APPENDIX F

DIGESTER GAS UTILIZATION

1. Introduction

By using digester gas, heating of digestion tank contents and drying of wastewater sludge are widely practiced in many countries, and, in large plants, the gas may be used as fuel for boilers and internal combustion engines, that is, in turn, used for pumping wastewater, operating blowers, and generating electricity.

Among above utilizations, the thing Bangkok requires earnestly must be electric power generation.

In the past, the economy of power generation by digester gas utilization has been questionable. However, because of rising costs associated with the tightening energy situation, sludge gas is likely to become an increasingly attractive energy source.

In this appendix, a possibility of electric power generation by digester gas in the proposed wastewater treatment plant is studied, considering practices in European and American countries in which electric power generation by digester gas is widely applied.

2. Characteristics of Digester Gas

The digester gas with potential high energy source is produced from the anaerobic digestion process at normal condition, temperature at approximately 30°C and detention time of 30 days.

As shown in Table F.1, digester gas is composed of approximately 60 percent methane, 35 percent carbon dioxide, and 5 percent varying amounts of nitrogen, hydrogen, and hydrogen sulfide by volume.
The heating value of the gas is 5,000 - 6,000 $Kcal/Nm^3$.

Table F.1 Digester Gas Component

Component	Percentage (%)
Methane (CH_4)	57 - 62
Carbon Dioxide (CO_2)	33 - 38
Hydrogen (H_2)	0 - 2
Nitrogen (N_2)	0 - 6
Hydrogen Sulfide (H_2S)	1.005 - 0.010

3. Electric Power Generation Process by Digester Gas

Energy balance of electric power generation process by digester gas is illustrated as Figure F.1.

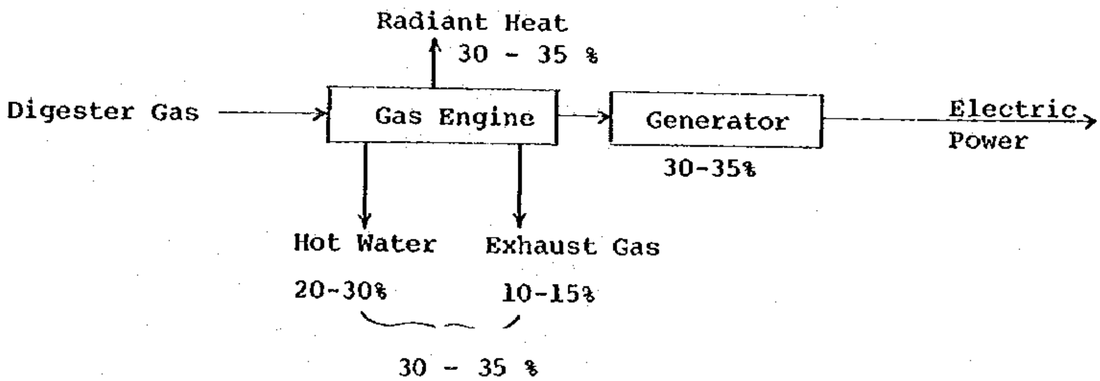


Figure F.1 Energy Balance of Gas Engine

As shown in the Figure, heat energy recovered through a process of converting heat to electric power is in a rather low range of approximately one third of supplied energy. That is energy recovery through gas

generator is not always of high efficiency.
However, if it is economically feasible, this energy recovery system is favorable because electric power is very convenient for use for any purposes.

The next one third of total energy being latent in cooling water (hot water) and exhaust gas are possibly recovered and may be used for heating or cooling.

The rest of one third is hardly recovered and is wasted as radiant heat.

4. Estimation of Energy to be Recovered

Electric power to be generated by digester gas and room area to be air-conditioned using recovered heat energy from cooling water (hot water) and exhaust gas are estimated, assuming to be used in the proposed wastewater treatment plant.

(1) Electric Power to be Generated by Digester Gas

Estimations were performed based on two wastewater flows, that is, flow of this Feasibility Study Area (called Ist Stage) with modified aeration treatment and flow of whole Zone-2 (called Final Stage) with conventional activated sludge treatment. And all basic figures adopted here are average value.

<Estimation of Electric Power Generated by Digester Gas>

Item	First Stage	Final Stage
Design Flow	135,800 m^3/day	380,000 m^3/day
Inflowing Solid to Digester (refer to Appendix D)	16,210 kg/day	86,280 kg/day
Digester Gas	275 [1/] l/kg x 16,210 kg/day x 1/1,000 = 4,458 m^3/day	275 [1/] x 86,280 x 1/1,000 = 23,727 m^3/day

	First Stage	Second Stage
Potential Heating Value of Digester Gas	4,458 x 5,500 2/ = 24.5 x 10^6 kcal/Nm^3	23,727 x 5,500 2/ = 130.5 x 10^6 kcal/Nm^3
Potential Power Generation via Digester Gas	24.5 x 10^6 x 1/860 3/ x 0.33 4/ = 9,401 kW/day	130.5 x 10^6 x 1/860 3/ x 0.33 4/ = 50,008 kW/day
Power of Generator	9,401 kW / 24 hr = 392 kWh	50,008 kW / 24 hr = 2,084 kWh
Power of Engine	392 kWh x 1.36 5/ = 533 ps	2,084 kWh x 1.36 5/ = 2,834 ps

Note : 1/ .... Gas generation rate per solid weight

200 - 350 l/kg (average 275 l/kg)

2/ .... Potential heating value per standard cubic meter of digester gas

5,000 - 6,000 kcal/Nm^3 (average 5,500 kcal/Nm^3)

3/ .... Power generation rate to gas heating value

1 kWh = 860 kcal/Nm^3

4/ .... Engine efficiency (dual fuel engine*)

30 - 35 percent (average 33 percent)

* Two types of engines, namely dual fuel and spark ignition, are adaptable for gas engine system. Although these two types have both merits and demerits, dual fuel engine is selected for this study purpose because this type is superior to spark ignition type in that heavy oil can be used for fuel when gas supply is not enough.

5/ .... Conversion rate kW to ps

1 kW = 1.36 ps

(2) Air-Conditioning by Energy from Hot Water and Exhaust Gas

As one of potential heat energy recovery systems, air-conditioning (cooling) of operation building was considered here.

By means of heat recovery, approximately 1,900 m^2 of room area (more than the office room area of the proposed operating building) may be air-conditioned as shown in the following calculation made on the condition of using average values in the First Stage.

<Estimation of Room Area to be Air-conditioned>

Total heat value of collected gas (refer to prior section)

.... 24.5×10^6 kcal/day

Heat value obtained from hot water and exhaust gas

.... $24.5 \times 10^6 \times 0.33 = 8.085 \times 10^6$ kcal/day

(Heat recovery rate is assumed at 33 percent)

Required air-conditioning (cooling) load in normal office room on the condition that outdoor temperature is 32 °C and expected indoor temperature is 26 °C

.... 180 kcal/hr/m^2

(This vlue is varied from 160 to 200 kcal/hr/m^2 depend on structure of room. From exemplary data in Japan.)

Expected room area to be air-conditioned

.... $\dfrac{8.085 \times 10^6}{180 \times 24} = 1,871\ m^2$

Total area of office room in the proposed operating building

.... 915 m^2

Above calculation was carried out on the condition that temperature of hot water was more than 95 °C and water temperature at outlet point of heat-exchanger was more than 125 °C. (Refer to Figure F.2)

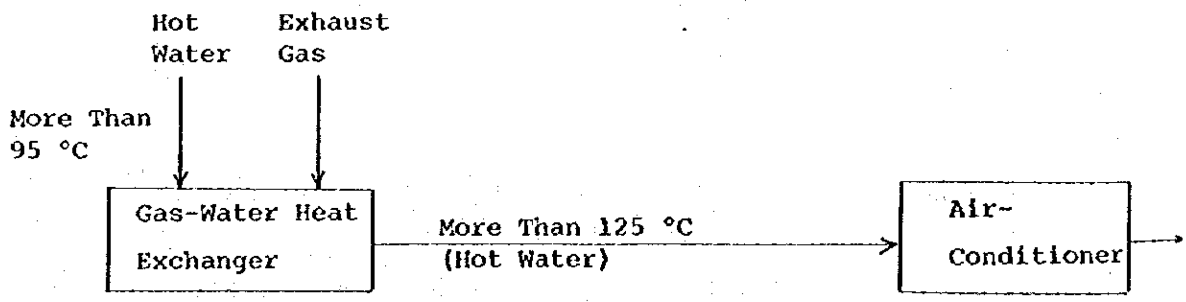


Figure F.2 Air-Conditioning System

Usually above temperatures are not high enough and supplemental heating device is required prior to air-conditioning. Therefore this system is usually economically unfeasible.

5. Cost Saving by Electric Power Generation

If collected gas is good in quality and sufficient in quantity, as shown in the following calculation, approximately 23 and 43 percent of total required electric power are self-supplied in the 1st Stage and Final Stage respectively. In monetary terms, approximately 3.3 million Baht and 17.2 million Baht of total required electricity will be saved in the Ist Stage and Final Stage respectively.

Item	Ist Stage	Final Stage
Average daily power generation		
	9,401 kW/day x 0.75	50,008 kW/day x 0.75
	= 7,051 kW/day	= 37,506 kW/day
	(safety factor is assumed at 75 %)	
Total required electric power	1/	1/
	135,800 m^3/day x 0.23 kw/m^3	380,0000 x 0.23
	= 31,234 kW/day	= 87,400 kW/day
To be self supplied electric power		
	7,051 / 31,234 x 100	37,506 / 87,400 x 100
	= 22.6 percent	= 42.9 percent
Required heavy oil (class A) to operate gas engine		
	13 l/hr 2/ x 24 x 1 unit	13 l/hr 2/ x 24 x 6 units
	= 312 l/day	= 1,872 l/day
Daily cost saving		
	7,051 x 1.42 baht/kW 3/	37,506 x 1.42 baht/kW 3/
	- 312 x 3.5 baht/kW 4/	- 1,872 x 3.5 baht/kW 4/
	= 9,000 baht	= 47,000 baht
Annual cost saving		
	9,000 x 365 x 10^6	47,000 x 365 x 10^6
	= 3.3 million baht	= 17.2 million baht

Note : 1/ Required power per influent wastewater flow (from exemplary data in Japan)

2/ Required heavy oil (pilot oil) for the gas engine of 550 ps

3/ Electric charge of MEA

4/ Unit price of heavy oil (class A)

