Table 6.3.1 Characteristic of Public/On-Site Wastewater Treatment (T.) Zones in Nhue River Basin (Urban Area)

Item	(Year)	U.T.Zone 1		U.T.Zone 2		U.T.Zone 3	U.T.Zone 4	U.T.Zone 5	U.T.Zone 6		U.T.Zone 7	U.T.Zone 8	Total/Average
		T.Zone 1-1	T.Zone 1-2	T.Zone 2-1	T.Zone 2-2				T.Zone 6-1	T.Zone 6-2			
Name of Environmental Zone		Tay Ho Lake & Old City Center	Red River Right Bank North West	Old City Center	Red River Right Bank South	Old City Center	Old City Center	Red River Right Bank North West	Red River Right Bank South	Red River Right Bank North West	Sub-urban (Thanh Tri)	Sub-urban (Nhue West)	
Area (ha)		930	1,060	1,033	1,220	1,350	500	2,405	970	1,898	7,989	3,786	23,141
Population	(1997)	45,042	29,211	298,488	136,069	337,036	157,334	135,470	92,968	112,437	154,898	70,438	1,569,391
	(2005)	49,478	50,909	279,768	125,989	321,996	148,232	144,441	95,461	121,673	173,055	75,957	1,586,958
	(2010)	53,595	69,897	263,389	117,169	308,836	140,267	152,291	97,641	129,754	188,942	80,787	1,602,568
	(2020)	57,000	80,534	255,000	135,000	299,000	135,800	175,466	112,500	149,500	217,338	86,623	1,703,761
Population Density (person /ha)	(2020)	61.3 (167)	76.0	246.9	110.7	221.5	271.6	73.0	116.0	78.8	27.2	22.9	73.6
Wastewater Yield (m3/d)	(1997)	7,000	6,200	46,600	25,700	52,600	24,500	21,100	16,000	21,600	11,700	4,600	237,600
	(2005)	10,300	18,500	58,200	31,500	67,000	30,800	30,000	21,400	30,000	20,000	7,900	325,600
	(2010)	12,500	26,600	61,600	32,800	72,300	32,800	35,600	24,400	35,000	24,100	9,500	367,200
	(2020)	14,800	35,600	66,300	40,400	77,700	35,300	45,600	30,800	43,500	30,300	11,300	431,600
Pollutant Load (BOD kg/d)	(1997)	2,300	2,200	15,500	8,900	17,500	8,200	7,000	5,400	7,500	8,700	3,700	86,900
	(2005)	3,200	6,500	18,200	10,300	20,900	9,600	9,400	6,800	9,800	12,000	4,900	111,600
	(2010)	3,800	9,100	18,800	10,500	22,100	10,000	10,900	7,600	11,100	14,300	5,800	124,000
	(2020)	4,400	12,200	19,890	12,700	23,300	10,600	13,700	9,400	13,500	17,800	6,800	144,290
Specific Yield (m3/d/ha)	(2020)	15.9 (43.4)	33.6	64.2	33.1	57.6	70.6	19.0	31.8	22.9	3.8	3.0	18.7
Specific Load (kg/d/ha)	(2020)	4.7 (12.9)	11.5	19.3	10.4	17.3	21.2	5.7	9.7	7.1	2.2	1.8	6.2
Raw wastewater Quality (BOD & SS :mg/l)		297 268	343 308	300 270	314 283	300 270	300 270	300 270	305 275	310 279	587 529	602 542	334 301
Name of Receiving Water		West Lake	Nhue	Kim Nguu	Kim Nguu	To Lich	Lu	Nhue	To Lich	Nhue	Nhue	Nhue	
Proposed Wastewater Disposal System		Small Scale Centralized	On-site/ Community	Large Scale Centralized		Mediun Scale Centralized	Mediun Scale Centralized	Large Scale Centralized	Large Scale Centralized		On-site	On-site	
Alternative Wastewater Disposal System		On-site/ Community	Small Scale Centralized	Mediun Scale Centralized		Large Scale Centralized		Mediun Scale Centralized	Mediun Scale Centralized		Community		
Priority of Development Zone		4	9	1	5	3	2	8	6	7	10	11	
Population of On-site system	(1997)	45,042	29,211	298,488	136,069	337,036	157,334	135,470	92,968	112,437	154,898	70,438	1,569,391
	(2005)	0	50,909	0	125,989	321,996	148,232	144,441	95,461	121,673	173,055	75,957	1,257,712
	(2010)	0	34,949	0	117,169	0	0	152,291	97,641	129,754	188,942	80,787	801,532
	(2020)	0	40,267	0	0	0	0	0	0	0	217,338	86,623	344,228

