Table II.25 Cost Estimate for Power Generating Equipment by Generated Gas

Engine Output ; 650 PS
Generator Output ; 440 kW
Digestor ; 4,000 m^3 x 2 tanks

No.	Work Item	Capacity	Unit Cost US$	Amount US$
1.	Construction Cost			
	Civil and Architecture	L.S.		300,000
	Turbine and Generator	440 kW	3,750	1,650,000
	Sub-total			1,950,000
2.	Annual Operation and Maintenance Cost			
	Maintenance	L.S.		42,000
	Personnel	L.S.		10,500
	Sub-total			52,500

For Reference;

Power Unit Cost (US$/kWh)

1) Depreciation Cost
1,950,000 ÷ 440 kW ÷ (20 years x 320 days/year x 20 hours/day) = 0.0346 US$/kWh

2) Operation and Maintenance Cost
52,500 ÷ 440 kW ÷ (320 days/year x 20 hours/day) = 0.0186 US$/kWh

3) Power Unit Cost
1) + 2) = 0.0532 US$/kWh
0.0532 US$/kWh = 1.92 Baht/kWh < 2.25 Baht/kWh = 3.00 x 0.75

Table H.26 Annual Operation and Meintenance Cost for Integrated Anearobic Digesting and Composting Plants

No.	Dry Solid	Digesting		Generating		Odor Removal		Dewatering (by Belt Press)		Leachet		Sub-Total	Composting		Total
	Capacity	Cap.	Cost	Cap.	Cost	Cap.	Cost	Cap.	Cost	Cap.	Cost	Cost	Cap.	Cost	Cost
	t DS/d	m^3/d	US $	kW	US $	m^3/min	US $	t DS/d	US $	m^3/d	US $	US $	t DS/d	US $	US $
1	10.0	200	28.800	440	52.500	L.S	55.000	7.0	253.000	190	4.800	394.100	7.0	203.000	597.100
2	80.0	1.600	86.500	3.520	335.000	L.S	440.000	56.0	371.000	1.520	30.000	1.262.500	56.0	1.400.000	2.662.500
3	160.0	3.200	140.000	7.040	500.000	L.S	800.000	112.0	550.000	3.040	45.000	2.035.000	112.0	2.630.000	4.665.000

