repair Cost
- o Replacement

This cost is calculated in local currency only.

(2) Energy Cost

It is practical that the energy for the operation will be provided in the form of the electricity by Provincial Electricity Authority (PEA).

The Energy cost is calculated separately for the demand charge and energy charge with the PEA rate in 1989 which are:

Demand Charge : Baht 229 /KW/month

Energy Charge : Baht 1.23 /KWH

(3) Chemical Cost

Unit chemical costs are as follows:

Alum : Baht 3.9 /kg

Lime : Baht 1.25 /kg

Chlorine Gas : Baht 15.6 /kg (excluding gas container)

(4) Manning Cost

The unit manning costs of each year are calculated from the average manning cost in 1987, which is Baht 7,322 per person per month. The annual increment of the monthly salary is set to be 5 percent.

(5) Repair Cost

Repair cost should be counted for repairing and maintaining the plant equipment. This cost is calculated as 0.3 percent of the construction cost of the mechanical and electrical works.

(6) Replacement

Each facility to be constructed should have a certain life time. The span for the life time is varying depending on its nature of the facility. The followings are the life time of the facilities to be taken in this study and concept for replacement:

Item	Life time span	To be replaced after life time
Pipeline		
A/C pipes	20 years	50 percent
Steel Pipes	30	50
Concrete Structures		
Treatment Plant	50	100
Reservoir	50	100
Mechanical Equipment	20	100
Electrical System	20	50

(7) Cost of the Head and Regional Office

Cost of the PWA's head office and the regional office are allocated and added, in the financial study in Chapter 17, to the direct operation costs above. The allocation is determined assuming the future increment of their costs in each office, detailes of which is explained in Chapter 17.

Part 2
DEVELOPMENT PLAN

Part 2 DEVELOPMENT PLAN

7. CONSIDERATION FOR DEVELOPMENT PLAN

Construction of a new raw water intake and the expansion of the existing treatment plant capacity are the two main subjects in consideration for the development plan.

A new raw water intake is proposed to improve the present unfavorable condition in quality of raw water which is caused by domestic wastewater being discharged upstream of raw water intake. Therefore, it is reasonable to take raw water of better quality at the other point at more upstream.

PWA has prepared a detailed design of the new raw water intake pumping station and the raw water transmission pipeline. The site of the intake is located at approximately 7 km south of the municipality. The capacity of the intake facility should be taken into consideration to verify whether it would conform with the planned water demand.

The treatment plant capacity should be increased to produce the planned amount of water demand in 2011. Expansion of facilities is required although the improvement plan is prepared by PWA in the same manner as implemented at the Thung Song Waterworks in 1987. The expansion of the treatment plant is recommended to be made at the land near the new intake which was purchased by PWA.

Expansion of the distribution network will be planned according to the planned extent of the future service area. Improvement in the existing network is also discussed.

8. DEFINITION AND EVALUATION OF ALTERNATIVES

8.1 Water Source

8.1.1 General

The water demand in 2011 will be 0.18 cu.m/s at intake level, while the minimum series flow in once in ten years is estimated at 2.5 cu.m/s. This intake amount of water will not interfere with the downstream water rights. However, it is recommended that coordination with the authorities concerned will be necessary because the Golok River is an international river and water demand for other purposes will be increased in the future.

PWA has an improvement plan to construct a new pump station at about 7 km upstream of the existing intake, where raw water is less contaminated.

8.1.2 Construction of Pumping Station

(1) Design Criteria

(a) Pump Capacity

The daily maximum water demand in the year 2011 is 13,988 cu.m/d and the intake amount is accordingly 15,400 cu.m/d adding the 10% loss. As studied in the following section, the two treatment plants will be operated at the proposed raw water intake and the existing plant. The raw water will be conveyed to these two plants by the separate pipelines. The raw water pumps will, therefore be installed separately for these two lines.

The existing treatment plant will have a maximum treatment capacity of 5,760 cu m/day after it is modified. The new treatment plant will be designed with a maximum treatment capacity of 9,400 cu m/day to meet a water demand in 2011. The raw water pumps are designed for these plant as follows:

(i) for the existing treatment plant

Pump capacity	:	2.0 cu m/min
Pump Head	:	55.0 m
Diameter	:	200 mm
Motor output	:	30 kw
No. of unit	:	3 units (including 1 stand-by)

(ii) for new treatment plant

Pump capacity	:	3.3 cu m/min
Pump Head	:	20.0 m
Diameter	:	200 mm
Motor output	:	20 kw
No. of unit	:	3 units (including 1 stand-by)

(b) Water Level

Water level is gauged at Rantau Panjang about 4 km downstream of the

proposed intake point. The cross section of the river is considered to be the same as Rantau Panjang.

Low Water Level

The height of the low water in the return period of 1/10 (Q = 2.5 cu m/s) will be 0.5 m above the river bed as shown in Figure 8-1-1. Namely,

93.996 + 0.5 = 94.496 m

High Water Level

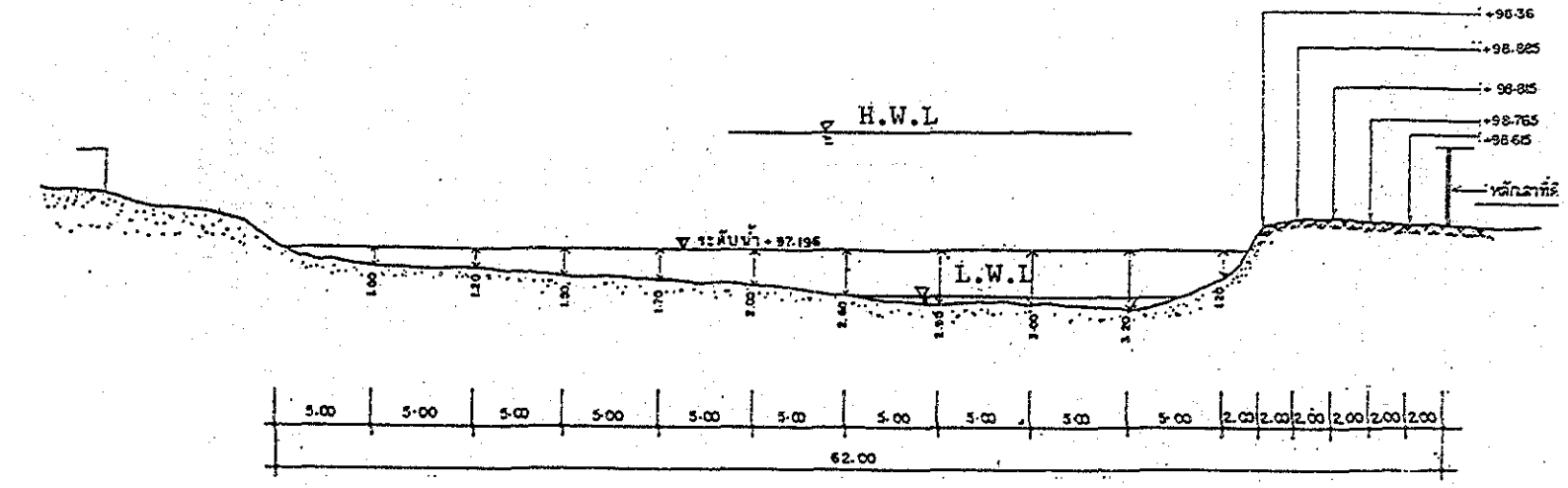
As shown in Table 8-1-1, the flood discharge in the return period of 1/10 will be 840 cu.m/s. The height of the high water in the return period of 1/10 will be 8.2 m above the river bed as shown in Figure A6-3-1. Namely,

93.996 + 8.2 = 102.196 m

The top of the pumping station wall is 103.50 m in elevation. Therefore, the wall is safe enough for the flood appearing once in ten years. In addition, the flood over 98.90 m in elevation has much larger flow area so that the flood water level will not reach as high as 102.196 m in elevation

Table 8-1-1 Annual Maximum Series of Instantaneous Peak Discharge at Rantau Panjang (Unit cu.m/s)

Water Year	Observed	Observed plus Estimated
1963/64	241	241
1964/65	181	181
1965/66	377	476
1966/67	580	1,176
1967/68	326	326
1968/69	215	215
1969/70	405	494
1971/72	292	292
1972/73	402	583
1973/74	337	337
1974/75	-	-
1975/76	-	-
1976/77	-	-
1977/78	230	230
1978/79	339	339
1979/80	370	370
1980/81	332	332
1981/81	498	512
1982/83	515	538



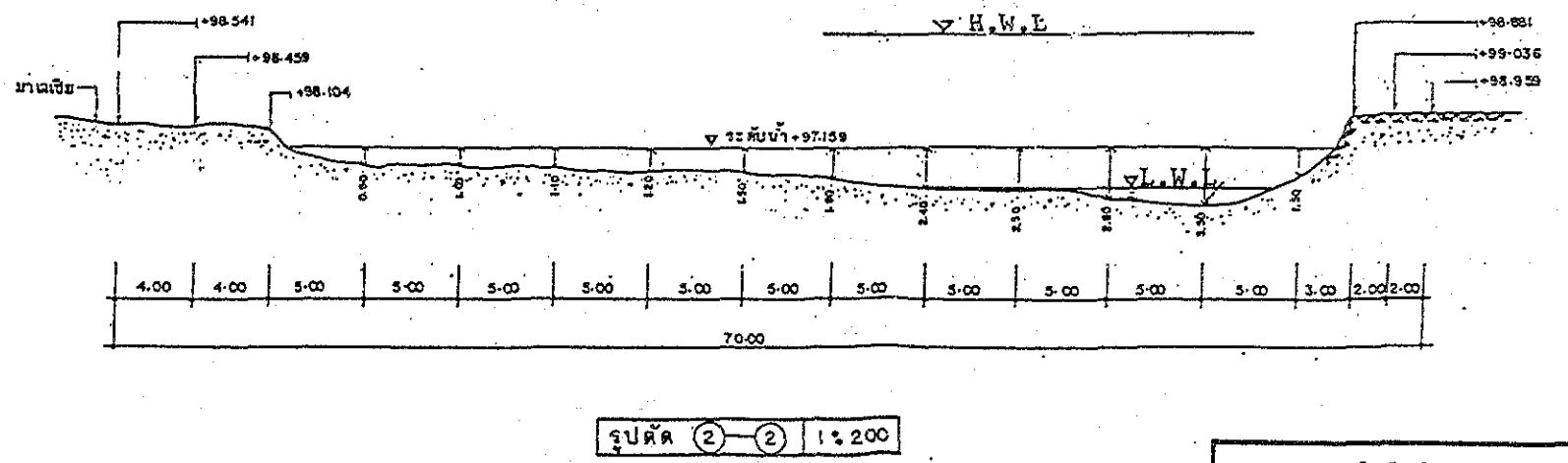


FIGURE 8-1-1

Cross Section of the Golok River

Of these distributions, the Gumbel (extreme type 1) distribution was found to give the best fit (as evidenced by the chi-sqyared test) in a majority of the distribution fitted and has been selected as the basis for both comparative and design purposes.

The fitted Gumbel distributions are shown in Figure 8-1-2.

However, there are records during the 1983 flooding that although the peak river flow at the bridge at Rantau Panjang was 520 cu.m/d, the total catchment discharge at this point was considerably in excess of this, the catchment model giving a peak discharge of 790 cu.m/s, which ties in with the estimated overspill of 300 cu.m/s (GRBS 1984).

Table 8-1-2 Frequency Analysis of instantaneous Peak Discharge at Rantau Panjang

(Unit : cu.m/s)

	Discharge for Return Period (Years)						
A) Observed Series (Mean Annual Flood 356 cu.m/s)							
Log Normal	343	449	517	663	724	926	1,139
Log. Person III	348	450	511	629	674	812	935
Gumbel (Log)	326	461	580	960	1,187	2,400	4,843
Arith. Normal	359	453	502	589	619	704	776
Gumbel	342	462	542	717	791	1,035	1,279
Ven Te Chow	343	458	535	703	774	1,009	1,243
B) Observed plus Estimated Series (Mean Annual Flood 433 cu.m/s)							
Log. Normal	387	577	711	1,026	1,167	1,678	2,274
Log. Person III	372	567	725	1,158	1,385	2,351	3,798
Gumbel (Log)	360	600	840	1,767	2,419	6,826	19,226
Arith. Normal	433	634	738	922	987	1,168	1,320
Gumbel	399	654	822	1,194	1,351	1,871	2,389
Ven Te Chow	401	637	793	1,136	1,282	1,761	2,240

8-1-3 Comparative Study

Two intake methods are considered: (i) Case 1 (Figure 8-1-3), in which pumps are installed on the lower place inside the concrete structure, and (ii) Case 2 (Figure 8-1-4), in which pumps are installed at the higher place on the floor above the flood water level. The both methods aim at preventing the pump from being damaged by the flooding. The features of both methods are tabulated in Table 8-1-3.

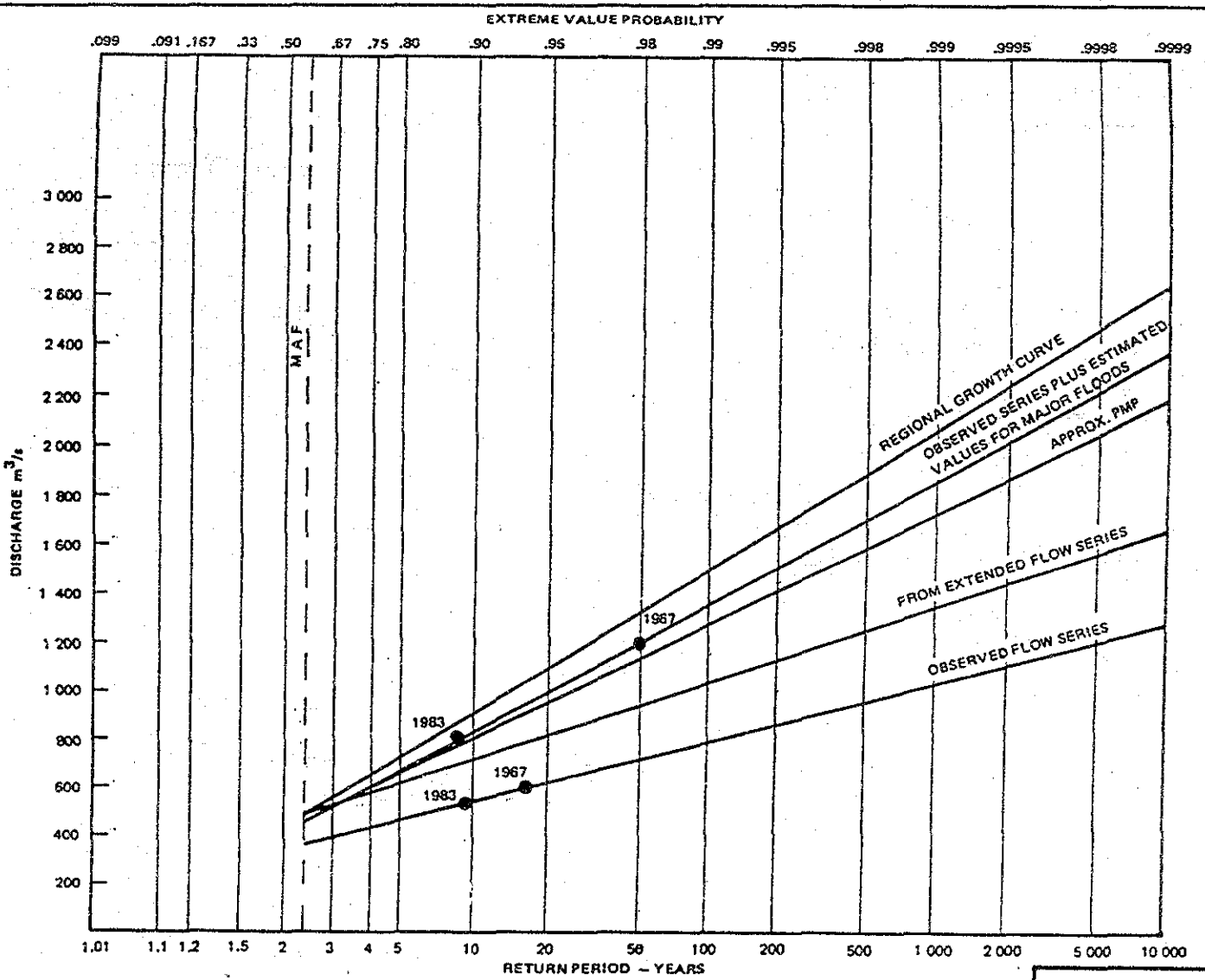
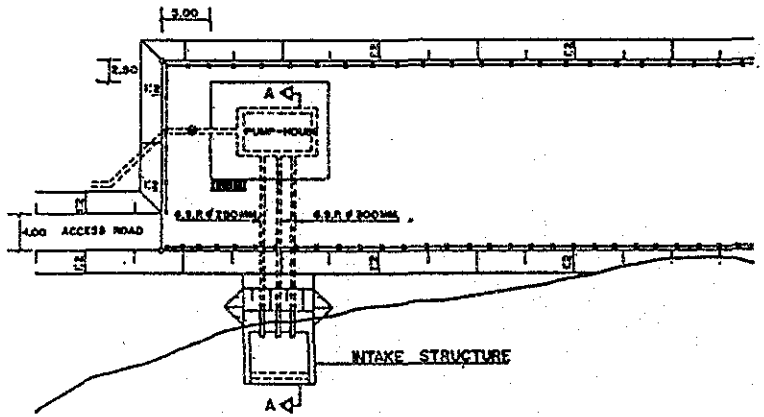


FIGURE 8-1-2
Frequency Curve for Instantaneous Maximum Discharge



PLAN OF PUMP STATION
(CASE 1)