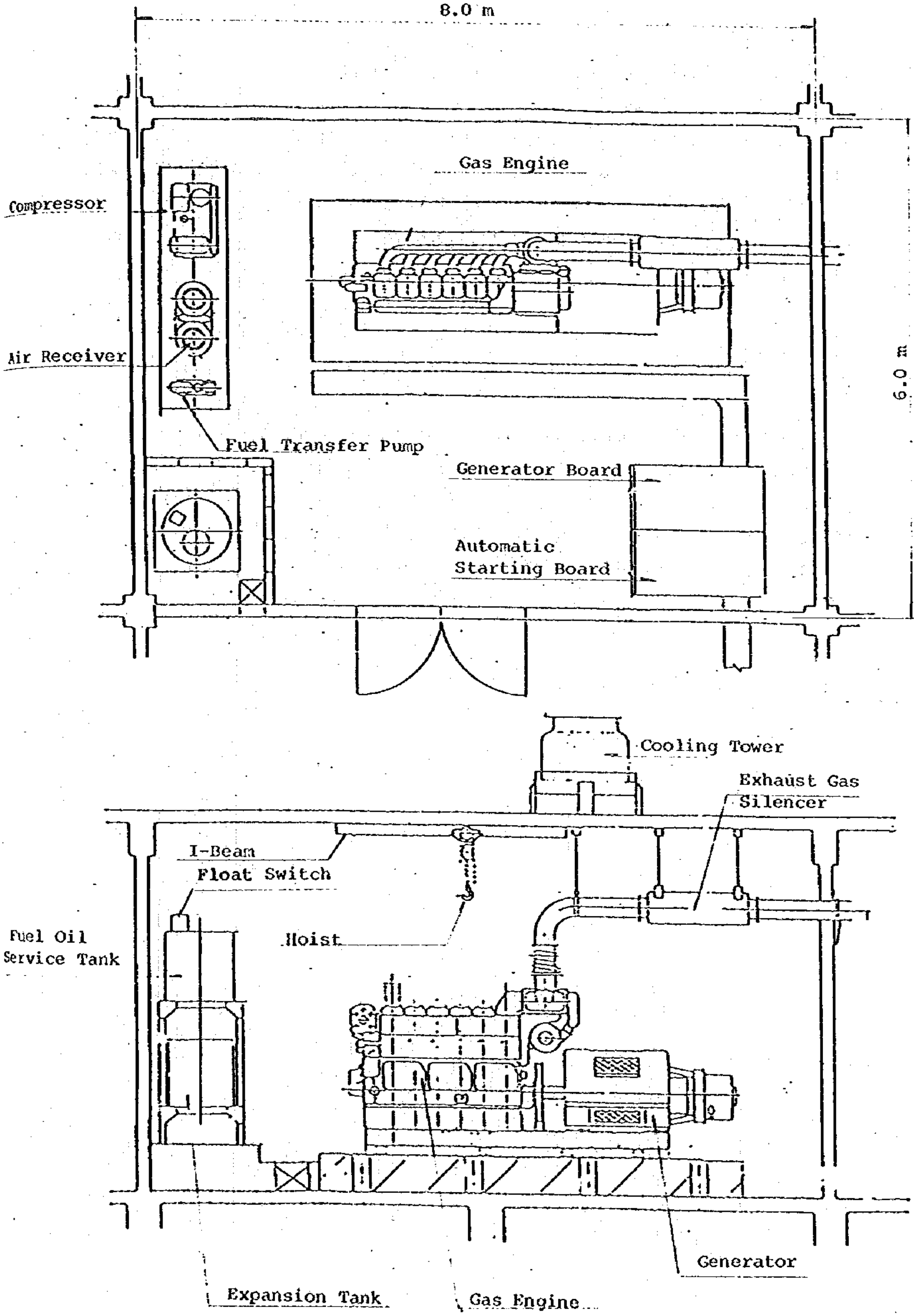
6. Construction Cost of Electric Power Generation System

The following is the estimated construction cost of electric power generation system by digester gas for the proposed first stage program.

Cost estimation was carried out based on Figure F.3 and all machines were assumed to be imported.

1) Civil and Archtectual Works	
$48\ m^2 \times 5{,}000$ baht/m^2 = 240,000 baht	
2) Electric Generation System	
Machinery	12,800,000 baht
Piping	150,000
Installation Cost	100,000
Overhead Expense (20 %)	2,610,000
Sub-Total	15,660,000 baht
Total (1 + 2)	15.9 million baht

Figure F.3 Plan of Gas-Engine and Generator Room



7. Practices in European and American Countries

In European and American countries' wastewater treatment plants, electric power generation by digester gas has been widely applied since 2493 (1950). The system is installed in many plants of wastewater treatment capacity ranging from 20,000 to 1,300,000 m^3/day with high electric self-supply rate ranging from 50 to 100 percent.

One of the reasons why the system has been widely applied in Europe and America is that the public electric power supply system had not been established well and wastewater treatment plants had been constructed on the condition with provision of power generator. In addition, as shown in Table F.2, it seems that inflowing wastewaters are in favorable quality of BOD and SS for gas production. Moreover their operation and maintenance procedure must be well controlled based on plenty of experience extended over a long time.

Table F.2 Practices in Europe and America

Name of Treatment Plant / Item	K in West Germany	B in England	S in U.S.A.	H in U.S.A.
Served Population (persons)	1,160,000	2,400,000	920,000	3,000,000
Treatment Capacity (m^3/day)	350,000	910,000	290,000	1,325,000
Influent BOD (mg/l)	350	237	435	260
SS (mg/l)	400	300	394	280
Effluent BOD (mg/l)	100	7	28	128
SS (mg/l)	80	15	32	72
Sludge Volume Produced (ton/day)	90	180	177	241
Digester Gas Volume Produced (m^3/day)	35,000	84,000	56,600	119,000
Heat Value of Digester Gas (kcal/m^3)	5,400	5,600	5,100	5,300
Electric Power Generated (kWh/day)	40,800	106,000	173,600	124,000
Required Electric Power (kWh/day)	38,400	185,000	189,000	160,000
Self-Supply Rate (percent)	106	57	92	77

Data Source : Journal of Japan Sewage Works Association, Vol. 17, No. 195

8. Conclusion and Recommendation

The study, so far made with some assumptions, reveals that the electric power generation using the digester gas to be generated at the proposed treatment plant will contribute to the saving of power cost by 20 to 50 percent. The calculation also shows that there would be a saving, in monetary terms, of 3.3 million Baht for the first stage plant and 17.2 million Baht for the final stage plant, and the estimated construction cost of the first stage capacity system is 15.9 million Baht. Conclusively, the electric power generation by digester gas for the plant use is economically feasible.

Regarding the implementation of the said system, however, there are still some issues to be considered, namely, 1) Bangkok has little experience in wastewater treatment, 2) Estimated wastewater BOD and SS are pretty low, and 3) Bangkok has a well established electric power supply system. Therefore, the following must be verified and assured when the treatment plant is put in service, before proceeding to the detailed design.

1) Digester gas component is suitable for gas engine.
2) Gas volume routinely produced is sufficient for gas engine operation.
3) Application of this system is less costly than purchase of MEA electric power.
4) Operation of the treatment plant has become constant and routine.

From the above consideration, it is recommended that detailed investigation with regard to the above items be carried out after the completion of the first stage project, and then the detailed design of the system and its construction be implemented in the second stage project, which is sheduled to start in 2532 (1989).

APPENDIX G

CONSTRUCTION METHOD OF TRUNK INTERCEPTOR

In view of the importance of the main interceptor between the existing Rama IV Sewer nearest to the railway and the proposed treatment plant, some alternative construction methods will be studied hereunder to select the least cost and most suitable one.

1. Given Condition

Characteristic features of the route of this interceptor are as follows: 1) Rama IV Road, one of the main roads of the City, has constantly heavy traffic all day long, and 2) no space is available to construct a pumping station. And besides, the sewer has a large size, 2.4 m in diameter or 2.1 m square, due to the planned large flow, 6.204 m^3/sec, and the small available gradient of the route, 0.0008 in 700 m length (Refer to Figure G.1).

2. Alternative Methods

Under the above given conditions, conceivable alternative methods are the following three:

Alternative I	:	Jacking for the 450 m span from the diversion chamber to the approach road to the treatment plant, and open-trench for the remaining 250 m span.
Alternative II	:	Jacking for all the length.
Alternative III	:	Shielding for all the length.

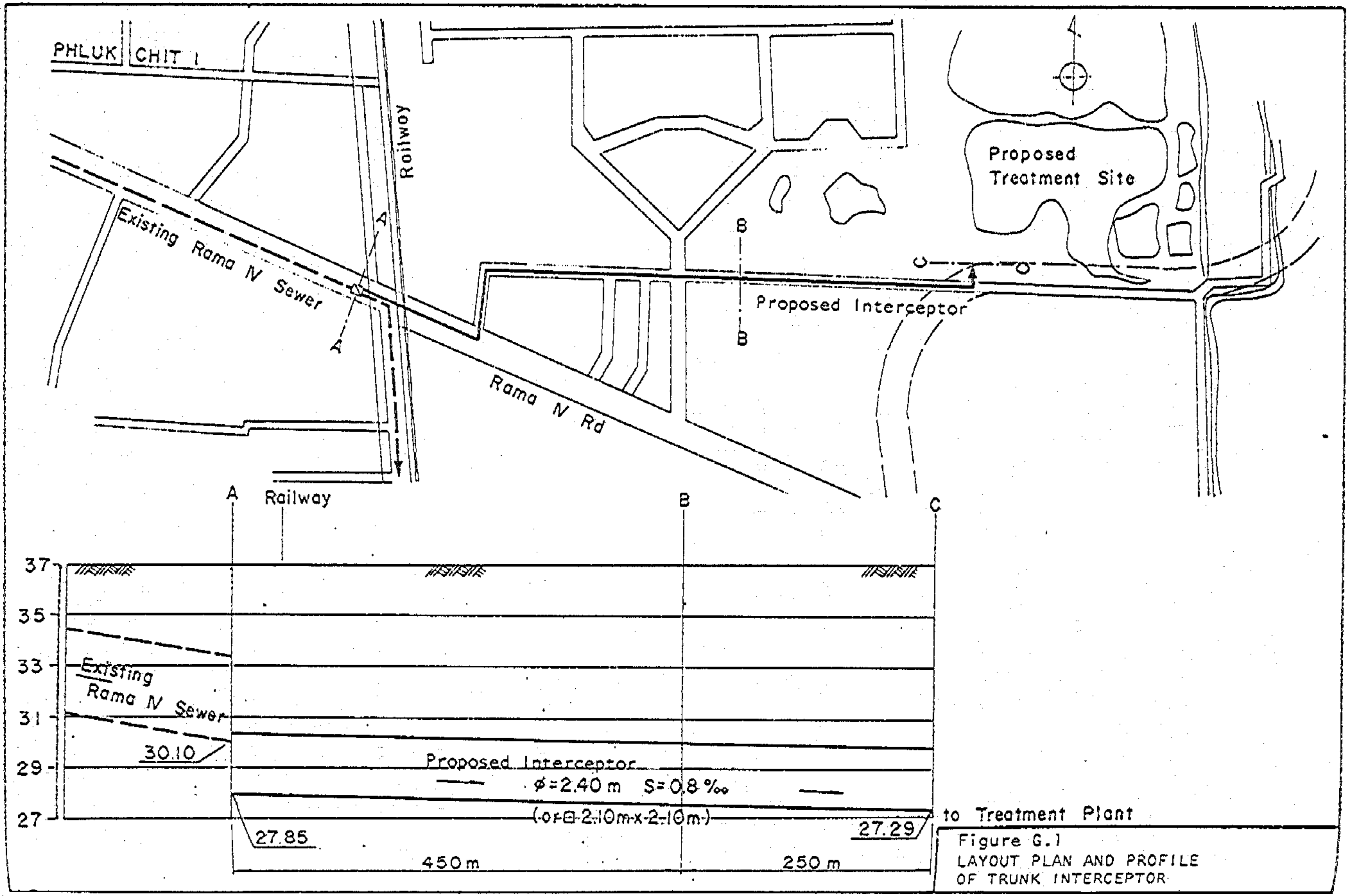


Figure G.1
LAYOUT PLAN AND PROFILE
OF TRUNK INTERCEPTOR

3. Particulars to be Compared

With regard to the above alternatives, the following aspects will be compared and the most suitable one will be selected.

1) Capital cost
2) Suitability of the method to the specific site condition
3) Other related technical matters

4. Comparison

With regard to the above particulars, each alternative has the following characteristics. Summary of capital cost for each alternative is shown in Table G.1.