Table 6.3.2 Characteristic of Public/On-Site Wastewater Treatment (T.) Zones in Sub-districts

Item	(Year)	Gia Lam			Dong Anh					Soc Son	Total/Average
		G.T.Zone 1	G.T.Zone 2	G.T.Zone 3	D.T.Zone 1	D.T.Zone 2	D.T.Zone 3	D.T.Zone 4	D.T.Zone 5		
Name of Environmental Zone		Gia Lam Urban Area	Gia Lam Urban Area (Yen Vien Town)	Sub-urban (Gia Lam)	Dong Anh Urban Area (Phuong Trach Center)	Dong Anh Urban Area (Axe of Co Loa - Red River Center)	Dong Anh Urban Area (North Thang Long & South Van Tri)	Dong Anh Urban Area (Others)	Sub-urban (Dong Anh)	Sub-urban (Soc Son)	
Area (ha)		4,095	200	12,382	550	660	2,110	5,205	9,310	29,521	64,033
Population	(1997)	118,859	10,531	183,420	5,058	6,827	27,650	74,382	120,253	233,166	780,146
	(2010)	145,499	7,953	214,463	35,088	35,088	64,562	179,652	146,683	277,571	1,106,559
	(2020)	311,000	17,000	235,730	75,000	75,000	138,000	384,000	166,742	301,489	1,703,961
Population Density (person /ha)	(2020)	75.9	85.0	19.0	136.4	113.6	65.4 (79.1)	73.8	17.9	10.2	26.6
Wastewater Yield (m3/d)	(1997)	24,900	1,600	11,900	800	1,100	4,300	14,400	7,800	16,400	83,200
	(2010)	46,400	1,900	25,100	8,200	8,200	29,100	48,100	17,200	34,100	218,300
	(2020)	101,300	4,400	35,600	19,500	19,500	49,900	121,600	21,700	41,200	414,700
Pollutant Load (BOD kg/d)	(1997)	8,700	500	9,500	300	400	1,400	4,900	6,300	12,600	44,600
	(2010)	15,400	600	15,300	2,500	2,500	10,200	15,300	10,500	20,500	92,800
	(2020)	32,400	1,300	18,400	5,900	5,900	16,400	38,500	13,000	24,300	156,100
Specific Yield (m3/d/ha)		24.7	22.0	2.9	35.5	29.5	23.6	23.4	2.3	1.4	6.5
Specific Load (kg/d/ha)		7.9	6.5	1.5	10.7	8.9	7.8	7.4	1.4	0.8	2.4
Raw wastewater Quality (BOD & SS :mg/l)		320 288	295 266	517 465	303 272	303 272	329 296	317 285	599 539	590 531	376 339
Name of Receiving Water		Bac Hung	Canal/Field	Canal/Field	Canal/Field	Canal/Field	Canal/Field	Canal/Field	Canal/Field	Canal/Field	
Proposed Wastewater Disposal System		Large Scale Centralized	Small Scale Centralized	On-site	Small Scale Centralized	Small Scale Centralized	Large Scale Centralized	Community /On-site	On-site	On-site	
Alternative Wastewater Disposal System		Mediun Scale Centralized	Community		Large Scale Centralized						
Priority of Developed Zone		1	2	6	3	4	On-going	5	7	8	
Population of On-site system	(1997)	118,859	10,531	183,420	5,058	6,827	27,650	74,382	120,253	233,166	780,146
	(2010)	145,499	7,953	214,463	35,088	35,088	0	89,826	146,683	277,571	952,171
	(2020)	0	0	235,730	75,000	75,000	0	192,000	166,742	301,489	1,045,961