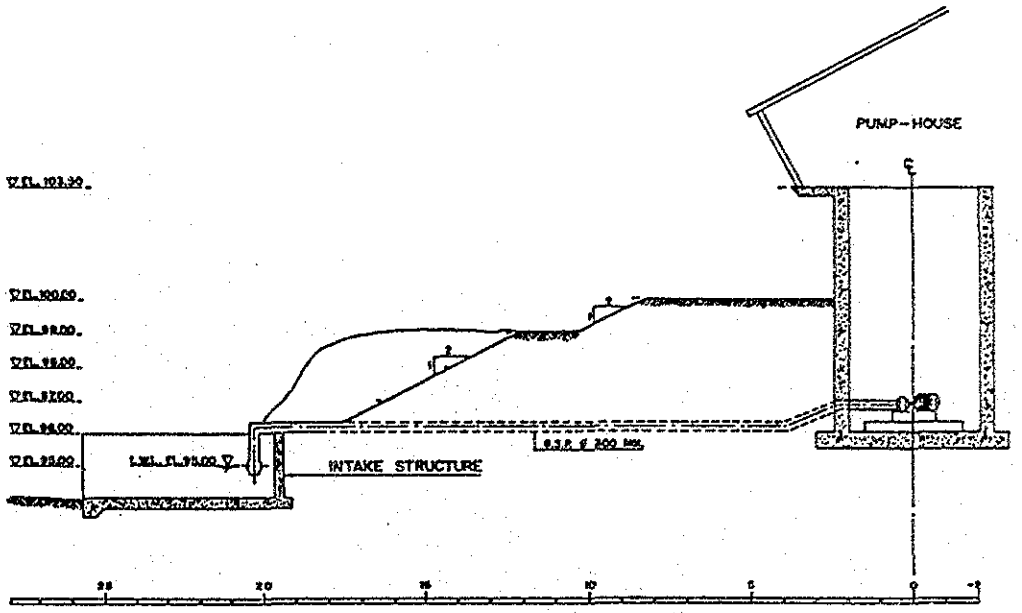


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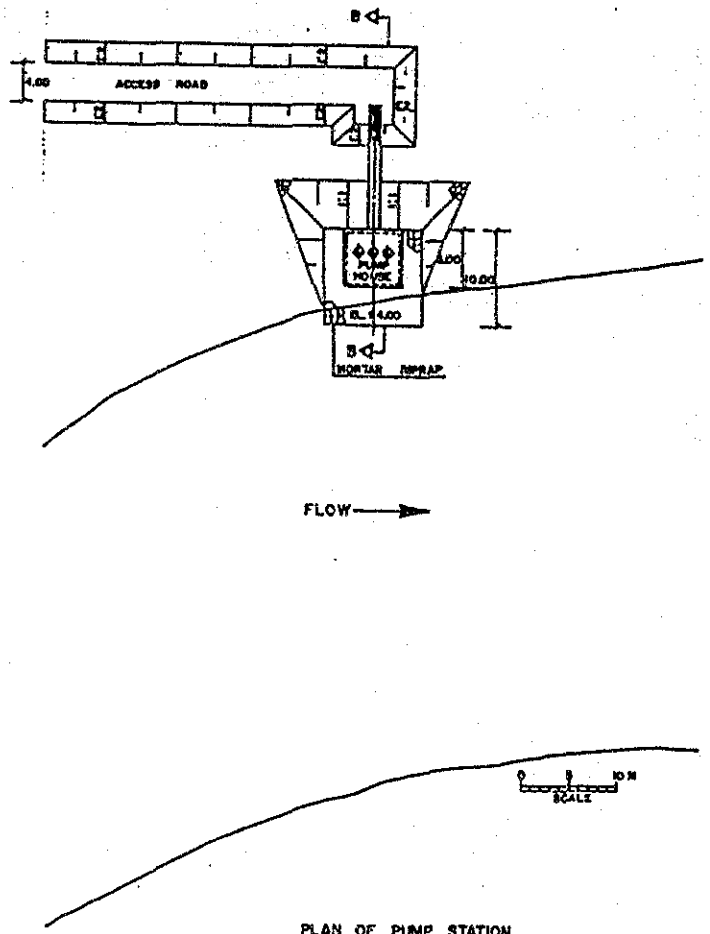
FIGURE 8-1-3
Raw Water Intake Pumping Station (Case 1)



PLAN OF PUMP STATION
(CASE 2)

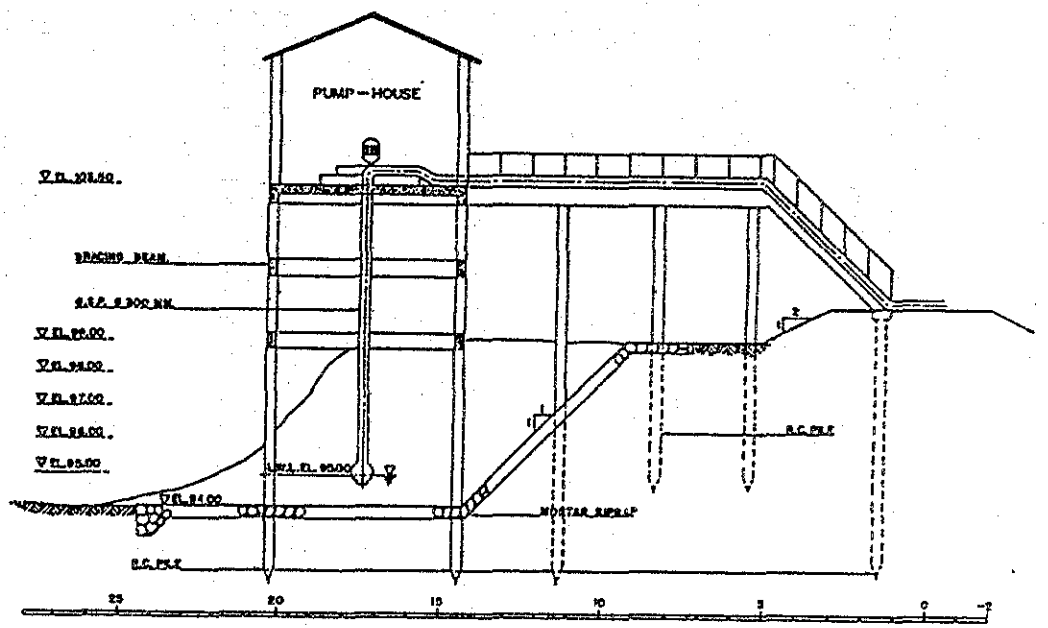


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FIGURE 8-1-4
Raw Water Intake Pumping Station (Case 2)

Table 8-1-3 Comparison of Two Methods

	Case 1	Case 2
Pump Location	in the basement (below high water level)	on the floor slab (above high water level)
Protection against flooding	need structural barrier	safe
Pump operation	easy and safe	cavitation likely happen
Pump maintenance	easy	occurence of cavitaion should be checked

From the viewpoint of the pump operation and maintenance, Case 1 is recommended.

8-1-4 Water Source Development Plan

The water source development plan is given in Figure 8-1-5. The pump station will be constructed at the PWA's proposed intake point in two phases with one pump with a capacity of 2.55 cu.m/min in Phases I and II, respectively.

Table 8-1-6 Water Source Development Plan

(Unit : cu.m/min)

Project	Year	Water Intake Capacity	Daily Maximum Water Demand
(1) Phase I Intake Pit Pump Sta.	1990	6,340	5,333 *)
(2) Phase II add Pump	1995	11,510	6,853
(3) Phase III add Pump	2003	16,700	9,814

*) : Maximum capacity of the existing treatment plant

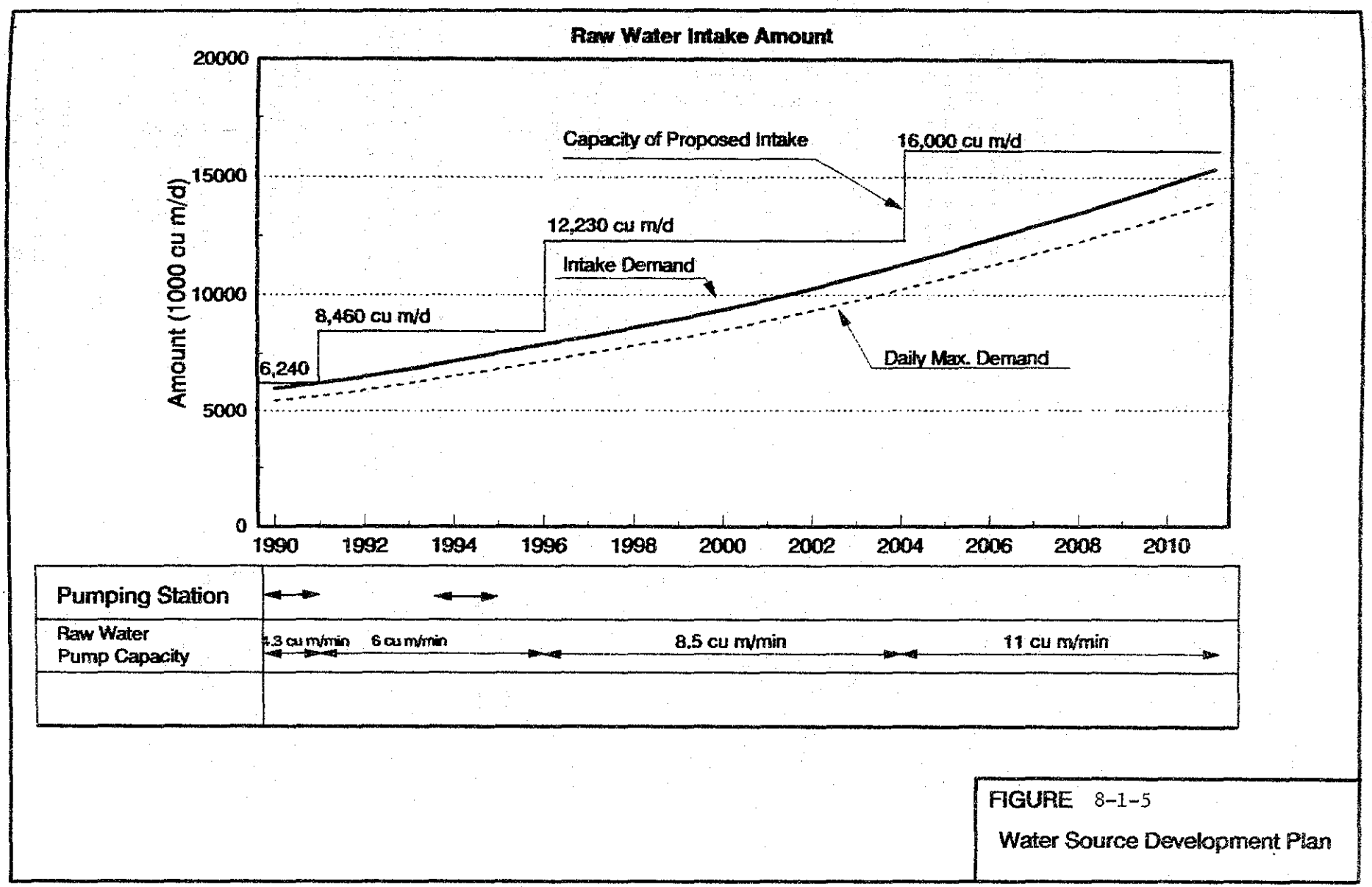


FIGURE 8-1-5

Water Source Development Plan

8.2 Water Supply System

8.2.1 General

The development of the water supply system should be based on the predicted water demand. Water demand of each year is calculated on the basis of the water demand prediction described in the previous Chapter. Figure 8-2-1 shows a yearly breakdown of the water demand, detailed calculation of which is presented in Appendix A-8-1.

8.2.2 Raw Water Transmission Pipeline

(1) Transmission capacity of the pipe designed by PWA

PWA has prepared a detailed design for a raw water transmission pipeline with a diameter of 300 mm. Figure 8-2-2 shows a right of way of the proposed pipeline. Intake pumps are designed to have a pumping head of 55 meters. With these characteristics and topographic profile, maximum transmission capacity was calculated to be 8,480 cu m/d with a maximum hydraulic gradient of 0.0072 as shown in Figure 8-2-3.

This amount is larger than the planned daily maximum demand in 2001 (8,945 cu m/d) but insufficient for the demand in 2011 (13,988 cu m/d).

(2) Recommended scheme for the raw water transmission pipeline

As the present design is not sufficient in capacity to meet a planned water demand in 2011, the transmission capacity should be increased.

The construction of the another pipeline will be needed in addition to the 300 mm A/C pipe which had been designed and is being implemented by PWA. The size of the additional pipeline will depend on the location of the water treatment plants as compared in the following part in this report.

8.2.3 Proposed Location for Water Treatment Plant

PWA has prepared an detailed design for modification of the existing water treatment plant to increase its treatment capacity from 160 cu m/h (3,840 cu m/d) to 240 cu m/h (5,760 cu m/d). Since this modification is to be implemented in the early stage in 1989, it should be incorporated in the development plan.

Planned daily maximum water demand, however exceeds the increased capacity of the plant before 1996. Therefore, some measure to further increase the plant capacity should be taken.

Considering the location of the new raw water intake and the existing water treatment plant, there are two alternatives for increasing plant capacity:

(1) Water treatment by two plants

Existing treatment site obviously has no room to expand the facilities; therefore, additional facilities should be constructed at other site which must be away from the existing plant site.

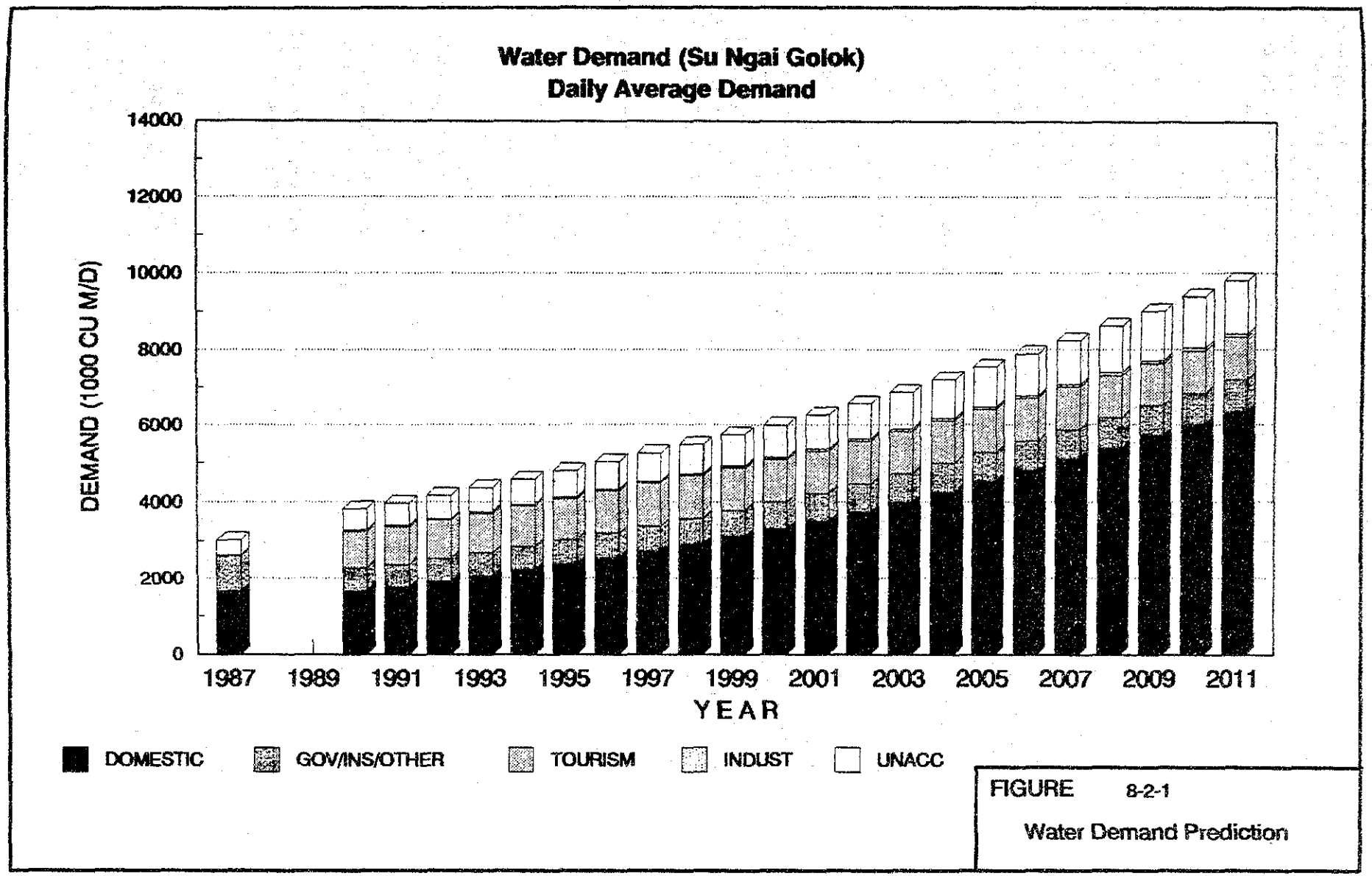


FIGURE 8-2-1

Water Demand Prediction

In this case, however, raw water is assumed to be taken only from the proposed intake at 7 km upstream from the municipality (existing raw water intake is to be abandoned). Considering that water quality at the existing intake will become worse in the future by pollution derived from the discharge of domestic wastewater, this concept should be maintained to establish a safe water supply.

As the raw water will be taken only from the proposed intake, the location of an additional treatment plant may be limited at two points: (i) near the service area, or (ii) at the raw water intake site (PWA has purchased the land of about 39,000 sq m near the intake site and along the national highway). In case that the new plant is to be constructed near the service area, the land should be purchased. In the comparison study of the alternatives, the land requirement is assumed to be 20 rais (32,000 sq m) so that the sludge lagoon or other ancillary buildings will be accommodated.

(2) Water treatment by a single plant at the new raw water intake

The construction of a new treatment plant with a capacity to fully meet a future water demand is proposed as an alternative.