<u>Alternative I</u>

- Capital cost is 37.8 million Baht
- Jacking method requires an aera of approximately 200 m^2 as a shaft space at intervals of approximately 50 m and at turning of road in progress of construction. The required areas are available for all the length. Required areas at Rama IV Road do not hinder the traffic in progress of construction.
- The open-trench span has area enough for construction of open-trench method.
- Local contractors have a capability of jacking and open-trench methods.

<u>Alternative II</u>

- Capital cost is 42.2 million Baht.
- Jacking method requires an area of approximately 200 m^2 as a shaft space at intervals of approximately 50·m and at turning of road in progress of construction. The required areas are available for all the length. Required areas at Rama IV Road do not obstruct the traffic, however required areas at northern road of Rama IV road may stop the traffic in progress of construction.
- Local contractors have a capability of jacking method.

Alternative III

- o Capital cost is 54.4 million Baht.
- o Shielding method requires an area of approximately 1,000 m^2 as a shaft space at starting and end of the line and at turning with an acute angle of road. Required areas are obtainable for all length, but these areas at northern road of Rama IV Road may stop the traffic
- o Local contractors have a capability of shielding method.

5. Conclusion

From the above comparison, Alternative I is slected for the construction method of Trunk Interceptor.

Table G.1 Estimated Construction Cost of Interceptor by Alternative

Alternative I

Facilities or Works	Specification	Quantity	Unit Price (baht)	Amount (baht)
A to B line	Ø2.40 m, 450 m length, Invert Elevation = 27.60 m, and Jacking Method			
* Steel pipe with PVC lining		665.8 ton	23,400	15,579,720
* Jacking		445 m	8,078	3,594,710
* Pipe laying		445 m	1,157	514,865
* Pipe welding		111 units	17,246	1,914,306
* Back filling		445 m	2,969	1,321,205
* Temporary works		9 places	194,501	1,750,509
* Shaft construction		9 places	204,168	1,837,512
* Dewatering		203 days	138	28,014
* Manhole construction		3 units	30,982	92,946
* Division Chamber (at Rama IV Sewer)		1 unit		771,977
				27,405,764
B to C line	□ 2.1 x 2.1 m, 250 m length Average excavation depth = 9.80 m, and Open-trench method			
* Concrete works		892.5 m³	1,280	1,142,400
* Crushed stone works		150.0 m³	316	47,400
* Form works		9,000 m²	240	2,160,000
* Excavation		11,795 m³	24	283,080
* Restoration of paving		1,200 m²	247	296,400
* Gravel		360 m³	316	113,760
* Back filling		6,155 m³	20	123,100
* Sand filling		2,760 m³	150	414,000
* Soil removal		5,640 m³	114	642,960
* Piling	Ø200 mm 8 m length	1,000 pieces	410	410,000
* Steel sheet piling	17 m length	250 m	13,013	3,253,250
* Dewatering		280 days	138	38,640
* Lean concrete works		75 m³	1,100	82,500
* Timbering		1,425 m²	85	121,125
* Scaffolding		1,102.5 m³	130	143,325
* Steel works		90 ton	11,400	1,026,000
* Manhole setting	Type IV	2 units	45,526	91,052
				10,388,992
Total				37,794,756

Alternative II

Facilities or Works	Specification	Quantity	Unit Price (baht)	Amount (baht)
A to C	Ø2.40 m, 700 m length Invert elevation = 27.60 m, and Jacking Method			
* Steel pipe with PVC lining		1,035.7 ton	23,400	24,235,380
* Jacking		692.8 m	8,078	5,596,438
* Pipe laying		692.8 m	1,157	801,569
* Pipe welding		173 units	17,246	2,983,558
* Back filling		692.8 m	2,969	2,056,923
* Temporary works		14 places	194,501	2,723,014
* Shaft construction		14 places	204,168	2,858,352
* Dewatering		316 days	138	43,608
* Manhole construction		4 units	30,982	123,928
* Diversion Chamber (at Rama IV Sewer)		1 unit		771,977
Total				42,194,747

Alternative III

Facilities or Works	Specification	Quantity	Unit Price (baht)	Amount (baht)
A to C	Ø2.40 m, 700 m length, Invert elevation = 27.60 m, and Shield Method			
* Shield works		700 m		53,364,984
* Manhole construction		4 units		262,563
* Diversion chamber (at Rama IV Sewer)		1 unit		771,977
Total				54,399,524

APPENDIX H

BASIC COST DATA AND UNIT PRICES

1. Introduction

This Appendix presents basic cost data used for cost estimates of facilities of this Study.

All the costs presented here are based on those official costs prevailing in Bangkok as of October 2524(1981). The costs of locally produced materials include standard profit and business tax, and those of locally available imported or directly imported materials and equipment include customs duty, standard profit and business tax.

Table H.1 shows the local labor costs including those of skilled laborers.

Table H.2 shows the cost of major materials for construction of civil work structures.

Table H.3 shows costs of pipe materials and Table H.4 shows the rental rate of construction machine and equipment in Bangkok.

Table H.5 shows the unit rates of civil works and architecture.

Table H.6 and H.7 show the cost of machinery and equipment to be imported for the project.

Table H.8 shows the sewer construction costs per meter run and Table 9 shows manhole construction costs.

Table H.10 shows electric rates which can be applicable to the estimating electric charge of pumping stations and treatment plants.

Table H.11 shows monthly allowances of BMA Staff.

Table H.1 Labor Costs

Item	Unit	Rate (Baht)
Common Worker	day (8 hrs)	70
Carpenter	"	100
Plumber	"	90
Steel Worker	"	120
Brick Layer	"	80
Bulldozer Operator	"	200 - 300
Power Shovel Operator	"	200 - 300
Cement Finisher	"	150
Foreman	"	150
Supervisor	"	200
Driver	"	70
Painter	"	130
Electrician	"	130
Welding Operator	"	100

Table H.2 Costs of Major Materials

Item	Unit	Cost (Baht)
Crushed Stone (for concrete)	m^3	210
Sand (for concrete)	"	180
Wood (for form works)	m^2	160
Portland Cement	ton	1,400
Round Steel Bar (ø15,19,20mm)	"	8,480
Deformed Steel Bar (ø16,20,25,28mm)	"	8,890
Prestressed Concrete Pile (400mm x 400mm x 21m length)	piece	9,100
Gasoline	liter	11

Table H.3 Costs of Pipe Materials (Baht/m)

Dia. (m)	VCP	AC	RCP	CRCP (Rocla Pipe)	SP
0.15	63	83	-	-	
0.20	100	152	-	-	
0.25	126	220	-	-	
0.30	176	315	115	-	
0.40		553	220	352	1,380
0.50		872	300	452	1,820
0.60		1,162	335	587	2,220
0.70			-	722	2,540
0.80			550	826	
0.90			-	1,010	
1.00			805	1,262	3,776
1.20			1,060	1,642	
1.50			1,735	2,568	6,625

These prices are estimated based on the quotations of factories.
The price includes joints and transportation.

Table H.4 Rental Rates of Construction Machine and Equipment

Item	Unit	Rate (Baht)
Back Hoe	8 hrs	3,200
Bulldozer	"	5,500
Air Compressor	"	1,250
Dragline	"	3,500
Truck (6 ton)	"	600
Dump Truck (6 ton)	"	800
Crane (8 ton)	"	2,300
Compactor (Tumper)	"	700
*Dewatering Pump (ø100mm, Head: 20m)	set	40,000

* The rate is purchase price.

Table H.5 Unit Rates of Civil Works and Architecture

Item	Description	Unit	Rate(Baht)
Labor excavation	For pipelaying For foundation of civil structure	m^3	90
Machine excavation	For trench For foundation of civil structure	m^3	24
Backfilling	With excavated soil	m^3	20
Backfilling and compaction	With selected soil	m^3	150 - 160
Form works	By Timber	m^2	240
Turfing	For bank	m^2	25
Lean concrete works	For foundation of civil works	m^3	840
Steel works	For civil structure	ton	11,400
Concrete works	Mix 1:2:4 for civil structure	m^3	1,280
Mortar works	Mix 1:2	m^2	75
Open caisson construction	For pump well	m^3	3,000
Building construction	For operator building floor	m^2	8,000

Table H.6 Costs of Electric Equipment

Item	CIF (Baht)	Duty & Tax (Baht)	Transportation & Local Handling(Baht)	Total (Baht)
For high voltage				
o Voltage detector	40,000	21,760	300	62,060
o Disconnecting switch (outdoor)	260,000	141,440	2,000	403,440
o Air blast circuit breaker (outdoor)	700,000	380,800	5,400	1,086,200
o Current transformer (outdoor)	50,000	27,200	390	77,590
o Grounding Transformer (outdoor)	100,000	54,400	770	155,170
o Load disconnecting switch (outdoor)	180,000	97,920	1,390	279,310
o Transformer (outdoor)	900,000	489,600	6,940	1,396,540
o Lightning arrester (outdoor)	49,000	26,650	370	76,020
o Disconnecting switch (outdoor)	40,000	21,760	300	62,060
For low voltage				
o Transformer for electric power	770,000	418,890	5,940	501,830
o Electric power master controller	500,000	272,000	3,860	775,860
o Electric power switch-board	500,000	272,000	3,860	775,860
o Transformer for lighting	400,000	217,600	3,090	620,690

Table H.7 Costs of Mechanical Equipment

Item	Description	CIF (Baht)	Duty & Tax (Baht)	Trans-portation & Local Handling (Baht)	Total (Baht)
Inlet gate	1.50 x 1.50m cast iron make	390,000	167,000	3,300	560,300
Traveling crane and Hoist with bucket	0.3 m^3 bucket	5,200,000	2,862,000	40,000	8,102,000
Sewage Pump	Ø600mm x 45m^3/min x 13.5m Head	1,430,000	450,000	5,600	1,885,600
Mortor for sewage pump	6kV x 1,000rpm x 140kW	790,000	268,000	2,100	1,060,100
Electric-powered sluice valve	Ø600mm x 1.5kW	270,000	115,000	1,900	386,900
Check valve	Ø600mm	280,000	120,000	2,000	402,000
Check valve	Ø800mm	550,000	235,000	3,900	788,900
Controller and resistor	140kW use	160,000	87,000	1,000	248,000
Controller and resistor	250kW use	210,000	114,000	1,500	325,500
Submersible pump	Ø50mm x 0.3m^3/min x 1.5kW x 10m Head	25,000	7,900	200	33,100
Movable inlet weir for aeration tank	1.0m x 0.5,	150,000	64,000	1,000	215,000
Manual inlet gate	0.5m x 0.5m	68,000	28,600	500	97,100
Driving unit of sludge scraper	Ø26m x 2.5m high x 1.5kW	770,000	424,000	6,000	1,200,000
Electric-powered sluice valve for sludge extraction	Ø250mm x 0.4kW	89,000	37,600	600	127,200
Control butterfly valve	Ø400mm x 0.4kW	140,000	60,000	1,000	201,000
Chlorination injector	40kg/hr	490,000	271,000	1,500	762,500
Compressor	300 l/min x 7kg/cm^2 x 22kW	30,000	12,800	200	43,000
Incinerator for excess gas		650,000	358,000	5,000	1,013,000
Ductile cast iron pipe	Ø300mm, per 1 meter	20,000	10,900	400	31,300

Table H.8 Unit Sewer Construction Costs Per Meter Run

(Unit: Baht)

Pipe Dia. (mm)	Depth of Earth Covering (m) 1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0
0.30	1,624	1,723	1,922	5,915	8,317	8,976	-	-
0.40	1,894	1,994	2,192	6,186	8,588	9,246	-	-
0.50	2,293	2,367	2,599	6,597	9,004	9,667	11,533	-
0.60	2,659	2,770	2,979	6,984	9,403	10,324	12,197	13,475
0.80	3,859	3,981	4,201	8,512	10,923	11,603	13,487	14,776
1.00	5,338	5,573	9,604	12,056	12,752	14,651	15,955	16,732
1.20	6,543	10,183	10,827	13,288	13,992	15,900	17,214	17,999
1.50	8,040	11,695	12,355	14,838	15,558	17,481	18,810	19,611

Table H.9 Manhole Construction Cost by Sewer Size and Depth

(Unit: Baht)

Manhole Type	Inter-(1) nal Size(m)		Depth to Sewer Invert Elevation of Lower Point (m) 2.0	3.0	4.0	5.0	6.0	7.0	8.0
Type I	0.90	(2)	15,723	17,246	18,722	20,198	21,721	23,197	24,672
Type II	1.20	(3)		22,889	24,464	26,037	27,661	29,234	30,809
Type III	1.50	(4)		30,234	31,954	33,672	35,440	37,157	38,877
Type IV	1.80	(5)		36,297	38,132	39,969	41,853	43,689	45,526

Note: (1) Internal manhole sizes are decided by those of sewers connected to the manholes.

