Table 10.7 Annual Operation and Maintenance Costs for the Treatment Plant

Unit: Million Baht at 2524(1981) Price Level

Item	Cost	Remarks
Power cost	6.85	
Repairing cost	7.11	Including sludge transportation
Chemicals cost	0.33	
Total	14.29	

10.3 Capital Investment Schedule

An implementation schedule for the First Stage is presented in Table 10.8. The assumptions made for the implementation schedule are: (1) one-year period is needed for detailed design, and (2) four-year period is needed for the construction of treatment plant.

The disbursement schedule for the five-year period from 2527 (1984) to 2531 (1988) is planned based on the above implementation schedule and the project cost, and presented in Table 10.9.

The descriptions of implementation schedule for each item are as follows:

a) Consulting Services

In the year 2527(1984), engineering consultants will be employed for detailed design. The designs of sewers, intermediate pumping stations and treatment plant will be made based on the preliminary designs prepared in the present feasibility study report.

Throughout the course of construction activities, construction supervision will be made by expatriate engineers with cooperation of local consultants.

b) Land Acquisition

Land acquisition for the intermediate pumping stations and the treatment plant will be finished by the beginning year of construction for each facility.

c) Sewer

Construction of the interceptors is distributed over the two-year construction period, considering the financial burden on the agency.

d) Intermediate Pumping Stations

As the intermediate pumping stations are intended to pump up wastewater of the interceptors, their construction is timed to the construction of each corresponding interceptor.

e) Treatment Plant

With due consideration of the condition of treatment plant site which is mostly ponds at present, construction of the treatment plant will be commenced from the civil and architectural works, and afterward the mechanical and electrical works will be made.

f) Cleaning Machine and Laboratory Equipment

In the year 2531 (1988), the cleaning machine and laboratory equipment will be provided for cleaning of sewers and testing of wastewater quality.

Table 10.8 Implementation Schedule for the Sewerage Facilities in the First Stage

Item \ Year	2526 (1983)	2527 (1984)	2528 (1985)	2529 (1986)	2530 (1987)
I) Sewers					
1. Chula Interceptor	.....	.....	.....	C	
2. Charoen Krung Interceptor	.....	.....	.....	C	
3. Klong Sathorn Interceptor	.....	.....	.....	C	
4. Chong Nonsi Combined Sewer	.....	.....	.....	C	
5. Trunk Interceptor	.....	.....	.....	C	
II) Intermediate Pumping Station					
1. Chula Intermediate Pumping Station	.....	.....	.....	.....	C,A,M&E
2. Charoan Krung Intermediate Pumping Station	.....	.....	.....	.....	C,A,M&E
3. Klong Sathorn Intermediate Pumping Station	.....	.....	.....	.....	C,A,M&E
III) Treatment Plant					
1. Pumping & Operating Building	.....	C & A	M & E		
2. Grit Chamber	.....	C & A	M		.....
3. Aeration Tank	.....	C & A	M & E		.....
4. Final Sedimentation Tank	.....	.....	C & A		M & E
5. Chlorination Chamber	.....	.....	C & A		M & E
6. Outlet	.....	.....	C	.....	.....
7. Thickening Tank	.....	.....	C & A		M
8. Digestion Tank	.....	.....	C & A		M & E
9. Gas Holder	.....	.....	C & A		M
10. Drying Bed	.....	.....	C & A		M
11. Electric Room	.....	.....	C & A	E	
12. Power Receiving	.....	.....	C & A	E	
13. Labor Room	.....	.....	C & A	.....	.....
14. Earthwork	.....	C	C		.....
15. Land Scaping	.....	.....	C & A		E
IV) Cleaning Machine & Laboratory Equipment	.....	.....	.....	.....	
V) Land Acquisition					
1. Chula Intermediate Pumping Station	.....	.....	.....		.....
2. Charoan Krung Intermediate Pumping Station	.....	.....	.....		.....
3. Klong Sathorn Intermediate Pumping Station	.....	.....	.....		.....
4. Treatment Plant		.....	.....	.....	.....
VI) Consulting Services					
1) Engineering Design		.....	.....	.....	.....
2) Supervision	.....				

Note: C: Civil Works A:Architectural Works M: Mechanical Works E: Electrical Works

Table 10.9 Disbursement Schedule in the First Stage

Item \ Year	2527 (1984)			2528 (1985)			2529 (1986)			2530 (1987)			2531 (1988)			Total		
	F.C.	L.C.	Sub-total	F.C.	L.C.	Sub-total	F.C.	L.C.	Sub-total	F.C.	L.C.	Sub-total	F.C.	L.C.	Sub-total	F.C.	L.C.	Sub-total
1. Sewers	-	-	-	-	-	-	-	-	-	66.19	11.86	78.05	66.22	11.89	78.11	132.41	23.75	156.16
2. Intermediate Pumping Station	-	-	-	-	-	-	-	-	-	-	-	-	5.91	4.89	10.80	5.91	4.89	10.80
3. Treatment Plant	-	-	-	88.69	9.82	98.51	101.11	-	101.11	43.07	80.87	123.94	41.47	54.13	95.60	274.34	144.82	419.16
4. Cleaning machine & laboratory equipment	-	-	-	-	-	-	-	-	-	-	-	-	4.50	5.10	9.60	4.50	5.10	9.60
5. Sub-total	-	-	-	88.69	9.82	98.51	101.11	-	101.11	109.26	92.73	201.99	118.10	76.01	194.11	417.16	178.56	595.72
6. Consulting Services																		
a) Engineering Design	14.90	14.90	29.80	-	-	-	-	-	-	-	-	-	-	-	-	14.90	14.90	29.80
b) Supervision	-	-	-	2.45	2.45	4.90	2.55	2.55	5.10	5.05	5.05	10.10	4.85	4.85	9.70	14.90	14.90	29.80
7. Contingencies	3.00	3.00	6.00	18.20	2.50	20.70	20.70	0.50	21.20	22.90	19.50	42.40	24.60	16.20	40.80	89.40	41.70	131.10
8. Land Acquisition	93.75	-	-	-	-	-	-	-	-	2.94	-	2.94	-	-	-	96.69	-	96.69
9. Sub-total	111.65	17.90	129.55	20.65	4.95	25.60	23.25	3.05	26.30	30.89	24.55	55.44	29.45	21.05	50.50	215.89	71.50	287.39
10. Total	111.65	17.90	129.55	109.34	14.77	124.11	124.36	3.05	127.41	140.15	117.28	257.43	147.55	97.06	244.61	633.05	250.06	883.11

Note: L.C. means local currency component.
F.C. means foreign currency component.

CHAPTER 11
FINANCIAL PLAN FOR THE FIRST STAGE PROGRAM

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

11.1 Existing Financial Situation

The existing financial situation of the Bangkok Metropolitan Administration (BMA) has been reviewed under the basic assumption that BMA would undertake the financial management of the proposed sewerage project. As mentioned in previous paragraph BMA is presently organized into 11 departments and Office of Secretary as well as 24 district offices with specific functions assigned. Such departments have, however, no independent accounting system except for the expenditure recording practice. The annual budget to meet the expenditure is allocated by BMA's department of finance.

BMA's most recent revenue in 2524 (1981) to meet the amount of expenditure is approximately 3,300 million Baht and substantial part of income is derived from the taxation occupying about 75 percent of total income. The other sources of income are subsidy from the central government about 10 percent and other miscellaneous income about 15 percent of total income. The major portion of budget is distributed to (1) civil works related to public utilities development and improvement and (2) educational services occupying about 27 percent and 20 percent of total BMA's expenditure respectively.

The expenditure related to drainage improvement and maintenance is 135 million Baht approximately 4 percent of total expenditure and expenditure for sanitary improvement is 230 million Baht approximately 7 percent of total expenditure. The high proportion of the government expen-

diture is increasingly necessitated to meet the demand to maintain the growth and improve the quality of economic and social life in the Bangkok Metropolitan area.

The present collection of revenue of BMA is authorized by Municipal Revenue Act B.E. 2497 (1954). This Act includes the procedure of the taxation which is the main source of BMA's revenue. The Land Development Tax Act B.E. 2508 (1965) and House and Land Tax B.E. 2475 (1950) specify the provisions dealing with above mentioned two kinds of taxes on the property. The rate for house and land tax is a flat rate of 12.5 percent of the annual rental or equivalent value of the house and land. The land development tax is levied in 43 tax rates for 43 different prices of land. The tax ranges from 0.5 baht per rai (1,600 m^2) to 400 baht per rai with 100 baht per rai for each subsequent increase of land value of 100,000 baht per rai thereafter.

The present taxation system for above is, however, based on the extensive exemption which is resulted in a limited tax revenue. As for the land development tax, the owners of the house built on small land in the Metropolitan are exempted from the land tax due to legalized tax exempted land area of 0.25 rai or 100 square wah (400 m^2). The tax for house and land is levied on the owners of house and land which are utilized for the commercial purposes such as rental and other profit making business, and taxes are exempted for those houses in which the owners themselves reside.

The new attempt has recently been made to amend both of above two kinds of taxation systems by the Finance Ministry and the Cabinet has already approved the proposal for such amendment. The amendment includes the reduction of the maximum tax exempted area from 100 square wah to 50 square wah and increase of tax rate for the higher land value as well as taxation on owners of the property for non-commercial purpose who have ever been tax exempted.

Table 11.1 Revenue and Expenditure of BMA
2518 (1975) - 2522 (1979)

(Baht)

	2518 (1975)	2519 (1976)	2520 (1977)	2521 (1978)	2522 (1979)
Revenue					
A. Regular Income:					
a. Taxation					
1. House and Land Tax	157,256,973	172,444,366	196,265,806	224,151,301	263,874,075
2. Beverage Tax	42,280,418	24,625,968	30,099,417	37,404,227	46,093,059
3. Business Tax	517,199,074	523,933,077	639,621,475	777,324,308	885,728,190
4. Land Development Tax	33,370,643	33,631,389	37,606,508	52,017,559	49,108,666
5. Vehicle Tax	378,383,732	424,565,105	505,918,571	500,741,300	481,882,765
6. Sign Board Tax	25,800,339	26,731,078	28,625,317	28,993,724	31,046,869
7. Gamble Tax	43,853,264	48,205,314	53,800,167	59,150,945	67,189,812
8. Slaughtering Tax	5,472,934	7,679,255	7,781,476	8,281,845	13,317,405
9. Entertainment Tax	13,201,676	16,597,960	15,931,231	18,321,628	20,976,038
10. Rice Export Tax	2,659,720	3,793,320	3,526,339	7,751,776	6,752,865
Sub-total	1,219,478,773	1,282,206,832	1,519,176,307	1,714,138,613	1,865,909,744
b. Fees for Licencing Permits and Public Services					
1. Licencing for various commercial activities	28,902,333	31,158,408	38,158,296	42,397,087	58,591,948
2. Refuse Collection Fee	9,869,048	10,197,173	11,138,629	11,769,667	12,553,435
3. Desludging Fee	5,336,075	5,271,790	6,053,655	6,605,353	6,898,123
Sub-total	44,107,456	46,627,371	55,350,580	60,772,107	78,043,506
c. Income from Commercial Business of BMA	54,398,463	106,705,119	114,456,010	170,697,831	186,714,111
d. Miscellaneous Income	44,182,922	61,000,032	112,870,262	246,756,433	299,285,394
e. Subsidy from Central Government	20,000,000	96,200,000			
Total of Regular Income	1,382,167,614	1,592,739,356	1,801,853,159	2,192,364,984	2,430,012,755
B. Special Subsidy for Project:	94,062,288	134,157,130	79,345,483	285,551,621	463,591,253
Total Revenue (A+B)	1,476,229,902	1,726,896,486	1,881,198,642	2,477,916,605	2,893,604,008
Expenditure					
1. Public Works	408,421,384	511,018,193	507,548,910	835,728,505	881,647,882
2. Education	326,507,051	376,332,610	553,669,250	605,215,750	658,330,420
3. General Administration	177,837,199	184,738,644	157,855,707	251,353,682	292,769,385
4. Medicine and Sanitation	163,880,297	185,990,132	194,301,610	221,962,020	273,712,280
5. Cleaning	167,962,450	200,435,622	173,394,720	233,599,730	227,347,230
6. Drainage System	68,765,986	75,080,532	114,991,350	187,830,780	135,074,231
7. Social Welfare	34,263,650	68,705,765	97,076,100	68,184,500	94,832,485
8. Commerce	27,221,055	24,372,883	31,504,250	33,583,900	44,631,250
9. Loan Repayments	13,606,281	9,463,282	11,303,982	11,303,982	9,303,982
10. Miscellaneous	119,211,299	-	-	-	-
11. Project funded by Central Government	125,019,258	254,264,852	298,873,128	464,009,211	681,500,805
Total Expenditure	1,632,695,910	1,890,402,515	2,140,519,007	2,912,772,060	3,299,149,950

In addition to above taxes there are other categories of taxes levied on liquor and refreshment sales, business and purchase, signboard, animal slaughtering business, vehicle, gambling, entertainment and rice which are to be exported. Among above taxes, BMA is collecting directly house and land tax, land development tax, tax on signboard and slaughtering, and other six categories of tax are collected by other government agency mainly by Ministry of Interior, providing that proceeds are transferred to BMA after reducting necessary expenses.

The revenue and expenditure for past 5 years are presented in Table 11.1.

11.2 Funding Arrangements

(1) Cost Estimates

The required costs broken down into annual disbursement for the first stage construction program from the year 2527 (1984) to 2531 (1988) and operation and maintenance costs after the completion of sewerage construction are presented in Table 11.2 and Table 11.3 respectively. The capital disbursement for the construction is graphically indicated in Figure 11.1. The total costs are escalated assuming future price increases as normally practiced for the realistic financial analysis. The price escalation rate is assumed to be 5 per cent per annum compounding price indices from various data sources for the past few years and future economic prospects. Data for such price escalation is presented in Appendix K.

(2) Potential Sources of Funds

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

Table 11.2 Disbursement Schedule in the First Stage Program

Unit: Million Baht

Year / Item	2527 (1984)			2528 (1985)			2529 (1986)			2530 (1987)			2531 (1988)			Total		
	L.C.	F.C.	Sub-total	L.C.	F.C.	Sub-total	L.C.	F.C.	Sub-total	L.C.	F.C.	Sub-total	L.C.	F.C.	Sub-total	L.C.	F.C.	Sub-total
1. Sewers	-	-	-	-	-	-	-	-	-	66.19	11.86	78.05	66.22	11.89	78.11	132.41	23.75	156.16
2. Intermediate Pumping Stations	-	-	-	-	-	-	-	-	-	-	-	-	5.91	4.89	10.80	5.91	4.89	10.80
3. Treatment Plant	-	-	-	88.69	9.82	98.51	101.11	-	101.11	43.07	80.87	123.94	41.47	54.13	95.60	274.34	144.82	419.16
4. Cleaning machine & laboratory equipment	-	-	-	-	-	-	-	-	-	-	-	-	4.50	5.10	9.60	4.50	5.10	9.60
5. Sub-total	-	-	-	88.69	9.82	98.51	101.11	-	101.11	109.26	92.73	201.99	118.10	76.01	194.11	417.16	178.56	595.72
6. Consulting Services																		
a) Engineering Design	14.90	14.90	29.80	-	-	-	-	-	-	-	-	-	-	-	-	14.90	14.90	29.80
b) Supervision	-	-	-	2.45	2.45	4.90	2.55	2.55	5.10	5.05	5.05	10.10	4.85	4.85	9.70	14.90	14.90	29.80
7. Contingencies	3.00	3.00	6.00	18.20	2.50	20.70	20.70	0.50	21.20	22.90	19.50	42.40	24.60	16.20	40.80	89.40	41.70	131.10
8. Land Acquisition	93.75	-	93.75	-	-	-	-	-	-	2.94	-	2.94	-	-	-	96.69	-	96.69
9. Sub-total	111.65	17.90	129.55	20.65	4.95	25.60	23.25	3.05	26.30	30.89	24.55	55.44	29.45	21.05	50.50	215.89	71.50	287.39
10. Total (1981 price)	111.65	17.90	129.55	109.34	14.77	124.11	124.36	3.05	127.41	140.15	117.28	257.43	147.55	97.06	244.61	633.05	250.06	883.11
Escalation Factors (a)		1.158			1.216			1.276			1.340			1.407				
11. Total Project Costs (Escalated Price)	128.29	20.73	150.02	132.96	17.96	150.92	158.68	3.89	162.57	187.80	157.16	344.96	207.60	136.56	344.16	816.33	336.30	1152.63

Note: L.C. Local Currency
F.C. Foreign Currency
(a) - 5% per annum for total cost

Table 11.3 Operation and Maintenance Costs

Unit: Million Baht

	2527 (1984)	2528 (1985)	2529 (1986)	2530 (1987)	2531 (1988)	2532 (1989)	2533 (1990)	2534 (1991)	2535 (1992)	2536 (1993)	2537 (1994)	2538 (1995)	2539 (1996)	2540 (1997)	2541 (1998)	2542 (1999)
Sewers						1.63	1.63	1.63	1.63	1.63	1.63	1.63	1.63	1.63	1.63	1.63
Pumping Station						0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86
Treatment Plant						14.29	14.29	14.29	14.29	14.29	14.29	14.29	14.29	14.29	14.29	14.29
Administration (a)	0.46	0.65	0.92	1.56	1.62	2.38	2.38	2.38	2.38	2.38	2.38	2.38	2.38	2.38	2.38	2.38
Total (at 1981 prices)	0.46	0.65	0.92	1.56	1.62	19.16	19.16	19.16	19.16	19.16	19.16	19.16	19.16	19.16	19.16	19.16
Escalation Factors	1.158	1.216	1.276	1.340	1.407	1.477	1.551	1.629	1.710	1.796	1.886	1.980	2.079	2.183	2.292	2.407
Total (Escalated Prices)	0.53	0.79	1.170	2.09	2.28	28.30	29.72	31.21	32.76	34.41	36.14	37.94	39.83	41.83	43.91	46.12

Note: (a) Include salaries and wages for the personnel to be newly employed as scheduled in Staffing Schedule, Table 12.1, Chapter 12 for the sewerage works and other miscellaneous expenses.

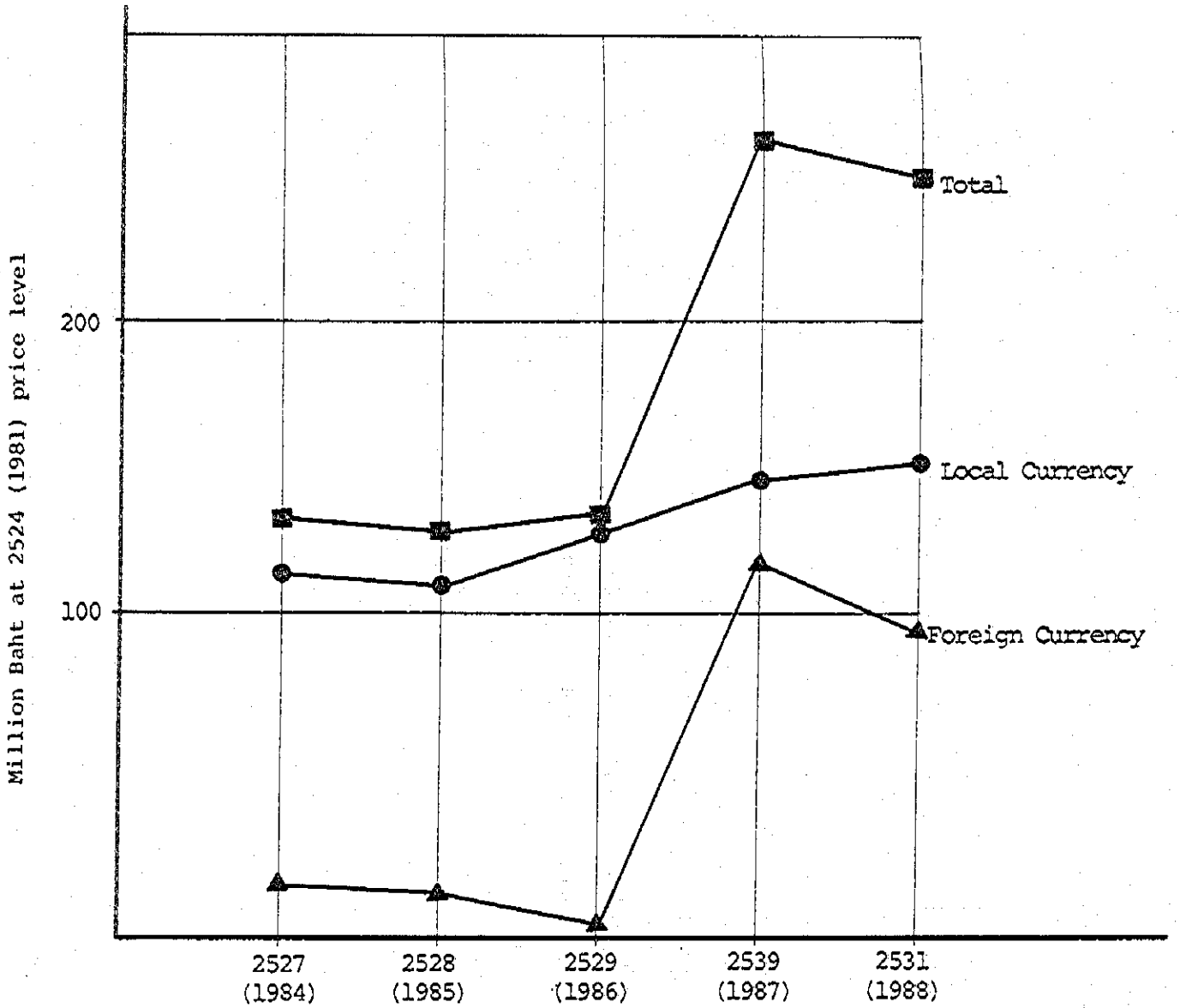


Figure 11.11 Capital Disbursement Schedule in the First Stage

1) Funds for the Construction Costs

Among the total capital costs the foreign currency portion is financed by the international lending agency and local portion is financed by the government subsidies 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.

a. Loan from the international lending agencies

The international loans are broadly grouped by two categories as multilateral and bilateral loans. The multilateral loans are exemplified as loans from the World Bank and Asian Development Bank. The interest of such loans are presently ranging from 10-12 percent per annum and repayment period is normally 20 years with grace period of 5 years. The bilateral loans are exemplified by the loan from West Germany and U.S. or Japan with very concessionary terms, for example, low interest rates of 3-4 percent per annum and long maturity periods (up to 30 years) including 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, water supply, feeder roads and other infrastructure development projects.

The sewerage development as proposed to enhance community benefits such as public sanitation and amenity development is necessary to be encouraged by the government initiative with allocation of meaningful amount of subsidy.

c. Loan from the central government

The local currency portion of the capital costs are normally financed by the government through the national bank, wholly or partly depending on availability of other sources of capital as subsidy. The terms and condition of such loan is not fixed and flexible presently in Thailand. The recent government loan condition is not so favorable with approximate interest rate of 10 percent and pay back period of 20 years.

2) Funds for the 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 countries that such recurrent costs are met by the users of the system who receive the benefits through the collection of sewerage use charges either by imposing surcharge on water rate or taxation.

a. Surcharge on Water Rate

The water rate surcharge is service charge related to water consumption which is calculated by adding a fixed rate to metered water consumption. This method is widely employed in the world including Japan as the volume of waste discharge is closely related to water consumption which is accurately metered. Another benefit of this method would be that the collection of charges can be made without difficulty in combination of billing procedure for water supply already in existence. The collection of the charge is enforceable by cutting off the water supply in event of non-payment.

b. Sewerage Tax

Another method to collect the charge can be employed by imposing the tax on property owned by sewerage users. Such method is employed as a second alternative to the above mentioned surcharge on water rate when surcharge method is found not effective due to some local constraints and especially when the existing taxation systems can be conveniently utilized.

11.3 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 executive agency of the project is most desirable subject, however, to the availability of sufficient fund or the loan of lenient condition.

The following four alternative funding arrangements have been considered to assess the financial impact on the executive agency of BMA as well as individual sewerage users and thereby select adequate funding arrangement.