A new plant is recommended to be located at the proposed raw water intake since it will help easy operation of raw water intake by treatment plant staffs; in other words, raw water intake pumps can be effectively operated in response to the needs at a treatment plant. In this case, the existing plant will be abandoned. A pipeline which is firstly to be constructed for raw water transmission will be later converted to be used for treated water transmission.

From the conditions set above, three alternatives are proposed as follows:

Table 8.2.1 Alternatives of the Water Supply System

Alternative	Water Treatment Plant in Use Exis.Plant	 New Plant	Transmission Pipeline
1	5,760 cu m/d	9,400 cu m/d (Location A)	A/C 300mm, 7,000m (Raw Water) A/C 300mm, 6,000m (Raw Water)
2	- (abondoned)	15,150 cu m/d (Location B)	A/C 300mm, 7,000m (Treated Water) A/C 400mm, 6,000m (Treated Water)
3	5,760 cu m/d	9,400 cu m/d (Location B)	A/C 300mm, 7,000m (Raw Water) A/C 400mm, 6,000m (Treated Water)

Note : Location A: near the service area
Location B: at the Raw Water Intake

The facility plan and schematic diagram of each alternative are shown in Figures 8.2.4 to 8.2.6.

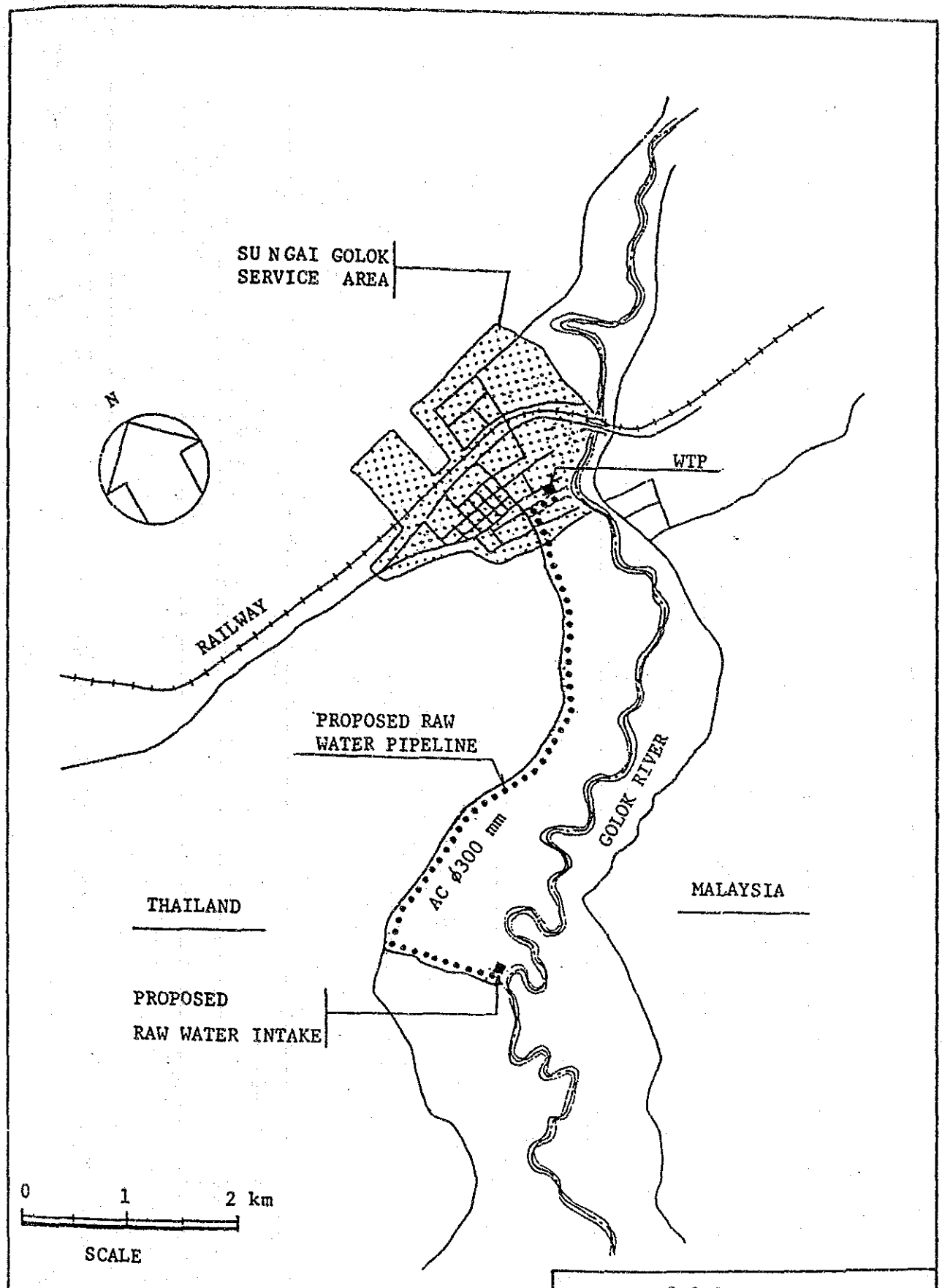


FIGURE 8-2-2
PROPOSED RAW WATER TRANSMISSION PIPELINE

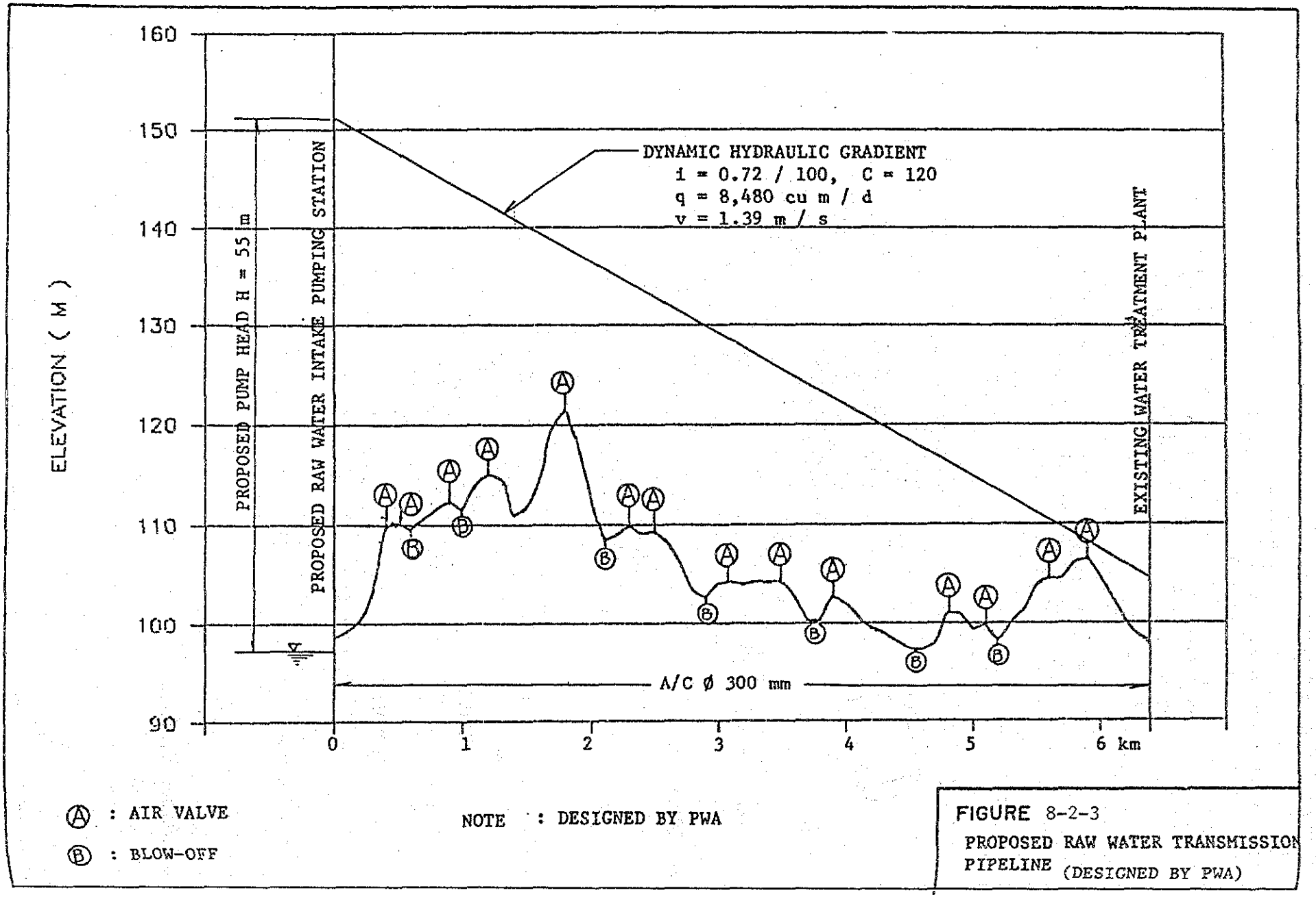


FIGURE 8-2-3
PROPOSED RAW WATER TRANSMISSION PIPELINE (DESIGNED BY PWA)

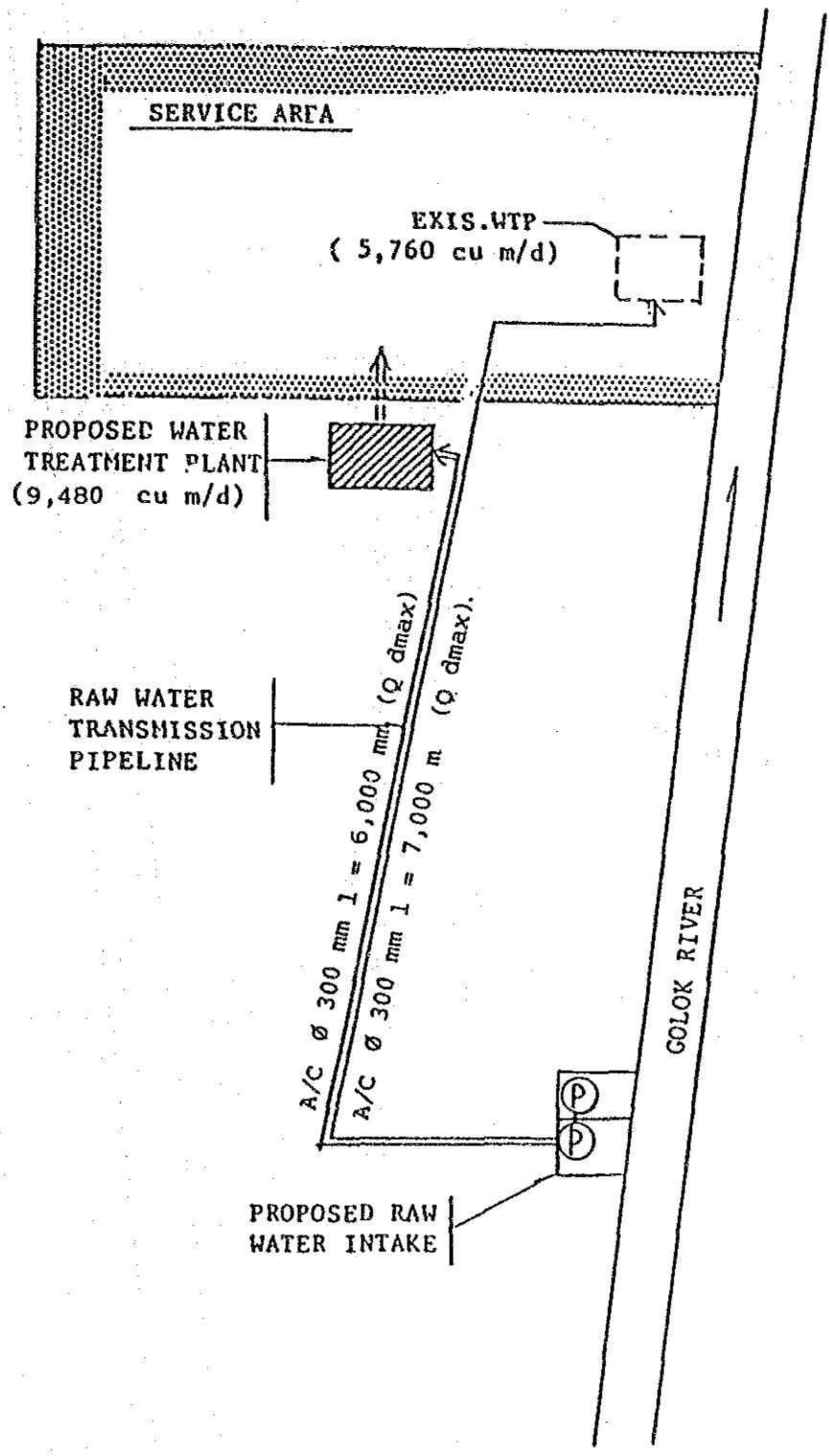


FIGURE 8-2-4
SCHEMATIC PLAN FOR PROPOSED TREATMENT PLANT SYSTEM (ALTERNATIVE 1)

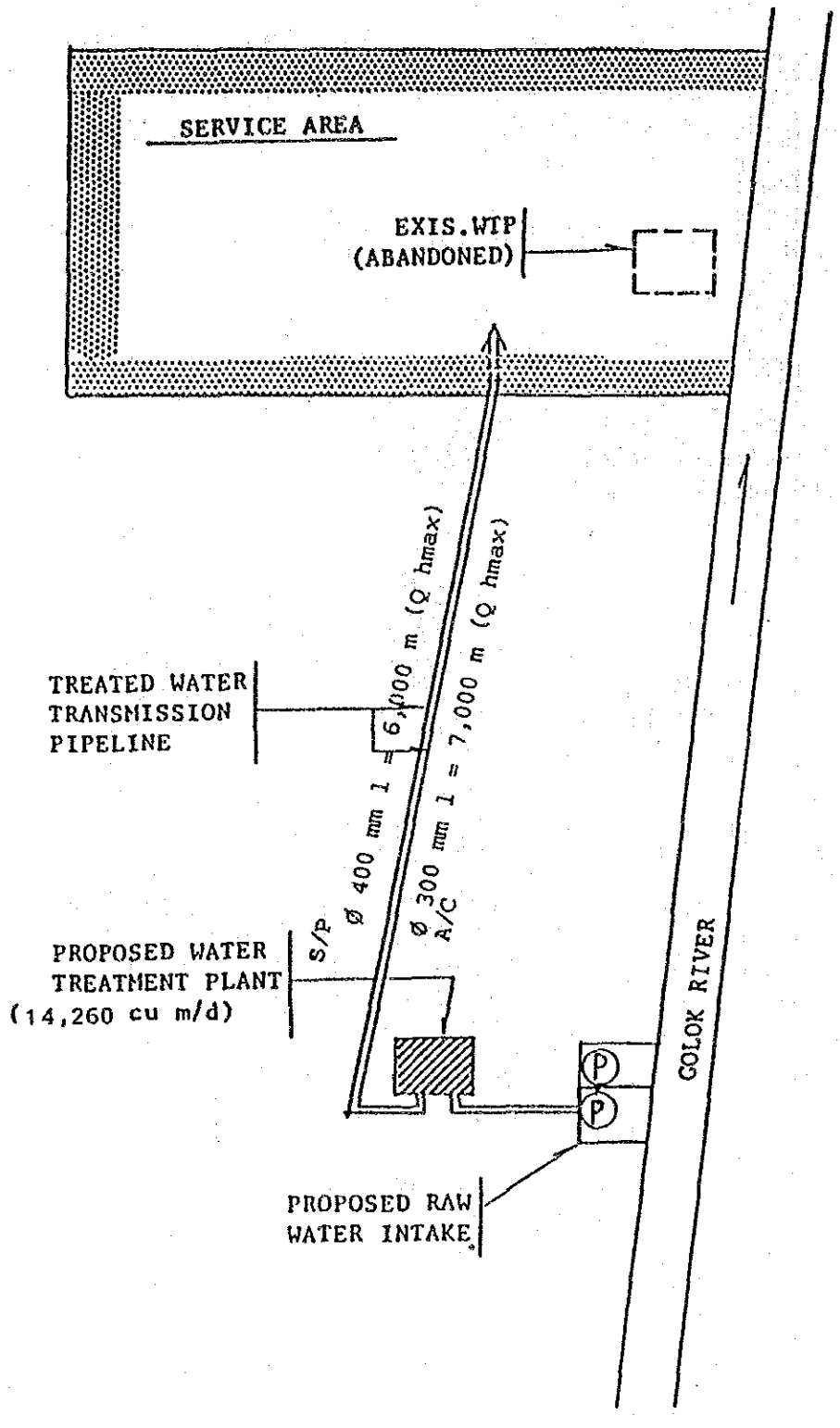


FIGURE 8-2-5
SCHEMATIC PLAN FOR PROPOSED TREATMENT PLANT SYSTEM
(ALTERNATIVE 2)