(2) Less than 0.5 m sewers are connected.

(3) 0.6 m - 0.8 m sewers are connected.

(4) 1.0 m - 1.2 m sewers are connected.

(5) 1.3 m - 1.5 m sewers are connected.

Table H.10 Electric Rates (SCHEDULE 5 LARGE INDUSTRIAL)

Item	Description

Applicable

To the electric service through a single demand meter for lighting and appliances used in industrial establishments including related grounds with a maximum 15-minute integrated demand of 500 kiloWatts or over.

Monthly Rate

Demand Charge:	Baht 90.00 per kW of billing demand
Energy Charge:	First 200 kWhr per kW of billing demand Baht 1.46 kWhr
	Next 280 kWhr per kW of billing demand Baht 1.45 per kWhr
	All over 480 kWhr per kW of billing demand Baht 1.43 per kWhr
Minimum Charge:	The demand charge for 60% of the highest billing demand occurring during the last 12 months ended with the current month.
Billing Demand:	The billing demand (determined to the nearest whole kiloWatt) shall be the maximum 15-minute integrated demand during the monthly billing period.

Power Factor Charge

For lagging power factor customer, in any monthly billing period during which customer's maximum 15-minute kilovar demand is in excess of 63% of his maximum 15-minute kiloWatt demand, a monthly power factor charge of Baht 15.00 for each kilovar of such excess (determined to the nearest whole kilovar) will be made.

Note

1. For 69 or 115 kv delivery, the above rate is applicable.
2. For delivery at 12 or 24 kv, the demand charge in the above monthly rate will be increased by Baht 5.00 per kiloWatt.
3. For below 12 kv delivery, the demand charge in the above monthly rate will be increased by Baht 7.00 per kiloWatt.
4. Where transformers belong to customer, if deemed necessary, MEA may elect to meter on the load side of transformers, in which case meter readings shall be increased by the amount of the transformer losses individually determined by tests or estimate.

Table H.11 Monthly Allowances of BMA Staff

Item	Rate (Baht)
Labor	1,000 - 2,500
Technician	2,200 - 4,600
Draftman	2,200 - 4,600
Engineer	2,700 - 5,700
" (Section Chief)	3,700 - 9,300
Division Head	6,900 -14,000
Director General	10,400 -17,700

APPENDIX I

ESTIMATION OF CONSTRUCTION COST

Estimation of construction cost is made based on the preliminary engineering design and the basic cost data. This appendix presents procedure and breakdown of construction cost estimates for sewers, intermediate pumping stations and treatment plant, as shown in Table I.1 through Table I.6.

Table I.1 Sewer Construction Costs

Pipe Dia. (mm)	Pipe Length (m)	Unit Cost (Baht)	Amount (million Baht)	No. of Diversion Chamber	Unit Costs (Baht)	Amount (million Baht)	No. of Manhole	Unit Costs (Baht)	Amount (million Baht)	Sub-total Cost	Expenditure (20%)	Total Cost (million Baht)
1. Chula Interceptor												
600	140	2,659	0.372 (0.044)	1	19,741	0.020 (0.002)	1	20,868	0.021 (0.002)	0.413	0.083	0.496 (0.046)
1,000	1,005	5,573	5.601 (0.679)	2	19,741	0.039 (0.004)	8	38,132	0.305 (0.018)	5.945	1.189	7.134 (0.701)
600	295	2,593	0.765 (0.091)	-	-	-	1	20.868	0.021 (0.002)	0.786	0.157	0.943 (0.093)
										Sub-total		8.573 (0.840)
2. Charoen Krung Interceptor												
400	295	1,894	0.559	1	19,741	0.020 (0.002)	4	15,723	0.063 (0.008)	0.642	0.128	0.770 (0.010)
500	465	2,599	1.209	2	19,741	0.039 (0.004)	8	17,246	0.138 (0.016)	1.386	0.277	1.663 (0.020)
600	465	2,979	1.385 (0.231)	1	19,741	0.020 (0.002)	6	24,464	0.147 (0.012)	1.552	0.310	1.862 (0.245)
1,000	325	12,056	3.918 (0.683)	1	19,741	0.020 (0.002)	4	33,672	0.135 (0.008)	4.073	0.815	4.888 (0.693)
600	165	2,593	0.428	-	-	-	1	20,868	0.021 (0.002)	0.449	0.090	0.539 (0.002)
										Sub-total		9.772 (0.970)
3. Klong Sathorn Interceptor												
300	20	1,624	0.032	1	19,741	0.020 (0.002)	-	-	-	0.052	0.011	0.063 (0.002)
300	240	1,922	0.461 (0.081)	1	19,741	0.020 (0.002)	4	18,722	0.075 (0.008)	0.556	0.117	0.673 (0.091)
400	260	2,192	0.570 (0.100)	2	19,741	0.039 (0.004)	3	18,722	0.056 (0.006)	0.665	0.140	0.805 (0.110)
500	240	2,599	0.624 (0.109)	1	19,741	0.020 (0.002)	3	18,722	0.056 (0.006)	0.700	0.147	0.847 (0.117)
600	95	2,979	0.283 (0.050)	1	19,741	0.020 (0.002)	-	-	-	0.303	0.064	0.367 (0.052)
600	220	6,984	1.536 (0.269)	1	19,741	0.020 (0.002)	2	26,037	0.052 (0.004)	1.608	0.338	1.946 (0.275)
800	310	8,512	2.639 (0.463)	2	19,741	0.020 (0.004)	2	26,037	0.052 (0.004)	2.711	0.569	3.280 (0.471)
800	175	8,512	1.490 (0.261)	1	19,741	0.020 (0.002)	2	27,661	0.055 (0.004)	1.565	0.329	1.894 (0.267)
1,500	160	8,040	1.286 (0.225)	1	19,741	0.020 (0.002)	2	38,132	0.076 (0.004)	1.382	0.290	1.672 (0.231)
1,500	710	11,695	8.303 (1.455)	5	19,741	0.099 (0.010)	1	39,969	0.040 (0.002)	8.442	1.773	10.215 (1.467)
1,500	755	12,355	9.328 (1.635)	2	19,741	0.039 (0.002)	4	39,969	0.160 (0.008)	9.527	2.001	11.528 (1.465)
500	90	2,142	0.193	-	-	-	-	-	-	0.913	0.041	0.234
										Sub-total		33.524 (4.726)
4. Chong Nonsi Combined Sewer												
	1,275	43,305	55.214	-	-	-	8	36,297	0.290 (0.016)	55.504	11.05	66.554 (0.016)
5. Trunk Interceptor (refer to G.1 of Appendix G)												

Note: Figures in parentheses indicate Foreign Currency Component.

Table I.2 Civil & Architectural Works for Intermediate Pumping Station

Cost: Million Baht at 2524 (1981) Price Level

Name	Items	Civil Works									Architectural Works	Sub-total Cost	Expenditure	Total Cost
		Concrete W. m^3	Steel W. ton	Form W. m^2	Scaffolding W. m^2	Timbering W. m^3	Lean Concrete W. m^3	Crushed Stone m^3	Pile W. No.	Earth W. set	Total Floor Area m^2		Sub-total Cost x 20%	
	Unit Rate (Baht)	1,280	11,400	240	85	130	840	316	13,000		3,000			
o Chula Station	Volume	100	7	350	170	90	7	14	6		20			
	Cost	0.128	0.080	0.084	0.015	0.012	0.006	0.004	0.080	0.270	0.060	0.74	0.14	0.88 F 0.09 L 0.79 (0.02)
o Charoen Krung Pumping Station	Volume	120	8	450	200	120	7	14	6		20			
	Cost	0.154	0.091	0.108	0.017	0.016	0.006	0.004	0.080	0.370	0.060	0.91	0.17	1.08 F 0.14 L 0.94 (0.02)
o Klong Sathorn Pumping Station	Volume	100	7	420	210	90	8	16	6		16			
	Cost	0.128	0.008	0.101	0.018	0.012	0.007	0.005	0.080	0.340	0.050	0.82	0.15	0.97 F 0.12 L 0.85 (0.02)

Note: F means Foreign currency component

L means Local currency component

Figures in parentheses indicate import duty, standard profit and business tax.

Table I.3 Mechanical Works for Intermediate Pumping Station

Unit: Million Baht at 2524 (1981) Price Level

Name of Equipment	Description	Number	Foreign Currency			Local Currency			Total
			Foreign (1)	Expenditure (1) x 20%	Sub-total	Local (2)	Expenditure (2) x 20%	Sub-total	
o Chula & Charoen Krung									
Inlet Gate	Square type manual cast iron gate □500 mm	2	0.140	0.028	0.168	0.060	0.012	0.072	0.240
Coarse Screen	Manually raked bar screen FB@60 mm channel width 0.9 m " depth 3.8 m	2	-	-	-	0.030	0.006	0.036	0.036
Main Pump	Sump pump Ø300 x11.5 m^3/min x 7 m x 21KW	3	0.630	0.126	0.756	0.198	0.040	0.238	0.994
Pipes	SGP	1 set	-	-	-	0.200	0.040	0.240	0.240
Transportation	3.8 ton		-	-	-	0.005	0.001	0.006	0.006
Installation & Local Handling	Supervisor		0.124	0.025	0.149	-	-	-	0.149
	Common worker		-	-	-	0.001	0.000	0.001	0.001
	Plumber		0.030	0.006	0.036	0.030	0.006	0.036	0.072
	Equipment x 3%		-	-	-	0.031	0.006	0.037	0.037
Total					1.11			0.66 (0.26)	1.77
o Klong Sathorn									
Inlet Gate	Square type manual cast iron gate □500 mm	1	0.070	0.014	0.084	0.030	0.006	0.036	0.120
Coarse Screen	Manually raked bar screen FB@60 mm channel width 0.9 m depth 3.8 m	1	-	-	-	0.015	0.003	0.018	0.018
Main Pump	Sump pump Ø250 x 6.5 m^3/min x 7 m x 15KW	2	0.340	0.068	0.408	0.107	0.021	0.128	0.536
Pipes		1 set	-	-	-	0.100	0.020	0.120	0.120
Transportation	1.7 ton		-	-	-	0.002	0.000	0.002	0.002
Installation & Local Handling	Supervisor		0.056	0.011	0.067	-	-	-	0.067
	Common worker		-	-	-	0.001	0.000	0.001	0.001
	Plumber		0.015	0.003	0.018	0.015	0.003	0.018	0.036
	Equipment x 3%		-	-	-	0.016	0.003	0.019	0.019
Total					0.58			0.34 (0.14)	0.92

Note: Figures in parentheses indicate import duty, standard profit and business tax.