Table 6.3.3 Comparison of Typical Wastewater Treatment Method

Item		AS	EA	MA	OD	SP	AL	TF	RB
Flexibility	Shock Load	1	2	1	2	3	3	3	2
	Over Load	1	2	1	2	3	3	3	2
	Toxic/Hazardous	2	2	1	2	2	2	2	2
Workability	Workability of O&M	1	2	1	3	3	3	3	2
	Reliability of O&M System	3	3	3	3	3	3	2	1
	Complication	2	2	1	3	3	3	3	2
	Necessity of High Technology	2	2	2	2	3	3	3	1
Characteristics	Excess Sludge	1	3	1	3	3	3	2	1
	Stability of temperature	2	2	2	3	1	1	2	2
	Nitrification	2	3	1	3	2	3	3	3
	Actual Results	3	3	1	3	3	3	1	1
	Side effect against the circumference	2	2	2	2	1	1	1	2
Required Land	(OD : 100%)	3 (50)	2 (75)	3 (45)	2 (100)	1 (730)	1 (270)	2 (70)	3 (55)
Removal Efficiency	(BOD) (%) (SS) (%)	3 90 85	3 90 85	1 70 70	2 85 80	1 70 70	1 70 70	1 70 70	3 90 85
Required Cost	Construction	1	1	2	2	3	3	3	1
	O & M	1	1	2	2	3	3	3	2
Evaluation		30	35	25	39	38	39	37	30

Remarks: 3 : Excellent 2 : Moderate 1 : Inferior

AS : Conventional Activated Sludge Process
EA : Extended Aeration Process
MA : Modified Aeration Process
OD : Oxidation Ditch Process
SP : Stabilization Pond Process
AL : Aerated Lagoon Process
TF : High Rate Trickling Filter Process
RB : Rotating Biological Contactor Process

Table 6.3.4 - Annual Investment and Operating Costs for HSDC Reform for Sewerage (1/2)

Sewerage	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Wastewater Treatment plants				pilot treatment			Zone 2-1			Zone 4		Zone 3
Process Engineers	ea.	1	1	1	1	1	2	2	2	2	2	2
Process Operators	ea.	2	2	2	2	2	4	4	4	6	6	8
Mechanics	ea.	3	3	3	3	3	6	6	6	9	9	12
Electricians	ea.	2	2	2	2	2	4	4	4	6	6	8
lab technicians	ea.	2	2	2	2	2	4	4	4	5	5	6
Total	ea.	10	10	10	10	10	20	20	20	28	28	36
Staff costs for operations	1000 USD	7	7	7	7	7	14	14	14	20	20	25
Trucks for travelling operators, lab techs & mtce trades	ea.	5	5	5	5	5	10	10	10	14	14	18
investment cost	1000 USD	250		-			250			200		250
Operating cost for vehicles	1000 USD	75	75	75	75	75	150	150	150	210	210	270
Collection system pumping station maintenance												
Mechanics	persons	1	1	1	1	1	2	2	2	3	3	4
Electricians	persons	1	1	1	1	1	2	2	2	3	3	4
Apprentices	persons	2	2	2	2	2	4	4	4	6	6	8
Drivers	persons	1	1	1	1	1	2	2	2	3	3	4
Total	ea.	5	5	5	5	5	10	10	10	15	15	20
Staff costs for operations	1000 USD	3.50	3.5	3.5	3.5	3.5	7.0	7.0	7.0	10.5	10.5	14.0
Trucks for travelling maintenance trades	ea.	1	1	1	1	1	2	2	2	3	3	4
investment cost	1000 USD	50					50			50		50
Operating cost for vehicles	1000 USD	15	15	15	15	15	30	30	30	45	45	60
Sewer inspection program												
engineers	persons							1	1	1	1	1
inspectors	persons							5	5	5	5	5
surveyors	persons							6	6	6	6	6
laborers	persons							10	10	10	10	10
Total	persons	-	-	-	-	-	-	22	22	22	22	22
Staff costs for operations	1000 USD	-	-	-	-	-	-	15.40	15.4	15.4	15.4	15.4
Trucks for work crews	ea.	-	-	-	-	-	-	7	7	7	7	7
investment cost	1000 USD	-						350				
Operating cost for vehicles	1000 USD	-	-	-	-	-	-	105	105	105	105	105
Compiling sewer inventory data												
information management specialist	persons							1	1	1	1	1
technicians	persons							3	3	3	3	3
CAD operators	persons							3	3	3	3	3
clerks	persons							1	1	1	1	1
Total	persons							8	8	8	8	8
Staff costs for operations	1000 USD							5.6	5.6	5.6	5.6	5.6
computers	ea.							8	-	-	-	-
Investment cost	1000 USD							80	-	-	-	-
Total costs												
Annual investment cost	1000 USD	300	-	-	-	-	300	430	-	250	-	300
Annual operating costs	1000 USD	101	101	101	101	101	201	327	327	411	411	495
Training (technical assistance)	1000 USD						340					430