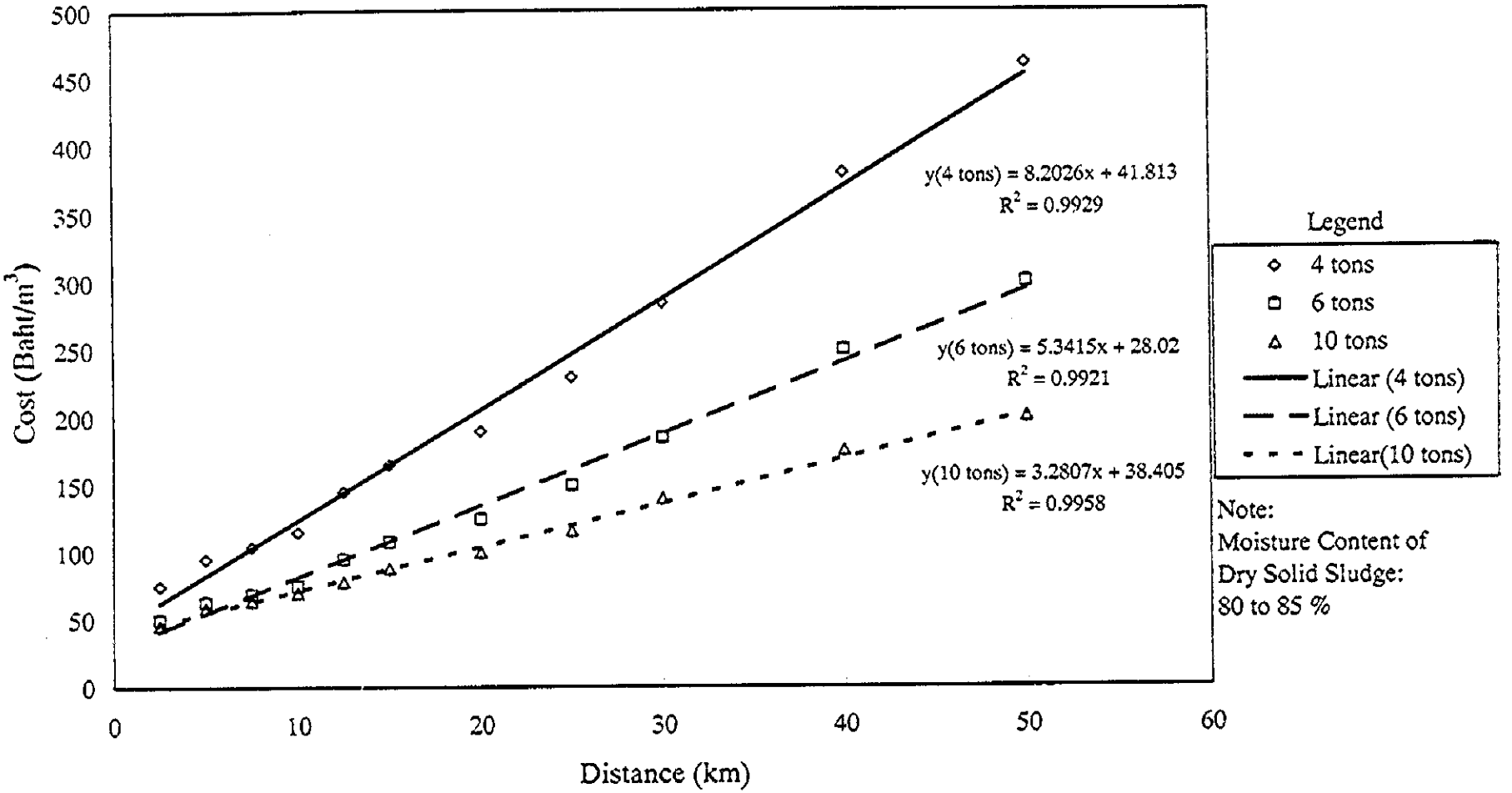


Figure H.1 TRANSPORTATION COST OF SOLID SLUDGE CAKE BY DUMP TRUCK

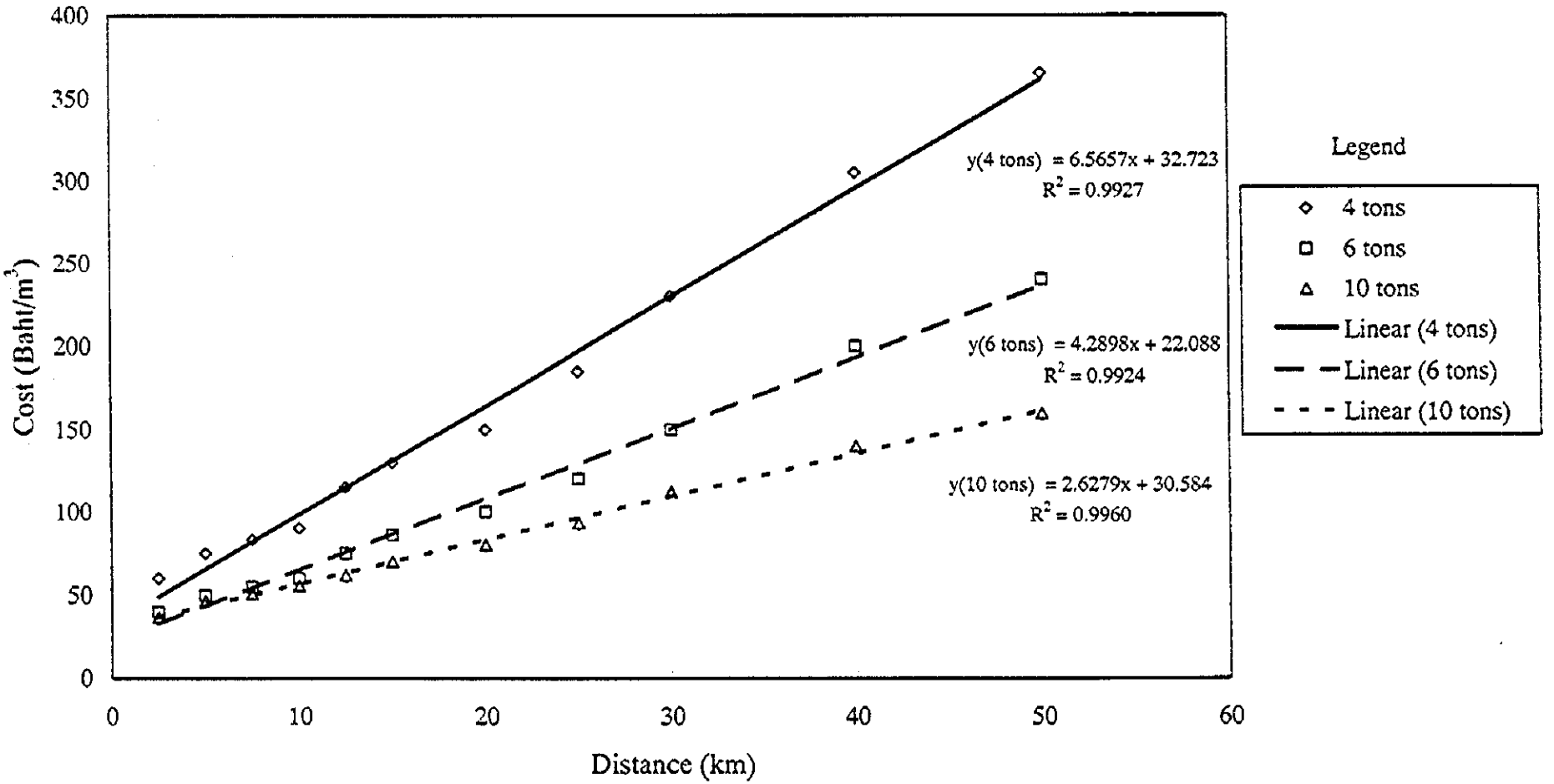


Figure H.2 TRANSPORTATION COST OF ASH AND COMPOST BY DUMP TRUCK

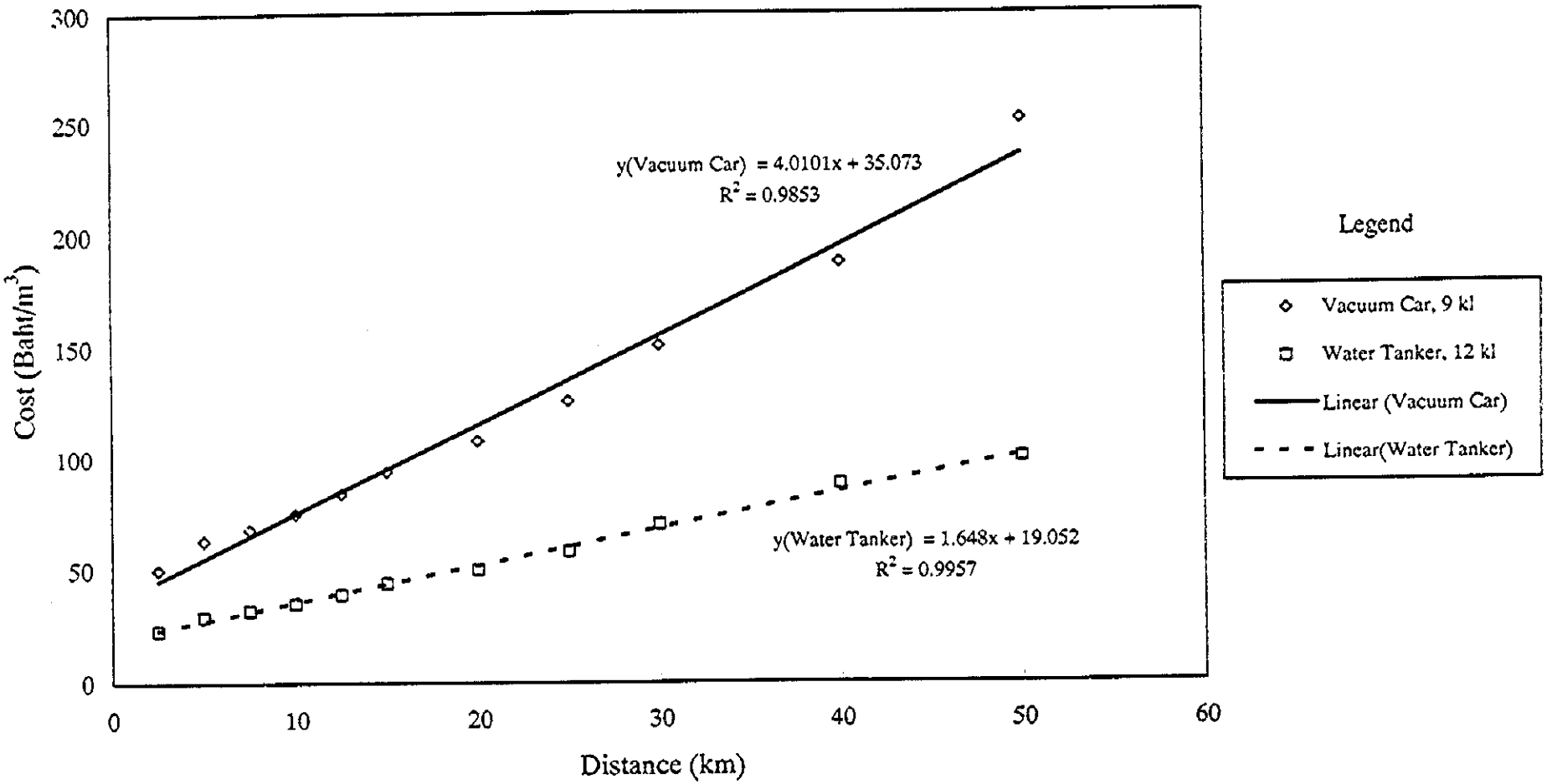


Figure H.3 TRANSPORTATION COST OF RECLAIMED WATER BY TANKER

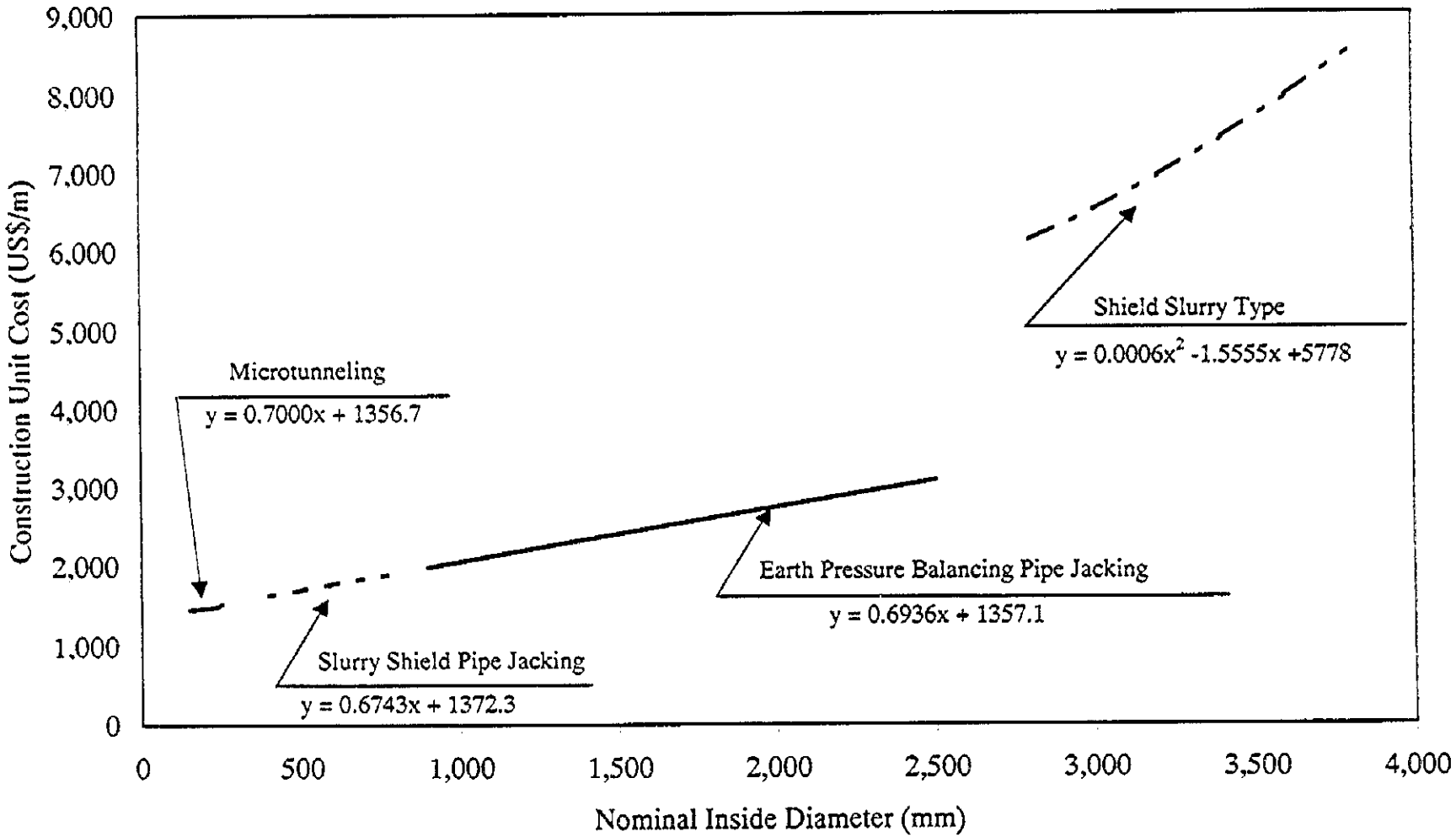
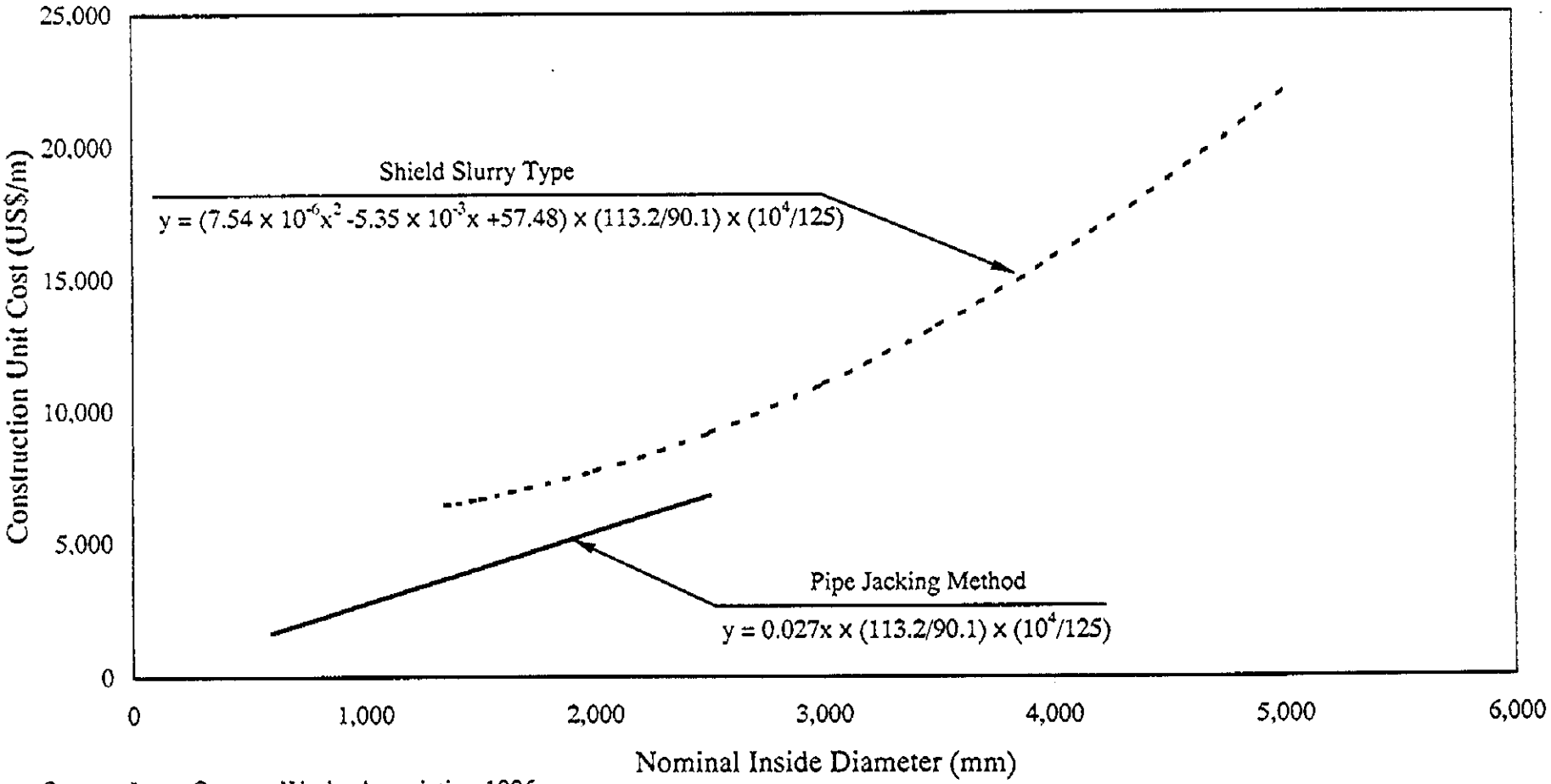


Figure H.4 CONSTRUCTION UNIT COST FOR COLLECTOR SYSTEM



Source: Japan Sewage Works Association 1996

Figure H.5 CONSTRUCTION UNIT COST FOR COLLECTING SYSTEM (JAPANESE)

I. HYDRAULIC DESIGN CALCULATIONS FOR MAIN INTERCEPTOR SEWERS FOR PROPOSED WASTEWATER SCHEMES

Table I.1 Preliminary Hydraulic Design of Interceptor Sewers for Thonburi South

DWF: 212,700 m^3/d
Peak Flow = 5 x DWF: 1,063,500 m^3/d
Area: 22.3 km^2
Peak Flow per km^2: 47,700 m^3/d = 0.55 m^3/s

Pipe ref.	Area (km^2)	Cumul. Area (km^2)	Required Sewer Capacity (m^3/s)	Sewer Selection			
				Dia (mm)	Length (km)	Vel. (m/s)	Grad (‰)
1	2.1	2.1	1.2	1,000	0.9	1.5	1.5
2	1.6	1.6	0.9	1,000	1.3	1.1	0.8
3	0.3	4.0	2.2	1,400	0.3	1.4	0.9
4	2.5	2.5	1.4	1,200	1.5	1.2	0.8
5	2.5	9.0	5.0	2,000	1.4	1.6	0.8
6	2.3	2.3	1.3	1,000	1.5	1.7	1.8
7	1.4	12.7	7.0	2,200	0.6	1.8	0.8
8	1.6	1.6	0.9	1,000	2.1	1.1	0.8
9	2.2	3.8	2.1	1,400	1.1	1.4	0.8
10	0.0	16.5	9.1	2,400	0.5	2.0	0.8
11	0.9	0.9	0.5	800	1.2	1.0	0.9
12	2.0	2.0	1.1	1,000	0.6	1.4	1.3
13	2.9	5.8	3.2	1,600	0.7	1.6	0.9

Design using Manning Formula with n = 0.01

Table I.2 Preliminary Hydraulic Design of Interceptor Sewers for Thonburi Central

DWF: 155,900 m^3/d

Peak Flow = 5 x DWF: 779,500 m^3/d

Area: 17.5 km^2

Peak Flow per km^2: 44,500 m^3/d = 0.52 m^3/s

Pipe ref.	Area (km^2)	Cumul. Area (km^2)	Required Sewer Capacity (m^3/s)	Sewer Selection			
				Dia (mm)	Length (km)	Vel. (m/s)	Grad (‰)
1	0.9	0.9	0.5	800	1.9	0.9	1.0
2	0.4	0.4	0.2	600	1.5	0.7	1.0
3	0.5	0.5	0.3	600	1.4	0.9	1.5
4	2.7	4.5	2.3	1,400	2.6	1.5	0.9
5	2.8	2.8	1.5	1,200	2.8	1.3	0.9
6	2.2	9.5	5.0	2,000	2.0	1.6	0.7
7	2.3	2.3	1.2	1,000	3.1	1.5	1.5
8	2.9	14.7	7.7	2,200	1.8	2.0	0.9
9	1.7	1.7	0.9	800	2.9	1.8	2.8
10	1.1	17.5	9.1	2,400	2.9	2.0	0.8

Design using Manning Formula with n = 0.01

Table I.3 Preliminary Hydraulic Design of Interceptor Sewers for Thonburi North

DWF: 77,900 m^3/d
Peak Flow = 5 x DWF: 390,000 m^3/d
Area: 11.4 km^2
Peak Flow per km^2: 34,000 m^3/d = 0.40 m^3/s

Pipe ref.	Area (km^2)	Cumul. Area (km^2)	Required Sewer Capacity (m^3/s)	Sewer Selection			
				Dia (mm)	Length (km)	Vel. (m/s)	Grad (‰)
1	2.1	2.1	0.8	1,000	2.2	1.1	0.8
2	1.9	4.0	1.6	1,400	1.5	1.6	1.0
3	1.8	1.8	0.7	800	2.6	1.7	1.7
4	0.4	0.4	0.2	500	0.9	1	1.7
5	1.5	7.7	3.0	1,600	1.9	1.5	0.8
6	0.9	0.9	0.4	800	1.4	1.7	2.5
7	1.1	1.1	0.4	800	1.0	1.7	2.5
8	0.7	10.4	4.1	2,000	1.2	1.4	0.5
9	1.0	1.0	0.4	800	1.2	1.7	2.5

Design using Manning Formula with n = 0.01

Table I.4 Preliminary Hydraulic Design of Interceptor Sewers for Khlong Toey West

DWF: 165,000 m^3/d

Peak Flow = 5 x DWF: 825,000 m^3/d

Area: 25.7 km^2

Peak Flow per km^2: 32,100 m^3/d = 0.37 m^3/s

Pipe ref.	Area (km^2)	Cumul. Area (km^2)	Required Sewer Capacity (m^3/s)	Sewer Selection			
				Dia (mm)	Length (km)	Vel. (m/s)	Grad (‰)
1	1.7	1.7	0.6	800	1.6	1.2	1.3
2	1.6	1.6	0.6	800	1.6	1.2	1.3
3	2.1	5.4	2.0	1,400	2.7	1.3	0.9
4	3.7	3.7	1.4	1,000	2.6	2.2	2.0
5	2.5	11.6	4.3	1,800	2.2	1.7	0.8
6	3.8	3.8	1.4	1,000	2.7	2.2	2.0
7	2.9	6.7	2.5	1,400	2.0	1.7	1.1
8	0.5	0.5	0.2	600	0.8	1.8	4.0
9	0.5	19.3	7.2	2,200	1.6	1.9	0.8
10	1.1	1.1	0.4	600	1.8	1.4	2.5
11	1.1	1.1	0.4	600	0.9	1.4	2.5
12	4.2	6.4	2.4	1,400	3.0	1.6	1.0
13	0.0	25.7	9.6	2,600	0.9	1.8	0.6

Design using Manning Formula with n = 0.01

Table I.5 Preliminary Hydraulic Design of Interceptor Sewers for Khlong Toey East

DWF: 154,900 m^3/d

Peak Flow = 5 x DWF: 774,500 m^3/d

Area: 31.9 km^2

Peak Flow per km^2: 24,300 m^3/d = 0.28 m^3/s

Pipe ref.	Area (km^2)	Cumul. Area (km^2)	Required Sewer Capacity (m^3/s)	Sewer Selection			
				Dia (mm)	Length (km)	Vel. (m/s)	Grad (‰)
1	2.2	2.2	0.6	800	1.9	1.2	1.3
2	2.3	2.3	0.6	800	1.8	1.2	1.3
3	0.6	5.1	1.4	1,200	1.3	1.2	0.6
4	1.1	1.1	0.3	600	1.9	1.1	1.5
5	2.1	8.3	2.3	1,400	3.1	1.5	0.9
6	3.6	3.6	1.0	1,000	2.1	1.3	1.0
7	2.0	13.9	3.9	1,800	1.8	1.5	0.9
8	3.6	3.6	1.0	1,000	2.9	1.3	1.0
9	0.5	18.0	5.1	2,000	1.4	1.6	0.6
10	2.8	2.8	0.8	800	2.2	1.6	2.1
11	3.8	3.8	1.1	1,000	3.4	1.4	1.3
12	1.9	5.7	1.6	1,200	2.0	1.4	1.0
13	0.3	24.0	6.7	2,200	1.1	1.8	0.7
14	3.5	3.5	1.0	1,000	2.3	1.3	1.0
15	1.6	1.6	0.5	600	1.8	1.8	4.0
16	0.0	5.1	1.4	1,200	1.0	1.2	0.8

Design using Manning Formula with n = 0.01

Table I.6 Preliminary Hydraulic Design of Interceptor Sewers for Bang Sue

DWF: 126,100 m^3/d
Peak Flow = 5 x DWF: 631,000 m^3/d
Area: 19.7 km^2
Peak Flow per km^2: 32,000 m^3/d = 0.37 m^3/s

Pipe ref.	Area (km^2)	Cumul. Area (km^2)	Required Sewer Capacity (m^3/s)	Sewer Selection			
				Dia (mm)	Length (km)	Vel. (m/s)	Grad (‰)
1	3.1	3.1	1.1	1,200	1.1	1.4	1.0
2	1.3	1.3	0.5	800	0.7	1.1	1.0
3	1.6	6	2.2	1,400	0.8	1.6	1.0
4	2.7	2.7	1.0	1,000	2.0	1.3	1.0
5	1.6	4.3	1.6	1,200	0.9	1.6	1.0
6	3.3	13.6	5.0	2,000	1.9	1.6	0.7
7	2.5	2.5	0.9	1,000	1.7	1.3	1.0
8	1.3	3.8	1.4	1,200	2.0	1.6	1.0
9	1.5	1.5	0.6	800	0.9	1.3	1.5
10	0.8	6.1	2.3	1,400	0.5	1.6	1.0
11	0	19.7	7.3	2,400	0.5	1.5	0.5

Design using Manning Formula with n = 0.01

Table I.7 Preliminary Hydraulic Design of Interceptor Sewers for Huay Kwuang

DWF: 124,200 m^3/d
Peak Flow = 5 x DWF: 621,000 m^3/d
Area: 15.3 km^2
Peak Flow per km^2: 40,600 m^3/d = 0.47 m^3/s

Pipe ref.	Area (km^2)	Cumul. Area (km^2)	Required Sewer Capacity (m^3/s)	Sewer Selection			
				Dia (mm)	Length (km)	Vel. (m/s)	Grad (‰)
1	3.8	3.8	1.8	1,200	3.1	1.6	1.3
2	1.5	1.5	0.7	800	0.7	1.4	1.7
3	0.0	5.3	2.5	1,400	0.4	1.6	1.1
4	1.9	1.9	0.9	800	2.2	1.8	2.8
5	1.8	1.8	0.8	800	1.0	1.7	2.2
6	0.6	9.6	4.5	1,800	1.1	1.8	0.9
7	2.3	2.3	1.1	1,000	2.8	1.4	1.3
8	2.0	2.0	0.9	800	1.4	1.9	2.8
9	0.0	4.3	2.0	1,400	0.1	1.3	0.7
10	1.4	15.3	7.2	2,200	0.7	1.9	0.8

