

CHAPTER 8

UNIT WASTEWATER QUANTITY AND QUALITY

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8.1 General

Major wastewater sources identified in the study area with reference to humankind activities are population entailing business/institutional wastewater, livestock, fish pond and factory as distributed sources; and fresh market and slaughterhouse as concentrated/point ones. Aside from these water pollution sources, agricultural and natural pollution sources are considered for water pollution analysis.

Unit wastewater quantity and quality covering above-mentioned sources are studied both for water pollution analysis and sewerage planning.

Wastewater quantity is estimated, in principle, using the data on water consumption or discharged wastewater amount on a measurement basis, while wastewater quality for the planning purpose is limited to BOD loading as a representative index of the organic substances. The index is convenient to study the relationship between generated/discharged pollution load and runoff pollution load in the river through the future.

Unit BOD loading by different pollution source is estimated based on the investigation results conducted by concerned agencies in Thailand, referring to the experiences in Japan and other countries.

8.2 Domestic Wastewater

8.2.1 Unit Quantity of Domestic Wastewater

8.2.1.1 Present Water Supply

There are several agencies concerned for the water supply in the study area; MWA, PWA, PWD, DOH, ARD, etc. In addition, some of rural communities have their own water supply systems supplemented by individual household water supply using wells, rainwater, etc.

The domestic water is defined, in convenience, for this study consisting of two components; domestic water (residential water), and business water

broken down into institutional, industrial (small-size), commercial and others.

Data on the water supply were collected from concerned agencies; MWA (annual report , 1991), PWA (Data Processing and Reporting Division), PWD and municipalities. Table 8.2.1 shows present water supply (1991) for municipalities/SDs in the study area.

8.2.1.2 Projection of Wastewater Discharge Rate

With regard to per capita water consumption, classification of municipalities and sanitary districts was made. Water consumption rates at the final target year (2011) are projected by the class, referring to previous study/plan in the similar municipalities/SDs.

Unit wastewater discharge rate (lpcd) is regarded as equal as water consumption rate.

Table 8.2.1 Present Water Supply for Municipalities and Sanitary Districts in the Study Area

Province	Municipality / Sanitary District	Water Supply Agency	Population in Service Area	Population Served	Annual Water Sales (m ³ /year)	No. of Connections	Consumption Rate lpcd
1. Chai Nat	1. Muang Chai Nat Mun.	PWA	14,500	10,960	714,650	2,739	179
	2. Han Kha S.D	PWA	5,420	3,500	131,760	700	103
2. Sing Buri	1. Muang Sing Buri Mun.	PWA	20,800	17,030	927,044	3,785	149
	2. Thon Sa Mo S.D	PWA	10,200				
	3. Sing S.D	PWA	20,700	4,330	140,971	867	89
3. Lop Buri	1. Muang Lop Buri Mun. and Military	PWA	-	-	10,219,627 * (4,580,000)	8,903	* (280)
	2. Ban Mi Mun.	PWA					
	3. Khok Samrong Mun.	PWA	-	-	1,427,962	6,136	128
	4. Nong Muang S.D	PWA					
	5. Chai Badan S.D	PWA	-	-	620,009	2,312	133
4. Ang Thong	1. Muang Ang Thong Mun. and Surroundings	PWA	25,810	13,490	780,835	2,698	159
	2. Pa Mok Mun.	PWA					
	3. Sanchao Rong Thong S.D	PWA	10,900	4,360	179,682	872	113
5. Ayutthaya	1. Muang Ayutthaya Mun.	PWA					314
	2. Sena Mun.	PWA	13,600	6,680	487,311	1,671	200
	3. Pak Hai S.D	PWA	13,600	5,430	148,642	905	75
	4. Khok Muang S.D	PWA	6,850	13,140	615,649	2,627	128
	5. Tha Luang S.D	PWA	14,700				
	6. Ayutthaya S.D	PWA	11,200				
	7. Lam Ta Sao S.D	PWA	13,500				
	8. Ban Laue S.D	PWA	9,320	22,050	678,783	4,410	80
	9. Ban Saeng S.D	PWA	2,280				
	10. Phra In Thro Raja	PWA	4,100				
6. Pathum Thani	1. Muang Pathum Thani	PWA	13,500	12,330	1,325,129	3,083	294
	2. Rangsit Area S.Ds **	PWA	95,540	60,590	4,008,395	10,096	181
7. Nonthaburi	1. Muang Nonthaburi Mun.	MWA	258,037				
	2. Pak Kret Mun.	MWA	107,347		66,094,544	110,413	226
	3. Bang Bua Thong Mun.	MWA	35,342				

Note: * For Lop Buri, annual water sales in parenthesis is the figure excluding the use at military camp sites (more than 50% of total sales), then, the domestic consumption Rate is 280 lpcd.

** There are 4 S.Ds.

(1) Classification of Municipalities/S.Ds in the Study area

Municipality

In view of the present status and future prospects in terms of present population size, economic activity and present unit water consumption rate, the municipalities are classified into three. The following are classification criteria adapted. Table 8.2.2 presents evaluation results employing scoring method.

1) Classification Criteria

	<u>Weight</u>
a) Present population	
more than 50,000	3
between 10,000 and 50,000	2
less than 10,000	1
b) Economic activity through the future	
high performance	3
medium performance	2
low performance	1
c) Present unit water consumption rate	
more than 200 lpcd	3
between 110 and 200 lpcd	2
less than 110 lpcd	1

Table 8.2.2 Classification of Municipalities in the Study Area

Municipality	Present Population	Economic Activity	Present Unit Water Consumption Rate	Total Weight	Evaluation Class
1. Muang Chai Nat	2	2	2	6	B
2. Wat Sing	1	1	1	3	C
3. Muang Sing Buri	2	2	2	6	B
4. Muang Lop Buri	2	2	3	7	B
5. Ban Mi	1	1	2	4	C
6. Khok San Rong	1	1	2	4	C
7. Muang Ang Thong	2	2	2	6	B
8. Pa Mok	2	2	2	6	B
9. Muang Ayutthaya	3	2	3	8	A
10. Sena	1	2	3	6	B
11. Tha Rua	1	1	1	3	C
12. Muang Pathum Thani	2	3	3	8	A
13. Muang Nonthaburi	3	3	3	9	A
14. Pak Kret	3	3	3	9	A
15. Bang Bua Thong	2	3	3	8	A

Note : Evaluation Criteria are as follows:

Class A : weight 8 or more

Class B : weight 5-7

Class C : weight 4 or less

Sanitary Districts

Among S.Ds in the study area, those in Pathum Thani Province are different from other S.Ds in their population size, economic activities and present water consumption. These S.Ds are located in Rangsit area along Phaholyothin road, Rangsit - Pathum thani road; Thanyaburi S.D, Prachatipat S.D, Khu Kot S.D and Khlong Luang S.D.

Water consumption in this area may be considered to be on a same level as class A established for the municipalities.

The other S.Ds in the study area may be classified as the same class of C for the municipality.

- (2) Projection of water consumption rate in the year 2011 by classification

Water consumption rate at the final target year (2011) was projected referring to the similar municipalities in Thailand by the classification. References include latest projections by PWA, MWA and PWD.

Present average water consumption rates by class in the study area are calculated as follows (refer to Table 8.2.1):

Class A : 280 lpcd
 Class B : 180 lpcd
 Class C : 120 lpcd

Class A Municipality

Regarding the composition of the water consumption, the percentage of business water against residential water was studied for the representative cases (Nonthaburi and Ayutthaya).

a) Water supply for Nonthaburi : Nonthaburi office of MWA

Item	1989	1990
Annual water sales (mil. m ³ /year)	52.220	66.095
Residential consumption (mil. m ³ /year)	39.362	46.685
Business & other consumption (mil. m ³ /year)	12.858	19.410
Unit consumption rate (lpcd)	209	226

Note: MWA assumed that an average number of persons per connection is 7.2.

The percentage of business consumption against residential one is between 30% and more than 40%.

b) Water supply for Ayutthaya: Comprehensive study of Sewerage systems for the First Group Area, PWD in 1992.

Item	Unit consumption rate
Residential area	Ave. 290 lpcd
Commercial & high Pop. density area	Ave. 342 lpcd
F/S area	112-499 lpcd, ave. 314 lpcd

Note: Data is from field investigations on April 10-12, 1992.

Based on the field investigation, business water seems to be 20-60 percent of residential consumption.

- c) Projection of water consumption rate for Chiang Mai Water Supply : Data form Review Report of PWA for four cities water supply, 1991.

The following are the projection of unit consumption rate (lpcd) excluding tourist supply.

Item	1989	1990	2000	2015
Residential consumption	171	175	220	250
Public	106	106	108	110
Commercial & Others	22	23	26	32
Total	299	304	354	392

In case of Chiang Mai, public consumption is rather high, since there are a lot of large-size institutional facilities. Accordingly, the percentage of public, commercial and other water against residential water is more than 70% at present.

The Water Consumption rate for class A municipality in the year 2011 is recommended as follows:

Residential consumption : 242 lpcd on the same projection
base as Chiang Mai

Percentage of business consumption against residential
consumption : about 50% (118 lpcd)

Domestic water consumption rate : 360 lpcd

Class B Municipality

References are made on Suphan Buri and Warin municipalities, since these municipalities have similarities in the locational conditions, population size and economic development level.

The following are present consumption rate of the municipalities

classified as B rank, and percentage of business water against residential water

a) Present water supply for class B municipalities

Municipality	Domestic/Residential Consumption rate (1991) lpcd	Business Consumption/ Residential Consumption
Muang Chai Nat	179	55%
Muang Sing Buri	149	no data available
Muang Lop Buri	280	30%
Muang Ang Thong	159	30%
Pa Mok	113	15%

Average percentage of business consumption against residential consumption is about 30 percent.

b) Projection of water consumption rate for Suphan Buri and Warin municipalities : Data from Review Report of PWA for four cities water supply, 1991.

Suphan Buri Municipality

Item	1989	1990	2000	2015
Residential consumption	120	123	154	200
Public	10	10	13	17
Business	10	10	13	18
Total	140	143	180	235

Warin municipality

Item	1989	1990	2000	2015
Residential consumption	119	122	153	200
Public	40.5	49	61	80
Business	17.6	24	30	40
Total	177	195	244	320

Business water consumption is 20-50% of residential consumption.

The present consumption rate in the study area is more than 150 lpcd

in average of class B municipalities. Therefore, residential water consumption in 2011 is assumed to be 200 lpcd. In addition, business water consumption is assumed to be 40% of 200 lpcd.

Domestic water consumption for class B municipalities is, therefore, recommended to be 280 lpcd in 2011 as follows.

Residential consumption rate: 200 lpcd

Business consumption rate: 80 lpcd (40%)

Domestic consumption rate: 240 lpcd

Class C Municipality and S.Ds

Projections on water consumption rates for Ubon S.D and Phophraya S.D (Suphan Buri Waterworks) are referred to for class C municipalities and S.Ds except for those in Rangsit area.

a) Projection of water consumption rate for Ubon and Phophraya S.Ds

Ubon S.D

Item	1990	2000	2010	2015
Residential consumption	122	153	184	200
Other	49	61	74	80
Total	171	214	258	280

Other consumption is about 40% of residential consumption.

Phophraya S.D

Item	1990	2000	2010	2015
Residential consumption	123	139	154	200
Others	10	12	13	17
Total	133	151	167	217

Other consumption is about 10% of residential consumption.

From the above two projections, consumption rate in 2011 arrived

at 190 and 170 lpcd for Ubon and Phophraya S.D, respectively.

In assumption of the subject percentage to be about 20% and an average rate of 180 lpcd for residential consumption, domestic consumption rate in 2011 is recommended as follows:

Residential consumption rate:	180 lpcd
Other consumption rate:	40 lpcd (about 20%)
Domestic consumption rate:	220 lpcd

Rural communities

In the report "Thailand Country Profile on Drinking Water Supply and Sanitation", August 1989, the Government target for rural area is set to be 95 lpcd in 1991.

The consumption rate at the final target year for the rural areas is projected to be 120 lpcd in the plan prepared by PWA (small villages such as Ubon Ratchathani villages for the four city water supply).

From the above information, 120 lpcd is recommended as a final target consumption rate in 2011.

Water consumption rates by target year for the municipalities and sanitary districts in the study area are calculated. The projection in the intermediate years (1996 and 2001) are proportionately made using the present consumption rates and projected for the year 2011. Since present consumption rate of most of sanitary districts is not available, an average consumption rate (100 lpcd) of existing data (seven waterworks in Table 8.2.1) is applied for the year 1991 except for Rangsit area. Table 8.2.3 shows consumption rates through the future by category.

Table 8.2.3 Water Consumption Rate by Category

Category	Province	Municipality / S. D.	Consumption Rate (lcpd)											
			1991			1992			1996			2001		
			dome.	busi.	Total	dome.	busi.	Total	dome.	busi.	Total	dome.	busi.	Total
Municipality	Chai Nat	Muang Chai Nat	179	53	184	131	58	204	146	58	204	164	65	229
		Wat Sing	(120)	21	125	104	24	145	121	24	145	142	28	170
	Sing Buri	Muang Sing Buri	149	45	156	111	52	182	130	52	182	154	61	215
	Lop Buri	Muang Lop Buri	280	80	280	200	80	280	200	80	280	200	80	280
		Khok Samrong	128	22	133	111	25	151	126	25	151	145	29	174
		Muang Bang Mi	128	22	133	111	25	151	126	25	151	145	29	174
	Ang Thong	Muang Ang Thong	159	47	165	118	54	189	135	54	189	156	63	219
S. D.s		Pa Mok	113	35	121	86	44	155	111	44	155	141	56	197
	Ayutthaya	Muang Ayutthaya	314	105	316	211	109	326	217	109	326	225	112	337
		Muang Sena	200	58	204	146	63	220	157	63	220	171	69	240
		Tha Rua	128	22	133	111	25	151	126	25	151	145	29	174
	Pathum Thani	Muang Pathum Thani	294	99	297	198	104	311	207	104	311	218	109	327
	Nonthaburi	Muang Nonthaburi	226			226								
		Pek Kret	226	78	233	155	87	260	173	87	260	195	98	293
S. D. in Rangsit area		Muang Bang Bua Thong	226			226								
S. D. Rural Area	Pathum Thani	Prachatipat												
		Thanyaburi	181	63	190	127	75	226	151	75	226	181	90	271
		Khu Kot												
		Klong Luang												
S. D. Rural Area	S. D.s except for Rangsit area		120	21	125	104	24	145	121	24	145	142	28	170
Rural Area	Rural Communities		95	96	96	96	-	101	101	-	101	108	-	108

Note : () present average consumption rate in class B.

8.2.2 Unit BOD Load of Domestic Wastewater

There are several reports on the study of unit BOD load of domestic wastewater stemming from field investigations. Explanation in such reports are sometimes made on BOD concentration, and generated and discharged loads are mixed depending on their manner of investigation and field conditions.

The study purpose under this subject is to come up with per capita BOD loading for future projection of both generated and discharged loads.

Reference information/reports collected and analyzed are as follows:

- (1) Domestic Wastewater and Water Pollution Problems in Bangkok and Its vicinity by Dr. Thongchai Pasawasdi and Associates, ONEB, 1987
- (2) Master Plan of Bangkok Wastewater Treatment Plant Project by JICA, 1981
- (3) Feasibility Study on The Construction of Wastewater Treatment Plant for Muang Nonthaburi Municipality by the Mahidol University, 1989
- (4) Flood Control, Drainage and Sewerage System for Nonthaburi Province, Progress Report, PWD, 1992
- (5) Comprehensive Study of Sewerage Systems for the First Group Area (5 provinces), PWD, 1992

Table 8.2.4 presents a summary of study results between 1968 and 1985 in Thailand, before above-mentioned studies were conducted.

In the table; No.1 - No.8 are based on local study in Thailand and No.9 - No.16 study results referring to the experiences in foreign countries.

Table 8.2.4 Investigation Results on Domestic BOD Load in Thailand

No	Domestic BOD Loading gpcd	Wastewater Flow Rate lpcd	Data Base	Year
1.	5.2 (3.33-6.78)	138	TISTR - NHA (pretreated by Septic Tank)	1980
2.	9.3	-	TISTR and Suphan - Municipality	1983
3.	13	-	JICA	1980
4.	14	110	Mahidol University	1979
5.	15.5	-	TISTR and Samchock S.D	1983
6.	19.7	-	Chariya Thongchantuk	1985
7.	19.8	138	TISTR - NHA	1980
8.	35	390	Thongchai Pansawasdi	1982
9.	45	-	ONEB	1982
10.	45	-	B.N. Lohani	1978
11.	48	-	JICA	1980
12.	54	-	Drew & Nakamura	978
13.	54	-	DIW	1978
14.	55	-	DIW	1984-1985
15.	61	-	JICA	1980
16.	85	154	CDM	1968

Note: Data from the report "Domestic Wastewater and Water Pollution Problems in Bangkok and Its vicinity, ONEB, 1987"

8.2.2.1 Unit BOD Load of Domestic Wastewater

The following are the findings and study results from previous reports on the unit BOD load of domestic/residential wastewater.

BOD load for business water will be added finally.

(1) Domestic Wastewater and Water Pollution Problems in Bangkok and Its Vicinity

Unit BOD loading for domestic wastewater (residence) in 1987 is concluded as follows:

Type of BOD loading	Per capita BOD loading (1987) gpcd
Generated load : overall daily activity	53
Discharged load : after septic tank & other facilities	48
Concentrated load : through khlongs/channels	12.6
Inflow load at WWTP : through sewers	20

As an additional information, discharged load from buildings is reported as shown below.

Building Type	Unit BOD Loading (discharged)
Hotel	123 g/room/day
Housing estates	12.6 g/cap/day or 63 g/house/day

Of the total BOD generated (53 gpcd), the following break down by water use is suggested as well as SS loading.

Index	Nightsoil		Sullage			Total
BOD	11.42	14.82	3.15	23.97	41.94	53.36
SS	8.69	4.98	2.02	9.64	16.64	25.33

Note: BOD of kitchen waste is the figure with screen

The removal ratio at the septic tank for nightsoil is assumed to be 50% of generated BOD load, while 63% for SS.

Nightsoil (gpcd)	Generated	Septic tank effluent	Removal ratio
BOD	11.42	5.75	50%
SS	8.69	3.22	63%

(2) Findings/results by other reports

1) Master Plan of Bangkok Wastewater Treatment Plant Project

Year	BOD load (gpcd)
1980	48
1992	50.4 (increase : 0.2 gpcd/year)
2000	52

- Note : a. Nightsoil is assumed to be 18 gpcd using the experience in Japan and removal ratio at the septic tank is 70% of generated load.
- b. BOD concentration of commercial and institutional wastewater is regarded to be same as that for domestic wastewater

2) Feasibility study on the Construction of Wastewater Treatment Plant for Muang Nonthaburi

Unit domestic BOD load is reported to be 31.5 gpcd in 1989.

BOD concentration : 150 mg/l

Wastewater quantity : 210 lpcd

3) Comprehensive study of Sewerage System for the First Group Area

The results of field investigation conducted in February - March, 1992 are summarized. Sampling of wastewater from 2 areas (A and B) were conducted to get information on average discharged load in Pathum Thani municipality.

Area type	Water Consumption rate (lpcd)		BOD (mg/l)		Unit BOD load (gpcd)		SS load (gpcd)	
	A	B	A	B	A	B	A	B
Residential area	335	312	8	53	2.7	16.5	20	62
Commercial area	290	290	40	560	11.6	162.4	34	414

Note: BOD concentration of "A" area is low because of groundwater inflow.

4) Flood control, Drainage and Sewerage Systems for Nonthaburi Province

For the base year 1992, the following discharged rates are recommended.

Type	Wastewater Quantity (lpcd)	BOD (mg/l)	Unit BOD load (gpcd)
Low pop. density area	120	110	12
Medium pop. density area	200	110	22
Commercial/high pop. density area	290	125	36.25
Housing estate	320	125	40

Note: BOD concentration for governmental and institutional office is assumed to be 125 mg/l

(2) Unit BOD load of domestic wastewater

Unit generated BOD load (residential load) reported by previous studies ranges between 32 and 53 gpcd. In Japan, an average figure on this subject is more or less 50 gpcd at present (nightsoil, 15-18 gpcd and sullage, 32-39 gpcd).

For this study, a total of 53 gpcd (generated base) may be employed as the base year figure in 1992, broken down into nightsoil, 11 gpcd and sullage, 42 gpcd. In addition, BOD load of business wastewater is considered in assumption of BOD concentration (120mg/l). For the future projection, annual increase of 0.1 gpcd is employed for sullage, while nightsoil load (11 gpcd) is assumed to be constant.

Discharged BOD load is calculated in assumption of removal ratio at the septic tank to be around 50% (investigation result by Domestic Wastewater and Water Pollution Problems in Bangkok and Its Vicinity). Tables 8.2.5 and 8.2.6 present unit BOD load on generated and discharged basis, respectively.

Table 8.2.6 Unit Discharged BOD Load of Domestic Wastewater

Unit BOD Load gpcd														
Category	Province	Municipality / S. D.	1992			1996			2001			2011		
			Sullage & Busi.	N.S	Total	Sullage & Busi.	N.S	Total	Sullage & Busi.	N.S	Total	Sullage & Busi.	N.S	Total
	Chai Nat	Muang Chai Nat	48.4	5.5	53.9	49.4	5.5	54.9	50.7	5.5	56.2	53.5	5.5	59.0
		Wat Sing	44.5	5.5	50.0	45.3	5.5	50.8	46.3	5.5	51.8	48.7	5.5	54.2
		Muang Sing Buri	47.4	5.5	52.9	48.6	5.5	54.1	50.2	5.5	55.7	53.5	5.5	59.0
	Lop Buri	Muang Lop Buri	51.6	5.5	57.1	52.0	5.5	57.5	52.5	5.5	58.0	53.5	5.5	59.0
		Khok Samrong	44.6	5.5	50.1	45.4	5.5	50.9	46.4	5.5	51.9	48.7	5.5	54.2
		Muang Bang Mi	44.6	5.5	50.1	45.4	5.5	50.9	46.4	5.5	51.9	48.7	5.5	54.2
	Ang Thong	Muang Ang Thong	47.6	5.5	53.1	48.9	5.5	54.4	50.5	5.5	56.0	53.5	5.5	59.0
		Pa Mok	46.2	5.5	51.7	47.7	5.5	53.2	49.6	5.5	55.1	53.5	5.5	59.0
	Ayutthaya	Muang Ayutthaya	54.6	5.5	60.1	55.5	5.5	61.0	56.3	5.5	61.8	58.1	5.5	63.6
		Muang Sena	49.0	5.5	54.5	50.0	5.5	55.5	51.2	5.5	56.7	53.5	5.5	59.0
		Tha Rua	44.6	5.5	50.1	45.4	5.5	50.9	46.4	5.5	51.9	48.7	5.5	54.2
	Pathum Thani	Muang Pathum Thani	53.9	5.5	59.4	54.9	5.5	60.4	56.0	5.5	61.5	58.1	5.5	63.6
	Nontha Buri	Muang Nonthaburi	51.4	5.5	56.9	52.8	5.5	58.3	54.7	5.5	60.2	58.1	5.5	63.6
		Pak Kret	51.4	5.5	56.9	52.8	5.5	58.3	54.7	5.5	60.2	58.1	5.5	63.6
		Muang Bang Bua Thong	51.4	5.5	56.9	52.8	5.5	58.3	54.7	5.5	60.2	58.1	5.5	63.6
SDs in Rangsit area	Pathum Thani	Prachatipat	49.6	5.5	55.1	51.4	5.5	56.9	53.7	5.5	59.2	58.1	5.5	63.6
		Thanyaburi	49.6	5.5	55.1	51.4	5.5	56.9	53.7	5.5	59.2	58.1	5.5	63.6
		Khu Kot	49.6	5.5	55.1	51.4	5.5	56.9	53.7	5.5	59.2	58.1	5.5	63.6
		Khlong Luang	49.6	5.5	55.1	51.4	5.5	56.9	53.7	5.5	59.2	58.1	5.5	63.6
S. D.	SDs except for Rangsit area		44.5	5.5	50.0	45.3	5.5	50.8	46.3	5.5	51.8	48.7	5.5	54.2
Rural Area	Rural Communities		42.0	5.5	47.5	42.4	5.5	47.9	42.9	5.5	48.4	43.9	5.5	49.4

8.3 Industrial Wastewater

8.3.1 Unit Quantity of Industrial Wastewater

Unit quantity of industrial wastewater per employee by industrial type was calculated using the data of about 300 factories including various industrial types. The data base is the report on the investigations carried out by DIW for the study of industrial wastewater treatment plant project in Pathum Thani. Data and computation results are shown in Table 8.3.1.

Table 8.3.1 Number of Employees and Wastewater Quantity by Industrial Type (1991)

Industrial Type	No. of Fac.	Number of Employees	Wastewater Quantity (m ³ /day)			Unit Quantity (m ³ /d/head)		
			Total	Domestic	Industrial	Total	Dom.	Ind.
BEVERAGE	3	39	63.0	13.0	50.0	1.615	0.333	1.282
FOOD	23	1,570	1,661.0	475.0	1,186.0	1.058	0.303	0.755
FOOD PROCESSING TOTAL	26	1,609	1,724.0	488.0	1,236.0	1.071	0.303	0.768
NON-METALLIC MIN/CEMENT/CERAMIC TOTAL	14	2,529	1,619.0	805.0	814.0	0.640	0.318	0.322
	14	2,529	1,619.0	805.0	814.0	0.640	0.318	0.322
APPAREL	17	12,192	4,307.0	3,502.0	805.0	0.353	0.287	0.066
FOOTWEAR	5	5,428	703.0	703.0	0.0	0.130	0.130	0.000
LEATHER	7	1,413	614.0	164.0	450.0	0.435	0.116	0.318
TEXTILES	21	20,121	16,611.6	7,656.6	8,955.0	0.826	0.381	0.445
LIGHT PROCESSING TOTAL	50	39,154	22,235.6	12,025.6	10,210.0	0.568	0.307	0.261
BASIC METAL	12	1,921	3,012.8	2,142.8	870.0	1.568	1.115	0.453
ELECTRICAL MACHINERY	46	24,053	5,561.0	3,820.0	1,741.0	0.231	0.159	0.072
FABRICATED MACHINERY	24	2,874	753.6	393.6	360.0	0.262	0.137	0.125
MACHINERY	11	1,127	407.4	345.4	62.0	0.361	0.306	0.055
TRANSPORT EQUIPMENT	14	2,225	622.6	463.6	159.0	0.280	0.208	0.071
OTHERS	34	7,217	1,533.8	1,527.8	6.0	0.213	0.212	0.001
MACHINE/ELECT. TOTAL	141	39,417	11,891.2	8,693.2	3,198.0	0.302	0.221	0.081
CHEMICAL	19	1,176	2,060.0	366.0	1,694.0	1.752	0.311	1.440
FURNITURE	9	897	101.0	76.0	25.0	0.113	0.085	0.028
PAPER	4	1,299	845.0	490.0	355.0	0.651	0.377	0.273
PLASTICS	16	2,426	3,854.0	1,706.0	2,148.0	1.589	0.703	0.885
PRINTING	3	273	69.0	49.0	20.0	0.253	0.179	0.073
RUBBER	8	2,446	2,503.0	672.0	1,831.0	1.023	0.275	0.749
TOBACCO	1	70	30.0	30.0	0.0	0.429	0.429	0.000
WOOD	7	177	42.8	42.8	0.0	0.242	0.242	0.000
OTHERS	1	400	25.0	5.0	20.0	0.063	0.013	0.050
OTHERS TOTAL	67	9,164	9,529.8	3,436.8	6,093.0	1.040	0.375	0.665
GRAND TOTAL	299	91,873	46,999.6	25,448.6	21,551.0	0.512	0.277	0.235

Source: Department of Industrial Works

In accordance with grouping of industrial types employed in the projection of frame value, unit quantity per employee by industrial group was estimated.