Alternative - I : The foreign currency portion equivalent to 336.30 million Baht is financed by the international lending agency (IBRD or ADB) and local currency portion of 816.33 million Baht is financed by equal contribution of national government subsidy and BMA's own fund allocation.

Alternative - II : The foreign currency portion equivalent to 336.30 million Baht is financed by bilateral loan and local currency portion of 816.33 million Baht is financed by equal contribution of national government subsidy and BMA's own fund allocation.

Alternative - III : The total of foreign currency portion and a part of local currency portion equivalent to 461.05 million Baht (approximately 40% of total project costs) is financed by bilateral loan 691.58 million Baht is financed by equal contribution of national government and BMA's own revenue.

Alternative - IV : The total of foreign currency portion and a part of local currency portion equivalent to 461.05 million Baht (approximately 40% of total project costs) is financed by bilateral loan and remaining portion of 691.58 million Baht is financed by national government loan.

In above alternative plans, portion of the government funding is assumed based on the past example of the subsidy allocated to the drainage and water supply project and BMA's budgeting practice to the infrastructure development as shown in Table 11.1 of Page 11-3. Such government funding contribution can also be justified by prospective increase of property tax, one of the socioeconomic benefits to be derived from the proposed project as manifested in subsequent Chapter 14, Project Evaluation.

The conditions of the loan are assumed as follows.

IBRD or ADB:	20 years repayment including 5 years grace period with 11% interest per annum
Bilateral Loan:	30 years repayment period including 10 years grace period with 3% interest per annum
Government Loan:	20 years repayment including 5 years grace period with 10% interest per annum.

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 11.4 and the funding burden to be imposed on BMA in each alternative is highlighted in Figure 11.2.

As it is clear from this figure the Alternative II and III appear more agreeable since required funds from BMA in successive years are less than other alternatives. Although there is no significant difference in graphic indication between Alternative II and III, Alternative III imposes less initial funding burden on BMA during construction stage.

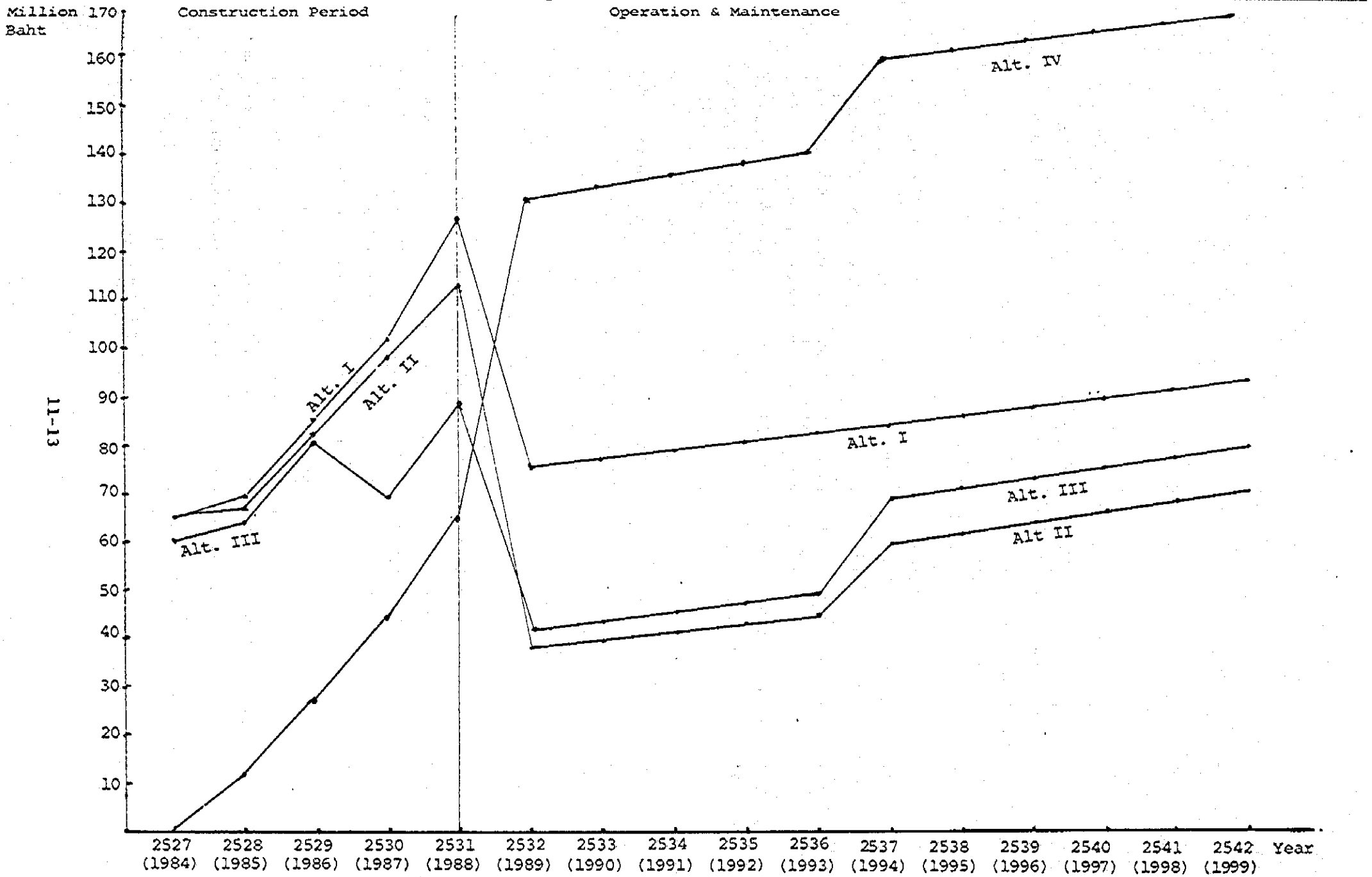
Alternative III is therefore assumed as a recommendable funding arrangement and further financing analysis are made based on this alternative to identify the various factors needed to make the project financially viable.

Table 11.4 Capital and Annual Costs Cash Outlay
(at escalated prices)

Unit: Million Baht

	2527 (1984)	2528 (1985)	2529 (1986)	2530 (1987)	2531 (1988)	2532 (1989)	2533 (1990)	2534 (1991)	2535 (1992)	2536 (1993)	2537 (1994)	2538 (1995)	2539 (1996)	2540 (1997)	2541 (1998)	2542 (1999)
Alternative I																
Capital Costs																
BMA's Fund	64.65	66.48	79.34	93.90	103.80											
Subsidy	64.64	66.48	79.34	93.90	103.80											
Foreign Loan	20.73	17.96	3.89	157.16	136.56											
Recurrent Costs																
O/M costs	0.53	0.79	1.17	2.09	2.28	28.30	29.72	31.21	32.76	34.41	36.14	37.94	39.83	41.83	43.91	46.12
Debt Service		2.28	4.26	4.68	21.97	46.74	46.74	46.74	46.74	46.74	46.74	46.74	46.74	46.74	46.74	46.74
Total	150.55	153.99	168.00	351.73	368.41	75.04	76.46	77.95	79.50	81.15	82.88	84.68	86.57	88.57	90.65	92.86
Alternative II																
Capital Costs																
BMA's Fund	64.65	66.48	79.34	93.90	103.80											
Subsidy	64.64	66.48	79.34	93.90	103.80											
Foreign Loan	20.73	17.96	3.89	157.16	136.56											
Recurrent Costs																
O/M costs	0.53	0.79	1.17	2.09	2.28	28.30	29.72	31.21	32.76	34.41	36.14	37.94	39.83	41.83	43.91	46.12
Debt Service		0.62	1.16	1.28	5.99	10.09	10.09	10.09	10.09	10.09	22.60	22.60	22.60	22.60	22.60	22.60
Total	150.55	152.33	164.90	348.33	352.43	38.39	39.81	41.30	42.85	44.50	58.74	60.54	62.43	64.43	66.51	68.72
Alternative III																
Capital Costs																
BMA's Fund	60.80	63.15	78.62	64.75	78.47											
Subsidy	60.80	63.15	78.62	64.75	78.47											
Foreign Loan	28.42	24.62	5.33	215.46	187.22											
Recurrent Costs																
O/M costs	0.53	0.79	1.17	2.09	2.28	28.30	29.72	31.21	32.76	34.41	36.14	37,94	39.83	41.83	43.91	46.12
Debt Service		0.85	1.59	1.75	8.21	13.83	13.83	13.83	13.83	13.83	30.97	30.97	30.97	30.97	30.97	30.97
Total	150.55	151.66	165.33	348.30	354.65	42.13	43.55	45.04	46.59	48.24	67.11	68.91	70.80	72.80	74.88	77.09
Alternative IV																
Capital Costs																
Local Loan	121.60	126.30	157.24	129.50	156.94											
Foreign Loan	28.42	24.62	5.33	215.46	187.22											
Recurrent Costs																
O/M costs	0.53	0.79	1.17	2.09	2.28	28.30	29.72	31.12	32.76	34.41	36.14	37.94	39.83	41.83	43.91	46.12
Debt Service		13.01	26.38	42.26	61.67	104.75	104.75	104.75	104.75	104.75	121.91	121.91	121.91	121.91	121.91	121.91
Total	150.55	164.72	190.12	389.31	408.11	133.05	134.47	135.96	137.51	139.16	158.05	159.85	161.74	163.74	165.82	168.03

(at escalated price)



11.4 Revenue Plan

11.4.1 Sewerage Charge

The revenue is required to be raised by the executing agency to meet the annual cash requirement after the construction of the systems and 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.

The most of the required revenue is raised by collecting the sewerage charges from the individual beneficiaries since BMA is not able to afford such revenue from their own fund and it is desirable to attain self-sufficiency of the project to the possible extent. The gross revenue to cover the annual cash requirements are estimated and broken down to unit cashes per capita and family in the Table 11.5 to plan the reasonable sewerage charges with due consideration on the residents' ability to pay and the equity to existing utility services fee such as water supply charges.

As indicated in the table the operation expenses for the first 5 years construction period is minimum mainly for the administrative expenses and interests of the loan and after the completion of sewerage system in 2532 (1989) approximately 40 million Baht is required with annual increase of about 3.4%.

The required cash is to be increased substantially from 2537 (1994) when repayment for principal of the loan is initiated up to approximately 67 million Baht with annual increase of about 3% hereafter. The unit cashes per household as indicated in the table is considered equivalent to the minimum sewerage charge to be collected from the residents in the study area. As it is not desirable to modify the charges annually in accordance with the annual fluctuation of unit cashes as estimated, such charge should be fixed estimated as follows based on above unit cashes per household taking into account the allowance to cover approximately 10% extra on cash requirement.

Table 11.5 Annual Cash Requirements (Million Baht), and Unit Cash/cap/household

	O/M costs	Debt Service	Total (Million Baht)	Served Population	Per Capita (Baht)	Per Household (Baht)
2527(1984)	0.53		0.53			
2528(1985)	0.79	0.85	1.64			
2529(1986)	1.17	1.59	2.76			
2530(1987)	2.09	1.75	3.84			
2531(1988)	2.28	8.21	10.49			
2532(1989)	28.30	13.83	42.13	252,300	167	835
2533(1990)	29.72	13.83	43.55	252,300	173	865
2534(1991)	31.21	13.83	45.04	252,300	179	895
2535(1992)	32.76	13.83	46.59	252,300	185	925
2536(1993)	34.41	13.83	48.24	252,400	191	955
2537(1994)	36.13	30.97	67.10	252,400	266	1,330
2538(1995)	37.94	30.97	68.91	252,400	273	1,365
2539(1996)	39.83	30.97	70.80	252,400	281	1,405
2540(1997)	41.83	30.97	72.80	252,400	288	1,440
2541(1998)	43.91	30.97	74.88	252,500	297	1,485
2542(1999)	46.12	30.97	77.09	252,500	305	1,525

Note: Average number of persons per household is assumed to be five.

Sewerage Charge/Household (Baht):

	2532 (1989)	2533 (1990)	2534 (1991)	2535 (1992)	2536 (1993)	2537 (1994)	2538 (1995)	2539 (1996)	2540 (1997)	2541 (1998)	2542 (1999)
Yearly	1,050	1,050	1,050	1,050	1,050	1,634	1,634	1,634	1,634	1,634	1,892
Monthly	88	88	88	88	88	136	136	136	136	136	158

11.4.2 Ability and Willingness to Pay

The field survey was conducted by visiting selected 500 households in the study area during the present study period in order to gage the paying ability of individual households and their awareness of the benefits to be derived from the proposed sewerage system. The object of the survey included not only households incomes but also other relevant matters as existing disposal systems and existing water supply charges. The summary results are indicated in Table 11.6.

The ability to pay is commonly measured by the ratio of the proposed charge to total income of potential householders. The maximum limit of the ratio commonly employed for sewerage charge in developing countries is approximately two percent.

Table 11.6 Findings of House Visit Survey, as of 2524 (1981)

1. Monthly income (Baht/month):

3,000 or below	36%
3,000 - 5,000	30%
5,000 - 7,000	14%
7,000 - 9,000	12%
9,000 - 11,000	4%
11,000 or more	4%

Weighted Average Income:
4,920 Baht/month

2. Average number of family: 5

3. Awareness of offensive odour of ditches, canals and klongs:
95% indicated willingness to pay.

4. Willingness to pay for sanitary improvement (Sewerage Services):
63% indicated willingness to pay.

5. Amount of willingness to pay (Baht/month):

10 - 20	= 13%
30	= 50%
45	= 17%
90	= 11%
100 - 200	= 9%

Weighted Average Amount of Willingness to pay: 48 Baht/month

6. Average water supply charge: 100 Baht/month/house. (domestic)
300 Baht/month/house. (commercial)

7. Existing Waste Disposal System:.

7.1	No. of toilet/urinal	one toilet and one urinal	39%
		two " two "	42%
		three " three "	16%
		other	12%
7.2	Provision of septic tank		55%
7.3	Septic tank connected to seepage pit		35%
7.4	Provision of seepage pit only		23%
7.5	Availability of flush toilet		24%
	pour-flush toilet		76%

If the proposed charge is under two per cent of household income, the owners of such householders are considered capable of paying such charges. The ratios of the proposed charges to average income estimated at 5% annual increase are calculated as follows.

	2532 (1989)	2533 (1990)	2534 (1991)	2535 (1992)	2536 (1993)	2537 (1994)	2538 (1995)	2539 (1996)	2540 (1997)	2541 (1998)	2542 (1999)
A. Proposed Sewerage Charge	88	88	88	88	88	136	136	136	136	136	158
B. Average Monthly Income	7,268	7,631	8,013	8,414	8,834	9,276	9,740	10,227	10,738	11,275	11,839
C. Ratio A/B	1.2	1.1	1.1	1.0	1.0	1.5	1.4	1.3	1.3	1.2	1.3

A: Proposed Sewerage charge/household/month (Baht)
B: Average monthly income
C: $\frac{A}{B} \times 100$ (%)

As apparent from above table the ratio as measured are ranging from 1% to 1.5% which indicate the sufficient capability of potential householders in the study area.

As for the willingness to pay, it is not necessarily consistent with ability to pay as it depends mainly on the individuals' awareness and evaluation of the benefits deriving from sewerage services, and further individuals have common desire to underestimate their amount to pay the charges.

Especially those residents provided with septic tank systems are likely to indicate less willingness to pay as they are not disturbed by evident inconveniences in addition to their unawareness of the benefit of sewerage system.

The figures of 63% representing those residents who have willingness to pay and average amount of willingness to pay of 48 Baht/month (68 Baht/month at 1981 price) as indicated in the survey results, are, however, considered significant indication of their interests in the sewerage systems if their common attitude as mentioned above is taken into account.

11.4.3 Collection of Sewerage Charge

As mentioned in previous section, funds for the recurrent costs, on page 11-9, there are two methods commonly applied to collect the sewerage charges. Such two alternative sewerage charge collection methods have been examined as below to select the most adequate method.

1. <u>The method to raise necessary revenue by imposing additional tax to existing House & Land Tax</u>

   The present House & Land Tax is imposed on the owners of the property at the rate of 12.5% of total value of their houses and lands.

The present total value in the study area is approximately 643 million Baht which has been assumed based on the data obtained from the district office in the study area. The new tax rate for sewerage charge to be added to the existing House & Land Tax has been calculated by the following assumptions. The property value as of the year 1981 will be reassessed after years in accordance with general price escalation. If such revaluation is executed in every 5 years in conformity with price escalation at 5% per annum, the property value will be increased to 950 million Baht, 1,212 million Baht and 1,547 million Baht in 2532 (1989), 2537 (1994) and 2542 (1999) respectively. The tax rate to raise required revenue as estimated in the report is therefore computed as follows.

	2532 (1989)	2533 (1990)	2534 (1991)	2535 (1992)	2536 (1993)	2537 (1994)	2538 (1995)	2539 (1996)	2540 (1997)	2541 (1998)	2542 (1999)
Property Value	950	950	950	950	950	1,212	1,212	1,212	1,212	1,212	1,547
Required Revenue	52.98	52.98	52.98	52.98	52.98	82.52	82.52	82.52	82.52	82.52	95.55
Tax Rate (%)	5.6	5.6	5.6	5.6	5.6	6.8	6.8	6.8	6.8	6.8	6.2

Unit: Million Baht

This Alternative has an advantage to ensure sound collection of required revenue which can be conveniently combined with present reliable taxation system. The major disadvantage is, however, an uncertain acceptability for charging tax to proporty owners who are not necessarily be responsible for discharging such a quantity of wastewater as corresponding to the required tax payment while others who own no property and exempted from the tax are discharging substantial quantity of wastewater.

2. <u>The method to collect the charge based on unit cost for wastewater quantity (to be combined with water supply charge)</u>

The average unit cost per cubic meter has been calculated based on average daily wastewater quantity and required annual revenue

through 10 years from 2532 (1989) to 2541 (1998). The average daily wastewater flow is 135,800 cubic meters and required revenue is 52.98 million Baht from 2532 (1989) to 2536 (1993) and 82.52 million Baht from 2537 (1994) to 2541 (1998). The unit price per one cubic meter of wastewater is calculated as follows.

From 2532 (1989) to 2536 (1993):

$$\frac{52.98 \text{ million Baht}}{135{,}800 \text{ (m}^3\text{) x 365 (days)}} \fallingdotseq 1.10 \text{ Baht/m}^3$$

From 2537 (1994) to 2541 (1998):

$$\frac{82.52 \text{ million Baht}}{135{,}800 \text{ (m}^3\text{) x 365 (days)}} \fallingdotseq 1.66 \text{ Baht/m}^3$$

The charges based on above unit prices are required to be combined with water billing. The advantage of this alternative is a dominant rationality in that the sewerage users are responsible to pay the charges in fair proportion to their wastewater discharges. There is a crucial disadvantage in this alternative, however, for the realistic implementation of this method combined with water billing since present water billing is not practiced under accurate gaging of the water consumption and resultant deficient collection of the charges.

It is widely recognized that imposing the sewerage charges combined with the existing water supply charges is one of the best method as it satisfies the easiness, reason and enforceability. It was found, however, in the course of the present study that immediate implementation of this method is not advisable since existing billing of water supply charge is not dependent on accurate metering of water consumption due mainly to malfunctioning of water meters and unsatisfactory billing efficiency as mentioned in above alternative methods.

The collection of the sewerage charges by taxation is therefore recommended as a more practical alternative to ensure sound collection of the charges since taxation has presently more enforceability than billing of water charges.

11.5 Financial Projection

The financial sheet are prepared in the following pages taking account of all analyses made in the previous sections to manifest the financial viability of the project. Such financial sheet are Income Statement, Cash Flow Statement and Balance Sheet as indicated by Table 11.7 - 11.9 and summarized by Table 11.10.

Table 11.7 Projected Income Statement, 2527 (1984) - 2542 (1998)

Unit: Million Baht

	2427 (1984)	2528 (1985)	2529 (1986)	2530 (1987)	2531 (1988)	2532 (1989)	2533 (1990)	2534 (1991)	2535 (1992)	2536 (1993)	2537 (1994)	2538 (1995)	2539 (1996)	2540 (1997)	2541 (1998)	2542 (1999)
Operating Revenue																
Sewerage Charge	-	-	-	-	-	52.98	52.98	52.98	52.98	52.98	82.52	82.52	82.52	82.52	82.52	95.55
Municipal Fund	0.76	1.75	3.04	3.85	19.68	-	-	-	-	-	-	-	-	-	-	-
Total Operating Revenue	0.76	1.75	3.04	3.85	19.68	52.98	52.98	52.98	52.98	52,98	82.52	82.52	82.52	82.52	82.52	95.55
Operating Expenses																
Billing and Collection Fees (a)	-	-	-	-	-	1.06	1.06	1.06	1.06	1.06	1.65	1.65	1.65	1.65	1.65	1.91
Provision for Bad Debits (b)	-	-	-	-	-	0.53	0.53	0.53	0.53	0.53	0.83	0.83	0.83	0.83	0.83	0.96
Sewers	-	-	-	-	-	2.41	2.53	2.65	2.79	2.93	3.07	3.23	3.39	3.56	3.74	3.92
Pump Station	-	-	-	-	-	1.27	1.33	1.40	1.47	1.54	1.62	1.70	1.79	1.88	1.97	2.07
Treatment Plant	-	-	-	-	-	21.11	22.16	23.28	24.43	25.67	26.95	28.30	29.70	31.20	32.75	34.40
Administration	0.53	0.79	1.17	2.09	2.28	3.51	3.70	3.88	4.07	4.27	4.50	4.71	4.95	5.19	5.45	5.73
Total Operating Expenses	0.53	0.79	1.17	2.09	2.28	29.89	31.31	32.80	34.35	36.00	38.26	40.42	42.31	44.31	46.39	48.99
Net Operating Income	0.23	0.96	1.87	1.76	17.40	23.09	21.67	20.18	18.63	16.98	43.90	42.10	40.21	38.21	36.13	46.56
Depreciation (c)	-	-	-	-	-	32.27	32.27	32.27	32.27	32.27	32.27	32.27	32.27	32.27	32.27	32.27
Interest	-	0.85	1.59	1.75	8.21	13.83	13.83	13.83	13.83	13.83	13.83	13.32	12.79	12.24	11.68	11.10
Net Income (Deficit)	0.23	0.11	0.28	0.01	9.19	(23.01)	(24.43)	(25.92)	(27.47)	(29.12)	(2.20)	(3.49)	(4.85)	(6.30)	(7.82)	3.19

(a) : Estimated at 2% of Sewerage Charge

(b) : Estimated at 1% of Sewerage Charge

(c) : Composite rate of 2.8% for Assets in Service

Table 11.8 Projected Cash Flow Statement, 2527 (1984) - 2542 (1999)

Unit: Million Baht

	2527 (1984)	2528 (1985)	2529 (1986)	2530 (1987)	2531 (1988)	2532 (1989)	2533 (1990)	2534 (1991)	2535 (1992)	2536 (1993)	2537 (1994)	2538 (1995)	2539 (1996)	2540 (1997)	2541 (1998)	2542 (1999)
Sources of Funds																
Net Operating Income	0.23	0.96	1.87	1.76	17.40	23.09	21.67	20.18	18.63	16.98	43.90	42.10	40.21	38.21	36.13	46.56
Increase in Account Payable	0.04	0.03	0.03	0.07	0.02	2.30	0.12	0.12	0.13	0.14	0.22	0.15	0.16	0.16	0.18	0.21
Decrease in Current Assets (less cash)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Foreign Loan	28.42	24.62	5.33	215.46	187.22											
Government Subsidy	60.80	63.15	78.62	64.75	78.47											
BMA Fund	60.80	63.15	78.62	64.75	78.47											
Total Sources	150.29	151.91	164.47	346.79	361.58	25.39	21.79	20.30	18.76	17.12	44.12	42.25	40.37	38.37	36.31	46.77
Application of Funds																
Capital Expenditure	150.02	150.92	162.57	344.96	344.16	-	-	-	-	-	-	-	-	-	-	-
Interest:																
Foreign Loan	-	0.85	1.59	1.75	8.21	13.83	13.83	13.83	13.83	13.83	13.83	13.32	12.79	12.24	11.68	11.10
Amortization of Principle																
Foreign Loan	-	-	-	-	-	-	-	-	-	-	17.14	17.65	18.18	18.73	19.29	19.87
Total Debt Service	-	0.85	1.59	1.75	8.21	13.83	13.83	13.83	13.83	13.83	30.97	30.97	30.97	30.97	30.97	30.97
Increase in Current Assets (less cash)	0.01	0.01	-	0.02	0.01	4.97	0.03	0.03	0.03	0.03	2.51	0.04	0.04	0.04	0.04	0.05
Decrease in Current Liabilities	-	-	-	-	-	-	-	-	-	-	-					
Total Applications	150.03	151.78	164.16	346.73	352.38	18.80	13.86	13.86	13.86	13.86	33.48	31.01	31.01	31.01	31.01	31.02
Net Cash Increase (Decrease)	0.26	0.13	0.31	0.06	9.20	6.59	7.93	6.44	4.90	3.26	10.64	11.24	9.36	7.36	5.30	15.75
Cash Available at End of Year	0.26	0.39	0.70	0.76	9.96	16.55	24.48	30.92	35.82	39.08	49.72	60.96	70.32	77.68	82.98	98.73