Design using Manning Formula with n = 0.01

TableI.8 Preliminary Hydraulic Design of Interceptor Sewers for Wang Thong Lang

DWF: 141,100 m^3/d

Peak Flow = 5 x DWF: 705,500 m^3/d

Area: 35.7 km^2

Peak Flow per km^2: 19,800 m^3/d = 0.2287 m^3/s

Pipe ref.	Area (km^2)	Cumul. Area (km^2)	Required Sewer Capacity (m^3/s)	Sewer Selection			
				Dia (mm)	Length (km)	Vel. (m/s)	Grad (‰)
1	3.4	3.4	0.8	800	2.3	1.5	2.2
2	3.7	3.7	0.8	800	1.9	1.7	2.2
3	0.0	7.1	1.6	1,200	0.2	1.4	1.0
4	1.9	1.9	0.4	600	1.0	1.5	2.5
5	1.9	1.9	0.4	600	1.3	1.5	2.5
6	0.6	11.5	2.6	1,400	1.5	1.7	1.2
7	2.6	2.6	0.6	800	1.7	1.2	1.4
8	0.9	15.0	3.4	1,600	1.2	1.7	1.0
9	1.7	1.7	0.4	600	1.1	1.4	2.5
10	4.7	21.4	4.9	2,000	2.8	1.6	0.6
11	3.4	3.4	0.8	800	1.2	1.5	2.2
12	3.1	3.1	0.7	800	1.3	1.4	1.7
13	1.8	8.3	1.9	1,400	1.1	1.2	0.7
14	3.6	3.6	0.8	800	1.7	1.6	2.2
15	2.4	14.3	3.3	1,600	0.8	1.6	0.9
16	0.0	35.7	8.2	2,400	0.6	1.8	0.6

Design using Manning Formula with n = 0.01

Table I.9 Preliminary Hydraulic Design of Interceptor Sewers for Bung Kum

DWF: 147,800 m^3/d
Peak Flow = 5 x DWF: 739,000 m^3/s
Area: 42.8 km^2
Peak Flow per km^2: 17,200 m^3/s = 0.20 m^3/s

Pipe ref.	Area (km^2)	Cumul. Area (km^2)	Required Sewer Capacity (m^3/s)	Sewer Selection			
				Dia (mm)	Length (km)	Vel. (m/s)	Grad (‰)
1	6.3	6.3	1.3	1,000	1.7	1.6	1.8
2	5.6	5.6	1.1	1,000	1.2	1.4	1.3
3	4.1	16.0	3.2	1,600	1.4	1.6	0.9
4	3.6	19.6	3.9	1,800	3.1	1.5	0.7
5	2.7	2.7	0.5	800	1.6	1.1	0.9
6	2.8	5.5	1.1	1,000	1.7	1.4	1.3
7	2.9	2.9	0.6	800	1.8	1.2	1.3
8	3.9	12.3	2.5	1,400	1.5	1.6	1.1
9	0.8	32.7	6.5	2,200	1.0	1.7	0.9
10	4.3	4.3	0.9	800	2.1	1.7	2.8
11	1.8	1.8	0.4	600	1.2	1.3	2.5
12	1.5	7.6	1.5	1,200	1.0	1.3	0.9
13	2.5	10.1	2.0	1,400	2.4	1.3	0.9

Design using Manning Formula with n = 0.01

J. WASTEWATER QUALITY DETERMINED BY YANNAWA PROJECT CONTRACTOR

Table J.1 List of Sampling at Yannawa by Project Contractor

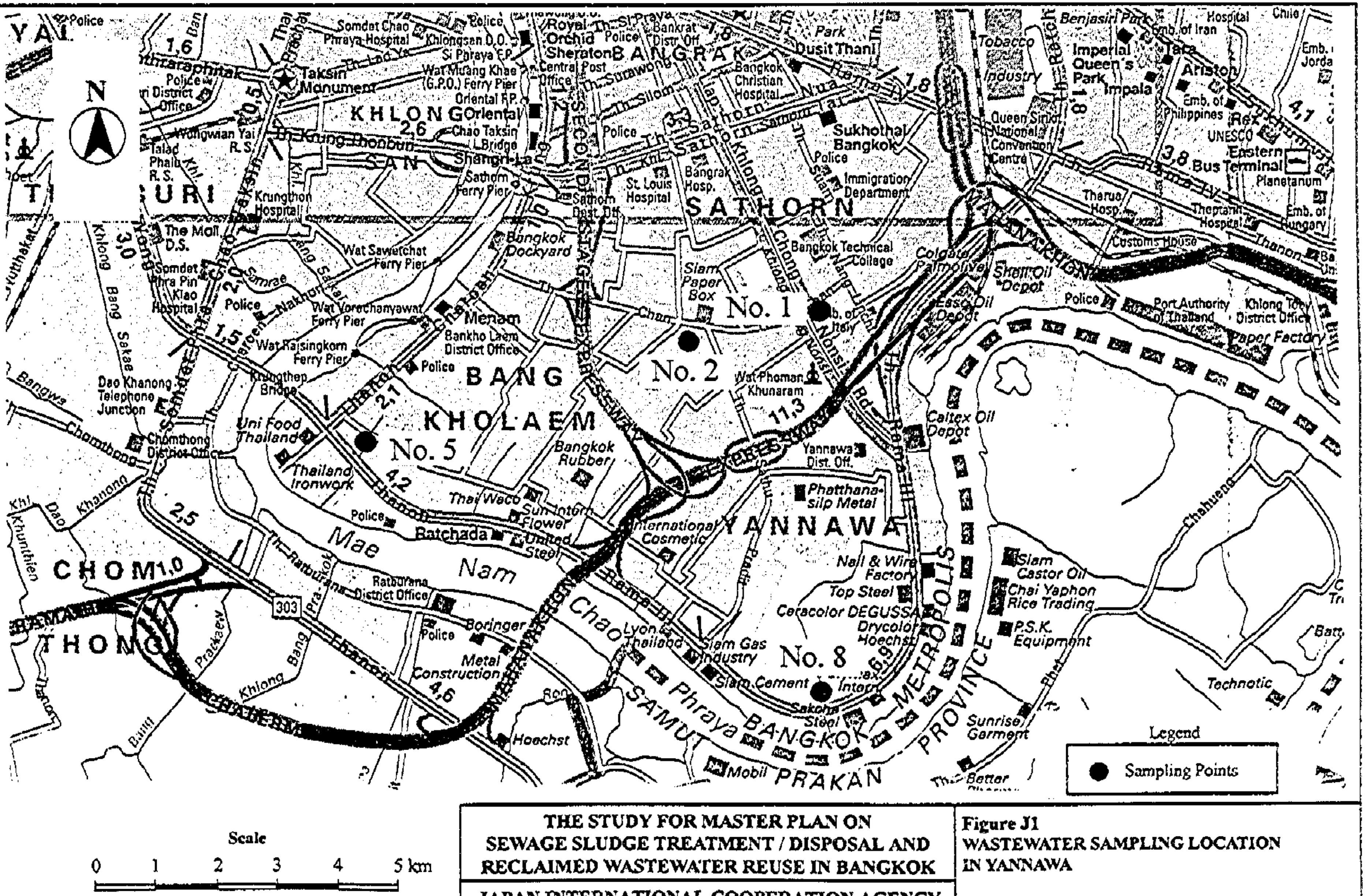
Point No.	Sampling Points	Date	No. of Sampling	Analysis Parameter
No. 1	Thanon Chan Large gas station & vehicle washing shop in Thanon Chan	3-Apr-95	2	1. BOD_5 2. COD 3. SS 4. TDS 5. TKN 6. NH_3-N 7. T-P 8. OIL
No. 2	Khlong Bangkho House, factories & residental area	3-Apr-95	2	
No. 5	Krungthep bridge area House, factories & slum area in Charoen Krung 107	3-Apr-95	2	
No. 8	Sathupradit road (Rama III) Residential area opposite Wat Dan	3-Apr-95	2	

Table J.2 Wastewater Quality (by Yannawa Project Contractor)

Unit : mg/l

Sampling Points	No. 1		No. 2		No. 5		No. 8	
Sampling No.	1A	1B	2A	2B	5A	5B	8A	8B
BOD_5	25.50	59.70	69.00	214.20	39.00	99.60	13.80	32.40
COD	297.60	198.26	364.80	356.52	230.40	100.87	76.80	55.65
SS	411.00	216.00	49.00	72.00	21.00	126.00	115.00	316.00
TDS	387.00	526.00	427.00	340.00	313.00	236.00	374.00	576.00
TKN	2.87	10.06	19.93	10.90	23.41	11.45	9.81	12.41
NH_3-N	0.95	5.20	12.66	7.91	18.98	10.41	8.86	6.25
T-P	1.12	10.80	2.37	5.00	1.82	5.55	0.15	4.90
OIL	0.60	13.60	0.00	8.00	0.00	26.58	0.00	7.50

Source: Yannawa Project Design Data, 1995
A and B are test results from the samples derived from the same sampling bottle.
No.2 is a Khlong water quality nearby.



THE STUDY FOR MASTER PLAN ON SEWAGE SLUDGE TREATMENT / DISPOSAL AND RECLAIMED WASTEWATER REUSE IN BANGKOK

JAPAN INTERNATIONAL COOPERATION AGENCY

Figure J1
WASTEWATER SAMPLING LOCATION IN YANNAWA

K. WASTEWATER QUALITY IN LUMPHINI DETERMINED BY JICA EXPERT

Table K.1 List of Sampling at Lumphini by JICA Expert

Point No.	Type of Wastewater	Date	No. of Sampling	Sampling Method	Analysis Parameter
1-2	Fresh Wastewater Sewer at Soi Rumludee before discharge to Khlong Pai Sin Toe	17/3/97	3	Grab Sampling	1. Air Temp 2. Water Temp 3. Color 4. Odor 5. Flow Direction 6. pH 7. DO 8. BOD_5 9. SS
		19/3/97	3	Grab Sampling	
		21/3/97	3	Grab Sampling	
1-3	Fresh Wastewater Sewer at Soi Polo discharge to Khlong Pai Sin Toe	17/3/97	3	Grab Sampling	1. Air Temp 2. Water Temp 3. Color 4. Odor 5. Flow Direction 6. pH 7. DO 8. BOD_5 9. SS
		19/3/97	3	Grab Sampling	
		21/3/97	3	Grab Sampling	

Source: Final Report of Technical Assistance on Sewerage Management, JICA Expert, 1998

Table K.2 Wastewater Quality at Lumphini (by JICA Expert)

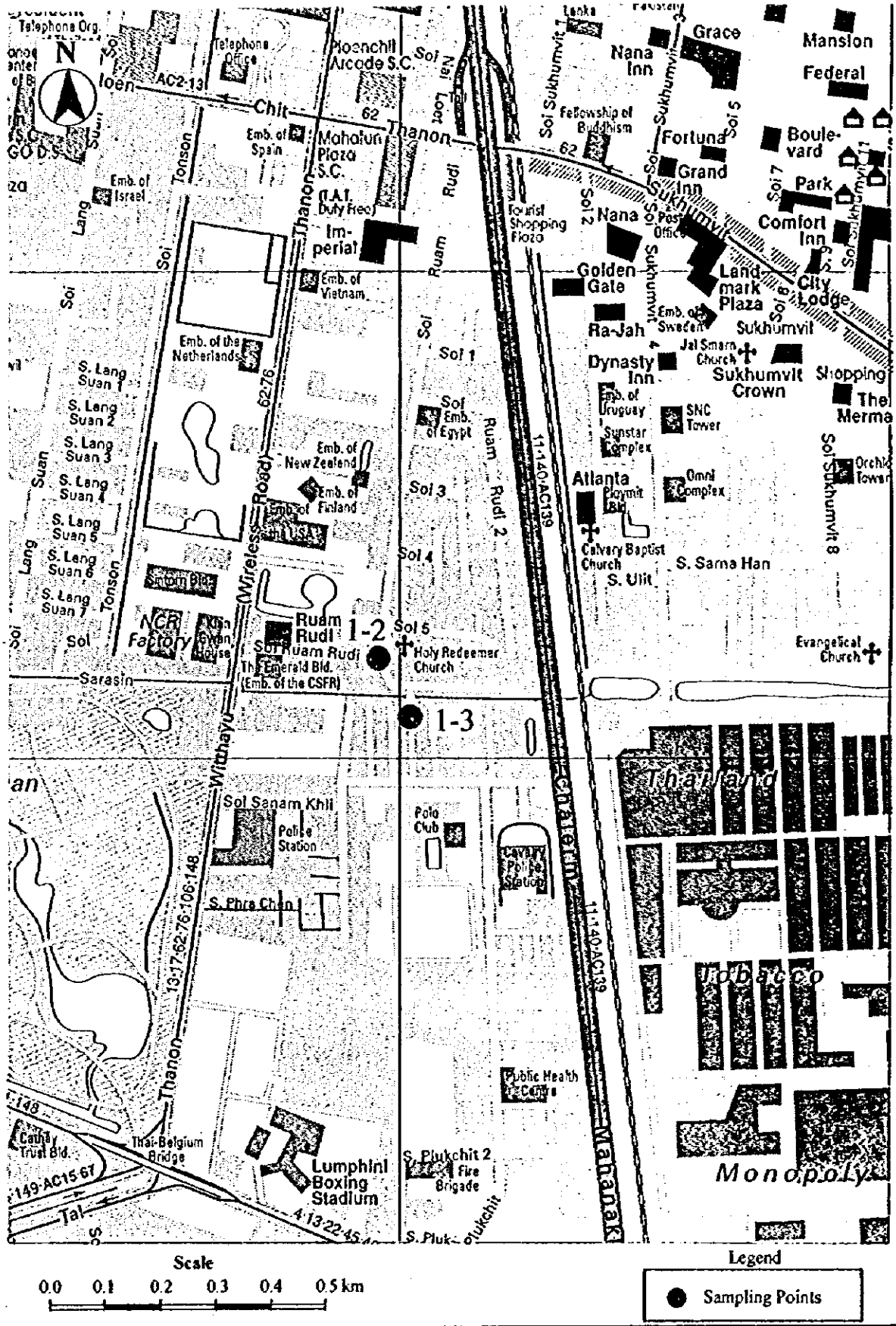
Point No. 1-2

Date	17/03/97			19/03/97			21/03/97		
Water Temp. (° C)	29.8	29.9	29.9	29.7	29.8	29.8	30.0	30.2	30.2
Air Temp. (° C)	28.8	28.8	28.8	29.2	29.2	29.2	30.7	30.7	30.6
Color	Black	Black	Black	Gray	Gray	Gray	Gray	Gray	Gray
Odor	Faint	Faint	Faint	Faint	Faint	Faint	Faint	Faint	Faint
Flow Direction	S --> N	S --> N	S --> N	S --> N	S --> N	S --> N	-	-	-
pH	6.6	6.7	6.7	7.1	7.0	7.0	7.0	7.0	7.0
DO (mg/l)	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0
BOD^5_{20} (mg/l)	35	38	40	48	47	45	44	60	80
SS (mg/l)	25	26	28	22	18	15	23	25	21