Table I.4 Civil & Architectural Works for Treatment Plant

Cost:Million Baht at 2524 (1981) Price Level

Name of Facility	Item	Civil Works									Architectural Works	Sub-total Cost	Expenditure	Total Cost
		Concrete W.	Steel W.	Form W.	Scaffolding W.	Timbering W.	Lean Concrete W.	Crushed Stone	Pile W.	Others	Total Floor Area			
	Unit	m^3	ton	m^2	m^2	m^3	m^3	m^3	N	set	m^2		Sub-total Cost x 20%	
	Rate(Baht)	1,280	11,400	240	85	130	840	316	90,000 *1 13,000		3,600 *1 3,000			
o Pumping & Operating Building	Volume	3,800	270	6,350	2,900	12,100	80	160	50		1,980			
	Cost	4.864	3.078	1.524	0.247	1.573	0.067	0.051	4.500	14.650 *2	16.830	47.38	9.48	56.86
o Grit Chamber	Volume	380	30	1,570	810	1,590	8	16	21	-	-			
	Cost	0.486	0.342	0.377	0.069	0.207	0.007	0.005	0.270	-	-	1.76	0.35	2.11
o Aeration Tank	Volume	3,920	270	9,610	3,700	4,330	353	706	340	-	20			
	Cost	5.018	3.078	2.306	0.315	0.563	0.297	0.223	4.420	-	0.060	16.28	3.26	19.54
o Final Sedimentation Tank	Volume	4,740	330	8,960	4,310	1,110	540	1,080	362		60			
	Cost	6.067	3.762	2.150	0.366	0.144	0.454	0.341	4.706	0.290 *3	0.120	18.40	3.68	22.08
o Chlorination Chamber	Volume	680	50	2,110	920	800	60	120	54		216			
	Cost	0.870	0.570	0.506	0.078	0.104	0.050	0.038	0.702		0.648	3.57	0.71	4.28
o Outlet	Volume	620	50	2,300	1,100	-	60	120	34					
	Cost	0.794	0.570	0.552	0.094	-	0.050	0.038	0.442			2.54	0.50	
												0.50	0.10	3.64
o Thickening Tank	Volume	700	50	1,540	1,080	200	70	140	70		10			
	Cost	0.896	0.570	0.370	0.092	0.026	0.059	0.044	0.910		0.030	3.00	0.60	3.60
o Digestion Tank	Volume	2,680	190	5,240	2,310	10,470	120	240	259		111			
	Cost	3.430	2.166	1.258	0.196	1.361	0.101	0.076	3.370		0.333	12.29	2.46	14.75
o Gas Holder	Volume	250	20	45	-	-	45	90	11					
	Cost	0.320	0.228	0.011	-	-	0.038	0.028	0.140			0.77	0.15	0.92
o Drying Bed	Volume	790	55	6,660	-	-	210	420						
	Cost	1.011	0.627	1.598	-	-	0.176	0.133		0.675 *4		4.22	0.84	5.06
o Electric Room	Volume								6		90			
	Cost								0.078		0.270	0.35	0.07	0.42
o Power Receiving	Volume	330	20	20	-	-	55	110	18					
	Cost	0.422	0.228	0.014	-	-	0.046	0.035	0.234			0.98	0.20	1.18

(to be continued)

Cost:Million Baht At 2524 (1981) Price Level

Name of Facility	Item	Concrete W.	Steel W.	Form W.	Scaffolding W.	Timbering W.	Lean Concrete W.	Crushed Stone	Pile W.	Others	Architectural Works: Total Floor Area	Sub-total Cost	Expenditure Sub-total Cost x 20%	Total Cost
	Unit	m^3	ton	m^2	m^2	m^3	m^3	m^3	No.	set	m^2			
	Rate (Baht)	1,280	11,400	240	85	130	840	316	13,000		3,000			
o Laber Room	Volume								14		376			
	Cost								0.182		1.128	1.31	0.26	1.57
o Earthwork		Removal of Soil		46,500 m^3	x 50 ฿/m^3	= 2.325								
		Excavation		13,800	x 24	= 0.031								
		Bachfilling		349,000	x120	=41.880						44.54	8.91	53.45
o Land Scaping														10.16
													Total	199.62

Note: *1 Pumping & Operating Building

*2 Cast in site diaphragms method 1,800 m^2 x 7,000 ฿/m^2 = 12.50
Ø1,200 steel pipe 90 m x 2

*3 Scume removal

*4 Miscellaneous materials

Table I.5 Mechanical Works for Treatment Plant

Unit: Million Baht at2524 (1981) Price Level

Name of Equipment	Description	Number	Foreign Currency: Foreign (1)	Foreign Currency: Expenditure (1) x 20%	Foreign Currency: Sub-total	Local Currency: Local (2)	Local Currency: Expenditure (2) x 20%	Local Currency: Sub-total	Total
o Pumping and Operating Building									
Inlet Gate	Square type manual cast iron gate □1,500 mm	2	0.780	0.156	0.936	0.334	0.067	0.401	1.337
Coarse Screen	Manually raked bar screen FB@60 mm channel width 2 m " depth 4 m	2	-	-	-	0.089	0.018	0.107	1.107
Pump Pit Gate	Square type mannual cast iron gate □1,500 mm	1	0.390	0.078	0.468	0.167	0.033	0.501	0.969
No. 1 Main Pump	Vertical shaft mixed flow volute pump Ø600 x 45 m^3/min x 15 m	2	2.860	0.572	3.432	0.900	0.180	1.080	4.512
No. 1 Main Motor	6,000V x 6P x 1,000 r.p.m. x 150kW	2	1,580	0.316	1.896	0.536	0.107	0.643	2.539
No. 2 Main Pump	Vertical shaft mixed flow volute pump Ø800 x 80 m^3/min x 15 m	2	4.220	0.844	5.064	1.326	0.265	1.591	6.655
No. 2 Main Motor	6,000V x 8P x 750 r.p.m. x 270kW	2	2.640	0.528	3.168	0.892	0.178	1.070	4.328
No. 1 Delivery Valve	Motor driven sluice valve Ø600 x 1.5kW	2	0.540	0.108	0.648	0.230	0.046	0.276	0.924
No. 2 Delivery Valve	Motor driven sluice valve Ø800 x 2.2kW	2	1.000	0.200	1.200	0.428	0.086	0.514	1.714
No. 1 Suction Valve	Manual sluice valve Ø600	2	0.360	0.072	0.432	0.152	0.030	0.182	0.614
No. 2 "	" Ø800	2	0.780	0.156	0.936	0.334	0.067	0.401	1.337
Communicating Valve	" Ø800	1	0.550	0.110	0.660	0.235	0.047	0.282	0.942
No. 1 Check Valve	Gradually closing type Ø600	2	0.560	0.112	0.672	0.240	0.048	0.288	0.960
No. 2 "	" Ø800	2	1.100	0.220	1.320	0.470	0.094	0.564	1.884
Pit Drain Pump	Submerged sewage pump Ø50 x 0.3 m^3/min x 10 m x 1.5kW	2	0.050	0.010	0.060	0.016	0.003	0.019	0.079
Overhead Crave	All manual crab type 10 ton	1	0.650	0.130	0.780	0.358	0.072	0.430	1.210
Controller & Resister	150kW use	2	0.320	0.064	0.384	0.174	0.035	0.209	0.593
"	270kW use	2	0.420	0.084	0.504	0.228	0.046	0.274	0.778
Pipes		1 set	1.496	0.299	1.795	0.814	0.163	0.977	2.772

(to be continued)

Unit: Million Baht at 2524 (1981) Price Level

Name of Equipment	Description	Number	Foreign Currency: Foreign (1)	Foreign Currency: Expenditure (1) x 20%	Foreign Currency: Sub-total	Local Currency: Local (2)	Local Currency: Expenditure (2) x 20%	Local Currency: Sub-total	Total
o Final Sedimentation Tank									
Inlet Gate	Square type manual cast iron gate □500	8	0.544	0.109	0.653	0.229	0.046	0.275	0.928
Sludge Collector	Circular type clarifire Ø26 m	8	6.160	1.232	7.392	3.392 5.808	0.678 1.162	4.070 6.970	18.432
Sludge Extraction Valve	Motor driven sluice valve Ø250	8	0.712	0.142	0.854	0.301	0.060	0.361	1.215
Return Sludge Pump	Horizontal non clog type Ø200 x 5.6 m^3/min x 15kW	4	0.640	0.128	0.768	0.200	0.040	0.240	1.008
Return Sludge Control Valve	Motor dirven butterfly valve Ø400 x 0.4kW	2	0.208	0.056	0.336	0.120	0.024	0.144	0.480
Excess Sludge Pump	Horizontal non clog type Ø100 x 1 m^3/min x 5.5kW	4	0.380	0.076	0.456	0.119	0.024	0.143	0.599
Pit Drain Pump	Submerged sewage pump Ø50 x 0.3 m^3/min x 10 m x 1.5kW	2	0.050	0.010	0.060	0.016	0.003	0.019	0.079
Scum Remover	Rotary drum type	2	0.660	0.132	0.792	0.244	0.049	0.293	1.085
Pipes		1 set	-	-	-	1.985	0.397	2.382	2.382
Transportation			-	-	-	0.049	0.010	0.059	0.059
Installation & Local Handling	Supervisor Common worker Plumber Equipment x 3% (16.032 x 0.03)		4.276 - 0.298 -	0.855 - 0.060 -	5.131 - 0.358 -	- 0.050 0.298 0.481	- 0.010 0.060 0.096	- 0.060 0.358 0.577	5.131 0.060 0.716 0.577
Sub-total						16.80		15.95 (5.55)	32.75
o Chlorination Tank									
Container Weighter		1	0.500	0.100	0.600	0.275	0.055	0.330	0.930
Chlorinator	Vertical type 35 kg/hr	2	0.980	0.196	1.176	0.542	0.108	0.650	1.826
Chlorine Solution Water Pump	Ø50 x 280 l/min x 30 m x 5.5kW	2	0.060	0.012	0.072	0.019	0.004	0.023	0.095
Neutralization Equipment	Vertical type obsorption tower	1	0.630	0.126	0.756	0.347	0.069	0.416	1.172
Caustic Soola Pump	Horizontal shaft chemical pump Ø80 x 500 l/min x 15 m x 3.7kW	1	0.100	0.020	0.120	0.032	0.006	0.038	0.158

Unit: Million Baht at 2524 (1981) Price Level

Name of Equipment	Description	Number	Foreign Currency: Foreign (1)	Foreign Currency: Expenditure (1) x 20%	Foreign Currency: Sub-total	Local Currency: Local (2)	Local Currency: Expenditure (2) x 20%	Local Currency: Sub-total	Total
Transportation	103.6 ton		-	-	-	0.124	0.025	0.149	0.149
Installation & Local Handling	Supervisor		2.150	0.430	2.580	-	-	-	2.580
	Common worker		-	-	-	0.025	0.005	0.030	0.030
	Plumber		0.347	0.069	0.416	0.347	0.069	0.416	0.832
	Equipment x 3% (28.219 x 0.03)		-	-	-	0.847	0.169	1.016	1.016
Sub-total					27.35			11.42 (9.70)	38.77
o <u>Grit Chamber</u>									
Grit Collector	Bridge style crane with grab bucket	1	5.200	1.040	6.240	2.862	0.572	3.434	9.674
Flow Meter	Parshall Flume	1	-	-	-	0.056	0.011	0.067	0.067
Transportation	32 ton		-	-	-	0.038	0.008	0.046	0.046
Installation & Local Handling	Supervisor		0.904	0.181	1.085	-	-	-	1.085
	Common worker		-	-	-	0.011	0.002	0.013	0.013
	Equipment x 3% (8.156 x 0.03)		-	-	-	0.245	0.049	0.294	0.294
Sub-total						7.33		3.85 (3.43)	11.18
o <u>Aeration Tank</u>									
Wastewater Control Weir	Manual cast iron weir	4	0.600	0.120	0.720	0.256	0.051	0.307	1.027
Return Sludge Control Weir	"	4	0.320	0.064	0.384	0.136	0.027	0.163	0.547
Aerator	Vertical shaft surface aerator	16	6.080	1.216	7.296	3.360	0.672	4.032	11.328
Transportation			-	-	-	0.054	0.011	0.065	0.065
Installation & Local Handling	Supervisor		1.126	0.243	1.459	-	-	-	1.459
	Common worker		-	-	-	0.014	0.003	0.017	0.017
	Equipment x 3% (10.752 x 0.03)		-	-	-	0.322	0.064	0.386	0.386
Sub-total					9.86			4.97 (4.50)	14.83