The unit quantity per employee will be strongly affected by the promotion of labor productivity in the future. In proportion to the increase of labor productivity the unit quantity of industrial wastewater per employee will increase, assuming that the wastewater quantity per product is stable in the future. Thus, labor productivity increasing factors, as shown in Table 8.3.2, used in UCRS for projection of future labor requirements are adopted.

Table 8.3.2 Labor Productivity Increase Factor

year		Ratio to 1991	Adopted
1987	1.00	0.79	-
1991	(1987) $\times 1.06^4 = 1.26$	1.00	1.00
1992*	interpolated -	1.06	1.06
1996	(1987) $\times 1.055^9 = 1.62$	1.28	1.28
2001	(1987) $\times 1.05^{14} = 1.98$	1.57	1.57
2010	(1987) $\times 1.045^{23} = 2.75$	2.18	-
2011*	extrapolated -	2.28	2.28

*: Study team projection

In addition, saving of industrial water provided by improvement of production processes affects the unit wastewater quantity. Possibility of the saving in industrial water use in Thailand was investigated by JICA for the study on effective use of industrial water in Samut Phrakan area in 1988. The results of investigation on 59 factories were summarized as shown in Table 8.3.3.

Table 8.3.3 Ratio of Industrial Water Use Saving

Industrial Type	Investigated Fact. No.	Possible Saving Rate
Food Processing	14	14.9%
Paper	5	31.0%
Textiles	7	19.4%
Metal Products	20	18.8%
Chemical	13	14.8%
Total	59	22.2%

Source: Study on Effective Use of Industrial Water, 1989, JICA

Based on the figures shown in Table 8.3.3, saving rate of industrial water by type of industry are assumed as shown in Table 8.3.4.

Table 8.3.4 Industrial Water Use Saving Rate

Industrial Group	Industrial Water Saving Rate				
	1991	1992	1996	2001	2011
Food Processing	1.000	0.993	0.963	0.925	0.850
Min/Cement/Ceramic	1.000	0.990	0.950	0.900	0.800
Light Processing	1.000	0.990	0.950	0.900	0.800
Machine/Electric.	1.000	0.990	0.950	0.900	0.800
Others	1.000	0.990	0.950	0.900	0.800

Using data and figures shown in Tables 8.3.1, 8.3.2 and 8.3.4, the unit quantity per employee in the future was obtained as shown in Table 8.3.5.

Table 8.3.5 Unit Industrial Wastewater Quantity per Employee

Industrial Group	unit : m ³ /d/head				
	1991	1992	1996	2001	2011
Food Processing	0.768	0.810	0.950	1.110	1.490
Min/Cement/Ceramic	0.322	0.340	0.390	0.450	0.590
Light Processing	0.261	0.270	0.320	0.370	0.480
Machine/Electric.	0.081	0.080	0.100	0.110	0.150
Others	0.665	0.700	0.810	0.940	1.210

8.3.2 Unit BOD Load of Industrial Wastewater

The investigation on BOD load generated and discharged from major factories was conducted by DIW in 1990. Table 8.3.6 summarizes the data of 250 factories located along the Chao Phraya river between Nakhon Sawan and Samut Phrakan including Saraburi.

Unit BOD load per employee is affected by the promotion of labor productivity in assumption that unit wastewater quantity per unit product is stable through the future. For example, if labor productivity becomes double, unit BOD load per employee may be double as well. While, promotion of saving in industrial water use will not affect unit BOD load per employee, although BOD concentration will be increased.

Under the above assumptions, unit BOD load in the future was projected using the data presented in Tables 8.3.1, 8.3.2 and 8.3.6. Computation results are shown in Tables 8.3.7 and 8.3.8.

Table 8.3.6 BOD Load of Industrial Wastewater by Industrial Type

Industrial Type	No. of Fac.	Wastewater Quantity (m3/day)	BOD Concentration (mg/l)		BOD Load (kg/d)	
			Generated	Discharged	Generated	Discharged
Beverage	18	16,710	1,972.0	10.7	32,952.9	178.3
Food	73	19,916	872.0	24.0	17,366.0	478.2
FOOD PROCESSING TOTAL	91	36,626	1,373.9	17.9	50,318.9	656.5
Non-metallic	9	940	371.7	3.2	349.4	3.0
MIN/CEMENT/CERAMIC TOTAL	9	940	371.7	3.2	349.4	3.0
Apparel	1	90	400.0	55.0	36.0	5.0
Leather	3	603	473.5	277.1	285.5	167.1
Textiles	89	33,633	462.9	35.7	15,568.4	1,200.2
LIGHT PROCESSING TOTAL	93	34,326	462.9	40.0	15,889.9	1,372.3
Basic Metal	1	100	240.0	5.0	24.0	0.5
Transport Equipment	1	100	250.0	30.9	25.0	3.1
Others	2	210	61.9	6.4	13.0	1.4
MACHINE/ELECTRIC. TOTAL	4	410	151.2	12.0	62.0	4.9
Chemical	20	4,668	390.1	40.2	1,820.9	187.5
Paper	20	41,620	623.3	31.2	25,942.5	1,297.5
Plastics	1	12	0.0	0.0	0.0	0.0
Others	12	2,732	606.1	48.3	1,655.9	132.1
OTHERS TOTAL	53	49,032	600.0	33.0	29,420.7	1,617.3
GRAND TOTAL	250	121,334	791.5	30.1	96,040.8	3,654.1

Source: Department of Industrial Works

Table 8.3.7 Projected Unit BOD Load per Employee (Generated)

Industrial Group	Avg. BOD Concen'n (mg/l)	Unit I.W.W. Quantity (m3/d/head)	Unit BOD Load (g/d/head)	Projected Unit BOD Load (g/day/head)			
				1992	1996	2001	2011
Food Processing	1,374	0.768	1,055	1,115	1,354	1,655	2,404
Min./Cement/Ceramics	372	0.322	120	126	154	188	273
Light Processing	463	0.261	121	128	155	189	275
Machine/Electrical.	151	0.081	12	13	16	19	28
Others	600	0.665	399	421	512	626	909

Table 8.3.8 Projected Unit BOD Load per Employee (Discharged)

Industrial Group	Avg. BOD Concen'n (mg/l)	Unit I.W.W. Quantity (m3/d/head)	Unit BOD Load (g/d/head)	Projected Unit BOD Load (g/day/head)			
				1992	1996	2001	2011
Food Processing	18	0.768	14	15	18	22	31
Min./Cement/Ceramics	3	0.322	1	1	1	2	2
Light Processing	40	0.261	10	11	13	16	24
Machine/Electrical.	12	0.081	1	1	1	2	2
Others	33	0.665	22	23	28	34	50

Figures of average BOD concentration shown in Table 8.3.8 are derived from Table 8.3.6. Almost all of the factories included in Table 8.3.6 have wastewater treatment facilities. However, some non-registered small-scale industries discharge wastewater without any treatment. Considering such a practice, it is assumed that about 50 percent of employees belong to small-scale and non-registered factories where generated pollution load is discharged. Thus average unit discharged BOD load is revised as shown in Table 8.3.9.

Table 8.3.9 Revised Unit BOD Load per Employee (Discharged)

Industrial Group	Unit BOD Load from Factory w/WWTP. (g/d/head)	Unit BOD Load from Factory w/o WWTP. (g/d/head)	Average Unit BOD Load from Factory (g/d/head)	Projected Unit BOD Load per Employee (g/day/head)			
				1992	1996	2001	2011
Food Processing	14	1,055	544	567	684	839	1,219
Min./Cement/Ceramics	1	120	61	64	77	95	138
Light Processing	10	121	66	69	84	103	149
Machine/Electrical.	1	12	7	7	8	10	15
Others	22	399	211	223	269	330	480

8.4 Unit Quantity and BOD Load of Other Wastewater Sources

Aside from domestic and industrial pollution loads, those generated by livestock, slaughterhouses, fresh market and fish pond are projected in addition to natural pollution.

The types of BOD loading to be studied are depending on data available as follows:

<u>Pollution Source</u>	<u>Available Data/information</u>
Livestock	: generated/discharged load
Slaughterhouse	: generated/discharged load
Fresh market	: discharged load
Fish pond	: discharged load
Natural pollution:	concentrated load

8.4.1 Livestock

Unit BOD load shall be established by cattle and swine. However, there is no data available in Thailand at present. The standard figures on generated load used in Japan for water pollution control plan may be employed as shown in Table 8.4.1.

Table 8.4.1 Unit Pollution Load of Livestock

Item	Generated		Discharged	
	Cattle	Swine	Cattle	Swine
Wastewater (l/head/day)	90 (45-135)	13.5	-	13.5
BOD (g/head/day)	640	200	0	100

Note : Discharged BOD load for Cattle is assumed to be zero percent, while for swine 50 percent

Data source: Guideline for comprehensive Basin-Wide Water Pollution Control plan, Japan

8.4.2 Slaughterhouse

Data on unit BOD load on the wastewater at slaughterhouse in Thailand are not sufficient for the study. BOD concentration at those in Nonthaburi and Pathum Thani municipalities is reported to be 1,020 mg/l (generated load)

and 112 mg/l (effluent from WWTP), respectively.

The standard figures (generated load) in Japan may be employed as shown below.

Table 8.4.2 Unit Pollution Load of Slaughterhouse

Item	Quantity (l/head/d)	BOD (g/head/d)
Raw wastewater	1,166	2,200
Effluent from WWTP	1,450	160

Note: Effluent quality is based on the experience in Thailand (110 mg/l).

The figures are in case of swine and conversion rate of cattle to swine is 3:1.

8.4.3 Fresh Market

There are some investigation results on BOD concentration of discharged wastewater from the fresh market under sewerage plans as mentioned in Section 6.4.3. These are as follows:

- Study result in "Domestic Wastewater and Water Pollution Problems in Bangkok and Its Vicinity : 1,123 mg/l
- Feasibility study on the Construction of Wastewater Treatment Plant for Muang Nonthaburi Municipality : 1,416 mg/l
- Flood control, Drainage and Sewerage Systems for Nonthaburi Province : 500 mg/l (high water consumption)

It is assumed that a constant volume (40 m³/d) of wastewater is discharged from each municipality with the BOD concentration of 1,000 mg/l (40 kg/day BOD) which is an average concentration of the above investigation results.

8.4.4 Fish Pond

In the water pollution study, "Lower Chao Phraya River Basin Water Pollution Control Master Plan, effluent quantity and quality (BOD concentration) are assumed to be 93.8 m³/ha/day (15 m³/rai/day) and 20 mg/l, respectively. For this study, the same base is adopted.

8.4.5 Natural Pollution

Natural pollution load by organic substances is defined as that generated along natural streams without any effects from humankind activities. Pollution caused by agricultural activities is combined in the natural pollution for this study under the conditions of pollution study (dry season and organic substances).

From the field investigation conducted by the Study Team during June, 1992, 0.02-1.42 kg/km²/d is obtained as a unit natural pollution load. While, the figure of 0.5-1.0 kg/km²/d is commonly used in Japan for the similar study.

Under the complex networks of the water bodies in the subject basin, it is difficult to get accurate information thereof. Through the field work by the Study Team, it is noticed that water is rather stagnant in the tributaries of the main river and irrigation canals/khlongs especially in the upper portion of the river basin, and phenomenon like a stabilization pond are observed. In this connection, natural pollution to the main river during dry season may be regarded to be minimal in the upper portion of the basin. While, the unit pollution load at downstream area may be a larger figure according to the increase of specific flow rate of the river.

The figure of 0.5 - 1.0 kg/km²/d as concentrated load is used for the planning purpose as follows:

Provinces in UCR - 0.5 kg/km²/day

Provinces adjacent to Bangkok (Pathum Thani & Nonthaburi)

- 1.0 kg/km²/day

CHAPTER 9

PRESENT WATER POLLUTION ANALYSIS

CHAPTER 9 PRESENT WATER POLLUTION ANALYSIS

9.1 General

Present water pollution analysis is undertaken to establish a run-off model through out the future, and basic factors for the prediction of future pollution at water quality checking points. The analysis shall be on a practical basis suitable in cases where data are limited due to unpredictability of natural phenomenon at this stage. Figure 9.1.1 presents the conceptual flow system of the pollution load.

Calculation of the present generated BOD load is made simultaneously with the setting up of the run-off model. The basic parameters are then determined including generation, discharge, concentration, and purification in the flow mechanism of the pollution load.

9.2 Run-off Model of Pollution Load with Water Quality Checking Points

The study area for water pollution analysis is delineated to be in areas along the Chao Phraya river between Chai Nat before inflow of pollution load therefrom and the provincial office of Nonthaburi. Figure 9.2.1 shows the run-off model of the river including sub-areas and water intake points for water supply and irrigation uses. Study points along the river for present pollution analysis, where water quality and quantity data are available, are also presented. A representative intake point is assumed for the five (5) gates/P.S. for irrigation use located in Pathum Thani and Nonthaburi as indicated in Section 9.2.1 of Volume IV-Data Report. Figure 9.2.2 shows the sub-areas with reference to administrative units.

Water quality checking points along the main river are established as shown in Figure 9.2.2 and Table 9.2.1. Inflow/outflow points of pollution load are presented in Table 9.2.2.

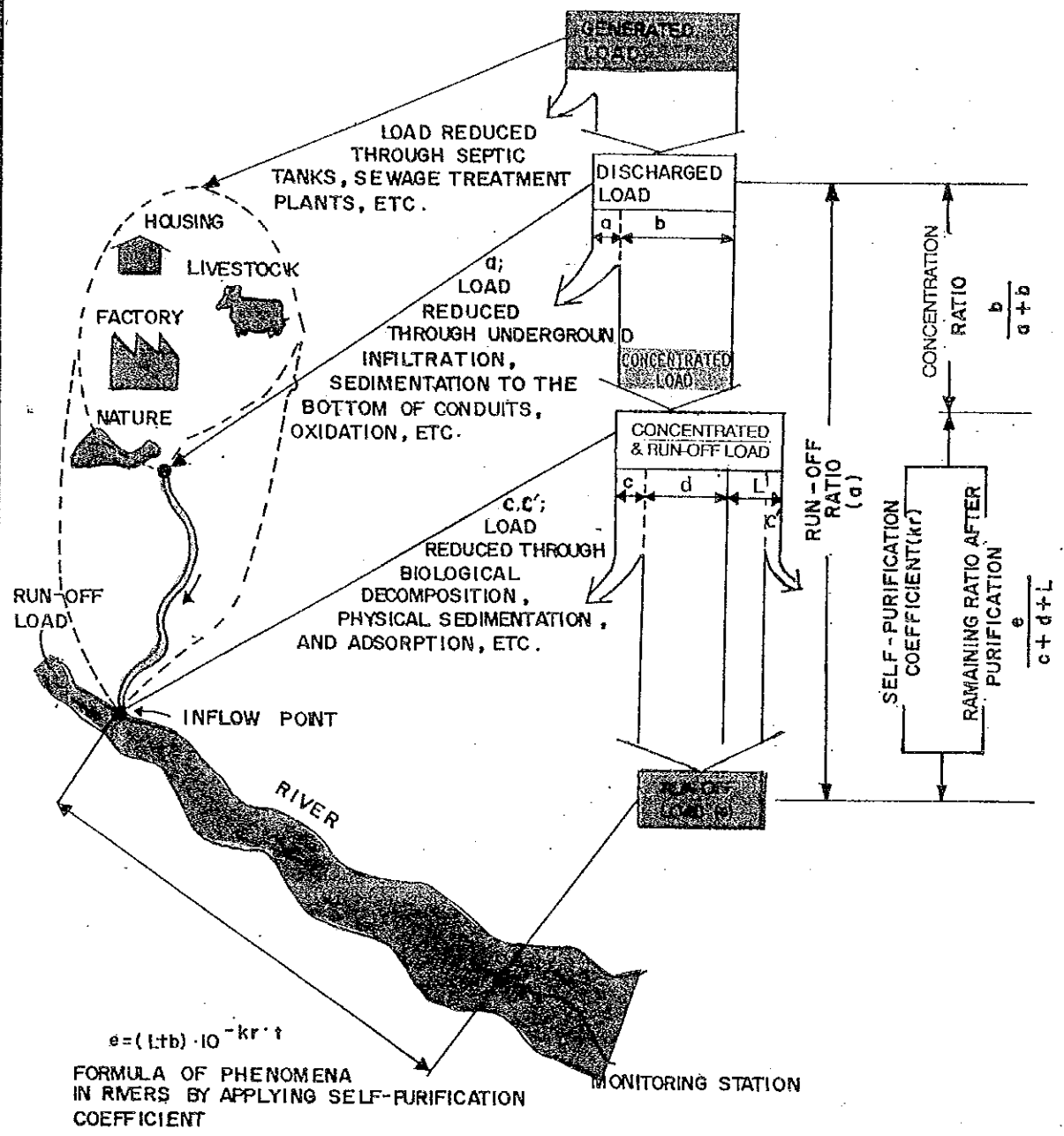


FIG. 9.1.1 FLOW SYSTEM OF THE POLLUTION LOAD

MASTER PLANNING FOR THE SEWERAGE
DEVELOPMENT PROJECT FOR LOWER CHAO PHRAYA RIVER BASIN
JAPAN INTERNATIONAL COOPERATION AGENCY

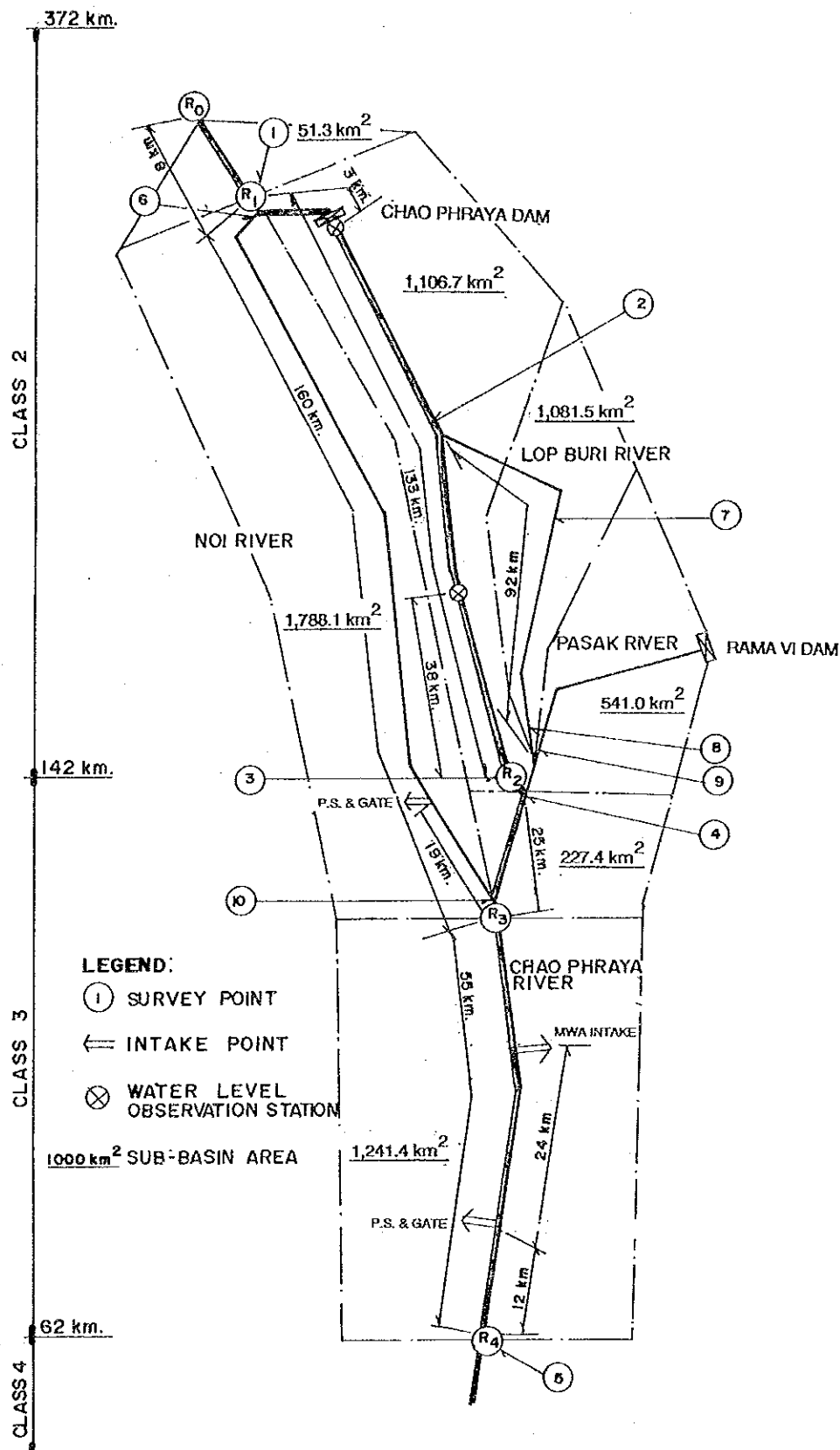


FIG. 9.2.1. RUN - OFF MODEL

MASTER PLANNING FOR THE SEWERAGE
DEVELOPMENT PROJECT FOR LOWER CHAO PHRAYA RIVER BASIN
JAPAN INTERNATIONAL COOPERATION AGENCY

Table 9.2.1. Water Quality Checking Point

Checking Point No.	Location	Distance from River Mouth (km)	Basin Area (km ²)	Remarks
R0	Chai Nat	283	-	Before inflow of pollution load of Chai Nat Municipality
R1	Chai Nat	275	51.3	Before branching to Noi river
R2	Pompetch, Ayutthaya	142	1,158.0	Before confluence with Pasak river, Environmental standard point
R3	Royal Craft Center, Bang Shai, Ayutthaya	117	4,796.0	After confluence with Noi river
R4	Provincial Office, Nonthaburi	62	6,037.4	Environmental standard point

Table 9.2.2 Sub-areas and In/Outflow Points of Pollution Load

No.	River Basin	Location	Sub-area No.	Province	Area (km2)		Inflow Point	Distance from River Mouth (km)
					Sub-area	Total		
1.	Upper Part of Chao Phraya River	from Chai Nat to confluence with Pasak river at A. Muang, Ayutthaya	C-1	Chai Nat	51.3		Ban Tha Chin, Sanphaya, Chainat	281
			C-2	Chai Nat	288.5		Ban Hua Hat, Sanphaya, Chainat	269
			C-3	Sing Buri	369.5		Ban Dong Makham Thet, M.Sing Buri, Sing Buri	218
			C-4	Lop Buri	43.5		Phrom Buri, Sing Buri	194
			C-5	Ang Thong	187.2		Ban Bang Keao, M. Ang Thong, Ang Thong	181
			C-6	Ayutthaya	218.0	1,158.0	Bang Phra Ram, M. Ayutthaya, Ayutthaya	146
2.	Lop Buri River	from diversion at Sing Buri to confluence with Pasak River at A. Muang, Ayutthaya	L-1	Sing Buri	108.6		Tha Wung, Lop Buri	231
			L-2	Lop Buri	806.0		Wat Pho Ngam, M. Lop Buri	211
			L-3	Saraburi	25.9		Lop Buri Don Phut, Sara Buri	166
			L-4	Ayutthaya	141.0	1,081.5	Bang Pahan, Ayutthaya	153
3.	Pasak River	from Rama VI dam to confluence with Chao Phraya River at A. Muang, Ayutthaya	P-1	Saraburi	160.4		Tha Rua, Ayutthaya	186
			P-2	Ayutthaya	380.6	541.0	Nakhon Luang, Ayutthaya	171
4.	Noi River	from diversion at Chai Nat to confluence at A. Bang Shai, Ayutthaya	N-1	Chai Nat	284.5		Sankhaburi, Chai Nat	240
			N-2	Sing Buri	344.4		Khai Bang Rachan, Sing Buri	207
			N-3	Ang Thong	701.0		Pho Thong, Ang Thong	173
			N-4	Ayutthaya	458.2	1,788.1	Sena, Ayutthaya	141
5.	Lower Part of Chao Phraya River	from confluence with Pasak River at A. Muang Ayutthaya to Nonthaburi	C-7	Ayutthaya	227.4		Bang Pa-In, Ayutthaya	128
			C-8	Ayutthaya	482.3		Wat Pho Taeng Nua, Bang Shai, Ayutthaya	114
			C-9	Pathum Thani	485.5		Ban Khlong Rangsit 1, Muang P.T., Pathum Thani	93
			C-10	Nonthaburi	273.6	1,468.8	Ban Bang Phraek, M.Nonthaburi, Nonthaburi	63
Total Drainage Basin Area						6,037.4		

Note: Distance from river mouth of Noi, Lop Buri and Pasak rivers is measured from PCD's set up point at Pompetch, A. Muang, Ayutthaya (142.0 km from river mouth).

9.3 Frame Values and Generated/Discharged Pollution Load
 by Administrative Unit in Terms of Different Land Use

9.3.1 Domestic Wastewater

Further breakdown of estimated population in 1992 as reflected in Section 6.1 was made in terms of Municipality (Class A, Class B, Class C), Sanitary District and Rural Community, as presented in Table 9.3.1, using the different categories discussed in Section 8.2.

Based on this classified population, domestic wastewater quantity, generated BOD load and discharged BOD load were calculated applying the unit domestic wastewater quantity and quality studied in Section 8.2. Calculation results are presented in Tables 9.3.2 to 9.3.4.

9.3.2 Industrial Wastewater

The number of employees in the industrial sector, estimated for the year 1992 in Section 6.2, is summarized in Table 9.3.5. Based on the estimated number of employees by province and by industrial group as presented in the Table, the quantity and generated BOD load were calculated as shown in Tables 9.3.6 and 9.3.7 using unit industrial wastewater quantity and generated BOD load presented in Section 8.3.

Discharged BOD load was also estimated using the same frame value and unit BOD load as shown in Table 9.3.8. In the estimation of discharged BOD load, the following assumptions were applied:

- Fifty (50) percent of the employees belongs to small-scale/non-registered factories. Pollution load from these factories is discharged without any treatment (Unit generated BOD load in Table 8.3.7 is used).
- Other factories discharge pollution load with the average pollution load after treatment as presented in Table 8.3.8.