Table 11.9 Projected Balance Sheet, 2527 (1984) - 2542 (1999)

Unit: Million Baht

	2527 (1984)	2528 (1985)	2529 (1986)	2530 (1987)	2531 (1988)	2532 (1989)	2533 (1990)	2534 (1991)	2535 (1992)	2536 (1993)	2537 (1994)	2538 (1995)	2539 (1996)	2540 (1997)	2541 (1998)	2542 (1999)
Assests																
Fixed Assets:																
Land	108.56	108.56	108.56	112.50	112.50	112.50	112.50	112.50	112.50	112.50	112.50	112.50	112.50	112.50	112.50	112.50
Utility Plant in Service	-	-	-	-	-	1040.13	1040.13	1040.13	1040.13	1040.13	1040.13	1040.13	1040.13	1040.13	1040.13	1040.13
Less Accumulative Depreciation	-	-	-	-	-	32.27	64.54	96.81	129.08	161.35	193.62	225.89	258.16	290.43	322.70	354.97
Net Fixed Assets in Service	-	-	-	-	-	1120.36	1088.09	1055.82	1023.55	991.28	959.01	926.74	894.47	862.20	829.93	797.66
Construction in Progress	41.46	192.38	354.95	695.97	1040.13	-	-	-	-	-	-					
Total Fixed Assets	150.02	300.94	463.51	808.47	1152.63	1120.36	1088.09	1055.82	1023.55	991.28	959.01	926.74	894.47	862.20	829.93	797.66
Current Assets:																
Cash	0.26	0.39	0.70	0.76	9.96	16.55	24.48	30.92	35.82	39.08	49.72	60.96	70.32	77.68	82.98	98.73
Account Receivable (a)	-	-	-	-	-	4.42	4.42	4.42	4.42	4.42	6.88	6.88	6.88	6.88	6.88	7.96
Inventory (b)	0.01	0.02	0.02	0.04	0.05	0.60	0.63	0.66	0.69	0.72	0.77	0.81	0.85	0.89	0.93	0.98
Total Current Assets	0.27	0.41	0.72	0.80	10.01	21.57	29.53	36.00	40.93	44.22	57.37	68.65	78.05	85.45	90.79	106.59
Total Assets	150.29	301.35	464.23	809.27	1162.64	1141.93	1117.62	1091.82	1064.48	1035.50	1016.38	995.39	972.52	947.65	920.72	904.25
Liabilities and Equity																
Long Term Dept:																
Foreign Loan	28.42	53.04	58.37	273.83	461.05	461.05	461.05	461.05	461.05	443.91	426.26	408.08	389.35	370.06	350.19	329.72
Current Liabilities:																
Accounts Payable (c)	0.04	0.07	0.10	0.17	0.19	2.49	2.61	2.73	2.86	3.00	3.22	3.37	3.53	3.69	3.87	4.08
Current Debt Maturities	-	-	-	-	-	-	-	-	-	17.14	17.65	18.18	18.73	19.29	19.87	20.47
Total Current Liabilities	0.04	0.07	0.10	0.17	0.19	2.49	2.61	2.73	2.86	20.14	20.87	21.55	22.26	22.98	23.74	24.55
Equity:																
National Government	60.80	123.95	202.57	267.32	345.79	345.79	345.79	345.79	345.79	345.79	345.79	345.79	345.79	345.79	345.79	345.79
Municipal	60.80	123.95	202.57	267.32	345.79	345.79	345.79	345.79	345.79	345.79	345.79	345.79	345.79	345.79	345.79	345.79
Retained Earnings	0.23	0.34	0.62	0.63	9.82	(13.19)	(37.62)	(63.54)	(91.01)	(120.13)	(122.33)	(125.82)	(130.67)	(136.97)	(144.79)	(141.60)
Total Liabilities and Equity	150.29	301.35	464.23	809.27	1162.64	1141.93	1117.62	1091.82	1064.48	1035.50	1016.38	995.39	972.52	947.65	920.72	904.25

(a) Estimated at 1/12 of Sewerage Charge
(b) Estimated at 2% of Operating Expenses
(c) Estimated at 1/12 of Operating Expenses

Table 11.10 Highlights of the Projected Financial Statements of the First Stage Program

Unit: Million Baht

	Construction Period					Sub-Total	Operation Period										
	2527 (1984)	2528 (1985)	2529 (1986)	2530 (1987)	2531 (1988)		2532 (1989)	2533 (1990)	2534 (1991)	2535 (1992)	2536 (1993)	2537 (1994)	2538 (1995)	2539 (1996)	2540 (1997)	2541 (1998)	2542 (1999)
A. Revenue																	
1. Government subsidy	60.80	63.15	78.62	64.75	78.47	345.79	-	-	-	-	-	-	-	-	-	-	-
2. Municipal funds (Construction)	60.80	63.15	78.62	64.75	78.47	345.79	-	-	-	-	-	-	-	-	-	-	-
3. Municipal funds (Operation)	0.76	1.75	3.04	3.85	19.68	20.08	-	-	-	-	-	-	-	-	-	-	-
4. Foreign loan	28.42	24.62	5.33	215.46	187.22	461.05	-	-	-	-	-	-	-	-	-	-	-
5. Sewerage charge	-	-	-	-	-		52.98	52.98	52.98	52.98	52.98	82.52	82.52	82.52	82.52	82.52	95.55
Total Revenue	150.78	152.67	165.61	348.81	363.84	1181.71	52.98	52.98	52.98	52.98	52.98	82.52	82.52	82.52	82.52	82.52	95.55
B. Expenditure																	
1. Direct construction costs	-	143.77	154.76	324.78	327.78	951.09	-	-	-	-	-	-	-	-	-	-	-
2. Land acquisition	108.56	-	-	3.94	-	112.50	-	-	-	-	-	-	-	-	-	-	-
3. Consulting services	41.46	7.15	7.81	16.24	16.38	89.04	-	-	-	-	-	-	-	-	-	-	-
4. Operation and maintenance	0.53	0.79	1.17	2.09	2.28	6.86	29.89	31.31	32.80	34.35	36.00	38.62	40.42	42.31	44.31	46.39	48.99
5. Foreign loan amortization																	
a. Interest	-	0.85	1.59	1.75	8.21	12.40	13.83	13.83	13.83	13.83	13.83	13.83	13.32	12.79	12.24	11.68	11.10
b. Principal	-	-	-	-	-		-	-	-	-	-	17.14	17.65	18.18	18.73	19.29	19.87
Total Expenditure	150.55	152.56	165.33	348.80	354.65	1171.89	43.72	45.14	46.63	48.18	49.83	69.59	71.39	73.28	75.28	77.36	79.96
C. Balance (A - B)	0.23	0.11	0.28	0.01	9.19	9.82	9.26	7.84	6.35	4.80	3.15	12.93	11.13	9.24	7.24	5.16	15.59
D. Balance increase (decrease) at end of year	0.22	0.33	0.61	0.62	9.81	9.81	19.07	26.91	33.26	38.06	41.21	54.14	65.27	74.51	81.75	86.91	102.50

CHAPTER 12
ADMINISTRATIVE ASPECTS

12.1 Review of Existing Organization

There is no nucleus authority to assume the entire responsibility on wastewater control, however, several agencies have been separately conducting the activities related to pollution control of their own interests. The National Environmental Board chaired by Deputy Prime Minister who is designated by Prime Minister was established in 2518 (1975), consisting of representatives from agencies concerned to encourage the environmental control activities and coordinate the planning of each agency as a result of recent increasing public concern for the environmental pollution problem.

Most recently in 2524 (1981), the Executive Committee chaired by Governor of Bangkok for Drainage and Sewerage Project for Bangkok was established, consisting of members representing the various agencies at national and municipal level concerned for drainage and sewerage development project.

a. Agencies concerned at national level

The following national agencies are more or less related to the pollution control and prospective sewerage development activities to be involved either in engineering aspects or administrative aspects.

- Engineering Advisory Agencies -

1) National Environmental Board (NEB)
2) Ministry of Public Health
3) Ministry of Industry
4) Ministry of Agriculture

- Administrative and Managerial Advisory Agencies -

1) Ministry of Interior
2) National Economic and Social Development Board (NESDB)
3) Ministry of Finance
4) Budget Bureau

National Environment Board (NEB) was established under Improvement and Conservation of National Environment Quality Act B.E. 2518 (1975) as mentioned previously as an advisory agency for policy and planning to protect environmental resources and quality.

NEB's major responsibilities are:

- to recommend and develop environmental quality standards as well as enforcement measures for protection of environmental resources including water, land, air and aesthetic values.

- to submit proposals for development, improvement and conservation of environmental quality to the Council of Ministers.

- to coordinate plans and project development activities of government agencies, state enterprises and private sectors.

- to assess environmental impact of any project to prevent any adverse effect on environmental quality.

- to conduct study and research of the environmental condition and perform amendment of laws and provisions of guidelines for the enhancement of the national environmental quality.

Ministry of Public Health is concerned with public health, sanitatio and medical services in whole Thailand and is responsible for technical and legislative supports for sanitary conservation program.

As for the aspect of pollution control, the agency conducts inspection and survey of water pollution problems and waste treatment especially of hospitals. The ministry is presently, however, not involved directly in any implementation of sewerage system development.

Ministry of Industry is responsible for the development of national major industries including mining, petroleum and sugar industries. The legal control is also executed for all kinds of factory's activities. With respects to the pollution problems their control is extended to prevent any deleterious wastewater discharged from the industries and factories setting up the effluent standard and precautionary regulations.

Ministry of Agriculture is mainly responsible for land reform and development of agribusiness which includes rice and other food production, livestock, forestry and fisheries. The other important activities related to above works is executed by its Royal Irrigation Department which is responsible for the provision, management and control of water resources for irrigation purposes including maintenance and improvement of rivers including the Chao Phya River and major trunk drains. As for the pollution control, above department is concerned for the protection of water sources and distributed water for irrigation purpose and therefore involved in pollution control programs related when necessary.

Ministry of Interior is a central agency to administer and control the overall activities of local and regional authorities including BMA for the development of public welfare and security service including infrastructural development project. As one of the infrastructural development project, the proposed wastewater control program is to be under administrative control of this agency in the aspects of project formation and approval.

The NESDB is staffed with the qualified personnel in the various fields especially in the field of socioeconomic development planning and project evaluation. The NESDB reviews the national and regional sector plan and assess the priority of the projects from the viewpoint of nation's overall economic and social development plan as formulated in the series of 5 years national economic plan. NESDB plays a vital role in screening the project of priority especially those major project which require the foreign currency loan.

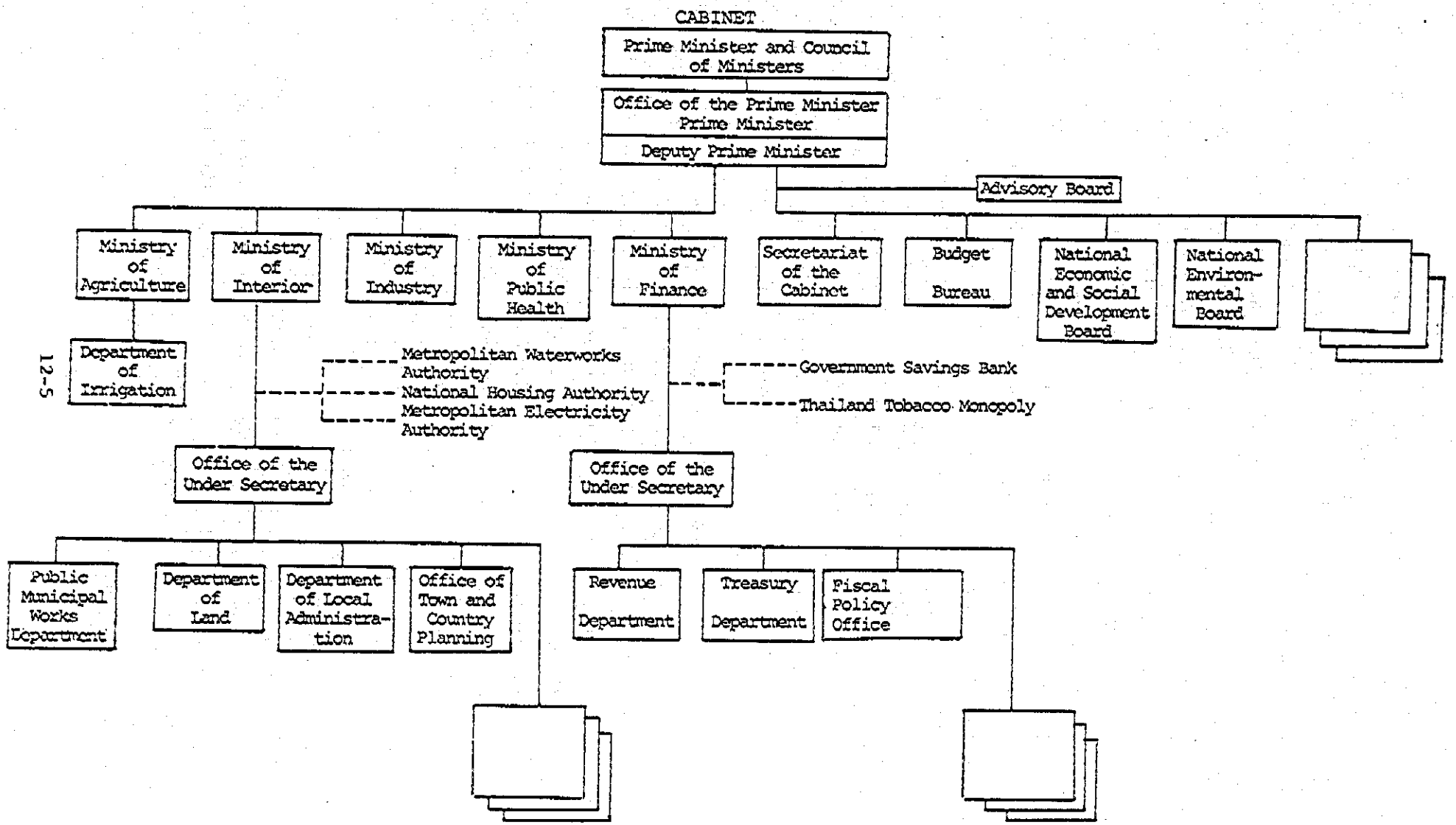
Ministry of Finance is largely responsible for financial administration including national treasury and foreign loan administration as well as revenue projection such as national taxation of income tax and customs duty.

As for the proposed sewerage project this agency will involve in the project in the aspect of loan approval and its administration if such project requires foreign and local loan through Project Loan Operation Division of the Fiscal Policy Office.

Budget Bureau is responsible for the national government's annual budget administration which is important for the national fiscal policy and planning as well as national economic plan. If the national project as proposed sewerage project requires substantial local currency fund and government expenditure, this agency would play a vital role submitting its recommendation to the Cabinet for the budgetary approval.

The organization chart for the above agencies at national level is indicated by Figure 12.1

Figure 12.1 The Organization Units Concerned at National Level



b. Local Agency to administer Project Area

Bangkok Metropolitan Administration (BMA):

The Study Area is administered by the Bangkok Metropolitan Administration (BMA) which was found in 2515 (1972) merging the former Municipality of Bangkok and Thonburi. In 2518 (1975) the Bangkok Metropolitan Administration Act was promulgated and the first election of the Governor and Deputies as well as Assembly was held in same year. BMA has principally been established as a local municipal government to exert an autonomy with minimal control from the central government. The Governor as the chief executive of the BMA is under the ultimate control of Bangkok Metropolitan Assembly, a legislative body consisting of 45 assemblymen elected each representing approximately 100,000 persons from the 24 administrative districts covering an area of 1,589 km^2 with approximate population of 5 million.

The Assembly approves or rejects ordinances and annual budget of BMA. The personnel administration is under the Bangkok Metropolis Civil Service Commission chaired by the Minister of Interior.

BMA is organized into 11 departments and one office of secretary comprising approximately 8,300 permanent staff and 24 district offices comprising 3,500 officials directly responsible for activities of local interests under Secretary of State for Bangkok Metropolis as indicated by the Organization Chart, Figure 12.2. BMA's main policy is land use planning, environmental development, economic and social development and internal development of BMA. The unit of Under Secretary of State is playing a vital role as a nucleus coordinating unit in BMA and most activities are under the administrative control of this unit.

BMA's major functions are: maintenance and construction of roads, water ways and drainage system, cleanliness, sanitation and orderliness of the city and public welfare in addition to public health, medical services, conservation of the environment, public housing, education, controlling markets, ports and ferries, slums, policing and commercial business in Bangkok Metropolis.

The functional involvement of central government agency is, however, significant and major public utilities such as transportation, electricity, water supplies, telecommunication are under the jurisdiction of other central government agency and some functions normally expected to be under BMA are under the jurisdiction of central government, and quasi-government enterprises and other Ministries of central government. Among such organizations of central government, the Minister of the Interior exerts direct control over BMA as mentioned above. The followings are functional units of BMA more or less related to the proposed Sewerage System Project.

(1) Department of Policy and Planning

This Department recently created in BMA is responsible for coordination of various activities in BMA especially for the development of project planning. The department is also responsible for the administrative and organizational development of BMA in line with the government policy. As for the aspect of the project, this department is instrumental to formulate the project which is evaluated and submitted to BMA's Governor and to the project committee for the selection and approval.

(2) Department of Public Health

This Department is responsible largely for public health and environmental sanitary conservation and health hazard prevention program especially eradication of communicable diseases. The activities more or less related to the wastewater control program is examination of public utility system planning to conform to their public health criteria. In this respect the Environmental Health Division of this Department is responsible for the approval of human excreta disposal or toilet system.

(3) Department of Public Works (DPW)

DPW is one of the departments which have more influence over the constructions and control of city's infrastructure, such as public buildings, roads in Bangkok Metropolitan Area. DPW has 884 officials and more than 1,200 laborers. DPW is organized into Division of (1)

Construction Supervision and Inspection, (2) Building Control, (3) Design, (4) Right of Way and Land Acquisition, (5) Construction and Maintenance of Road, (6) Office of Public Works Planning and (7) Office of Secretary. The Office of Secretary (Administrative), DPW has the responsibility to coordinate utilities installations with other agencies such as Metropolitan Waterworks Authority (MWWA), Highway Department and Metropolitan Electricity Authority (MEA).

(4) Department of Drainage and Sewerage (DDS)

The Bureau of Drainage and Sewerage was established in BMA in 2520 (1977) as one of two bureaus split from the former Bureau of Cleansing with primary objective to alleviate or possibly eliminate the recurrent flooding and to dispose ever-increasing wastewater which is one of the major concerns of BMA. The official name of this bureau has been changed in 2524 (1981) to Department of Drainage and Sewerage (DDS)in line with BMA's policy toward reinforcement of administrative authority. DDS is currently exerting efforts in cleaning, dredging and improving numerous klongs throughout the city as one of the measure for the flood protection, especially during the rainy season. In this connection DDS is partly implementing the drainage improvement plan worked out several years ago. The wastewater control related to sludge and solid waste disposal site is also exerted

DDS is headed by a Director General who reports to one of the four Deputy Governors of BMA. DDS is organized into five regular divisions such as (1) Office of Secretary, (2) Technical, (3) Drainage Control, (4) Canal Maintenance, (5) Waste Water Treatment and temporarily provided Special Project Divisions as shown in Figure 12.3. The special Project Division has recently been provided envisaging the increasing importance of drainage project implementation. The total officials of DDS in 2524 (1981) is 450 consisting of 151 engineers, 39 technicians, 103 experts, 157 administrative personnel and 1,373 laborers. In addition to above the significant numbers of temporary laborers are also employed to undertake the cleaning of canals and drain pipes and the contracting firms are engaged to perform the most construction work of canals and parts of its maintenance work.

DDS has been dealing with the solution of important problems such as flood protection and pollution control since its establishment in 2520 (1977). The project advisory committee and special project office have been provided on ad hoc base for the implementation of flood protection and drainage control program and most recently Executive Committee was provided to facilitate the progress of both of the drainage and sewerage development program.

(5) Department of Sanitation (DOS)

This department is another part derived from the former Bureau of Cleansing. DOS has 386 officials and approximately 900 laborers mainly responsible for the disposal of night soil including solid waste of the BMA's 24 districts and control of disposal sites, refuse dump and compost plants. The septic tank systems widely prevalent in the Bangkok Metropolitan Area are under the control of this department and their task of desludging of such spetic tank and disposal to the public sludge disposal sites, On-Nooch and Nong Khen are presently considered one of the important activities to sustain the sanitation in Bangkok.

(6) Department of Finance

This Department composed of 580 officials including financial experts and accountants is responsible for overall control of BMA's financing activities such as revenue and expenditure control, BMA's fiscal planning, treasury, accounting, auditing and assets administration. This department also deals with foreign loan under the control of Ministry of Finance when BMA undertakes the project financed under such foreign loan with pertinent arrangement of accounting documents to be acceptable to the lending agency for the project.

(7) Twenty Four (24) District Offices

Each district office located in 24 districts in the Metropolitan area represents BMA's authority in dealing with local day to day activities as registration, tax collection and other routine public services such as cleaning of small drains and public places and garbage collection.