(to be continued)

Unit: Million Baht at 2524
(1981) Price Level

Name of Equipment	Description	Number	Foreign Currency			Local Currency			Total
			Foreign (1)	Expenditure (1) x 20%	Sub-total	Local (2)	Expenditure (2) x 20%	Sub-total	
Blower	Turbo fan (belt drive) 40 m^3/min x 200 mm Aq x 5.5kW	1	0.090	0.018	0.108	0.039	0.008	0.047	0.155
Hoist	Motor driven hoist 2 ton x 4.1kW	1	0.070	0.014	0.084	0.039	0.008	0.047	0.131
Chlorination Tank Inlet and Bypass Gate	Square type manual cast iron gate 1,500 mm	2	0.780	0.156	0.936	0.334	0.067	0.401	1.337
Pipes		1 set	-	-	-	0.484	0.097	0.581	0.581
Transportation			-	-	-	0.007	0.001	0.008	0.008
Installation & Local Handling	Supervisor		0.164	0.033	0.197	-	-	-	0.197
	Common worker		-	-	-	0.002	0.000	0.002	0.002
	Plumber		0.073	0.015	0.088	0.073	0.015	0.088	0.176
	Equipment x 3% (5.321 x 0.03)		-	-	-	0.160	0.032	0.192	0.192
Sub-total						4.14		2.82 (1.95)	6.96
Thickening Tank									
Sludge Collector	Circular type thickener Ø17.70 m x 3.00 m x 1.5kW	2	1.420	0.284	1.704	0.782 0.792	0.156 0.158	0.938 0.950	3.592
Sludge Extraction Valve	Motor driven sluice valve Ø200 x 0.2kW	2	0.156	0.031	0.187	0.166	0.013	0.079	0.266
Concentrated Sludge Pump	Horizontal shaft non clog type Ø100 x 1 m^3/min x 10 m x 5.5kW	2	0.190	0.038	0.228	0.060	0.012	0.072	0.300
Pit Drain Pump	Submerged sewage pump Ø50 x 0.3 m^3/min x 10 m x 1.5kW	1	0.025	0.005	0.030	0.008	0.002	0.010	0.040
Pipes		1 set	-	-	-	0.350	0.070	0.420	0.420
Transportation			-	-	-	0.008	0.002	0.010	0.010
Installation & Local Handling	Supervisor		0.838	0.168	1.006	-	-	-	1.006
	Common worker		-	-	-	0.010	0.002	0.012	0.012
	Equipment x 3% (3.849 x 0.03)		-	-	-	0.115	0.023	0.138	0.138
Sub-total						3.16		2.63 (1.10)	5.79

(to be continued)

Unit: Million Baht at 2524
(1981) Price Level

Name of Equipment	Description	Number	Foreign Currency			Local Currency			Total
			Foreign (1)	Expenditure (1) x 20%	Sub-total	Local (2)	Expenditure (2) x 20%	Sub-total	
o Digestion Tank									
Center Dome Cover	Safety valve Ø200	2	-	-	-	0.074	0.015	0.089	0.089
Mixing Equipment	Ø22.0 m x $^{H}10.8$ m	1	0.600	0.120	0.720	0.330	0.066	0.396	1.116
Gas Mixing Blower	Rotary blower Ø80 x 4.4 m^3/min x 1.5 kg/cm^2 x 7.5kW	2	0.170	0.134	0.204	0.074	0.015	0.089	0.293
Appurtenances	Cyclone separator segment trap oil filter	2	0.200	0.040	0.240	0.110	0.022	0.132	0.372
Digested Sludge Extraction Valve	Air driven sluice valve Ø200	1	0.078	0.016	0.094	0.033	0.007	0.040	0.134
Air Compressor	Oil free compressor with pressure switch 300 l/min x 7 kg/cm^2 x 2.2kW	2	0.060	0.012	0.072	0.026	0.005	0.031	0.103
Pit Drain Pump	Submerged sewage pump Ø50 x 0.3 m^3/min x 10 m x 1.5kW	1	0.025	0.005	0.030	0.008	0.002	0.010	0.040
Sludge Circulation Pump	Horizontal shaft non clog type Ø150 x 2 m^3/min x 5 m x 7.5kW	1	0.140	0.028	0.168	0.044	0.009	0.053	0.221
Digested Sludge Pump	Horizontal shaft non clog type Ø100 x 1 m^3/min x 5 m x 3.7kW	2	0.190	0.038	0.028	0.060	0.012	0.072	0.300
Water Gas Burner		1	0.650	0.130	0.780	0.358	0.072	0.430	1.120
Pipe		1 set	-	-	-	1.610	0.322	1.932	1.932
Transportation			-	-	-	0.012	0.002	0.014	0.014
Installation & Local Handling	Supervisor		0.328	0.066	0.394	-	-	-	-
	Common worker		-	-	-	0.004	0.001	0.005	0.005
	Plumber		0.242	0.048	0.290	0.242	0.048	0.290	0.580
	Equipment x 3% (4.84 x 0.03)		-	-	-	0.145	0.029	0.174	0.174
Sub-total						3.22		3.76 (1.25)	6.98

(to be continued)

Unit: Million Baht at 2524 (1981) Price Level

Name of Equipment	Description	Number	Foreign Currency			Local Currency			Total
			Foreign (1)	Expenditure (1) x 20%	Sub-total	Local (2)	Expenditure (2) x 20%	Sub-total	
o <u>Gas Holder</u>									
Gas Holder	Dry sheel type gas tank 5,000 m^3		10.900	2.180	13.080	3.599	0.720	4.319	17.399
Sub-total					13.08			4.32 (4.32)	17.40
o <u>Drying Bed</u>									
Pipes			-	-	-	0.500	0.100	0.600	0.600
Installation			-	-	-	0.150	0.030	0.180	0.180
Sub-total								0.78 (-)	0.78

Table I.6 Electric Works for Treatment Plant

Unit: Million Baht at 2524, (1981) Price Level

Name of Equipment	Description	Number or Unit	Foreign Currency: Foreign (1)	Foreign Currency: Expenditure (1) x 20%	Foreign Currency: Sub-total	Local Currency: Local (2)	Local Currency: Expenditure (2) x 20%	Local Currency: Sub-total	Total
<u>Central Supervisory Control System</u>									
Control Panel		12 m	2.376	0.475	2.851	1.293	0.259	1.552	4.403
Control Peek		6 m	0.652	0.130	0.782	0.355	0.071	0.426	1.208
Cable			-	-	-	0.519	0.104	0.623	0.623
Transportation			-	-	-	0.061	0.012	0.073	0.073
Installation & Local Handling	Supervisor		0.228	0.046	0.274	-	-	-	0.274
	Common worker		-	-	-	0.006	0.001	0.007	0.007
Sub-total					3.91			2.68 (1.98)	6.59
<u>Pumping Building</u>									
High Incoming Panel		2	0.440	0.088	0.528	0.239	0.048	0.287	0.815
High Sewage Pump Panel		4	2.000	0.400	2.400	1.088	0.218	1.306	3.706
No. 1 Control Center		1	0.750	0.150	0.900	0.403	0.082	0.490	1.390
No. 1 Assistance Relay Panel		1	0.440	0.088	0.528	0.239	0.048	0.287	0.815
Cable		1	-	-	-	0.209	0.042	0.251	0.251
Instrumentation System	Water level meter	1	0.096	0.019	0.115	0.045	0.009	0.054	
			-	-	-	0.013	0.003	0.016	0.185
Transportation			-	-	-	0.073	0.015	0.088	0.088
Installation & Local Handling	Supervisor		0.017	0.003	0.020	-	-	-	0.001
	Common worker		-	-	-	0.001	0.000	0.001	0.001
Sub-total					4.49			2.78 (2.42)	7.27
<u>Aeration Tank</u>									
No. 4 Control Center		1	1.750	0.350	2.100	0.952	0.190	1.142	3.242
No. 4 Assistance Relay Panel		1	1.320	0.264	1.584	0.718	0.144	0.862	2.446
Local Control Center	1-A type	5	0.175	0.035	0.210	0.095	0.019	0.114	0.324
"	1-B type	3	0.156	0.031	0.187	0.085	0.017	0.102	0.289
"	1-C type	4	0.320	0.064	0.384	0.174	0.035	0.209	0.593
Cable			-	-	-	0.174	0.035	0.209	0.209
Instrumentation system	Parshall flume	1	0.092	0.018	0.110	0.043	0.009	0.052	0.162
			-	-	-	0.004	0.001	0.005	0.005
Transportation			-	-	-	0.061	0.012	0.073	0.073

(to be continued)

Unit: Million Baht at 2524 (1981) Local Currency

Name of Equipment	Description	Number or Unit	Foreign Currency			Local Currency			Total
			Foreign (1)	Expenditure (1) x 20%	Sub-total	Local (2)	Expenditure (2) x 20%	Sub-total	
Installation & Local Handling	Supervisor		0.032	0.006	0.038	-	-	-	0.038
	Common worker		-	-	-	0.001	0.000	0.001	0.001
Sub-total					4.61			2.77 (2.48)	7.38
Final Sedimentation Tank									
No. 5 Control Center		1	1.750	0.350	2.100	0.952	0.190	1.142	3.242
No. 5 Assistance Relay Panel		1	1.320	0.264	1.584	0.718	0.144	0.862	2.446
Local Control Center	1-A type	5	0.175	0.035	0.210	0.095	0.019	0.114	0.324
"	1-B type	3	0.156	0.031	0.187	0.085	0.017	0.102	0.289
"	1-C type	4	0.320	0.064	0.384	0.174	0.035	0.209	0.593
Cable			-	-	-	0.132	0.026	0.158	0.158
Instrumentation System	Return sludge: Ø400	2	0.971	0.194	1.165	0.457	0.091	0.548	1.713
"	Excess sludge: Ø200	2	0.413	0.083	0.496	0.195	0.039	0.234	0.730
"	Sludge draw out: Ø250	8	2.116	0.423	2.539	0.996	0.199	1.195	3.734
"	Recorder	2	0.080	0.016	0.096	0.338	0.068	0.406	0.502
"	Cable	1	-	-	-	1.721	0.344	2.065	2.065
Transportation			-	-	-	0.081	0.016	0.097	0.097
Installation & Local Handling	Supervisor		0.034	0.007	0.041	-	-	-	0.041
	Common worker		-	-	-	0.001	0.000	0.001	0.001
Sub-total					8.80			7.13 (4.81)	15.93
Chlorination Tank									
No. 6 Control Center		1	0.750	0.150	0.900	0.408	0.082	0.490	1.390
No. 6 Assistance Relay Panel		1	0.440	0.088	0.528	0.239	0.048	0.287	0.815
Cable			-	-	-	0.064	0.013	0.077	0.077
Instrumentation System		1	0.347	0.069	0.416	0.163	0.033	0.916	0.612
"	Cable		-	-	-	0.021	0.004	0.025	0.025
Transportation			-	-	-	0.029	0.006	0.035	0.035
Installation & Local Handling	Supervisor		0.015	0.003	0.018	-	-	-	0.018
	Common worker		-	-	-	0.001	0.000	0.001	0.001
Sub-total					1.86			1.11 (0.97)	2.97