Table 9.3.1 Population by Land Use Type (1992)

Province / Amphoe	Total Population	Municipalities (Urban)			Sanitary Districts (Sub- urban)	Rural Community
		Class A	Class B	Class C		
Chai Nat	151,628	0	14,618	0	12,138	124,872
** Muang Chai Nat	47,594	0	14,618	0	0	32,976
* Sankhaburi	50,486	0	0	0	6,116	44,370
* Sanphaya	53,548	0	0	0	6,022	47,526
Sing Buri	234,635	0	23,379	0	50,860	160,396
** Muang Sing Buri	54,800	0	23,379	0	0	31,421
* Khai Bang Rachan	30,904	0	0	0	3,737	27,167
* Tha Chang	16,228	0	0	0	10,573	5,655
* Bang Rachan	40,110	0	0	0	21,321	18,789
* Phrom Buri	25,657	0	0	0	7,380	18,277
* In Buri	66,936	0	0	0	7,849	59,087
Lop Buri	292,658	0	37,871	0	25,771	229,016
** Muang Lop Buri	215,307	0	37,871	0	20,721	156,715
Khok Samrong	1,013	0	0	0	0	1,013
* Tha Wung	52,627	0	0	0	5,050	47,577
Ban Mi	23,711	0	0	0	0	23,711
Ang Thong	262,613	0	21,275	0	51,045	190,293
** Muang Ang Thong	47,943	0	10,283	0	0	37,660
* Chaiyo	22,613	0	0	0	12,476	10,137
** Pa Mok	29,016	0	10,992	0	0	18,024
* Pho Thong	56,421	0	0	0	7,087	49,334
* Wiset Chai Chan	60,246	0	0	0	21,163	39,083
* Samko	10,250	0	0	0	6,475	3,775
* Sawaengha	36,124	0	0	0	3,844	32,280
Ayutthaya	557,651	71,273	4,867	8,602	138,339	334,570
** Muang Ayutthaya	123,553	71,273	0	0	11,463	40,817
** Tha Rua	52,192	0	0	8,602	16,322	27,268
* Nakhon Luang	33,899	0	0	0	7,862	26,037
* Bang Sai	16,558	0	0	0	6,356	10,202
* Bang Shai	44,297	0	0	0	11,422	32,875
* Bang Ban	34,675	0	0	0	11,099	23,576
* Bang Pahan	37,077	0	0	0	6,692	30,385
* Bang Pa-In	55,888	0	0	0	16,581	39,307
* Ban Phraek	9,301	0	0	0	2,641	6,660
* Phak Hai	45,138	0	0	0	23,999	21,139
* Maha Rat	23,614	0	0	0	2,889	20,725
* Lat Bua Luang	21,742	0	0	0	0	21,742
** Sena	59,257	0	4,867	0	21,013	33,377
Uthai	460	0	0	0	0	460
Pathum Thani	296,315	130,032	0	0	19,915	146,368
** Muang Pathum Thani	96,546	14,486	0	0	5,470	76,590
* Sam Khok	40,517	0	0	0	8,578	31,939
* Lat Lum Kaeo	36,664	0	0	0	5,867	30,797
* Thanyaburi	39,957	39,957	0	0	0	0
* Lam Luk Ka	26,308	26,308	0	0	0	0
* Khlong Luang	56,323	49,281	0	0	0	7,042
Nonthaburi	449,979	354,773	0	0	0	95,206
** Muang Nonthaburi	202,595	186,045	0	0	0	16,550
Bang Yai	9,309	0	0	0	0	9,309
** Bang Bua Thong	68,406	47,105	0	0	0	21,301
* Pak Kret	169,669	121,623	0	0	0	48,046
Saraburi	30,792	0	0	0	0	30,792
Don Phunt	5,541	0	0	0	0	5,541
Ban Mo	15,433	0	0	0	0	15,433
Nong Don	9,818	0	0	0	0	9,818
Total	2,276,271	556,078	102,010	8,602	298,068	1,311,513

Note: *** refers to Amphoes that have a municipality within the basin.

** refers to Amphoes that have sanitary district/s within the basin.

Table 9.3.2 Quantity of Domestic Wastewater by Land Use Type (1992)

(unit: m³/day)

Province / Amphoe	Total Quantity	Municipalities (Urban)			Sanitary Districts (Sub- urban)	Rural Community
		Class A	Class B	Class C		
Chai Nat	16,195	0	2,690	0	1,518	11,987
** Muang Chai Nat	5,855	0	2,690	0	0	3,165
* Sankhaburi	5,024	0	0	0	765	4,259
* Sanphaya	5,316	0	0	0	753	4,563
Sing Buri	25,403	0	3,647	0	6,358	15,398
** Muang Sing Buri	6,663	0	3,647	0	0	3,016
* Khai Bang Rachan	3,075	0	0	0	467	2,608
* Tha Chang	1,865	0	0	0	1,322	543
* Bang Rachan	4,469	0	0	0	2,665	1,804
* Phrom Buri	2,678	0	0	0	923	1,755
* In Buri	6,653	0	0	0	981	5,672
Lop Buri	35,811	0	10,604	0	3,221	21,986
** Muang Lop Buri	28,239	0	10,604	0	2,590	15,045
Khok Samrong	97	0	0	0	0	97
* Tha Wung	5,199	0	0	0	631	4,568
Ban Mi	2,276	0	0	0	0	2,276
Ang Thong	27,676	0	3,027	0	6,381	18,268
** Muang Ang Thong	5,313	0	1,697	0	0	3,616
* Chaiyo	2,533	0	0	0	1,560	973
** Pa Mok	3,060	0	1,330	0	0	1,730
* Pho Thong	5,622	0	0	0	886	4,736
* Wiset Chai Chan	6,397	0	0	0	2,645	3,752
* Samko	1,171	0	0	0	809	362
* Sawaengha	3,580	0	0	0	481	3,099
Ayutthaya	74,067	22,522	993	1,144	17,293	32,115
** Muang Ayutthaya	27,872	22,522	0	0	1,433	3,917
** Tha Rua	5,802	0	0	1,144	2,040	2,618
* Nakhon Luang	3,483	0	0	0	983	2,500
* Bang Sai	1,775	0	0	0	795	980
* Bang Shai	4,584	0	0	0	1,428	3,156
* Bang Ban	3,650	0	0	0	1,387	2,263
* Bang Pahan	3,753	0	0	0	837	2,916
* Bang Pa-In	5,845	0	0	0	2,072	3,773
* Ban Phraek	969	0	0	0	330	639
* Phak Hai	5,029	0	0	0	3,000	2,029
* Maha Rat	2,350	0	0	0	361	1,989
* Lat Bua Luang	2,087	0	0	0	0	2,087
** Sena	6,824	0	993	0	2,627	3,204
Uthai	44	0	0	0	0	44
Pathum Thani	42,797	26,256	0	0	2,489	14,052
** Muang Pathum Thani	12,339	4,302	0	0	684	7,353
* Sam Khok	4,138	0	0	0	1,072	3,066
* Lat Lum Kao	3,690	0	0	0	733	2,957
* Thanyaburi	7,592	7,592	0	0	0	0
* Lam Luk Ka	4,999	4,999	0	0	0	0
* Khlong Luang	10,039	9,363	0	0	0	676
Nonthaburi	91,801	82,661	0	0	0	9,140
** Muang Nonthaburi	44,937	43,348	0	0	0	1,589
Bang Yai	894	0	0	0	0	894
** Bang Bua Thong	13,020	10,975	0	0	0	2,045
* Pak Kret	32,950	28,338	0	0	0	4,612
Saraburi	2,957	0	0	0	0	2,957
Don Phunt	532	0	0	0	0	532
Ban Mo	1,482	0	0	0	0	1,482
Nong Don	943	0	0	0	0	943
Total	316,707	131,439	20,961	1,144	37,260	125,903

Note: *** refers to Amphoes that have a municipality within the basin.

* ** refers to Amphoes that have sanitary district/s within the basin.

Table 9.3.3 Generated BOD Load of Domestic Wastewater by Land Use Type (1992)
(unit: kg/day)

Province / Amphoe	Total Generated BOD	Municipalities (Urban)			Sanitary Districts (Sub- urban)	Rural Community
		Class A	Class B	Class C		
Chai Nat	8,159	0	868	0	673	6,618
** Muang Chai Nat	2,615	0	868	0	0	1,747
* Sankhaburi	2,691	0	0	0	339	2,352
* Sanphaya	2,853	0	0	0	334	2,519
Sing Buri	12,690	0	1,365	0	2,823	8,502
** Muang Sing Buri	3,030	0	1,365	0	0	1,665
* Khai Bang Rachan	1,647	0	0	0	207	1,440
* Tha Chang	887	0	0	0	587	300
* Bang Rachan	2,179	0	0	0	1,183	996
* Phrom Buri	1,379	0	0	0	410	969
* In Buri	3,568	0	0	0	436	3,132
Lop Buri	15,939	0	2,371	0	1,430	12,138
** Muang Lop Buri	11,827	0	2,371	0	1,150	8,306
* Khok Samrong	54	0	0	0	0	54
* Tha Wung	2,801	0	0	0	280	2,521
Ban Mi	1,257	0	0	0	0	1,257
Ang Thong	14,149	0	1,232	0	2,832	10,085
** Muang Ang Thong	2,599	0	603	0	0	1,996
* Chaiyo	1,229	0	0	0	692	537
** Pa Mok	1,584	0	629	0	0	955
* Pho Thong	3,008	0	0	0	393	2,615
* Wiset Chai Chan	3,246	0	0	0	1,175	2,071
* Samko	559	0	0	0	359	200
* Sawaengha	1,924	0	0	0	213	1,711
Ayutthaya	30,855	4,676	292	478	7,677	17,732
** Muang Ayutthaya	7,476	4,676	0	0	636	2,164
** Tha Rua	2,829	0	0	478	906	1,445
* Nakhon Luang	1,816	0	0	0	436	1,380
* Bang Sai	894	0	0	0	353	541
* Bang Shai	2,377	0	0	0	634	1,743
* Bang Ban	1,866	0	0	0	616	1,250
* Bang Pahan	1,981	0	0	0	371	1,610
* Bang Pa-In	3,003	0	0	0	920	2,083
* Ban Phraek	500	0	0	0	147	353
* Phak Hai	2,452	0	0	0	1,332	1,120
* Maha Rat	1,258	0	0	0	160	1,098
* Lat Bua Luang	1,152	0	0	0	0	1,152
** Sena	3,227	0	292	0	1,166	1,769
Uthai	24	0	0	0	0	24
Pathum Thani	16,804	7,941	0	0	1,106	7,757
** Muang Pathum Thani	5,303	940	0	0	304	4,059
* Sam Khok	2,169	0	0	0	476	1,693
* Lat Lum Kao	1,958	0	0	0	326	1,632
* Thanyaburi	2,421	2,421	0	0	0	0
* Lam Luk Ka	1,594	1,594	0	0	0	0
* Khlong Luang	3,359	2,986	0	0	0	373
Nonthaburi	27,182	22,137	0	0	0	5,045
** Muang Nonthaburi	12,486	11,609	0	0	0	877
Bang Yai	493	0	0	0	0	493
** Bang Bua Thong	4,068	2,939	0	0	0	1,129
* Pak Kret	10,135	7,589	0	0	0	2,546
Saraburi	1,632	0	0	0	0	1,632
Don Phunt	294	0	0	0	0	294
Ban Mo	818	0	0	0	0	818
Nong Don	520	0	0	0	0	520
Total	127,410	34,754	6,128	478	16,541	69,509

Note: "***" refers to Amphoes that have a municipality within the basin.

"**" refers to Amphoes that have sanitary district/s within the basin.

Table 9.3.4 Discharged BOD Load of Domestic Wastewater by Land Use Type (1992)
(unit: kg/day)

Province / Amphoe	Total Discharged BOD	Municipalities (Urban)			Sanitary Districts (Sub- urban)	Rural Community
		Class A	Class B	Class C		
Chai Nat	7,325	0	788	0	607	5,930
** Muang Chai Nat	2,354	0	788	0	0	1,566
* Sankhaburi	2,413	0	0	0	306	2,107
* Sanphaya	2,558	0	0	0	301	2,257
Sing Buri	11,399	0	1,237	0	2,543	7,619
** Muang Sing Buri	2,730	0	1,237	0	0	1,493
* Khai Bang Rachan	1,477	0	0	0	187	1,290
* Tha Chang	798	0	0	0	529	269
* Bang Rachan	1,958	0	0	0	1,066	892
* Phrom Buri	1,238	0	0	0	369	869
* In Buri	3,198	0	0	0	392	2,806
Lop Buri	14,329	0	2,162	0	1,289	10,878
** Muang Lop Buri	10,642	0	2,162	0	1,036	7,444
Khok Samrong	48	0	0	0	0	48
* Tha Wung	2,513	0	0	0	253	2,260
Ban Mi	1,126	0	0	0	0	1,126
Ang Thong	12,703	0	1,114	0	2,552	9,037
** Muang Ang Thong	2,334	0	546	0	0	1,788
* Chaiyo	1,106	0	0	0	624	482
** Pa Mok	1,424	0	568	0	0	856
* Pho Thong	2,697	0	0	0	354	2,343
* Wiset Chai Chan	2,914	0	0	0	1,058	1,856
* Samko	503	0	0	0	324	179
* Sawaengha	1,725	0	0	0	192	1,533
Ayutthaya	27,793	4,284	265	431	6,917	15,896
** Muang Ayutthaya	6,796	4,284	0	0	573	1,939
** Tha Rua	2,542	0	0	431	816	1,295
* Nakhon Luang	1,630	0	0	0	393	1,237
* Bang Sai	803	0	0	0	318	485
* Bang Shai	2,133	0	0	0	571	1,562
* Bang Ban	1,675	0	0	0	555	1,120
* Bang Pahan	1,779	0	0	0	335	1,444
* Bang Pa-In	2,697	0	0	0	829	1,868
* Ban Phraek	449	0	0	0	132	317
* Phak Hai	2,204	0	0	0	1,200	1,004
* Maha Rat	1,129	0	0	0	144	985
Lat Bua Luang	1,033	0	0	0	0	1,033
** Sena	2,901	0	265	0	1,051	1,585
Uthai	22	0	0	0	0	22
Pathum Thani	15,175	7,227	0	0	996	6,952
** Muang Pathum Thani	4,772	860	0	0	274	3,638
* Sam Khok	1,946	0	0	0	429	1,517
* Lat Lum Kaeo	1,756	0	0	0	293	1,463
* Thanyaburi	2,202	2,202	0	0	0	0
* Lam Luk Ka	1,450	1,450	0	0	0	0
* Khlong Luang	3,049	2,715	0	0	0	334
Nonthaburi	24,708	20,186	0	0	0	4,522
** Muang Nonthaburi	11,372	10,586	0	0	0	786
Bang Yai	442	0	0	0	0	442
** Bang Bua Thong	3,692	2,680	0	0	0	1,012
* Pak Kret	9,202	6,920	0	0	0	2,282
Sara Buri	1,462	0	0	0	0	1,462
Don Phunt	263	0	0	0	0	263
Ban Mo	733	0	0	0	0	733
Nong Don	466	0	0	0	0	466
Total	114,894	31,697	5,566	431	14,904	62,296

Note: "***" refers to Amphoes that have a municipality within the basin.

"**" refers to Amphoes that have sanitary district/s within the basin.

Table 9.3.5 No. of Employee in Industrial Sector by Province (1992)

Industrial Group	Food Processing	Min./Ceme. Ceramics	Light Processing	Machine/ Electric.	Others	Total
Chai Nat	4,547	226	205	240	478	5,697
Sing Buri	6,378	896	795	671	839	9,579
Lop Buri	6,091	2,447	686	4,908	1,942	16,073
Ang Thong	2,459	4,872	8,051	424	2,898	18,504
Ayutthaya	18,895	6,892	10,481	83,148	29,183	148,599
Pathum Thani	4,244	10,485	69,751	86,517	21,201	192,198
Nonthaburi	2,470	4,230	40,595	50,353	12,339	109,987
Saraburi	17,860	49,515	53,531	16,610	14,235	151,751
Total	62,944	79,363	184,095	242,871	83,115	652,388

Table 9.3.6 Quantity of Industrial Wastewater by Province (1992)

(unit: m3/day)

Industrial Group	Food Processing	Min./Ceme. Ceramics	Light Processing	Machine/ Electric.	Others	Total
Unit Quantity	0.81	0.34	0.27	0.08	0.70	-
Chai Nat	3,683	77	55	19	335	4,169
Sing Buri	5,166	305	215	54	587	6,327
Lop Buri	4,934	832	185	393	1,359	7,703
Ang Thong	1,992	1,588	2,174	34	2,029	7,817
Ayutthaya	15,305	2,343	2,830	6,652	20,428	47,558
Pathum Thani	3,438	3,565	18,833	6,921	14,841	47,598
Nonthaburi	2,001	1,438	10,961	4,028	8,637	27,065
Saraburi	14,467	16,835	14,453	1,329	9,965	57,049
Total	50,986	26,983	49,708	19,430	58,181	205,286

Note: unit for Unit Quantity; m3/day/employee

Table 9.3.7 Generated BOD of Industrial Wastewater by Province (1992)

(unit: kg/day)

Industrial Group	Food Processing	Min./Ceme. Ceramics	Light Processing	Machine/ Electric.	Others	Total
Unit Quantity	1,115	126	128	13	421	-
Chai Nat	5,070	28	26	3	201	5,328
Sing Buri	7,111	113	102	9	353	7,688
Lop Buri	6,791	308	88	64	818	8,069
Ang Thong	2,742	589	1,031	6	1,220	5,588
Ayutthaya	21,068	868	1,342	1,081	12,286	36,645
Pathum Thani	4,732	1,321	8,928	1,125	8,926	25,032
Nonthaburi	2,754	533	5,196	655	5,195	14,333
Saraburi	19,914	6,239	6,852	216	5,993	39,214
Total	70,182	9,999	23,565	3,159	34,992	141,897

Note: unit of Unit Quantity; g/day/employee

Table 9.3.8 Discharged BOD of Industrial Wastewater by Province (1992)

(unit: kg/day)

Industrial Group	Food Processing	Min./Ceme. Ceramics	Light Processing	Machine/ Electric.	Others	Total
Unit Load w/ TP	14	1	10	1	22	-
Unit Load w/o TP	1,115	126	128	13	421	-
Chai Nat	2,567	14	14	2	106	2,703
Sing Buri	3,600	57	55	5	185	3,903
Lop Buri	3,438	155	47	34	430	4,104
Ang Thong	1,388	297	556	3	642	2,886
Ayutthaya	10,666	438	723	582	6,464	18,873
Pathum Thani	2,396	666	4,813	606	4,696	13,177
Nonthaburi	1,394	269	2,801	352	2,733	7,549
Saraburi	10,082	3,144	3,694	116	3,153	20,189
Total	35,531	5,040	12,703	1,700	18,410	73,384

Note: unit of Unit Quantity; g/day/employee

9.3.3 Other Wastewater Sources

(1) Livestock

Quantity of wastewater, generated BOD load and discharged BOD load from livestock by province were calculated as shown in Table 9.3.9 using the estimated number of livestock and unit quantity of wastewater, generated BOD load and discharged BOD load presented in Tables 6.3.1 and 8.4.1.

(2) Slaughterhouse

Quantity of wastewater, generated BOD load and discharged BOD load from slaughterhouse by province were calculated as shown in Table 9.3.10 using the estimated number of slaughtered livestock and unit quantity of wastewater, generated BOD load and discharged BOD load presented in Tables 6.4.1 and 8.4.2.

(3) Fresh Market

Quantity of wastewater, generated BOD load and discharged BOD load from fresh market by province were calculated as shown in Table 9.3.11 considering the assumed location of fresh market either within or outside the study area and unit generated and discharged BOD load presented in Section 8.4.3.

(4) Fish Pond

Quantity of wastewater, generated BOD load and discharged BOD load from fishpond by province were calculated as shown in Table 9.3.12 using the projected area of fish pond and unit generated/discharged BOD load presented in Table 6.3.3 and Section 8.4.4.

The figures within the study basin was arrived at in proportion to the area coverage in each province.

Table 9.3.9 Number of Livestock and Generated/Discharged BOD by Province (1992)

Province	Livestock	Estimated Number of Livestock	Generated Wastewater			Generated BOD Load			Discharged BOD Load		
			Unit Qt'ty (l/h./day)	Qt'ty (m3/day)		Unit Qt'ty (g/h./day)	Qt'ty (kg/day)		Unit Qt'ty (g/h./day)	Qt'ty (kg/day)	
Chai Nat	Buffaloes	22,000	90.0	1,980		640	14,080		0	0	
	Cattle	53,700	90.0	4,833		640	34,368		0	0	
	Swine	36,400	13.5	491		200	7,280		100	3,640	
Sing Buri	Buffaloes	2,500	90.0	225		640	1,600		0	0	
	Cattle	32,600	90.0	2,934		640	20,864		0	0	
	Swine	22,900	13.5	309		200	4,580		100	2,290	
Lop Buri	Buffaloes	16,100	90.0	1,449		640	10,304		0	0	
	Cattle	176,700	90.0	15,903		640	113,088		0	0	
	Swine	83,700	13.5	1,130		200	16,740		100	8,370	
Ang Thong	Buffaloes	6,100	90.0	549		640	3,904		0	0	
	Cattle	36,500	90.0	3,285		640	23,360		0	0	
	Swine	45,200	13.5	610		200	9,040		100	4,520	
Ayutthaya	Buffaloes	23,900	90.0	2,151		640	15,296		0	0	
	Cattle	34,900	90.0	3,141		640	22,336		0	0	
	Swine	52,000	13.5	702		200	10,400		100	5,200	
Pathum Thani	Buffaloes	7,900	90.0	711		640	5,056		0	0	
	Cattle	10,700	90.0	963		640	6,848		0	0	
	Swine	45,200	13.5	610		200	9,040		100	4,520	
Nonthaburi	Buffaloes	1,600	90.0	144		640	1,024		0	0	
	Cattle	3,400	90.0	306		640	2,176		0	0	
	Swine	4,500	13.5	61		200	900		100	450	
Saraburi	Buffaloes	16,900	90.0	1,521		640	10,816		0	0	
	Cattle	63,400	90.0	5,706		640	40,576		0	0	
	Swine	105,700	13.5	1,427		200	21,140		100	10,570	
TOTAL	Buffaloes	97,000	90.0	8,730		4,480	62,080		0	0	
	Cattle	411,900	90.0	37,071		4,480	263,616		0	0	
	Swine	395,600	13.5	5,341		200	79,120		100	39,560	

Table 9.3.10 Quantity and BOD Load of Slaughterhouse Wastewater by Province (1992)

Generated Wastewater

Province	No. of Slaughtered Livestock			Unit Wastewater Qt'y			Generated Wastewater Quantity			
	Buffaloes (head)	Cattle (head)	Swine (head)	Buffalo (l/h/d)	Cattle (l/h/d)	Swine (l/h/d)	Buffaloes (m3/day)	Cattle (m3/day)	Swine (m3/day)	Total (m3/day)
Chai Nat	1,570	500	17,300	3,498	3,498	1,166	5,492	1,749	20,172	27,413
Sing Buri	90	510	6,610	3,498	3,498	1,166	315	1,784	7,707	9,806
Lop Buri	240	7,000	26,280	3,498	3,498	1,166	840	24,486	30,642	55,968
Ang Thong	1,160	1,440	25,790	3,498	3,498	1,166	4,058	5,037	30,071	39,166
Ayutthaya	6,450	7,920	49,890	3,498	3,498	1,166	22,562	27,704	58,172	108,438
Pathum Thani	29,460	22,660	86,350	3,498	3,498	1,166	103,051	79,265	100,684	283,000
Nonthaburi	6,270	5,830	42,250	3,498	3,498	1,166	21,932	20,393	49,264	91,589
Sara Buri	1,870	3,950	52,550	3,498	3,498	1,166	6,541	13,817	61,273	81,632
Total	47,110	49,810	307,020	3,498	3,498	1,166	164,791	174,235	357,985	697,011

Generated BOD Load

Province	No. of Slaughtered Livestock			Unit Gen'd BOD Load			Generated BOD Load			
	Buffaloes (head)	Cattle (head)	Swine (head)	Buffalo (g/h/d)	Cattle (g/h/d)	Swine (g/h/d)	Buffaloes (kg/day)	Cattle (kg/day)	Swine (kg/day)	Total (kg/day)
Chai Nat	1,570	500	17,300	6,600	6,600	2,200	10,362	3,300	38,060	51,722
Sing Buri	90	510	6,610	6,600	6,600	2,200	594	3,366	14,542	18,502
Lop Buri	240	7,000	26,280	6,600	6,600	2,200	1,584	46,200	57,816	105,600
Ang Thong	1,160	1,440	25,790	6,600	6,600	2,200	7,656	9,504	56,738	73,898
Ayutthaya	6,450	7,920	49,890	6,600	6,600	2,200	42,570	52,272	109,758	204,600
Pathum Thani	29,460	22,660	86,350	6,600	6,600	2,200	194,436	149,556	189,970	533,962
Nonthaburi	6,270	5,830	42,250	6,600	6,600	2,200	41,382	38,478	92,950	172,810
Sara Buri	1,870	3,950	52,550	6,600	6,600	2,200	12,342	26,070	115,610	154,022
Total	47,110	49,810	307,020	6,600	6,600	2,200	310,926	328,746	675,444	1,315,116

Discharged Quantity

Province	No. of Slaughtered Livestock			Unit Wastewater Qt'y			Discharged Wastewater Quantity			
	Buffaloes (head)	Cattle (head)	Swine (head)	Buffalo (l/h/d)	Cattle (l/h/d)	Swine (l/h/d)	Buffaloes (m3/day)	Cattle (m3/day)	Swine (m3/day)	Total (m3/day)
Chai Nat	1,570	500	17,300	4,350	4,350	1,450	6,830	2,175	25,085	34,090
Sing Buri	90	510	6,610	4,350	4,350	1,450	392	2,219	9,585	12,195
Lop Buri	240	7,000	26,280	4,350	4,350	1,450	1,044	30,450	38,106	69,600
Ang Thong	1,160	1,440	25,790	4,350	4,350	1,450	5,046	6,264	37,396	48,706
Ayutthaya	6,450	7,920	49,890	4,350	4,350	1,450	28,058	34,452	72,341	134,850
Pathum Thani	29,460	22,660	86,350	4,350	4,350	1,450	128,151	98,571	125,208	351,930
Nonthaburi	6,270	5,830	42,250	4,350	4,350	1,450	27,275	25,361	61,263	113,898
Sara Buri	1,870	3,950	52,550	4,350	4,350	1,450	8,135	17,183	76,198	101,515
Total	47,110	49,810	307,020	4,350	4,350	1,450	204,929	216,674	445,179	866,781

Discharged BOD Load

Province	No. of Slaughtered Livestock			Unit Disc'd BOD Load			Discharged BOD Load			
	Buffaloes (head)	Cattle (head)	Swine (head)	Buffalo (g/h/d)	Cattle (g/h/d)	Swine (g/h/d)	Buffaloes (kg/day)	Cattle (kg/day)	Swine (kg/day)	Total (kg/day)
Chai Nat	1,570	500	17,300	480	480	160	754	240	2,768	3,762
Sing Buri	90	510	6,610	480	480	160	43	245	1,058	1,346
Lop Buri	240	7,000	26,280	480	480	160	115	3,360	4,205	7,680
Ang Thong	1,160	1,440	25,790	480	480	160	557	691	4,126	5,374
Ayutthaya	6,450	7,920	49,890	480	480	160	3,096	3,802	7,982	14,880
Pathum Thani	29,460	22,660	86,350	480	480	160	14,141	10,877	13,816	38,834
Nonthaburi	6,270	5,830	42,250	480	480	160	3,010	2,798	6,760	12,568
Sara Buri	1,870	3,950	52,550	480	480	160	898	1,896	8,408	11,202
Total	47,110	49,810	307,020	480	480	160	22,513	23,909	49,123	95,645

Table 9.3.11 Quantity and Discharged BOD Load of Fresh Market Wastewater

Province / Amphoe	Fresh Market Wastewater Quantity Total (m3/day)	F.M. Wastewater Quantity		F.M. W.W. Discharged BOD	
		within Basin (m3/day)	out of Basin (m3/day)	within Basin (kg/day)	out of Basin (kg/day)
Chai Nat	80	40	40	40	40
Muang Chai Nat	40	40	0	40	0
Wat Sing	40	0	40	0	40
Sing Buri	40	40	0	40	0
Muang Sing Buri	40	40	0	40	0
Lop Buri	120	40	80	40	80
Muang Lop Buri	40	40	0	40	0
Khok Samrong	40	0	40	0	40
Ban Mi	40	0	40	0	40
Ang Thong	80	80	0	80	0
Muang Ang Thong	40	40	0	40	0
Pa Mok	40	40	0	40	0
Ayutthaya	120	120	0	120	0
Muang Ayutthaya	40	40	0	40	0
Tha Rua	40	40	0	40	0
Sena	40	40	0	40	0
Pathum Thani	40	40	0	40	0
Muang Pathum Thani	40	40	0	40	0
Nonthaburi	120	120	0	120	0
Muang Nonthaburi	40	40	0	40	0
Bang Bua Thong	40	40	0	40	0
Pak Kret	40	40	0	40	0
Saraburi	160	0	160	0	160
Muang Saraburi	40	0	40	0	40
Kaeng Khoi	40	0	40	0	40
Phra Phutthabat	40	0	40	0	40
Nong Khae	40	0	40	0	40
Total	760	480	280	480	280