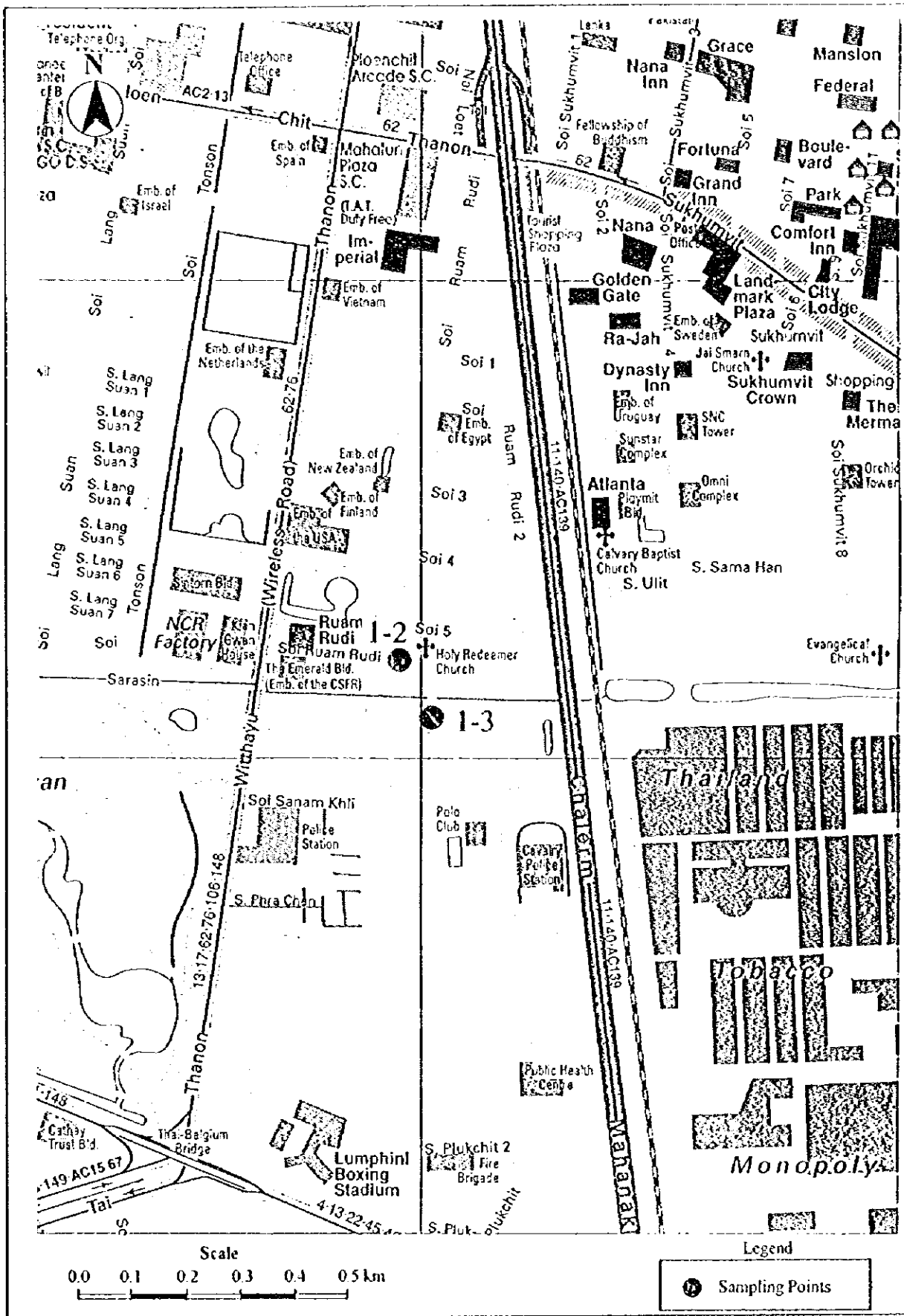
Point No. 1-3

Date	17/03/97			19/03/97			21/03/97		
Water Temp. (° C)	29.7	29.6	29.60	29.3	29.4	29.5	30.0	30.0	30.0
Air Temp. (° C)	29	29	29	29.2	29.2	29.2	30.3	30.2	30.2
Color	Black	Black	Black	Black	Black	Black	Black	Black	Black
Odor	Offensive	Offensive	Offensive	Offensive	Offensive	Offensive	Offensive	Offensive	Offensive
Flow Direction	S --> N	S --> N	S --> N	-	-	-	S --> N	S --> N	S --> N
pH	6.7	6.7	6.8	7.0	7.0	7.0	6.7	6.9	7.0
DO (mg/l)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BOD^5_{20} (mg/l)	145	180	165	210	250	230	300	300	245
SS (mg/l)	80	90	70	51	83	48	130	120	110

Source: Final Report of Technical Assistance on Sewerage Management, JICA Expert, 1998



THE STUDY FOR MASTER PLAN ON SEWAGE SLUDGE TREATMENT / DISPOSAL AND RECLAIMED WASTEWATER REUSE IN BANGKOK	Figure K1 WASTEWATER SAMLING LOCATION IN LUMPHINI
JAPAN INTERNATIONAL COOPERATION AGENCY	



THE STUDY FOR MASTER PLAN ON SEWAGE SLUDGE TREATMENT / DISPOSAL AND RECLAIMED WASTEWATER REUSE IN BANGKOK	Figure K1 WASTEWATER SAMLING LOCATION IN LUMPHINI
JAPAN INTERNATIONAL COOPERATION AGENCY	

L. STUDY AND COUNTERPART TEAM

WASTEWATER SURVEY RESULTS

Contents

Introduction

This Data Book includes all the wastewater analyses undertaken by the Study Team in 1998 and 1999 and by the Counterpart Team in 1999 together with related surveys on catchment properties, populations and water consumption.

Wastewater analyses undertaken by the Study Team were carried out in accordance with the Standard Methods for the Examination of Water and Wastewater: APHA, AWWA and WEF, 19th edition, 1995 as indicated below:

Parameter	Reference	Method of Analysis
TSS	2540 B	GF/C and Drying at 103° C
VSS	2540 E	Ignited at 550° C
BOD	4500-OC, 5210 B	Azide modification - 5 day BOD test
COD	5220 C	Closed reflux titrimetric method

Table L.1 Sewage and Treated Effluent Flow and Quality at Si Phraya WWTP (Sheet 1/2)

Source	Season	Weather	Date	Time	Sample Type	Rainfall	Flow (m^3/d)	TSS (mg/l)	VSS (mg/l)	BOD (mg/l)	COD (mg/l)
Incoming Sewage	Wet	Normal	21.10.98	18.00	Spot	none	8,600	65		32	79
			22.10.98	00.00			9,300	67		33	80
				06.00			9,100	26		23	100
				12.00			14,900	62		35	100
			Average				10,500	55		30	90
			Maximum				14,900	67		35	100
	Dry		10.11.98	12.00	Spot	none	11,000	21		26	105
				18.00			13,200	26		8	30
			11.11.98	00.00			12,700	38		13	90
				06.00			12,800	28		9	75
			Average				12,400	28		14	75
			Maximum				13,200	38		26	105
			27.01.99	13.00	Spot			31		45	76
				17.00				16		64	76
				21.00				23		48	86
			28.01.99	1.00				10		29	52
				5.00				15		33	93
				9.00				10		29	36
			02.02.99	12.00				35		45	74
				16.00				40		59	94
				20.00				49		82	144
			03.02.99	0.00				43		66	86
				4.00				89		58	110
				8.00				34		42	67
			08.02.99	11.00				24		35	97
				3.00				31		54	126
				7.00				26		50	118
				11.00				28		48	154
			09.02.99	3.00				26		53	112
				7.00				22		48	100
			Average					31		49	95
			Maximum					89		82	154
	Wet		21.06.99	10.00	Composite	none		28	20	26	96
			22.06.99	start							
			23.06.99	10.00		none		26	18	60	120
				start							
				10.00		none		43	29	47	80
				start							
			Average					32	22	44	99
		Storm	26.06.99	17.15	Spot	moderate		83	56	66	189
			(Storm	17.30	(a)	moderate		81	55	56	182
			commenced	17.45		moderate		77	56	50	138
			17.00)	18.00		moderate		67	52	51	138
				18.15		slight		65	49	32	124
				18.30		slight		82	60	51	152
				18.45		slight		68	47	33	145
				19.00		none		53	38	28	102
				19.15		none		49	35	26	102
				19.30		none		42	32	28	87
				19.45		none		43	30	20	116
				20.00		none		50	33	28	94
			Average					63	45	39	131
			Maximum					83	60	66	189

Table L.1 Sewage and Treated Effluent Flow and Quality at Si Phraya WWTP (Sheet 2/2)

Source	Season	Weather	Date	Time	Sample Type	Rainfall	Flow (m^3/d)	TSS (mg/l)	VSS (mg/l)	BOD (mg/l)	COD (mg/l)
Incoming Sewage	Wet	Storm	20.07.99 (storm commenced 23:30 on 19.07.99) (b)	00.25	Spot	slight		57	32	47	99
				00.40		slight		50	30	51	113
				00.55		slight		49	31	51	141
				01.10		slight		53	29	36	120
				01.25		slight		56	35	57	127
				01.40		slight		54	31	41	106
				01.55		slight		65	37	50	113
				02.10		slight		61	35	45	127
				02.25		slight		55	37	36	127
				02.40		slight		45	23	39	141
				02.55		slight		53	30	29	127
				03.10		slight		47	27	27	99
			Average					54	31	42	120
			Maximum					65	37	57	141
Treated Effluent	Wet	Normal	21.10.98	18.00	Spot	none	8,600	3		3	10
			22.10.98	00.00		none	9,300	8		5	20
				06.00		none	9,100	1		2	10
				12.00		none	14,900	10		3	10
			Average				10,500	6		3	13
			Maximum				14,900	10		5	20
	Dry		10.11.98	12.00	Spot	none	11,000	4		8	15
				18.00		none	13,200	3		7	15
			11.11.98	00.00		none	12,700	1		8	30
				06.00		none	12,800	1		7	30
			Average				12,400	2		8	22
			Maximum				13,200	4		8	30
	Wet		21.06.99	10.00 start	Composite	none		5	4	3	16
			22.06.99	10.00 start		none		6	5	9	64
			23.06.99	10.00 start		none		7	6	7	32
			Average					6	5	7	37

* Composite samples from equal volumes of spot samples taken at 2 h intervals over 24 h.

(a) Rainfall at Queen Sirikit Convention Center Meteorological Station indicates 7.6 mm/h and 0.3 mm/h between 17.00 and 19.00 with no rain before or after.

(b) No rainfall records available for this storm event at time of reporting.

All Surveys by Study Team except Jan - Feb.1999 Survey by Counterpart Team

Table L.2 Sewage and Treated Effluent Heavy Metals at Si Phraya WWTP

	Date	Cd (mg/l)	Cr (mg/l)	Pb (mg/l)	Mn (mg/l)	Ni (mg/l)	Hg (mg/l)
Incoming Sewage	Wet Season Oct.1998	0.0015	<0.05	0.04	0.13	0.04	0.001
	Dry Season Nov. 1998	<0.001	<0.05	<0.01	0.27	0.007	<0.001
Treated Effluent	Wet Season Oct.1998	<0.001	<0.05	0.02	0.02	0.03	<0.001
	Dry Season Nov. 1998	<0.001	<0.05	<0.01	0.006	0.017	<0.001

Survey by Study Team

Table L.3 Sewage and Treated Effluent Flow and Quality at Huay Kwuang WWTP

Source	Season	Weather	Date	Time	Sample Type	Rainfall	Flow (m^3/d)	TSS (mg/l)	BOD (mg/l)	COD (mg/l)
Incoming Sewage	Wet	Normal	15.10.98	12.00	Spot	little	1,880	174	102	326
				18.00			1,460	160	125	403
			16.10.98	00.00			1,300	146	105	193
				06.00			1,070	158	107	326
			Average				1,430	160	110	312
			Maximum				1,880	174	126	403
	Dry		09.11.98	12.00	Spot	none	1,300	164	189	412
				18.00			1,380	100	192	412
			10.11.98	00.00			1,150	92	153	262
				06.00			1,070	86	189	262
			Average				1,230	111	181	337
			Maximum				1,380	164	192	412
			28.01.99	13.00	Spot			38	160	306
				16.00				28	160	227
				20.00				22	150	317
			29.01.99	00.00				12	150	245
				04.00				20	160	234
				08.00				46	160	321
			04.02.99	00.00				136	190	270
				16.00				114	240	349
				20.00				108	230	386
			05.02.99	00.00				92	200	340
				04.00				132	200	328
				08.00				114	240	335
			08.02.99	00.00				144	130	338
				16.00				142	170	212
				20.00				46	150	234
				00.00				66	150	331
			09.02.99	04.00				72	160	190
				08.00				92	230	381
			Average					79	179	297
			Maximum					144	240	386
	Wet	Storm	30.10.98	16.45	Spot	heavy at	1,150	70	120	285
			(Storm	17.15		first	4,710	1,030	540	1,649
			commenced	17.45		(a)	7,440	1,325	615	1,799
			16:15)	18.15			5,580	420	204	712
			Average				4,720	711	370	1,111
			Maximum				7,440	1,325	615	1,799
Treated Effluent	Wet	Normal	15.10.98	12.00	Spot	little	1,880	2	6	48
				18.00			1,460	1	5	39
			16.10.98	00.00			1,300	3	5	31
				06.00			1,070	3	5	29
			Average				1,430	2	5	37
			Maximum				1,880	3	6	48
	Dry		9.11.98	12.00	Spot	none	1,300	2	27	45
				18.00			1,380	5	24	30
			10.11.98	00.00			1,150	8	32	60
				06.00			1,070	4	18	30
			Average				1,230	5	25	41
			Maximum				1,380	8	32	60

(a) Rainfall at Queen Sirikit Convention Center Meteorological Station indicates 2.0 mm/h and 4.0 mm/h between 16.00 and 18.00 with no rain before or after.

All Surveys by Study Team except Jan - Feb.1999 Survey by Counterpart Team

Table L.4 Sewage and Treated Effluent Heavy Metals at Huay Kwuang WWTP

	Date	Cd (mg/l)	Cr (mg/l)	Pb (mg/l)	Mn (mg/l)	Ni (mg/l)	Hg (mg/l)
Incoming Sewage	Wet Season Oct. 1995	<0.001	<0.05	<0.01	0.25	0.02	0.001
	Dry Season Nov. 1995	<0.001	<0.05	0.01	0.162	0.01	<0.001
Treated Effluent	Wet Season Oct. 1995	<0.001	<0.05	<0.01	0.06	0.011	<0.001
	Dry Season Nov. 1995	<0.001	<0.05	<0.01	0.07	0.004	<0.001

Survey by Study Team

Table L.5 Population of Huay Kwuang WWTP Catchment in 1998

Block No.	No. of Flats	Empty Flats	Surveyed Flats	Flats Not Surveyed	Surveyed Population	Population Not Surveyed	Estimated Population
2001	80	0	50	30	157	108	265
2002	80	4	55	21	193	76	269
2003	80	0	67	13	233	47	280
2004	80	5	59	16	182	58	240
2005	80	3	72	5	245	18	263
2006	80	2	68	10	261	36	297
2007	80	3	59	18	179	65	244
2008	80	0	67	13	213	47	260
2009	80	0	55	25	184	90	274
2010	80	0	57	23	270	83	353
2011	80	0	65	15	290	54	344
2012	80	2	78	0	281	0	281
2013	80	0	67	13	245	47	292
2014	80	2	62	16	239	58	297
2015	80	1	53	26	208	94	302
2016	80	1	52	27	211	97	308
2017	80	2	56	22	205	79	284
2018	80	0	57	23	230	83	313
2019	80	3	50	27	212	97	309
2020	80	2	64	14	239	50	289
2021	100	0	71	29	317	104	421
2022	100	0	89	11	306	40	346
2023	100	2	78	20	281	72	353
2024	100	1	72	27	280	97	377
2025	100	1	73	26	276	94	370
2026	100	0	60	40	258	144	402
2027	100	0	55	45	221	162	383
2028	100	0	76	24	230	86	316
2029	100	1	81	18	283	65	348
2030	100	1	69	30	232	108	340
2031	100	1	64	35	218	126	344
2032	100	0	67	33	238	119	357
2033	100	0	76	24	203	86	289
2034	100	0	69	31	205	112	317
2035	100	1	81	18	294	65	359
2036	100	2	85	13	298	47	345
2037	80	0	46	34	163	122	285
2038	80	1	61	18	214	65	279
Total	3,360	41	2,486	833	8,994	3,001	11,995

Survey by Study Team
Estimated Population = Surveyed Population + (Surveyed Population / Surveyed Flats) × Flats Not Surveyed
Surveyed Population / Surveyed Flats = 3.6

Table L.6 Monthly Metered Water Consumption in Huay Kwuang WWTP Catchment in 1998