(to be continued)

Unit: Million Baht at 2524 (1981) Price Level)

Name of Equipment	Description	Number or Unit	Foreign Currency: Foreign (1)	Foreign Currency: Expenditure (1) x 20%	Foreign Currency: Sub-total	Local Currency: Local (2)	Local Currency: Expenditure (2) x 20%	Local Currency: Sub-total	Total
Digestion Tank (Thickening Tank)									
No. 7 Control Center		1	1.000	0.200	1.200	0.544	0.109	0.653	1.853
No. 7 Assistance Relay Panel		1	0.880	0.176	1.056	0.479	0.096	0.575	1.631
Local Control Panel	1-A type	5	0.175	0.035	0.210	0.095	0.019	0.114	0.324
"	1-B type	3	0.156	0.031	0.187	0.085	0.017	0.102	0.289
"	1-C type	4	0.320	0.064	0.384	0.174	0.035	0.209	0.593
Cable			-	-	-	0.083	0.017	0.100	0.100
Transportation			-	-	-	0.078	0.016	0.094	0.094
Installation & Local Handling	Supervisor		0.024	0.005	0.029	-	-	-	0.029
	Common worker		-	-	-	0.001	0.000	0.001	0.001
Sub-total					3.07			1.85 (1.65)	4.92
Electric Room									
6kV Receiving Panel	PTx2, LAx3, 7.2kV VCB 800A 25A	2	1.200	0.240	1.440	0.652	0.130	0.782	2.222
Bus Tying Panel	3P DSx1 7.2kV 600A with S	1	0.280	0.056	0.336	0.152	0.030	0.182	0.518
Primary Panel For Main Transformer & Primary Panel For Lighting Transformer	7.2kV VCBx2 800A 25kA	1	0.660	0.132	0.792	0.359	0.072	0.431	1.223
Primary Panel For Main Transformer Static Condenser	7.2kV VCBx2 800A 25kA	2	1.320	0.264	1.584	0.718	0.144	0.862	2.446
Primary Panel For High Main, No. 2 Grounded Type Instrument Transformer	G.PTx1, 7.2kV VCBx1 800A 25kA	1	0.660	0.132	0.792	0.359	0.072	0.431	1.223
Static Condenser Panel	DS-3Px1 SC200kVAx1	4	2.000	0.400	2.400	1.088	0.218	1.306	3.706
Generator Tying Disconnecting Switch & No. 1 Grounded Type Instrument Transformer	DS-3Px1 G.PTx1	1	0.440	0.088	0.528	0.239	0.048	0.287	0.815
Main Transformer Panel	750kVA 3Ø 6.6kV/380V	2	1.660	0.332	1.992	0.902	0.180	1.082	3.074
Lighting Transformer Panel	250kVA 1Ø 6.6kV/220V	1	0.400	0.080	0.480	0.218	0.044	0.262	0.742

(to be continued)

Unit: Million Baht at 2524 (1981) Price Level

Name of Equipment	Description	Number or Unit	Foreign Currency: Foreign (1)	Foreign Currency: Expenditure (1) x 20%	Foreign Currency: Sub-total	Local Currency: Local (2)	Local Currency: Expenditure (2) x 20%	Local Currency: Sub-total	Total
Secondary Panel Main Transformer	MCB 600V 800AFx2	1	0.700	0.140	0.840	0.381	0.076	0.457	1.297
"	MCB 600V 2000AFx1	1	0.500	0.100	0.600	0.272	0.054	0.326	0.926
Low Tention Main Panel	600V MCBx8 225AF	2	1.000	0.200	1.200	0.544	0.108	0.652	1.852
Low Tention Lighting Panel	250V MCBx8 100AF	1	0.400	0.080	0.480	0.218	0.044	0.262	0.742
DC. Power Source Panel	AHH 100AH/1HR	1	1.610	0.322	1.932	0.876	0.175	1.051	2.983
Cable			-	-	-	0.083	0.017	0.100	0.100
Transportation			-	-	-	0.192	0.038	0.230	0.230
Installation & Local Handling			0.133	0.027	0.160	-	-	-	0.160
			-	-	-	0.006	0.001	0.007	0.007
Sub-total					15.56			8.71 (8.37)	24.27
<u>Power Receiving</u>									
Voltage Detector	12,000V	2	0.080	0.160	0.240	0.044	0.009	0.053	0.293
High Voltage Disconnecting Switch	12kV 600V TP-DS 3P	5	1.300	0.260	1.560	0.707	0.141	0.848	2.408
Air Blast Circuit Breaker	12.5kV 1,200A 31.5kV	2	1.400	0.280	1.680	0.761	0.152	0.913	2.593
Current Transformer	12.5kV 200/5A	6	0.300	0.060	0.360	0.195	0.039	0.234	0.594
Grounding Transformer	12.5kV/110V/ $\frac{110}{3}$ V	1	0.100	0.020	0.120	0.054	0.011	0.065	0.185
Load Disconnecting Switch	12,5kV 600A 3PL-DS	2	0.360	0.072	0.432	0.196	0.039	0.235	0.667
Transformer	3Ø 1,250kVA 12kV/6.6kV, 50HZ	2	1.800	0.360	2.160	0.980	0.916	1.176	3.336
Lighting Arrester	14kV 10kA LA	3	0.147	0.029	0.176	0.080	0.016	0.096	0.272
Disconnecting Switch	12.5kV 600A IP-DS	2	0.080	0.016	0.096	0.044	0.009	0.053	0.149
Cable & Others						1.650	0.330	1.980	1.980
Transportation			-	-	-	0.111	0.022	0.133	0.133

(to be continued)

Unit: Million Baht at 2524 (1981) Price Level

Name of Equipment	Description	Number or Unit	Foreign Currency			Local Currency			Total
			Foreign (1)	Expenditure (1) x 20%	Sub-total	Local (2)	Expenditure (2) x 20%	Sub-total	
Installation & Local Handling	Supervisor		0.780	0.156	0.936	-	-	-	0.936
	Common worker		-	-	-	0.086	0.017	0.103	0.103
Sub-total					7.76			5.89 (3.67)	13.65
<u>Land Scaping</u>									
Illumination	200W sodium-vapor lamp					0.933	1.120	1.120	

APPENDIX J

STAFFING AND ORGANIZATION FOR OPERATION AND MAINTENANCE

Staffing and organization required for operation and maintenance of the present project, except for that required for the headquarters of the sewerage agency are planned as detailed in the following. From the difference in nature of work between the sewers and the treatment plant, staffing and organization are considered separately for the two sections, and further it is assumed that the operation and maintenance of the new sewerage system will be performed under the proposed Sewerage Control Division.

(1) Staffing and Organization for Sewer Maintenance

The scope of work of this section covers operation and maintenance of the existing sewers, proposed interceptor, gates, and intermediate pumping stations in the present project area.

In planning the staffing for the sewers, special consideration is given to the fact that the existing sewers are to be used as combined sewers. Due to the above, the sewers of the present project may possibly require more frequent cleansing because of grit and others settling. Therefore, frequency of cleansing is assumed as once a year. From the total length of sewers, 100 km, two crews consisting of 12 persons will be required.

The recommended organization and staffing, including above crews, are shown in the following Table J.1.

Table J.1 Staffing and Organization for Sewer Maintenance Section

Function	Required Personnel	Total Staff
Section Chief	1 Engineer	1
Sewer Cleansing, Sewer Inspection	1 Field Engineer (Assistant Engineer)	
	2 Cleansing Foremen	
	2 Secutity Guards	
	8 Laborers	13
Inspection & Maintenance for Pumping Station & Gates	1 Inspector	
	1 Labor	2
Total		16

(2) Staffing and Organization for Treatment Plant

Basically, the staff for the treatment plant is planned to be organized into four subsections as shown in Fig. J.1. The required number of staff for all the subsections are estimated in Table J.2.

The estimation of staff number is made on the assumption that working day is 5 days a week, and all the subsection teams are on duty only in the day time. Therefore, the required number of staff is computed as 1.4 (= 7 ÷ 5) x the number of team members.

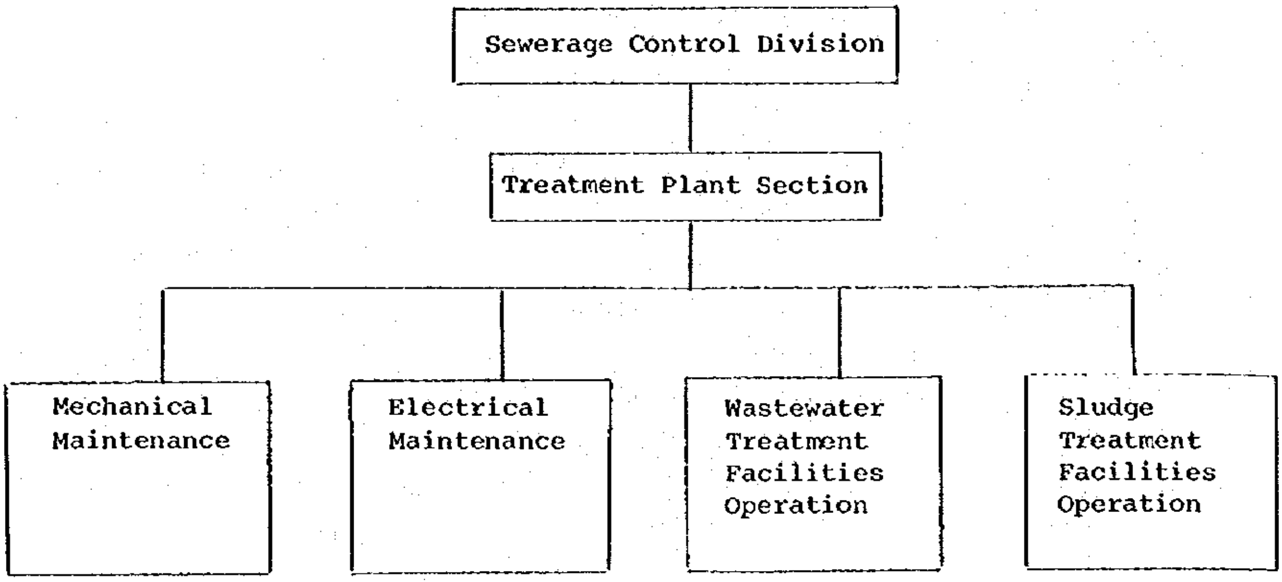


Figure J.1 Organization for Treatment Plant Section

Table J.2 Estimation of Required Number of Staff

Name of Sub-Section	Initial Stage		Final Stage	
a. Electrical Maintenance	Members of 1 team: 1 technicians 2 laborers		2 technicians 2 laborers	
	Required number of staff o technician 1.4 team x 1 = 1.4	2 persons	1.4 x 2 = 2.8	3 persons
	o Labor 1.4 team x 2 = 2.8	3 persons	1.4 x 2 = 2.8	3 persons
b. Mechanical Maintenance	- ditto -		- ditto -	
c. Wastewater Treatment	Members of 1 team: 1 technician 2 laborers		3 technicians 3 laborers	
	Required number of staff o Technician 1.4 team x 1 = 1.4	2 persons	1.4 x 3 = 4.2	5 persons
	o Labor 1.4 team x 2 = 2.8	3 persons	1.4 x 3 = 4.2	5 persons.
d. Sludge Treatment	Members of 1 team: 1 technician 2 laborers		3 technicians 6 laborers	
	Required number of staff o Technician 1.4 team x 1 = 1.2	2 persons	1.4 x 3 = 4.2	5 persons
	o Labor 1.4 team x 2 = 2.8	3 persons	1.4 x 6 = 8.4	9 persons
Total	Manager 1(1) Section Chief 4(4) Technician 8(4) Labor 12(8)	25(17)	Manager 1(1) Section Chief 4(4) Technician 16(10) Labor 20(13)	41(28)

Note: Figure in ( ) are number of staff at daily work.