**Table 9.3.12 Quantity and Generated BOD Load
of Fish Pond Wastewater**

Province / Amphoe	Administrative Area (km2)			Area of Fish Pond (m2)	Quantity of Fish Pond Wastewater *			Generated BOD of F.P. Wastewater**		
	Admin. Total	Within Basin	Out of Basin		Total (m3/day)	within Basin	out of Basin	Total (kg/day)	within Basin	out of Basin
Chai Nat	2,469.7	624.3	1,845.4	1,331,446	12,482	5,561	6,921	250	111	138
Muang Chai Nat	255.4	147.0	108.4	276,237	2,590	1,491	1,099	52	30	22
Manorom	225.6	0.0	225.6	136,588	1,281	0	1,281	26	0	26
Wat Sing	606.3	0.0	606.3	138,400	1,298	0	1,298	26	0	26
Sankhaburi	354.8	249.0	105.8	383,200	3,593	2,521	1,071	72	50	21
Sanphaya	226.3	226.3	0.0	165,236	1,549	1,549	0	31	31	0
Hankha	799.3	0.0	799.3	231,785	2,173	0	2,173	43	0	43
Sing Buri	822.5	822.5	0.0	460,874	4,321	4,321	0	86	86	0
Muang Sing Buri	112.4	112.4	0.0	90,776	851	851	0	17	17	0
Khai Bang Rachan	88.4	88.4	0.0	90,730	851	851	0	17	17	0
Tha Chang	34.4	34.4	0.0	32,452	304	304	0	6	6	0
Bang Rachan	190.5	190.5	0.0	109,148	1,023	1,023	0	20	20	0
Phrom Buri	82.5	82.5	0.0	75,613	709	709	0	14	14	0
In Buri	314.3	314.3	0.0	62,155	583	583	0	12	12	0
Lop Buri	6,199.8	849.5	5,350.3	1,204,595	11,293	3,350	7,943	226	67	159
Muang Lop Buri	565.6	426.8	138.8	263,113	2,467	1,861	605	49	37	12
Khok Samrong	982.5	17.5	965.0	131,055	1,229	22	1,207	25	0	24
Chai Badan	1,253.0	0.0	1,253.0	37,360	350	0	350	7	0	7
Tha Luang	538.9	0.0	538.9	-	0	0	0	0	0	0
Tha Wung	242.8	242.8	0.0	79,015	741	741	0	15	15	0
Ban Mi	585.7	162.4	423.3	279,477	2,620	726	1,894	52	15	38
Pattana Nikom	517.0	0.0	517.0	412,975	3,872	0	3,872	77	0	77
Sa Boat	304.7	0.0	304.7	1,600	15	0	15	0	0	0
Khok Charoen	317.1	0.0	317.1	-	0	0	0	0	0	0
Lam San Thi	447.0	0.0	447.0	-	0	0	0	0	0	0
Nang Muang	445.5	0.0	445.5	-	0	0	0	0	0	0
Ang Thong	968.4	888.2	80.2	695,419	6,520	6,036	483	130	121	10
Muang Ang Thong	102.9	102.0	0.9	124,966	1,172	1,161	10	23	23	0
Chalyo	72.3	72.3	0.0	15,804	148	148	0	3	3	0
Pa Mok	80.9	80.9	0.0	75,745	710	710	0	14	14	0
Pha Thong	219.4	212.4	7.0	173,318	1,625	1,573	52	32	31	1
Wiset Chai Chan	224.7	189.3	35.4	277,756	2,604	2,194	410	52	44	8
Samko	86.9	50.0	36.9	2,800	26	15	11	1	0	0
Sawaengha	181.3	181.3	0.0	25,010	234	234	0	5	5	0
Ayutthaya	2,556.6	1,907.5	649.1	8,118,624	76,112	68,836	7,276	1,522	1,377	146
Muang Ayutthaya	130.6	130.6	0.0	37,200	349	349	0	7	7	0
Tha Rua	106.2	106.2	0.0	14,100	132	132	0	3	3	0
Nakhom Luang	198.9	198.9	0.0	56,050	525	525	0	11	11	0
Bang Sai	150.7	119.3	31.4	1,886,350	17,685	14,000	3,685	354	280	74
Bang Shai	219.7	219.7	0.0	481,900	4,518	4,518	0	90	90	0
Bang Ban	135.3	135.3	0.0	46,209	433	433	0	9	9	0
Bang Pahan	121.9	121.9	0.0	135,931	1,274	1,274	0	25	25	0
Bang Pa-In	229.1	189.1	40.0	146,676	1,375	1,195	240	28	23	5
Ban Phraek	39.1	39.1	0.0	33,148	311	311	0	6	6	0
Phak Hai	189.0	189.0	0.0	1,580,472	14,617	14,617	0	296	296	0
Phachi	104.5	0.0	104.5	43,370	407	0	407	8	0	8
Maharat	120.1	120.1	0.0	307,044	2,879	2,879	0	58	58	0
Lat Bua Luang	199.9	136.9	63.0	633,520	5,939	4,067	1,872	119	81	37
Wang Noi	219.2	0.0	219.2	4,700	44	0	44	1	0	1
Sena	205.6	198.9	6.7	2,689,554	25,215	24,393	822	504	488	16
Uthai	188.8	2.5	186.3	22,400	210	3	207	4	0	4
Pathum Thani	1,525.9	485.5	1,040.4	7,052,761	66,120	32,745	33,375	1,322	655	668
Muang Pathum Thani	120.2	120.2	0.0	470,150	4,408	4,408	0	88	88	0
Sam Khok	95.0	95.0	0.0	740,590	6,943	6,943	0	139	139	0
Lat Lum Kao	188.1	188.1	0.0	1,864,051	17,475	17,475	0	350	350	0
Thanya Buri	112.1	8.7	103.4	545,914	5,118	397	4,721	102	8	94
Lam Luk Ka	297.7	6.0	291.7	1,456,540	13,655	275	13,380	273	6	268
Klong Luang	299.2	67.5	231.7	1,534,756	14,388	3,246	11,142	288	65	223
Nong Sua	413.6	0.0	413.6	440,760	4,132	0	4,132	83	0	83
Nonthaburi	622.3	273.6	348.7	1,999,314	18,744	10,112	8,632	375	202	173
Muang Nonthaburi	77.0	42.3	34.7	653,600	6,128	3,366	2,761	123	67	55
Kruai	57.4	0.0	57.4	150,670	1,413	0	1,413	28	0	28
Bang Yai	96.4	25.9	70.5	133,140	1,248	335	913	25	7	18
Bang Bua Thong	116.4	116.4	0.0	589,764	5,529	5,529	0	111	111	0
Pak Kret	89.0	89.0	0.0	94,000	881	881	0	18	18	0
Sai Noi	186.1	0.0	186.1	378,140	3,545	0	3,545	71	0	71
Total	15,166.2	5,851.1	9,314.1	20,863,033	195,591	130,960	64,630	3,912	2,619	1,293

Note: 1) unit wastewater quantity; 15 m3/rai/day (93.75 m3/ha/day)

2) unit BOD load generation; 0.3 g/rai/day (1.875 g/ha/day)

BOD concentration; 20 mg/l

(5) Natural Pollution Load

Natural pollution load in the study basin (defined as concentrated BOD load) was calculated as shown in Table 9.3.13 based on the administrative area of each province either within or outside the study area and assumed unit BOD load presented in Section 8.4.5.

9.4 Frame Values and Generated/Discharged Pollution Load by Each Area of Water Quality Checking Point/Pollution Load Inflow Point

Frame values and generated/discharged pollution load by province were further sub-divided into sub-areas by each area of pollution load inflow point as shown in Figure 9.2.2. Areas of amphoes by province were sub-divided into related river basins, as presented in Table 9.4.1, from measurement on topographic map. Composition of related river basins by province is shown in Table 9.4.2.

In the delineation by sub-areas (covered area by weighted pollution load inflow point, one each per province), the following conditions were taken into account.

(1) Domestic wastewater

Population in 1992 (Table 9.3.1) was further distributed to 20 sub-areas as presented in Table 9.4.3. Population in the rural communities was distributed in proportion to the area of amphoes belonging to respective sub-areas.

Location of municipalities and sanitary districts was also taken into account for population proportioning. The following were the major consideration:

Table 9.3.13 Natural Pollution Load by Province and Amphoe

Province / Amphoe	Area (km ²)			Natural P. Load Unit Q'ty (kg/km ² /d)	Natural Pollution Load (BOD) (kg/day)		
	Admin. Total	Within Basin	Out of Basin		Admin. Total	Within Basin	Out of Basin
Chai Nat	2,489.7	624.3	1,845.4	0.5	1,235	312	923
Muang Chai Nat	255.4	147.0	108.4	0.5	128	74	54
Manorom	225.6	0.0	225.6	0.5	113	0	113
Wat Sing	606.3	0.0	606.3	0.5	303	0	303
Sankhaburi	354.8	249.0	105.8	0.5	177	125	53
Sanphaya	228.3	228.3	0.0	0.5	114	114	0
Hankha	799.3	0.0	799.3	0.5	400	0	400
Sing Buri	822.5	822.5	0.0	0.5	411	411	0
Muang Sing Buri	112.4	112.4	0.0	0.5	56	56	0
Khai Bang Rachan	88.4	88.4	0.0	0.5	44	44	0
Tha Chang	34.4	34.4	0.0	0.5	17	17	0
Bang Rachan	190.5	190.5	0.0	0.5	95	95	0
Phrom Buri	82.5	82.5	0.0	0.5	41	41	0
In Buri	314.3	314.3	0.0	0.5	157	157	0
Lop Buri	6,199.8	849.5	5,350.3	0.5	3,100	425	2,675
Muang Lop Buri	565.6	426.8	138.8	0.5	283	213	69
Khok Samrong	982.5	17.5	965.0	0.5	491	9	483
Chai Badan	1,253.0	0.0	1,253.0	0.5	627	0	627
Tha Luang	538.9	0.0	538.9	0.5	269	0	269
Tha Wung	242.8	242.8	0.0	0.5	121	121	0
Ban Mi	585.7	162.4	423.3	0.5	293	81	212
Pattana Nikom	517.0	0.0	517.0	0.5	259	0	259
Sa Boat	304.7	0.0	304.7	0.5	152	0	152
Khok Charoen	317.1	0.0	317.1	0.5	159	0	159
Lam San Thi	447.0	0.0	447.0	0.5	224	0	224
Nang Muang	445.5	0.0	445.5	0.5	223	0	223
Ang Thong	988.4	888.2	80.2	0.5	484	444	40
Muang Ang Thong	102.9	102.0	0.9	0.5	51	51	0
Chaiyo	72.3	72.3	0.0	0.5	36	36	0
Pa Mok	80.9	80.9	0.0	0.5	40	40	0
Pha Thong	219.4	212.4	7.0	0.5	110	106	4
Wiset Chal Chan	224.7	189.3	35.4	0.5	112	95	18
Samko	86.9	50.0	36.9	0.5	43	25	18
Sawaengha	181.3	181.3	0.0	0.5	91	91	0
Ayutthaya	2,556.6	1,907.5	649.1	0.5	1,278	954	325
Muang Ayutthaya	130.6	130.6	0.0	0.5	65	65	0
Tha Rua	106.2	106.2	0.0	0.5	53	53	0
Nakhorn Luang	198.9	198.9	0.0	0.5	99	99	0
Bang Sai	150.7	119.3	31.4	0.5	75	60	16
Bang Shai	219.7	219.7	0.0	0.5	110	110	0
Bang Ban	135.3	135.3	0.0	0.5	68	68	0
Bang Pahan	121.9	121.9	0.0	0.5	61	61	0
Bang Pa-In	229.1	189.1	40.0	0.5	115	95	20
Ban Phraek	39.1	39.1	0.0	0.5	20	20	0
Phak Hai	189.0	189.0	0.0	0.5	95	95	0
Phachi	104.5	0.0	104.5	0.5	52	0	52
Maha Rat	120.1	120.1	0.0	0.5	60	60	0
Lat Bua Luang	199.9	136.9	63.0	0.5	100	68	32
Wang Noi	219.2	0.0	219.2	0.5	110	0	110
Sena	205.6	198.9	6.7	0.5	103	99	3
Uthai	186.8	2.5	184.3	0.5	93	1	92
Pathum Thani	1,525.9	485.5	1,040.4	1.0	1,526	486	1,040
Muang Pathum Thani	120.2	120.2	0.0	1.0	120	120	0
Sam Khok	95.0	95.0	0.0	1.0	95	95	0
Lat Lum Kaeo	188.1	188.1	0.0	1.0	188	188	0
Thanya Buri	112.1	8.7	103.4	1.0	112	9	103
Lam Luk Ka	297.7	6.0	291.7	1.0	298	6	292
Klong Luang	299.2	67.5	231.7	1.0	299	68	232
Nong Sua	413.6	0.0	413.6	1.0	414	0	414
Nonthaburi	622.3	273.6	348.7	1.0	622	274	349
Muang Nonthaburi	77.0	42.3	34.7	1.0	77	42	35
Kruai	57.4	0.0	57.4	1.0	57	0	57
Bang Yai	96.4	25.9	70.5	1.0	96	26	71
Bang Bua Thong	116.4	116.4	0.0	1.0	116	116	0
Pak Kret	89.0	89.0	0.0	1.0	89	89	0
Sai Noi	186.1	0.0	186.1	1.0	186	0	186
Sara Buri	3,576.6	186.3	3,390.3	0.5	1,788	93	1,695
Muang Sara Buri	503.8	0.0	503.8	0.5	252	0	252
Kaeng Khoi	871.1	0.0	871.1	0.5	436	0	436
Don Phunt	65.6	65.6	0.0	0.5	33	33	0
Ban Mo	279.0	93.7	185.3	0.5	140	47	93
Phra Phuthabat	324.6	0.0	324.6	0.5	162	0	162
Muak Lek	752.5	0.0	752.5	0.5	376	0	376
Wihan Daeng	228.8	0.0	228.8	0.5	114	0	114
Sachai	125.1	0.0	125.1	0.5	63	0	63
Nong Khae	293.8	0.0	293.8	0.5	147	0	147
Nong Saeng	97.4	0.0	97.4	0.5	49	0	49
Nong Don	34.9	27.0	7.9	0.5	17	14	4
Total	18,741.8	6,037.4	12,704.4	-	10,445	3,398	7,047

Table 9.4.1 Area of Provinces and Amphoes by Sub-area

Province / Amphoe	Area (km ²)			Breakdown by Sub-area (km ²)						
	Admin. Total	Within Basin	Out of Basin	Noi River	Lop Buri River	Pasek River	Main R. (R0 - R1)	Main R. (R1 - R2)	Main R. (R2 - R3)	Main R. (R3 - R4)
Chai Nat	2,469.7	624.3	1,845.4	284.5	0.0	0.0	51.3	288.5	0.0	0.0
** Muang Chai Nat	255.4	147.0	108.4	34.3	0.0	0.0	51.3	61.4	0.0	0.0
Manorom	225.6	0.0	225.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wat Sing	606.3	0.0	606.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
* Sankhaburi	354.8	249.0	105.8	226.3	0.0	0.0	0.0	22.7	0.0	0.0
* Sanphaya	228.3	228.3	0.0	23.9	0.0	0.0	0.0	204.4	0.0	0.0
Hankha	799.3	0.0	799.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sing Buri	822.5	822.5	0.0	344.4	108.6	0.0	0.0	369.5	0.0	0.0
** Muang Sing Buri	112.4	112.4	0.0	31.3	15.2	0.0	0.0	65.9	0.0	0.0
* Khai Bang Rachan	88.4	88.4	0.0	88.4	0.0	0.0	0.0	0.0	0.0	0.0
* Tha Chang	34.4	34.4	0.0	34.4	0.0	0.0	0.0	0.0	0.0	0.0
* Bang Rachan	190.5	190.5	0.0	180.1	0.0	0.0	0.0	10.4	0.0	0.0
* Phrom Buri	82.5	82.5	0.0	8.2	0.0	0.0	0.0	74.3	0.0	0.0
* In Buri	314.3	314.3	0.0	2.0	93.4	0.0	0.0	218.9	0.0	0.0
Lop Buri	6,199.8	849.5	5,350.3	0.0	806.0	0.0	0.0	43.5	0.0	0.0
** Muang Lop Buri	565.6	426.8	138.8	0.0	426.8	0.0	0.0	0.0	0.0	0.0
Khok Samrong	982.5	17.5	965.0	0.0	17.5	0.0	0.0	0.0	0.0	0.0
Chai Badan	1,253.0	0.0	1,253.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tha Luang	538.9	0.0	538.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
* Tha Wung	242.8	242.8	0.0	0.0	199.3	0.0	0.0	43.5	0.0	0.0
Ban Mi	585.7	162.4	423.3	0.0	162.4	0.0	0.0	0.0	0.0	0.0
Patana Nikom	517.0	0.0	517.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sa Boet	304.7	0.0	304.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Khok Charoen	317.1	0.0	317.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lam San Thi	447.0	0.0	447.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nang Muang	445.5	0.0	445.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ang Thong	988.4	888.2	80.2	701.0	0.0	0.0	0.0	187.2	0.0	0.0
** Muang Ang Thong	102.9	102.0	0.9	41.5	0.0	0.0	0.0	60.5	0.0	0.0
* Chaiyo	72.3	72.3	0.0	0.0	0.0	0.0	0.0	72.3	0.0	0.0
** Pa Mok	80.9	80.9	0.0	26.5	0.0	0.0	0.0	54.4	0.0	0.0
* Pho Thong	219.4	212.4	7.0	212.4	0.0	0.0	0.0	0.0	0.0	0.0
* Wiset Chai Chan	224.7	189.3	35.4	189.3	0.0	0.0	0.0	0.0	0.0	0.0
* Samko	86.9	50.0	36.9	50.0	0.0	0.0	0.0	0.0	0.0	0.0
* Sawaengha	181.3	181.3	0.0	181.3	0.0	0.0	0.0	0.0	0.0	0.0
Ayutthaya	2,558.6	1,907.5	649.1	458.2	141.0	380.6	0.0	218.0	227.4	482.3
** Muang Ayutthaya	130.6	130.6	0.0	7.6	7.1	33.4	0.0	44.0	38.5	0.0
** Tha Rua	106.2	106.2	0.0	0.0	0.0	106.2	0.0	0.0	0.0	0.0
* Nakhorn Luang	198.9	198.9	0.0	0.0	11.9	187.0	0.0	0.0	0.0	0.0
* Bang Sai	150.7	119.3	31.4	65.1	0.0	0.0	0.0	0.0	0.0	54.2
* Bang Shai	219.7	219.7	0.0	83.9	0.0	0.0	0.0	0.0	1.2	134.6
* Bang Ban	135.3	135.3	0.0	33.2	0.0	0.0	0.0	68.9	33.2	0.0
* Bang Pahan	121.9	121.9	0.0	0.0	45.5	18.6	0.0	57.8	0.0	0.0
* Bang Pa-In	229.1	189.1	40.0	0.0	0.0	0.0	0.0	0.0	152.0	37.1
* Ben Phraek	39.1	39.1	0.0	0.0	29.6	0.0	0.0	9.5	0.0	0.0
* Phak Hai	189.0	189.0	0.0	189.0	0.0	0.0	0.0	0.0	0.0	0.0
Phachi	104.5	0.0	104.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
* Maha Rat	120.1	120.1	0.0	0.0	46.9	35.4	0.0	37.8	0.0	0.0
Lat Bua Luang	199.9	136.9	63.0	0.0	0.0	0.0	0.0	0.0	0.0	136.9
Wang Noi	219.2	0.0	219.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
** Sena	205.6	188.9	6.7	79.4	0.0	0.0	0.0	0.0	0.0	119.5
Uthai	186.8	2.5	184.3	0.0	0.0	0.0	0.0	0.0	2.5	0.0
Pathum Thani	1,525.9	485.5	1,040.4	0.0	0.0	0.0	0.0	0.0	0.0	485.6
* Muang Pathum Thani	120.2	120.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	120.2
Sam Khok	95.0	95.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	95.0
Lat Lum Kaeo	188.1	188.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	188.1
Thanya Buri	112.1	8.7	103.4	0.0	0.0	0.0	0.0	0.0	0.0	8.7
Lam Luk Ka	297.7	6.0	291.7	0.0	0.0	0.0	0.0	0.0	0.0	6.0
Klong Luang	299.2	67.5	231.7	0.0	0.0	0.0	0.0	0.0	0.0	67.5
Nong Sua	413.6	0.0	413.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nonthaburi	622.3	273.6	348.7	0.0	0.0	0.0	0.0	0.0	0.0	273.6
* Muang Nonthaburi	77.0	42.3	34.7	0.0	0.0	0.0	0.0	0.0	0.0	42.3
Kruai	57.4	0.0	57.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bang Yai	96.4	25.9	70.5	0.0	0.0	0.0	0.0	0.0	0.0	25.9
** Bang Bua Thong	116.4	116.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	116.4
* Pak Kret	89.0	89.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	89.0
Sai Noi	186.1	0.0	186.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sara Buri	3,576.6	186.3	3,390.3	0.0	25.9	160.4	0.0	0.0	0.0	0.0
Muang Sara Buri	503.8	0.0	503.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Keang Khoi	871.1	0.0	871.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Don Phunt	65.6	65.6	0.0	0.0	21.9	43.7	0.0	0.0	0.0	0.0
Ban Mo	279.0	93.7	185.3	0.0	0.0	93.7	0.0	0.0	0.0	0.0
Phra Phutthabat	324.6	0.0	324.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Muak Lek	752.5	0.0	752.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wihan Daeng	228.8	0.0	228.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Saohai	125.1	0.0	125.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nong Khae	293.8	0.0	293.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nong Saeng	97.4	0.0	97.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nong Don	34.9	27.0	7.9	0.0	4.0	23.0	0.0	0.0	0.0	0.0
Total	18,741.8	6,037.4	12,704.4	1,788.1	1,081.5	541.0	51.3	1,106.7	227.4	1,241.4

Remarks: *** refers to Amphoes that have a municipality within the basin.

** refers to Amphoes that have sanitary district/s within the basin.

Table 9.4.2 Composition of Related River Basins by Province

Province	Noi River	Lop Buri River	Pasak River	Main R. (R0 - R1)	Main R. (R1 - R2)	Main R. (R2 - R3)	Main R. (R3 - R4)
Chai Nat	N1	-	-	C1	C2	-	-
Sing Buri	N2	L1	-	-	C3	-	-
Lop Buri	-	L2	-	-	C4	-	-
Ang Thong	N3	-	-	-	C5	-	-
Ayutthaya	N4	L4	P2	-	C6	C7	C8
Pathum Thani	-	-	-	-	-	-	C9
Nonthaburi	-	-	-	-	-	-	C10
Sara Buri	-	L3	P1	-	-	-	-

Table 9.4.3 Population by Sub-area (1992)

Province / Amphoe	Noi River										Lop Buri River										Pasak River										Main River (Up. Part, RC-RI)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
	Sub-area N1					Sub-area N2					Sub-area N3					Sub-area N4					Sub-area L1					Sub-area L2					Sub-area L3					Sub-area P1					Sub-area P2					Sub-area C1																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																													
	Total Population	Class A	Class B	Class C	Class C	Total Population	Class A	Class B	Class C	Class C	Total Population	Class A	Class B	Class C	Class C	Total Population	Class A	Class B	Class C	Class C	Total Population	Class A	Class B	Class C	Class C	Total Population	Class A	Class B	Class C	Class C	Total Population	Class A	Class B	Class C	Class C	Total Population	Class A	Class B	Class C	Class C																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																			
Chai Nat	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	0	0	0	0	59,445	

Note: "==" refers to Amphicoes that have a municipality within the basin.
 "==" refers to Amphicoes that have sanitary districts within the basin.

<u>Municipality/S.D.</u>	<u>Population percentage in the study basin</u>
Muang Nonthaburi Muni.	70 %
Prachatipat SD.	80 %
Khu Khot SD.	80 %

Based on the population of each sub-area, wastewater quantity, generated BOD load and discharged BOD load were calculated.

(2) Industrial wastewater

Industrial wastewater and BOD load of each province were allocated only to amphoes with municipality/s in proportion to its population. Distribution of factories in the respective amphoes is assumed to be uniform.

(3) Livestock wastewater

Wastewater quantity and BOD load were allocated to sub-areas in proportion to respective area. Discharged BOD load of buffalo and cattle was assumed to be negligible, while 50% of generated BOD load was regarded to be discharged load.

(4) Fresh market wastewater

The location of municipalities were taken into account for the distribution of fresh market wastewater.

(5) Fish pond wastewater

Wastewater quantity and BOD load were allocated in proportion to the area of related amphoes by respective sub-area. Distribution of fishponds in respective amphoes was assumed to be uniform and discharged BOD load was estimated.

(6) Natural pollution load

BOD load was allocated in proportion to the area of related amphoes by respective sub-area. Distribution of the load was assumed to be uniform.

Generated and discharged BOD load covering all pollution sources by sub-area and water quality checking point are summarized in Tables 9.4.4 and 9.4.5, respectively. Detailed calculations are incorporated in Section 9.4 of Volume III-Supporting Report.