Block No.	No. of Flats	Estimated Population	Monthly Water Consumption (m^3)									
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
2001	80	265	1,295	1,305	1,129	1,620	1,231	1,287	1,322	1,121	1,334	1,097
2002	80	269	1,561	1,600	1,234	1,536	1,508	1,641	1,222	1,244	1,658	1,198
2003	80	280	1,376	1,523	1,694	1,394	1,601	1,635	1,374	1,635	1,649	1,527
2004	80	240	1,333	1,423	1,608	1,447	1,406	1,456	1,198	1,252	1,262	1,325
2005	80	263	1,326	1,212	1,214	1,425	1,274	1,360	1,159	1,480	1,502	1,299
2006	80	297	1,928	1,921	1,980	2,127	1,913	1,740	1,656	1,553	1,697	1,527
2007	80	244	1,820	1,523	1,715	1,625	1,462	1,430	1,294	1,463	1,486	1,539
2008	80	260	1,441	1,404	1,377	1,615	1,561	1,695	1,448	1,423	1,430	1,454
2009	80	274	1,746	1,729	1,851	2,100	1,898	2,067	1,934	2,034	1,980	1,975
2010	80	353	1,662	1,620	1,463	1,495	1,530	1,438	1,312	1,415	1,410	1,510
2011	80	344	1,788	1,728	1,854	1,811	1,642	1,531	1,592	1,596	1,864	1,746
2012	80	281	1,917	2,138	2,093	2,135	1,781	1,777	1,784	1,845	1,822	1,953
2013	80	292	1,594	1,255	1,443	1,383	1,368	1,429	1,222	1,215	1,320	1,244
2014	80	297	1,496	1,513	1,915	1,499	1,606	1,576	1,390	1,518	1,472	1,428
2015	80	302	2,075	1,968	2,207	2,003	2,161	2,096	1,855	1,995	1,829	1,773
2016	80	308	1,492	1,606	1,576	1,474	1,438	1,492	1,532	1,420	1,392	1,334
2017	80	284	1,359	1,637	1,642	1,569	1,522	1,549	1,389	1,527	1,492	1,373
2018	80	313	1,582	1,791	1,622	1,718	1,977	1,717	1,520	1,616	1,665	1,609
2019	80	309	1,366	1,662	1,631	1,758	1,644	1,520	1,475	1,661	1,499	1,540
2020	80	289	2,053	1,778	1,740	1,684	1,704	1,653	1,580	1,636	1,640	1,470
2021	100	421	1,549	1,917	1,931	1,927	1,950	2,046	1,818	1,845	1,824	1,754
2022	100	346	1,844	2,377	2,433	2,759	1,909	2,554	1,873	2,108	2,355	1,924
2023	100	353	2,187	1,943	1,654	2,582	2,091	2,111	1,796	2,024	1,872	2,214
2024	100	377	1,486	2,280	1,726	2,157	1,936	2,204	1,798	1,846	1,911	1,820
2025	100	370	1,404	2,011	1,681	2,317	2,199	2,289	1,702	1,766	1,895	1,894
2026	100	402	1,834	1,918	1,680	2,048	1,736	2,320	1,567	1,854	1,830	1,756
2027	100	383	1,533	1,557	1,383	1,895	1,994	1,792	1,594	1,741	1,849	1,580
2028	100	316	1,361	1,490	1,353	2,201	1,723	2,070	1,616	1,752	1,625	1,544
2029	100	348	2,113	2,320	2,250	3,140	2,376	2,677	2,349	2,221	2,319	2,047
2030	100	340	1,955	1,927	2,659	2,169	1,968	2,070	1,981	2,020	2,014	1,969
2031	100	344	2,181	2,497	2,294	2,375	2,034	2,216	2,380	2,129	2,140	2,067
2032	100	357	1,294	2,191	2,363	1,968	2,275	2,502	1,900	2,074	1,905	1,735
2033	100	289	1,720	1,567	2,153	2,026	1,719	1,743	1,690	2,039	1,886	2,061
2034	100	317	1,443	1,660	1,660	1,685	1,666	1,747	1,660	1,595	1,535	1,493
2035	100	359	1,279	1,882	2,115	1,815	1,872	1,960	1,888	1,763	1,810	1,614
2036	100	345	1,530	1,990	2,284	1,926	1,844	2,016	2,201	2,036	1,775	1,773
2037	80	285	1,093	1,385	1,230	1,714	1,490	1,494	1,337	1,405	1,315	1,267
2038	80	279	1,661	1,536	1,543	1,354	1,315	1,339	1,280	1,389	1,432	1,199
Total	3,360	11,995	61,677	66,784	67,380	71,476	66,327	69,239	61,688	64,256	64,695	61,632

Source: National Housing Authority

Table L.7 Daily Per Capita Water Consumption in Huay Kwuang WWTP Catchment in 1998

Block No.	No. ofFlats	Estimated Population	Daily Water Consumption (l/c/d)		
			Max.	Min.	Ave.
2001	80	265	204	138	160
2002	80	269	205	148	178
2003	80	280	202	164	183
2004	80	240	223	166	190
2005	80	263	190	147	168
2006	80	297	239	171	202
2007	80	244	249	177	210
2008	80	260	217	177	190
2009	80	274	255	210	235
2010	80	353	157	124	140
2011	80	344	181	148	166
2012	80	281	254	211	228
2013	80	292	182	139	154
2014	80	297	215	156	173
2015	80	302	244	196	220
2016	80	308	174	144	160
2017	80	284	193	160	177
2018	80	313	211	162	179
2019	80	309	190	147	170
2020	80	289	237	170	195
2021	100	421	162	123	147
2022	100	346	266	178	213
2023	100	353	244	156	193
2024	100	377	202	131	169
2025	100	370	209	126	173
2026	100	402	192	130	154
2027	100	383	174	120	147
2028	100	316	232	143	177
2029	100	348	301	196	228
2030	100	340	261	189	203
2031	100	344	242	197	216
2032	100	357	234	121	189
2033	100	289	248	181	215
2034	100	317	184	152	170
2035	100	359	196	119	167
2036	100	345	221	148	187
2037	80	285	200	128	161
2038	80	279	198	143	168
Total	3,360	11,995	215	156	183

Source: National Housing Authority

Table L.8 Properties in Soi Song Phra Drainage Catchment in Si Phraya Area

Number	Type
83	2 storey terraced shop houses, generally of poor quality with businesses on ground floor
83	3 storey as above
59	4 storey as above
7	5 storey as above
2	5 storey as above but large and good quality
234	Total shop houses, say 234 dwellings
8	2 storey terraced town houses generally of poor quality
1	5 storey as above with probably 2 dwellings
6	6 storey as above each with probably 3 dwellings
15	Total town houses, say 28 dwellings
1	7 storey new good quality apartment block with ground floor used for business premises, estimated 4*6 dwellings and 70% occupancy, say 17 dwellings
1	6 storey poor quality apartment block, estimated 5 x 2 = 10 dwellings
1	5 storey good quality apartment block, estimated 5 dwellings
1	4 storey poor quality apartment block with warehouse of factory below, with estimated 2 x 3 = 6 dwellings
1	3 storey poor quality apartment block, estimated 2 x 3 = 6 dwellings
1	3 storey medium quality apartment block, estimated 3 dwellings
6	Total apartment blocks, say 47 dwellings
12	2 storey detached houses of medium quality
4	3 storey detached houses of good quality
16	Total detached houses
2	Small warehouses or factories
271	Total residential properties, say 325 dwellings

Survey by Study Team
Sampling Location Shown in Figures L1 and L2

Table L.9 Sewage Flow and Quality in Soi Song Phra in Si Phraya Area

Season	Weather	Date	Time	Sample Type	Rainfall	Flow (m^3/d)	TSS (mg/l)	BOD (mg/l)	COD (mg/l)
Wet	Normal	26.10.98	17.00	Spot	none	1,380	55	87	173
			23.00			1,100	32	53	116
		27.10.98	05.00			450	26	93	232
			11.00			1,040	33	75	155
		Average				990	37	77	169
		Maximum				1,380	55	93	232
Dry		19.11.98	12.00	Spot	none	510	14	66	116
			18.00			1,470	17	81	145
		20.11.98	00.00			840	31	81	160
			06.00			920	14	69	116
		Average				936	19	74	134
		Maximum				1,470	31	81	160
		28.01.99	10.00	Spot			36	48	90
			14.00				18	48	72
			18.00				48	72	162
		29.01.99	20.00				7	75	209
			2.00				6	75	111
			6.00				27	82	108
		02.02.99	10.00				73	110	216
			14.00				73	80	145
			18.00				49	96	126
		03.02.99	22.00				65	100	198
			2.00				46	72	111
			6.00				48	60	104
		09.02.99	10.00				42	120	230
			16.00				27	93	230
			22.00				52	120	356
		10.02.99	4.00				44	120	378
		Average					41	86	178
		Maximum					73	120	378
Wet	Storm	30.10.98	18.00	Spot	moderate	2,500	835	120	255
			18.15		(a)	2,680	310	48	150
			18.30			2,070	90	42	140
			18.45			1,840	44	41	134
			19.00		none	1,730	32	26	112
			19.15			1,620	19	27	119
			19.30			1,510	23	25	112
			19.45			1,310	36	36	127
		Average				1,910	174	46	144
		Maximum				2,680	835	120	255

(a) Rainfall at Queen Sirikit Convention Center Meteorological Station indicates 2.0 mm/h and 4.0 mm/h between 16.00 and 18.00 with no rain before or after.

All Surveys by Study Team except Jan - Feb.1999 by Counterpart Team

Table L.10 Heavy Metals in Sewage in Soi Song Phra in Si Phraya Area

Date	Time	Cd (mg/l)	Cr (mg/l)	Pb (mg/l)	Mn (mg/l)	Ni (mg/l)	Hg (mg/l)
20.11.98	06.00	<0.001	<0.05	<0.01	0.074	<0.01	0.001

Survey by Study Team
Sampling Location shown in Figures L1 and L2

Table L.11 Properties in Charoen Krung Soi 77 Drainage Catchment in Yannawa Area

Number	Type
162	3 storey terraced town houses generally of good quality. This excludes a few properties which were evidently not occupied
4	2 storey terraced town houses generally of poor quality.
4	3 storey detached houses of good quality
2	2 storey detached houses of medium quality
1	3 storey good quality apartment block, estimated 2*23 = 4 dwellings
51	2 storey terraced shop houses, generally of poor quality with businesses on ground floor
1	Medium sized supermarket
225	Total residential properties, say 227 dwellings

Survey by Study Team

Table L.12 Sewage Flow and Quality in Charoen Krung Soi 77 in Yannawa Area

Season	Weather	Date	Time	Sample Type	Rainfall	Flow (m^3/d)	TSS (mg/l)	BOD (mg/l)	COD (mg/l)
Wet	Normal	26.10.98	13.15	Spot	none	36	66	144	232
			19.00			70	47	90	155
		27.10.98	01.00			22	52	65	155
			07.00			43	19	53	94
		Average				43	46	88	159
		Maximum				70	66	144	232
Dry		19.11.98	13.00	Spot	none	58	31	98	291
			19.00			77	20	99	276
		20.11.98	01.00			41	17	84	255
			07.00			89	15	86	182
		Average				65	21	92	251
		Maximum				89	31	99	291
		28.01.99	11.00	Spot			12	120	205
			15.00				5	130	306
			19.00				10	130	223
			23.00				4	94	165
		29.01.99	3.00				4	94	180
			9.00				7	140	240
		02.02.99	11.00				31	94	104
			15.00				26	110	133
			19.00				43	150	252
			23.00				100	53	86
		03.02.99	3.00				143	45	83
			7.00				30	34	43
		09.02.99	11.00				26	120	306
			19.00				25	110	162
			23.00				33	150	234
		10.02.99	5.00				29	100	162
		Average					33	105	180
		Maximum					143	150	306
Wet	Storm	18.11.98	19.00	Spot	heavy	370	142	129	449
			19.15		none	197	74	81	239
			19.30		(a)	178	54	57	194
			19.45			106	40	51	209
			20.00			125	47	78	180
			20.15			96	44	98	254
			20.30			94	64	78	254
			20.45			91	44	81	299
		Average				157	64	82	260
		Maximum				370	142	129	449

(a) Rainfall at Queen Sirikit Convention Center Meteorological Station indicates 5.8 mm/h between 18.00 and 19.00 with no rain before or after.

Survey by Study Team except Jan – Feb 1999 by Counterpart Team

Sampling Location shown in Figures L.1 and L.3

Table L.13 Heavy Metals in Sewage at Charoen Krung Soi 77 in Yannawa Area

Date	Time	Cd (mg/l)	Cr (mg/l)	Pb (mg/l)	Mn (mg/l)	Ni (mg/l)	Hg (mg/l)
20.11.98	07.00	<0.001	<0.05	0.01	0.12	0.01	0.003

Survey by Study Team
Sampling Location shown in Figures L.1 and L.3

Table L.14 Properties in Soi Wachirathum Sahit 31 Drainage Catchment in Khlong Toey Area

Number	Type
22	2 storey semi-detached houses of medium quality
1	3 storey semi-detached house of medium quality
36	2 storey detached houses of good quality
4	2 storey very large detached houses or villas of good quality
1	Small shop
1	Small hairdresser
63	Total residential properties

Survey by Study Team
Sampling Location shown in Figure L.1

Table L.15 Sewage Flow and Quality in Soi Wachirathum Sahit 31 and 33 in Khlong Toey Area

Season	Weather	Location	Date	Time	Sample Type	Rainfall	Flow (m^3/d)	TSS (mg/l)	BOD (mg/l)	COD (mg/l)
Wet	Normal	A	26.10.98	14.00	Spot	none	98	12	39	94
				20.00			113	11	32	77
			27.10.98	02.00			89	27	30	77
				08.00			106	35	35	79
			Average				101	21	34	82
			Maximum				113	35	39	94
Dry		B	19.11.98	14.00	Spot	none	none	3	3	29
				20.00				4	2	44
			20.11.98	02.00				8	2	44
				08.00				2	7	29
			Average					4	4	36
			Maximum					8	7	44
		C	9.02.99	12.00	Spot			31	52	129
				18.00				31	52	107
			10.02.99	00.00				14	43	90
				06.00				35	53	90
			Average					28	50	104
			Maximum					35	53	129

A : Sukumvit Soi 101/1 Soi Wachirathum Sahit 31
B : Sukumvit Soi 101/1 Soi Wachirathum Sahit 33
C : Sukumvit Soi 101/1 near junction with Soi Wachirathum Sahit 33
Survey by Study Team except Jan – Feb 1999 by Counter part Team
Sampling Locations shown in Figure L.1

Table L.16 Heavy Metals in Sewage at Soi Wachirathum Sahit 33 in Klong Toey Area

Date	Time	Cd (mg/l)	Cr (mg/l)	Pb (mg/l)	Mn (mg/l)	Ni (mg/l)	Hg (mg/l)
20.11.98	08.00	<0.001	<0.05	<0.01	0.078	<0.01	<0.001

Survey by Study Team

Table L.17 Wastewater Quality in Th. Maitri Chit in Si Phraya Scheme Area

Season	Weather	Date	Time	Sample Type*	Rain	TSS (mg/l)	VSS (mg/l)	BOD (mg/l)	COD (mg/l)
Wet	Normal	25.06.99 start	12:00 start	composite		122	85	56	
		26.06.99 start	12:00 start	composite		55	44	47	
		Average				89	65	52	
	Storm Events	26.06.99	17:00	spot	heavy	336	189	87	400
		(storm	17:15	spot	slight	180	71	48	182
		commenced	17:30	spot	slight	58	39	26	102
		16:45)	17:45	spot	slight	56	42	48	102
		(a)	18:00	spot	none	38	26	30	116
			18:15	spot	none	40	28	41	138
			18:30	spot	none	41	31	28	196
			18:45	spot	none	30	26	24	102
			19:00	spot	none	23	22	28	131
			19:15	spot	none	25	24	42	160
			19:00	spot	none	32	28	54	160
			19:45	spot	none	23	22	48	131
		Average of Storm Event Samples				74	46	42	160
		Maximum during Storm				336	189	87	400
		28.06.99	18:30	spot	heavy	107	67	92	188
		(storm	18:45	spot	moderate	45	35	57	105
		commenced	19:00	spot	none	32	28	42	82
		18:00)	19:15	spot	none	27	23	59	97
		(b)	19:30	spot	none	217	128	57	105
			19:45	spot	none	34	27	50	97
			20:00	spot	none	42	34	69	150
			20:15	spot	none	42	33	78	158
			20:30	spot	none	42	33	102	188
			20:45	spot	none	39	34	66	143
			21:00	spot	none	89	64	111	210
			21:15	spot	none	39	33	90	165
		Average of Storm Event Samples				63	45	73	141
		Maximum during Storm				217	128	111	210

* Composite samples from equal volumes of spot samples taken at 2h intervals over 24h

(a) Rainfall at Queen Sirikit Convention Center Meteorological Station indicates 7.6 mm/h and 0.3 mm/h between 17.00 and 19.00 with no rain before or after.