APPENDIX K

DATA FOR PRICE ESCALATION

The costs for the first stage construction have been estimated at available price data in 1981. Such costs are, assumed, however, to be increased at the implementation stage in accordance with future price escalation which will affect the procurement of materials and labor costs. In order to estimate the realistic costs for the financing purposes the trend of price escalation in the past has been surveyed based on the following data.

A. Foreign Currency Portion (materials to be imported)

1. Wholesale Price Indexes, 1981 by Research and Statics Dept., The Bank of Japan

a. All Commodities

1975 — 1978	1978 — 1979	1979 — 1980	1980 — 1981
Annual Average 1.4%	7.3%	17.8%	1.7%

b. Iron & Steel

1975 — 1978	1978 — 1979	1979 — 1980	1980 — 1981
Annual Average 4.3%	5.2%	9.2%	0.5%

c. Machinery & Equipment

1975 — 1978	1978 — 1979	1979 — 1980	1980 — 1981
Annual Average -0.03%	1.0%	3.3%	1.6%

B. Local Currency Portion

1. Wholesale Price Index, Bangkok Bank, 1981

1976–1977	1977–1978	1978–1979	1979–1980	1980–1981
7,8%	7,4%	11.2%	20,1%	9.3%

* Personal view of treasury officer of Bangkok Bank for future estimation of price escalation is 5 - 7% per annum.

2. Major Indicators of the Economy, 1970 - 1978

1970–1971	1971–1972	1972–1973	1973–1974	1974–1975	1975–1976	1976–1977	1977–1978
0.4%	4,8%	15,6%	24.3%	5.4%	4.2%	7.2%	8.4%

3. Statistical Handbook of Thailand, 1977

a. Wholesale Price Index

1975–1976	1976–1977
4%	5%

b. Construction Materials

1975–1976	1976–1977
14%	5%

APPENDIX L

EXISTING SANITARY CONTROL REGULATIONS

The followings are existing regulations more or less related to sanitary control.

(1) Public Health Act B.E. 2484 (1941)
(2) Act for the cleanliness and Orderlines of the Country B.E. 2503 (1960)
(3) Building Control Act B.E. 2522 (1979) and its By-Law
(4) Bangkok Metropolitan Administration Act B.E. 2518 (1975)
(5) City Planning Act B.E. 2518 (1975)
(6) National Environmental Quality Act (No. 2) B.E. 2521 (1978)
(7) Notification of the Ministry of Industry issued under the Factories Act B.E. 2512 (1969)
(8) By-Law of Bangkok Metropolis on Control of Trade which is objectionable or may be dangerous to Health B.E. 2519 (1976)
(9) Other Regulations

(1) Public Health Act B.E. 2484 (1941)

This Act appears comprehensive in its wide coverage of sanitary control for the area where no sewerage services are available. This Act regulates the disposal of rubbish, filth and drift and authorizes the local authority to issue by-law or rules which stipulates the method and procedure of such disposal. The other items to be controlled by local authority are commercial undertakings to be objectionable or injurious to health and unsanitary dwelling place, latrines, night soil receptacles, urinals, nuisance including places and facilities, watercourse and drain in such a state to be hazardous to health. This Act has penal clause but the amount of fine is minimal not exceeding 50 - 100 Baht.

(2) Act for the Cleanliness and Orderliness of the Country B.E. 2503 (1960)

This Act is established to regulate and control mainly the public offence including disturbance and anti-aesthetic activities. Such forbidden activities include passing fecal matter as urine on the road or any place of public places visible from the road or public or disposing into the river or canal with the local authority's poster forbidding such acts, and the owners of food or refreshment shops, are required to provide lavatories for persons' willing to pay.

(3) Building Control Act B.E. 2522 (1979) and its Municipal By-Law, B.E. 2522 (1979)

The above Building Control Act and its Municipal By-Law are renewed version of respective old Control of the Construction of Buildings Act B.E. 2479 (1936) and Municipal Regulation on Building Control B.E. 2483 (1940). The Act stipulates mainly control on the building construction as licensing, construction modification, tearing down and removal of buildings including a provision to empower local authority to issue By-Laws to control, among others, design and number of bathrooms and toilets. The Municipal By-Law, namely, the BMA's Regulation of Building Control, B.E. 2522 (1979) issued on the above Act includes following provisions in its Section 8, Sanitation.

No. 84 Buildings in construction shall have the systems of storm water, wastewater drainage, which are adequate.

No. 85 The slope of drain pipe from Buildings to public drain in drainage be set in gradient of 1:200 and try to keep it. In case of circular pipe the manhole have to be built at every interval of not more than 12.00 m, at every change of and at every point of interconnection between a private property to the public drain.

No. 86 The waste drain in buildings must be at least 10 cm wide before it reaches a public drain. There must be an opening for inspection where a refuse screen must be installed. These shall allow convenient inspection and the building owners have to take care about that.

No. 87 The Industry, Hospital, Fresh Goods Market, Restaurant, Building Complex, Dormitory and Commercial Buildings have to build a disposal system for the wastewater, before discharge to the public drain.

No. 88 The Building which people may live in/or otherwise utilize must be equipped with adequate sanitary facilities, and these must at least include the followings:

Type of Building	Latrine for Excrement	Urinal	Wash-basin
Each Unit of Residential Building	1	-	-
Each Unit of Building Complex	1	-	1
Row House and attached Commercial Buildings (which is not taller than 3 stories in any section)	1	-	1
Attached Commercial Buildings (which is not taller than 3 stories in any section)	2	1	1
Hotel/room	1	-	1
Dormitory/50 m^2	1	-	1
Office Building, School, Hospital & Commercial Buildings/75 m^2	1	1	1
Assembly Hall and Theatre/250 m^2	1	1	1
Industrial Factory/400 m^2	1	1	1

The excess of specified areal sizes shall be taken as a full size.

No. 89 The inner area of a toilet room shall not be smaller than 0.9 m^2, width 0.9 m. In case bathing is included the area shall not be smaller than 1.50 m^2. The configuration shall allow ease of cleansing and ventilation shall be provided by an opening of at least in an area not less than 10 percent of the floor area or otherwise a force ventilation shall be provided.

No. 90 The latrine for excrement shall be the type which allows cleansing with water and discharge into a septic tank-seepage pit. A latrine which is built within a distance of 20.00 m from public canal and water courses must be made into a water tight tank.

No. 91 A complex building for residential purpose or large buildings which are neither a row house nor an attached commercial building which occupies area more than 2,000 m^2, or a hotel shall have an area for garbage disposal without causing any nuisance to the nearby building.

Note: Manhole is the opening where the inspection of the flowing condition of water in the drain may be made possible.

(4) Bangkok Metropolitan Administration Act B.E. 2518 (1975)

This Act empowers BMA to execute the following duties, among others, related to the proposed sewerage project.

1. Control on sanitary in public places and entertainment places
2. Activities to enhance public health, family sanitation and medical care
3. Development and improvement of public utilities facilities
4. Maintenance of cleanliness and order of the metropolitan area
5. Construction and maintenance of streets, water ways, and drainage

The financial procedures for BMA are stipulated for the following items such as (a) Tax, license fee or service fee

(b) Revenue and expenditure

(c) Borrowing money and payment of loan

(d) Commercial activities of BMA

(e) Issuance of Bonds

In each case a draft by-law shall be proposed by the council of BMA to be enforced subject to approval of the Governor of BMA. BMA is empowered by its Section 68 of the Act, among others, render services to private individuals, state agencies or other official units by receiving fees. Section 81 specifies the authorized revenue of BMA which include income from public utility fee, license fee, fines, service fee, loans and subsidy through the central government, assistance from foreign and international agency with the consent of the Cabinet, taxes and other duty fees. This Act authorizes the central government to supervise the administration and financial operation of BMA.

(5) City Planning Act B.E. 2518 '(1975)

This Act specifies the formation of City Planning Committee for Bangkok Metropolis and empowers the Committee to play instrumental role to proceed the comprehensive city planning and other utilities project planning by virtue of the Ministerial Regulation issued by the Minister of Interior. The land and other immovable property are expropriated under the law on expropriation of immovable property.

(6) National Environmental Quality Act (No. 2) B.E. 2521 (1978)

This is a revision of old Act enacted in B.E. 2518 (1975) with broad objective to conserve and improve the environmental and sanitary condition in whole Thailand by establishing the "National Environment Board" as an advisory board for any development plan, project, standard including recommendation and amendment of laws related to the environmental quality. The office of the National Environment Board entrusted by National Environment Board has the duty to carry out the study, research of the environmental conditions and quality to be used for the standard or the guidelines for the enhancement of the national environmental quality.

The Prime Minister may, under this Act, require submission of categories and magnitude of Projects of the government agencies and other private organization to prepare the study report for prevention of and remedy for the adverse effects on the environmental quality during preparation stage of the project to National Environment Board and such report shall be approved prior to further proceedings. The Prime Minister also has a power to issue an order prohibiting the person from causing such danger or damage which will intensify environmental pollution. This Act has also the penal provision for the persons who violates or fails to comply with order of the Prime Minister and other law, rule or regulation concerning the control of environmental quality.

(7) Notification of the Ministry of Industry issued under the Factories Act B.E. 2512 (1969)

Under the Factories Act, the person obtaining a license to operate the factory are legally required to make an arrangement for the removal of wastewater such as pretreatment system for the offensive wastewater and shall be punished with fine not exceeding 2,000 Baht in case they failed to comply with above requirement. Above Notification is issued by virtue of above regulation to notify the details of required arrangement for wastewater disposal specifying allowable chemical component. Among the regulated contents of the wastewater to be discharged to public waterways, BOD value is limited to 20 milligrams per litre depending, however, on geographic condition and judgement of officials concerned, providing maximum loading is 60 milligrams per litre.

(8) By-Law of Bangkok Metropolis on Control of Trade which is objectionable or may be dangerous to Health B.E. 2519 (1976)

This By-Law is issued basically in conformance with Public Health Act B.E. 2484 (1941), Sections 7 - 9 which generally stipulates about licensing the commercial undertakings subject to public health control. This By-Law regulates the sanitary systems required including dishcarge of all kinds of trade and factories, installment of drains for wastewater drainage, toilet, refuse receptacles to prevent any annoyance in accordance with the advice of the Public Health Officials.

(9) Other Regulations

There are other regulations which are concerned for the activities of pollution control and waste disposals such as Royal Decree on BMA organization B.E. 2520 (1977) in which Department of Drainage and Sewerage is authorized to plan and control the disposal of wastewater and Department of Sanitation is authorized to control activities related to disposal of rubbish and faecal waste disposal, and Department of Public Works is authorized to design and construct the buildings under the Building Control Act. The Declaration of the Revolution Party on the Distributing Sale of Land No. 286 B.E. 2520 (1977) which regulates the persons who organize the sale of land to provide facility of discharging both of the storm water and sewage from the land.