Table 9.4.4 Generated BOD Load by Sub-area (1992)

Water Quality Checking Point	Sub-area Code	Generated BOD Load (kg/day)														
		Domestic					Factory	Livestock			Slaughter-house	Fresh Market	Fish Pond	Natural Pollution	TOTAL	
		Urban		Sub-urban	Rural	Total		Buffaloes	Cattle	Swine						Total
R1	C1	868	0	561	1,429	1,136	292	714	151	1,157	110	40	10	26	3,908	
R2	C2	0	334	3,231	3,565	647	1,645	4,015	850	6,510	0	0	45	144	10,911	
	C3	1,365	846	3,997	6,208	5,728	719	9,373	2,058	12,150	51	40	32	185	24,394	
	C4	0	0	466	466	0	72	793	117	982	0	0	3	22	1,473	
	C5	1,232	692	2,278	4,202	3,912	755	4,516	1,748	7,019	202	80	26	94	15,535	
	C6	4,676	0	2,546	7,222	12,811	1,304	1,905	887	4,096	471	40	38	109	24,787	
	Total	7,273	1,872	12,518	21,663	23,098	4,495	20,602	5,650	30,757	724	160	144	554	77,100	
R3	C7	0	708	2,782	3,490	2,253	1,361	1,987	925	4,273	0	0	23	114	10,153	
	N1	0	339	2,826	3,165	362	1,622	3,959	839	6,420	0	0	56	142	10,145	
	N2	0	1,977	3,326	5,303	1,319	670	8,736	1,918	11,324	0	0	49	172	18,167	
	N3	0	2,140	7,807	9,947	1,651	2,826	16,910	6,544	26,280	0	0	94	351	38,323	
	N4	292	4,101	3,057	7,450	6,199	2,741	4,003	1,864	8,608	32	40	681	229	23,239	
	N ST.	292	8,557	17,016	25,865	9,531	7,859	33,608	11,165	52,632	32	40	880	894	89,874	
	P1	0	0	1,457	1,457	0	485	1,820	948	3,253	0	0	0	80	4,790	
P2	478	1,978	3,839	6,295	11,076	2,277	3,325	1,548	7,150	57	40	35	190	24,843		
P ST.	478	1,978	5,296	7,752	11,076	2,762	5,145	2,496	10,403	57	40	35	270	29,633		
	L1	0	0	1,179	1,179	641	211	2,755	605	3,571	0	0	6	54	5,451	
	L2	2,371	1,430	11,672	15,473	4,462	1,340	14,702	2,176	18,218	207	40	64	403	38,867	
	L3	0	0	175	175	0	78	294	153	525	0	0	0	13	713	
	L4	0	678	1,415	2,093	415	844	1,232	574	2,650	0	0	38	71	5,267	
	L ST.	2,371	2,108	14,441	18,920	5,518	2,473	18,983	3,508	24,964	207	40	108	541	50,298	
	Total	3,141	13,351	39,535	56,027	28,378	14,455	59,723	18,094	92,272	296	120	1,046	1,819	179,958	
R4	C8	0	212	4,096	4,305	3,437	2,886	4,214	1,962	9,062	0	0	561	241	17,506	
C9	7,941	1,106	7,757	16,804	25,032	1,603	2,179	2,876	6,664	1,463	40	655	486	51,144		
C10	22,137	0	5,045	27,182	14,333	450	957	396	1,803	473	120	202	274	44,387		
Total	30,078	1,318	16,895	48,291	42,802	4,945	7,350	5,234	17,529	1,936	160	1,418	1,001	113,137		
GRAND TOTAL	41,360	16,541	69,509	127,410	95,414	24,187	88,389	29,139	141,715	3,066	480	2,618	3,400	374,103		

Table 9.4.5 Discharged BOD Load by Sub-area (1992)

Water Quality Checking Point	Sub-area Code	Discharged BOD Load (kg/day)									
		Domestic		Factory		Live-stock		Slaughter-house		Fresh Market	
		Urban	Sub-urban	Rural							
R1	C1	788	0	503	576	76	8	40	10	26	2,027
R2	C2	0	301	2,895	328	425	0	0	45	144	4,138
	C3	1,237	761	3,582	2,908	1,029	4	40	32	185	9,778
	C4	0	0	418	0	59	0	0	3	22	502
	C5	1,114	624	2,042	2,021	874	15	80	26	94	6,890
	C6	4,284	0	2,283	6,598	443	34	40	38	109	13,829
	Total	6,635	1,686	11,220	11,855	2,830	53	160	144	554	35,137
R3	C7	0	638	2,494	1,160	463	0	0	23	114	4,892
	N1	0	306	2,532	183	419	0	0	56	142	3,638
	N2	0	1,782	2,981	670	959	0	0	49	172	6,813
	N3	0	1,928	6,995	853	3,272	0	0	94	351	13,493
	N4	265	3,695	2,740	3,193	932	2	40	681	229	11,777
	N ST.	265	7,711	15,248	4,899	5,582	2	40	880	894	35,521
	P1	0	0	1,305	0	474	0	0	0	80	1,859
	P2	431	1,782	3,441	5,705	774	4	40	35	190	12,402
	P ST.	431	1,782	4,746	5,705	1,248	4	40	35	270	14,261
	L1	0	0	1,056	325	302	0	0	6	54	1,743
R4	L2	2,152	1,289	10,460	2,270	1,088	15	40	64	403	17,791
	L3	0	0	157	0	77	0	0	0	13	247
	L4	0	611	1,269	214	287	0	0	38	71	2,490
	L ST.	2,152	1,900	12,942	2,809	1,754	15	40	108	541	22,271
	Total	2,858	12,031	35,430	14,573	9,047	21	120	1,046	1,819	76,945
	C8	0	191	3,669	1,770	981	0	0	561	241	7,413
R4	C9	7,227	996	6,952	13,177	1,438	106	40	655	486	31,077
	C10	20,186	0	4,522	7,549	198	34	120	202	274	33,085
	Total	27,413	1,187	15,143	22,496	2,617	140	160	1,418	1,001	71,575
GRAND TOTAL		37,694	14,904	62,296	49,500	14,570	222	480	2,618	3,400	185,684

9.5 Study on Concentration and Purification Ratios

Water pollution analysis entails estimation of run-off load at water quality checking points. Concentration ratio and run-off ratio/residual purification ratio in the river are basic factors to be established.

Due to the absence of previous study in Thailand on concentration and residual purification ratios on Chao Phraya river, the field measurement was carried out at the 2nd stage of the Study adopting the following concepts and procedures.

Investigations on water quality of Chao Phraya river and drainage channels were conducted to analyze concentration ratio and run-off ratio/residual purification ratio covering a total of 18 points; 12 points for concentration ratio covering highly populated, medium populated and rural areas, and 6 points along main river and its tributary for the study of run-off ratio. Results of these surveys are presented in Section 9.5 of Volume III- Supporting Report.

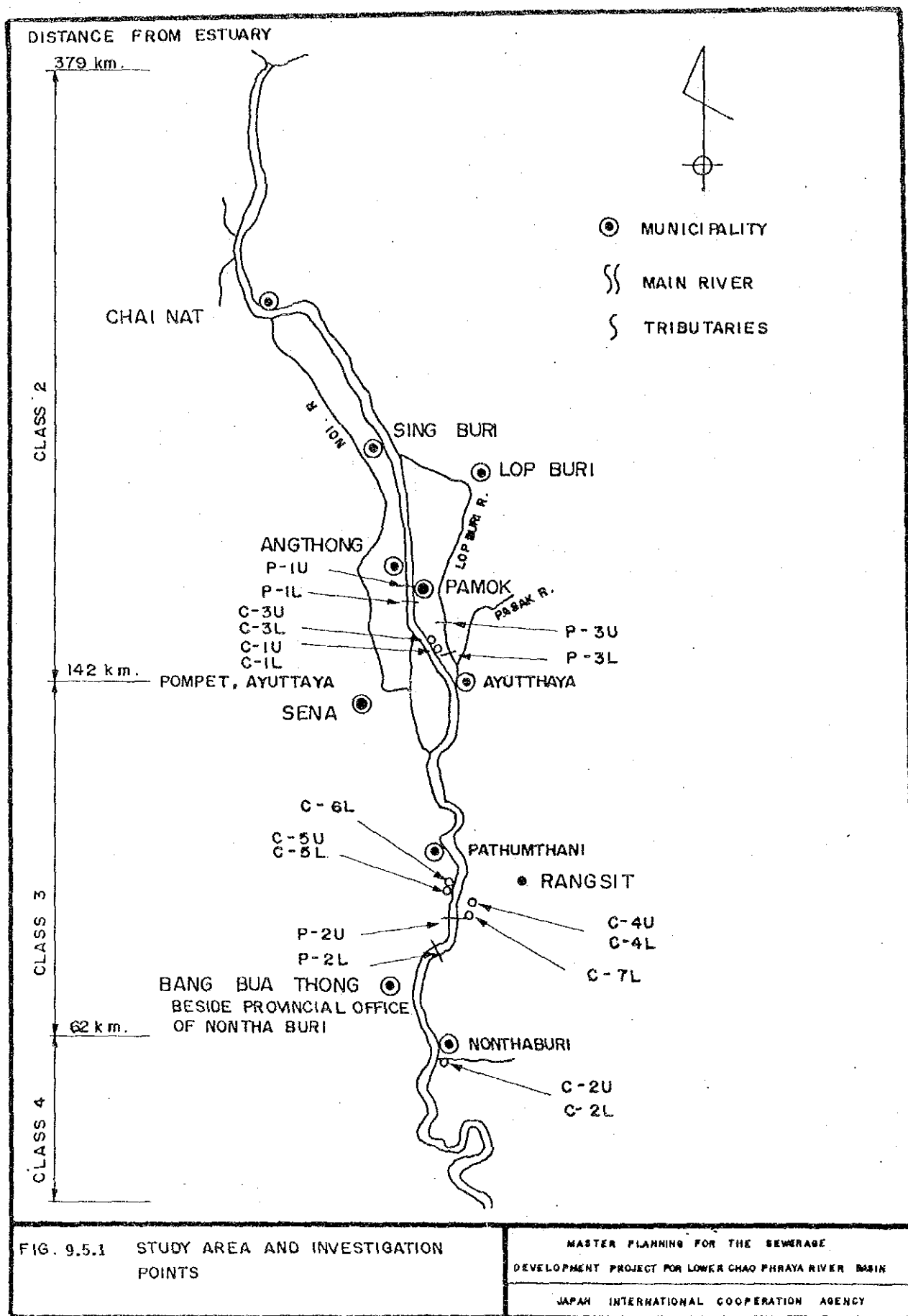
Water quality examination results and data for flow rate calculation (cross sectional survey of rivers, flow rate calculation, and RID records on the flow rate are included in Section 9.5.1 of Volume IV-Data Report. Table 9.5.1 summarizes the investigation points and Figure 9.5.1 shows the general locations.

9.5.1 Concentration Ratio

Concentration ratio during dry season was studied referring to the results of field survey. In general, concentrated load in a sub-area against discharged load therein is considerably small caused by sedimentation, oxidation and infiltration in the flowing process of pollution load before reaching the main river. The ratio is mainly affected by population density including the lay-out of the drainage systems.

Table 9.5.1 Investigation Points by Study Purpose

Concentration Ratio			Run-off Ratio		
Land use type	Area	No. of sampling	River	Section	Distance&No.
(1) High population density	Ayutthaya	2	Main River	<u>Ang Thong</u>	6.2 km; 2
	Monthaburi	2		Ban Bang Kaeo	
				Ban Radain	
(2) Medium population density	Ayutthaya	2		<u>Pathum Thani</u>	6.2 km; 2
	Pathum Thani	2		Ban Wat Chong Lom	
				Pak Kret	
(3) Rural area	Pathum Thani	2	Tributary	<u>Lop Buri</u>	6.5 km; 2
				Ban Muang	
(4) Natural Pollution	Pathum Thani-1	1		Ban Ma (3)	
	Pathum Thani-2	1			
Total		12 points	6 points		



(1) Background Information on Sub-Study Areas

Table 9.5.2 presents a summary of the findings taken from the reconnaissance survey in the study area, and data/information obtained from municipalities and Sanitary Health Offices.

The characteristics of study areas by type of land use are as follows:

Highly Populated Area

Nonthaburi is located within the extension area of the Bangkok Metropolitan area, while Ayutthaya is the main local city. Drainage channels in these areas flow across the city center. The appearance of water in these channels resembled like sewage and the analysis results indicated an inflow from septic tanks. Although the drainage system is inadequate for its purpose, the drainage pipes are installed properly.

Medium Population Density Area

Subject areas in Ayutthaya and Pathum Thani are both suburban with houses situated along klongs. The surrounding areas, however are categorized as rural areas with scattered houses. Wastewater sources in this area are mainly domestic in origin which are directly discharged into klongs.

Rural Area

Scattered houses along the khlong exist in subject area of Pathum Thani. Livestock breeding was not observed in this area. Wastewater discharged into the khlong is mainly from households and agricultural activities.

Table 9.5.2 Findings on the Study Areas : Concentration Ratio

Station No.	Ayuthaya C-1U ~ C-1L	Nonthaburi C-2U ~ C-2L	Ayuthaya C-3U ~ C-3L	Pathum Thani C-4U ~ C-4L
Item	Medium Population Density			
Land use type	High Population Density			
Location	Tambon Hoa Rattanachai	Tambon Suan-Yai (Klong Bang-Kwang)	Ban Klong Takhian	Klong Krasaeng
Land use features	<ul style="list-style-type: none"> - Population is concentrated on left bank area. Business activities are remarkable including cottage industries - On the right bank area, houses are moderately located 	<ul style="list-style-type: none"> - Central area of the municipality with high population density and business activities. 	<ul style="list-style-type: none"> - Houses are located along the klong, medium population density 	<ul style="list-style-type: none"> - Houses are located along the klong, medium population density
Major pollution sources and drainage system	<ul style="list-style-type: none"> - Sullage from houses and business areas is the major pollution source. Overflow from nightsoil treatment facilities was identified - Drainage facilities: RCP dia. 0.4, 0.6 and 1.0 m, under sidewalk and along roads 	<ul style="list-style-type: none"> - Sullage from houses and business areas is the major pollution source. Overflow from nightsoil treatment facilities was identified. - Drainage facilities: RCP dia. 0.4, 0.6 and 1.0 m, under sidewalk and along roads. 	<ul style="list-style-type: none"> - Domestic wastewater from houses along the klong - Channels along roads are connected to the klong 	<ul style="list-style-type: none"> - Domestic wastewater from houses along the klong - Channels along roads are connected to the klong
Drainage area (ha)	167	36	39	46
Section distance (km)	1.50	1.45	0.95	1.50
Population (persons)	20,130	8,200	1,174	774
Population density (persons/ha)	120	228	30.3	16.8
Situation of drainage Channel	<ul style="list-style-type: none"> - Drainage channel (3-4 m in width): flow is controlled by a regulator, water is deteriorated and offensive odor was felt 	<ul style="list-style-type: none"> - Drainage channel passing through the urban area (1.5 m in width) provided a regulator at the downstream - Water colour was black, anaerobic condition with a deposit at the bottom of the channel (offensive odor) 	<ul style="list-style-type: none"> - The klong is connected to the main river (0.10 m in width) - Water quality is similar to main river 	<ul style="list-style-type: none"> - The klong has a width of about 20 m, water quality is good
Concentrated BOD load Flowrate (m ³ /day) BOD load (kg/day)	17,018 353.4	10,162 419	514 3.87	678 15.11

...cont'd

Table 9.5.2 Findings on the Study Areas : Concentration Ratio (cont'n)

Station No.	Pathum Thani C-5U ~ C-5L	Pathum Thani C-6L	Pathum Thani C-7L
Item			
Land use type	Rural Area	Natural Pollution	
Location	Klong Bang Pho Nua	Klong Bang Pho	Ban Kiang
Land use features	- Rural area, but there are scattered houses along the klong	- Rural area, but there are scattered houses along the klong	- Rural area, but there are scattered houses along the klong
Major pollution sources and drainage system	- Irrigation water and domestic wastewater from houses	- Irrigation water and domestic waste - water from houses	- Irrigation water and domestic waste - water from houses
Drainage area (ha)	72	70	53
Section distance (km)	1.44	1.68	0.96
Population (persons)	3,892	-	-
Population density (persons/ha)	54	-	-
Situation of drainage Channel	- The klong has a width of about 20 m, water was stagnant	- The klong has a width of about 20 m, water was stagnant	- The width of the channel is about 2 m.
Concentrated BOD load Flow rate (m ³ /day) BOD load (kg/day)	36,120 0.12	19,448 45.75 (2.4 mg/l)	15,035 25.75 (1.7 mg/l)

Natural Pollution

Locational conditions of the two selected survey points in Pathum Thani is the same as in the rural area of Pathum Thani. Hence, natural pollution in the subject area would be more or less the same as in the rural area.

(2) Conditions to Estimate Concentration Ratio

The concentration ratio was estimated considering the following conditions:

Drainage Area

Based on confirmation of drainage system through reconnaissance survey, drainage area was delineated on the topographic map.

Population

Data on the number of households/population in the tambon were collected from concerned agencies. Estimation of population in the subject area was made and validated by the residents.

Unit Discharged BOD Load

Discharged pollution load in each drainage area is estimated based on the unit BOD load (gpcd - gram per capita per day) for each municipality/sanitary district as of 1992 and the above-mentioned population.

Highly Populated Area:

The Unit BOD Load is determined covering of sullage, business wastewater and nightsoil based on the analysis results of water quality in Ayutthaya and Nonthaburi that revealed overflow of wastewater from septic tank to the drainage channels. Treatment efficiency at septic tank is considered at 50%.

Medium Population Density and Rural Area:

The unit BOD load is considered only for sullage considering the fact that most of households along khlongs have toilet facilities without effects of overflow therefrom.

(3) Findings on Concentration Ratio

The results of computation on discharged BOD load, concentrated BOD load and concentration ratio are presented in Table 9.5.3. While standard ratios by land use with reference to the above mentioned factors are recommended in the guidelines of comprehensive basin-wide water pollution control plan in Japan as shown in Table 9.5.4.

Table 9.5.3 Calculation Results of Concentration Ratio

Land Use type	High Population Density		Medium Population Density		Rural Area	Natural Pollution	
Location Sta. No.	Ayuthaya C-1U~C-1L	Nonthaburi C-2U~C-2L	Ayuthaya C-3U~C-3L	Pathum Thani C-4U~C-4L	Pathum Thani C-5U~C-5L	Pathum Thani C-6L	Pathum Thani C-7L
Discharged BOD Load							
Population (persons)	20,130	8,200	1,174	774	3,892	—	—
Unit BOD load (gpcd)	60.1	56.9	42.0	42.0	42.0	—	—
BOD load (kg/day)	1,209.8	466.6	49.3	32.5	163.5	—	—
Concentrated BOD Load							
Flow Rate (m3/day)	17,018	10,162	514	678	3,612	19,448	15,035
BOD Concent'n (mg/l)	20.8	41.2	7.6	22.3	0.03	2.4	1.7
BOD load (kg/day)	353.4	419.0	3.9	15.1	0.12	45.8	25.8
Concentration Ratio (%)	29.2	89.8	7.9	46.5	0.1	—	—

Table 9.5.4 Concentration Ratio in Japan

Land use type	Concentration ratio	Remarks
Rural area	0.0 - 0.20	The ratio is depending on the arrangement status of drainage facilities.
Urban area 1) med.-low pop. density	0.1 - 0.60	
2) high pop. density	0.60 - 1.0	
Sewerage system	1.0	

Highly Populated Area

Concentration ratio of Nonthaburi having high population density and good drainage system services was as high as 0.9 which coincided with the range of Japanese standard ratio of 0.6 to 1.0.

The area in Ayutthaya situated in UCR has lower population density than Nonthaburi and lower coverage of drainage system at about 50%. Lower concentration ratio of 0.3 was obtained for the area.

Medium Population Density Area

The ratio for Pathum Thani was taken at 0.47 which was similar to the Japanese standard ratio, while for Ayutthaya, it was 0.08.

Rural Area

It was calculated to be almost negligible with a value of 0.001.

Natural Pollution

The survey result showed 2 mg/l of BOD, while natural pollution was at BOD levels of 0.5 to 1.0 mg/l.

As stated above, the concentration ratios have close relationship with population density. Figure 9.5.2 shows a summary of field measurements in major river basins in Japan and in Chao Phraya river. Although the river systems are different between Thailand and Japan, the survey results in Chao Phraya river are closely related to the cases in Japan, except for one survey point.

Concentration ratios by land use type under the existing conditions in UCR and BMR are assumed as shown in Table 9.5.5 which reflects the survey results.

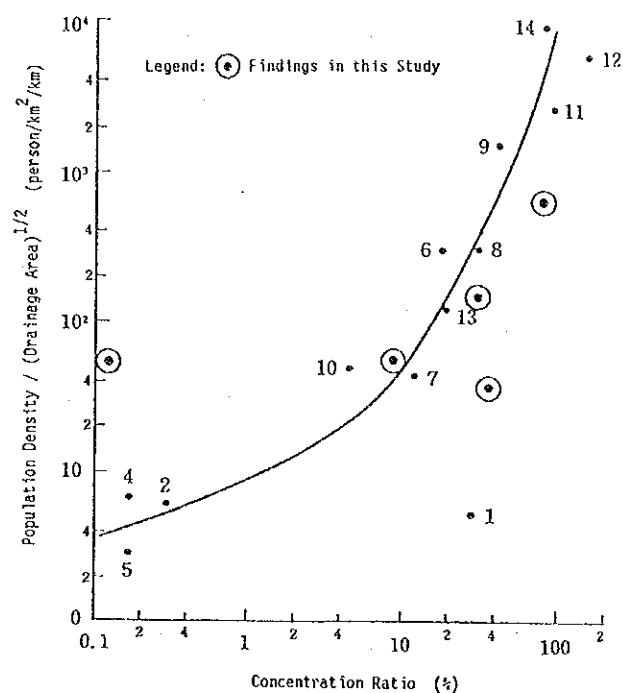


Figure 9.5.2 Relationship between Concentration Ratio and Population Density

Table 9.5.5 Recommended Concentration Ratio

Land Use Type	Application for the Study	Concentration Ratio	
		UCR	BMR
Rural Area	Outside area of municipality and S.D., fish pond	0.1	0.1
Urban Area			
1) Med.-Low population density	S.D., factory, slaughterhouse	0.2	0.5
2) High population density	Municipality including Rangsit area, fresh market	0.4	0.9
Sewerage System		1.0	1.0

Note: BMR includes Pathum Thani and Nonthaburi.

9.5.2 Measured Residual Purification Ratio

Concentrated load is usually reduced in the main river section contributed by biological decomposition, sedimentation and absorption. The run-off ratio after purification in the subject river section differs depending on the flow rates. For this study, the ratio during the dry season was analyzed. Aside from such ratios, a study using self-purification coefficient (k_r) was made.

(1) Background Information on Sub-Study Areas

Background information on three selected sections is summarized in Table 9.5.6 and enumerated below:

- a) Each examination section has a distance of approximately six (6) km.
- b) A larger pollution source is located upstream of each river section. Pollution load is discharged into the main river.
- c) There is no confluence or diversion points in the subject sections.
- d) Run-off time is considerably long, i.e., approximately 10 hours at Aug Thong, 20 hours at Lop Buri due to quite low flow velocity.
- e) Surrounding conditions along subject sections are rural areas.

(2) Findings on Run-off/Residual Purification Ratio

Residual purification ratio is calculated and presented in Table 9.5.7.

Table 9.5.6 Findings on the Study Areas : Residual Purification Ratio

Station No.	Ang Thong	Pathum Thani	Lop Buri
Item	P-1U ~ P-1L	P-2U ~ P-2L	P-3U ~ P-3L
Name of river	Chao Phraya River	Chao Phraya River	Lop Buri River
Location	Ban Bang Kaeo ~ Ban Radain	Ban Wat Chong Lom ~ Pak Kret	Ban Muang ~ Ban Ma (3)
Land use features	<ul style="list-style-type: none"> - Built-up area of Ang Thong is located about one km upstream of P-1U point - Although some houses are located along the river, there is no large amount of inflow between the two points. - Most of the area is farm land 	<ul style="list-style-type: none"> - Built-up area of Pathum Thani is located about 8 km. upstream of P-2L point - Wastewater is discharged from part of Pak Kret at immediate upstream of P-2L point - Scattered houses exist along the river and of area is used as farm land 	<ul style="list-style-type: none"> - Amphoe Bang Pahan is located about 5 km upstream of P-3U point. - Scattered houses along the river/farm land
Section distance (km)	6.2	6.2	6.5
Average velocity (cm/sec)	18.5	7.2	9.6
Average flow arrival time (hr)	9.3	23.9	18.8
Flow rate (million m ³ /d)	Upstream 11.54 Downstream 10.49	19.46 19.63	0.92 1.09
BOD Conc'n (mg/l)	Upstream 2.3 Downstream 2.0	1.7 1.8	4.0 2.4
BOD Load (ton/d)	Upstream 26.2 Downstream 20.8	33.1 35.6	3.7 2.6

Table 9.5.7 Residual Purification Ratio

Section	Run-off BOD Load		Residual Purifi'n Ratio (%)	Time of Flow (days)	Self- purifi'n Coeff. (kr)
	at Upstream (ton/day)	at Downstream (ton/day)			
Chao Phraya River (Ang Thong)	26.2	20.8	79.4	0.42	0.55
Chao Phraya River (Pathum Thani)	33.1	35.6	107.6	0.71	-0.10
Lop Buri River (Lop Buri)	3.7	2.6	70.3	0.83	0.42

9.5.3 Flow Rates and Water Quality at Strategic Points for Present Pollution Analysis

A total of 10 study points were selected along the main river and its major tributaries and are shown in Figure 9.5.3. Through field measurements in June 1992 and January 1993 and data collected from concerned authority, flow rates are summarized in Figure 9.5.3 and Table 9.5.8. Figure 9.5.4 presents the fluctuation of flow rate along each river (detailed data are in Section 9.5.2 of Volume IV-Data Report. The results of cross-sectional survey of rivers and water level measurements at each point are also reflected in the same section.

Specific discharged rates by sub-area associated with tributaries and covered area by water quality checking point are calculated as shown in Table 9.5.9.

Since flow rates in the study basin are controlled and the figures are obtained during the dry season, the discharged amount into the main river is quite related to wastewater from each study area. Considering the water use of the Chao Phraya river through out the future without drastic change of intake amount, specific discharged rate may be used as follows:

- 1) Upper part of Chao Phraya river (from Chao Phraya Dam to R2):
1,931 m³/d/km² (0.0223 m³/s/km²)
- 2) Pasak & Lop Buri rivers and Noi river:
2,345 m³/d/km² (0.027 m³/s/km²,

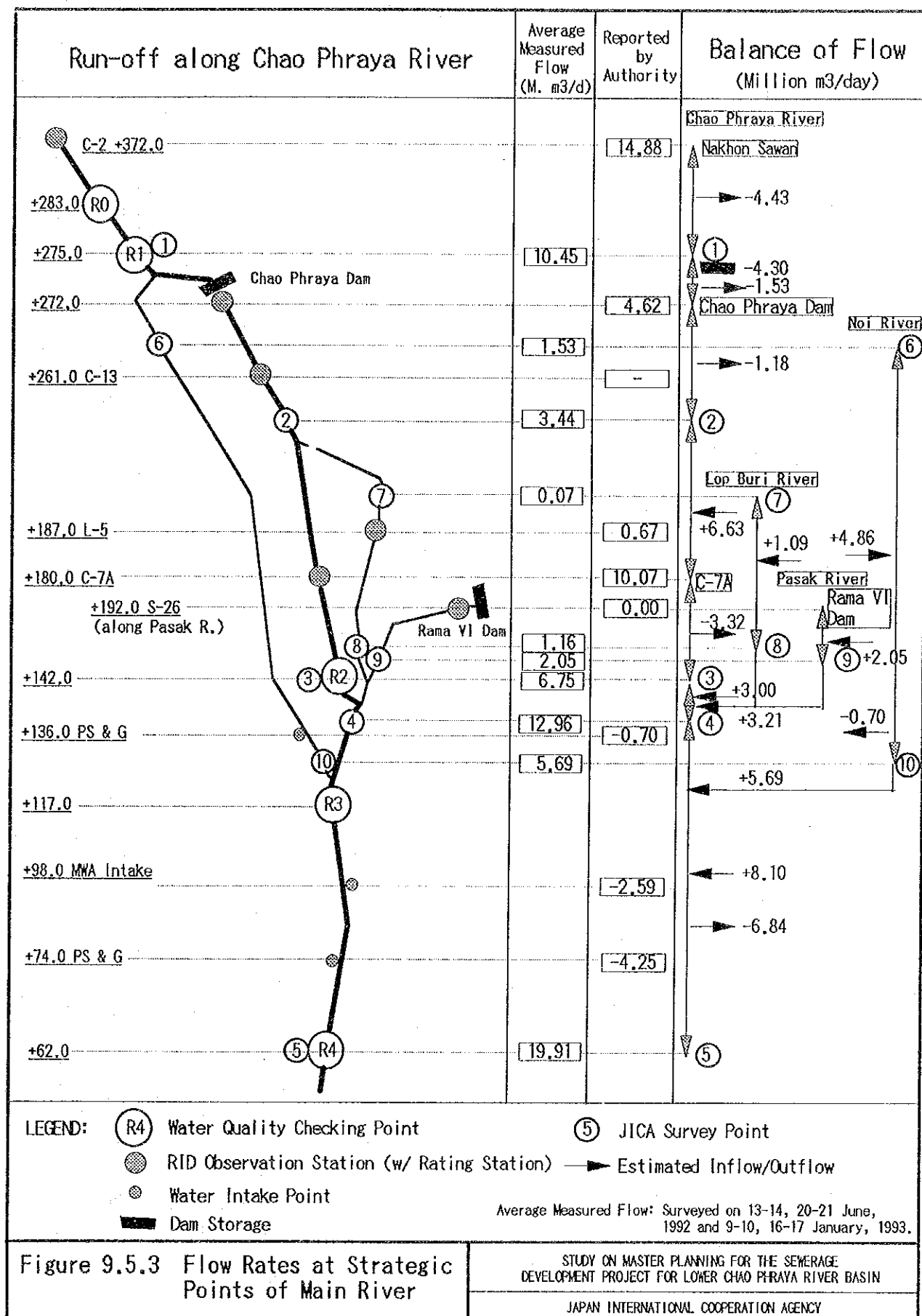


Table 9.5.8 Flow Rate Measured/Reported along Chao Phraya River and Its Tributaries
(Average values on 13-14, 20-21 June 1992 and 9-10, 16-17 January 1993)