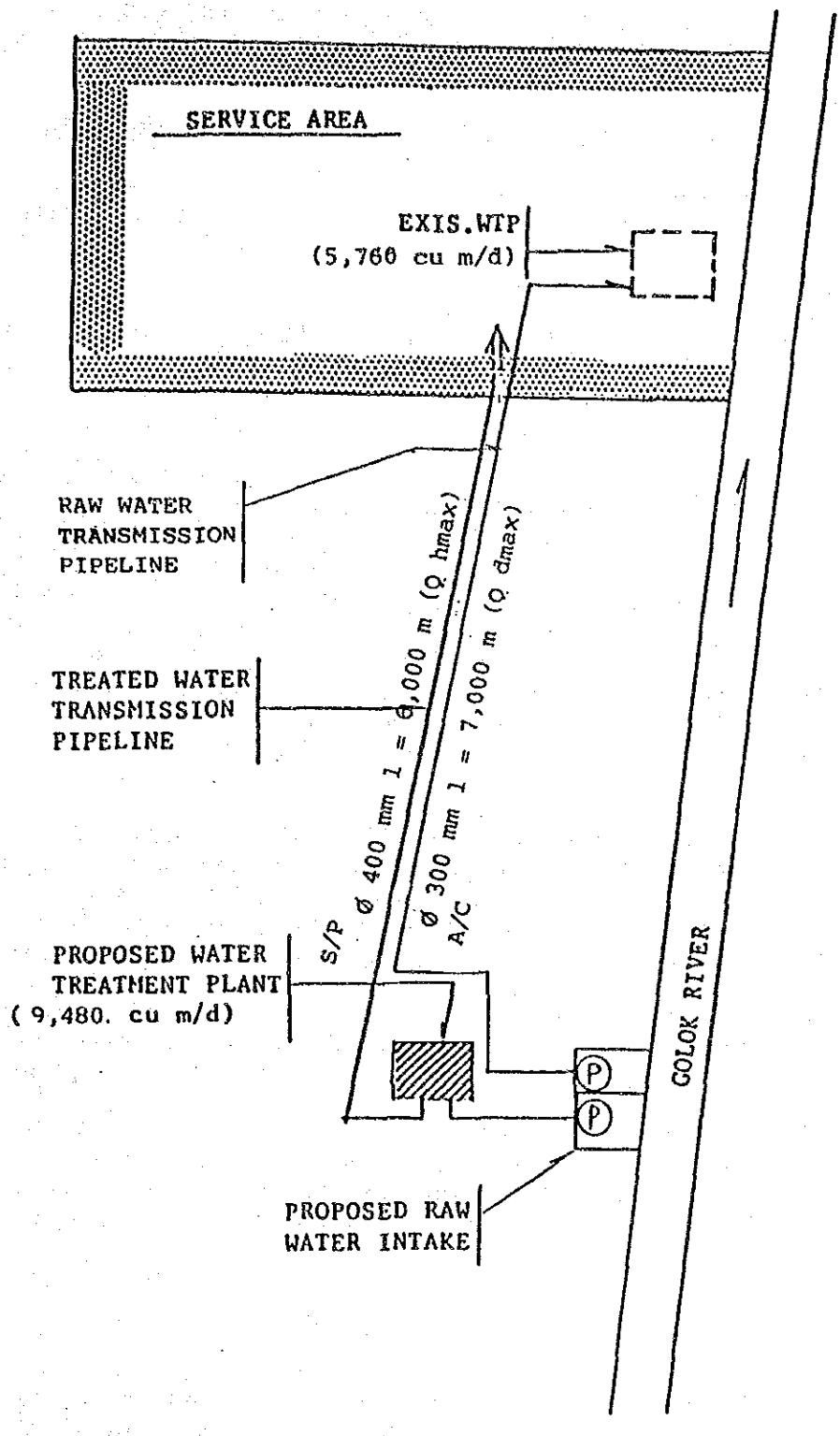


FIGURE 8-2-6
SCHEMATIC PLAN FOR PROPOSED
TREATMENT PLANT SYSTEM
(ALTERNATIVE 3)

8.2.4 Comparison of Alternatives

The cost evaluation of the alternatives are made by comparing the construction and operation costs of each plan. The costs are calculated on the 1989 price bases and compared in the present net value. Table 8.2.2 shows a result of the comparison.

Table 8.2.2 Cost Comparison Summay of Alternative Plan
(Unit: Baht 1000)

Parameter	Alternative 1	Alternative 2	Alternative 3
Construction Cost			
Raw Water Intake	4,320	4,890	4,320
Treatment Plant	35,944	49,986	35,944
Pipeline	9,300	17,400	17,400
Land Cost	20,000	0	0
Operation Cost			
Energy	41,946	34,020	44,248
Chemical	5,657	5,657	5,657
Manning	12,466	0	12,466
Total Cost	129,633	111,953	120,036
NPV	66,459	54,661	54,097

Note: Net Present Value (NPV) is calculated with a discount rate of 9 percent.
Operation Cost is calculated for years 1990 to 2011.
Breakdown of the cost study is presented in Appendix.

As presented in above Table, Alternative 2 shows the least cost in the present-base value. However, Alternative 3 shows the lowest cost in the Net Present Value. This is because Alternative 2 needs a larger investment for the treatment plant construction in the early stage while Alternative 3 will require the higher operation cost through the operating period.

From the technical point of view, Alternative 2 is the most advantageous in the ease of operation, particularly in water treatment efficiency and easy communication between raw water intake and treatment plant.

Alternative 3 is recommended because of the economical advantage. This alternative will, however be able to modified to the system proposed as Alternative 2 in case any difficulties will arise in the future in operation of the two treatment plants so that the technical disadvantage will be improved.

8.2.5 Facility Planning

On the basis of the system layout selected in the previous subsection, the detailed planning is prepared for the facilities as follows:

(i) Treatment plant
(ii) Distribution Reservoir
(iii) Transmission and Distribution Pipelines

(1) Treatment plant

To treat the raw water taken from Su Ngai River, treatment process should consist of chemical coagulation, sedimentation, and rapid sand filtration. This is a process normally applied for treating surface water with high turbidity. There is no alternative to be considered for the treatment process in this respect.

The followings are the proposed facilities as the major treatment plant components.

a. Receiving well
b. Mixing basin
c. Flocculation channel
d. Sedimentation basin
e. Rapid sand filter
f. Clear water reservoir
g. Sludge lagoon
h. Sludge drying bed

Some buildings and housings, such as administration building, chemical storage, staff houses, warehouses will be incorporated in the facility planning of the treatment plant.

The characteristics of the major facilities of the treatment plant are summarized as follows:

a. Receiving Well
Type : Circular
Dimension : Dia. 2.5 m x D 2.0 m
No. : 1

b. Mixing Basin
Type : Square
Dimension : L 1.5 m x W 1.5 m x D 1.5 m
No. : 2

c. Flocculator
Type : Hydraulic flocculation
Dimension : L 10.0 m x W 1.0 m x D 2.5 m
No. : 1

d. Sedimentation Basin
Type : Rectangular
Dimension : L 25.0 m x W 4.0 m x D 4.0 m
No. : 4

e. Sand Filter
Type : Rapid Sand Filter,
Dimension : L 4.0 m x W 2.5 m
No. : 8

f. Clear Water Reservoir
Type : Rectangular
Dimension : L 30.0 m x W 22.0 m x D 5.0 m
No. : 1

g. Sludge Lagoon
Type : Open cut, Rectangular

Dimension : L 10.0 m x W 8.0 m x D 2.0 m
No. : 2

h. Sludge Drying Bed
Type : Concrete Bed, Rectangular
Dimension : L 5.0 m x W 15.0 m x D 1.0 m
No. : 2

Appendix A-8-3 and A-8-4 show capacity calculation and plans of each facility of the treatment plant.

8.2.5 Staging of the Water Treatment Plant Construction

Staging for construction and modification of the treatment plants are established on the basis of the planned water demand.

The existing plant after modification will be used in the future. The new plant will then start its operation with a treatment capacity of 4,700 cu m/d in 1995. The new plant will then be expanded in 2003 its capacity by 4,700 cu m/d to have a total capacity of 9,400 cu m/d.

8.2.6 Proposed distribution system

The distribution system with a water demand in 2011 was analized to optimize the system. The minimum pressure in the maximum hourly flow is set at 1.0 kg/sq.cm for general application.

The proposed system includes installation of 24 km long mains, ranging from 100 mm to 400 mm diameter. Based on the results of the distribution network analysis, distribution pipeline are sized to serve the maximum hourly flows with sufficient service pressure throughout the proposed system.

A schematic plan of the system is shown in Figure 8.2.7. The results of the distribution network analysis are presented in Appendix A-8-5.

Breakdown of the proposed distribution pipeline including a replacement of the existing pipeline system are tabulated in Table 8.2.2.

Table 8.2.2 Proposed Distribution pipelines

Dia (mm)	Length (m)	Materials
Replacement		
400	740	AC
300	530	AC
250	1,970	AC
200	3,330	AC
Sub-total	6,570	
New Construction		
300	2,320	AC
250	880	AC
200	5,690	AC
150	6,940	AC
100	8,235	AC
Sub-total	24,065	
Total	30,635	

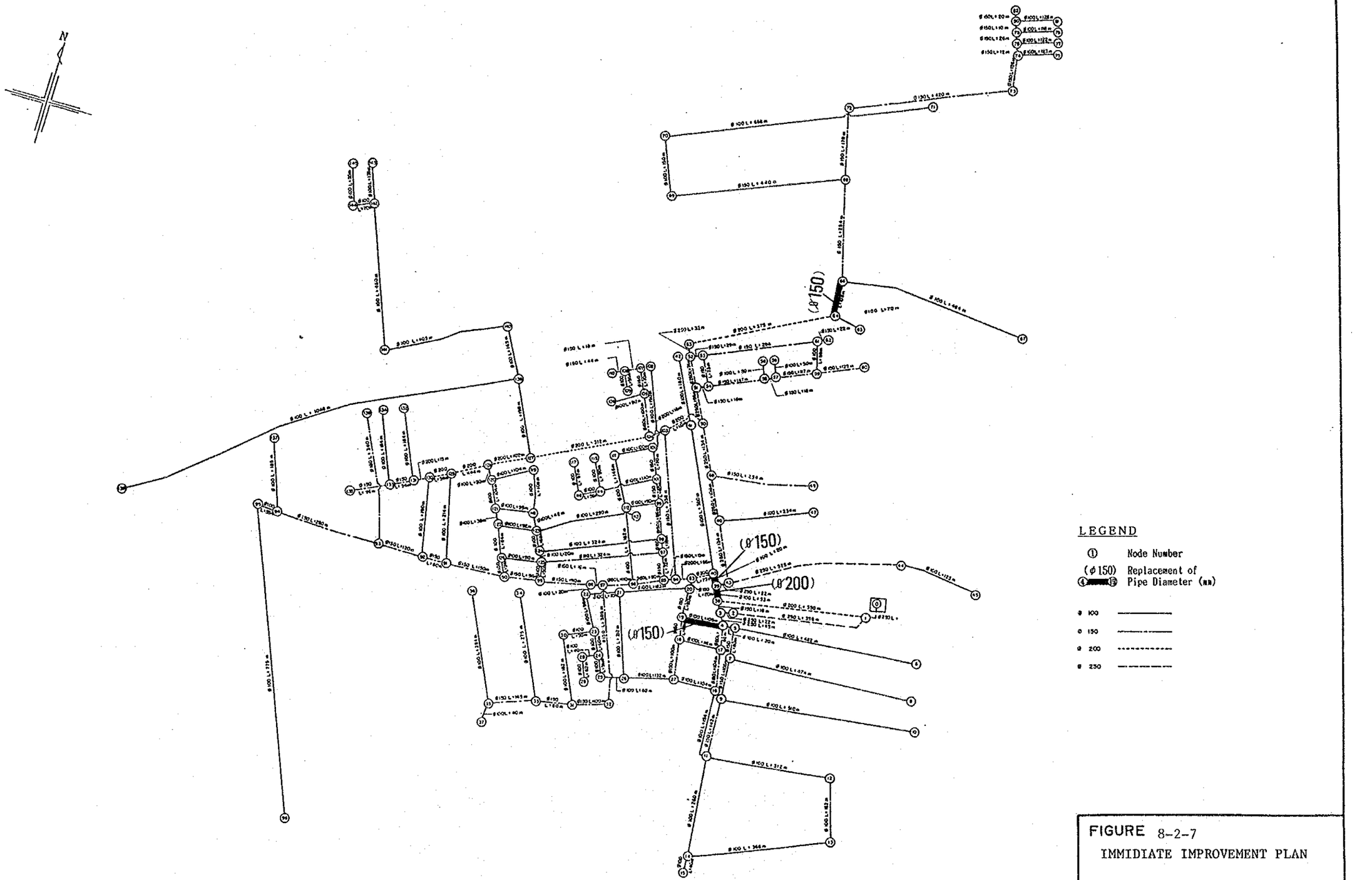
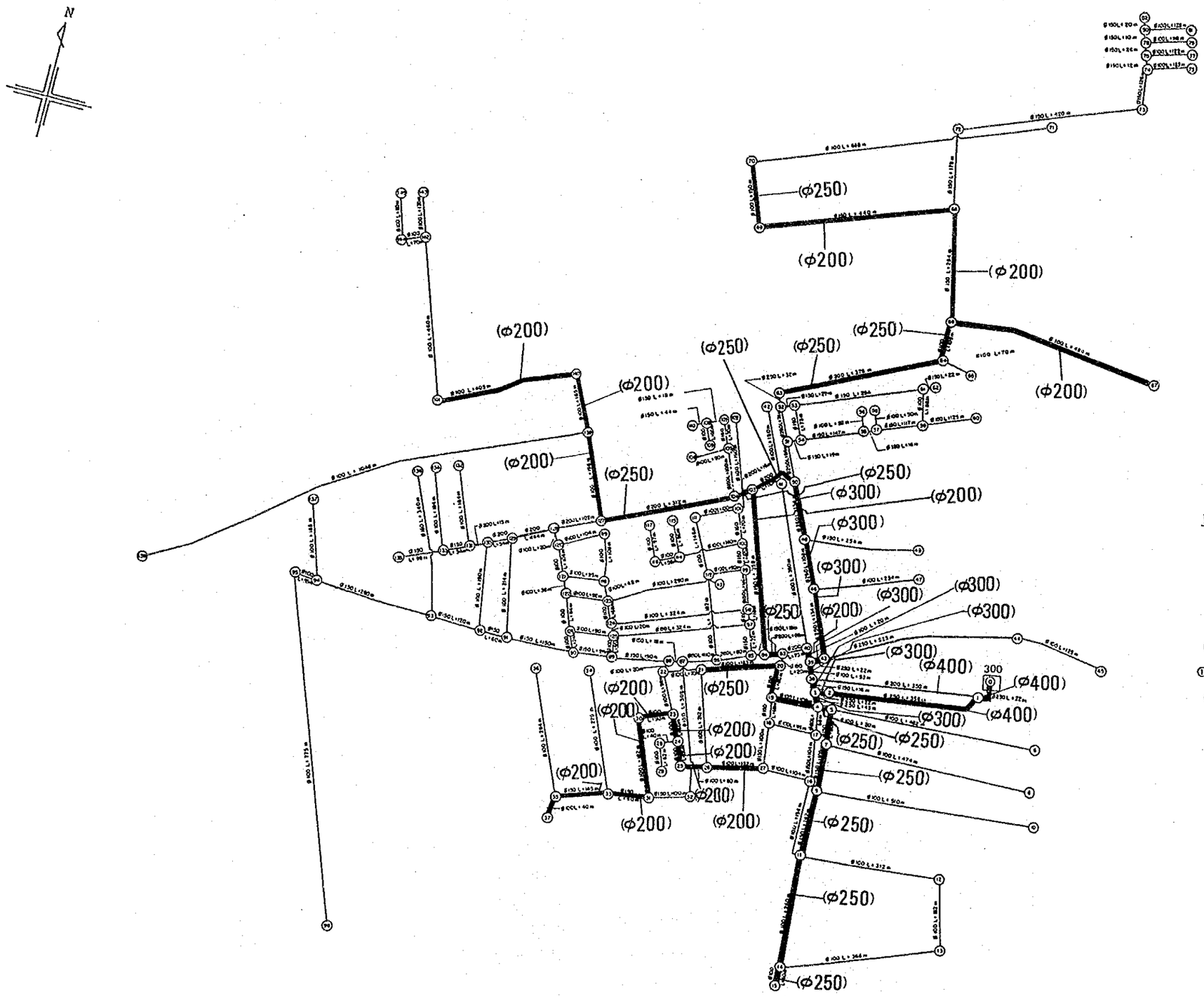


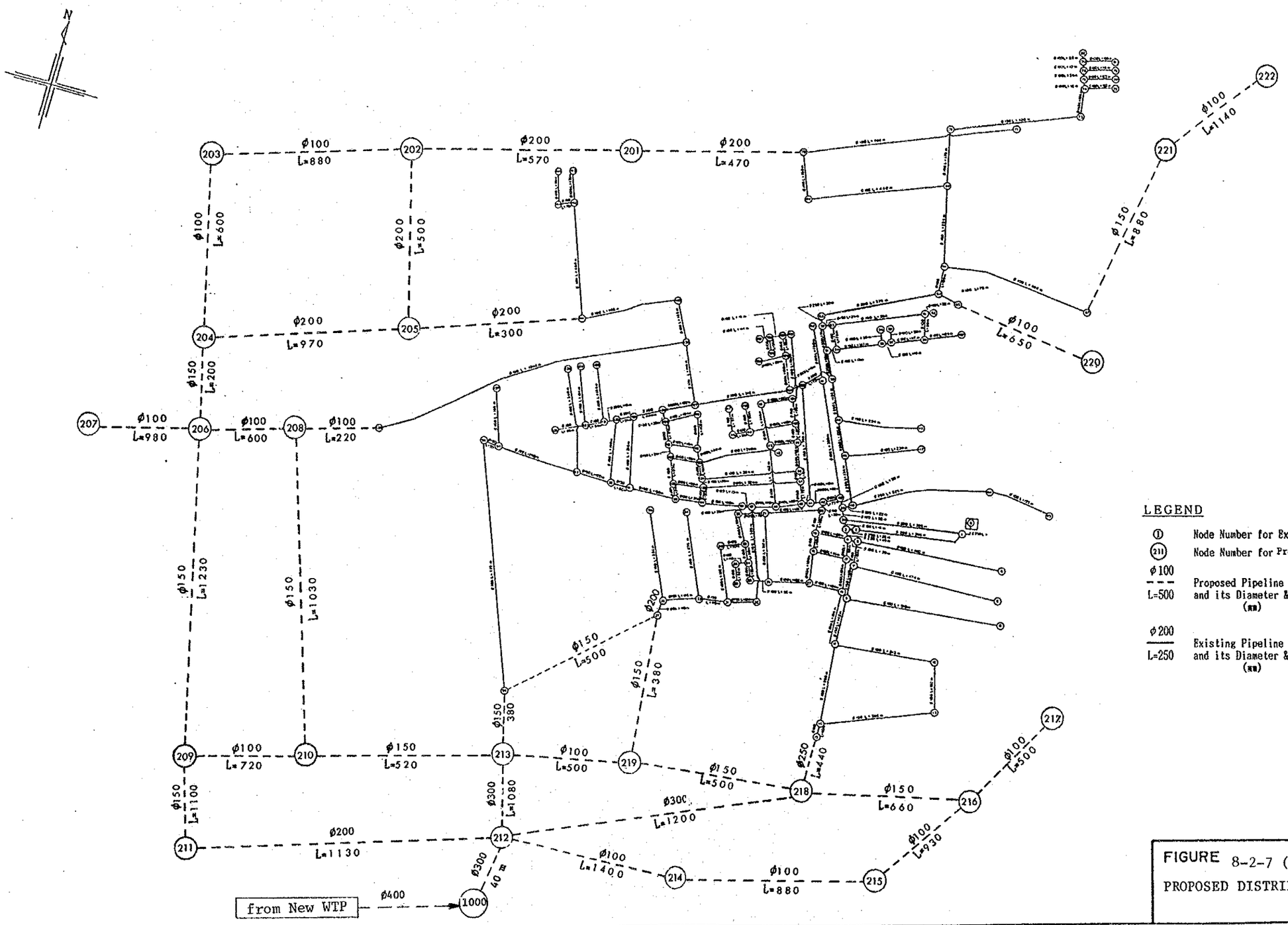
FIGURE 8-2-7
IMMIDIATE IMPROVEMENT PLAN



LEGEND

①	Node Number for Existing Pipeline
(211)	Node Number for Existing Pipeline
φ100 / L=500	Proposed Pipeline and its Diameter & Length (mm) (m)
(φ150)	← Proposed Diameter (mm)
φ100 ① ② L=500	Replacement of Existing Pipeline
(L= 450)	← Proposed Length (m) if necessary, otherwise same as the existing one.
φ200 / L=250	Existing Pipeline and its Diameter & Length (mm) (m)

FIGURE 8-2-7 (Cont'd)
PROPOSED DISTRIBUTION PIPELINE



LEGEND

①	Node Number for Existing Pipeline
(211)	Node Number for Proposed Pipeline
φ100 L=500	Proposed Pipeline and its Diameter & Length (mm) (m)
φ200 L=250	Existing Pipeline and its Diameter & Length (mm) (m)

FIGURE 8-2-7 (Cont'd)
PROPOSED DISTRIBUTION PIPELINE

9. IMPLEMENTATION PLAN

The implementation plan of the total project is proposed as shown in Figure 9-1. In this program, the facility construction is prepared following the water demand prediction. The construction of the treatment plant will be carried out in one phase. It is assumed that the distribution pipelines will be constructed for two years.