(b) No rainfall records available for this storm event at time of reporting.

Sampling Location shown in Figures L.1 and L.2

Table L.18 Wastewater Quality in Th. Sathu Pradit in Yannawa Scheme Area

Season	Weather	Date	Time	Sample Type*	Rain	TSS (mg/l)	VSS (mg/l)	BOD (mg/l)	COD (mg/l)
Wet	Normal	25.06.99 start	13:00 start	composite		33	27	36	
		26.06.99 start	13:00 start	composite		32	25	66	
		Average				33	26	51	
	Storm Events	20.07.99	21:50	spot	slight	61	36	68	189
		(storm	22:05	spot	slight	64	34	65	142
		commenced	22:20	spot	slight	60	31	54	142
		20:20)	22:35	spot	slight	53	28	47	142
		(a)	22:50	spot	slight	53	28	54	142
			23:05	spot	little	70	34	26	126
			23:20	spot	little	39	24	33	126
			23:35	spot	none	44	25	63	126
			23:50	spot	none	40	24	42	79
		21.07.99	0:05	spot	none	36	22	42	126
			0:20	spot	none	27	20	35	126
			0:35	spot	none	23	17	35	110
		Average of Storm Event Samples				48	27	47	131
		Maximum during Storm				70	36	68	189
		25.07.99	21:00	spot	slight	39	26	51	128
		(storm	21:15	spot	slight	35	25	36	128
		Commenced	21:30	spot	slight	32	25	44	112
		15:00, 6 h	21:45	spot	slight	25	22	44	112
		before	22:00	spot	slight	30	24	44	144
		Sampling)	22:15	spot	none	34	29	49	128
		(a)	22:30	spot	none	32	26	48	112
			22:45	spot	none	86	38	50	144
			23:00	spot	none	29	19	42	112
			23:15	spot	none	24	20	47	96
			23:30	spot	none	23	18	38	112
			23:45	spot	none	22	19	42	96
		Average of Storm Event Samples				34	24	45	119
		Maximum during Storm				86	38	51	144
		10.08.99	18:00	spot	moderate	180	96	141	291
		(storm	18:15	spot	moderate	340	140	108	291
		Commenced	18:30	spot	moderate	280	120	51	204
		17:30)	18:45	spot	moderate	280	110	42	174
		(a)	19:00	spot	slight	210	78	41	189
			19:15	spot	none	140	54	57	160
			19:30	spot	none	140	53	36	174
			19:45	spot	none	72	31	29	87
			20:00	spot	none	75	33	38	102
			20:15	spot	none	46	22	21	58
			20:30	spot	none	43	21	26	44
			20:45	spot	none	27	15	17	44
		Average of Storm Event Samples				153	64	51	152
		Maximum during Storm				340	140	141	291

* Composite samples from equal volumes of spot samples taken at 2h intervals over 24h

(a) No rainfall records available for these storms at the time of reporting.

Sampling Location shown in Figures L.1 and L.3

Table L.19 Wastewater Quality in Th. Banthat Thong in Din Deang Scheme Area

Season	Weather	Date	Time	Sample Type*	Rain	TSS (mg/l)	VSS (mg/l)	BOD (mg/l)	COD (mg/l)
Wet	Normal	25.06.99 start	11:00 start	composite		45	39	47	
		26.06.99 start	11:00 start	composite		76	49	27	
		Average				61	44	37	
	Storm Events	20.07.99 (storm commenced 21:30) (a)	22:15	spot	moderate	192	77	29	126
			22:30	spot	slight	60	29	23	79
			22:45	spot	slight	53	27	23	95
			23:00	spot	slight	41	21	20	79
			23:15	spot	slight	29	20	26	79
			23:30	spot	slight	25	16	8	79
			23:45	spot	slight	17	13	11	63
		21.07.99	0:00	spot	slight	16	12	18	63
			0:15	spot	slight	18	13	29	47
			0:30	spot	none	22	14	20	32
			0:45	spot	none	27	15	21	95
			1:00	spot	none	28	17	15	47
		Average of Storm Event Samples				44	23	20	74
		Maximum during Storm				192	77	29	126
		25.07.99 (storm commenced 19:00) (a)	20:00	spot	slight	55	44	129	280
			20:15	spot	slight	60	46	69	240
			20:30	spot	none	52	41	63	224
			20:45	spot	none	46	38	95	224
			21:00	spot	none	44	37	98	208
			21:15	spot	none	44	36	92	224
			21:30	spot	none	63	56	150	288
			21:45	spot	none	39	35	108	192
			22:00	spot	none	46	41	84	192
			22:15	spot	none	54	49	144	256
			22:30	spot	none	55	47	132	256
			22:45	spot	none	54	48	120	256
		Average of Storm Event Samples				51	43	107	237
		Maximum during Storm				63	56	150	288

* Composite samples from equal volumes of spot samples taken at 2h intervals over 24h

(a) No rainfall records available for these storms at the time of reporting.

Sampling Location shown in Figures L.1 and L.4

Table L.20 Wastewater Quality in Th. Ti Thong in Ratanakosin Scheme Area

Season	Weather	Date	Time	Sample Type*	Rain	TSS (mg/l)	VSS (mg/l)	BOD (mg/l)	COD (mg/l)
Wet	Normal	01.07.99 start	12:00 start	composite		19	18	21	
		02.07.99 start	12:00 start	composite		23	21	18	
		Average				21	20	20	
	Storm Events	20.07.99	22:45	spot	moderate	125	70	50	189
		(storm	23:00	spot	slight	104	67	66	142
		commenced	23:15	spot	slight	65	45	48	157
		21:00)	23:30	spot	slight	60	42	42	110
		(a)	23:45	spot	slight	39	24	36	142
		21.07.99	0:00	spot	slight	29	21	27	126
			0:15	spot	none	21	16	51	110
			01:15**	spot	none	11	8	26	48
			1:30	spot	none	12	10	30	126
			1:45	spot	none	13	9	30	173
			2:00	spot	none	13	10	14	16
			2:15	spot	none	11	7	24	95
		Average of Storm Event Samples				42	27	37	120
		Maximum during Storm				125	70	66	189
		25.07.99	21:00	spot	none	30	24	29	96
		(storm	21:15	spot	none	31	25	23	112
		Commenced	21:30	spot	none	28	23	20	96
		21:00, 6 h	21:45	spot	none	21	19	18	80
		Before	22:00	spot	none	18	15	17	64
		Sampling)	22:15	spot	none	23	19	20	96
		(a)	22:30	spot	none	22	20	18	64
			22:45	spot	none	18	17	20	64
			23:00	spot	none	55	36	26	64
			23:15	spot	none	12	10	18	64
			23:30	spot	none	17	13	20	64
			23:45	spot	none	14	11	26	80
		Average of Storm Event Samples				24	19	21	79
		Maximum during Storm				55	36	29	112
		10.08.99	19:30	spot	slight	62	44	45	87
		(storm	19:45	spot	slight	56	43	51	87
		commenced	20:00	spot	slight	69	53	36	58
		17:15)	20:15	spot	slight	37	28	36	87
		(a)	20:30	spot	none	41	32	42	73
			20:45	spot	none	38	29	35	87
			21:00	spot	none	35	27	36	87
			21:15	spot	none	29	25	44	73
			21:30	spot	none	37	27	41	87
			21:45	spot	none	43	29	39	73
			22:00	spot	none	28	22	36	73
			22:15	spot	none	37	30	38	73
		Average of Storm Event Samples				43	32	40	79
		Maximum during Storm				69	44	51	87

* Composite samples from equal volumes of spot samples taken at 2h intervals over 24h

** Delay due to sampling pump failure

(a) No rainfall records available for these storms at the time of reporting.

Sampling Location shown in Figures L.1 and L.5

Table L.21 Wastewater Quality in Bang Kae Market, Th Phet Kasem in Nong Khaem Scheme Area

Season	Weather	Date	Time	Sample Type*	Rain	TSS (mg/l)	VSS (mg/l)	BOD (mg/l)	COD (mg/l)
Wet	Normal	01.07.99 start	11:00 start	composite		43	38	53	
		02.07.99 start	11:00 start	composite		47	39	77	
		Average				45	39	65	
	Storm Events	20.07.99	22:15	spot	heavy	73	30	32	126
		(storm	22:30	spot	heavy	47	22	24	126
		commenced	22:45	spot	heavy	38	24	42	142
		22:00)	23:00	spot	moderate	48	25	29	142
		(a)	23:15	spot	slight	50	28	32	189
			23:30	spot	slight	49	25	41	110
			23:45	spot	none	57	37	62	157
		21.07.99	0:00	spot	none	59	37	54	189
			0:15	spot	none	46	26	44	126
			0:30	spot	none	69	47	59	173
			0:45	spot	none	73	47	72	220
			1:00	spot	none	70	47	95	205
		Average of Storm Event Samples				57	33	49	159
		Maximum during Storm				73	47	95	220
		22.07.99	17:15	spot	heavy	61	45	83	304
		(storm	17:30	spot	moderate	134	84	204	416
		Commenced	17:45	spot	slight	76	63	165	368
		17:00)	18:00	spot	slight	88	54	132	320
		(a)	18:15	spot	none	99	57	120	320
			18:30	spot	none	79	51	129	272
			18:45	spot	none	62	46	123	256
			19:00	spot	none	59	43	123	240
			19:15	spot	none	75	50	83	240
			19:30	spot	none	47	33	72	208
			19:45	spot	none	40	32	33	176
			20:00	spot	none	37	27	60	160
		Average of Storm Event Samples				71	49	111	273
		Maximum during Storm				134	84	204	416

* Composite samples from equal volumes of spot samples taken at 2h intervals over 24h

(a) No rainfall records available for these storms at the time of reporting.

Sampling Location shown in Figures L.1 and L.6

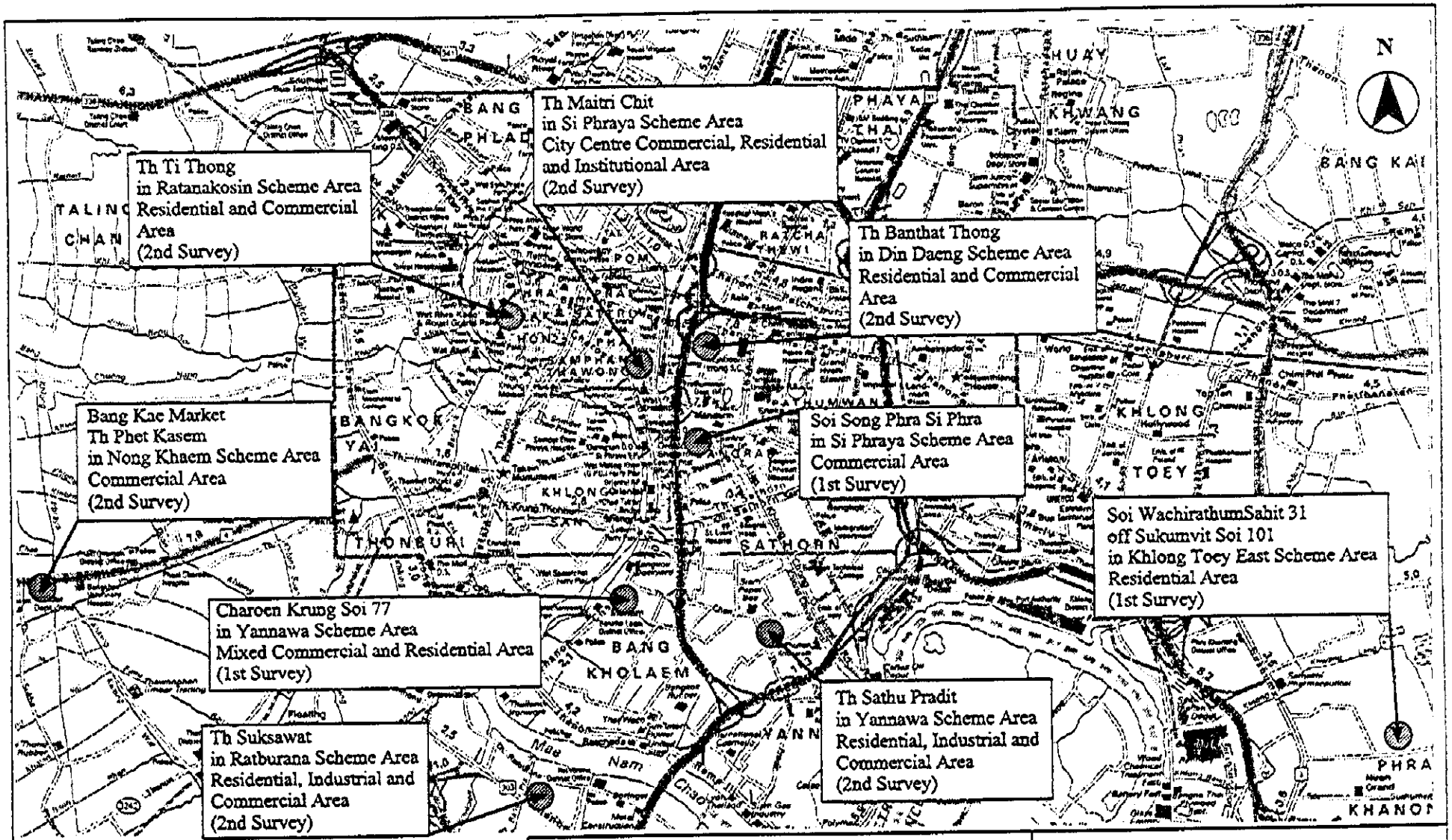
Table L.22 Wastewater Quality in Th Suksawat near Soi 23 in Ratburana Scheme Area