Figure 12.2 The Organization Units Concerned at Local Level (Bangkok Metropolitan Administration)

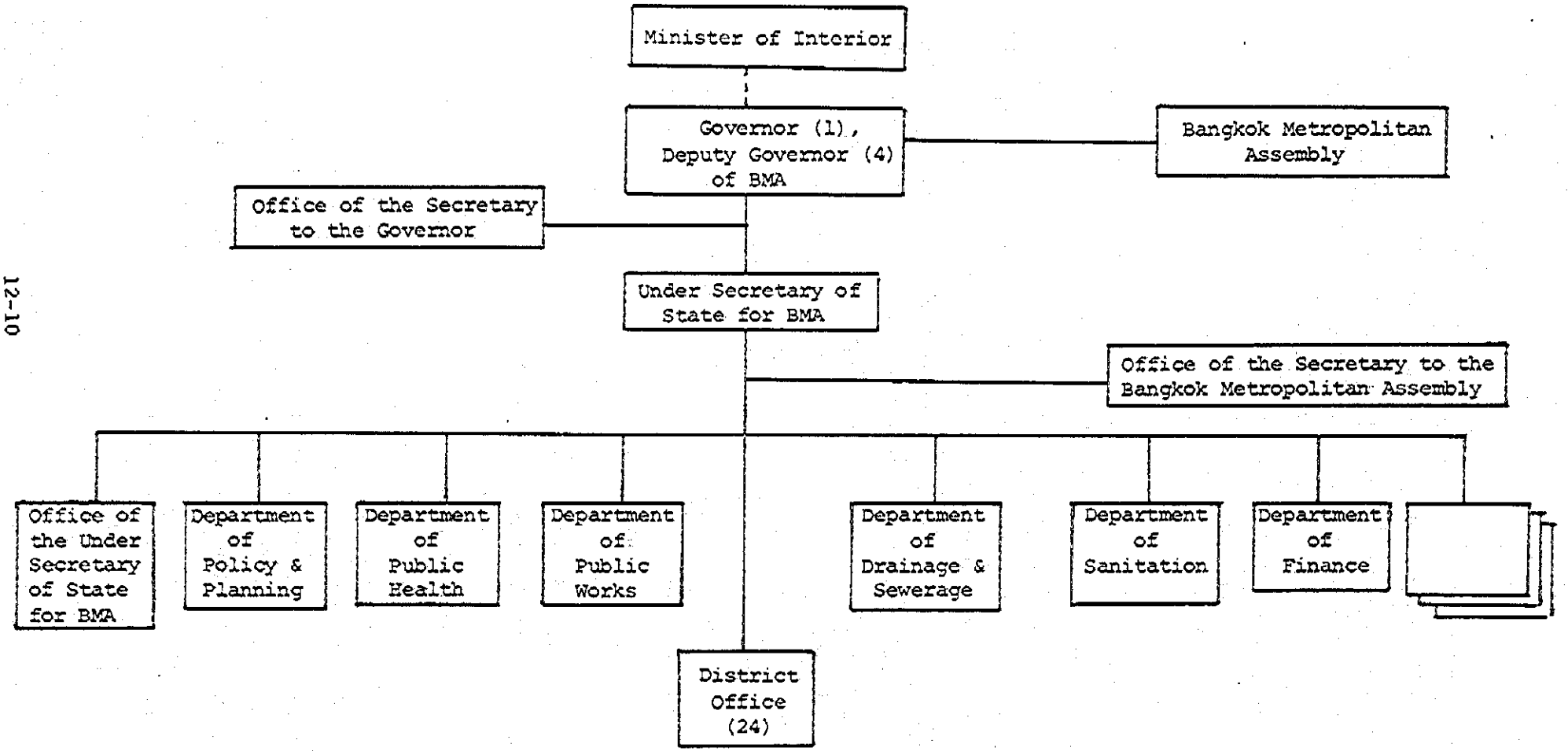
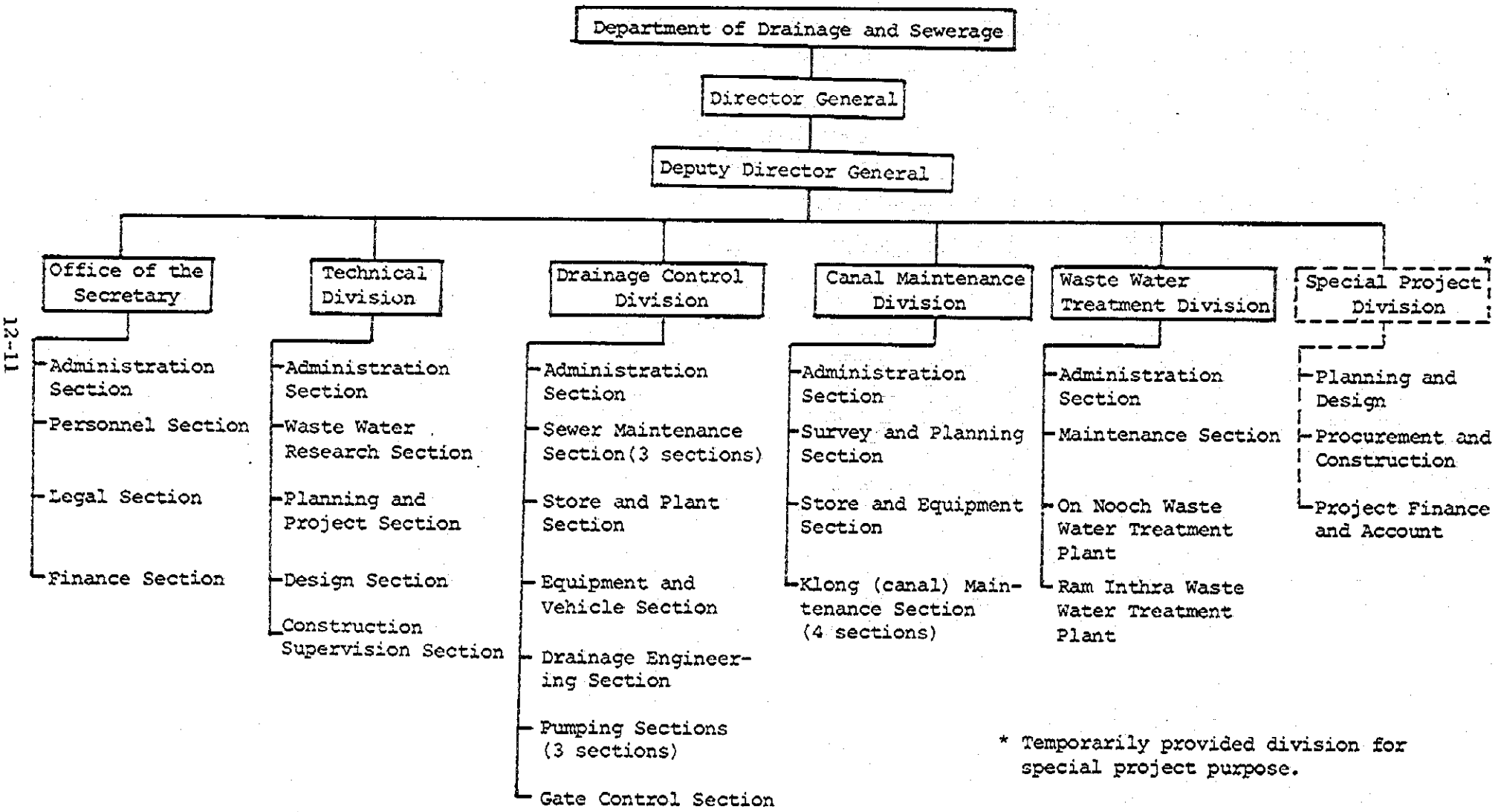


Figure 12.3 Existing Organization of Department of Drainage and Sewerage (DDS)



c. Existing procedures to formulate the project

There are some different procedures in practice to implement projects depending on the magnitude. A minor project of smaller magnitude of capital costs is normally implemented by its own authority of local agency. Projects of larger magnitude especially those requiring the loan from foreign lending agencies are required to be passed through the screening agencies and approved finally by the Cabinet. The procedures or steps to be taken to obtain the Cabinet approval are, however, not so rigidly fixed and some contingent procedure is taken to meet the nature of the project such as urgency and political needs. Two alternative steps in normal and special case are generally practiced.

In the normal case, the Governor of local agency (such as BMA) submits the project proposal after internal screening to NESDB through Ministry of Interior and NESDB evaluates the proposed project in coordination with Ministry of Finance and Budget Bureau and submits it to the Cabinet with recommendation and advice. The Cabinet makes final decision mainly based on the opinions of NESDB. In the special case, the Governor submits project proposal after internal screening directly to ad hoc National Steering Committee consisting of various national agencies concerned for the project. If the project is concluded to be agreeable in the Committee, it is forwarded to Cabinet to obtain the approval.

The above two cases are indicated by following chart, Figure 12.4, assuming that the proposed sewerage project is required to obtain the Cabinet approval.

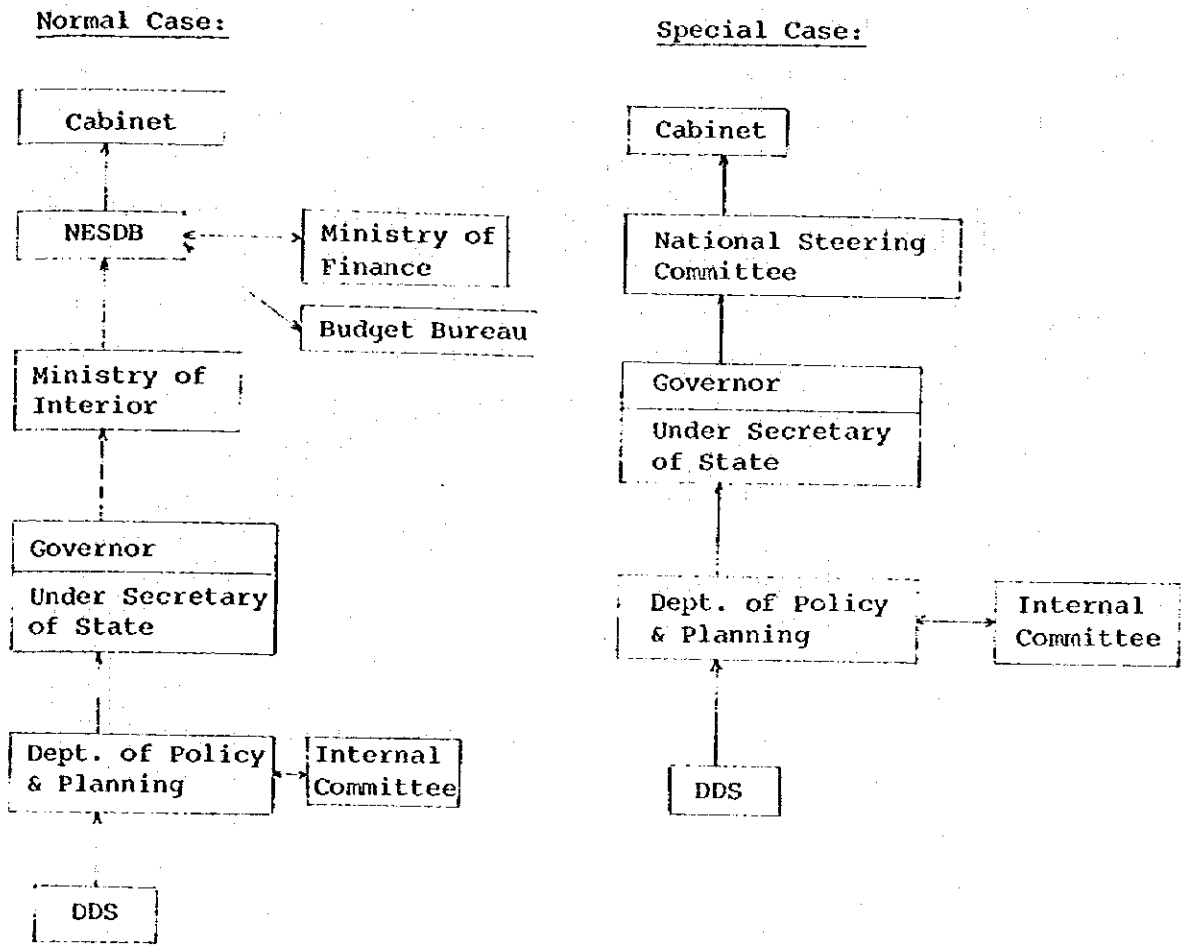


Figure 12.4 Flow Chart for the Project Formation

12.2 Proposed Organization

After reviewing the existing administrative organization more or less related to the proposed sewerage project as stated in previous section, it is considered necessary to reinforce or expand the present Department of Drainage and Sewerage of BMA as a sewerage works executive agency to undertake the sewerage project and achieve a satisfactory control and management of total wastewater control program. The coordination of other related agencies and supports from the central government will also be required. The present study therefore aims, placing emphasis on functional arrangement required in the project implementation, at working out a most suitable organization which will provide dependable services in an efficient manner and work in good coordination with other related agencies for wastewater collection, treatment and disposal.

(1) Suggested Organization Arrangement

Most functions required for the proposed project appear to have been established already in present Department of Drainage and Sewerage (DDS), BMA as can be seen in the Figure 12.3. These existing units, however, are mainly dealing with maintenance and improvement of drainage and canal systems. It is therefore desirable to integrate the necessary functions for sewerage works into the present organization. The more simplified and economized organizational arrangements are desirable with maximum utilization of existing units for the initial step to lessen difficulties in personnel recruitment and time-consuming juridical procedure for organizational reformation providing that step by step upgrading should be attempted over a number of years with ultimate objective to set up the desired organization. Such organizational development has already been proposed in the previous Master Plan and organization arrangement presently proposed is based on the concept as accepted in the Master Plan.

The initial step organization assumed to function for approximately 10 years (2527 - 2537) especially for the first stage project implementation is suggested as charted in Figure 12.5. In this organizational arrangement the existing sections of Technical Division are assumed to perform the required sewerage functions with necessary expansion of

Figure 12.5 Proposed Organization Chart for the First Stage

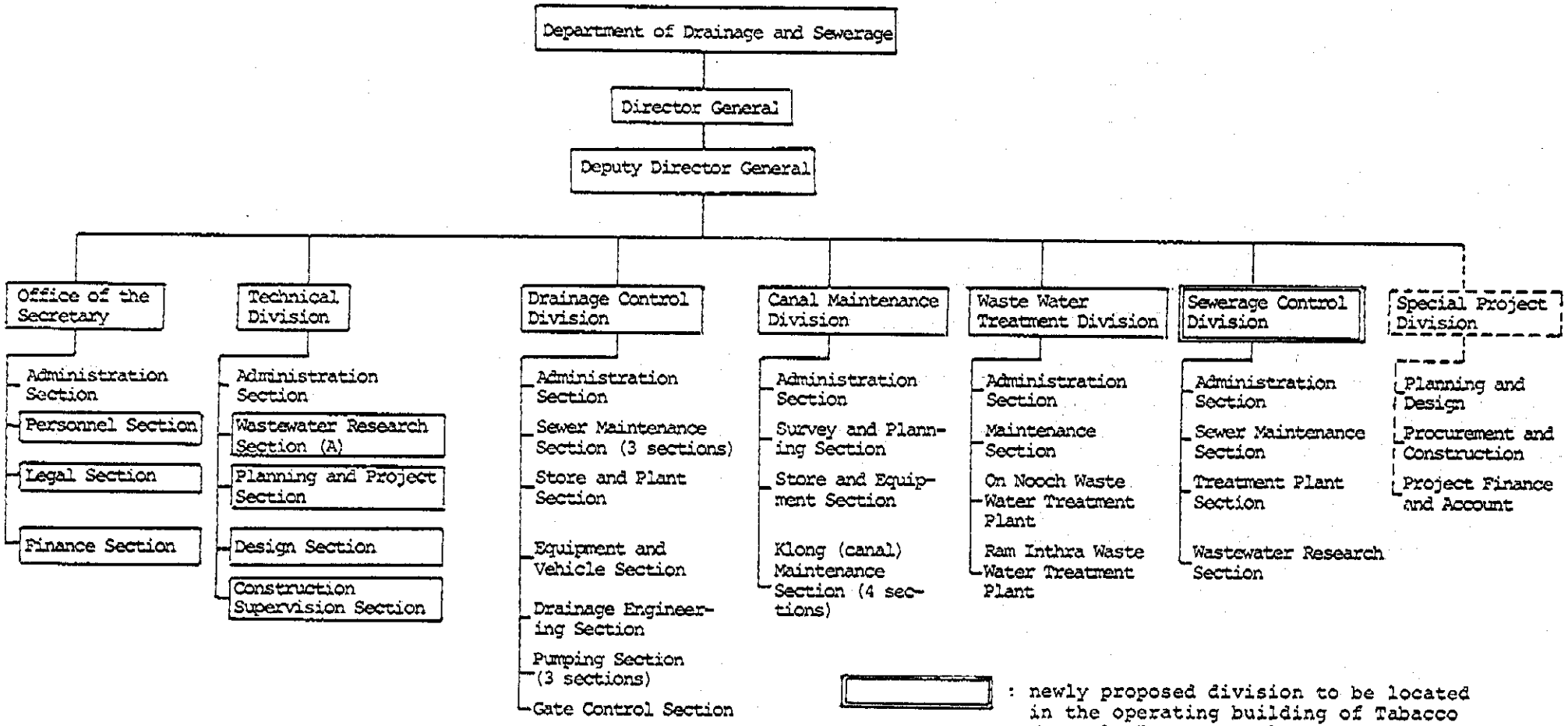
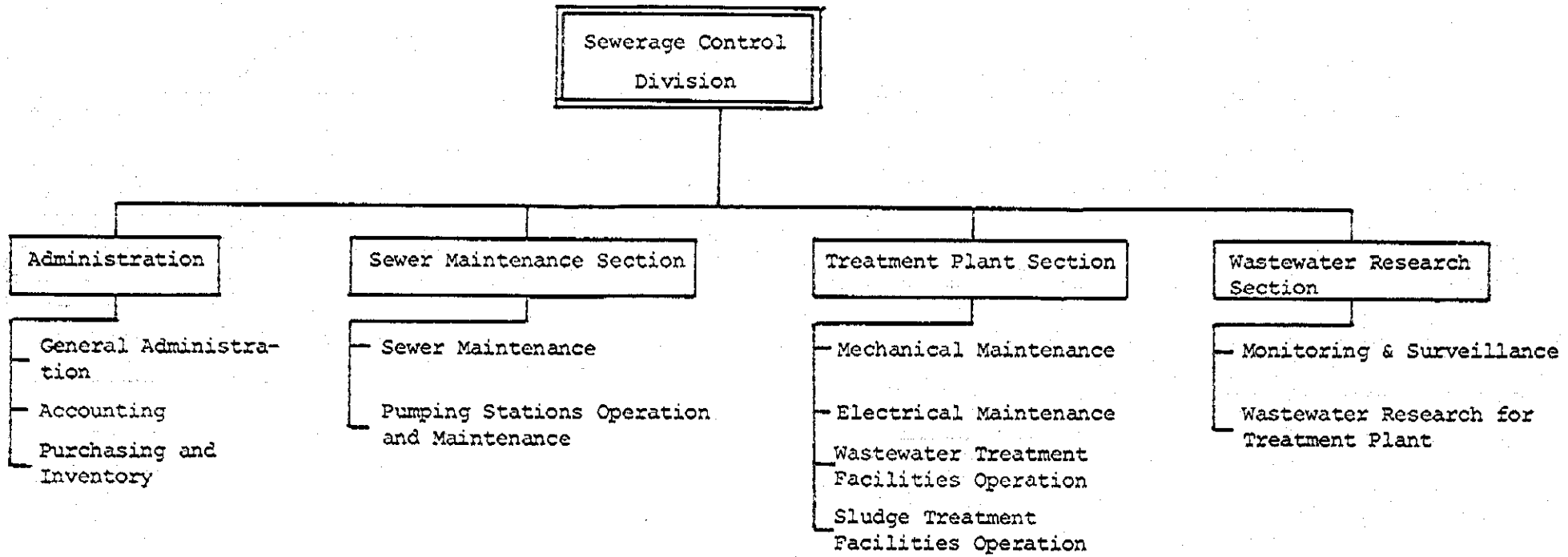


Figure 12.6 Function Chart of Proposed Sewerage Control Division



man-power. The existing Waste Water Research Section is incorporated in newly proposed Sewerage Control Division to perform monitoring and surveillance of wastewater for treatment plant. And those functions of planning and design as well as construction should be performed by existing sections of Planning & Project Section, Design Section and Construction Supervision Section. The detail of new Sewerage Control Division is presented in Figure 12.6.

(2) Staffing Schedule

The staffing schedule is prepared for the first stage implementation of the proposed sewerage program as indicated in Table 12.1 on the assumption that the system construction initiates from 2528 (1985) after the detailed designing in 2527 (1984) and fully operate the schemed treatment plant from 2532 (1989) after completion in 2531 (1988).

The full supports of existing staff for the newly required functions are also schemed to lessen the anticipated difficulty to recruit the qualified and experienced engineers.

The strengthening of the staff by recruiting the qualified engineers and experts is a vital aspect of the organizational program especially at the initial stage of the project. It is anticipated that difficulties may arise in such recruiting since the qualified professionals in the field of sewerage are not sufficiently available internally in the existing department except for the laborers who are comparatively sufficient in number to be involved in sewerage works. The present staff of Technical Division would be therefore required to exert the efforts to be involved in the sewerage functions until newly required functions become viable and adequately staffed. The assistance of the foreign consultants experienced in the field of sewerage project might also be recommended especially in a design stage with vigorous training program to transfer the skills and expertise to the staff of proposed sewerage organization.

Table 12.1 Schedule of Estimated Staff Requirement for the First Stage

Job Title	Number of Staff Required at the End of Year					
	2527 (1984)	2528 (1985)	2529 (1986)	2530 (1987)	2531 (1988)	2532 (1989)
Sewerage Control Division						
Division Head	1	1	1	1	1	1
Secretary-Typist	-	-	-	1	1	1
Administration Section						
Head	-	-	1	1	1	1
Purchasing Officer	-	1	1	1	1	1
Accounting Officer	-	-	-	1	1	1
Clerk	-	-	-	2	2	2
Sewer Maintenance Section						
Head	1	1	1	1	1	1
Assistant Engineer	-	-	1	1	1	1
Technician (Inspector)	-	-	1	2	2	3
Foreman	-	-	1	1	1	2
Laborer	-	-	2	5	5	9
Treatment Plant Section						
Head	1	1	1	1	1	1
Sanitary Engineer	-	-	-	1	1	2
Mechanical Engineer	-	-	-	-	1	1
Electrical Engineer	-	-	-	1	1	1
Technician (Operator)	-	-	-	2	2	8
Laborer	-	-	-	2	2	12
Wastewater Research Section (a)						
Head	(1)	(1)	(1)	(1)	(1)	(1)
Biologist	-	-	-	(1)	(1)	(1)
Chemist	-	-	-	(1)	(1)	(1)
Technician	-	-	-	2(3)	2(3)	2(3)
Technical Division (b)						
Planning and Project Section						
Head	(1)	(1)	(1)	(1)	(1)	(1)
Sanitary Engineer	1	1	1	1	1	1
Design Section						
Head	(1)	(1)	(1)	(1)	(1)	(1)
Assistant Engineer	1	1	1	1	1	1
Technicain	(1)	(1)	(1)	(1)	(1)	(1)
Draftman	(2)	(2)	(2)	(2)	(2)	(2)
Construction Supervision Section						
Head	(1)	(1)	(1)	(1)	(1)	(1)
Civil Engineer	-	1	1	1	1	1
Technician (Inspector)	-	1	1	1	1	1
Laborer	-	1	1	1	1	1
Office of the Secretary (b)						
Head	(1)	(1)	(1)	(1)	(1)	(1)
Personnel Officer	-	(1)	(1)	(1)	(1)	(1)
Budget Officer	(1)	(1)	(1)	(1)	(1)	(1)
Legal Officer	(1)	(1)	(1)	(1)	(1)	(1)
Total (c)	5(10)	9(11)	15(11)	31(16)	32(16)	55(16)

Note: (a): Wastewater Research Section is an existing section to be included in new Sewerage Control Division.

(b): Existing organization to provide required functions.

(c): Figures in parentheses indicate the numbers of existing staff who are required to be involved in Sewerage Works and figures without parentheses indicate the numbers of staff to be newly recruited.

(3) Job Description of Staff to be Assigned

The followings are the required tasks for the staff to be assigned in the proposed organization as scheduled in Table 12.1.

Sewerage Control Division

Division Head: Responsible as the head of the new division for the operation and management of total sewerage system in the proposed sewerage zone. He coordinates each section of the division including personnel administration as disciplinary development of the staff and gives adequate orders to the section heads under full comprehension of the sections. He has a duty to report the development and progress of the activities of the division to the Deputy Director General of DDS as required.

Secretary-Typist: Assists Division Head in handling documentation and filing and other miscellaneous works.

Administration Section

Section Head: Responsible for overall control of administration works related to sewerage system operation.

Purchasing Officer: Responsible for the procurement and supply of local and offshore materials to be required for construction and maintenance of the facilities including inventory control of materials.

Accounting Officer: Responsible to record all disbursements for the operation of the sewerage systems and prepare regular accounting reports to Finance Section of Office of the Secretary, DDS including programming the releases of local money to required expenditure for the procurement of materials, equipments and chemicals to be required for the system maintenance and operation.

Clerk: Supports above officers in day to day works handling documentation and other general administrative works.

Sewer Maintenance Section

Section Head: Supervises activities necessary in keeping sewers and pumping stations as well as gates in efficient working order administering the inspectors, foremen and other laborers to be involved in all maintenance and repair works.

Assistant Engineer: As an assistant to Section Head, responsible for the direct control and supervision of routine maintenance and emergent repair crews to ensure that cleaning activities are performed to keep the sewers in satisfactory condition and to ensure interrupted sewer service to users in accordance with maintenance schedule.