CHAO PHRAYA RIVER			TRIBUTARIES			Average Flow Rate Measured		Flow Rate Reported by Authority		Balance of Flow (million m3/day)			
Sta. No.	Dist. (km)	Location	Sta. No.	Dist. (km)	Location	m3/s	m3/day	m3/s	m3/day	Chao P.	Lop Buri	Pasak	Noi
C-2	372.0	Nakorn Sawan RID Obs. Sta.						172.20	14,875,488	-4.43			
1	275.0	Chai Nat before diversion					10,447,920			-4.30			
	272.0	Downstream release Chao Phraya Dam						53.50	4,622,400				
C-13	261.0	Chai Nat RID Obs. Sta.						-	-	-1.18			
2	221.0	Sing Buri				39.81	3,439,152						
						17.72	1,531,224						
			6	277.0	Noi R. Upstream after diversion								
			7	209.0	Lop Buri R. Upstream	0.86	74,088						
			L-5	187.0	Lop Buri R. Sing Buri, RID Obs. Sta.			7.80	672,840	+6.63			
			8	145.5	Lop Buri R. downstream	13.41	1,158,624						
					Downstream release Rama VI D., Pasak R.			0.00	0				
			9	145.2	Lop Buri R. downstream	23.76	2,052,864						
C-7A	180.0	Ang Thong RID Obs. Sta.						116.50	10,065,600	-3.32			
3	142.0	Ayuthaya, before confl. with Pasak R.				78.14	6,750,864						
4	141.0	Ayuthaya, after confl. with Pasak R.				149.97	12,957,408			+3.00			
			136.0		Pumping Sta., Noi R.			-8.10	-701,352	+8.10			
			10	118.0	Noi R., Downstream	65.88	5,692,032			-2.59			
	98.0	MWA Pumping Sta.						-30.00	-2,592,000	-4.25			
	74.0	Rep. Pumping Sta.						-49.20	-4,250,880				
5	62.0	Nonthaburi Provincial Office				230.47	19,912,824						

Unit: Average Flow Rate million m3/day

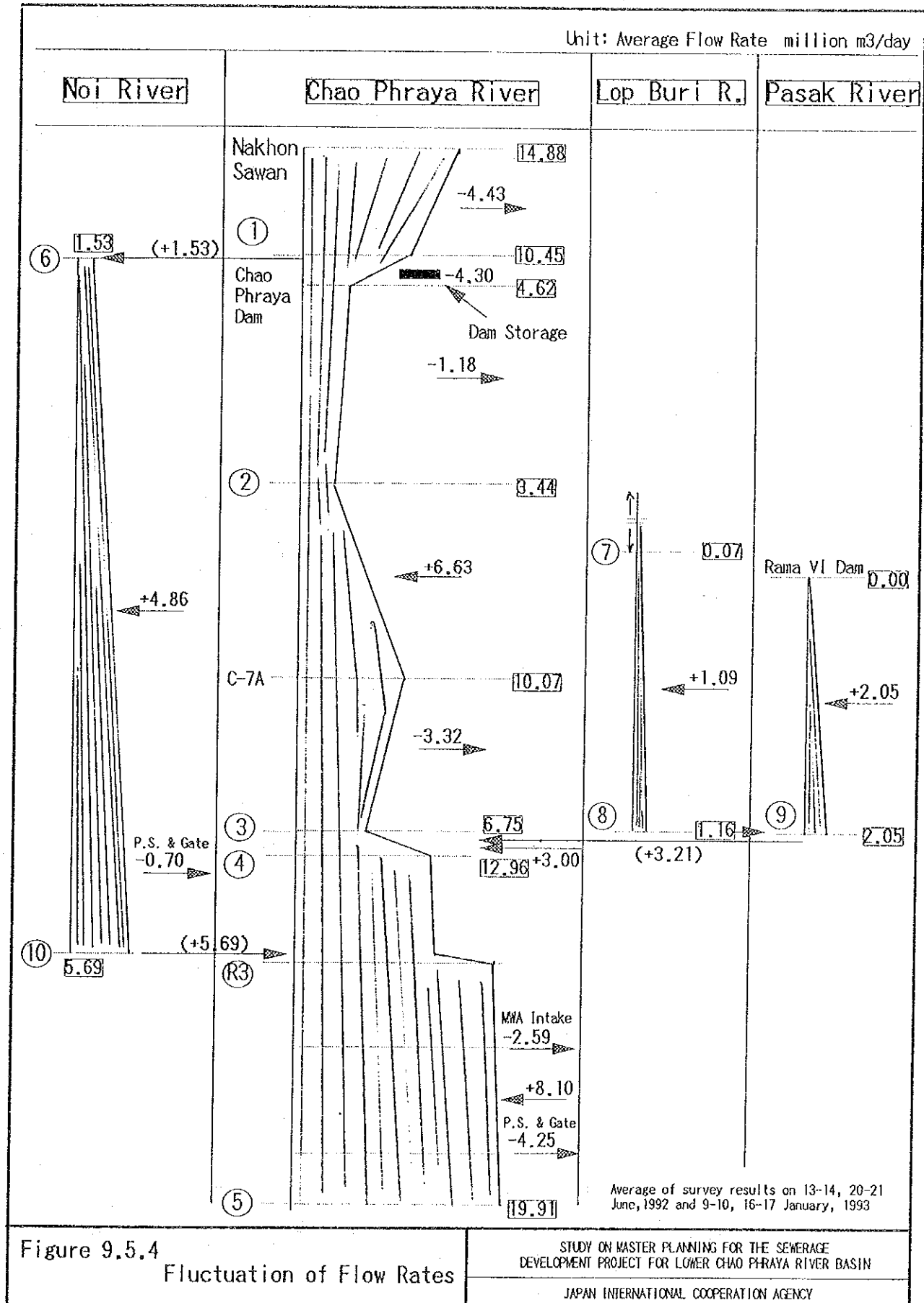


Table 9.5.9 Specific Discharge Rate

Sub-area Study Point	Area (km ²)	Flow Rate (m ³ /day)		Discharged amount from the basin (m ³ /day)	Specific Discharge Rate		Remarks
		Upstream	Downstream	Water Intake /Inflow	per day (m ³ /km ² /d)	per second (m ³ /km ² /s)	
Upper Part of Chao Phraya river Chao Phraya Dam - No.3	1,102.4	4,622,400	6,750,864		1,931	0.0223	Rural representative area
Pasak & Lop Buri river No. 7 - No. 8 & 9	1,622.5	74,088	3,211,488		1,934	0.0224	Rural area
No. 6 - No. 10 Avg. of Pasak, Lop Buri and Noi river	1,788.1	1,531,224	5,692,032	-701,352	2,719	0.0315	Rural area
Lower Part of Chao Phraya river No.4 - No. 5 (R2 - R4)	3410.6	12,957,408	19,912,824	5,692,032 -4,250,880 -2,592,000	2,345	0.0271	
					5,519 revised 6,074	0.0639 0.0703	Pathum Thani & Nonthaburi (developed area)

Data: Flow rate measurement on 13-14, 20-21 June 1992 and 9-10, 16-17 January 1993

Note: Revised rate for the area between R3 and R4 (the area between R2 and R3, 227.4 km², is assumed to be same discharged) rate as upper part of the main river, 1930 m³/km²/day).

$$\{ 8,106,264 + (5,519 - 1,931) \times 227.4 \} / 1,468.8 = 6,074 \text{ m}^3/\text{km}^2/\text{day}$$

average figures of the three rivers)

3) From R2 to R3:

1,931 m³/km²/d (similar to item 1)

4) From R3 to R4:

6,074 m³/d/km² (0.0703 m³/s/km²)

Water quality examination results on the same day when flow measurements were taken are also summarized in Table 9.5.10 and Figure 9.5.5.

Using the above specific discharged rate, flow rates at the water intake point of MWA, consolidated intake point for irrigation use (Phathum Thani and Nonthaburi area), and consolidated intake points along the Noi river are calculated as follows:

R3 point:

(Flow rate at No.4) + (Flow rate at No.10) + (Discharged rate in the area between R2 and R3 points)
= 12,957,408 + 5,692,032 + 1,900 x 227.4
= 19,081,500 m³/d (19.08 x 10⁶ m³/d, 220.9 m³/s)

MWA intake point:

(Flow rate at R3 point) + (Discharged rate in the area between R3 and the intake point)
= 19,088,549 + 6,100 x 490
= 22,077,549 m³/d (22.08 x 10⁶ m³/d)

Intake percentage: 2.59 / 22.08
= 11.7 %

Consolidated intake point along the main river (P.S and Gates):

(Flow rate at MWA intake point) - (MWA intake amount)
+ (Discharged rate between MWA intake point and the point)
= 22,077,549 - 2,592,000 + 6,100 x 606.3
= 23,183,979 m³/d (23.18 x 10⁶ m³/d)

Intake percentage: 4.25 / 23.18
= 18.3 %

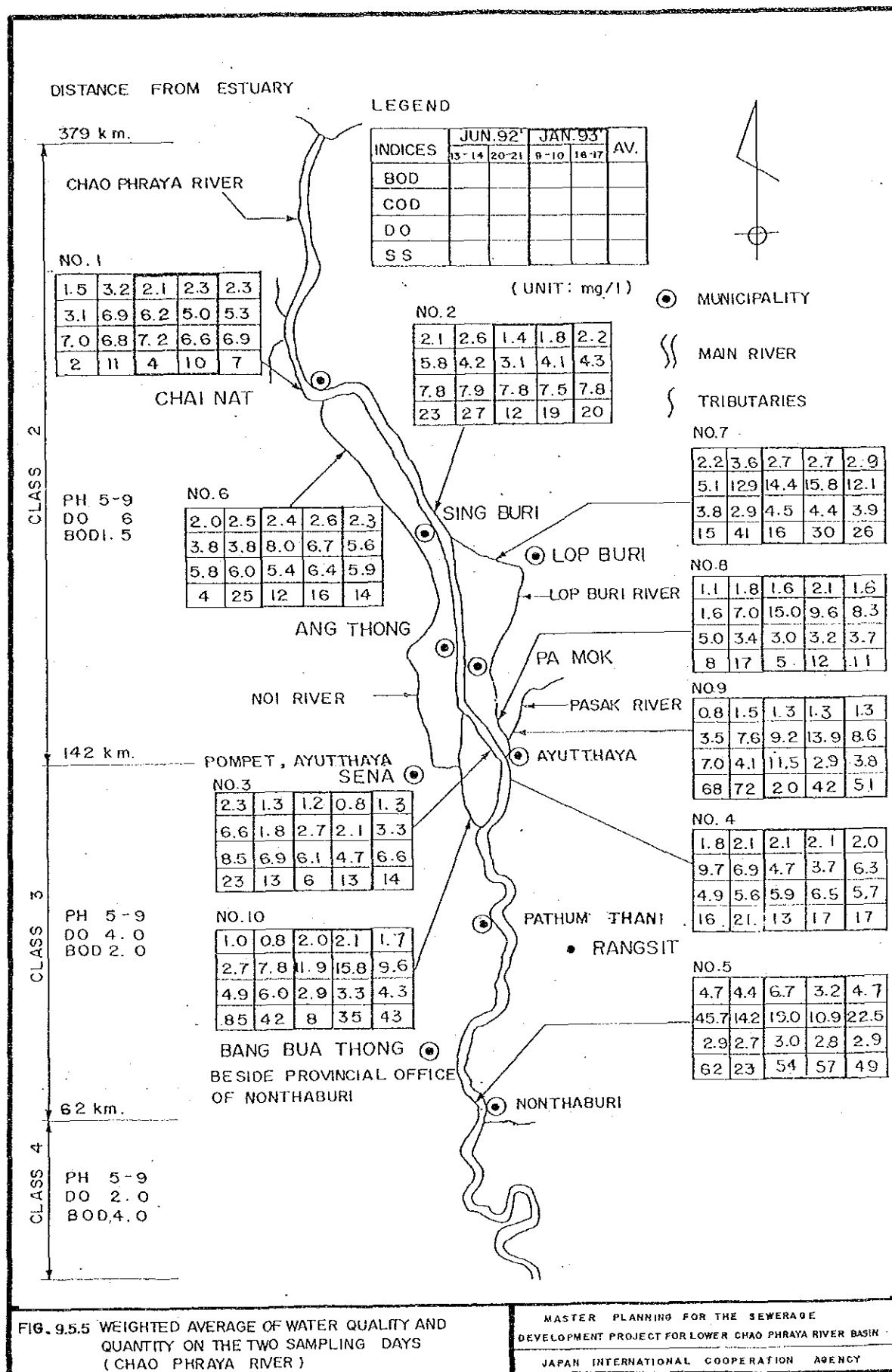
Consolidated intake point along the Noi river (P.S and Gates):

(Flow rate at No. 6) + (Discharged rate between No. 6 and the point)

Table 9.5.10 Results of River Investigation

Date	1st June 13-14, 1992					2nd June 20-21, 1992					3rd January 9-10, 1993					4th January 16-17, 1993					Average*		
	Inv.	Cross- Sectional Area (m2)	Flow Rate (m3/s)	Average Velocity (m/s)	BOD Conc'n (mg/lit)	Inv.	Cross- Sectional Area (m2)	Flow Rate (m3/s)	Average Velocity (m/s)	BOD Conc'n (mg/lit)	Inv.	Cross- Sectional Area (m2)	Flow Rate (m3/s)	Average Velocity (m/s)	BOD Conc'n (mg/lit)	Inv.	Cross- Sectional Area (m2)	Flow Rate (m3/s)	Average Velocity (m/s)	BOD Conc'n (mg/lit)	Average	Average	
1	1,480.61	168.48	0.114	1.5	1,455.91	151.86	0.104	3.2	1,518.65	93.23	0.061	2.1	1,374.73	70.11	0.051	2.3	1,457.48	120.93	10,447,920	0.083	2.3		
2	161.60	38.22	0.237	2.1	271.36	80.78	0.298	2.6	169.57	25.14	0.148	1.4	137.99	15.08	0.109	1.8	185.13	39.81	3,439,152	0.215	2.2		
3	276.61	48.82	0.176	2.3	400.87	88.28	0.220	1.3	387.85	119.47	0.306	1.2	375.48	56.17	0.150	0.8	360.20	78.14	6,750,864	0.217	1.3		
4	1,033.51	174.65	0.169	1.8	955.56	133.48	0.140	2.1	1,069.82	187.06	0.175	2.1	1,042.52	104.69	0.100	2.1	1,025.35	149.97	12,957,408	0.146	2.0		
5	2,386.65	289.72	0.121	4.7	2,372.81	206.74	0.087	4.4	2,525.08	207.82	0.082	6.7	2,509.64	217.61	0.087	3.2	2,448.55	230.47	19,912,824	0.094	4.7		
6	67.57	25.43	0.376	2.0	79.57	13.21	0.166	2.5	62.66	23.66	0.378	2.4	31.37	8.59	0.274	2.6	60.29	17.72	1,531,224	0.294	2.3		
7	36.49	1.55	0.042	2.2	50.52	1.74	0.034	3.6	3.35	0.12	0.036	2.7	0.16	0.02	0.125	2.7	22.63	0.86	74,088	0.038	2.9		
8	328.92	11.18	0.034	1.1	131.84	7.48	0.057	1.8	180.46	23.93	0.133	1.6	171.78	11.05	0.064	2.1	203.25	13.41	1,158,624	0.066	1.6		
9	155.64	0.53	0.003	0.8	300.35	9.53	0.032	1.5	327.18	41.89	0.128	1.3	316.92	43.09	0.136	1.3	275.02	23.76	2,052,864	0.086	1.3		
10	523.89	59.91	0.114	1.0	525.29	31.31	0.060	0.8	610.04	116.93	0.192	2.0	585.30	55.37	0.095	2.1	561.13	65.88	5,692,032	0.117	1.7		
11	17.76	1.90	0.107	2.0	15.82	2.22	0.140	3.3	6.16	0.32	0.052	1.9	4.64	0.34	0.073	2.0	11.10	1.20	103,248	0.108	2.6		
12	99.89	7.63	0.076	0.2	87.68	27.11	0.309	1.1	111.92	14.92	0.133	1.6	102.45	3.65	0.036	1.8	100.49	13.33	1,151,496	0.133	1.2		
13	1.08	0.11	0.102	11.4	3.19	0.06	0.019	19.7	1.77	0.19	0.107	16.3	1.61	0.30	0.186	19.7	1.91	0.17	14,256	0.086	17.3		
14	0.57	0.03	0.053	70.3	9.89	0.46	0.047	33.1	11.58	0.00	0.000	-	14.28	0.14	0.010	-	9.08	0.16	13,608	0.017	35.4		
15	1.68	0.11	0.065	25.0	1.35	0.17	0.126	63.2	2.41	0.16	0.066	23.1	2.20	0.03	0.014	115.0	1.91	0.12	10,152	0.062	43.9		

Note: Average BOD concentration of No. 14 is calculated from the values of 1st and 2nd investigation.
Weighted average (geometric mean) BOD concentration is shown as average figures.



$$\begin{aligned}
&= 1,531,224 + 2,300 \times 1,581 \\
&= 5,167,524 \text{ m}^3/\text{d} \quad (5.17 \times 10^6 \text{ m}^3/\text{d})
\end{aligned}$$

$$\begin{aligned}
\text{Intake percentage: } &0.70 / 5.17 \\
&= 13.5 \%
\end{aligned}$$

9.5.4 Self-Purification Coefficient

(1) Concept of water pollution analysis

Concentrated load is usually reduced in the main river section contributed by biological decomposition, sedimentation and absorption. The run-off ratio after purification in the subject river section is different depending on flow rates.

In this study, the following assumptions were adopted for water pollution analysis.

Self-purification phenomenon of rivers can be described by the Streeter-Phelps equation as follows:

<Streeter-Phelps equation> (modified)

$$Ll = \{ Lu - La / (2.31 \cdot K_r) \} \times 10^{(-K_r \cdot t)} + La / (2.31 \cdot K_r)$$

where

L: BOD (ppm)

l -- at downstream, u -- at upstream

La -- BOD added from river bed (ppm/day)

K_r : BOD reduction coefficient (self-purification coefficient)
 $(=K_1+K_3)$ (1/day)

K_1 -- deoxygenation coefficient

K_2 -- re-aeration coefficient

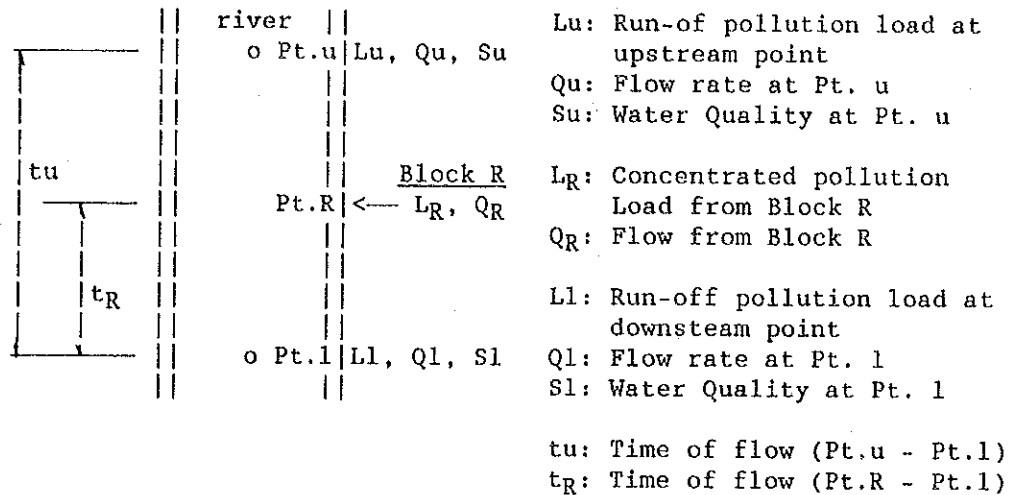
K_3 -- physical coefficient

t: time of flow from upstream to downstream

Assuming L_a is negligible ($=0$), above equation becomes as follows;

$$L_1 = L_u \times 10^{(-K_r \cdot t)} \quad \text{or} \\ = L_u \times e^{(-k_r \cdot t)}$$

In cases where pollution load flows along the river between the upstream and the downstream portions, the following calculation was made.



in the above figure,

$$Q_u + Q_R = Q_1$$

$$S_u = L_u / Q_u, S_1 = L_1 / Q_1$$

and using Streeter-Phelps equation, following equation can be obtained;

$$L_1 = L_u \cdot 10^{(-k_r \cdot t_u)} + L_R \cdot 10^{(-k_r \cdot t_R)}$$

The self-purification coefficient (k_r), is a summation of k_1 (deoxidization coefficient) and k_3 (physical coefficient). The range of k_1 is rather small with 0.05 - 0.3, however, k_3 fluctuates depending on the characteristics of water quality, especially related to physical conditions (suspended solid).

The study on self-purification coefficient (k_r) is undertaken using the investigation results from Stage I and Stage II field works.

Concentrated load by different pollution source is calculated using the concentration ratio assumed in Section 9.5.1. Inflow points of the pollution load along the main river and tributaries are set up under the following conditions:

- 1) Weighted inflow point/s by each area of respective water quality

checking points.

- 2) One inflow point for each province by each checking point area.

Table 9.5.11 presents the present concentrated load at present.

Figure 9.5.6 is a flow model that includes information for the present water pollution analysis in order to come up with the run-off ratio/remaining ratio after purification in the river.

- 1) Flow rate at study points (No.1-No.10) (Figure 9.5.3)
- 2) Concentrated and run-off BOD load at study points
- 3) Concentrated BOD load by province by water quality checking point

The flow model is prepared to analyze self-purification coefficient considering the difference of run-off time from each inflow point of pollution load to water quality checking point.

Figure 9.5.7 summarizes the major elements of pollution analysis including run-off load and concentrated load.

Computation of the self-purification coefficient (k_r) was made using the equation mentioned previously as shown in Table 9.5.12. In the computation, the following assumptions were adopted regarding k_r value of the river system.

- a) k_r of the section between R1 and the confluence of the main river and the Pasak river is regarded to be the same value.
- b) k_r of the Lop Buri river and the Pasak river is the same.
- c) k_r of the section between the confluence of the main river and the Pasak river, and R4 is the same.
- d) Check points for computation were set at R2 (survey point No. 3), the confluence of Lop Buri and Pasak rivers, survey point

Table 9.5.11 Concentrated BOD Load by Sub-area (1992)

Water Quality Checking Point	Sub-area Code	Concentration Ratio and Concentrated BOD Load by Sub--area (kg/day)										
		Land Use	Domestic			Factory	Live-stock	Slaughter-house	Fresh Market	Fish Pond	Natural Pollution	TOTAL
			Urban	Suburban	Rural							
		C.Rate										
		UCR	0.5	0.2	0.1	0.2	0.1	0.2	0.5	0.1	1.0	--
		BMR	0.9	0.5	0.2	0.5	0.2	0.5	0.9	0.2	1.0	--
R1	C1		394.0	0.0	50.3	115.2	7.6	1.6	20.0	1.0	26.0	615.7
R2	C2		0.0	60.2	289.5	65.6	42.5	0.0	0.0	4.5	144.0	606.3
	C3		618.5	152.2	358.2	581.6	102.9	0.8	20.0	3.2	185.0	2,022.4
	C4		0.0	0.0	41.8	0.0	5.9	0.0	0.0	0.3	22.0	70.0
	C5		557.0	124.8	204.2	404.2	87.4	3.0	40.0	2.6	94.0	1,517.2
	C6		2,142.0	0.0	228.3	1,319.6	44.3	6.8	20.0	3.8	109.0	3,873.8
	Total		3,317.5	337.2	1,122.0	2,371.0	283.0	10.6	80.0	14.4	554.0	8,089.7
R3	C7		0.0	127.6	249.4	232.0	46.3	0.0	0.0	2.3	114.0	771.6
	N1		0.0	61.2	253.2	36.6	41.9	0.0	0.0	5.6	142.0	540.5
	N2		0.0	356.4	298.1	134.0	95.9	0.0	0.0	4.9	172.0	1,061.3
	N3		0.0	385.6	699.5	170.6	327.2	0.0	0.0	9.4	351.0	1,943.3
	N4		132.5	739.0	274.0	638.6	93.2	0.4	20.0	68.1	229.0	2,194.8
	N ST.		132.5	1,542.2	1,524.8	979.8	558.2	0.4	20.0	88.0	894.0	5,739.9
	P1		0.0	0.0	130.5	0.0	47.4	0.0	0.0	0.0	80.0	257.9
	P2		215.5	356.4	344.1	1,141.0	77.4	0.8	20.0	3.5	190.0	2,348.7
	P ST.		215.5	356.4	474.6	1,141.0	124.8	0.8	20.0	3.5	270.0	2,606.6
	L1		0.0	0.0	105.6	65.0	30.2	0.0	0.0	0.6	54.0	255.4
	L2		1,081.0	257.8	1,046.0	454.0	108.8	3.0	20.0	6.4	403.0	3,380.0
	L3		0.0	0.0	15.7	0.0	7.7	0.0	0.0	0.0	13.0	36.4
	L4		0.0	122.2	126.9	42.8	28.7	0.0	0.0	3.8	71.0	395.4
	L ST.		1,081.0	380.0	1,294.2	561.8	175.4	3.0	20.0	10.8	541.0	4,067.2
	Total		1,429.0	2,406.2	3,543.0	2,914.6	904.7	4.2	60.0	104.6	1,819.0	13,185.3
R4	C8		0.0	38.2	366.9	354.0	98.1	0.0	0.0	56.1	241.0	1,154.3
	C9		6,504.3	498.0	1,390.4	6,588.5	287.6	53.0	36.0	131.0	486.0	15,974.8
	C10		18,167.4	0.0	904.4	3,774.5	39.6	17.0	108.0	40.4	274.0	23,325.3
	Total		24,671.7	536.2	2,661.7	10,717.0	425.3	70.0	144.0	227.5	1,001.0	40,454.4
GRAND TOTAL			29,812.2	3,279.6	7,377.0	16,117.8	1,620.6	86.4	304.0	347.5	3,400.0	62,345.1