Table 6.3.4 - Annual Investment and Operating Costs for HSDC Reform for Sewerage (2/2)

Sewerage	Unit	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Wastewater Treatment plants					Zone 2-2	Zone 6-1			Zone 5		Zone 6-2+GiaLam
Process Engineers	ea.	2	2	2	3	3	3	3	4	4	4
Process Operators	ea.	8	8	8	10	12	12	12	14	14	16
Mechanics	ea.	12	12	12	15	18	18	18	20	20	20
Electricians	ea.	8	8	8	10	12	12	12	12	12	12
lab technicians	ea.	6	6	6	7	8	8	8	8	8	8
Total	ea.	36	36	36	45	53	53	53	58	58	60
Staff costs for operations	1000 USD	25	25	25	32	37	37	37	41	41	42
Trucks for travelling operators, lab techs & mtce trades	ea.	18	18	18	23	27	27	27	29	29	30
investment cost	1000 USD			-			-			-	
Operating cost for vehicles	1000 USD	270	270	270	338	398	398	398	435	435	450
Collection system pumping station maintenance											
Mechanics	persons	4	4	4	4	5	5	5	6	6	7
Electricians	persons	4	4	4	4	5	5	5	6	6	7
Apprentices	persons	8	8	8	8	10	10	10	12	12	14
Drivers	persons	4	4	4	4	5	5	5	6	6	7
Total	ea.	20	20	20	20	25	25	25	30	30	35
Staff costs for operations	1000 USD	14.00	14	14	14	18	18	18	21	21	25
Trucks for travelling maintenance trades	ea.	4	4	4	4	5	5	5	6	6	7
investment cost	1000 USD					50			50		50
Operating cost for vehicles	1000 USD	60	60	60	60	75	75	75	90	90	105
Sewer inspection program											
engineers	persons	1	1	1	1	1	1	1	1	1	1
inspectors	persons	5	5	5	5	5	5	5	5	5	5
surveyors	persons	6	6	6	6	6	6	6	6	6	6
laborers	persons	10	10	10	10	10	10	10	10	10	10
Total	persons	22	22	22	22	22	22	22	22	22	22
Staff costs for operations	1000 USD	15.4	15.4	15.4	15.4	15.4	15.4	15.4	15.4	15.4	15.4
Trucks for work crews	ea.	7	7	7	7	7	7	7	7	7	7
investment cost	1000 USD			350							
Operating cost for vehicles	1000 USD	105	105	105	105	105	105	105	105	105	105
Compiling sewer inventory data											
information management specialist	persons	1	1	1	1	1	1	1	1	1	1
technicians	persons	3	3	3	3	3	3	3	3	3	3
CAD operators	persons	3	3	3	3	3	3	3	3	3	3
clerks	persons	1	1	1	1	1	1	1	1	1	1
Total	persons	8	8	8	8	8	8	8	8	8	8
Staff costs for operations	1000 USD	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6
computers	ea.		8						8	-	-
Investment cost	1000 USD	-	80					-	80	-	-
Total costs											
Annual investment cost	1000 USD	-	80	350	-	50	-	-	130	-	50
Annual operating costs	1000 USD	495	495	495	569	653	653	653	713	713	748
Training (operating budget)	1000 USD	15	15	15	15	15	20	20	20	20	20
		510	510	510	584	668	673	673	733	733	768

Table 6.3.5 Project Cost and Annual O&M Cost for Urban Public Sewerage Project

(Unit: US$1,000)