Technician: (Inspector) To be in charge of inspection of pumping station, sewer and gates for the maintenance and repair of pumps, motors, electric controls and other pumping accessories in accordance with the preventive maintenance program.

Foremen: Supervise the activities of laborers who undertake routine maintenance and repair of the sewers.

Laborers: Undertake the cleaning activities of sewers and screen of the pumps under the control of foremen.

Treatment Plant Section

Section Head: Responsible for the management and administration of the overall operation and maintenance of the wastewater treatment plant to ensure adequate treatment of wastewater and sludge and proper disposal of effluent.

Sanitary Engineer: Responsible for overall control of treatment functions to ensure adequate quality of wastewater supervising the activities of mechanical and electrical engineers for keeping the machinery, electrical equipments and facilities in good working condition.

Mechanical Engineer: Responsible for maintenance and repair of mechanical equipments of the treatment plant under the control of Sanitary Engineer.

Electrical Engineer: Responsible for maintenance and repair of electrical equipments of the treatment plant under the control of Sanitary Engineer.

Technician: (Operator) To be in charge of overall operating activities of the treatment facilities to achieve the desired volume and quality of the treated wastewater and proper disposal of the effluent including the preparation of the operating records in accordance with the operational instructions.

Laborers: Clean the various equipments in the wastewater treatment facilities for proper function of the equipments including grit, screenings, control valve, and gates etc., including premises of the plant.

Wastewater Research Section

Section Head: Supervision and administration of all necessary activities in conducting water quality analyses of the Klongs in Zone 2-A area and monitoring of the water quality in the treatment facilities including the preparation of all records of laboratory analyses and tests conducted.

Biologist: Responsible for water quality analyses especially for biological component of wastewater to ensure the successful operation of the treatment facilities.

Chemist: Supervises and control all activities of water quality testing including collection of sample water in Klongs and treatment facilities and their analyses.

Technicians: Perform routine collection of sample water at monitoring points as required by operational instructions, and perform routine water quality analyses and testings as well as other testings that may be required from time to time under the direction of Section Head.

Technical Division

Planning and Project Section

Section Head: Responsible for overall planning of the sewerage system development in Bangkok Metropolis in the most effective and economical manner especially for the proposed first stage implementation program in coordination with other related agencies and project consultants.

Sanitary Engineer: Responsible for satisfactory progress of the proposed sewerage system development program under full comprehension of the engineering aspects of the proposed sewerage project.

Design Section

Section Head: Responsible for reviewing the detailed design, working drawing, bill of quantities and specifications to be required for the construction stage of proposed sewerage system and repair works at the later stage, supervising design engineer.

Assistant Engineer: Assists Section Head in every aspects of activities required for design stage of the proposed project supervising the activities of technician and draftmen of this section.

Technician: To be in charge of plan and detailed design as required for the construction, improvement, repair of sewerage facilities.

Draftmen: Undertake the drawing of every systems, facilities and appurtenances under direction of the technician.

Construction Supervision Section

Section Head: Responsible for supervisory services for overall construction works with attendant field surveys and inspections to assure compliance with regulation and required specification with administrative control of the subordinate personnel involved.

Civil Engineer: Assists Section Head to perform the activities as above mentioned with direct control of the personnel involved in the construction works.

Technician: (Inspector) To be in charge of inspection of the construction in progress including equipment and materials and issuance of the resultants reports to Section Head to ensure adequacy and completeness of the construction works.

Labor: Performs miscellaneous works pertinent to above supervisory works.

Office of the Secretary

Head: Responsible for administration and management aspects of the project in timely assessment of the personnel administration and control over budget and legislative proceedings.

Personnel Officer: Responsible for the personnel management and recruitment of new personnel, transfer of existing personnel and wage control including development of training program for the newly required functions.

Budget Officer: Responsible to ensure proper budgeting of the project with systematic and efficient control of the cash flow. The loan administration for foreign loan will be one of the important tasks for this officer if such loan is realized.

Legal Officer: Responsible for the legal arrangement required for the project such as right-of-way, contracting and other legal settlement for any conceivable disputes in connection with sewerage works.

(4) Training Program

The proposed organization should maintain the qualified and experienced personnel in order to cope with the expanded functions for the sewerage activities. Under the present situation such experienced and qualified personnel are not readily available and vigorous training should be necessary for the personnel to be assigned for the newly proposed tasks especially for the key personnel in order that they can upgrade their skills and knowledge required.

Such training program should be made in accordance with the progress of the project and functions required in the respective fields. The building on the treatment plant site has been planned with particular emphasis on the importance of such training and training rooms are to be provided in the building.

(a) The personnel to be assigned for the operation and maintenance of the treatment plant should be recruited and properly trained for the satisfactory functioning of the treatment plant which is the essential part of the proposed project. It is desirable for the key operators to acquire the following basic knowledge prior to startup of the treatment plant about:

o role required for plant operator
o processess involved in wastewater treatment
o basic theory of above processess
o equipment used in wastewater treatment
o routine operation procedures
o preventive maintenance procedures
o safety

The above basic knowledge about operation technology can be delivered to a potential key personnel by the foreign expert through the training course afforded normally by bilateral technical assistance program.

The actual operation skills are, however, more important and such skills can be afforded to the personnel to be assigned for operating job by training on the job and direct contact with the personnel sufficiently experienced in the operation of the treatment plant. The despatch of the potential engineers or technician to the treatment plant already in operation such as existing Huay Kwang treatment plant administered by National Housing Authority (NHA) for a agreed period is therefore considered most appropriate for such purpose.

(b) The personnel to be involved in the sewer maintenance should acquire the knowledge and skills for various sewer maintenance techniques such as maintenance schedule, inspection of sewers, method for repairs and use of maintenance equipments. On the job training by field demonstration and exercise would be preferable to achieve such training purpose.

(c) The key personnel to be involved in the planning and designing functions as well as construction supervision will be required to acquire knowledge about planning, detail designing and construction of the sewerage system development especially for the proposed sewerage project. Such training can be achieved through the transfer of knowledge from the foreign consultants directly participating in the planning and designing as well as construction supervision works to be performed by such consultants at design and construction phases of the project.

(d) The key personnel to be involved in administration and financial functions are advised to attend some short course for management and finance which can be afforded by certain management experts internally or externally recruited at initial stage of the project. The subjects should cover basic accounting, cost accounting, inventory control, general and project management and public relations.

(5) Coordination with Department of Sanitation (DOS)

In the proposed project the existing septic tanks and cesspools in the sewerage zone will continue their functions since the private disposal systems of wastewater such as human excreta and the control of such systems in Sub-zone 2-A may not be excluded completely from proposed responsible organization of DDS. In this connection following three alternatives for the division of responsibility to control the above disposal systems have been suggested as a guidance for the government to develop further functional coordination with DOS.

Alt. 1: DOS will undertake the desludging of existing septic tank systems and its disposal as well as the treatment works at the existing disposal site of On Nooch or Nong Khaem as presently practiced.

Alt. 2: DDS will newly undertake the desludging and disposal service for the proposed sewerage area of Sub-zone 2-A and DOS will undertake the treatment works at On Nooch or Nong Khaem.

Alt. 3: DDS will undertake the collection, disposal of the sludge for Sub-zone 2-A area and treat them at the wastewater treatment plant newly proposed for the present sewerage development project.

Among above alternatives, Alt. 1 is based on the most conservative concept to avoid any reformation and revision of present practice of sludge control. In this alternative the administrative conflict to be derived from the transferring the responsibility conventionally fixed in the existing organization will not be anticipated and burden of additional works to be imposed on DDS will be lessened. DDS can not, however, directly control the septic tank systems and constant efforts for vigilant control of such private disposal systems through strict coordination with DOS will be required.

Alt. 2 is more ideal in view of the basic wastewater control policy in that the sewerage works agency should best be responsible for comprehensive and unified wastewater control in the sewerage zone including septic tanks and other private disposal facilities which are notably related to wastewater control. This alternative has an added advantage to raise revenue to be derived from the desludging. This alternative requires, however, the juridical or political intervention to transfer the responsibility in addition to agreement for functional abandonment from DOS, and the new activity for DDS will require additional personnel and vehicles mainly necessary for the removal and transportation of the sludge as estimated as 87 persons and 7 vehicles.

Alt. 3 is based on the concept developed further from above Alt. 2 allowing the sludge treatment in the treatment plant newly proposed for the present sewerage development project with same advantage as Alt. 2. This alternative is considered most ideal if anticipated restraints and problems as mentioned in Alt. 2 are solved.

The newly required personnel and vehicles for Alt. 2 and Alt. 3 are estimated on the following assumption.

For vehicles:

1. Served population: 252,500
2. Number of septic tank: 50,500 (252,500 persons ÷ 5 persons/unit)
3. Volume of sludge per unit: 0.9 m^3
4. Total volume of sludge per year: 45,450 m^3 (50,500 x 0.9/year)
5. Working days: 7 days a week

6. Collection volume per one vehicle(5 m^3/day): 20 m^3/day
(5 m^3 x 4 times)

7. Required vehicle for Sub-zone 2-A: 7 vehicles (45,450 m^3/year ÷ 365 d/year ÷ 20 m^3/day)

For personnel:

1. Section Head: 1
2. Mechanical Engineer: 1
3. Technician: 2
4. Laborer (including driver: 62(3 persons x 7 vehicles x 2 shift $\times \frac{365 \text{ day}}{250 \text{ day}}$)
5. Foremen: 21 (1 person x 7 vehicles x 2 shift $\times \frac{365 \text{ day}}{250 \text{ day}}$)

CHAPTER 13

REGULATION ARRANGEMENT

As there is no complete sewerage system except for quasi wastewater disposal system such as storm sewer and septic tank system, the regulation normally required for the sewage work is not available other than several laws and ordinances to administer the general sanitary control with common objective to ensure public health and protection of environment including klongs, the Chao Phya River and other public water ways. The existing regulations are presented in Appendix L of this report.

13.1 Proposed Legislative Arrangement

As mentioned above, the existing regulations are considered not sufficient to implement the proposed sewerage programs with legal enforcement. Some legal provisions are therefore recommended as the guideline to be followed with adequate adjustment and amplification to conform to the existing condition as enumerated as follows.

a. To authorize the proposed agency to execute the sewerage works:

The Department of Drainage and Sewerage, the proposed executive agency for the proposed project in the Study Area, Sub-zone 2-A is authorized to undertaken such works by Clause 32 of Royal Decree on BMA organization B.E. 2520 (1977) which reads "Department of Drainage is authorized concerning the planning and operation of drainage, flood protection as well as the disposal of wastewater within the boundary of the BMA.

b. To regulate the wastewater quality:

The wastewater to be discharged from domestic, commercial and institutional establishments into proposed combined seweras should be regulated in order to avoid deleterious effects upon the sewers, treatment facilities and related equipments. Such deleterious wastewater is normally discharged from the industrial complex and

factory is also regulated by virtue of effluent quality standard authorized by the above Act. Since no major industry or factory exists in the Study Area except small workshop, wastewater quality is considered sufficiently regulated by applying above effluent standard which is presented as below.

Parameters	Limits*	Remarks
pH	5 - 9	
Permanganate Value	60 mg/l	
Dissolved Solids	2,000 mg/l	
Sulfide	1 mg/l	as H_2S
Cyanide	0.2 mg/l	as HCN
Heavy Metals	1 mg/l	Zn, Cr, As, Ag, Cu, Hg, Cd, Ba, Se, Pb, and Ni together or separately
Tar	No content	
Oil and Grease	No content	
Formaldehyde	1 mg/l	
Phenols and Cresols	1 mg/l	
Free Chlorine	1 mg/l	
BOD	20 mg/l or 60 mg/l	Depends on locations, but must not exceed the maximum
Temperature	40 °C	
Color and Smell	Not objectionable	

* Each content must not exceed the limits.

c. To regulate the discharge of the wastewater:

Under existing Building Control Act, the human wastes from domestic residence and other wastewater from industry, hospital, fresh goods market, restaurant and commercial buildings are regulated to be discharged to the private disposal systems as septic tank and cesspool.

The effluents from such private disposal systems are prohibited to be discharged to waterways and storm sewers although they are presently discharged illegally to such water receptacles or surrounding area due to malfunction of disposal systems causing deplorable pollution.

Some modification and legal array would be necessary to define the category of wastewater and place for disposal. Under the proposed sewerage system the use of combined sewers as designated as public sullage water from the kitchen and bothroom except the human excreta which should be discharged to private disposal systems.

d. Others

Necessary provisions should be provided:

(1) To empower the executive Authority to levy and collect charges including sewerage service charge and tax
(2) To apply the loan or subsidies for the sewerage system development
(3) To empower the Authority to purchase and acquire land or obtain easement or right-of-way for the purpose of sewerage system development including eminent domain procedures.
(4) To protect all facilities of Sewerage Executing Agency to facilitate the filing of a court case for any damage.
(5) To enable the Authority to impose fines and imprisonment for any violations or regulations stipulated for sewerage works.
(6) To enable the Authority to enter private property for the purpose of making inspections and tests, obtaining samples, and other checks to ensure satisfactory maintenance and operation of the sewerage facilities.

Above legal provisions are recommended mainly for the implementation of the first stage program of sewerage project and it is considered necessary to apply such provisions in a flexible manner in coordination with existing regulations under the jurisdiction of other government agencies and national policy for comprehensive pollution control to be developed under National Environmental Board.

CHAPTER 14
PROJECT EVALUATION

This chapter evaluates the anticipated socioeconomic benefits to be derived from the First Stage Project of the sewerage system.

Evaluation will be mainly concentrated on such benefits, among others, as public health, improvement of living environment and economic contribution to the community. Discussions and analyses will be made in the above order in the succeeding sections.

In the meantime, regarding the evaluation of the above benefits, a most preferable approach may be quantification of the benefits. But in this case, there are many unquantifiable benefits, and so this approach is not considered appropriate. Also it may be, alternatively, possible to classify the benefits according to the categories of beneficiary, but it is not adequate, either. These approaches, besides, are not necessarily accurate in evaluation nor convincing to those concerned. Hence, the approach stated at the outset of this introduction is utilized for the present evaluation.

14.1 Benefits Pertinent to Health

Benefits pertaining to health, to attain which is the foremost of the purposes of installing a sewerage system, involve both the community concerned and the individuals in the area. The anticipated benefits concerning health, viewed from public and individual standpoints, are detailed in the following.

(1) Benefits from Public Health Standpoint

Health benefit to accrue to the community from the sewerage system has two aspects, namely, 1) the preventive effect brought forth by the sewerage system reduces the burden on the local and central governments for the disease preventive activities and patient treatment facilities, and 2) the elimination of opportunities of contact with infected matters reduces epidemic cases on the part of the individuals.

Regarding the first item above, budgetary and physical provisions of the governments will be lightened with respect to: chemical disinfection for prevention of epidemics, hospitals together with necessary personnel and equipment and materials, and activities for maintaining klongs and the River at acceptable sanitary levels. Regarding the second item, details will be presented in the next subsection.

(2) Individual Health Benefits

The provision of the proposed sewerage system results in health benefits to the individual people in the sewered area, such as reduction in the risk and incidence of water borne diseases, consequent elongation of life span, reduced expenditure on medical care, reduction in income loss through absence from work, and others. Most of the above benefits are quantifiable if due assumptions are made based on various available data. Hence, an estimate of such benefits in the monetary terms is made in the later subsection. The results indicate that a gain amounting to 40.8 million Baht can be expected by completion of the project.

14.2 Improvement in Living Environment

One of the basic purposes of the project, as important as health improvement, is enhancement of amenity of the area where water and air pollution has been rapidly aggravated in the recent years. This will be achieved by the construction of the present project of the sewerage system. Details are as follows.

(1) Improvement of Environment from Aesthetic Viewpoint

Unpleasant filthy conditions of klongs and ditches in the area due to stagnant sullage water will be eliminated by the proposed project, and also offensive smells emitted from the sullage and trash in the water-ways will be all eradicated. This in the project area where human activities are most concentrated, amenity that is essential for such an area will be largely enhanced.

(2) Recreational Effect

Elimination of sewage contamination of waterways, klongs and the Chao Phya River renders them safer as well as more attractive for fishing, boating, and similar activities of the residents. Most of the populace appreciate the opportunity to take the fresh air along such clean waterways. In addition, tourism and shopping in the area can be readily promoted, if the aesthetic quality of the waterways is improved and the streets are well sewered, free from the stagnation of sewage and piling up of other waste materials.

14.3 Contribution to Local Economy

The construction of the sewerage system contributes substantially to the local economy in several ways. In the first place, land value in the area will be appreciated, and in accordance with such an increase in land value, related properties will also rise in value. On the other hand, the construction of the system furnishes employment opportunities to the local people and purchases local products of materials and equipment. Some of the above benefits are quantifiable and others are not. Details are described below.

(1) Value Added to Land

Investments in sewerage facilities, and also in other public utilities such as water, electricity and road improvement, have the effect of raising the intrinsic value of the parcels of land served by those facilities. The value added per unit of land tends to equal or exceed pro rata share of the investment involved. In the present project area, this benefit is considered especially significant. The value of the benefit will be measured by the additional prices buyers are willing to pay for properties on which physical improvements have been made. It is because the buyers appreciate the possible intensive use of land, not to mention the improved quality of amenity in the area.

The benefit stated above is quantified as shown in subsection 14.5 using some reasonable assumptions. The estimated value amounts to 1,166.10 million Baht.

(2) Intensified Land Use

When sanitary and storm sewers become available, coupled with water supply and other public utilities in general, the land in the area can be more intensively used, as the present project is the case. More people can be supported and more activities in commerce and others can be conducted in the same area. This can not be immediately quantifiable, but definitely one of socioeconomic benefits to be noted.

(3) Public Revenue

Public tax revenues to the local and central governments, except sewerage charges, will be increased in two ways. First, the appreciated land value will produce an increase in land tax revenue. On the other hand, buildings, such as for commerce, dwelling and others, will be graded up in quality and quantity, thus making possible an increase in property tax. This benefit cannot necessarily be quantified, but it constitutes an important reliable tax source for the governments concerned.

(4) Employment and Local Products

During the 5-year period of construction, the local economy will benefit through the employment of individuals for construction work and through the purchase of locally made materials and supplies. The amount of investment for the project is sizable. The project after completion will also provide permanent employment opportunities for the operation and maintenance of the sewerage facilities, including the pumping stations and treatment plant (Refer to Table 12.1).

14.4 Conclusion

Benefits of the proposed project have so far been considered from the three viewpoints of health, improvement in living environment and contribution to the local economy. Some of the benefits were quantified, but most of them were treated as unquantifiable. Therefore, the benefits of the latter category have been elaborated in words. The calculations of the quantifiable benefits show that the monetary values to be gained in the period of twenty years after the completion of the project area equal to 1,206.9 million Baht an enormous amount, converted to present worth, 515.4 million Baht.

Some of the socioeconomic benefits, presently regarded as unquantifiable, may become quantifiable in the future when scientific tools useful for such evaluation are deviced. Even at this stage where those benefits cannot be measured in the monetary terms the benefits justify, it is judged, the proposed investment in the present sewerage project. And further, the evaluation justifies that the investment is to be made from the fund sources of public and private beneficiaries, namely, the central and local governments and the people in the area involved.

14.5 Calculation of Quantifiable Benefits

Calculation 1: Medical Care Cost

The following assumptions are made to calculate the saving of medical care cost by the installation of the sewerage system.

(1) The average number of water-borne disease occurred per 1,000 persons is to be 2.67 in the Study Area on the basis of the recorded incidences rate of whole Thailand in the year 2515 (1972).

(2) About 50 percent of the above cases is attributable to the inadequancy of the existing sewerage system.

(3) Hospitalization for treating these cases is on the average for two weeks, and amounts spent for medical care is about 300 Baht per day per person.

(4) The population growth rate from 2543 (2000) to 2551 (2008) is nil, because the Study Area is expected to reach a saturation point in 2543 (2000).

(5) Population served by the new sewerage system is assumed 100 percent.

Calculation of the benefits from reduction of direct costs of illness is shown in Table 14.1.

Table 14.1 Benefits from Reduction of Direct Costs of Illness
(In Million of Baht)

Year	Estimated Population (1,000s)	Existing Sewerage System		Improved Sewerage System		Benefits 4/
		Cases Per Year 1/	Costs (Baht) 2/	Cases Per Year 3/	Costs (Baht) 2/	
2524 (1981)	252.2	673	2.83			
2525 (1982)	252.2	673	2.83			
2526 (1983)	252.2	673	2.83			
2627 (1984)	252.2	673	2.83			
2528 (1985)	252.2	673	2.83			
2529 (1986)	252.3	674	2.83			
2539 (1987)	252.3	674	2.83			
2531 (1988)	252.3	674	2.83	338	1.42	1.41
2532 (1989)	252.3	674	2.83	338	1.42	1.41
2533 (1990)	252.3	674	2.83	338	1.42	1.41
2534 (1991)	252.4	674	2.83	338	1.42	1.41
2535 (1992)	252.4	674	2.83	338	1.42	1.41
2536 (1993)	252.4	674	2.83	338	1.42	1.41
2537 (1994)	252.4	674	2.83	338	1.42	1.41
2538 (1995)	252.4	674	2.83	338	1.42	1.41
2539 (1996)	252.5	674	2.83	338	1.42	1.41
2540 (1997)	252.5	674	2.83	338	1.42	1.41
2541 (1998)	252.5	674	2.83	338	1.42	1.41
2542 (1999)	252.5	674	2.83	338	1.42	1.41
2543 (2000)	252.5	674	2.83	338	1.42	1.41
2544 (2001)	252.5	674	2.83	338	1.42	1.41
2545 (2002)	252.5	674	2.83	338	1.42	1.41
2546 (2003)	252.5	674	2.83	338	1.42	1.41
2547 (2004)	252.5	674	2.83	338	1.42	1.41
2548 (2005)	252.5	674	2.83	338	1.42	1.41
2549 (2006)	252.5	674	2.83	338	1.42	1.41
2450 (2007)	252.5	674	2.83	338	1.42	1.41

Note: 1/ Morbidity Rate: 2.67 cases per 1,000 population, based on 2515 (1972) incidence of 91,839 cases of whole Thailand as reported by Ministry of Public Health, Bangkok and population of about 34,300,000 reported by Thailand Year Book.

2/ Direct Cost: 4,200 Baht per case.

3/ Morbidity Rate: 1.34 cases per 1,000 population.

4/ Net reduction in direct cost of illness, assuming 100 percent of population served by sewerage system.

Calculation 2: Estimate of Wages Lost to Illness

In estimating wages lost, the number of man-days lost due to disability is estimated. The average wages lost is calculated in terms of age group within the labor force, reflecting an average of 14 man-days lost due to the water-borne desease. The wages lost because of disability of each worker contracting a water-borne disease is estimated to be 1,008 Baht on the average. This assumes that the incidence and age distribution of disease are the same as for the population as a whole and reflect average earnings for each age group and a ratio of workers to total population of 30 percent. The calculation of average wages lost is shown in Table 14.2.

Table 14.2 Estimate of Wages Lost Due to Disability from Water-Borne Diseases

Age Group	Percent of Cases 1/	Wages per Day (Baht) 2/	Wages Lost per Case (Baht)	Wages Lost x % of cases (Baht)
Under 11	10	-	-	0
11-20	15	40	560	84
21-40	30	80	1,120	336
41-60	30	100	1,400	420
61 and older	15	80	1,120	168
			Weighted Average Loss =	1,008

Note: 1/ Percent of cases based on 1970 Population and Housing Census, National Statistical Office, Office of the Prime Minister.

2/ Data on wages based on questionary survey which was performed for the selected 500 households in the Study Area.

Calculation 3: Estimate of Earnings Lost due to Death

Earnings lost due to death are obtained by applying the mortality rates ascribed to water-borne diseases. The present value of future earnings is shown in Table 14.3. The calculation of this benefits also is shown in Table 14.4.