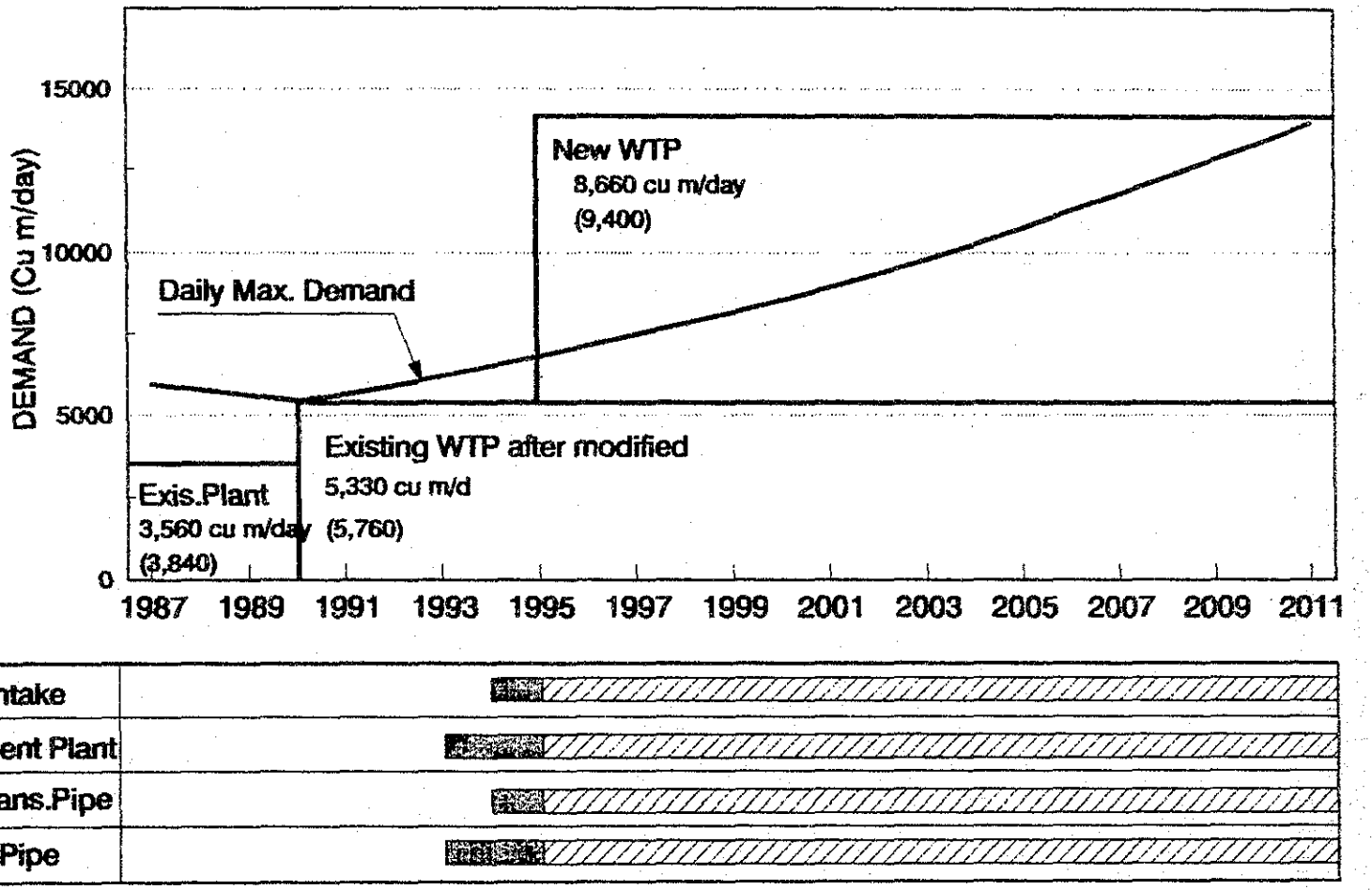


FIGURE 9-1
Implementation Plan

10. ORGANIZATION OF WATERWORKS

The organization of the waterworks is proposed with consideration on the components and size of the proposed water supply system. The construction of sections is based on the existing organization chart of the waterworks. Some additional sections are proposed for the operation of the proposed water treatment plant. The proposed organization consists of the administration, water production, and service sections as shown in Figure 10-1.

The major tasks of each section are described as follows:

(1) Administration Section

This section will be responsible for the administrative and financial issues of the waterworks. The works to be done will include the preparation of the general administration for the waterworks' staff, meter reading and preparation of bills, collectin of water charge, and management of the documents and records.

(2) Water Production Section (the Existing Treatment Plant)

This section will be responsible for the operation and maintenance of the existing water treatment plants.

(3) Water Production Section (for New Treatment Plant)

This section will be responsible for the operation and maintenance of the water treatment plants and the raw water intake. Inspection of the transmission pipelines will be performed by this section.

(4) Service Section

This section will be responsible for setting and repair of house connection.

Numbers of staff of each section are decided from the water demand in each year. Ratios of present number of staff and the water demand in 1987 are used in calculating the future number of staff.

Table 10-1 shows numbers of staff.

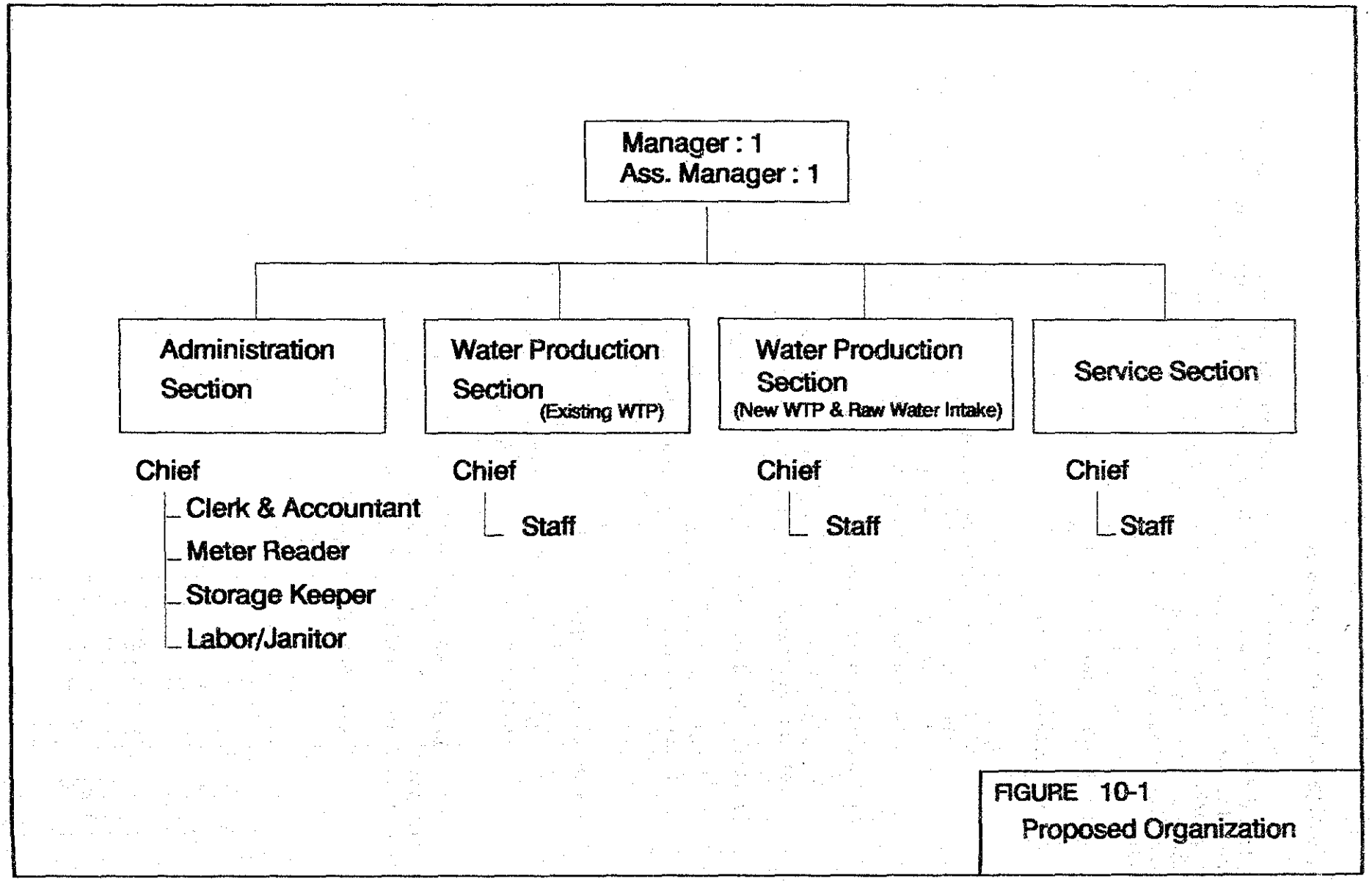


FIGURE 10-1
Proposed Organization

Table 10 - 1 Proposed No. of Staff

Year	No. of Staff	Manager	Administrative					Water Product (Exis.WTP)		Water Product (New WTP)		Service Section	
	Total		Chief	Clerk Account	Storage Keeper	Meter Reader	Labor etc.	Chief	Staff	Chief	Staff	Chief	Staff
1990	21	1	1	3	2	2	1	1	4	0	0	1	5
1991	21	1	1	3	2	2	1	1	4	0	0	1	5
1992	21	1	1	3	2	2	1	1	4	0	0	1	5
1993	22	1	1	3	2	2	1	1	4	0	0	1	6
1994	22	1	1	3	2	2	1	1	4	0	0	1	6
1995	31	1	1	3	3	3	1	1	4	1	6	1	6
1996	33	1	1	4	3	3	1	1	4	1	6	1	7
1997	33	1	1	4	3	3	1	1	4	1	6	1	7
1998	33	1	1	4	3	3	1	1	4	1	6	1	7
1999	34	1	1	4	3	3	1	1	4	1	6	1	8
2000	34	1	1	4	3	3	1	1	4	1	6	1	8
2001	34	1	1	4	3	3	1	1	4	1	6	1	8
2002	35	1	1	4	3	3	1	1	4	1	6	1	9
2003	38	1	1	4	4	4	2	1	4	1	6	1	9
2004	39	1	1	5	4	4	2	1	4	1	6	1	9
2005	40	1	1	5	4	4	2	1	4	1	6	1	10
2006	40	1	1	5	4	4	2	1	4	1	6	1	10
2007	41	1	1	5	4	4	2	1	4	1	6	1	11
2008	43	1	1	5	5	5	2	1	4	1	6	1	11
2009	45	1	1	6	5	5	2	1	4	1	6	1	12
2010	45	1	1	6	5	5	2	1	4	1	6	1	12
2011	46	1	1	6	5	5	2	1	4	1	6	1	13

11. Project Cost Estimates

11.1 Construction Cost

The construction cost of the water supply system was calculated for each component of facility. Table 11-1 shows a summary of the construction cost based on the 1989 price.

Table 11-1 Summary of the Construction Cost
(unit : Baht Million)

Item	Total Value	Foreign Currency Portion	Local Currency Portion
1.Raw Water Intake	4,320	2,192	2,128
2.Treatment Plant	35,944	26,172	9,772
3.Transmission Pipeline	17,400	5,220	12,180
4.Distribution Pipeline	26,787	8,036	18,751
Sub Total	84,451	41,620	42,831
5.Land Cost	0	0	0
Total	84,451	41,620	42,831

The breakdown of the cost estimates are shown in Tables 11-2 to 7.

Table 11-2 Cost Breakdown of the Raw Water Intake Facility
(unit : Baht 1000)

Item	Total Value	Foreign Currency Portion	Local Currency Portion
A. Civil/Architectural Works	1,060	318	742
B.Mechanical Works	1,140	912	228
C.Electrical Works	570	456	114
D.Raw Water Pipe	1,550	506	1,044
Total	4,320	2,192	2,128

Table 11-3 Cost Breakdown of the Treatment Plant

(unit : Baht 1000)

Item	Total Value	Foreign Currency Portion	Local Currency Portion
A. Civil/Architectural Works			
1. Receiving Well	20	6	14
2. Sedimentation Basin	7,840	2,352	5,488
3. Rapid Sand Filter	4,704	1,411	3,293
4. Clear Water Reservoir	8,320	2,496	5,824
5. Elevated Tank	1,800	540	1,260
6. Pumping House	360	108	252
7. Chemical House	380	114	266
8. Administration Bldg.	500	150	350
9. Staff Quarter	1,000	300	700
Sub-total of A.	24,924	7,477	17,447
B. Mechanical Works			
1. Clear Water Pump 200mm, 4 units	1,400	1,120	280
2. Chemical Equipment	1,520	1,216	304
3. Chlorination Equip	880	704	176
4. Others (20% ofabove)	760	608	152
Sub-total of B.	4,560	3,648	912
C. Electrical Works (70 % of Mechanical)	3,192	2,554	638
D. Miscellaneous(10%ofA,B,C)	3,268	1,368	1,900
Total	35,944	26,172	9,772

Table 11-4 Cost Breakdown of the Transmission Pipeline
(unit : Baht 1000)

PIpeline From	To	Dia(mm)	L (km)	Total Value	Foreign Currency Portion	Local Currency Portion
Intake	Exis.WTP	300	7.0	(not included)		
New WTP	Service Area	400	6.0	17,400	5,220	12,180
Total				17,400	5,220	12,180

Table 11-5 Cost Breakdown of the Distribution Pipeline
(unit : Baht 1000)

Pipe Dia(mm)	L (m)	Material	Total Value	Foreign Currency Portion	Local Currency Portion
Replacement					
400	740	AC	2,146	644	1,502
300	530	AC	890	267	623
250	1,970	AC	2,403	721	1,682
200	3,330	AC	3,064	919	2,145
Sub-Total	6,570		8,503	2,551	5,952
New Construction					
300	2,320	AC	3,898	1,169	2,728
250	880	AC	1,074	322	752
200	5,690	AC	5,235	1,570	3,664
150	6,940	AC	4,372	1,312	3,061
100	8,235	AC	3,706	1,112	2,594
Sub-Total	24,065		18,285	5,485	12,799
Total	30,635		26,787	8,036	18,751

11.2 Operation and Maintenance Cost

Operation and maintenance cost is calculated from the water demand in each year, and consists of energy, chemical, manning, repair, and replacement costs.

The energy and chemical costs are calculated in the alternative comparison.

Manning cost is based on the prediction of the staff number of waterworks as p Chapter 10.

Replacement of the mechanical and electrical equipment is considered to be made 20 years after the installation so that they are not included in the period of the development plan.

Total operation and maintenance cost is tabulated in Table 11-6.

Table 11.6 Summary of Operation and Maintenance Cost
(unit : Baht 1000)

Year	Energy Cost	Chemical Cost	Manning Cost	Repair Cost	Total
1990	479		2,034		2,513
1991	1,302	164	2,136		3,602
1992	1,318	172	2,243		3,733
1993	1,335	180	2,467		3,982
1994	1,352	189	2,590		4,131
1995	1,646	199	3,833		5,678
1996	1,698	208	4,284	921	7,111
1997	1,748	218	4,498	921	7,385
1998	1,800	227	4,723	921	7,671
1999	1,855	238	5,109	921	8,123
2000	1,912	248	5,365	921	8,446
2001	2,080	259	5,633	921	8,893
2002	2,147	272	6,089	921	9,429
2003	2,216	284	6,941	1,365	10,806
2004	2,288	298	7,480	1,365	11,431
2005	2,418	312	8,055	1,365	12,151
2006	2,496	327	8,458	1,769	13,050
2007	2,575	341	9,103	1,769	13,788
2008	2,766	356	10,024	1,769	14,915
2009	2,850	372	11,015	1,769	16,007
2010	2,938	388	11,566	1,769	16,661
2011	3,029	405	12,414	1,769	17,618

12. ANNUAL DISBURSEMENT SCHEDULE

The annual disbursement schedule is prepared on the basis of the construction schedule and the cost estimates as shown in the Chapter 9, and 10, respectively.