Sewerage Zone / Cost Item	U.T.ZONE 2-1	U.T.ZONE 2-2	U.T.ZONE 3	U.T.ZONE 4	U.T.ZONE 5	U.T.ZONE 6-1	U.T.ZONE 6-2	G.T.ZONE 1	G.T.ZONE 2	D.T.ZONE 1	D.T.ZONE 2	Toatl
1) Direct Cost	51,286	39,293	64,113	28,669	64,043	29,187	57,175	110,691	9,180	26,432	28,813	508,882
a. Treatment Plant	32,242	17,086	40,427	21,861	26,662	15,944	23,100	49,789	4,580	13,868	13,868	259,428
b. Sewer	18,662	22,040	23,464	6,605	37,013	12,876	33,891	59,091	4,329	11,905	14,286	244,160
c. Diversion Chamber	48		38	19				48				152
d. Relay Pumping Station	336	168	184	184	368	368	184	1,764	271	659	659	5,144
2) Land Acquisition Cost	2,505	1,253	15,200	11,419	2,755	728	1,029	2,250	500	1,000	1,000	39,639
3) Engineering Services Cost (15 % of 1)	7,693	5,894	9,617	4,300	9,606	4,378	8,576	16,604	1,377	3,965	4,322	76,332
4) Administration Cost (3% of 1)	1,539	1,179	1,923	860	1,921	876	1,715	3,321	275	793	864	15,266
5) Sub-total	63,023	47,619	90,853	45,248	78,325	35,169	68,495	132,866	11,332	32,190	34,999	640,119
6) Physical Contingency (10% of 5)	6,302	4,762	9,085	4,525	7,833	3,517	6,850	13,287	1,133	3,219	3,500	64,013
Total	69,325	52,381	99,938	49,773	86,158	38,686	75,345	146,153	12,465	35,409	38,499	704,132

(Annual O&M Cost)

Sewerage Zone / Cost Item (US$/year)	U.T.ZONE 2-1	U.T.ZONE 2-2	U.T.ZONE 3	U.T.ZONE 4	U.T.ZONE 5	U.T.ZONE 6-1	U.T.ZONE 6-2	G.T.ZONE 1	G.T.ZONE 2	D.T.ZONE 1	D.T.ZONE 2	Toatl
A.Treatment Plant	967	513	1,213	656	800	478	693	1,494	137	416	416	6,814
B.Collection Sewer System	57	67	71	20	112	40	102	183	14	38	45	652
Toatl	1,024	580	1,284	676	912	518	795	1,677	151	454	461	7,466

(Replacement cost)

25years after Construction	U.T.ZONE 2-1	U.T.ZONE 2-2	U.T.ZONE 3	U.T.ZONE 4	U.T.ZONE 5	U.T.ZONE 6-1	U.T.ZONE 6-2	G.T.ZONE 1	G.T.ZONE 2	D.T.ZONE 1	D.T.ZONE 2	Toatl
(US$)	23,326	14,191	28,074	17,123	18,009	11,561	16,001	35,352	2,304	8,406	8,406	163,638

Table 6.3.6 Priority of Public Sewerage Development Zones

Item	U.T.Zone 2		U.T.Zone 3	U.T.Zone 4	U.T.Zone 5	U.T.Zone 6		Gia Lam		Dong Anh		Total/ Average
	T.Zone 2-1	T.Zone 2-2				T.Zone 6-1	T.Zone 6-2	G.T.Zone 1	G.T.Zone 2	D.T.Zone 1	D.T.Zone 2	
Name of Environmental Zone	Old City Center	Red River Right Bank South	Old City Center	Old City Center	Red River Right Bank North West	Red River Right Bank South	Red River Right Bank North West	Gia Lam Urban Area	Gia Lam Urban Area (Yen Vien Town)	Dong Anh Urban Area (Phuong Trach Center)	Dong Anh Urban Area (Axe of Co Loa - Red River Center)	
(1) Area (ha)	1,033	1,220	1,350	500	2,405	970	1,898	4,095	200	550	660	14,881
(2) Served Population in 2020	255,000	135,000	299,000	135,800	175,466	112,500	149,500	311,000	17,000	75,000	75,000	1,740,266
(3) Served Population Dencity (person /ha)	246.9	110.7	221.5	271.6	73.0	116.0	78.8	75.9	85.0	136.4	113.6	116.9
(4) Wastewater Yield in 2020	66,300	40,400	77,700	35,300	45,600	30,800	43,500	101,300	4,400	19,500	19,500	484,300
(5) Pollutant Load in 2020	19,890	12,700	23,300	10,600	13,700	9,400	13,500	32,400	1,300	5,900	5,900	148,590
(6) Specific Yield (m3/d/ha)	64.2	33.1	57.6	70.6	19.0	31.8	22.9	24.7	22.0	35.5	29.5	32.5
(7) Specific Load (kg/d/ha)	19.3	10.4	17.3	21.2	5.7	9.7	7.1	7.9	6.5	10.7	8.9	10.0
(8) Raw wastewater Quality (BOD & SS :mg/l)	300 270	314 283	300 270	300 270	300 270	305 275	310 279	320 288	295 266	303 272	303 272	307 276
(9) Name of Receiving Water	Kim Nguu	Kim Nguu	To Lich	Lu	Nhue	To Lich	Nhue	Bac Hung	Canal/Field	Canal/Field	Canal/Field	
(10) Index of Influence to Receiving water Quality	1 (serious)	2 (polluted)	1 (serious)	1 (serious)	2 (polluted)	1 (serious)	2 (polluted)	1 (serious)	3 (slightly)	3 (slightly)	3 (slightly)	
(11) Direct cost (Million US$)	51.288	39.294	64.113	28.669	64.043	29.188	57.175	110.692	9.180	26.432	28.813	508.887
(12) Specific Direct Cost (US$/person) (Million US$/ha)	201 0.050	291 0.032	214 0.047	211 0.057	365 0.027	259 0.030	382 0.030	356 0.027	540 0.046	352 0.048	384 0.044	292 0.034
(13) Pollutant Load Runoff after Treatment (kg/d)	1,989	1,270	2,330	1,060	1,370	940	1,350	3,240	130	590	590	14,859
(14) Benifit per cost index (kg/Million US$))	349	291	327	333	193	290	213	263	127	201	184	263
Priority of Development Zone	1	5	3	2	8	6	7	9	10	11	12	