Talbe 14.3 Present Value of Future Earnings

1) Average Annual Earnings = 39,360 Baht
2) Average Expected Working Life = 45 years, beginning at age 15
3) Water borne Diseases Cases (Deaths)

   Assumed to occur:

   100/1,000 under age 10

   150/1,000 between 11 & 20

   300/1,000 between 21 & 40

   300/1,000 between 41 & 60

   150/1,000 age 61 and older
4) Therefore, Expected Life Earnings when death occurs are as follows:

Age Group	Death Rate per 1,000	Average Expected Working Year	Average Earnings/ Year (Baht)	Discount Factor (10%)	Present Value Earnings (Baht)	Weighted Average Present Value (Baht)
under 11	100	45	39,360	9.863	388,207	38,820
11 - 20	150	45	39,360	9.863	388,207	58,231
21 - 40	300	31	39,360	9.479	373,093	111,927
41 - 60	300	11	39,360	6,495	255,643	76,692
61 and older	150	0			0	0
						285,670

Table 14.4 Savings in Loss Due to Disability and Deaths from Water-Borne Diseases (In Million of Baht)

Year	Existing Sewerage System		Improved Sewerage System		Net Saving	Existing System		Improved System		Net Saving
	No. of Cases Working Population	Wages Lost	Cases	Wages Lost		No. of Deaths	Present Value of Expected Life Earnings	No. of Deaths	Present Value of Expected Life Earnings	
2532 (1989)	202	0.20	135	0.14	0.06	5	1.42	3	0.85	0.57
2533 (1990)	202	0.20	135	0.14	0.06	5	1.42	3	0.85	0.57
2534 (1991)	202	0.20	135	0.14	0.06	5	1.42	3	0.85	0.57
2535 (1992)	202	0.20	135	0.14	0.06	5	1.42	3	0.85	0.57
2536 (1993)	202	0.20	135	0.14	0.06	5	1.42	3	0.85	0.57
2537 (1994)	202	0.20	135	0.14	0.06	5	1.42	3	0.85	0.57
2538 (1995)	202	0.20	135	0.14	0.06	5	1.42	3	0.85	0.57
2539 (1996)	202	0.20	135	0.14	0.06	5	1.42	3	0.85	0.57
2540 (1997)	202	0.20	135	0.14	0.06	5	1.42	3	0.85	0.57
2541 (1998)	202	0.20	135	0.14	0.06	5	1.42	3	0.85	0.57
2542 (1999)	202	0.20	135	0.14	0.06	5	1.42	3	0.85	0.57
2543 (2000)	202	0.20	135	0.14	0.06	5	1.42	3	0.85	0.57
2544 (2001)	202	0.20	135	0.14	0.06	5	1.42	3	0.85	0.57
2545 (2002)	202	0.20	135	0.14	0.06	5	1.42	3	0.85	0.57
2546 (2003)	202	0.20	135	0.14	0.06	5	1.42	3	0.85	0.57
2547 (2004)	202	0.20	135	0.14	0.06	5	1.42	3	0.85	0.57
2548 (2005)	202	0.20	135	0.14	0.06	5	1.42	3	0.85	0.57
2549 (2006)	202	0.20	135	0.14	0.06	5	1.42	3	0.85	0.57
2550 (2007)	202	0.20	135	0.14	0.06	5	1.42	3	0.85	0.57
2551 (2008)	202	0.20	135	0.14	0.06	5	1.42	3	0.85	0.57

Calculation 4: Estimate of Land Value Increase

The projected land values over the entire Study Area are shown in Table 14.5. The projected land values is estimated assuming a very conservative increase rate of 150 percent up to the year 2536 (1993) which is 5 years after completion of the sewerage system. No attempt is made to estimate the effects of inflation on land values. On the basis of proportionate shares of estimated infrastructure investments in public utilities about 15 percent of the total increase in land values have been attributed to the availability of sewerage service. This benefit is developed in Table 14.6. The procedure used involves an appraisal of present sites where expansion of the sewerage system is being planned.

Table 14.5 Estimated Land Value in the Study Area

Land Use	Year 2524 (1981)		
	Area (ha)	Value per m^2 (Baht)	Total Value (Million Baht)
Commercial	113	3,000	3,390
Commercial-residential	277	2,000	5,540
Residential	229	1,500	3,435
Institutional	285	1,000	2,850
Green	66	500	330
Total	970		15,545

Table 14.6 Increase in Land Values due to the Construction of the Project (In Million of Baht)

Year	Estimated Total Value	Gain in Total Value	Factor Attributable to Sewer	Net Benefit
2524 (1951)	15,545	5,182	0.15	777.3
2532 (1989)	20,727	648	0.15	97.2
2533 (1990)	21,375	648	0.15	97.2
2534 (1991)	22,023	648	0.15	97.2
2535 (1992)	22,671	648	0.15	97.2
2536 (1993)	23,319	0	0.15	0
2537 (1994)	23,319	0	0.15	0
2538 (1995)	23,319	0	0.15	0
2539 (1996)	23,319	0	0.15	0
2540 (1997)	23,319	0	0.15	0
2541 (1998)	23,319	0	0.15	0
2542 (1999)	23,319	0	0.15	0
2543 (2000)	23,319	0	0.15	0
2544 (2001)	23,319	0	0.15	0
2545 (2002)	23,319	0	0.15	0
2546 (2003)	23,319	0	0.15	0
2547 (2004)	23,319	0	0.15	0
2548 (2005)	23,319	0	0.15	0
2549 (2006)	23,319	0	0.15	0
2550 (2007)	23,319	0	0.15	0
2551 (2008)	23,319	0	0.15	0

Summary of Quantifiable Benefits

Table 14.7 shows the summary of the quantifiable benefits calculated in Calculations 1 through 4 before discount, and Table 14.8 shows the discounted values of the above.

Table 14.7 Summary of Quantifiable Benefits
(In Million of Baht, before Discounting)

Benefit	Amount
o Reduction in Health Hazards	
Savings in Direct Costs	28.20
Savings in Wages Lost	1.20
Savings Due to Decrease in Death Rate	11.40
o Increases in Land Values Attributable to Sewerage System	1,166.10
Total	1,206.90

Table 14.8 Summary of Benefits
(In Million of Baht)

Year	Reduction in Direct Cost of Illness	Savings in Wages Lost	Saving in Life Earnings	Increase in Land Value	Total Benefits	Discounted Factor (to 1981 @10%)	Discounted Benefits
2532 (1989)	1.41	0.06	0.57	777.3	779.34	0.4665	363.6
2533 (1990)	1.41	0.06	0.57	97.2	99.24	0.4241	42.1
2534 (1991)	1.41	0.06	0.57	97.2	99.24	0.3855	38.3
2535 (1992)	1.41	0.06	0.57	97.2	99.24	0.3505	34.8
2536 (1993)	1.41	0.06	0.57	97.2	99.24	0.3186	31.6
2537 (1994)	1.41	0.06	0.57	0	2.04	0.2897	0.6
2538 (1995)	1.41	0.06	0.57	0	2.04	0.2633	0.5
2539 (1996)	1.41	0.06	0.57	0	2.04	0.2394	0.5
2540 (1997)	1.41	0.06	0.57	0	2.04	0.2176	0.4
2541 (1998)	1.41	0.06	0.57	0	2.04	0.1978	0.4
2542 (1999)	1.41	0.06	0.57	0	2.04	0.1799	0.4
2543 (2000)	1.41	0.06	0.57	0	2.04	0.1635	0.3
2544 (2001)	1.41	0.06	0.57	0	2.04	0.1486	0.3
2545 (2002)	1.41	0.06	0.57	0	2.04	0.1351	0.3
2546 (2003)	1.41	0.06	0.57	0	2.04	0.1228	0.3
2547 (2004)	1.41	0.06	0.57	0	2.04	0.1117	0.2
2548 (2005)	1.41	0.06	0.57	0	2.04	0.1015	0.2
2549 (2006)	1.41	0.06	0.57	0	2.04	0.0923	0.2
2550 (2007)	1.41	0.06	0.57	0	2.04	0.0839	0.2
2551 (2008)	1.41	0.06	0.57	0	2.04	0.0763	0.2
Total	28.20	1.20	11.40	1,166.10	1,206.90		515.40

CHAPTER 15
RECOMMENDATIONS

The proposed sewerage project has some particular features, namely, the proposed system is a combined sewerage to utilize all the existing storm sewer facilities as recommended in the Master Plan. And further, the present project has a nature of being a pilot project of sewerage in all Bangkok, and in general the sewerage project is not a self-supporting business. Taking into account all the above, the following will be recommended in order to assure unimpeded implementation of the project as well as appropriate operation and maintenance of the completed facilities.

15.1 Conversion of the System of Sewerage

The most outstanding feature of the proposed sewerage project is that the existing storm sewer facilities are all to be converted to a combined sewerage system, and in the future the combined system will again be converted to a separate system. This basic concept of the project is based on the ecnomy of the construction cost of the project and the materialization of effects of sewerage system construction within as short a period as possible. To attain the above purpose, such conversion of the sewerage system has been an inevitable measure. To satisfactorily operate the constructed system, the following is recommended.

(1) Combined Sewers Converted from Storm Sewers

As the storm sewers which are to be used as combined sewers have been laid with a small gradient, solid matters which tend to settle in the pipe should not be discharged into the sewers. Due to the above reason, the existing septic tanks must be kept continuously in use. Administrative measures, therefore, should be taken for property owners not to discharge the above solid matters, including human excreta directly into the existing storm sewers even after the completion of the project. However, such measures are not necessary for areas where house connections are to be connected with the Chula and Klong Sathorn Interceptor.

(2) Diversion Ratio of Wastewater

The present design has adopted the ratio of 1.0 as described earlier in the text. As far as dry weather continues, all wastewater will be treated, but when the flow of wastewater exceeds the dry-weather flow, part of wastewater diluted by rainwater is to be discharged into the public waterways. Therefore, the degree of pollution of klongs under such conditions should be monitored so as to obtain useful data for future planning the sewerage system.

15.2 Review of Population Growth

As the project area is supposed to be presently inhabited nearly to saturation, almost no increase in the future is allowed for in the design. In this connection, it must be considered that there may probably be some increase in population because the land in the project area has a possibility of more intensified use due to the environmental improvement by the sewerage system. If there is the increase of population, the wastewater discharge will also be subject to change. From the above consideration, the following is recommended.

(1) To review the annual increase of total population. If deemed necessary, the population projection made by the present feasibility study should be revised accordingly.

(2) To observe wastewater flow. Wastewater flow may deviate from the projected quantity by two reasons, namely, 1) population growth, and 2) increase or decrease in per capita water consumption from the projected value.

In accordance with the results of the above review and observation, the timing of implementation of the project of the succeeding stage must be adjusted.

15.3 Measure for Large Amount of Wastewater from New Building

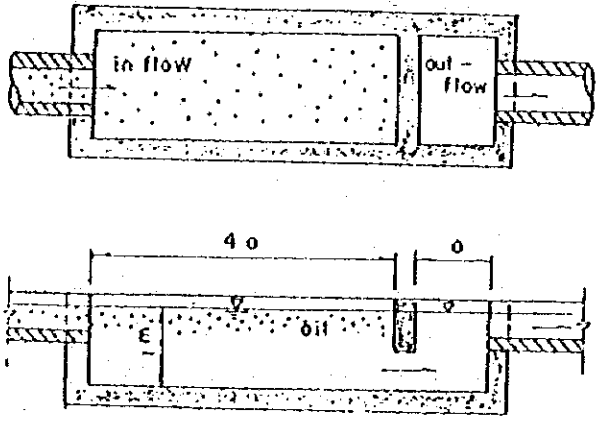
In this study, sewers in the commercial area are designed based on daily average flow of 116 m^3/ha as the commercial wastewater. In case new buildings such as hotel, department store and office building, which will discharge wastewater more than the equivalent flow of 116 m^3/d/ha, are constructed, the following measure is recommended.

House connections of such buildings should be allowed only to the public sewer which has room to receive the wastewater flow from the above facilities.

15.4 Pre-treatment for Waste Oil from Car Repairing Workshop and Gas Station

Many car repairing workshops and gas stations are located in the Study Area. Waste oil from these facilities cause the result of oil contamination in the storm sewers. Moreover, the waste oil cannot be removed by the proposed treatment process without additional facilities.

Therefore, oil trap is recommended to be provided in front of the final discharging point of each workshop and gas station as shown in the following schematic drawing. The trapped oil must be removed by each factory.



- o detention time = 1 hr
- o effective depth= 1 m

15.5 House connection

House connections, also called building sewer or house sewer, have not been shown at this stage. But they should be located during final design to serve each property where necessary. These are provided between the public sewer (existing storm sewers and proposed interceptors) and the property or curb line, serving individual properties. Construction costs of these facilities should be borne by each property owner. The average construction cost per one house connection is estimated at 10,500 Baht assuming that an average length of the house connection pipe is 15 m and unit construction cost is 700 Baht per meter. This cost seems to be a burden to some property owners.

Therefore, establishment of a house connection subsidy system or government loan system is recommended to promote installation of house connections.

15.6 Land Acquisition

Land acquisition of the proposed sites for intermediate pumping stations and treatment plant is very important to execute the project without hindrance. So that it is imperative that DDS and agencies concerned are to arrange land acquisition as soon as possible.

15.7 Monitoring of Wastewater Quality at Treatment Plant

For the First Stage, the modified aeration process was proposed as treatment method to cope with present water pollution at minimum cost. Designed influent and effluent BOD is 160 mg/l and 60 mg/l respectively.

On the other hand, the quality of effluent must be improved in the future when the minimum quality standards for the river are applied. Further, quantities of pollutants may happen to increase over the years.

To cope with the above situation, monitoring of wastewater qualities, of both inflow and outflow, is recommended. And these data will be reflected for future planning the treatment facilities.

15.8 Promotion of Public Relation

Good public relation is indispensable for implementation of the sewerage system. The construction of the system is almost impossible without understanding and cooperation of the citizens. Therefore, it is recommended that the executing agency make every effort to let the public know and understand the sewerage system through all possible communication media, such as pamphlet, radio/television, direct dialogue, etc.

15.9 Financial Aspects

As analysed in previous Chapter 11, the implementation of the proposed project will require the substantial amount of investment over one thousand million baht. In order to enable the proposed project to be implemented on a financially viable base, the government supports reprsented by subsidy from the central government is necessary for the funding of local costs of the project.

Such subsidy is one of essential part of the funding scheme which will substantiate the implementation of the project of public nature especially for the proposed project which contributes the benefits of the wastewater treatment works to the community as a whole. Such subsidy will further enable the sewerage charges to be imposed at an acceptable level within a paying ability of the individuals.

The foreign loan of long term and low interest as represented by bilateral loan is most desirable to be sought for the foreign currency costs of 461.05 million Baht to lessen the financial burden on the potential executive agency. Under such funding scheme the sewerage charge to be imposed on the individual residents can be minimized to be borne within their ability to pay.

The executive agency is therefore required to exert a concentrated efforts to institue the early concurrence of various agencies concerned for the project formation and subsequent mobilization of local and foreign funds. It should be emphasized that an intense manifestation of the requirement of foreign loan through the diplomatic channels as embassies is a vitally important initial step for the successful loan agreement.

Specific consideration is necessary for the manner to collect the sewerage charges since proposed project would provide no obvious modification of the individual disposal systems as represented by septic tanks which is likely to induce negative attitude towards the sewerage charges. Although the sewerage charges combined with existing water supply charge is conventionally utilized as a rational method corresponding to the costs relevant to the wastewater disposal and treatment, this method is not advisable since existing billing efficiency of water supply charge is far from satisfactory due mainly to malfunction of water meters and involuntary payment of the customers. It is therefore recommended to collect the charges by more reliable method to ensure a stable revenue collection. To avail the present taxation system is one of the examples which can enforce the collection of charges and resultant stable revenue. The combined charging method has, however, dominant advantage theoretically and it is advisable to employ this method in the future when the present billing practice is improved and realistic estimation of revenue can be made.

APPENDICES

TABLE OF CONTENTS

APPENDIX A
STUDY ON ALTERNATIVE WASTEWATER TREATMENT PROCESSES FOR THE FIRST STAGE

The purpose of this study is to select the best suited wastewater treatment process for the First Stage, reflecting existing local conditions. Thus, the study on alternatives is made with respect to site availability, their captial costs, operation and maintenance costs, and others, as follows.

1. Existing Conditions of Proposed Treatment Plant Site

In the Master Plan, the treatment plant site for the whole Zone 2 was proposed at an open space of Tabacco Monopoly Estate along the Klong Pai Sing Tow. Existing conditions of the proposed treatment plant site and its environment are shown in Table A.1.

Table A.1 Existing Conditions of Proposed Treatment Plant Site

Item	Description
Location	Tobacco Monopoly Estate along the Klong Pai Sing Tow (See Figure 8.1)
Area	30 ha
Usage	Pond (surface area of 20 ha and 3 - 4 m in depth)
Environment	Tobacco Monopoly Factory on the west and residential area on the east, north, and south

2. Alternatives

The following three alternatives are conceivable taking into account the previous existing conditions.

Alternative I : Stabilization Pond Process
Alternative II : Aerated lagoon process
Alternative III : Modified aeration process

With respect to the above alternatives, site area to be required for the First Stage is shown in Table A.2.

Table A.2 Site Area to be Required for the First Stage

Alternative	Process	Site Area (ha)
Alt. I (Stabilization Pond Process)	F.P. + M.P.	(1) Surface area to be required for F.P. $135{,}800m^3 \times \frac{1}{0.198m^3/d/c} \times 0.0384kg/d/c \times \frac{1}{300kg/ha} = 88$ ha (2) Surface area to be required for M.P. $135{,}800m^3/d \times 3d \times \frac{1}{1.5m} = 27$ ha (3) Site area $(1+2) \times \frac{1}{0.80} = \underline{144 \text{ ha}}$ where pond surface area/site area =0.80
Alt. II (Aerated Lagoon Process	A.L.+S.T. +C.T.+Sludge Treatment	(1) Surface area to be required $135{,}800m^3/d \times 3d \times \frac{1}{3.5m} = 11.7$ ha (2) Surface area of S.T. $135{,}800m^3/d \times 1.5d \times \frac{1}{2.0m} = 10.2$ ha (3) Site area $(1+2) \times \frac{1}{0.75} = \underline{30ha}$ where surface area/site area =0.75
Alt.III (Modified Aeration Process)	A.T.+S.T. +C.T.+Sludge Treatment	Site area: 12.5ha (refer to Chapter 8)

Note: F.P. ..... Facultative Pond
M.P. ..... Maturation Pond
S.T. ..... Sedimentation Tank
C.T. ..... Chlorination Tank
A.L. ..... Aerated Lagoon
A.T. ..... Aeration Tank

From Table A.2, stabilization pond process is not suitable because of no available area. For the Alternative II, there is no sufficient area for wastewater flow increase in the near future. Therefore it will need a sizable investment for its remodelling to other processes. On the other hand, the Alternative III has enough site area for not only flow rate condition of the First Stage but also the final stage.

From the above points, the Alternative III, modified aeration process is considered as an appropriate treatment process for the First Stage.

For reference, capital construction cost including land acquisition cost, annual operation and maintenance cost for Alternatives II and II are compared as shown in Table A.3. Also, capital construction costs and 10 years operation and maintenance cost for them are shown Table A.4. From Table A.4, the Alternative III is more economical.

Table A.3 Capital Construction, Operation and Maintenance Cost for Alt. II & Alt. III

Alternative	Item	Description	Cost (Million Baht)
II	(1) Land Acquisition Cost	30ha x 7.5million Baht/ha	225
	(2) Construction Cost		
	o Pumping & Operating Building	refer to Table 10.3	109.49
	o Aerated Lagoon & Sedimentation Tank	excavation works of ponds $220,000m^2 \times 0.5m \times 24฿/m^3 \times 1.20$	3.17
		disposal of excavated soil $110,000m^3 \times 50฿/m^3 \times 1.20$	6.60
		concrete works $100m^2 \times 28$ units $\times 0.05m \times 1,280฿/m^3 \times 1.20$	0.22
		Foundation works $100m^2 \times 28$ units $\times 0.10m \times 316฿/m^2 \times 1.20$	0.11
	o Chlorination Tank	refer to Table 10.3	14.21
	o Electric Room		28.00
	o Power Receiving		28.60
	o Aerators & Instrumentation	1.5 million ฿ x 37 units	55.50
	Sub-total		245.90
	(3) Annual Operation & Maintenance Cost		
	o Power	for pumps 13.3hr x (2 units x 140kW + 250kW) x 1.46 ฿/kW hr x 365 d	3.76
		for aerators 2,035kW x 24hr x 1.46 ฿/kW hr x 365d	26.03
	o Repairing	(2) x 0.01	2.46
	o Chemicals	$135,800m^3/d \times 3ppm \times 10^{-3} \times 2,200฿/t \times 10^{-3} \times 365d$	0.33
	o Allowance	6 men x 1,500 ฿/month x 12 month	0.11
	Sub-total		32.69
III	(1) Land Acquisition Cost	12.5ha x 7.5 million ฿/ha	93.75
	(2) Construction Cost	refer to Table 10.3	419.16
	(3) Annual Operation & Maintenance Cost		
	o Power	refer to Table 10.7	6.85
	o Repairing	refer to Table 10.7	7.11
	o Chemicals	refer to Table 10.7	0.33
	o Allowance	25 men x 1,500 ฿/month x 18 month	0.45
	Sub-total		14.74

Table A.4 Total Cost for Alt. II and Alt. III

Alt. II	o Land Acquisition Cost		225 million baht
	o Construction Cost		245.9
	o 10 yr O & M Cost	32.69 x 10	326.9
			797.8
Alt.III	o Land Acquisition Cost		93.75
	o Construction Cost		419.16
	o 10 yr O & M Cost	14.74 x 10	147.4
			660.31

APPENDIX B

PRACTICE OF COMPOSTING AND FERTILIZER PRODUCTION

Fertilizer is produced by Bureua of Fertilizer (BOF), BMA. Their products are classified into two kinds, namely, compost (called as No. 1) and mixed fertilizer (called as No. 2) of compost and digested sludge at the mixture ratio of 1 to 1. These two kinds of fertilizers are contained nutritive elements of nitrogen (as NH_4-N), phosphorus, (as P_2O_5) and potassium (as K_2O), and moisture as shown in Table B.1. Formerly, components had been adjusted using chemicals, but recently this method to utilize chemicals is relinquished by national policy.

Components of fertilizers produced presently and their market prices are shown in Tables B.1 and B.2.

Table B.1 Example of Fertilizer Components

No.	Sample	pH	Moisture Content (%)	NH_4-N (%)	P_2O_5 (%)	K_2O (%)	Others	Total
No. 1	a	6.7	32.64	1.76	3.81	0.59	61.20	100
	b	6.8	29.96	1.55	3.05	0.64	64.80	100
No. 2	c	6.9	37.20	0.99	2.33	0.84	58.64	100
	d	7.0	33.92	0.81	1.85	0.78	62.64	100

Data Source ..... Bureau of Fertilizer, 2524 (1981)

Note: No. 1 ..... Compost

No. 2 ..... Mixed Fertilizer

Table B.2 Market Price of Fertilizer

Small lots		No. 1	No. 2
Regular	5 kg	6 Baht	8 Baht
"	10	11	15
"	20	20	30
"	50	35	35
Fine	20	26	-
"	50	50	-
Big Order			
Regular		370 Baht/ton	-
Fine		650	740 Baht/ton

APPENDIX C

DIVERSION CHAMBER

A diversion chamber, as is termed here, is a chamber in which a diversion device is installed to divert the excess flow over the dry-weather flow into a storm sewer and to maintain the flow in the interceptor as predetermined.

There are three types of diversion chamber which are commonly used and adoptable for the present project. After describing characteristics of the three, diversion chambers suitable to the locality will be selected.