Table 12-1 shows an annual disbursement by item.

Table 12-1 Annual Disbursement Schedule

(Unit : Baht 1000)

Year	CONSTRUCTION COST							Engineering Cost			Operation Cost	Land Cost	Grand Total
	Intake	WTP (Line 1)	WTP (Line 2)	Trans. Pipe	Distrib. Pipe	Contin-gency	Sub-Total	Design	Super-vision	Sub-Total			
Total	4,320	25,016	10,927	17,400	26,787	8,445	92,895	7,432	3,716	11,147	207,125	0	311,167
1990	0	0	0	0	0	0	0	0	0	0	2,513	0	2,513
1991	0	0	0	0	0	0	0	0	0	0	3,602	0	3,602
1992	0	0	0	0	0	0	0	5,202	0	5,202	3,733	0	8,935
1993	0	3,752	1,639	0	4,018	941	10,350	2,229	557	2,787	3,982	0	17,119
1994	2,625	17,511	7,649	12,180	18,751	5,872	64,588	0	2,601	2,601	4,131	0	71,320
1995	1,125	3,752	1,639	5,220	4,018	1,575	17,330	0	557	557	5,678	0	23,565
1996	0	0	0	0	0	0	0	0	0	0	7,111	0	7,111
1997	0	0	0	0	0	0	0	0	0	0	7,385	0	7,385
1998	0	0	0	0	0	0	0	0	0	0	7,671	0	7,671
1999	0	0	0	0	0	0	0	0	0	0	8,123	0	8,123
2000	0	0	0	0	0	0	0	0	0	0	8,446	0	8,446
2001	0	0	0	0	0	0	0	0	0	0	8,893	0	8,893
2002	0	0	0	0	0	0	0	0	0	0	9,429	0	9,429
2003	0	0	0	0	0	0	0	0	0	0	10,806	0	10,806
2004	0	0	0	0	0	0	0	0	0	0	11,431	0	11,431
2005	570	0	0	0	0	57	627	0	0	0	12,151	0	12,778
2006	0	0	0	0	0	0	0	0	0	0	13,050	0	13,050
2007	0	0	0	0	0	0	0	0	0	0	13,788	0	13,788
2008	0	0	0	0	0	0	0	0	0	0	14,915	0	14,915
2009	0	0	0	0	0	0	0	0	0	0	16,007	0	16,007
2010	0	0	0	0	0	0	0	0	0	0	16,661	0	16,661
2011	0	0	0	0	0	0	0	0	0	0	17,618	0	17,618

Note: 1. Contingency = 10 % of the total of gross construction cost
2. Engineering Cost (Design) = 8 % of the total construction cost
3. Engineering Cost (Supervision) = 4 % of the total construction cost

Part 3
FEASIBILITY STUDY

Part 3. FEASIBILITY STUDY

13. FUNDAMENTALS FOR FEASIBILITY STUDY

There is a detailed disign for the modification of the existing treatment plant to increase its treatment capacity from 160 cu m/d to 240 cu m/d. The design was prepared by PWA itself in line with a design concept of PWA which is commonly applied for the modification of the existing waterworks under the jurisdiction of PWA.

The proposed modification of the treatment plant consist of: provision of the flocculation channel, overflow trough in the sedimentation basin, and surface washing in the sand filter, and replace ment of the filter sand.

The construction of the new raw water intake and the raw water transmission pipeline is also included in the modification plan.

The budget and the biddding schedule for the modification of the existing water supply system is already incorporated in the PWA's implementing program so that this work is excluded from the subject of this study.

The expansion works will consist of the construction of a new treatment plant, an additional raw water intake for the new plant, a transmission pipeline, and distribution pipelines as presented in Chapter 8 in this report.

As described above, there is an ongoing program for the rehabilitation and the new raw water intake construction. The future expansion plan is, therefore established to respect the concept of the existing program.

14. Feasibility Study

14.1 Rehabilitation/Modification Plan

As described in the previous Chapter, the rehabilitation program for the existing treatment plant will be implemented as planned.

The construction of the new raw water intake and the raw water transmission pipeline is also included in the modification plan.

Replacement of a part of the existing distribution pipes is recommended in this study on the basis of the network analysis. The replacement of these pipes is included in the scope of the First Phase of the project.

14.2 Expansion Works

The expansion works include the construction of a new treatment plant, an additional raw water intake for the new plant, a transmission pipeline, and distribution pipelines as presented in Chapter 8 in this report.

Implementation of the proposed water supply system is scheduled in accordance with the predicted water demand by year. The construction of the water treatment plant will be done in one stage. The new treatment plant will start operation in 1995 considering the time for the detailed design and the construction works.

The raw water intake and transmission pipeline will be constructed to meet the treatment plant operation.

The construction of the new distribution pipelines will also be separated in one phase as well as the treatment plant. The construction of the pipeline is proposed to be carried out in two years. The replacement of the existing pipes will also be made in this period.

15. IMPLEMENTATION PLAN

The implementation plan is established for the three stages of the process: (i) the pre-construction stage, (ii) the construction stage, and (iii) the operation stage. The necessary processes for each stage are summarized as follows:

(i) Pre-construction stage:

a. Land acquisition
b. Preparation of the PWA's own budget
c. Loan application
d. Selection of the consultants for the detailed design
e. Preparation of the detailed design
f. Pre-qualification of the contractors
g. Tendering
h. Contract award

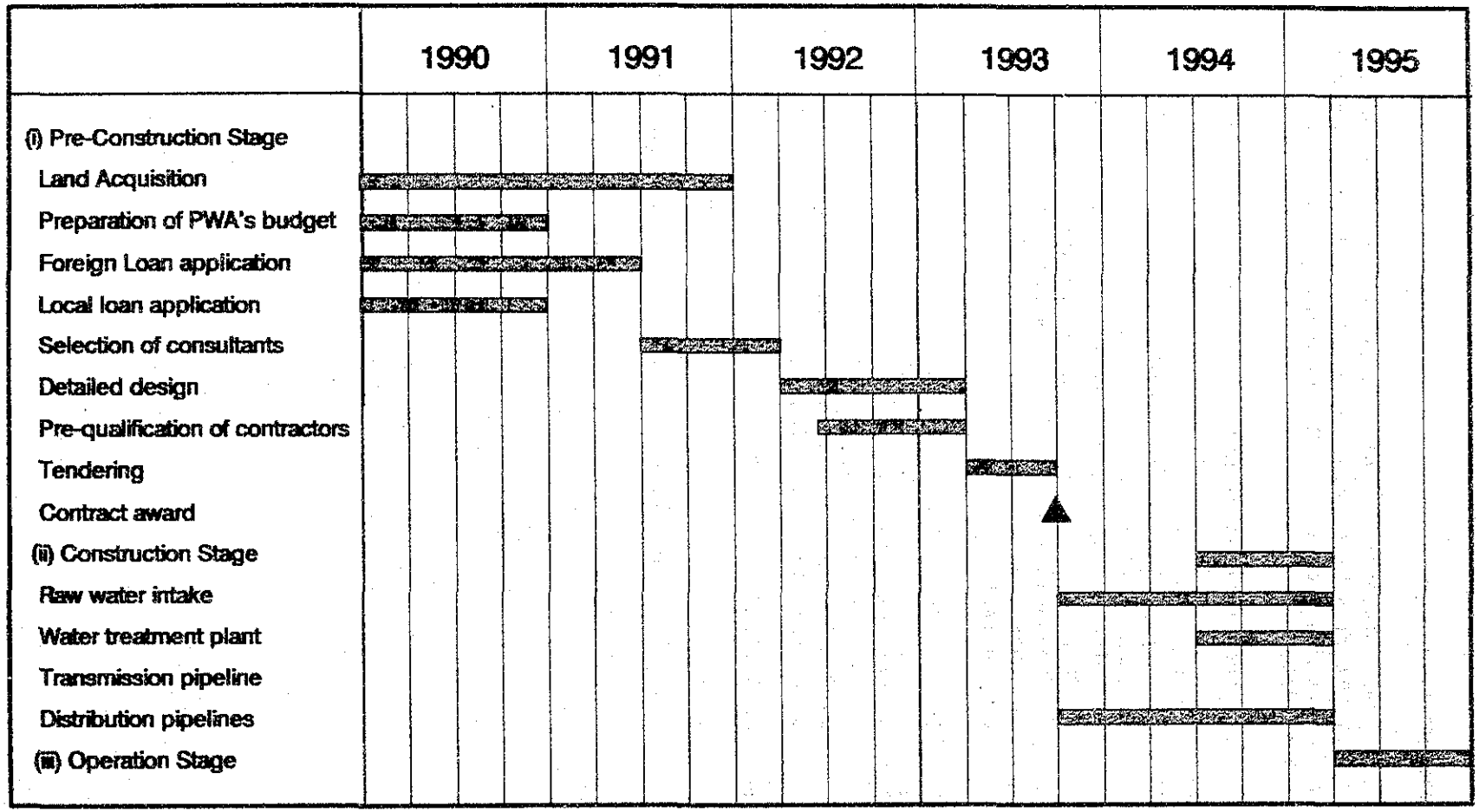
(ii) Construction stage

a. Raw water intake
b. Water treatment plant
c. Transmission pipelines and distribution reservoirs
d. Distribution pipelines

(iii) Operation

The total implementation schedule is as shown in Figure 15-1.

Figure 15 - 1 Implementing Schedule



16. Project Cost Estimates

As the project is proposed to be implemented in one phase, the schedule of the construction cost allocation is also integrated in one phase. The cost summary and breakdown shown in the Chapter 11 are therefore adopted as the one phase cost.

17. FINANCIAL AND ECONOMIC STUDY

17.1 Financial Study

The financial plan for the proposed water supply system is studied to enable the waterworks to take necessary steps for the viable implementation of the project with due consideration on the existing financial practices, potential finding sources to meet the estimated capital costs for the construction and recurrent costs for the operation.

17.1.1 Funding Arrangements

The funds are required largely in two categories for the construction capital and recurrent costs for yearly operating and maintenance of the systems, including debt service, depreciation and other miscellaneous expenses.

1) Cost Estimates

The required costs break down and the implementation-disbursement schedule into annual disbursement for the construction stage are presented in Table 17-1-1. The implementation plan of this program is separated into two stages. Phase I is constructed from 1992 to 1995 and Phase II is planned to be implemented on 2005.

The capital disbursement for the construction is graphically indicated in Figure 17-1-1.

2) Funds for Construction Costs

Out of the total capital costs, the foreign currency portion is financed by the international lending agency which the local currency portion is financed by the government subsidies, PWA's own equity or loan.

Such international loans are normally provided to finance the foreign currency portion of the project costs; however, in certain cases, a part of local currency portion is also financed by international loan when such is desirable.

If the funding capability of the executing agency is not sufficient, the subsidy from the central government to the possible extent may be desirable and more soft loans with low interest and longer period of repayment should be sought.

Table 17-1-1 Implementation/Disbursement Schedule

(Unit : Baht x 1000)

Year	Construction Cost			Engineering Cost						Sub-Total			Contingency			Grand Total		
				Design			Supervision											
	F.C.	L.C.	Total	F.C.	L.C.	Total	F.C.	L.C.	Total	F.C.	L.C.	Total	F.C.	L.C.	Total	F.C.	L.C.	Total
Total	41,616	42,833	84,449	3,663	3,768	7,431	1,832	1,883	3,715	47,111	48,484	95,595	4,162	4,283	8,445	51,273	52,767	104,040
1990	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	2,564	2,638	5,202	0	0	0	2,564	2,638	5,202	0	0	0	2,564	2,638	5,202
1993	5,130	4,279	9,409	1,099	1,130	2,229	275	282	557	6,504	5,691	12,195	513	428	941	7,017	6,119	13,136
1994	28,930	29,786	58,716	0	0	0	1,282	1,319	2,601	30,212	31,105	61,317	2,893	2,979	5,872	33,105	34,084	67,189
1995	7,267	8,487	15,754	0	0	0	275	282	557	7,542	8,769	16,311	727	848	1,575	8,269	9,617	17,886
1996	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1997	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2001	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2002	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2003	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2004	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2005	289	281	570	0	0	0	0	0	0	289	281	570	29	28	57	318	309	627
2006	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2007	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2008	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2009	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2010	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Note: 1.Contingency = 10 % of the total of gross construction cost
2.Engineering Cost (Design) = 4 % of the total construction cost
3.Engineering Cost (Supervision) = 2 % of the total construction cost
4.F.C. Foreign Currency
5.L.C. Local Currency

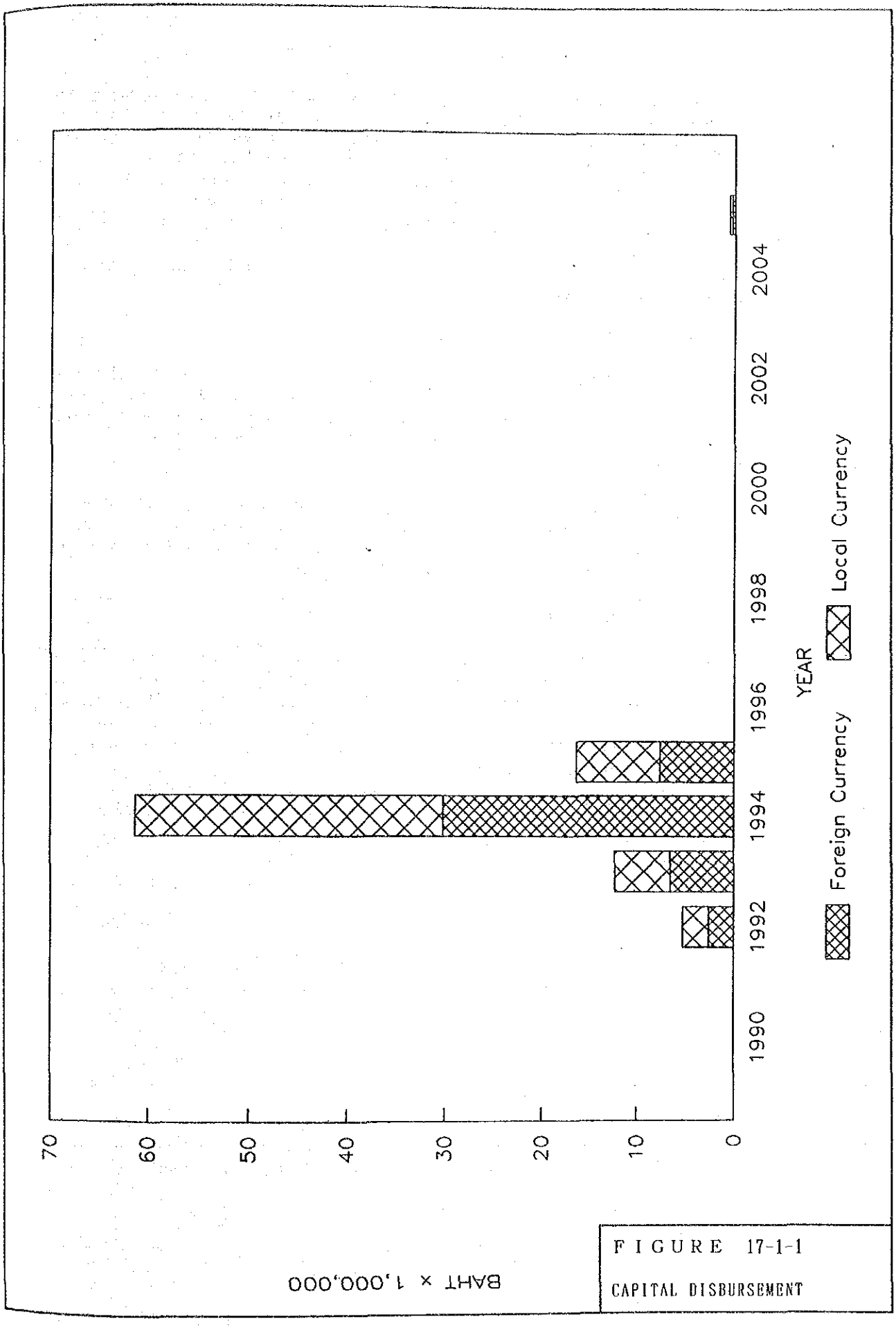


FIGURE 17-1-1

CAPITAL DISBURSEMENT

a. Loan from International Lending Agencies

The international loans are broadly grouped in two categories such as multilateral and bilateral loans. The multilateral loans are regarded as loans from the World Bank and Asian Development Bank. The interest of such loans are presently ranging from 6-8 percent per annum and repayment period is normally 20 years with a grace period of 5 years. The bilateral loans are exemplified by the loan from West Germany, U.S.A. or Japan with very concessionaire terms, for example, low interest rates of 2-3 percent per annum and long maturity periods (up to 30 years) including an extended grace period up to 10 years.

b. Government Subsidy

The subsidy from the central government is allocated to the local municipalities in Thailand for the construction project to develop public utilities such as irrigation and drainage system, sewerage system, feeder roads and other infrastructure development projects.

The water supply development project as proposed to enhance community benefits such as public health and economic development is necessary to be encouraged by the government initiative with allocation of meaningful amount of subsidy.

c. Loan from Domestic Banks

The local currency portion of the capital costs are normally financed by domestic banks, wholly or partly depending on availability of other sources of capital as subsidy. PWA presently borrows the fund from the Krung Thai Bank. In amortization period, PWA pays only interest part and capital repayments are in charge of the national government.