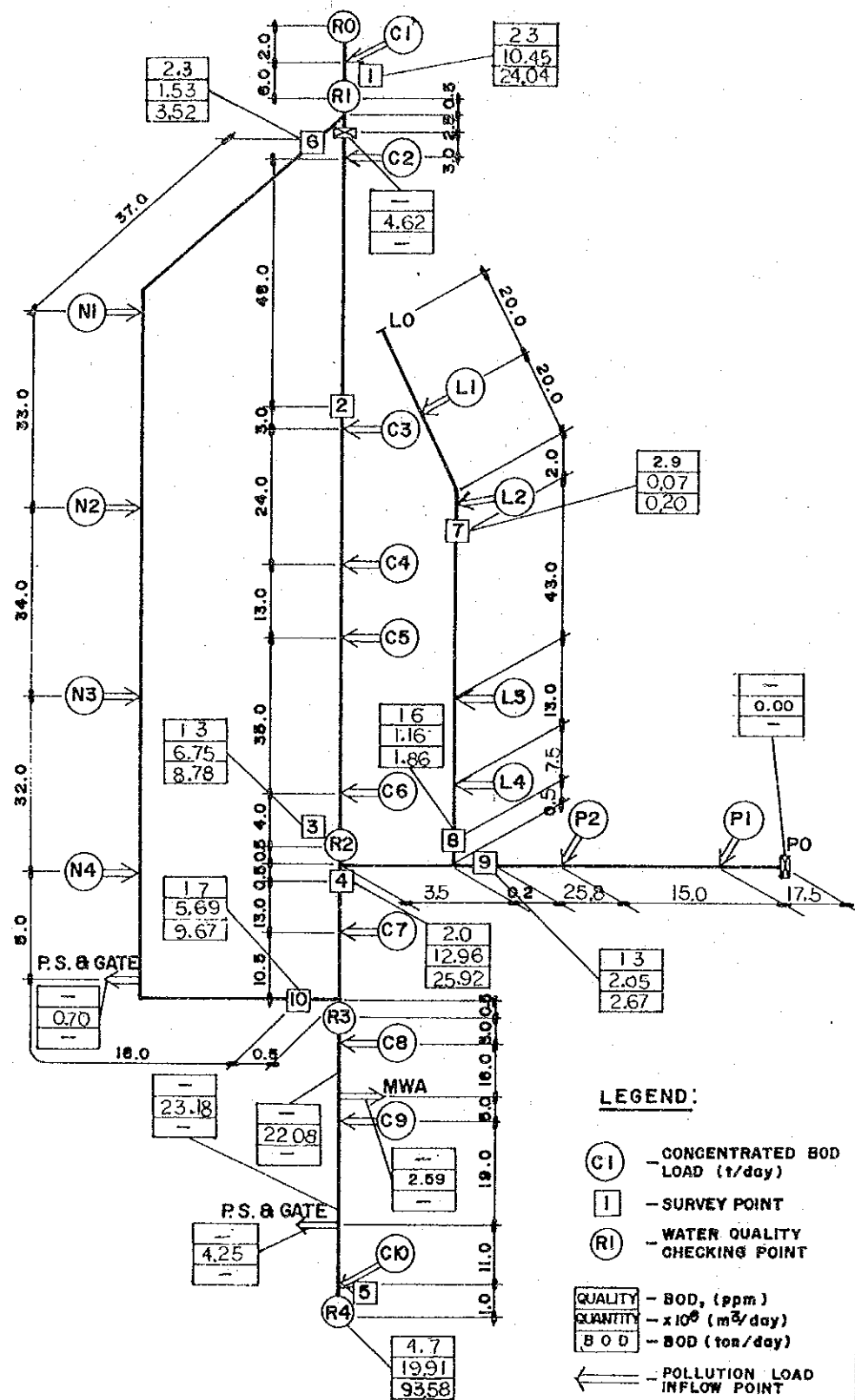


FIG. 9.5.6 FLOW MODEL FOR PRESENT WATER POLLUTION ANALYSIS

MASTER PLANNING FOR THE SEWERAGE
DEVELOPMENT PROJECT FOR LOWER CHAO PHRAYA RIVER BASIN
JAPAN INTERNATIONAL COOPERATION AGENCY

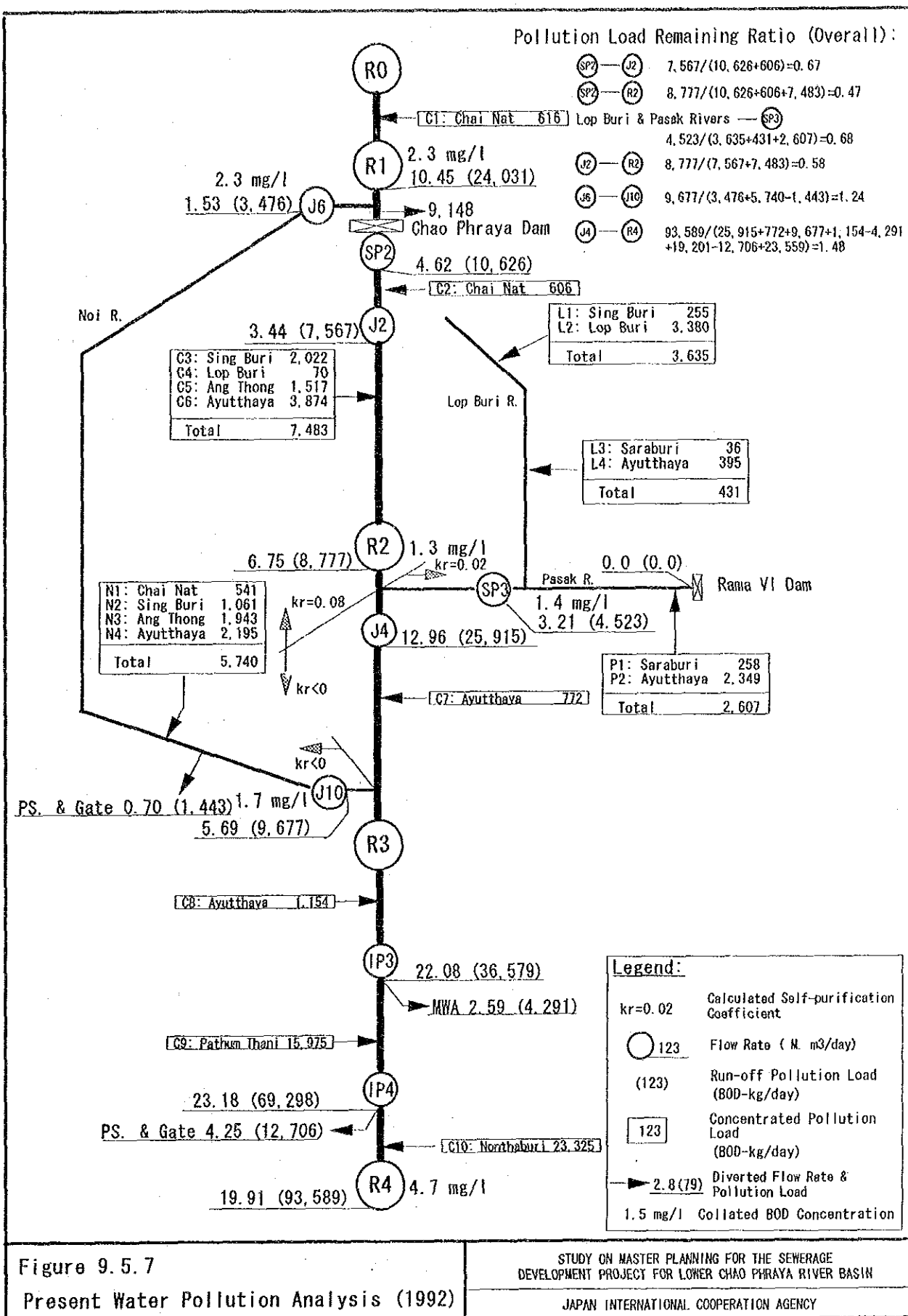


Table 9.5.12 Computation of Self-purification Coefficient

Current Point No.	Next Point No.	W. Distance C. Estuary (km)	Section Length (km)	Velocity (m/sec)	Time of Flow (day)		Concent'd Pollution Load (kg/day)	Diverted Pollution Load (kg/day)	P. Load at Current Pt. (kg/day)	Purified Load (kg/day)	P. Load at Next Pt. (kg/day)	Measured Flow at Next Point		P. Load Remaining Ratio	
					to next Point	to next W.O.C.P.						per sec. (m3/sec)	per day (M m3/day)	Quality (mg/lit)	to next Point
R0	C1	283.0	2.0	0.08	0.289	8.431	0.0	0.0	-	-	-	120.93	10.45	2.3	1.000
C1	R1 (J1)	281.0	6.0	0.08	0.868	8.141	615.7	0.0	-	-	-	24,031.2	-	-	1.000
R1 (J1)															
SP1	IP1	275.0	0.5	0.08	0.072	7.273	0.0	0.0	24,031.2	315.8	23,715.4	-	-	-	0.987
IP1	SP2	274.5	2.4	0.08	0.347	7.201	0.0	3,475.7	20,239.7	1,245.1	18,994.6	-	-	-	0.938
SP2	C2	272.1	0.1	0.08	0.014	6.854	0.0	9,147.8	9,846.8	26.0	9,820.8	53.47	4.62	2.3	0.997
C2	J2	272.0	3.0	0.22	0.158	6.839	0.0	0.0	9,820.8	279.4	9,541.4	-	-	-	0.972
C3	C4	269.0	48.0	0.22	2.525	6.861	606.3	0.0	10,147.7	3,752.9	6,394.7	39.81	3.44	2.2	0.930
J2	C3	221.0	3.0	0.22	0.158	4.156	0.0	0.0	6,394.7	181.9	6,212.8	-	-	-	0.972
C3	C4	219.0	24.0	0.22	1.263	3.998	2,022.4	0.0	8,235.2	1,597.8	6,637.4	-	-	-	0.938
C4	C5	194.0	13.0	0.22	0.684	2.736	70.0	0.0	8,607.4	776.8	7,830.6	116.35	10.07	-	0.974
C5	C6	181.0	35.0	0.22	1.841	2.052	1,517.2	0.0	7,347.8	2,100.8	5,247.2	-	-	-	0.882
C6	R2 (J3)	146.0	4.0	0.22	0.210	3.873.8	0.0	0.0	9,121.0	344.3	8,776.7	78.14	6.75	1.3	0.992
R2 (J3)	SP4	142.0	0.5	0.22	0.026	7.900	0.0	0.0	8,776.7	42.1	8,734.6	-	-	-	0.995
R2 (J3)															
L0	L1	251.0	20.0	0.04	5.787	26.061	0.0	0.0	0.0	0.0	0.0	-	-	-	0.776
L1	L2	231.0	20.0	0.04	5.787	20.274	255.4	0.0	255.4	57.2	198.2	-	-	-	0.776
L2	J7	211.0	2.0	0.04	0.579	14.487	3,380.0	0.0	3,578.2	89.6	3,488.5	0.86	0.07	2.9	0.975
J7	L3	209.0	43.0	0.05	9.954	13,908	0.0	0.0	3,488.5	1,233.6	2,254.9	-	-	-	0.975
L3	L4	166.0	13.0	0.06	2.503	3,954	36.4	0.0	2,291.3	238.6	2,052.8	-	-	-	0.841
L4	J8	153.0	7.5	0.06	1.447	1,447	395.4	0.0	2,448.2	150.5	2,297.7	13.41	1.16	1.6	0.939
J8	SP3	145.5	0.5	0.07	0.083	8.962	0.0	0.0	2,297.7	8.3	2,289.4	-	-	-	0.996
P0															
P1	P2	203.5	17.5	0.09	2.251	7.497	0.0	0.0	0.0	0.0	0.0	-	-	-	0.906
P2	J9	186.0	15.0	0.09	1.929	5.247	257.2	0.0	257.9	20.9	237.0	-	-	-	0.919
J9	SP3	171.0	25.8	0.09	3.318	3,318	2,348.7	0.0	2,585.7	350.0	2,235.7	23.76	2.05	1.3	0.865
SP3	SP4	145.2	0.2	0.09	0.026	8.905	0.0	0.0	2,235.7	2.5	2,233.1	-	-	-	0.999
SP3															
SP3	SP4	145.0	0.0	0.08	0.000	0.000	0.0	0.0	4,522.5	0.0	4,522.5	37.17	3.21	-	1.000
SP4	J4	145.0	3.5	0.08	0.306	8.280	0.0	0.0	4,522.5	99.3	4,423.2	-	-	-	0.978
J4	C7	141.5	0.5	0.15	0.039	7.773	0.0	0.0	13,157.8	-73.8	13,231.6	149.97	12.96	2.0	1.006
C7	SP5	141.0	13.0	0.14	1.075	7.735	0.0	0.0	13,231.6	-2,229.8	15,461.3	-	-	-	1.169
SP5	N1	128.0	10.5	0.13	0.935	6.660	771.5	0.0	16,232.9	-2,354.9	18,587.8	-	-	-	1.145
N0 (J6)															
N1	N2	277.0	37.0	0.27	1.586	9.545	0.0	0.0	3,475.7	-173.5	3,649.1	-	-	-	1.050
N2	N3	240.0	33.0	0.23	1.661	7.959	540.5	0.0	4,189.6	-219.2	4,408.8	-	-	-	1.052
N3	N4	207.0	34.0	0.20	1.968	6.238	1,061.3	0.0	5,470.1	-340.7	5,810.8	-	-	-	1.062
N4	IP2	173.0	32.0	0.16	2.315	4.331	1,943.3	0.0	7,754.1	-571.2	8,325.2	-	-	-	1.074
IP2	J10	141.0	5.0	0.14	0.413	2.016	2,194.8	0.0	10,520.0	-134.4	10,654.4	46.76	4.04	-	1.013
J10	SP5	136.0	18.0	0.13	1.503	1.503	0.0	1,442.6	9,211.8	-464.6	9,676.5	65.88	5.69	1.7	1.050
SP5	R3	116.0	0.5	0.12	0.048	5.773	0.0	0.0	9,676.5	-14.3	9,690.8	-	-	-	1.001
SP5															
R3	C8	117.5	0.5	0.13	0.045	5.725	0.0	0.0	28,278.6	-183.0	28,461.6	-	-	-	1.006
C8	IP3	117.0	3.0	0.13	0.267	5.881	0.0	0.0	28,461.6	-1,123.2	29,584.8	-	-	-	1.039
IP3	C9	114.0	16.0	0.12	1.543	5,414	1,154.3	0.0	30,739.1	-7,703.2	38,442.3	-	-	-	1.251
C9	IP4	98.0	5.0	0.12	0.482	3,870	0.0	4,509.3	33,930.0	-2,456.1	36,386.1	-	-	-	1.072
IP4	C10	93.0	19.0	0.11	1.999	3,388	15,974.8	0.0	52,363.9	-17,595.2	69,959.0	-	-	-	1.336
C10	R4 (J5)	74.0	11.0	0.10	1.273	1,389	0.0	12,826.8	57,132.2	-11,575.2	68,707.4	-	-	-	1.203
R4 (J5)	-	63.0	1.0	0.10	0.116	0.116	23,325.3	0.0	92,032.7	-1,556.6	93,589.3	230.47	19.91	4.7	1.017
-	-	62.0	-	-	-	-	0.0	0.0	93,589.3	-	-	-	-	-	-

RO-R4: Water quality checking point
C1-C10, L1-L4, P1-P2, N0-N4: Pollution load inflow point
J1-J10: Survey points by JICA team
IP1-IP4: Water intake point
SP1-SP5: Temporary point for computation

SP1-SP5: Temporary point for computation

J1-J10: Survey points by JICA team

IP1-IP4: Water intake point

RC-R4: Water quality checking point

C1-C10, L1-L4, P1-P2, N0-N4: Pollution load inflow point

No. 10, and R4 (survey point No. 5)

Based on the study of self-purification coefficient by study section, the coefficients presented in Table 9.5.13 are recommended under the assumed concentration ratio shown in Section 9.5.1.

Table 9.5.13 Recommended Self-purification Coefficients

River Section (Water Quality Checking Point)	Self-purification Coefficient	Remarks
<u>Main River</u>		
R ₀ - R ₁	0.08	Same ratio as the section of R ₁ - R ₂
R ₁ - R ₂	0.08	
R ₂ - R ₃	0.00	
R ₃ - R ₄	0.00	
<u>Tributaries</u>		
Noi river	0.02	Noi, Lop Buri and Pasak rivers are regarded to have same assimilation capacity
Lop Buri & Pasak rivers	0.02	

CHAPTER 10
FUTURE WATER
POLLUTION ANALYSIS

CHAPTER 10 FUTURE WATER POLLUTION ANALYSIS

10.1 General

Projection of water quality (BOD concentration) is made for the target years 1996 and 2001 (intermediate year), and 2011 (final target year) at established water quality checking points.

The flow model prepared for the present water pollution analysis is utilized in principle as well as other major factors to analyze flow process of pollution load. Frame values and their unit pollution load covering identified water pollution sources calculated in Sections 6 and 8 are adopted.

Flow rates at respective water quality checking points are studied using average figures of RID observation stations during March and April in the last 4 years, as representative flow rates to achieve water quality standard. Furthermore, it is assumed that the present countermeasures provided by the Government including effluent standards are maintained through out the future for this study.

10.2 Frame Values and Generated Pollution Load by Administrative Unit in Terms of Different Land Use

10.2.1 Domestic Wastewater

The projected population in Section 6.1 for the target years 1996, 2001 and 2011 were further broken down into 5 categories the same way as stipulated in Section 9.3.1. Computation results are presented in Tables 10.2.1 to 10.2.3. Based on this classified population by land use type, the domestic wastewater quantity and generated BOD load were derived applying the unit domestic wastewater quantity and unit generated BOD load as indicated in Section 8.2. Computation results are presented in Supporting Report 10.2.

Discharged BOD load projection was carried out under the same assumptions applied in the estimation of present pollution load mentioned in Section 9.3.1. The result of projection is presented in Tables 10.2.4 to 10.2.6.

Table 10.2.1 Population by Land Use Type (1996)

Province / Amphoe	Total Population	Municipalities (Urban)			Sanitary Districts (Sub- urban)	Rural Community
		Class A	Class B	Class C		
Chai Nat	154,680	0	15,977	0	12,762	125,941
** Muang Chai Nat	48,013	0	15,977	0	0	32,036
* Sankhaburi	51,775	0	0	0	6,389	45,386
* Sanphaya	54,892	0	0	0	6,373	48,519
Sing Buri	244,689	0	25,085	0	53,633	165,971
** Muang Sing Buri	58,326	0	25,085	0	0	33,241
* Khai Bang Rachan	32,406	0	0	0	3,766	28,640
* Tha Chang	16,571	0	0	0	11,077	5,494
* Bang Rachan	42,460	0	0	0	22,641	19,819
* Phrom Buri	25,130	0	0	0	7,610	17,520
* In Buri	69,796	0	0	0	8,539	61,257
Lop Buri	325,844	0	40,036	0	25,502	260,306
** Muang Lop Buri	241,980	0	40,036	0	20,502	181,442
Khok Samrong	800	0	0	0	0	800
* Tha Wung	56,864	0	0	0	5,000	51,864
Ban Mi	26,200	0	0	0	0	26,200
Ang Thong	266,821	0	23,413	0	53,253	190,155
** Muang Ang Thong	48,547	0	11,782	0	0	36,765
* Chaiyo	22,381	0	0	0	12,773	9,608
** Pa Mok	28,913	0	11,631	0	0	17,282
* Pho Thong	58,572	0	0	0	7,012	51,560
* Wiset Chai Chan	60,452	0	0	0	22,461	37,991
* Samko	10,692	0	0	0	7,204	3,488
* Sawaengha	37,264	0	0	0	3,803	33,461
Ayutthaya	575,221	83,138	5,432	10,057	151,664	324,930
** Muang Ayutthaya	130,757	83,138	0	0	12,780	34,839
** Tha Rua	53,740	0	0	10,057	19,061	24,622
* Nakhon Luang	35,949	0	0	0	8,532	27,417
* Bang Sai	16,269	0	0	0	6,289	9,980
* Bang Shai	45,229	0	0	0	12,341	32,888
* Bang Ban	34,826	0	0	0	12,149	22,677
* Bang Pahan	37,948	0	0	0	7,956	29,992
* Bang Pa-In	59,475	0	0	0	18,711	40,764
* Ban Phraek	9,152	0	0	0	2,613	6,539
* Phak Hai	44,086	0	0	0	24,988	19,098
* Maha Rat	24,103	0	0	0	2,971	21,132
* Lat Bua Luang	22,723	0	0	0	0	22,723
** Sena	60,494	0	5,432	0	23,273	31,789
Uthai	470	0	0	0	0	470
Pathum Thani	326,008	143,828	0	0	20,828	161,352
** Muang Pathum Thani	110,433	21,104	0	0	5,872	83,457
* Sam Khok	43,848	0	0	0	8,729	35,119
* Lat Lum Kao	39,752	0	0	0	6,227	33,525
* Thanyaburi	42,986	42,986	0	0	0	0
* Lam Luk Ka	27,922	27,922	0	0	0	0
* Khlong Luang	61,067	51,816	0	0	0	9,251
Nonthaburi	553,429	411,080	0	0	0	142,349
** Muang Nonthaburi	252,632	231,409	0	0	0	21,223
Bang Yai	10,216	0	0	0	0	10,216
** Bang Bua Thong	79,203	52,607	0	0	0	26,596
* Pak Kret	211,378	127,064	0	0	0	84,314
Sara Buri	29,724	0	0	0	0	29,724
Don Phunt	5,006	0	0	0	0	5,006
Ban Mo	15,350	0	0	0	0	15,350
Nong Don	9,368	0	0	0	0	9,368
Total	2,476,416	638,046	109,943	10,057	317,642	1,400,728

Note: "*" refers to Amphoes that have a municipality within the basin.

" **" refers to Amphoes that have sanitary district/s within the basin.

Table 10.2.2 Population by Land Use Type (2001)

Province / Amphoe	Total Population	Municipalities (Urban)			Sanitary Districts (Sub- urban)	Rural Community
		Class A	Class B	Class C		
Chai Nat	159,934	0	17,203	0	13,420	129,311
** Muang Chai Nat	48,763	0	17,203	0	0	31,560
* Sankhaburi	53,951	0	0	0	6,663	47,288
* Sanphaya	57,220	0	0	0	6,757	50,463
Sing Buri	260,869	0	28,375	0	56,620	175,874
** Muang Sing Buri	63,738	0	28,375	0	0	35,363
* Khai Bang Rachan	34,758	0	0	0	3,754	31,004
* Tha Chang	17,193	0	0	0	11,593	5,600
* Bang Rachan	46,087	0	0	0	24,098	21,989
* Phrom Buri	24,752	0	0	0	7,808	16,944
* In Buri	74,341	0	0	0	9,367	64,974
Lop Buri	373,889	0	42,918	0	24,906	306,065
** Muang Lop Buri	280,723	0	42,918	0	19,976	217,829
Khok Samrong	572	0	0	0	0	572
* Tha Wung	62,777	0	0	0	4,930	57,847
Ban Mi	29,817	0	0	0	0	29,817
Ang Thong	275,292	0	25,387	0	57,003	192,902
** Muang Ang Thong	49,864	0	13,327	0	0	36,537
* Chaiyo	22,344	0	0	0	14,301	8,043
** Pa Mok	29,108	0	12,060	0	0	17,048
* Pho Thong	62,062	0	0	0	6,832	55,230
* Wiset Chai Chan	61,340	0	0	0	24,035	37,305
* Samko	11,398	0	0	0	8,129	3,269
* Sawaengha	39,176	0	0	0	3,706	35,470
Ayutthaya	604,803	98,140	6,145	11,657	168,544	320,317
** Muang Ayutthaya	141,839	98,140	0	0	14,456	29,243
** Tha Rua	56,330	0	0	11,657	22,848	21,825
* Nakhon Luang	39,096	0	0	0	9,330	29,766
* Bang Sai	16,053	0	0	0	6,127	9,926
* Bang Shai	46,913	0	0	0	13,422	33,491
* Bang Ban	35,387	0	0	0	13,429	21,958
* Bang Pahan	39,479	0	0	0	9,752	29,727
* Bang Pa-In	64,898	0	0	0	21,533	43,365
* Ban Phraek	9,063	0	0	0	2,546	6,517
* Phak Hai	43,258	0	0	0	25,952	17,306
* Maha Rat	24,989	0	0	0	3,038	21,951
* Lat Bua Luang	24,293	0	0	0	0	24,293
** Sena	62,716	0	6,145	0	26,111	30,460
Uthai	489	0	0	0	0	489
Pathum Thani	372,455	162,102	0	0	22,740	187,613
** Muang Pathum Thani	130,632	24,910	0	0	6,694	99,028
* Sam Khok	48,401	0	0	0	9,079	39,322
* Lat Lum Kaeo	43,981	0	0	0	6,967	37,014
* Thanyaburi	49,075	49,075	0	0	0	0
* Lam Luk Ka	31,170	31,170	0	0	0	0
* Khlong Luang	69,196	56,947	0	0	0	12,249
Nonthaburi	714,281	507,268	0	0	0	207,013
** Muang Nonthaburi	329,631	296,470	0	0	0	33,161
Bang Yai	11,306	0	0	0	0	11,306
** Bang Bua Thong	95,127	60,396	0	0	0	34,731
* Pak Kret	278,217	150,402	0	0	0	127,815
Sara Buri	29,554	0	0	0	0	29,554
Don Phunt	4,573	0	0	0	0	4,573
Ban Mo	15,818	0	0	0	0	15,818
Nong Don	9,163	0	0	0	0	9,163
Total	2,791,077	767,510	120,028	11,657	343,233	1,548,649

Note: "***" refers to Amphoes that have a municipality within the basin.

" **" refers to Amphoes that have sanitary district/s within the basin.

Table 10.2.3 Population by Land Use Type (2011)

Province / Amphoe	Total Population	Municipalities (Urban)			Sanitary Districts (Sub- urban)	Rural Community
		Class A	Class B	Class C		
Chai Nat	166,847	0	19,765	0	14,720	132,362
** Muang Chai Nat	51,332	0	19,765	0	0	31,567
* Sankhaburi	56,079	0	0	0	7,184	48,895
* Sanphaya	59,436	0	0	0	7,536	51,900
Sing Buri	290,239	0	35,973	0	62,669	191,597
** Muang Sing Buri	74,318	0	35,973	0	0	38,345
* Khai Bang Rachan	39,043	0	0	0	3,698	35,345
* Tha Chang	18,074	0	0	0	12,592	5,482
* Bang Rachan	53,013	0	0	0	27,059	25,954
* Phrom Buri	23,445	0	0	0	8,148	15,297
* In Buri	82,346	0	0	0	11,172	71,174
Lop Buri	474,063	0	49,320	0	23,546	401,197
** Muang Lop Buri	363,651	0	49,320	0	18,792	295,539
Khok Samrong	148	0	0	0	0	148
* Tha Wung	73,337	0	0	0	4,754	68,583
Ban Mi	36,927	0	0	0	0	36,927
Ang Thong	287,019	0	29,753	0	65,810	191,456
** Muang Ang Thong	51,420	0	16,896	0	0	34,524
* Chaiyo	21,764	0	0	0	17,806	3,958
** Pa Mok	28,834	0	12,857	0	0	15,977
* Pho Thong	68,109	0	0	0	6,428	61,681
* Wiset Chai Chan	61,915	0	0	0	27,831	34,084
* Samko	12,660	0	0	0	10,260	2,400
* Sawaengha	42,317	0	0	0	3,485	38,832
Ayutthaya	654,556	135,531	7,790	15,519	208,572	287,144
** Muang Ayutthaya	162,824	135,531	0	0	18,327	8,966
** Tha Rua	60,380	0	0	15,519	32,529	12,332
* Nakhon Luang	45,112	0	0	0	11,065	34,047
* Bang Sai	15,265	0	0	0	5,764	9,501
* Bang Shai	49,239	0	0	0	15,732	33,507
* Bang Ban	35,644	0	0	0	16,271	19,373
* Bang Pahan	41,684	0	0	0	14,524	27,160
* Bang Pa-In	75,547	0	0	0	28,460	47,087
* Ban Phraek	8,671	0	0	0	2,395	6,276
* Phak Hai	40,631	0	0	0	27,761	12,870
* Maha Rat	26,206	0	0	0	3,151	23,055
* Lat Bua Luang	27,029	0	0	0	0	27,029
** Sena	65,811	0	7,790	0	32,593	25,428
Uthai	513	0	0	0	0	513
Pathum Thani	477,017	192,678	0	0	26,077	258,262
** Muang Pathum Thani	182,792	32,521	0	0	8,034	142,237
* Sam Khok	58,972	0	0	0	9,832	49,140
* Lat Lum Kaeo	53,836	0	0	0	8,211	45,625
* Thanyaburi	58,478	58,478	0	0	0	0
* Lam Luk Ka	36,326	36,326	0	0	0	0
* Khlong Luang	86,613	65,353	0	0	0	21,260
Nonthaburi	1,192,834	776,941	0	0	0	415,893
** Muang Nonthaburi	559,451	486,610	0	0	0	72,841
Bang Yai	14,177	0	0	0	0	14,177
** Bang Bua Thong	137,225	79,604	0	0	0	57,621
* Pak Kret	481,981	210,727	0	0	0	271,254
Sara Buri	25,941	0	0	0	0	25,941
Don Phunt	3,370	0	0	0	0	3,370
Ban Mo	14,830	0	0	0	0	14,830
Nong Don	7,741	0	0	0	0	7,741
Total	3,568,516	1,105,150	142,601	15,519	401,394	1,903,852

Note: "*" refers to Amphoes that have a municipality within the basin.