1. Hydraulic Separation of Excess Flow.

Hydraulic separation of excess flows from dry-weather flows is accomplished by the following divices:

a) Leaping Type

The dry-weather flow is diverted into an interceptor through an opening in the invert of the combined sewer. Excess flow mixed with storm water leaps across the opening and thus diverts from the interceptor. A vertical-section of leaping type is shown in Figure C.1.

b) Side-overflow Weir Type

The dry-weather flow continues along its normal path to the interceptor. Overflow weir constructed on the side of the combined sewer delivers excess flow during storm periods to the water course. The crest of the weir is set at an elevation corresponding to the desired depth of the dry-weather flow in the sewer. A plan of side-overflow weir type is shown in Figure C.2.

c) Siphon Spillway Type

Siphon spillway, as its name indicates, works on the siphonic principle and automatically goes into action when discharge in the sewer exceeds a certain limit. When discharge is flowing in sewer up to throat level no siphonic action is initiated. When wastewater level rises above the inlet level of the primary pipe it gets closed and the air at the throat is carried away by water. With a little more rise in water level, the siphon starts functioning and wastewater from the top layers is discharged into the relief sewer. Siphonic action continues till the wastewater level in the sewer falls below the inlet level of the primary pipe. Consequently air enters the throat of siphon and suspends the siphonci action. The same action is repeated whenever wastewater level rises above again. A vertical-section of siphon spillway type is shown in Figure C.3.

2. Characteristics of the Three Type

Among the three types, the leaping type does not cause the hydraulic loss in the sewer because no obstruction is in the chamber.

The side-overflow weir type is the most inexpensive among the three and the leaping type is more inexpensive than the siphon spillway which is intricate.

3. Type of Diversion Chamber to be Installed

Among the above three types, the leaping type and the side-overflow weir type are selected for the project.

Since Rama IV Sewer requires to avoid the hydraulic loss in the sewer, the leaping type is recommended to be installed at Rama IV Sewer.

For other existing sewers, the side-overflow weir type is recommended to be installed.

Figures C.4 and C.5 show a typical arrangement of diversion chamber to be installed at existing sewer.

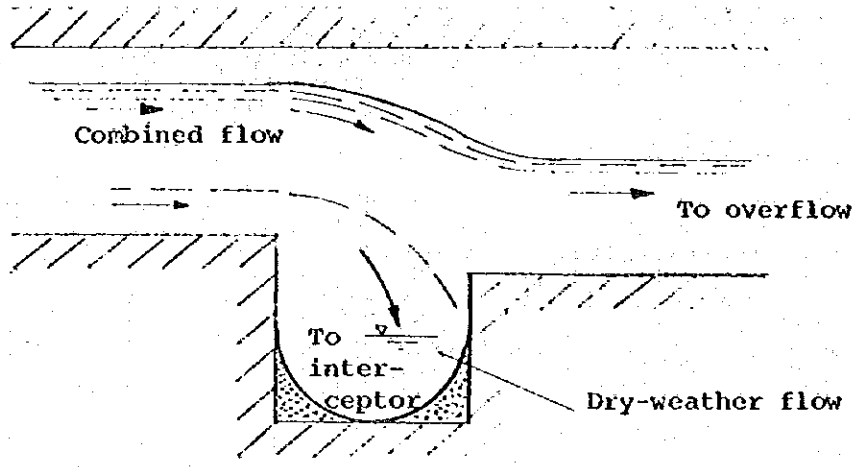


Figure C.1 A Vertical-Section of Leaping Type

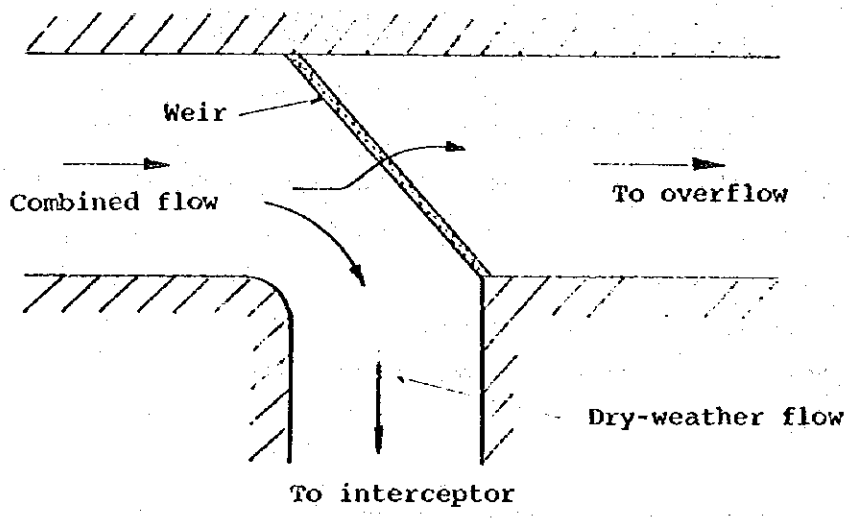


Figure C.2 A Plan of Side-Overflow Weir Type

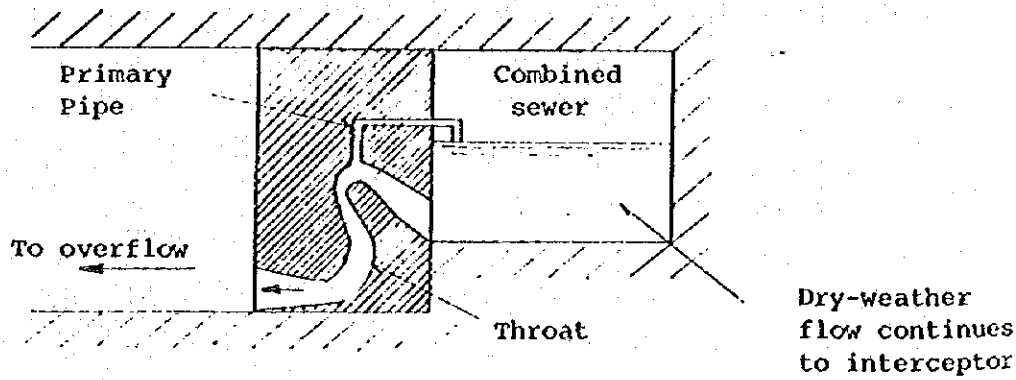
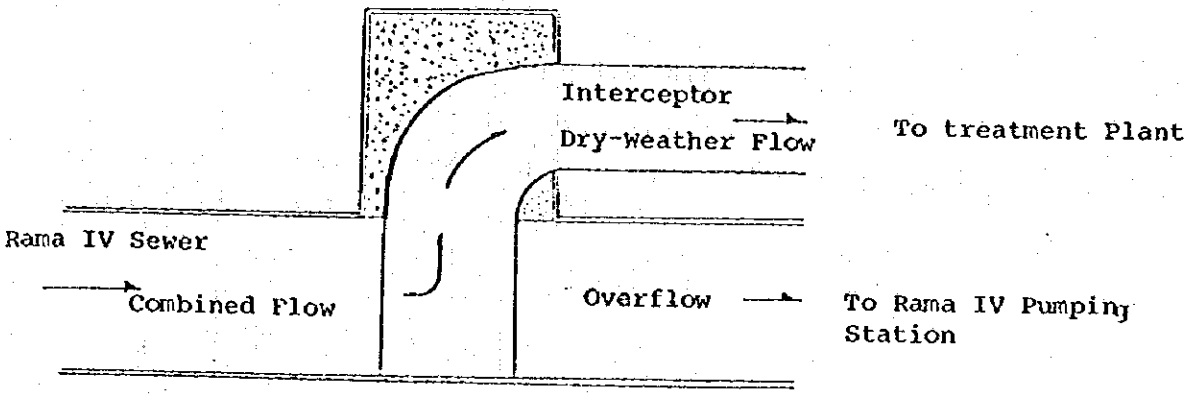
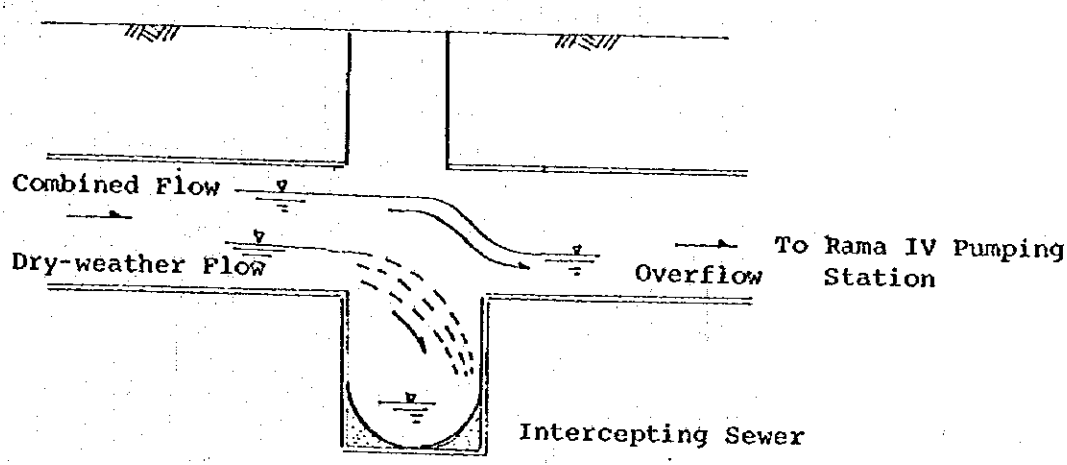


Figure C.3 A Vertical-Section of Siphon Spill-way Type



Plan



Cross Section

Figure C.4 Leaping Type for Rama IV Sewer

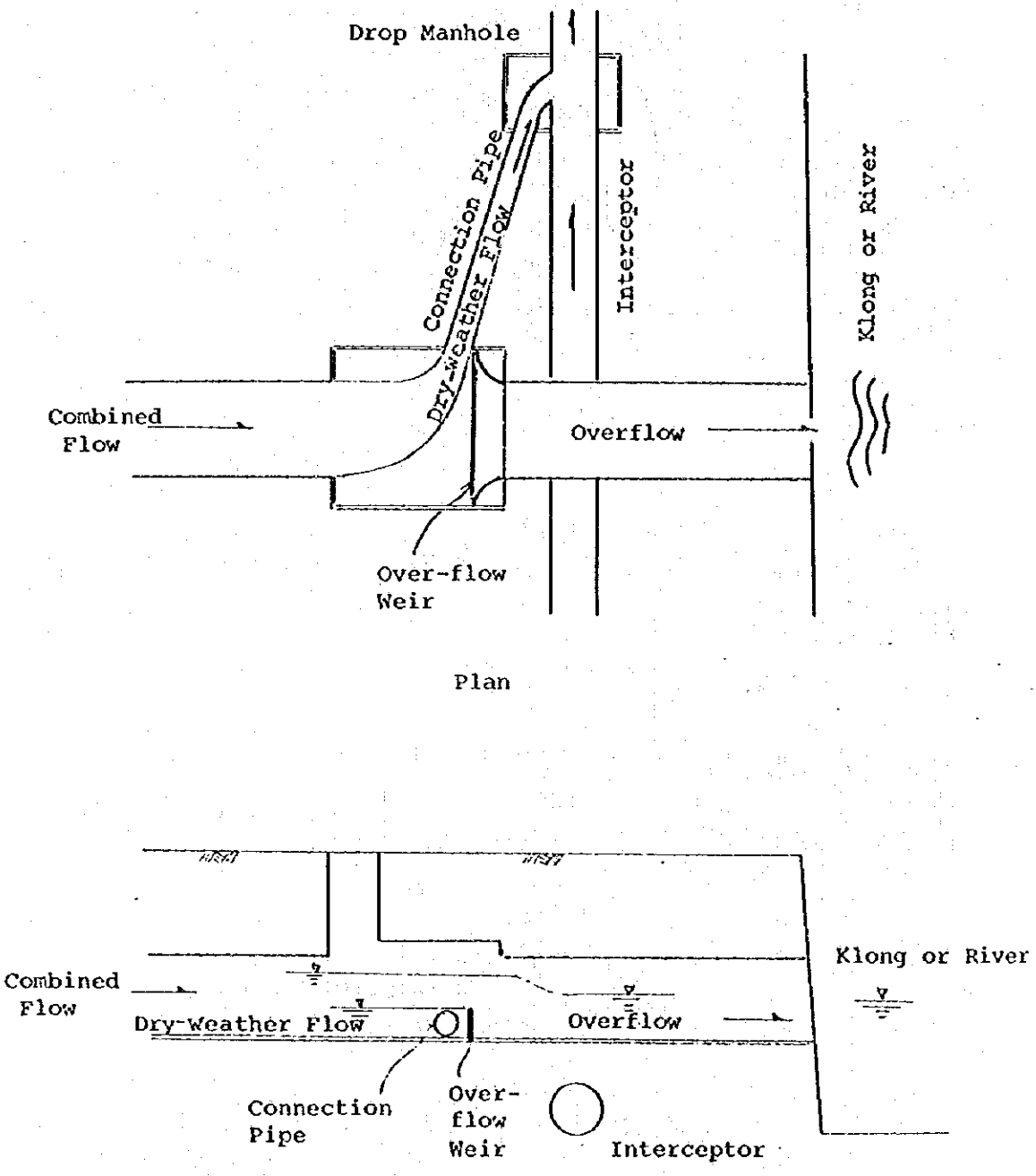


Figure C.5 Side Over-flow Weir Type for Other Existing sewers

APPENDIX D
DESIGN CALCULATION

Design calculation of sewers is carried out on the assumed condition in the year 2543 (2000), as defined in Chapter 6 Design Basis. Its results are shown in Table D.1.

On the other hand, design calculation of the treatment plant is made on the condition in the year 2535 (1992). The results of calculation are shown in Table D.2. As the facilities thereof, however, should be compatible with the facilities in the final stage, where the treatment process is to be converted to a conventional activated sludge process, another design calculation on the assumed condition in the year 2543 (2000) is also carried out. The results are shown in the same Table for convenience of comparison and confirmation of the compatibility of the facilities.

Table D.1 Design Calculation of Sewers (1/3)

No. of Sewers	Area		Design Wastewater Flow														Designed Sewer							Remarks
	Increment	Total	Domestic Wastewater				Commercial Wastewater			Institutional Wastewater		Total Flow (Avg.)	Peaking Factor	Peak Flow	Infiltration	Others	Total Design Flow	Diameter	Length	Slope	Velocity (Full)	Capacity (Full)	Ground Level	Sewer Invert Elevation	
			Inhabited Area	Population	Total Population	Flow (Avg.)	Area	Total Area	Flow (Avg.)	Area	Flow (Avg.)													
	ha	ha	ha	persons	persons	m³/s	ha	ha	m³/s	ha	m³/s	m³/s		m³/s	m³/s	m³/s	m³/s	mm	m	‰	m³/s	m³/s	m	m	
	Chula Interceptor																							
1	25.4	25.4	13.4	8,120	8,120	0.019	8.4	8.4	0.011	12.0	0.017	0.047	3.7	0.174	0.012		0.186	ø600	140	1.1	0.62	0.177	36.10 36.45	34.43 34.28	Wang Mai Tambol
2	31.5	56.9	31.5	19,089	27,209	0.063	10.2	18.6	0.025		0.017	0.105	3.6	0.378	0.026		0.404	ø1000	360	0.6	0.65	0.509	36.45 36.59	33.98 33.47	"
3	3.4	60.3	3.4	2,060	29,269	0.068	3.4	22.0	0.030		0.017	0.115	3.6	0.414	0.029		0.443	ø1000	645	0.6	0.65	0.509	36.59 36.44	33.47 33.08	"
	Chula Intermediate Pumping Station																							
4	—	60.3			29,269	0.068		22.0	0.030		0.017	0.115	3.6	0.414	0.029		0.443	Force Main ø600	2 95		1.58	0.445	36.44 (36.40)	34.20 35.30	"
	to Existing Rama IV Sewers																							ø1440x1600 EL=33.90
	Charoen Krung Interceptor																							
5	5.6	5.6	5.6	2,704	2,704	0.006	5.6	5.6	0.008			0.014	4.5	0.063	0.004		0.067	ø400	295	1.8	0.61	0.077	36.43 36.22	34.97 34.44	Maha Puth Tharam Tambol
6	1.7	7.3	1.7	821	3,525	0.008	1.7	7.3	0.010			0.018	4.2	0.076	0.005		0.081	ø500	155	1.3	0.60	0.118	36.22 36.20	33.62 33.42	"
7	4.7	12.0	4.7	2,270	5,795	0.013	4.7	12.0	0.016			0.029	3.8	0.110	0.007		0.117	ø500	310	1.3	0.60	0.118	36.20 (36.40)	33.42 33.02	"
8	1.0	13.0	1.0	483	6,278	0.015	1.0	13.0	0.017			0.032	3.8	0.122	0.008		0.130	ø600	465	1.1	0.62	0.177	(36.40) (36.40)	32.92 32.41	Bang Rak
9	47.0	60.0	21.0 4.0 22.0	5,397 1,932 5,873	19,481	0.045	47.0	60.0	0.081			0.126	3.0	0.378	0.032		0.410	ø1000	325	0.6	0.65	0.509	(36.40) 36.73	32.01 31.82	Bang Rak, Maha Puth Tharam, Si Phaya
	to Charoen Krung Intermediate Pumping Station																							
10																	0.410	Force Main ø600	165	—	1.46	0.412	36.73 (36.20)	33.90 35.20	"
	to Existing Sewer																							ø600 EL=35.15
	Chong Nonsri Combined Sewer																							

No. of Sewers	Area		Design Wastewater Flow														Designed Sewer							Remarks
	Increment	Total	Domestic Wastewater				Commercial Wastewater			Institutional Wastewater		Total Flow (Avg.)	Peaking Factor	Peak Flow	Infiltration	Others	Total Design Flow	Diameter	Length	Slope	Velocity (Full)	Capacity (Full)	Ground Level	Sewer Invert Elevation	
			Inhabited Area	Population	Total Population	Flow (Avg.)	Area	Total Area	Flow (Avg.)	Area	Flow (Avg.)													
	ha	ha	ha	persons	persons	m³/s	ha	ha	m³/s	ha	m³/s	m³/s		m³/s	m³/s	m³/s	m³/s	mm	m	‰	m³/s	m³/s	m	m	
11	34.6	34.6	8.8 25.8	4,250 6,889	11,139	0.026	34.6	34.6	0.046			0.072	3.3	0.238	0.018		0.256	⊡8500 x2000	460	0.4			36.39 36.31	34.01 33.83	Maha Metn Thoram, Si Phaya
12	25.8	60.4	10.0 15.8	2,670 10,270	24,079	0.056	25.8	60.4	0.081			0.126 0.137	2.7	0.710	0.066		0.776	⊡8500 x2000	275	0.4			36.31 36.32	33.83 33.72	Si Phaya, Su Riyawong
13	85.5	145.9	26.1 46.4 13.0	16,965 11,090 3,341	55,475	0.129	76.2	136.6	0.183	Loed Sin Hospital	0.009	0.126 0.321	2.7	1.207	0.112		1.319	⊡8500 x2000	540	0.4			36.32 (36.20)	33.72 33.50	Si Lom, Bang Rak
	to	25																						
	Klong Sathorn Interceptor																							
14	0.9	0.9	0.9	215	215	0.005	0.9	0.9	0.001			0.006	4.8	0.029	0.002		0.031	⊙300	20	2.6	0.61	0.043	(36.50) (36.50)	35.15 35.10	Si Lom
15	2.9	3.8	2.9	693	908	0.002	2.9	3.8	0.005			0.007	4.8	0.034	0.002		0.036	⊙300	240	2.6	0.61	0.043	(36.50) 36.67	33.90 33.28	"
16	2.7	6.5	2.7	645	1,553	0.004	2.7	6.5	0.009			0.013	4.7	0.061	0.003		0.064	⊙400	210	1.8	0.61	0.077	36.67 36.40	33.18 32.80	"
17	1.4	7.9	1.4	335	1,888	0.004	1.4	7.9	0.011			0.015	4.5	0.068	0.004		0.072	⊙400	50	1.8	0.61	0.077	36.40 (36.40)	32.80 32.71	"
18	6.5	14.4	6.5	1,554	3,442	0.008	6.5	14.4	0.019			0.027	4.0	0.108	0.007		0.115	⊙500	240	1.3	0.60	0.118	(36.40) 36.18	32.61 32.30	"
19	4.9	19.3	4.9	1,171	4,613	0.011	4.9	19.3	0.026			0.037	3.7	0.137	0.009		0.146	⊙600	95	1.1	0.62	0.177	36.18 (36.20)	32.20 32.10	"
20	3.8	23.1	3.8	908	5,521	0.013	1.1	20.4	0.027			0.040	3.7	0.148	0.010		0.158	⊙600	220	1.1	0.62	0.177	(36.20) (36.20)	32.10 31.86	"
21	9.7	32.8	9.7	2,318	7,839	0.018	3.8	24.2	0.032			0.050	3.5	0.175	0.013		0.188	⊙800	140	1.0	0.72	0.362	(36.20) 36.18	31.66 31.52	"
22	2.4	35.2	2.4	574	8,413	0.020		24.2	0.032			0.052	3.5	0.182	0.013		0.195	⊙800	170	1.0	0.72	0.362	36.18 36.14	31.52 31.35	"
23	9.3	44.5	9.3	2,223	10,636	0.025	1.6	25.8	0.035			0.060	3.4	0.204	0.015		0.219	⊙800	175	1.0	0.72	0.362	36.14 (36.20)	31.35 31.18	"
	to Klong Sathorn Intermediate Pumping Station																							
24	0	44.5			10,636	0.025		25.8	0.035			0.060	3.4	0.204	0.015		0.219	Force Main ⊙500	90	—	1.12	0.220	(36.20) (36.20)	34.50 34.65	
25	0	190.4			66,111	0.154		162.4	0.218		0.009	0.126 0.381	2.3	1.166	0.127		1.293	⊙1500	160	0.5	0.78	1.370	(36.20) 36.20	33.50 33.42	"

No. of Sewers	Area		Design Wastewater Flow															Designed Sewer							Remarks
	Increment	Total	Domestic Wastewater				Commercial Wastewater			Institutional Wastewater		Total Flow (Avg.)	Peaking Factor	Peak Flow	Infiltration	Others	Total Design Flow	Diameter	Length	Slope	Velocity (Full)	Capacity (Full)	Ground Level	Sewer Invert Elevation	
			Inhabited Area	Population	Total Population	Flow (Avg.)	Area	Total Area	Flow (Avg.)	Area	Flow (Avg.)														
	ha	ha	ha	persons	persons	m^3/s	ha	ha	m^3/s	ha	m^3/s	m^3/s		m^3/s	m^3/s	m^3/s	m^3/s	mm	m	‰	m^3/s	m^3/s	m	m	
26	3.4	193.8	3.4	813	66,924	0.156		162.4	0.218		0.009	0.126 0.383	2.3	1.171	0.127		1.298	ø1500	260	0.5	0.78	1.370	36.20 36.25	32.41 32.28	SI Lom
27	10.8	204.6	10.8	2,581	69,505	0.162	3.6	166.0	0.223		0.009	0.126 0.394	2.3	1.196	0.130		1.326	ø1500	135	0.5	0.78	1.370	36.25 36.33	32.28 32.21	"
28	3.6	208.2	3.6	860	70,365	0.164	1.4	167.4	0.225		0.009	0.126 0.398	2.3	1.205	0.131		1.336	ø1500	25	0.5	0.78	1.370	36.33 36.33	32.21 32.20	"
29	3.8	212.0	3.8	908	71,273	0.166	1.1	168.5	0.226		0.009	0.126 0.401	2.3	1.212	0.132		1.344	ø1500	130	0.5	0.78	1.370	36.33 (36.20)	32.20 32.14	"
30	6.7	218.7	6.7	1,601	72,874	0.170		168.5	0.226		0.009	0.126 0.405	2.3	1.221	0.133		1.354	ø1500	160	0.5	0.78	1.370	(36.20) 36.16	32.14 32.06	"
31	10.0	228.7	10.0	2,390	75,264	0.175	2.0	170.5	0.229		0.009	0.126 0.413	2.3	1.240	0.135		1.375	ø1500	470	0.6	0.85	1.501	36.16 (36.20)	32.06 31.78	"
32	4.6	233.3	4.6	1,099	76,363	0.178		170.5	0.229		0.009	0.126 0.416	2.3	1.247	0.136		1.383	ø1500	285	0.6	0.85	1.501	(36.20) 36.44	31.78 31.61	"
	to	Existing	Roma W	Sewer																					ø2700x2500 EL=31.30
	Trunk	Interceptor																							
	①	Future	Inflowing	Wastewater																					
		200.0	From 200.0	Zone 4 ;	23,000	0.054		75.0	0.168			0.222			0.018										
		488.0	From 488.0	Sub-zone 2-B ;	230,900	0.537		488.0	0.655			1.192			0.043										
		258.0	From 258.0	Sub-zone 2-C ;	111,600	0.260		258.0	0.346			0.606			0.023										
	②	From 970.0	First 720.0	Stage	Area 252,500	(Sub-zone 2-A) 0.588		446.0	0.598		0.157	1.343	1.7	5.717	0.403		6.204								
TS 1																	6.204	ø2400	450	0.9	1.42	6.436	(36.50) (36.50)	27.85 27.46	
TS 2																	6.204	ø2100 x2100	250	0.8	1.52	6.447	(36.50) (36.50)	27.30 27.10	
	to	Treatment	Plant																						