Table 17-1-2 shows loan conditions of international lending agencies.

Table 17-1-2 Loan Conditions

Agency	Interest Rate	Duration (Grace Period) Year	Charge
IBRD	7.74%	15-20 (3-5)	Front-end Fee: ——— Commitment Charge: 0.75%
IDA	0%	40 (10) or 35 (10)	Service Charge: 0.75% Commitment charge: ———
IDB	8.1%	15-25 (4-6)	Commitment Charge: 0.75% Inspection Fee 1% of loan amount
ADB	6.37%	10-30 (2-7)	Commitment Charge: 0.75%
OECF *	2.74%	28.8 (9.6)	———

* Average condition of 1988.

3) Funds for Recurrent Costs

The funds are normally required after the construction of the system to meet the annual costs including operation and maintenance costs, and debt service payment if any loan is provided. There are established practices in the developed counties that such recurrent costs are met by the users of the system who receive the benefits through the collection of water tariff.

17.1.2 Alternative Financing Plan

The financial plans are developed based on the capital disbursement schedule and funding arrangements. The funding arrangements are considered among others one of the most decisive factor for the financial viability of the project. The funding arrangement which will not impose unbearable burden upon the water works is most desirable subject, however, to the availability of sufficient fund or the loan of lenient condition.

The following five alternatives for the funding arrangement are considered to assess the financial impact on the waterworks as well as individual consumer and thereby to select adequate funding arrangement.

Alternative 1 : Total project costs is financed by the international lending agencies (ADB or IBRD).

Alternative 2 : The foreign currency portion equivalent to 47,111 thousand Baht is financed by bilateral loan and local currency portion of 48,484 thousand Baht is financed by the international lending agencies.

Alternative 3 : The foreign currency portion equivalent to 47,111 thousand Baht is financed by bilateral loan and local currency portion of 48,484 thousand Baht is financed by equal contribution of local loan and PWA's own equity allocation.

Alternative 4 : The total of foreign currency portion and a part of local currency portion equivalent to 20,190 thousand Baht (approximately 70 percent of the total project cost) is financed by bilateral loan and 28,294 thousand Baht is financed by equal contribution of local loan and PWA's own equity allocation.

Alternative 5 : The total of foreign currency portion and a part of local currency portion equivalent to 20,190 thousand Baht (approximately 70 percent of the total project cost) is financed by bilateral loan and remaining portion of 28,294 thousand Baht is financed by local loan.

In the alternative plans above, the conditions of the loan are assumed as follows.

IBRD or ADB: 20 year repayment period including 5 year grace period with 7 percent interest per annum.

Bilateral Loan: 30 year repayment period including 10 year grace period with 2.7 percent interest per annum.

Local Loan: 13 year repayment period including 3 year grace period with 11 percent interest per annum and in amortization period, PWA pays only interest part and principal repayments are depended on national government contribution.

Such government funding contribution can also be justified by the prospective increase of socio-economic benefits to be derived from the proposed project as manifested in economic project analysis.

Summarized fund arrangements for each alternative plan are shown in Table 17-1-3.

Table 17-1-3 Funds Arrangements

Unit : Baht x 1,000

Funds Plan	Source of Fund			
	International Loan	Bilateral Loan	Local Loan	PWA's own Equity
Alternative 1	95,595			
Alternative 2	48,484	47,111		
Alternative 3		47,111	24,242	24,242
Alternative 4		67,301	14,147	14,147
Alternative 5		67,301	28,294	

The sources of capital costs and subsequent recurrent costs including debt services and operation and maintenance costs are indicated in alternative funding plans in Table 17-1-4 and the funding burden to be imposed on PWA in each alternative is highlighted in Figure 17-1-2.

As clearly shown in this figure, the Alternatives 3 and 4 appear more agreeable since required funds from PWA in successive years are less than other alternatives. Although there is no significant difference in graphic indication between Alternatives 3 and 4, Alternative 4 imposes less initial funding burden on PWA during construction stage.

Alternative 4 is, therefore assumed as a recommendable funding arrangement. The further financing analysis are made based on this alternative to identify the various factors necessary for making the project financially viable.

Tables 17-1-5 to 17-1-7 show the detail debt service for Alternative 4 financing plan and Table 17-4 shows summarized project cost and funding allocation of Alternative 4.

Table 17-1-4 Capital and Annual Costs Cash Outlay

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Alternative 1																
Capital Costs																
PWA's Equity																
Subsidy																
Foreign loan	0	0	5,202	12,195	61,317	16,311	0	0	0	0	0	0	0	0	0	570
Local loan																
Recurrent Costs																
O/M costs	2,513	3,602	3,733	3,982	4,131	5,678	7,111	7,385	7,671	8,123	8,446	8,893	9,429	10,806	11,431	12,151
Debt Service	0	0	364	1,218	5,510	6,652	6,652	10,433	10,433	10,433	10,433	10,433	10,433	10,433	10,433	10,473
Total	2,513	3,602	4,097	5,200	9,641	12,330	13,763	17,818	18,104	18,556	18,879	19,326	19,862	21,239	21,864	23,194
Alternative 2																
Capital Costs																
PWA's Equity																
Subsidy																
Foreign loan(1)	0	0	2,564	6,504	30,212	7,542	0	0	0	0	0	0	0	0	0	289
Foreign loan(2)	0	0	2,638	5,691	31,105	8,769	0	0	0	0	0	0	0	0	0	281
Recurrent Costs																
O/M costs	2,513	3,602	3,733	3,982	4,131	5,678	7,111	7,385	7,671	8,123	8,446	8,893	9,429	10,806	11,431	12,151
Debt Service	0	0	254	828	3,821	4,638	4,638	6,557	6,557	6,557	6,557	6,557	8,353	8,353	8,353	8,380
Total	2,513	3,602	3,987	4,810	7,952	10,316	11,749	13,942	14,228	14,680	15,003	15,450	17,782	19,159	19,784	21,101
Alternative 3																
Capital Costs																
PWA's Equity	0	0	1,319	2,846	15,553	4,385	0	0	0	0	0	0	0	0	0	141
Subsidy	0	0	0	0	0	601	667	740	1,265	1,405	1,559	1,825	2,026	2,329	2,585	1,163
Foreign loan	0	0	2,564	6,504	30,212	7,542	0	0	0	0	0	0	0	0	0	289
Local loan	0	0	1,319	2,846	15,553	4,385	0	0	0	0	0	0	0	0	0	141
Recurrent Costs																
O/M costs	2,513	3,602	3,733	3,982	4,131	5,678	7,111	7,385	7,671	8,123	8,446	8,893	9,429	10,806	11,431	12,151
Debt Service	0	0	214	703	3,229	5,094	5,094	5,094	5,357	5,357	5,357	5,357	7,153	7,153	7,153	3,828
Total	2,513	3,602	5,266	7,531	22,913	15,157	12,205	12,479	13,028	13,480	13,803	14,250	16,582	17,959	18,584	15,979
Alternative 4																
Capital Costs																
PWA's Equity	0	0	770	1,452	9,079	2,769	0	0	0	0	0	0	0	0	0	79
Subsidy	0	0	0	0	0	305	338	375	744	826	917	1,096	1,216	1,364	1,514	816
Foreign loan	0	0	3,663	9,291	43,160	10,774	0	0	0	0	0	0	0	0	0	413
Local loan	0	0	770	1,452	9,079	2,769	0	0	0	0	0	0	0	0	0	79
Recurrent Costs																
O/M costs	2,513	3,602	3,733	3,982	4,131	5,678	7,111	7,385	7,671	8,123	8,446	8,893	9,429	10,806	11,431	12,151
Debt Service	0	0	184	594	2,758	4,029	4,029	4,029	4,195	4,195	4,195	4,195	6,761	6,761	6,761	4,862
Total	2,513	3,602	4,687	6,028	15,968	12,476	11,140	11,414	11,866	12,318	12,641	13,088	16,190	17,567	18,192	17,013
Alternative 5																
Capital Costs																
PWA's Equity																
Subsidy	0	0	0	0	0	609	676	751	1,489	1,653	1,835	2,191	2,432	2,728	3,028	1,631
Foreign loan	0	0	3,663	9,291	43,160	10,774	0	0	0	0	0	0	0	0	0	413
Local loan	0	0	1,539	2,904	18,157	5,537	0	0	0	0	0	0	0	0	0	157
Recurrent Costs																
O/M costs	2,513	3,602	3,733	3,982	4,131	5,678	7,111	7,385	7,671	8,123	8,446	8,893	9,429	10,806	11,431	12,151
Debt Service	0	0	268	838	4,001	6,253	6,253	6,253	6,584	6,584	6,584	6,584	9,150	9,150	9,150	5,341
Total	2,513	3,602	4,001	4,820	8,132	11,931	13,364	13,638	14,255	14,707	15,030	15,477	18,579	19,956	20,581	17,492

Table 17-1-4 Capital and Annual Costs Cash Outlay (Cont'd) (Unit : Bath x 1000)

Year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Alternative 1															
Capital Costs															
PWA's Equity															
Subsidy															
Foreign loan															
Local loan															
Recurrent Costs															
O/M costs	13,050	13,788	14,915	16,007	16,661	17,618	17,618	17,618	17,618	17,618	17,618	17,618	17,618	17,618	17,618
Debt Service	10,473	10,473	10,473	10,473	10,496	10,496	63	63	63	63	63	63	63	63	63
Total	23,523	24,261	25,388	26,480	27,157	28,114	17,681	17,681	17,681	17,681	17,681	17,681	17,681	17,681	17,681
Alternative 2															
Capital Costs															
PWA's Equity															
Subsidy															
Foreign loan(1)															
Foreign loan(2)															
Recurrent Costs															
O/M costs	13,050	13,788	14,915	16,007	16,661	17,618	17,618	17,618	17,618	17,618	17,618	17,618	17,618	17,618	17,618
Debt Service	8,380	8,380	8,392	8,392	8,392	8,392	3,099	3,099	3,099	3,110	3,110	3,110	3,110	3,110	3,110
Total	21,430	22,168	23,307	24,399	25,053	26,010	20,717	20,717	20,717	20,728	20,728	20,728	20,728	20,728	20,728
Alternative 3															
Capital Costs															
PWA's Equity															
Subsidy	1,291	1,434	477	530	588	383	425	246	273	303	337	374			
Foreign loan															
Local loan															
Recurrent Costs															
O/M costs	13,050	13,788	14,915	16,007	16,661	17,618	17,618	17,618	17,618	17,618	17,618	17,618	17,618	17,618	17,618
Debt Service	3,828	3,828	3,092	3,092	3,092	3,092	3,092	3,092	3,092	3,103	3,103	3,103	3,079	3,079	3,079
Total	16,878	17,616	18,007	19,099	19,753	20,710	20,710	20,710	20,710	20,721	20,721	20,721	20,697	20,697	20,697
Alternative 4															
Capital Costs															
PWA's Equity															
Subsidy	905	1,005	257	285	317	132	146	122	136	151	168	186			
Foreign loan															
Local loan															
Recurrent Costs															
O/M costs	13,050	13,788	14,915	16,007	16,661	17,618	17,618	17,618	17,618	17,618	17,618	17,618	17,618	17,618	17,618
Debt Service	4,862	4,862	4,397	4,397	4,397	4,397	4,397	4,397	4,397	4,412	4,412	4,412	4,399	4,399	4,399
Total	17,912	18,650	19,312	20,404	21,058	22,015	22,015	22,015	22,015	22,030	22,030	22,030	22,017	22,017	22,017
Alternative 5															
Capital Costs															
PWA's Equity															
Subsidy	1,811	2,010	514	570	633	263	292	245	272	302	335	372			
Foreign loan															
Local loan															
Recurrent Costs															
O/M costs	13,050	13,788	14,915	16,007	16,661	17,618	17,618	17,618	17,618	17,618	17,618	17,618	17,618	17,618	17,618
Debt Service	5,341	5,341	4,410	4,410	4,410	4,410	4,410	4,410	4,410	4,426	4,426	4,426	4,399	4,399	4,399
Total	18,391	19,129	19,325	20,417	21,071	22,028	22,028	22,028	22,028	22,044	22,044	22,044	22,017	22,017	22,017

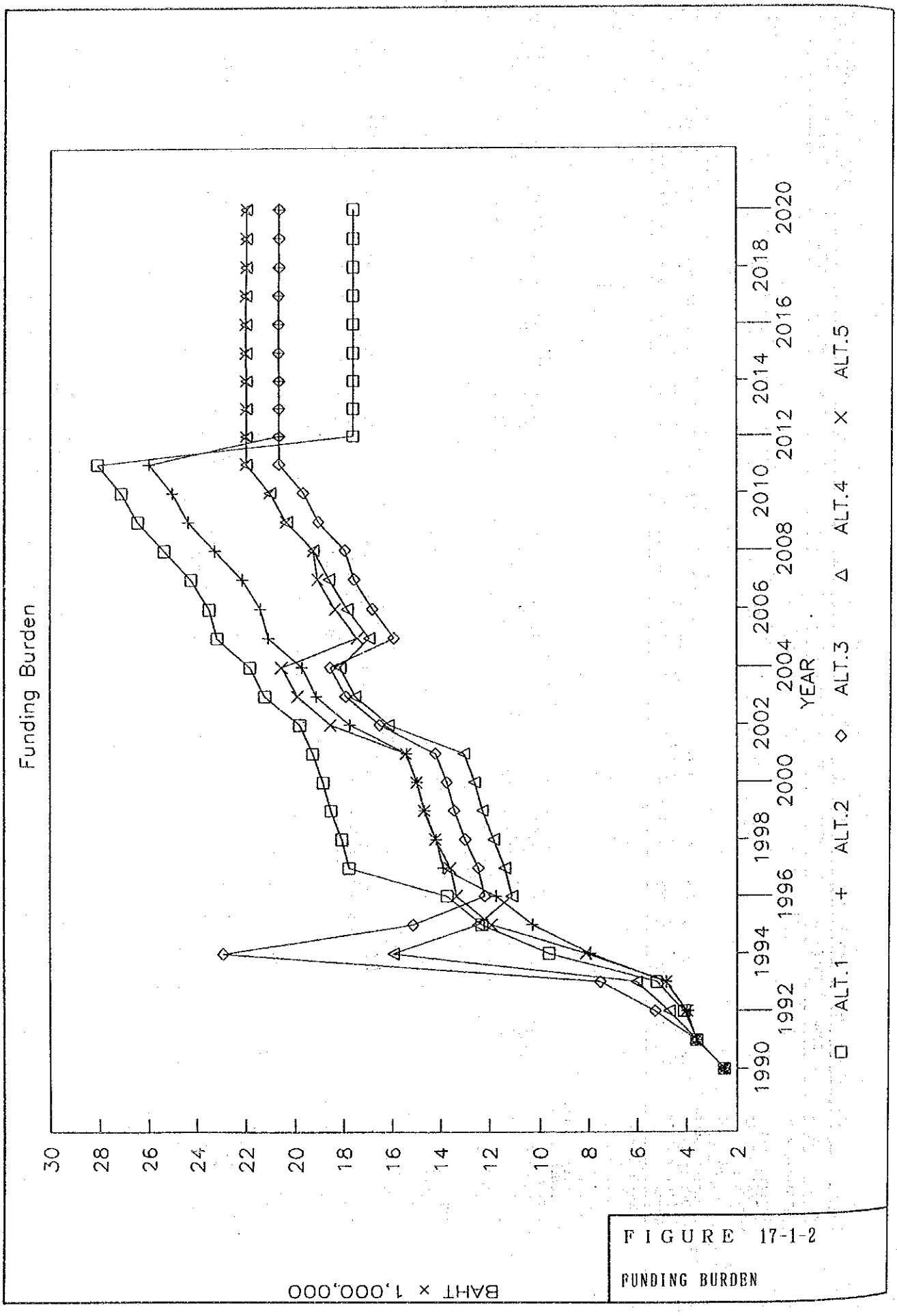


FIGURE 17-1-2

FUNDING BURDEN

Appendix A17-1-1 to A17-1-5 shows details of debt services for each alternative plans.