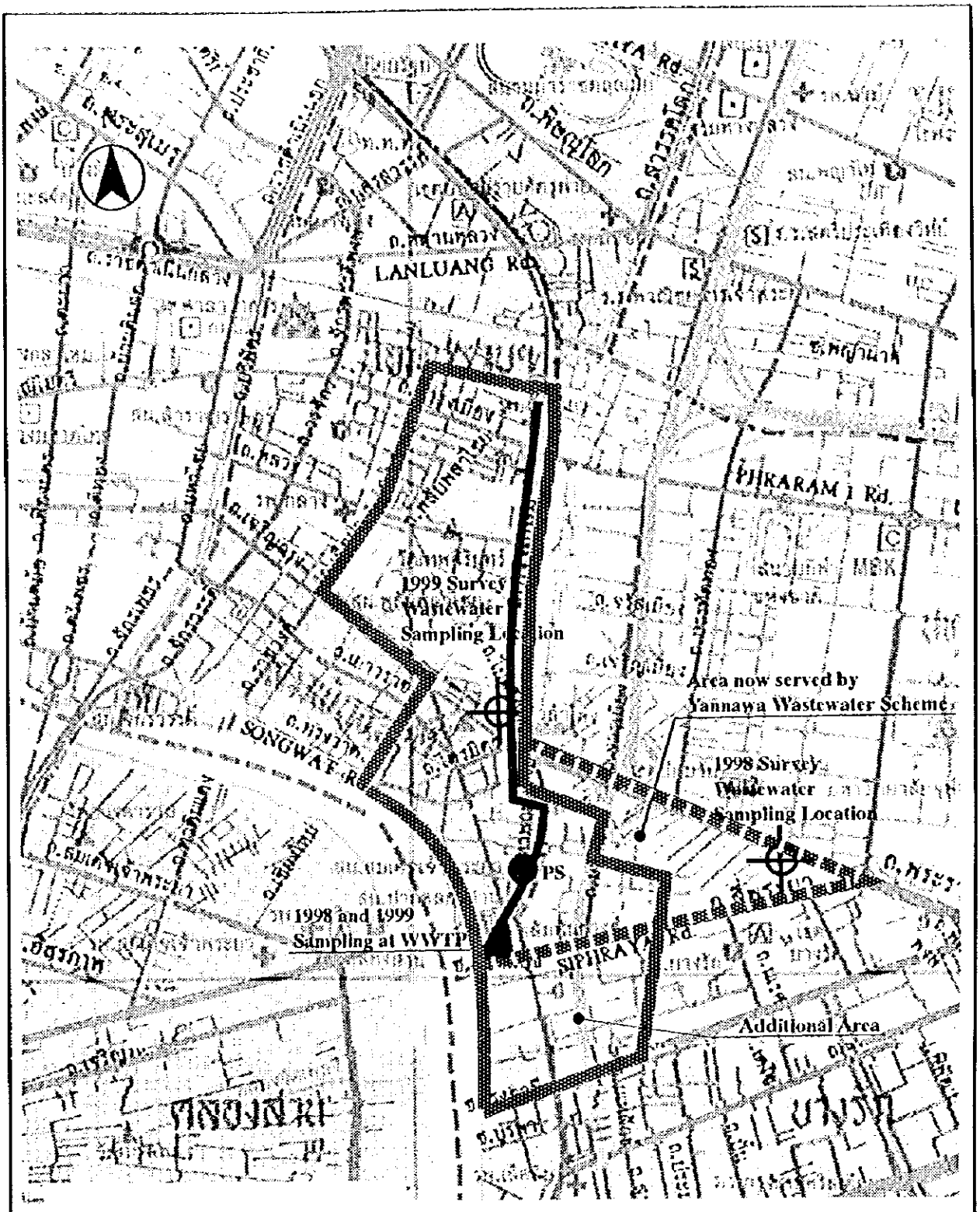
Season	Weather	Date	Time	Sample Type*	Rain	TSS (mg/l)	VSS (mg/l)	BOD (mg/l)	COD (mg/l)
Wet	Normal	01.07.99 start	10:00 start	composite		53	35	39	
		02.07.99 start	10:00 start	composite		43	39	57	
		Average				48	37	48	
	Storm Events	20.07.99	22:15	spot	moderate	59	36	86	173
		(storm	22:30	spot	slight	111	60	126	315
		commenced	22:45	spot	slight	147	76	56	126
		22:00)	23:00	spot	slight	35	30	57	142
		(a)	23:15	spot	none	32	25	63	126
			23:30	spot	none	50	31	69	315
			23:45	spot	none	45	30	47	110
		21.07.99	0:00	spot	none	42	25	48	95
			0:15	spot	none	45	29	48	95
			0:30	spot	none	31	15	75	205
			0:45	spot	none	33	21	20	79
			1:00	spot	none	28	15	39	157
		Average of Storm Event Samples				55	33	61	162
		Maximum during Storm				147	76	126	315
		22.07.99	17:30	spot	moderate	50	30	56	176
		(storm	17:45	spot	none	132	75	68	256
		commenced	18:00	spot	none	84	61	56	256
		17:00)	18:15	spot	none	65	45	68	208
		(a)	18:30	spot	none	45	35	86	192
			18:45	spot	none	44	34	99	208
			19:00	spot	none	91	57	93	224
			19:15	spot	none	44	32	75	288
			19:30	spot	none	36	21	75	208
			19:45	spot	none	65	44	71	176
			20:00	spot	none	30	28	59	192
			20:15	spot	none	32	27	63	176
		Average of Storm Event Samples				60	41	72	213
		Maximum during Storm				132	75	86	288

* Composite samples from equal volumes of spot samples taken at 2h intervals over 24h

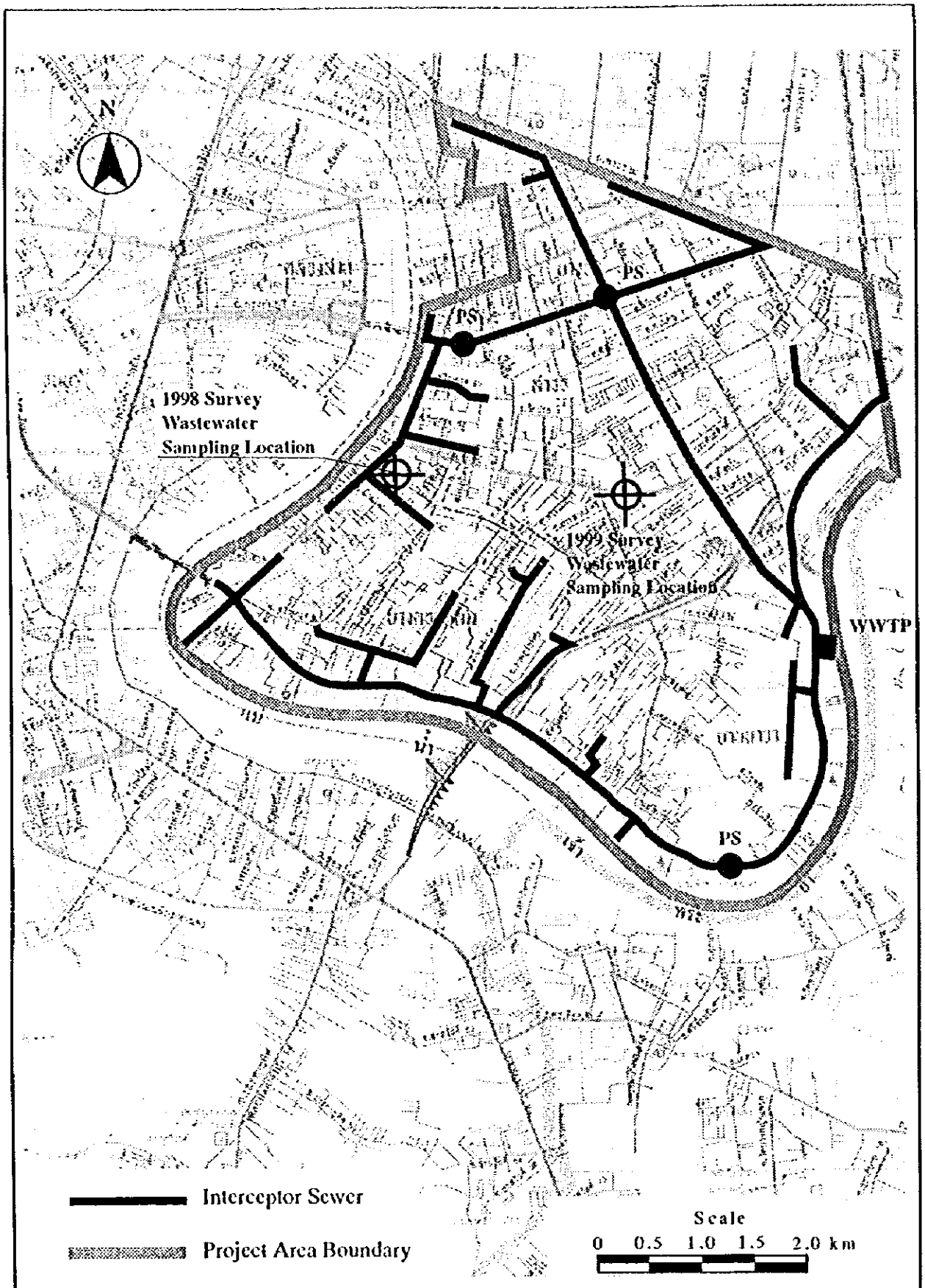
(a) No rainfall records available for these storms at the time of reporting.

Sampling Location shown in Figures L.1 and L.7

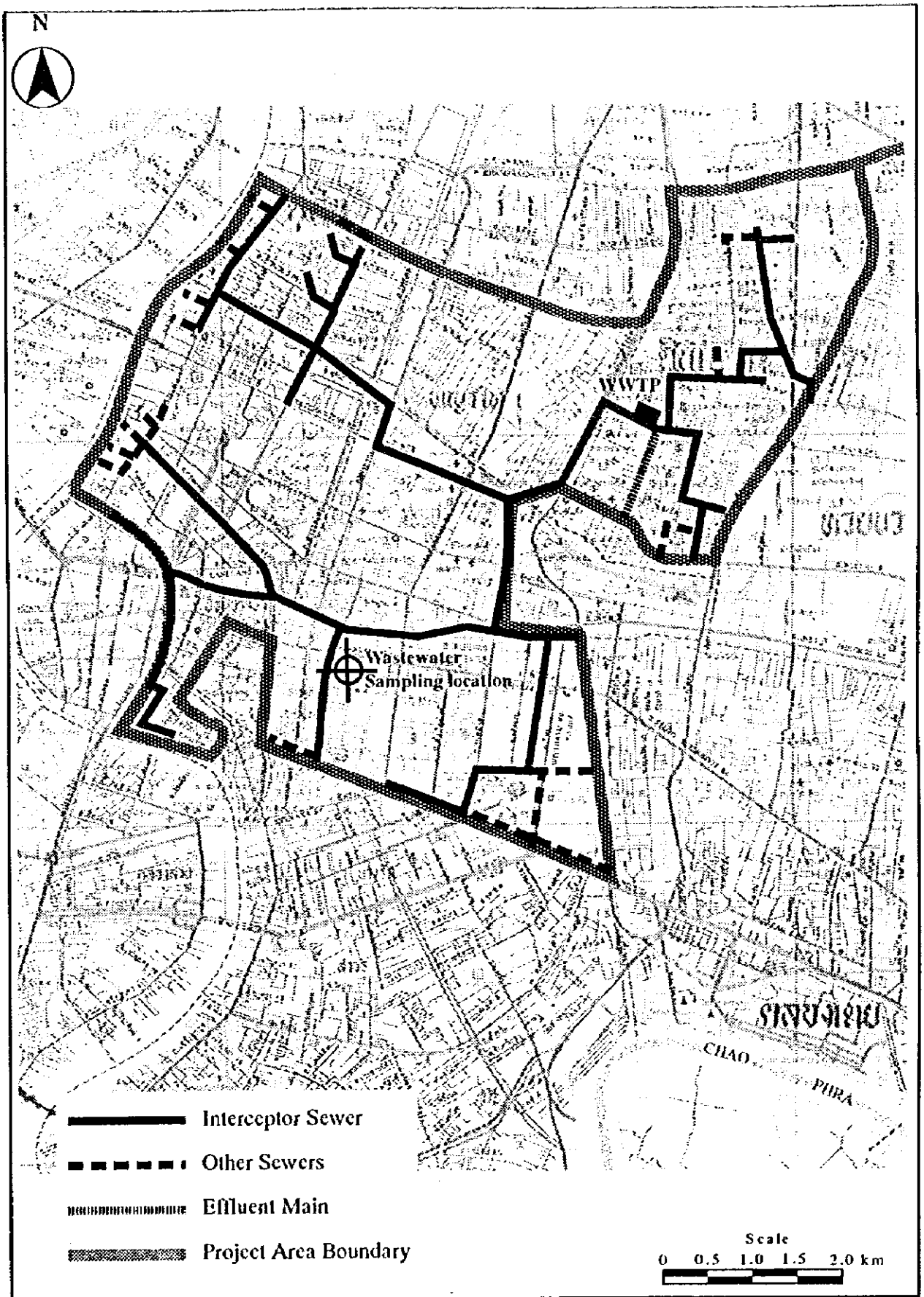

Th Ti Thong
in Ratanakosin Scheme Area
Residential and Commercial Area
(2nd Survey)
Th Maitri Chit
in Si Phraya Scheme Area
City Centre Commercial, Residential and Institutional Area
(2nd Survey)
Th Banthat Thong
in Din Daeng Scheme Area
Residential and Commercial Area
(2nd Survey)
Bang Kae Market
Th Phet Kasem
in Nong Khaem Scheme Area
Commercial Area
(2nd Survey)
Soi Song Phra Si Phra
in Si Phraya Scheme Area
Commercial Area
(1st Survey)
Soi WachirathumSahit 31
off Sukumvit Soi 101
in Khlong Toey East Scheme Area
Residential Area
(1st Survey)
Charoen Krung Soi 77
in Yannawa Scheme Area
Mixed Commercial and Residential Area
(1st Survey)
Th Sathu Pradit
in Yannawa Scheme Area
Residential, Industrial and Commercial Area
(2nd Survey)
Th Suksawat
in Ratburana Scheme Area
Residential, Industrial and Commercial Area
(2nd Survey)
N
Scale
0 1 2 3 4 5 km
THE STUDY FOR MASTER PLAN ON
SEWAGE SLUDGE TREATMENT / DISPOSAL AND
RECLAIMED WASTEWATER REUSE IN BANGKOK
JAPAN INTERNATIONAL COOPERATION AGENCY
Figure L1
SEWAGE QUALITY AND FLOW SURVEY
LOCATIONS IN THE DRAINAGE SYSTEM



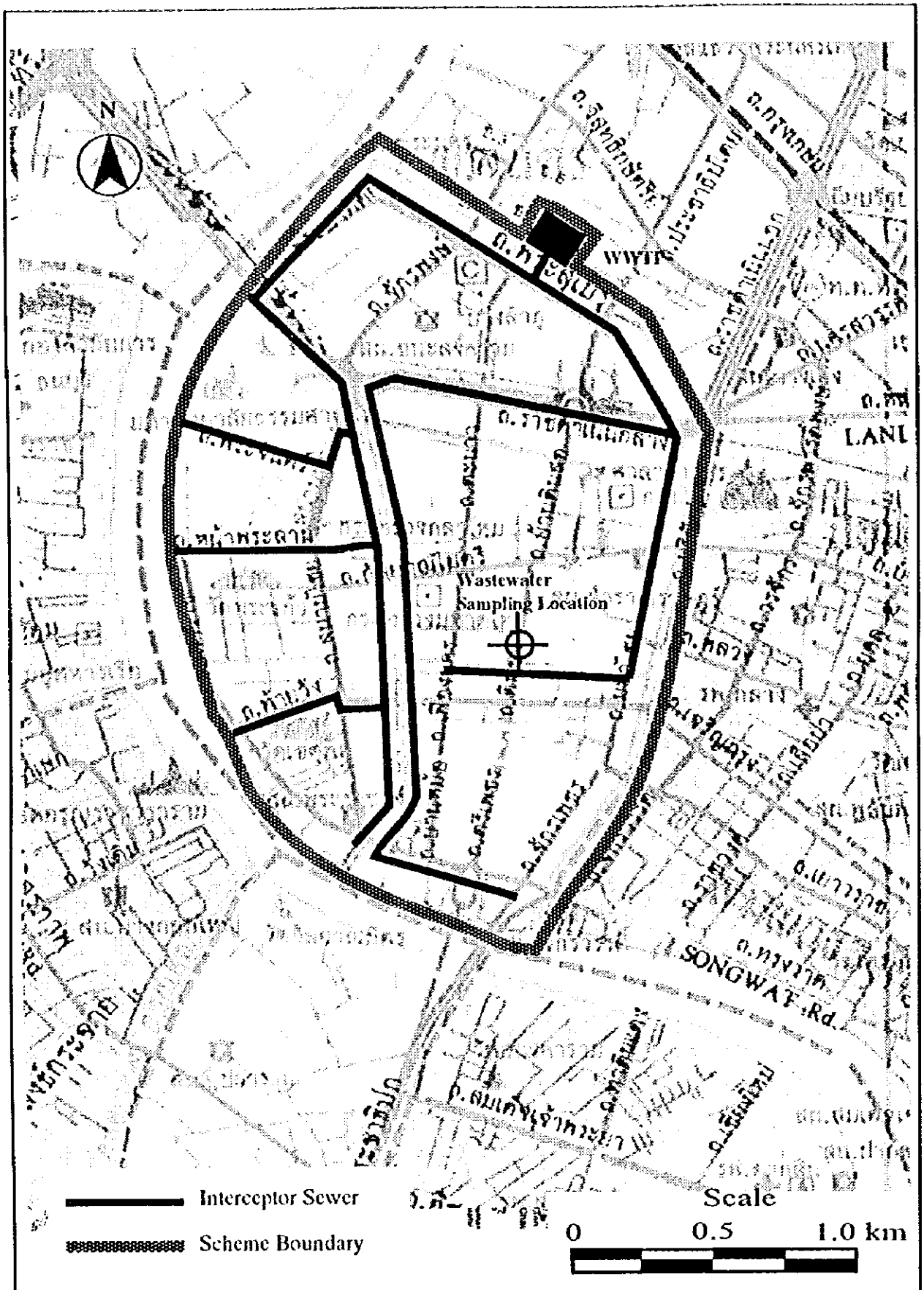
THE STUDY FOR MASTER PLAN ON SEWAGE SLUDGE TREATMENT / DISPOSAL AND RECLAIMED WASTEWATER REUSE IN BANGKOK	Figure L2 SI PHRAYA WASTEWATER SCHEME SHOWING SURVEY SAMPLING LOCATIONS
JAPAN INTERNATIONAL COOPERATION AGENCY	