Table D.2 Design Calculation of Treatment Plant

		Zone 2 (in the year 2000 condition)	Sub-zone 2-A (in the year 1992 condition)
(1) Basic Conditions			
a. Served Area:		3,600 ha	970 ha
b. Served Population		823,800 persons	252,400 persons
c. Design Flow:	average	380,000 m^3/day	135,800 m^3/day
	peak	668,000 m^3/day	243,200 m^3/day
d. Influent Quality:	BOD	240 mg/l	160 mg/l
	SS	240 mg/l	160 mg/l
(2) Treatment Process			
a. Treatment Process:		Conventional Activated Sludge	Modified Aeration

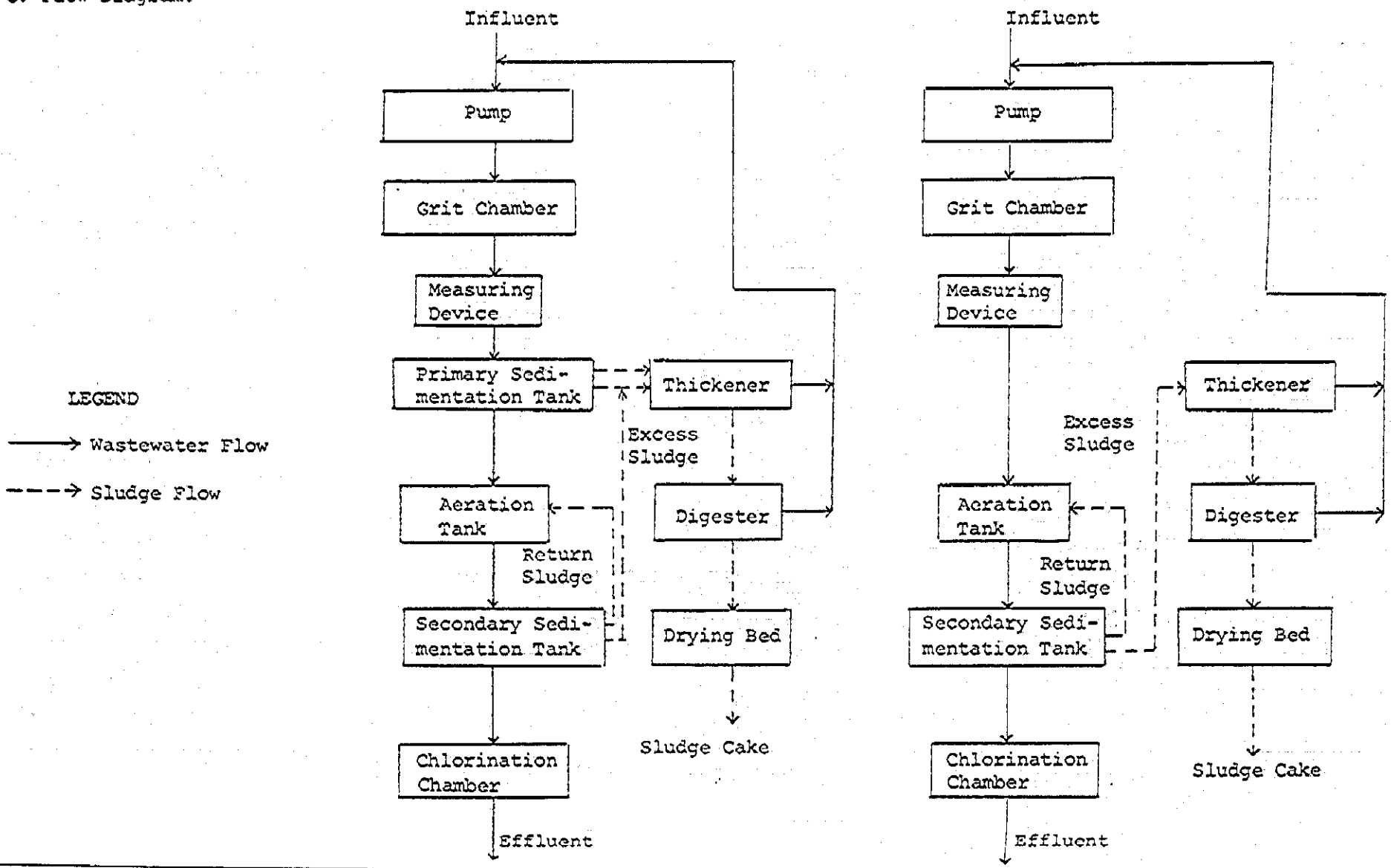
b. Expected Treatment Efficiency:

Item	Treatment Efficiency (%)			Water Quality (mg/l)			Treatment Efficiency (%)	Water Quality (mg/l)	
	Through PST	Through AT&SST	Total	Influent	Effluent from PST	Effluent	Through AT&ST	Influent	Effluent
BOD	30	88	92	240	168	20	65	160	56
SS	40	86	92	240	144	20	70	160	48

Note: PST ... Primary Sedimentation Tank
AT ... Aeration Tank
SST ... Secondary Sedimentation Tank
ST ... Sedimentation Tank

	Zone 2 (in the year 2000 condition)	Sub-zone 2-A (in the year 1992 condition)

C. Flow Diagram:



	Zone 2 (in the year 2000 condition)	Sub-zone 2-A (in the year 1992 condition)
(3) Sludge Production		
a. Raw Sludge		
Dry Solid:	380,000 m^3/day x 240 mg/l x 10^{-6} x 0.4 = 36.48 t/day	—
Sludge Volume:	36.48 x $\frac{100}{3}$ = 1,216 m^3/day (assumed solid concentration is 3%)	
b. Excess Sludge		
Dry Solid:	380,000 m^3/day x 240 mg/l x 10^{-6} x (1-0.4) x 0.86 = 47.06 t/day	135,800 m^3/day x 160 mg/l x 10^{-6} x 0.70 = 15.21 t/day
Sludge Volume:	47.06 x $\frac{100}{1}$ = 4,706 m^3/day (assumed solid concentration is 1%)	15.21 x $\frac{100}{1}$ = 1,521 m^3/day
c. Mixed Sludge		
Dry Solid:	36.48 t/day + 47.06 t/day = 83.54 t/day	
Sludge Volume:	1,216 m^3/day + 4,706 m^3/day = 5,922 m^3/day	—
d. Thickened Sludge		
Dry Solid:	83.54 t/day	15.21 t/day
Sludge Volume:	83.54 x $\frac{100}{4}$ = 2,089 m^3/day (assumed solid concentration is 4%)	15.21 x $\frac{100}{4}$ = 380 m^3/day

	Zone 2 (in the year 2000 condition)	Sub-zone 2-A (in the year 1992 condition)
e. Overflow from Thickener		
Overflow Volume:	5,922 m^3/day - 2,089 m^3/day = 3,833 m^3/day	1,521 m^3/day - 380 m^3/day = 1,141 m^3/day
BOD Load:	3,833 x 550 x 10^{-6} = 2.11 t/day (assumed BOD concentration is 550 mg/l)	1,141 x 550 x 10^{-6} = 0.63 t/day
SS Load:	3,833 x 600 x 10^{-6} = 2.30 t/day (assumed SS concentration is 600 mg/l)	1,141 x 600 x 10^{-6} = 0.68 t/day
f. Digested Sludge		
- Volatile solid concentration in thickened sludge is assumed at 70%. Fifty percent of volatile solid is decomposited through digestion. -		
Dry Solid:	83.54 x (1 - 0.7 x 0.5) = 54.30 t/day	15.21 x (1 - 0.7 x 0.5) = 9.89 t/day
Sludge Volume:	54.30 x $\frac{100}{5}$ = 1,086 m^3/day (assumed solid concentration is 5%)	9.89 x $\frac{100}{5}$ = 198 m^3/day
g. Supernatant		
Supernatant Volume:	2,089 - 1,086 = 1,003 m^3/day	380 - 198 = 182 m^3/day
BOD Load:	1,003 x 900 x 10^{-6} = 0.91 t/day (assumed BOD concentration is 900 mg/l)	182 x 900 x 10^{-6} = 0.16 t/day
SS Load:	1,003 x 440 x 10^{-6} = 0.44 t/day (assumed SS concentration is 440 mg/l)	182 x 44- x 10^{-6} = 0.08 t/day
h. Sludge Cake (Dried Sludge)		
Dry Solid:	54.30 t/day	9.89 t/day
Cake Volume:	54.30 x $\frac{100}{100-30}$ = 78 m^3/day (assumed solid concentration is 30%)	9.89 x $\frac{100}{100-30}$ = 14 m^3/day

	Zone 2 (in the year 2000 condition)	Sub-zone 2-A (in the year 1992 condition)
i. Wastewater from Sludge Treatment Process		
Volume:	3,833 + 1,003 = 4,836 m^3/day	1,141 + 182 = 1,323 m^3/day
BOD Load	2.11 + 0.91 = 3.02 t/day	0.63 + 0.16 = 0.79 t/day
SS Load	2.30 + 0.44 = 2.74 t/day	0.68 + 0.08 = 0.76 t/day
(4) Inflowing Rate to Each Treatment Facility		
a. Primary Sedimentation Tank		
Inflowing Rate:	380,000 + 4,836 = 384,836 m^3/day	
Inflowing BOD Load:	380,000 x 240 x 10^{-6} + 3.02 = 94.22 t/day	
Inflowing SS Load:	380,000 x 240 x 10^{-6} + 2.74 = 93.94 t/day	—
Removed BOD Load:	94.22 x 0.3 = 28.27 t/day	
Removed SS Load	380,000 x 240 x 10^{-6} x 0.4 + 2.74 = 39.22 t/day (assumed treatment efficiencies of wastewater from sludge treatment process are 30% in BOD and 100% in SS)	
Raw Sludge Production:	39,22 x $\frac{100}{3}$ = 1,307 m^3/day (assumed solid concentration is 3%)	
Effluent Rate:	384,836 - 1,307 = 383,529 m^3/day	
b. Aeration Tank		
Inflowing Rate	383,529 m^3/day	135,800 + 1,323 = 137,123 m^3/day
Return Sludge Volume:	383,529 x 0.25 = 95,882 m^3/day (return sludge rate is 0.25)	137,123 x 0.10 = 13,712 m^3/day (return sludge rate is 0.10)
MLSS Volume:	383,529 + 95,882 = 479,411 m^3/day	137,123 + 13,712 = 150,835 m^3/day

	Zone 2 (in the year 2000 condition)	Sub-zone 2-A (in the year 1992 condition)
Inflowing BOD Load:	$94.22 - 28.27 + 95,882 \times 20 \times 10^{-6}$ = 67.87 t/day	$135,800 \times 160 \times 10^{-6} + 0.79 + 13,712 \times 56 \times 10^{-6}$ = 23.29 t/day
Inflowing SS Load:	93.94 - 39.22 = 54.72 t/day	$135,800 \times 160 \times 10^{-6} + 0.76 + 13,712 \times 48 \times 10^{-6}$ = 23.15 t/day
c. Secondary Sedimentation Tank		
Inflowing Rate: (Effluent Rate from Aeration Tank)	479,411 m^3/day	150,835 m^3/day
Inflowing SS Load: (Inflowing SS Load from Aeration Tank)	54.72 t/day	23.15 t/day
Removed SS Load:	54.72 x 0.86 = 47.06 t/day	23.15 x 0.70 = 16.21 t/day
Excess Sludge Volume:	$47.06 \times \frac{100}{1}$ = 4,706 m^3/day (assumed solid concentration is 1%)	$16.21 \times \frac{100}{1}$ = 1,621 m^3/day
d. Chlorination Tank		
Inflowing Rate:	479,411 - 95,882 - 4,706 = 378,823 m^3/day	150,835 - 13,712 - 1,621 = 135,502 m^3/day
e. Thickener		
Inflowing Sludge Volume:	1,307 + 4,706 = 6,013 m^3/day	1,621 m^3/day
Inflowing Solid:	39.22 + 47.06 = 86.28 t/day	16.21 t/day
Thickened Sludge Volume:	$86.28 \times \frac{100}{4}$ = 2,157 m^3/day (assumed solid concentration is 4%)	$16.21 \times \frac{100}{4}$ = 405 m^3/day
Wastewater from Thickener:	6,013 - 2,157 = 3,856 m^3/day	1,621 - 405 = 1,216 m^3/day

	Zone 2 (in the year 2000 condition)	Sub-zone 2-A (in the year 1992 condition)
f. Digester		
Inflowing Sludge Volume:	2,157 m^3/day	405 m^3/day
Dry Solid in Digested Sludge:	86.28 x (1 - 0.7 x 0.5) - 0.44 = 55.64 t/day	16.21 x (1 - 0.7 x 0.5) - 0.08 = 10.46 t/day
Digested Sludge Volume:	$55.64 \times \frac{100}{5}$ = 1,113 m^3/day (assumed solid concentration is 5%)	$10.46 \times \frac{100}{5}$ = 209 m^3/day
Supernatant Volume:	2,157 - 1,113 = 1,044 m^3/day	405 - 209 = 196 m^3/day
g. Drying Bed		
Inflowing Dry Solid:	55.64 t/day	10.46 t/day
Sludge Cake (Dried Sludge):	$55.64 \times \frac{100}{100-30}$ = 79 m^3/day	$10.46 \times \frac{100}{100-30}$ = 15 m^3/day
h. Wastewater from Sludge Treatment Process	3,856 + 1,044 = 4,900 m^3/day	1,216 + 196 = 1,412 m^3/day
(5) Sizing of Treatment Facilities		
a. Primary Sedimentation Tank:		
(i) Capacity		
Required Surface Area:	380,000 ÷ 40 = 9,500 m^2 (assumed surface loading is 40 m^3/day/m^2)	—
Detention Time:	1.5 hrs	
Required Depth:	$\frac{380,000 \times 1.5}{9,500 \times 24}$ = 2.5 m	

	Zone 2 (in the year 2000 condition)	Sub-zone 2-A (in the year 1992 condition)
(ii) Type and Size		
Type:	Circular type	
Size and Number of Units:	22.5 m in diameter, 24 units	
b. Aeration Tank:		
(i) Capacity		
Return Sludge Concentration:	10,000 mg/l	10,000 mg/l
Return Sludge Rate:	0.25	0.10
MLSS Concentration:	$\frac{0.25 \times 10,000}{1 + 0.25} = 2,000$ mg/l	$\frac{0.1 \times 10,000}{1 + 0.10} = 909$ mg/l
BOD-SS Loading:	0.5 kg BOD/kg SS	3.0 kg BOD/kg SS
Required Volume:	$V = \frac{67.87 \times 10^3}{2,000 \times 0.5 \times 10^{-3}} = 67,870$ m^3	$V = \frac{23.29 \times 10^3}{909 \times 3.0 \times 10^{-3}} = 8,540$ m^3
Aeration Time:	$T = \frac{67,870 \times 24}{380,000} = 4.29$ hrs	$T = \frac{8,540 \times 24}{135,800} = 1.5$ hrs
(ii) Size		
Size and Number of Units:	Width 13.5 m	13.5 m
	Length 54.0 m	54.0 m
	Depth 4.0 m	4.0
	Number of Units: 24	4 units (1 stand by)

	Zone 2 (in the year 2000 condition)	Sub-zone 2-A (in the year 1992 condition)
c. Secondary Sedimentation Tank:		
(i) Capacity		
Required Surface Area:	380,000 ÷ 30 = 12,670 m^2 (assumed surface loading is 30 $m^3/day/m^2$)	135,800 ÷ 32 = 4,244 m^2 (assumed surface loading is 32 $m^3/day/m^2$)
Detention Time:	2.0 hrs	$\frac{4,244 \times 24 \times 2.5}{135,800}$ = 1.9 hrs
Required Depth:	$\frac{380,000 \times 2.0}{12,670 \times 24}$ = 2.5 m	2.5 m
(ii) Type and Size		
Type:	Circular type	Circular type
Size and Number of Units:	26.0 m in diameter, 24 units	26.0 m in diameter, 8 untis
d. Chlorination Chamber		
Detention Time	15 minutes	
Required Tank Volume:	$\frac{380,000 \times 15}{1,440}$ = 3,960 m^3	$\frac{135,800 \times 15}{1,440}$ = 1,415 m^3
Size:	Width 3.0 m	Width 3.0 m
	Depth 3.0 m	Depth 3.0 m
	Length 440 m	Length 158 m
e. Thickener:		
(i) Capacity:		
Inflowing Solid	86.29 t/day	16.21 t/day
Inflowing Sludge Volume:	6,013 m^3/day	1,621 m^3/day

	Zone 2 (in the year 2000 condition)	Sub-zone 2-A (in the year 1992 condition)
Solid Loading:	60 kg/day/m^2	67 kg/day/m^2
Required Surface Area:	$\frac{86.29 \times 10^3}{60}$ = 1,440 m^2	$\frac{16.21 \times 10^3}{67}$ = 242 m^2
(ii) Type and Size		
Type:	Circular Type	Circular Type
Size and Number of Units:	17.60 m in diameter, 3.0 m depth, 6 units	17.60 m in diameter, 3.0 m depth, 2 units
f. Digester:		
(i) Capacity		
Inflowing Sludge Volume:	2,157 m^3/day	405 m^3/day
Digested Sludge Volume:	1,113 m^3/day	209 m^3/day
Detention Time:	30 days	26.7 days
Required Volume:	$\frac{2,157 + 1,113}{2} \times 30$=49,050 m^3	$\frac{405 + 209}{2} \times 26.7$ = 8,197 m^3
(ii) Type and Size		
Type:	unheated anaerobic two-stage	unheated anaerobic two-stage
Size and Number of Units:	22.0 m in diameter, 10.80 m depth, 12 units	22.0 m in diameter, 10.80 m depth, 2 units

	Zone 2 (in the year 2000 condition)	Sub-zone 2-A (in the year 1992 condition)
g. Gas Holder:		
(i) Capacity		
Inflowing Solid to Digester:	86.28 t/day	16.21 t/day
Decomposited Organic Matters:	86.28 x 0.7 x 0.5 = 30.20 t/day	16.21 x 0.7 x 0.5 = 5.67 t/day
Gas Generation:	$30.20 \times 10^3 \times 1.0 = 30,200\ m^3$/day	$5.67 \times 10^3 \times 1.0 = 5,670\ m^3$/day
	(per decomposited organic matter gas generation is assumed at 1.0 m^3/kg)	
(ii) Size		
Detention Time:	12 hrs	
Required Tank Volume:	$30,200 \times \frac{12}{24} = 15,100\ m^3$	
Type:	Dry Seal Type	
Size and Number of Units:	22.0 m in diameter, 13.30 m height, 3 units	22.0 m in diameter, 13.30 m height, 1 unit
h. Drying Bed:		
(i) Capacity		
Digested Sludge Volume:	1,113 m^3/day	209 m^3/day
Sludge Thickness:	20 cm	20 cm
Drying Time:	10 days	10 days
(ii) Size		
Required Bed Area:	$1,113 \times 10 \times \frac{1}{0.2} = 55,650\ m^2$	$209 \times 10 \times \frac{1}{0.2} = 10,450\ m^2$

APPENDIX E
SELECTION OF MAIN EQUIPMENTS

Most suitable equipments for the present project are selected from among possible alternative equipments which are commonly utilized for the wastewater treatment works, as shown in the following Table E.1. In selecting most suitable ones, special emphasis is placed on the following items.

1) Operation and maintenance: to be easy
2) Function: to meet the following requirement
   a. High efficiency
   b. Low energy consumption
   c. Wide working range
   d. Quick operating speed
3) Durability: to be high
4) Cost: to be inexpensive

Table E.1 Selection of Main Equipments

Name of Equipments	Alternatives	Characteristics	Selected Equipments
Inlet Gate	1) Electric Driven	- easy operation - not require man-power - high cost	Manual operation cast-iron gate
	2) Manual	- takes long time for operation - low cost	
	1) Steel	- low cost - short life	
	2) Cast-iron	- higher cost than steel - long life (anti-corrosive)	
Screen	1) Electric driven continuously	- not require man-power - operated automatically - installed every channel - very high cost	Coarse screen Manual operation Fine screen (not installed at first stage) Automatic operation
	2) Simple mechanical	- operated on site - Multiple channels are controlled by one unit - relatively high cost - for coarse screen only	
	3) Manual	- low cost	

Name of Equipments	Alternatives	Characteristics	Selected Equipments
Grit Collecting Equipment	1) V-bucket conveyor	- chain, shaft, sprocket, and shaft holder are under water, so that has disadvantage in case of high influent variation - When overhaul is needed, the basin is required to be empty - operated automatically - installed every chamber	Bridge type crane with grab bucket
	2) Travelling sand pump	- Overhauling is easy because main devices are outside of the chamber - adaptable to influent variation - operated automatically, but many electric problems - Multiple chambers are controlled by one unit - relatively high cost	
	3) Bridge type crane with grab bucket	- Overhauling is easy, because main devices are out of chamber - adaptable to influent variation - operated on site - Multiple chambers are controlled by one unit - relatively low cost	
Main Pump	1) Horizontal or vertical mixed flow	- high adaptability for variation of head and discharge capacity - Maintaince procedure for horizontal type is easier than for vertical type because impeller of horizontal type is situated out side of pump well.	Vertical shaft mixed flow volute pump

Name of Equipments	Alternatives	Characteristics	Selected Equipments
		But, horizontal type has more number of appurtenances than vertical type - Because of existence of guide vane, there is potential of clogging	
	2) Vertical shaft mixed flow volute pump	- high adaptability for variation of head and discharge capacity - easy overhauling - larger space than other pumps for setting - Because no guide vane is installed, there is small potential clogging	
	3) Submergible wastewater pump	- small space for setting - low construction cost - fit for small scale of less than 30 m^3/min - high adaptability for head variation	
	4) Screw Pump	- high adaptability to flow variation - high resistance to sand - limited head (<7.5m) - low efficiency	
Sludge Collector	1) Double chain type	- For rectangular shape basin, required space is small - easy sludge withdraw - Main machines are under water, not easy overhauling - Many parts such as chain, flight, and shoe require periodic overhauling	Circular type

Name of Equipments	Alternatives	Characteristics	Selected Equipments
	2) Reciprocating scraper type	- For rectangular shape basin, required space is small - easy sludge withdraw - limited weir length - Because main machines are not under water, overhauling is easy - Many automatic circuit cause power supply problem - intermittent driven	
	3) Circular Type	- for round shape basin, requires larger space than rectangular - Drive unit is installed every basin, simple structure, easy maintenance - low cost	
Aeration System	1) Mechanical aerator	- relatively low electric power consumption - Automatic oxygen supply is difficult - relatively high oxygen supply efficiency - higher effluent BOD, SS, and turbidity than by air diffuser	Mechanical Aerator (at first stage) Mechanical and diffused air type (at final stage)
	2) Diffused air type	- relatively high electric power consumption - Automatic control of air supply is possible - Space for blower and air-pipe are required	

Name of Equipments	Alternatives	Characteristics	Selected Equipments
Mixing Device of Anaerobic Digester	1) Machanical mixing	- relatively low cost for installation - not always uniform mixing - Overhauling is very difficult	Gas mixing no heating
	2) Gas mixing	- relatively high cost for installation - uniform mixing - adaptable to liquid level variation - Because no equipment is inside, less mechanical trouble	
	3) Non mixing	- no installation cost - No mixing causes ununiform, deposit, and short pass - low digestion efficiency	