" **" refers to Amphoes that have sanitary district/s within the basin.

Table 10.2.4 Discharged BOD Load of Domestic Wastewater by Land Use Type (1996)
(unit: kg/day)

Province / Amphoe	Total Discharged BOD	Municipalities			Sanitary Districts	Rural Communities
		Class A	Class B	Class C		
Chai Nat	7,559	0	877	0	649	6,033
** Muang Chai Nat	2,412	0	877	0	0	1,535
* Sankhaburi	2,499	0	0	0	325	2,174
* Sanphaya	2,648	0	0	0	324	2,324
Sing Buri	12,033	0	1,357	0	2,725	7,951
** Muang Sing Buri	2,949	0	1,357	0	0	1,592
* Khai Bang Rachan	1,563	0	0	0	191	1,372
* Tha Chang	826	0	0	0	563	263
* Bang Rachan	2,099	0	0	0	1,150	949
* Phrom Buri	1,227	0	0	0	387	840
* In Buri	3,369	0	0	0	434	2,935
Lop Buri	16,066	0	2,302	0	1,296	12,468
** Muang Lop Buri	12,035	0	2,302	0	1,042	6,691
Khok Samrong	38	0	0	0	0	38
* Tha Wung	2,738	0	0	0	254	2,484
Ban Mi	1,255	0	0	0	0	1,255
Ang Thong	13,073	0	1,260	0	2,705	9,108
** Muang Ang Thong	2,402	0	641	0	0	1,761
* Chaiyo	1,109	0	0	0	649	460
** Pa Mok	1,446	0	619	0	0	827
* Pho Thong	2,826	0	0	0	356	2,470
* Wiset Chai Chan	2,961	0	0	0	1,141	1,820
* Samko	533	0	0	0	366	167
* Sawaengha	1,796	0	0	0	193	1,603
Ayutthaya	29,151	5,071	301	512	7,703	15,564
** Muang Ayutthaya	7,389	5,071	0	0	649	1,669
** Tha Rua	2,659	0	0	512	968	1,179
* Nakhon Luang	1,746	0	0	0	433	1,313
* Bang Sai	797	0	0	0	319	478
* Bang Shai	2,202	0	0	0	627	1,575
* Bang Ban	1,703	0	0	0	617	1,086
* Bang Pahan	1,840	0	0	0	404	1,436
* Bang Pa-In	2,903	0	0	0	951	1,952
* Ban Phraek	447	0	0	0	133	314
* Phak Hai	2,184	0	0	0	1,269	915
* Maha Rat	1,164	0	0	0	151	1,013
Lat Bua Luang	1,088	0	0	0	0	1,088
** Sena	3,006	0	301	0	1,182	1,523
Uthai	23	0	0	0	0	23
Pathum Thani	17,044	8,258	0	0	1,057	7,729
** Muang Pathum Thani	5,571	1,275	0	0	298	3,998
* Sam Khok	2,125	0	0	0	443	1,682
* Lat Lum Kaeo	1,922	0	0	0	316	1,606
* Thanyaburi	2,446	2,446	0	0	0	0
* Lam Luk Ka	1,589	1,589	0	0	0	0
* Khlong Luang	3,391	2,948	0	0	0	443
Nonthaburi	30,785	23,966	0	0	0	6,819
** Muang Nonthaburi	14,508	13,491	0	0	0	1,017
Bang Yai	489	0	0	0	0	489
** Bang Bua Thong	4,341	3,067	0	0	0	1,274
* Pak Kret	11,447	7,408	0	0	0	4,039
Sara Buri	1,423	0	0	0	0	1,423
Don Phunt	240	0	0	0	0	240
Ban Mo	735	0	0	0	0	735
Nong Don	448	0	0	0	0	448
Total	127,134	37,295	6,097	512	16,135	67,095

Note: *** refers to Amphoes that have a municipality within the basin.
** refers to Amphoes that have sanitary district/s within the basin.

Table 10.2.5 Discharged BOD Load of Domestic Wastewater by Land Use Type (2001)
(unit: kg/day)

Province / Amphoe	Total Discharged BOD	Municipalities			Sanitary Districts	Rural Communities
		Class A	Class B	Class C		
Chai Nat	7,920	0	967	0	695	6,258
** Muang Chai Nat	2,494	0	967	0	0	1,527
* Sankhaburi	2,634	0	0	0	345	2,289
* Sanphaya	2,792	0	0	0	350	2,442
Sing Buri	13,025	0	1,580	0	2,932	8,513
** Muang Sing Buri	3,292	0	1,580	0	0	1,712
* Khai Bang Rachan	1,695	0	0	0	194	1,501
* Tha Chang	872	0	0	0	601	271
* Bang Rachan	2,312	0	0	0	1,248	1,064
* Phrom Buri	1,224	0	0	0	404	820
* In Buri	3,630	0	0	0	485	3,145
Lop Buri	18,593	0	2,489	0	1,290	14,814
** Muang Lop Buri	14,067	0	2,489	0	1,035	10,543
Khok Samrong	28	0	0	0	0	28
* Tha Wung	3,055	0	0	0	255	2,800
Ban Mi	1,443	0	0	0	0	1,443
Ang Thong	13,701	0	1,411	0	2,953	9,337
** Muang Ang Thong	2,515	0	746	0	0	1,769
* Chaiyo	1,130	0	0	0	741	389
** Pa Mok	1,490	0	665	0	0	825
* Pho Thong	3,027	0	0	0	354	2,673
* Wiset Chai Chan	3,051	0	0	0	1,245	1,806
* Samko	579	0	0	0	421	158
* Sawaengha	1,909	0	0	0	192	1,717
Ayutthaya	31,251	6,065	348	605	8,730	15,503
** Muang Ayutthaya	8,229	6,065	0	0	749	1,415
** Tha Rua	2,845	0	0	605	1,184	1,056
* Nakhon Luang	1,924	0	0	0	483	1,441
* Bang Sai	797	0	0	0	317	480
* Bang Shai	2,316	0	0	0	695	1,621
* Bang Ban	1,758	0	0	0	696	1,062
* Bang Pahan	1,944	0	0	0	505	1,439
* Bang Pa-In	3,214	0	0	0	1,115	2,099
* Ban Phraek	447	0	0	0	132	315
* Phak Hai	2,182	0	0	0	1,344	838
* Maha Rat	1,219	0	0	0	157	1,062
* Lat Bua Luang	1,176	0	0	0	0	1,176
** Sena	3,176	0	348	0	1,353	1,475
Uthai	24	0	0	0	0	24
Pathum Thani	19,911	9,653	0	0	1,178	9,080
** Muang Pathum Thani	6,672	1,532	0	0	347	4,793
* Sam Khok	2,373	0	0	0	470	1,903
* Lat Lum Kao	2,152	0	0	0	361	1,791
* Thanyaburi	2,905	2,905	0	0	0	0
* Lam Luk Ka	1,845	1,845	0	0	0	0
* Khlong Luang	3,964	3,371	0	0	0	593
Nonthaburi	40,556	30,537	0	0	0	10,019
** Muang Nonthaburi	19,452	17,847	0	0	0	1,605
Bang Yai	547	0	0	0	0	547
** Bang Bua Thong	5,317	3,636	0	0	0	1,681
* Pak Kret	15,240	9,054	0	0	0	6,186
Sara Buri	1,431	0	0	0	0	1,431
Don Phunt	221	0	0	0	0	221
Ban Mo	766	0	0	0	0	766
Nong Don	444	0	0	0	0	444
Total	146,388	46,255	6,795	605	17,778	74,955

Note: "***" refers to Amphoes that have a municipality within the basin.

"**" refers to Amphoes that have sanitary district/s within the basin.

Table 10.2.6 Discharged BOD Load of Domestic Wastewater by Land Use Type (2011)
(unit: kg/day)

Province / Amphoe	Total Discharged BOD	Municipalities			Sanitary Districts	Rural Communities
		Class A	Class B	Class C		
Chai Nat	8,501	0	1,166	0	797	6,538
** Muang Chai Nat	2,725	0	1,166	0	0	1,559
* Sankhaburi	2,804	0	0	0	389	2,415
* Sanphaya	2,972	0	0	0	408	2,564
Sing Buri	14,986	0	2,122	0	3,397	9,467
** Muang Sing Buri	4,016	0	2,122	0	0	1,894
* Khai Bang Rachan	1,946	0	0	0	200	1,746
* Tha Chang	953	0	0	0	682	271
* Bang Rachan	2,750	0	0	0	1,467	1,283
* Phrom Buri	1,198	0	0	0	442	756
* In Buri	4,123	0	0	0	606	3,517
Lop Buri	24,006	0	2,910	0	1,277	19,819
** Muang Lop Buri	18,529	0	2,910	0	1,019	14,600
Khok Samrong	7	0	0	0	0	7
* Tha Wung	3,646	0	0	0	258	3,388
Ban Mi	1,824	0	0	0	0	1,824
Ang Thong	14,781	0	1,756	0	3,566	9,459
** Muang Ang Thong	2,702	0	997	0	0	1,705
* Chaiyo	1,161	0	0	0	965	196
** Pa Mok	1,549	0	759	0	0	790
* Pho Thong	3,395	0	0	0	348	3,047
* Wiset Chai Chan	3,192	0	0	0	1,508	1,684
* Samko	675	0	0	0	556	119
* Sawaengha	2,107	0	0	0	189	1,918
Ayutthaya	35,410	8,620	460	841	11,305	14,184
** Muang Ayutthaya	10,056	8,620	0	0	993	443
** Tha Rua	3,213	0	0	841	1,763	609
* Nakhon Luang	2,282	0	0	0	600	1,682
* Bang Sai	782	0	0	0	312	470
* Bang Shai	2,508	0	0	0	853	1,655
* Bang Ban	1,839	0	0	0	882	957
* Bang Pahan	2,128	0	0	0	787	1,341
* Bang Pa-In	3,868	0	0	0	1,542	2,326
* Ban Phraek	440	0	0	0	130	310
* Phak Hai	2,141	0	0	0	1,505	636
* Maha Rat	1,310	0	0	0	171	1,139
* Lat Bua Luang	1,335	0	0	0	0	1,335
** Sena	3,483	0	460	0	1,767	1,256
Uthai	25	0	0	0	0	25
Pathum Thani	26,425	12,253	0	0	1,413	12,759
** Muang Pathum Thani	9,530	2,068	0	0	435	7,027
* Sam Khok	2,961	0	0	0	533	2,428
* Lat Lum Kaeo	2,699	0	0	0	445	2,254
* Thanyaburi	3,719	3,719	0	0	0	0
* Lam Luk Ka	2,310	2,310	0	0	0	0
* Khlong Luang	5,206	4,156	0	0	0	1,050
Nonthaburi	69,957	49,413	0	0	0	20,544
** Muang Nonthaburi	34,546	30,948	0	0	0	3,598
Bang Yai	700	0	0	0	0	700
** Bang Bua Thong	7,909	5,063	0	0	0	2,846
* Pak Kret	26,802	13,402	0	0	0	13,400
Sara Buri	1,283	0	0	0	0	1,283
Don Phunt	167	0	0	0	0	167
Ban Mo	733	0	0	0	0	733
Nong Don	383	0	0	0	0	383
Total	195,349	70,286	8,414	841	21,755	94,053

Note: "***" refers to Amphoes that have a municipality within the basin.
" **" refers to Amphoes that have sanitary district/s within the basin.

10.2.2 Industrial Wastewater

The numbers of employees in the industrial sector projected for the years 1996, 2001 and 2011 in Section 6.2 are summarized in Table 10.2.7. Based on the projected number of employees by province and by industrial group presented in the Table, the quantity and generated BOD load were computed using unit wastewater quantity and unit generated BOD load as presented in Section 8.3). Computation results are presented in Supporting Report 10.2.

Discharged BOD load projection was carried out under the same assumptions applied in the estimation of present pollution load mentioned in Section 9.3.2. The result of projection is presented in Table 10.2.8.

10.2.3 Other Wastewater Sources

(1) Livestock

Quantity of wastewater, generated BOD load and discharged BOD load from livestock by province for the years 1996, 2001 and 2011 were calculated as shown in Table 10.2.9 using the estimated number of livestock and unit BOD load presented in Tables 6.3.1 and 8.4.1, respectively.

(2) Slaughterhouse

The quantity of wastewater, generated BOD load and discharged BOD load from slaughterhouse by province were calculated as shown in Table 10.2.10 using the estimated number of slaughtered livestock and unit BOD load presented in Tables 6.4.1 and 8.4.2, respectively.

(3) Fresh Market, Fish Pond and Natural Pollution Load

The quantities of wastewater and pollution load discharged from fresh market and fish pond are assumed to be constant from the present to the future (Tables 9.3.11 and 9.3.12).

In addition, natural pollution load is also assumed to be constant throughout the future (Table 9.3.13).

Table 10.2.7 No. of Employee of Industrial Sector by Province

(1996)

Industrial Group	Food Processing	Min./Ceme. Ceramics	Light Processing	Machine/ Electric.	Others	Total
Chai Nat	5,324	192	244	312	533	6,605
Sing Buri	7,468	759	947	873	936	10,983
Lop Buri	7,132	2,073	817	6,384	2,165	18,571
Ang Thong	2,879	3,959	9,594	551	3,232	20,215
Ayutthaya	22,124	5,840	12,490	108,148	32,546	181,148
Pathum Thani	4,385	10,795	72,065	89,389	21,905	198,539
Nonthaburi	2,551	4,369	41,929	52,008	12,745	113,602
Saraburi	20,912	41,954	63,793	21,604	15,876	164,139
Total	72,775	69,941	201,879	279,269	89,938	713,802

(2001)

Industrial Group	Food Processing	Min./Ceme. Ceramics	Light Processing	Machine/ Electric.	Others	Total
Chai Nat	6,419	177	277	340	579	7,792
Sing Buri	9,004	703	1,074	949	1,016	12,746
Lop Buri	8,599	1,919	926	6,943	2,350	20,737
Ang Thong	3,472	3,665	10,875	599	3,508	22,119
Ayutthaya	26,675	5,406	14,157	117,621	35,326	199,185
Pathum Thani	3,891	9,565	63,944	79,314	19,436	176,150
Nonthaburi	2,264	3,876	37,199	46,140	11,307	100,786
Saraburi	25,213	38,838	72,307	23,496	17,232	177,086
Total	85,537	64,149	200,759	275,402	90,754	716,601

(2011)

Industrial Group	Food Processing	Min./Ceme. Ceramics	Light Processing	Machine/ Electric.	Others	Total
Chai Nat	7,396	173	298	340	595	8,802
Sing Buri	10,374	685	1,153	951	1,044	14,207
Lop Buri	9,907	1,872	995	6,954	2,416	22,144
Ang Thong	4,000	3,575	11,684	600	3,606	23,465
Ayutthaya	30,733	5,273	15,209	117,808	36,315	205,338
Pathum Thani	3,971	9,703	65,255	80,940	19,835	179,704
Nonthaburi	2,309	3,954	37,941	47,061	11,532	102,797
Saraburi	29,049	37,884	77,682	23,534	17,714	185,863
Total	97,739	63,119	210,217	278,188	93,057	742,320

Table 10.2.8 Discharged BOD Load of Industrial Wastewater by Province

(1996)

(unit: g/day/employee, kg/day)

Industrial Group	Food Processing	Min./Ceme. Ceramics	Light Processing	Machine/ Electric.	Others	Total
Unit Load w/ TP	18	1	13	1	28	—
Unit Load w/o TP	1,354	154	155	16	512	—
Chai Nat	3,652	15	20	3	144	3,834
Sing Buri	5,123	59	80	7	253	5,522
Lop Buri	4,893	161	69	54	585	5,761
Ang Thong	1,975	307	806	5	873	3,965
Ayutthaya	15,177	453	1,049	919	8,787	26,386
Pathum Thani	3,008	837	6,053	760	5,914	16,572
Nonthaburi	1,750	339	3,522	442	3,441	9,494
Saraburi	14,346	3,251	5,359	184	4,287	27,426
Total	49,924	5,420	16,958	2,374	24,283	98,959

(2001)

Industrial Group	Food Processing	Min./Ceme. Ceramics	Light Processing	Machine/ Electric.	Others	Total
Unit Load w/ TP	22	2	16	2	34	—
Unit Load w/o TP	1,655	188	189	19	626	—
Chai Nat	5,382	17	28	4	191	5,622
Sing Buri	7,550	67	110	10	335	8,072
Lop Buri	7,210	182	95	73	776	8,336
Ang Thong	2,911	348	1,115	6	1,158	5,538
Ayutthaya	22,367	514	1,451	1,235	11,658	37,224
Pathum Thani	3,263	909	6,554	833	6,414	17,972
Nonthaburi	1,898	368	3,813	484	3,731	10,295
Saraburi	21,141	3,690	7,411	247	5,687	38,175
Total	71,723	6,094	20,578	2,892	29,949	131,235

(2011)

Industrial Group	Food Processing	Min./Ceme. Ceramics	Light Processing	Machine/ Electric.	Others	Total
Unit Load w/ TP	31	2	24	2	50	—
Unit Load w/o TP	2,404	273	275	28	909	—
Chai Nat	9,005	24	45	5	285	9,363
Sing Buri	12,630	94	172	14	501	13,412
Lop Buri	12,062	257	149	104	1,158	13,731
Ang Thong	4,870	492	1,747	9	1,729	8,846
Ayutthaya	37,417	725	2,274	1,767	17,413	59,596
Pathum Thani	4,835	1,334	9,756	1,214	9,511	26,649
Nonthaburi	2,811	544	5,672	706	5,530	15,263
Saraburi	35,367	5,209	11,613	353	8,494	61,037
Total	118,997	8,679	31,427	4,173	44,621	207,897

Table 10.2.9. Number of Livestock and BOD Load by Province

Province	Livestock	Projected No. of Livestock			Generated W.W. Quantity (m3/day)			Generated BOD Load (kg/day)			Discharged BOD Load (kg/day)		
		1996	2001	2011	Unit Q'ty (l/h./d.)	1996	2001	2011	Unit Q'ty (g/h./d.)	1996	2001	2011	Unit Q'ty (g/h./d.)
Chai Nat	Buffaloes	22,700	23,400	25,000	90.0	2,043	2,106	2,250	640	14,528	14,976	16,000	0
	Cattle	55,800	58,400	63,600	90.0	5,022	5,256	5,724	640	35,712	37,376	40,704	0
	Swine	35,300	33,900	31,200	13.5	477	458	421	200	7,060	6,780	6,240	100
Sing Buri	Buffaloes	1,900	1,600	1,300	90.0	171	144	117	640	1,216	1,024	832	0
	Cattle	42,700	51,100	61,400	90.0	3,843	4,599	5,526	640	27,328	32,704	39,296	0
	Swine	17,100	14,300	12,000	13.5	231	193	162	200	3,420	2,860	2,400	100
Lop Buri	Buffaloes	12,100	10,100	8,400	90.0	1,089	909	756	640	7,744	6,464	5,376	0
	Cattle	189,400	205,200	236,900	90.0	17,046	18,468	21,321	640	121,216	131,328	151,616	0
	Swine	81,600	79,000	73,800	13.5	1,102	1,067	996	200	16,320	15,800	14,760	100
Ang Thong	Buffaloes	4,600	3,800	3,200	90.0	414	342	288	640	2,944	2,432	2,048	0
	Cattle	39,300	42,900	50,000	90.0	3,537	3,861	4,500	640	25,152	27,456	32,000	0
	Swine	57,800	73,400	93,200	13.5	780	991	1,258	200	11,560	14,680	18,640	100
Ayutthaya	Buffaloes	17,500	14,100	11,800	90.0	1,602	1,269	1,062	640	11,392	9,024	7,552	0
	Cattle	35,800	37,000	39,400	90.0	3,222	3,330	3,546	640	22,912	23,680	25,216	0
	Swine	68,800	82,300	96,800	13.5	929	1,111	1,334	200	13,760	16,460	19,760	100
Pathum Thani	Buffaloes	10,300	13,400	15,800	90.0	927	1,206	1,422	640	6,592	8,576	10,112	0
	Cattle	14,600	17,400	20,900	90.0	1,314	1,566	1,881	640	9,344	11,136	13,376	0
	Swine	59,300	71,000	85,200	13.5	801	959	1,150	200	11,860	14,200	17,040	100
Nonthaburi	Buffaloes	2,000	2,400	3,200	90.0	180	216	288	640	1,280	1,536	2,048	0
	Cattle	3,600	3,700	4,100	90.0	324	333	369	640	2,304	2,368	2,624	0
	Swine	6,000	7,100	8,500	13.5	81	96	115	200	1,200	1,420	1,700	100
Saraburi	Buffaloes	12,700	10,600	8,900	90.0	1,143	954	801	640	8,128	6,784	5,696	0
	Cattle	62,200	60,700	57,700	90.0	5,598	5,463	5,193	640	39,808	38,848	36,928	0
	Swine	138,600	165,800	199,000	13.5	1,871	2,238	2,687	200	27,720	33,160	39,800	100
TOTAL	Buffaloes	84,100	79,400	77,600	90.0	7,569	7,146	6,984	640	53,824	50,816	48,192	0
	Cattle	443,400	476,400	534,000	90.0	39,906	42,876	48,060	640	283,776	304,896	341,760	0
	Swine	464,500	526,800	601,700	13.5	6,271	7,112	8,123	200	92,900	105,360	120,340	100

Table 10.2.10 Quantity and BOD Load of Slaughterhouse Wastewater by Province

(1996)

Province	No. of Slaughtered Livestock				Generated Wastewater Quantity 1)				Generated BOD Load 2)				Discharged BOD Load 3)			
	Buffaloes (head)	Cattle (head)	Swine (head)		Buffaloes (m ³ /day)	Cattle (m ³ /day)	Swine (m ³ /day)	Total (m ³ /day)	Buffaloes (kg/day)	Cattle (kg/day)	Swine (kg/day)	Total (kg/day)	Buffaloes (kg/day)	Cattle (kg/day)	Swine (kg/day)	Total (kg/day)
Chai Nat	1,330	390	18,560		4,652	1,364	21,641	27,658	8,778	2,574	40,832	52,184	638	187	2,970	3,795
Sing Buri	70	390	5,060		245	1,364	5,900	7,509	462	2,574	11,132	14,168	34	187	810	1,030
Lop Buri	190	6,150	27,650		665	21,513	32,240	54,417	1,254	40,590	60,830	102,674	91	2,952	4,424	7,467
Ang Thong	1,080	1,100	29,870		3,708	3,848	34,828	42,384	6,996	7,260	65,714	79,970	508	528	4,779	5,816
Ayutthaya	8,400	9,980	54,600		29,383	34,910	53,684	127,957	55,440	65,868	120,120	241,428	4,032	4,790	8,736	17,558
Pathum Thani	25,820	19,370	100,590		90,318	67,773	117,288	275,383	170,412	127,842	221,288	519,552	12,394	9,298	16,094	37,786
Nonthaburi	4,800	4,070	47,760		16,790	14,237	55,688	86,715	31,680	26,862	105,072	163,614	2,304	1,954	7,842	11,899
Saraburi	2,080	3,450	60,610		7,206	12,068	70,571	89,945	13,596	22,770	133,342	169,708	989	1,656	9,638	12,342
Total	43,730	44,900	344,700		152,968	157,060	401,920	711,948	268,618	296,340	758,340	1,343,298	20,990	21,592	55,152	97,694

(2001)

Province	No. of Slaughtered Livestock				Generated Wastewater Quantity 1)				Generated BOD Load 2)				Discharged BOD Load 3)			
	Buffaloes (head)	Cattle (head)	Swine (head)		Buffaloes (m ³ /day)	Cattle (m ³ /day)	Swine (m ³ /day)	Total (m ³ /day)	Buffaloes (kg/day)	Cattle (kg/day)	Swine (kg/day)	Total (kg/day)	Buffaloes (kg/day)	Cattle (kg/day)	Swine (kg/day)	Total (kg/day)
Chai Nat	1,020	330	20,140		3,568	1,154	23,483	28,205	6,732	2,178	44,308	53,218	490	153	3,222	3,870
Sing Buri	50	330	4,320		210	1,154	5,037	6,401	396	2,178	9,504	12,078	29	156	691	876
Lop Buri	130	5,090	29,360		455	17,805	34,234	52,489	868	33,594	64,582	99,044	52	2,443	4,698	7,203
Ang Thong	940	940	34,970		3,288	3,288	40,775	47,351	6,204	6,204	76,934	89,342	451	451	5,595	6,498
Ayutthaya	10,890	12,560	60,490		37,394	43,935	70,531	151,860	70,554	82,896	133,078	286,528	5,131	6,028	9,678	20,838
Pathum Thani	21,270	15,260	118,400		74,402	53,379	138,054	265,836	140,382	100,716	260,430	501,578	10,210	7,325	18,944	36,478
Nonthaburi	4,100	3,470	54,640		14,942	12,138	63,710	90,190	27,060	22,802	120,208	170,170	1,988	1,666	8,742	12,376
Saraburi	2,300	2,830	70,680		8,045	8,889	82,425	100,359	15,180	18,678	155,518	189,376	1,104	1,353	11,310	13,773
Total	40,510	40,810	359,010		141,704	142,753	458,250	742,707	267,366	269,346	864,822	1,401,334	19,445	19,589	52,882	101,915

(2011)

Province	No. of Slaughtered Livestock				Generated Wastewater Quantity 1)				Generated BOD Load 2)				Discharged BOD Load 3)			
	Buffaloes (head)	Cattle (head)	Swine (head)		Buffaloes (m ³ /day)	Cattle (m ³ /day)	Swine (m ³ /day)	Total (m ³ /day)	Buffaloes (kg/day)	Cattle (kg/day)	Swine (kg/day)	Total (kg/day)	Buffaloes (kg/day)	Cattle (kg/day)	Swine (kg/day)	Total (kg/day)
Chai Nat	690	260	23,280		2,414	979	27,144	30,538	4,554	1,848	51,216	57,618	331	134	3,725	4,190
Sing Buri	50	260	3,700		175	979	4,314	5,469	330	1,848	8,140	10,318	24	134	592	750
Lop Buri	110	3,050	32,790		365	10,663	38,233	49,267	726	20,180	72,138	92,994	53	1,464	5,246	6,763
Ang Thong	700	800	45,180		2,448	2,798	52,680	57,927	4,620	5,280	99,396	109,296	336	384	7,223	7,943
Ayutthaya	12,590	16,480	72,270		44,040	57,577	84,267	185,884	83,094	108,636	155,934	350,724	6,043	7,901	11,563	25,507
Pathum Thani	12,720	10,490	154,000		44,495	36,694	179,564	260,753	83,952	69,234	338,800	491,956	6,106	5,035	24,840	35,781
Nonthaburi	3,510	2,970	68,400		12,278	10,389	79,754	102,421	23,168	19,602	150,480	193,248	1,885	1,426	10,944	14,054
Saraburi	2,760	1,770	90,850		9,724	6,191	105,931	121,847	18,348	11,682	199,870	228,900	1,394	850	14,536	16,720
Total	33,150	36,100	490,470		115,959	126,278	571,888	814,125	218,790	236,260	1,079,034	1,536,084	15,912	17,326	78,475	111,715

Note: 1) Unit Wastewater Quantity (l/head/day); Buffalo 3.498; Cattle 3.498; Swine 1.166
2) Unit Generated BOD Load (kg/head/day); Buffalo 6.800; Cattle 6.800; Swine 2.200
3) Unit Discharged BOD Load (kg/head/day); Buffalo 4.800; Cattle 4.800; Swine 1.600