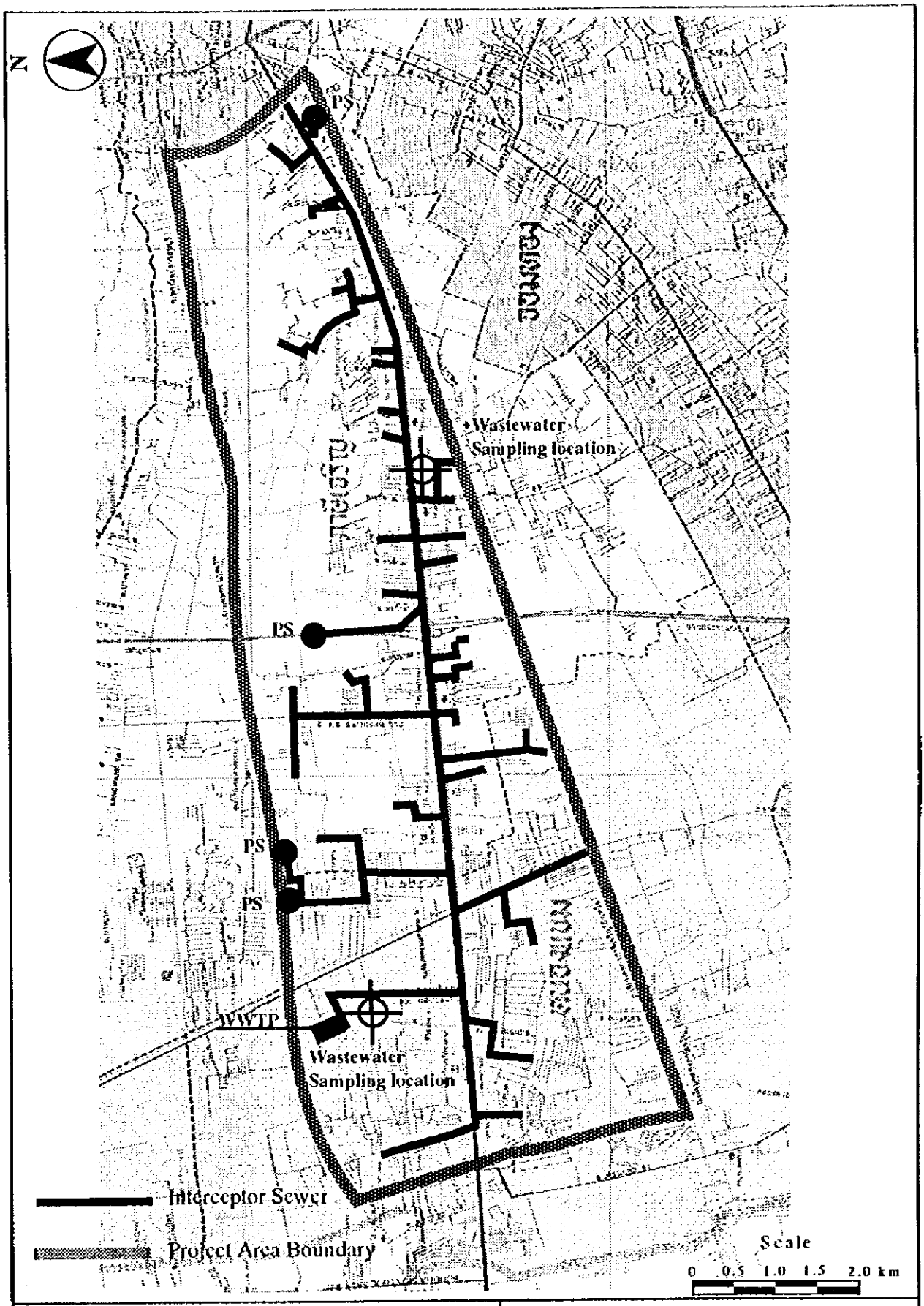
THE STUDY FOR MASTER PLAN ON SEWAGE SLUDGE TREATMENT / DISPOSAL AND RECLAIMED WASTEWATER REUSE IN BANGKOK	Figure I.3 YANNAWA WASTEWATER SCHEME SHOWING SURVEY SAMPLING LOCATIONS
JAPAN INTERNATIONAL COOPERATION AGENCY	



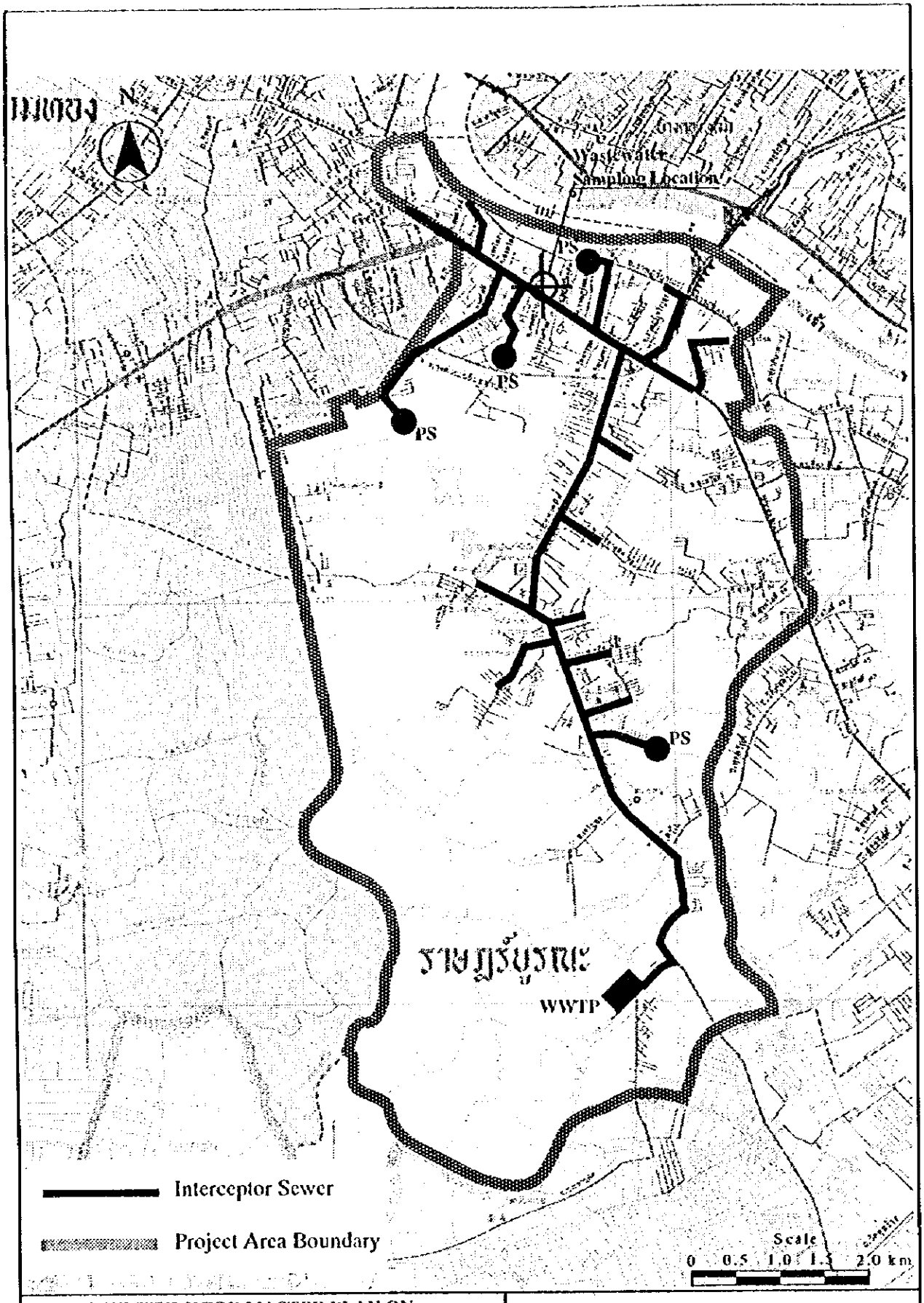
THE STUDY FOR MASTER PLAN ON SEWAGE SLUDGE TREATMENT / DISPOSAL AND RECLAIMED WASTEWATER REUSE IN BANGKOK	Figure I.4 DIN DAENG WASTEWATER SCHEME SHOWING SURVEY SAMPLING LOCATION
JAPAN INTERNATIONAL COOPERATION AGENCY	



THE STUDY FOR MASTER PLAN ON SEWAGE SLUDGE TREATMENT / DISPOSAL AND RECLAIMED WASTEWATER REUSE IN BANGKOK	Figure I.5 RATANAKOSIN WASTEWATER SCHEME SHOWING SURVEY SAMPLING LOCATION
JAPAN INTERNATIONAL COOPERATION AGENCY	



THE STUDY FOR MASTER PLAN ON SEWAGE SLUDGE TREATMENT / DISPOSAL AND RECLAIMED WASTEWATER REUSE IN BANGKOK	Figure 1.6 NONG KHAEM WASTEWATER SHOWING SURVEY SAMPLING LOCATION
JAPAN INTERNATIONAL COOPERATION AGENCY	



THE STUDY FOR MASTER PLAN ON SEWAGE SLUDGE TREATMENT / DISPOSAL AND RECLAIMED WASTEWATER REUSE IN BANGKOK	Figure I.7 RATBURANA WASTEWATER SCHEME SHOWING SURVEY SAMPLING LOCATION
JAPAN INTERNATIONAL COOPERATION AGENCY	

M. RECORDS OF WASTEWATER TREATMENT PLANT PERFORMANCE

Contents

Table M1 Si Phraya Wastewater Treatment Plant Performance Records

Month	Avr Flow (m^3 x 1000)	*BOD			Sludge Cake (m^3/d)
		Wastewater (mg/l)	Removal (%)	Effluent** (mg/l)	
Oct. 1995	8.5	66	92.4	5	
Nov	8.49	58	93.12	4	
Dec.	8.76	46	91.3	4	
Jan. 1996	8.65	67	94	4	
Feb	8.64	53	92.4	4	
Mar	8.72	58	93.1	4	
Apr	8.85	47	89.4	5	
May	8.5	61	93.4	4	
Jun	8.5	65	92.3	5	
Jul	8.4	70	92.9	5	
Aug	8.15	64	90.6	6	
Sep	8.78	75	93.3	5	
Oct	18.1	60	91	5	
Nov	19.2	66	93	5	
Dec	19	69	94.2	4	
Jan. 1997	19.1	75	94.7	4	
Feb	9.6	78	93.6	5	
Mar	9.6	62	93.5	4	
Apr	9.9	43	90.7	4	
May	9.95	49	92.2	4	
Jun	20.9	57.4	90.1	6	
Jul	18.25	55	92.7	4	(Avr. over
Aug	19.32	50	94	3	year to
Sep	20.2	55	94.5	3	Oct. 1997)
Oct	19.3	66	93.9	4	1.8
Nov	20.2	62.3	88.3	7	
Dec	20.28	62.3	88.3	7	
Jan. 1998	20.28	62.3	88.3	7	
Feb	20.28	62.3	88.3	7	
Mar	18.8	89.0	90.0	9	0.65
Apr	18.0	57.62	89.6	6	1.2
May	20.4	56.2	91.6	6	0.9
Jun	20.3	64.85	90.9	6	1.7
Jul	20.6	70.15	92.9	5	1.5
Aug	20.1	58.96	87.8	7	1.1
Sep	18.8	71.1		6.22	1.2
Oct	19.2	69.98		4.95	
Nov	18.9	68.81		6.75	
Dec	16.9	63.26		7.15	
Jan. 1999	16.7	45.43		5.21	
Feb	17.0	58.34		6.55	
Mar	17.6	44.68		5.90	
Apr	16.3	37.72		6.73	
Avr.	**15.3**	**61**		**5**	**1.6**
Max	20.9	89		9	
Min	8.2	37		3	

* Average of weekly analyses

** Effluent quality calculated from % removal to Aug 1998

Table M2 Huay Kwuang Wastewater Treatment Plant Performance Records (Sheet 1/2)

Month	Avr. Flow (m3 /d)	Wastewater			Effluent		
		* BOD (mg/l)	**COD (mg/l)	**SS (mg/l)	*BOD (mg/l)	**COD (mg/l)	**SS (mg/l)
1995							
Oct	1,242	314	657	295	19	89	17
Nov	1,084	256	482	232	33	89	37
Dec	952	170	367	161	16	69	15
Year Average	1,093	247	502	229	23	82	23
1996							
Jan	1,097	162		180	20		19
Feb	1,080	210	499	235	21	44	15
Mar	1,114	166	275	89	19	36	33
Apr	1,249	255	343	206	15	33	8
May	1,315	256	388	228	21	47	18
Jun	1,183	263	365	205	10	40	11
Jul	1,215	232	415	139	18	45	21
Aug	1,371	295	442	180	11	41	11
Sep	1,788	233	417	118	14	36	6
Oct	1,495	296	489	182	13	39	7
Nov	1,101	272	455	177	23	47	11
Dec	945	358	564	209	26	72	10
Year Average	1,246	250	423	179	18	44	14
1997							
Jan	904	335	541	201	17	46	11
Feb	944	341	400	266	19	46	15
Mar	1,033	290	484	206	14	47	15
Apr	1,064	211	434	151	19	37	15
May	992	383	558	266	19	47	15
Jun	1,095	223	384	205	17	38	14
Jul	1,025	400	408	168	12	38	15
Aug	993	291	483	180	16	36	13
Sep	1,321	310	391	127	18	64	21
Oct	1,383	212	322	144	35	55	33
Nov	1,151	210	333	235	38	67	37
Dec	1,249	241	325	181	26	72	21
Year Average	1,096	287	422	194	21	49	19

* Average of weekly analyses
** Average of twice weekly analyses

Table M2 Huay Kwuang Wastewater Treatment Plant Performance Records (Sheet 2/2)

Month	Avr. Flow (m3 /d)	Wastewater *BOD (mg/l)	Wastewater **COD (mg/l)	Wastewater **SS (mg/l)	Effluent *BOD (mg/l)	Effluent **COD (mg/l)	Effluent **SS (mg/l)
1998							
Jan	1,159	275	407	251	18	51	19
Feb	1,181	270		266	14		17
Mar	1,187	235		216	18		15
Apr	1,077	290	373	207	15	45	15
May	1,448	180		177	11		11
Jun	1,656	340		127	12		11
Jul	1,654	205	381	141	12	50	16
Aug	1,550	160	354	135	18	59	20
Sep	1,651	174	380	154	13	47	14
Oct	1,470	160	350	131	20	23	17
Nov	1,135	163	333	143	14	48	15
Dec	1,000	169	200	127	18	51	21
Year Average	1,347	218	347	173	15	47	16
1999							
Jan	1,313	171	238	153	26	21	32
Feb	1,415	186	320	150	21	67	26
Mar	1,447	200	323	176	16	49	16
Apr	1,775	210	377	113	23	53	20
Year Average	1,488	192	315	148	22	48	24
For Whole Period October 1995 - April 1999							
Av.	1,262	254	402	181	18	48	16
Max.	1,788	400	657	295	33	89	37
Min.	904	160	200	89	10	21	6

* Average of weekly analyses
** Average of twice weekly analyses

Table M3 Wastewater Quality and Quantity at Some BMA Community Wastewater Treatment Plants and Khlong Water Improvement Lagoons

	Wastewater	Capacity (m^3/d)	Typical Wastewater Quality BOD (mg/l)	COD (mg/l)	Solids (mg/l)	Typical Flow (m^3/d)
Community WWTPs						
1.	Khlong Chan	6,500	280	450	50	2,000
2.	Ram Indra	800	170	-	57	1,500
Khlong Water Improvement Lagoons						
3.	Makkason Pond	140,000	-	-	-	30,000 - 140,000
4.	Rama IX Pond	60,000	15	30	100	30,000 - 60,000