Table 17-1-8 Project Cost, Disbursement Schedule and Funding Allocation of Alternative 4

a. Project Cost and Disbursement Schedule

(Unit : Baht x 1,000)

Year	Foreign Portion	Local Portion	Total
1990	0	0	0
1991	0	0	0
1992	2,564	2,638	5,202
1993	6,504	5,691	12,195
1994	30,212	31,105	61,317
1995	7,542	8,769	16,311
1996	0	0	0
1997	0	0	0
1998	0	0	0
1999	0	0	0
2000	0	0	0
2001	0	0	0
2002	0	0	0
2003	0	0	0
2004	0	0	0
2005	289	281	570
Total	47,111	48,484	95,595

b. Funding allocation

(Unit : Baht x 1,000)

Year	Bilateral Loan	Local Loan	PWA's Equity	Total
1990	0	0	0	0
1991	0	0	0	0
1992	3,663	769.5	769.5	5,202
1993	9,291	1,452.0	1,452.0	12,195
1994	43,160	9,078.5	9,078.5	61,317
1995	10,774	2,768.5	2,768.5	16,311
1996	0	0	0	0
1997	0	0	0	0
1998	0	0	0	0
1999	0	0	0	0
2000	0	0	0	0
2001	0	0	0	0
2002	0	0	0	0
2003	0	0	0	0
2004	0	0	0	0
2005	413	78.5	78.5	570
Total	67,381	14,147.0	14,147.0	95,595

Table 17-1-5 Debt Services (Alternative 4)
for Foreign Portion

(Unit : Baht x 1000)

Year	Capital	Interest	Total Annual Repayment	Balance of Capital
1992	0	99	99	3,663
1993	0	350	350	12,954
1994	0	1,515	1,515	56,114
1995	0	1,806	1,806	66,888
1996	0	1,806	1,806	66,888
1997	0	1,806	1,806	66,888
1998	0	1,806	1,806	66,888
1999	0	1,806	1,806	66,888
2000	0	1,806	1,806	66,888
2001	0	1,806	1,806	66,888
2002	2,566	1,806	4,372	66,888
2003	2,635	1,737	4,372	64,322
2004	2,707	1,666	4,372	61,686
2005	2,780	1,604	4,383	59,393
2006	2,855	1,529	4,383	56,613
2007	2,932	1,451	4,383	53,758
2008	3,011	1,372	4,383	50,826
2009	3,092	1,291	4,383	47,815
2010	3,176	1,208	4,383	44,723
2011	3,262	1,122	4,383	41,547
2012	3,350	1,034	4,383	38,286
2013	3,440	943	4,383	34,936
2014	3,533	850	4,383	31,496
2015	3,644	755	4,399	27,963
2016	3,743	657	4,399	24,319
2017	3,844	556	4,399	20,577
2018	3,947	452	4,399	16,733
2019	4,054	345	4,399	12,786
2020	4,163	236	4,399	8,732
2021	4,276	123	4,399	4,568
2022	19	8	27	293
2023	20	7	27	274
2024	20	7	27	254
2025	21	6	27	234
2026	21	6	27	213
2027	22	5	27	192
2028	22	5	27	170
2029	23	4	27	148
2030	24	3	27	125
2031	24	3	27	101
2032	25	2	27	77
2033	26	1	27	52
2034	26	1	27	26
Total	67,301	35,399	102,700	

Table 17-1-6 Debt Services (Alternative 4)
for Local Portion

(Unit : Baht x 1000)

Year	Capital	Interest	Total Annual Repayment	Balance of Capital
1992	0	85	85	770
1993	0	244	244	2,222
1994	0	1,243	1,243	11,300
1995	676	1,548	2,223	14,069
1996	750	1,473	2,223	13,393
1997	833	1,391	2,223	12,643
1998	1,090	1,299	2,389	11,810
1999	1,210	1,179	2,389	10,720
2000	1,343	1,046	2,389	9,511
2001	1,490	898	2,389	8,168
2002	1,654	735	2,389	6,678
2003	1,836	553	2,389	5,023
2004	2,038	351	2,389	3,187
2005	344	135	479	1,227
2006	382	97	479	884
2007	424	55	479	502
2008	5	9	13	79
2009	5	8	13	74
2010	6	8	13	69
2011	6	7	13	63
2012	7	6	13	56
2013	8	5	13	49
2014	9	5	13	41
2015	10	4	13	33
2016	11	3	13	23
2017	12	1	13	12
Total	14,147	12,386	26,533	

Table 17-1-7 Debt Services (Alternative 4)

(Unit : Baht x 1000)

Year	Capital	Interest	Total Annual Repayment	Balance of Capital
1992	0	184	184	4,433
1993	0	594	594	15,176
1994	0	2,758	2,758	67,414
1995	676	3,354	4,029	80,957
1996	750	3,279	4,029	80,281
1997	833	3,197	4,029	79,531
1998	1,090	3,105	4,195	78,698
1999	1,210	2,985	4,195	77,608
2000	1,343	2,852	4,195	76,399
2001	1,490	2,704	4,195	75,056
2002	4,220	2,541	6,761	73,566
2003	4,472	2,289	6,761	69,345
2004	4,745	2,016	6,761	64,873
2005	3,123	1,739	4,862	60,620
2006	3,236	1,626	4,862	57,497
2007	3,355	1,507	4,862	54,260
2008	3,016	1,381	4,397	50,905
2009	3,097	1,299	4,397	47,889
2010	3,182	1,215	4,397	44,792
2011	3,268	1,129	4,397	41,610
2012	3,357	1,040	4,397	38,342
2013	3,448	949	4,397	34,986
2014	3,542	855	4,397	31,538
2015	3,654	759	4,412	27,996
2016	3,753	659	4,412	24,342
2017	3,856	557	4,412	20,589
2018	3,947	452	4,399	16,733
2019	4,054	345	4,399	12,786
2020	4,163	236	4,399	8,732
2021	4,276	123	4,399	4,568
2022	19	8	27	293
2023	20	7	27	274
2024	20	7	27	254
2025	21	6	27	234
2026	21	6	27	213
2027	22	5	27	192
2028	22	5	27	170
2029	23	4	27	148
2030	24	3	27	125
2031	24	3	27	101
2032	25	2	27	77
2033	26	1	27	52
2034	26	1	27	26
Total	81,448	47,785	129,233	

17.1.3 Revenue Plan

1) Water Sales

The revenue is required to be raised by waterworks to meet the annual cash requirement after the construction of the systems. Such annual cash requirements normally include the operation and maintenance costs as well as debt service if a certain loan is made to finance the capital costs.

a. PWA Water Tariff Schedule

Water tariffs are collected by reading water meters with the exception of negligible direct sale fees. PWA has three major sources of tariff revenue: namely, water sales, service charges and connection fees. Revenue from these tariffs contribute 95 percent to the total revenue of PWA. All the waterworkes have the same income structure as this. PWA also applies the same water tariff structure to all waterworks. Table 17-1-9 shows the current levels of water tariff structure.

Table 17-1-9 Present Water Tariff Structure

Consumption (cu m / mo)	Tariff (Baht / cu m)
0 - 10	3.75
11 - 20	4.50
21 - 30	6.50
31 - 50	7.50
51 - 80	8.00
81 - 100	8.50
101 - 300	9.00
300 - 1,000	9.25
1,100 - 2,000	9.50
2,001 - 3,000	9.75
3,001 and above	10.00

Connection Fees and Service Charges:

These fees and charges are of the nature which cover actual expenses to be borne by the consumers for connection work. PWA accounts these fees and charges as revenue sources as they actually form a significant part of its revenue.

Present Connection Fees:

The minimum connection fee is set at 2,050 Baht for 1/2" diameter pipe with a length of 10 meters. The additional fee can be added substantially to the total cost of a connection - for example a new 1/2" connection with a length of 30 meters from the main pipe which could cost over double that for an equivalent connection 10 meters from the main. The additional fees are not charged according to a fixed scale, but instead are levied by PWA on an ad hoc basis charges for the labor and material costs.

Present connection charge and estimated connection fees are shown in Tables 17-1-10 and 17-1-11, respectively.

Table 17-1-10 Present Connection Charge

Size of Connection	Basis Connection Fee (for connection less than 10 meters from main pipe) (Baht / conn.)
1/2"	2,050
3/4"	2,750
1"	3,750
1-1/2"	6,690
2"	9,575
2-1/2"	13,075
3"	15,495
4"	21,455
6"	30,025

Note: Basic connection fee is applied to the connection less than 10 m from the main pipe

Table 17-1-11 Connection Fee

Size of Conn. (inch)	0.5	0.75	1	1.5	2	2.5	3	4	6	
Conn. charge (Bath/conn.)	2,050	2,750	3,750	6,690	9,575	13,075	15,495	21,455	30,025	Conn. Charge
Year	No. of Conn.									(Bath x 1000)
1990	100	1	0	0	0	0	0	0	0	208
1991	102	1	0	0	0	0	0	0	0	212
1992	190	2	1	2	0	0	0	0	0	412
1993	200	2	1	2	0	0	0	0	0	433
1994	210	2	1	2	0	0	0	0	0	453
1995	219	2	1	2	0	0	0	0	0	472
1996	229	2	1	0	0	0	1	0	0	494
1997	220	3	0	2	0	0	0	0	0	473
1998	228	3	0	2	0	0	0	0	0	489
1999	237	3	0	2	0	0	0	0	0	507
2000	246	3	0	2	0	0	0	0	0	526
2001	255	0	2	1	0	0	1	0	0	552
2002	308	3	0	2	0	0	0	0	0	653
2003	322	3	0	2	0	0	0	0	0	682
2004	336	3	0	2	0	0	0	0	0	710
2005	349	3	0	2	0	0	0	0	0	737
2006	363	2	1	0	0	0	2	0	0	784
2007	352	3	0	2	0	0	0	0	0	743
2008	365	3	0	2	0	0	0	0	0	770
2009	376	3	0	2	0	0	0	0	0	792
2010	388	3	0	2	0	0	0	0	0	817
2011	400	2	0	2	0	0	2	0	0	870

Service charges are levied on consumers according to the size of

their connection,and increase rapidly for larger connections. The service charge is levied monthly and is fixed, regardless of the level of water consumption during a given month. Present service charges are shown in Table 17-1-12 below.

Table 17-1-12 Present Service Charge

Size of connection	Monthly Service Charge (Baht)
1/2"	10
3/4"	15
1"	30
1-1/2"	60
2"	100
2-1/2"	120
3"	160
4" and above	200

Service charges are estimated by multiplying the number of connections by the service charge per connection as shown in Table 17-1-13.

Table 17-1-13 Service Charge

Size of Conn. (inch)	0.5	0.75	1	1.5	2	2.5	3	4 & above	
Conn. charge (Bath/month.)	10	15	30	60	100	120	160	200	Total Service Charge
Year				No. of Conn.					(Bath x 1000)
1990	2,121	62	61	40	0	0	3	0	26.9
1991	2,223	63	61	40	0	0	3	0	27.9
1992	2,413	65	62	42	0	0	3	0	30.0
1993	2,613	67	63	44	0	0	3	0	32.1
1994	2,823	69	64	46	0	0	3	0	34.4
1995	3,042	71	65	48	0	0	3	0	36.8
1996	3,271	73	66	46	0	0	4	0	39.2
1997	3,491	76	66	48	0	0	4	0	41.6
1998	3,719	79	66	50	0	0	4	0	44.1
1999	3,956	82	66	52	0	0	4	0	46.5
2000	4,202	85	66	54	0	0	4	0	49.2
2001	4,457	85	68	55	0	0	5	0	52.0
2002	4,765	88	68	57	0	0	5	0	55.3
2003	5,087	91	68	59	0	0	5	0	58.7
2004	5,423	94	68	61	0	0	5	0	62.1
2005	5,772	97	68	63	0	0	5	0	65.8
2006	6,135	99	69	63	0	0	7	0	69.8
2007	6,487	102	69	65	0	0	7	0	73.6
2008	6,852	105	69	67	0	0	7	0	77.3
2009	7,228	108	69	69	0	0	7	0	81.2
2010	7,616	111	69	71	0	0	7	0	85.3
2011	8,016	113	69	73	0	0	9	0	89.7

b. Project Water Sales Revenue

Water Sales of the waterworks are estimated as tabulated in Table 17-1-14 with the following conditions adopted in the forecasting.

i) Water tariffs will remain unchanged until 2020.

ii) Water sales are estimated by use for domestic, commercial, institutional, industrial and other use as predicted in each year.

iii) Water sales are calculated from the monthly average water consumption multiplied by water tariff.

In the PWA's water tariff system, water charge is levied on consumers according to metered water consumption after every month. Charging method is to levey a progressive method for the amount metered. Prior to the increases, charges were levied on a sliding scale. Thus, for example, a consumer using 25 cu m of water in a month would pay 3.75 Baht per cu m for the first 10 cu m, 4.50 Baht per cu m for the next 10 cu m and 6.50 Baht per cu m only for the last 5 cu m above 20 cu m, so that a total payment will be 115 Baht.

Teble 17-1-14 Water Sales

(1)Domestic

Item/Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Water Sales (cu.m/d)	1,661	1,750	1,891	2,040	2,197	2,362	2,535	2,709	2,892	3,083	3,282	3,490
(cu.m/month)	49,830	52,500	56,730	61,200	65,910	70,860	76,050	81,270	86,760	92,490	98,460	104,700
No.of Connections	2,121	2,223	2,413	2,613	2,823	3,042	3,271	3,491	3,719	3,956	4,202	4,457
Water Cons./Conn.	23.49	23.62	23.51	23.42	23.35	23.29	23.25	23.26	23.33	23.38	23.43	23.49
Water Sales(Baht x1000)	223	236	254	274	294	316	339	362	387	413	440	469

(2)Governmental/Institutional

Item/Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Water Sales (cu.m/d)	603	612	621	631	640	649	659	669	681	691	702	712
(cu.m/month)	18,090	18,360	18,630	18,930	19,200	19,470	19,770	20,070	20,438	20,730	21,060	21,360
No.of Connections	40	40	42	44	46	48	46	48	50	52	54	55
Water Cons./Conn.												
Water Sales(Baht x1000)	163	165	168	169	172	174	177	180	183	184	187	188

(3)Commercial

Item/Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Water Sales (cu.m/d)	127	129	132	134	136	138	140	141	142	143	144	145
(cu.m/month)	3,810	3,870	3,960	4,020	4,080	4,140	4,200	4,230	4,260	4,290	4,320	4,350
No.of Connections	42	42	43	44	45	46	45	46	47	48	49	48
Water Cons./Conn.	90.71	92.14	92.09	91.36	90.67	90.00	93.33	91.96	90.64	89.38	88.16	90.63
Water Sales(Baht x1000)	26	27	28	28	28	29	29	29	30	30	30	30

(4)Industrial

Item/Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Water Sales (cu.m/d)	27	28	30	32	34	36	38	41	43	45	48	50
(cu.m/month)	810	840	900	960	1,020	1,080	1,140	1,230	1,290	1,350	1,440	1,500
No.of Connections	20	21	22	23	24	25	28	30	32	34	36	37
Water Cons./Conn.	40.50	40.00	40.91	41.74	42.50	43.20	40.71	41.00	40.31	39.71	40.00	40.54
Water Sales(Baht x1000)	5	5	5	5	6	6	6	7	7	7	8	8

(5)Tourism

Item/Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Water Sales (cu.m/d)	979	996	1,012	1,028	1,045	1,061	1,078	1,085	1,092	1,100	1,107	1,114
(cu.m/month)	29,370	29,880	30,360	30,840	31,350	31,830	32,340	32,550	32,760	33,000	33,210	33,420
No.of Connections	61	61	62	63	64	65	66	66	66	66	66	68
Water Cons./Conn.	481.48	489.84	489.68	489.52	489.84	489.69	490.00	493.18	496.36	500.00	503.18	491.47
Water Sales(Baht x1000)	255	260	264	268	273	277	281	283	285	288	290	291

(6)Others

Item/Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Water Sales (cu.m/d)	256	267	284	302	321	340	361	382	404	426	450	475
(cu.m/month)	7,680	8,010	8,520	9,060	9,630	10,200	10,830	11,460	12,120	12,780	13,500	14,250
No.of Connections	3	3	3	3	3	3	4	4	4	4	4	5
Water Cons./Conn.	2,560.00	2,670.00	2,840.00	3,020.00	3,210.00	3,400.00	2,707.50	2,865.00	3,030.00	3,195.00	3,375.00	2,850.00
Water Sales(Baht x1000)	72	75	80	85	91	97	102	108	114	121	128	134

Total	744	768	799	829	864	899	934	969	1,006	1,043	1,083	1,120

Table 17-1-14 (Cont'd)

(1)Domestic

Item/Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Water Sales (cu.m/d)	3,727	3,976	4,236	4,509	4,794	5,078	5,374	5,682	6,001	6,333
(cu.m/month)	111,810	119,280	127,080	135,270	143,820	152,340	161,220	170,460	180,030	189,990
No.of Connections	4,765	5,087	5,423	5,772	6,135	6,487	6,852	7,228	7,616	8,016
Water Cons./Conn.	23.46	23.45	23.43	23.44	23.44	23.48	23.53	23.58	23.64	23.70
Water Sales(Baht x1000)	500	534	568	605	643	682	723	765	809	854

(2)Governmental/Institu

Item/Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Water Sales (cu.m/d)	726	738	750	763	775	790	804	819	832	847
(cu.m/month)	21,780	22,140	22,500	22,890	23,250	23,700	24,120	24,570	24,960	25,410
No.of Connections	57	59	61	63	63	65	67	69	71	73
Water Cons./Conn.										
Water Sales(Baht x1000)	191	194	197	200	204	207	210	214	217	221

(3)Commercial

Item/Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Water Sales (cu.m/d)	145	146	146	146	147	147	147	147	148	148
(cu.m/month)	4,350	4,380	4,380	4,380	4,410	4,410	4,410	4,410	4,440	4,440
No.of Connections	48	48	48	48	49	49	49	49	49	49
Water Cons./Conn.	90.63	91.25	91.25	91.25	90.00	90.00	90.00	90.00	90.61	90.61
Water Sales(Baht x1000)	30	30	30	30	31	31	31	31	31	31

(4)Industrial

Item/Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Water Sales (cu.m/d)	53	57	60	63	67	70	74	78	82	86
(cu.m/month)	1,590	1,710	1,800	1,890	2,010	2,100	2,220	2,340	2,460	2,580
No.of Connections	40	43	46	49	50	53	56	59	62	64
Water Cons./Conn.	39.75	39.77	39.13	38.57	40.20	39.62	39.64	39.66	39.68	40.31
Water Sales(Baht x1000)	9	9	10	10	11	12	12	13	14	14

(5)Tourism

Item/Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Water Sales (cu.m/d)	1,117	1,121	1,124	1,127	1,130	1,131	1,133	1,134	1,135	1,137
(cu.m/month)	33,510	33,630	33,720	33,810	33,900	33,930	33,990	34,020	34,050	34,110
No.of Connections	68	68	68	68	69	69	69	69	69	69
Water Cons./Conn.	492.79	494.56	495.88	497.21	491.30	491.74	492.61	493.04	493.48	494.35
Water Sales(Baht x1000)	292	293	294	295	295	295	296	296	297	297

(6)Others

Item/Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Water Sales (cu.m/d)	503	533	563	596	629	663	698	734	772	811
(cu.m/month)	15,090	15,990	16,890	17,880	18,870	19,890	20,940	22,020	23,160	24,330
No.of Connections	5	5	5	5	7	7	7	7	7	9
Water Cons./Conn.	3,018.00	3,198.00	3,378.00	3,576.00	2,695.71	2,841.43	2,991.43	3,145.71	3,308.57	2,703.33
Water Sales(Baht x1000)	142	151	160	170	177	187	197	208	219	228

Total	1,164	1,211	1,259	1,310	1,361	1,414	1,469	1,527	1,587	1,645