Table 6.3.7 - Typical calculation method for estimating septage quantities

Populations		
Population requiring organised septage collection and disposal service		1,000,000
Assumptions		
A	dry solids produced per person (g/capita.day)	55
B	dry solids after reduction by digestion in septic tanks (g/capita.day)	34
C	water content of solids	87%
D	no. of persons per septic tank	8
E	average size of septic tank m3	4
F	density of septage (Kg/liter)	1.024
Quantities of septage		
G=Bx365/1000	Dry weight of solids accumulated per year (Kg/capita/year)	12
H=G/(1-C/100)	Wet weight of solids accumulated per capita per year (kg/capita per year)	95
I=H/1000/F	Volume of solids accumulated in septic tanks (m3/capita.year)	0.093
J=DxI	Volume of solids accumulated per septic tank (m3/year)	0.7
K=75% x E / J	cleaning frequency in years (75% = tanks cleaned when 3/4 full)	4.0
Assuming septic tanks are disconnected after sewers are installed		
L=Population/ D / K	no. of tanks to be cleaned every year	31,075
M=ExLx75%	volume of septage removed for disposal m3/year (75%=collectable amount)	93,224
N=L/365	volume of septage removed for disposal m3/d (1)	255
O=N/population	specific yield m3/day/capita	0.000255

Notes:

(1) Daily amount assuming collection 7 days per week, 52 weeks per year

Table 6.3.8 - Septage Quantities by Environmental and Wastewater treatment zone (1/3)

Area		Nhue River Basin						
Waste water treatment zone		T 1-1	T 1-2	T 2-1	T 2-2	T 3	T 4	T 5
Environmental zone		Tay Ho Lake & Old City Center	Red River Right Bank North West	Old City Center	Red River Right Bank South	Old City Center	Old City Center	Red River Right Bank North West
Urban Population	1997	45,042	29,211	298,488	136,069	337,036	157,334	135,470
	2005	49,478	50,909	279,768	125,989	321,996	148,232	144,441
	2010	53,595	69,897	263,389	117,169	308,836	140,267	152,291
	2020	57,000	80,534	255,000	135,000	299,000	135,800	175,466
Population Density	2020	61.3	76.0	246.9	110.7	221.0	271.6	73.0
Wastewater disposal system proposed		Small scale centralized	On-site/ community	Large scale centralized		medium scale centralized	medium scale centralized	Large Scale centralized
Population with septic tanks (not connected to public sewer system)	1997	45,042	29,211	298,488	136,069	337,036	157,334	135,470
	2005	0	50,909	0	125,989	321,996	148,232	144,441
	2010	0	34,949	0	117,169	0	0	152,291
	2020	0	40,267	0	0	0	0	0
Specific yield (m3/day/capita)		0.000255	0.000255	0.000255	0.000255	0.000255	0.000255	0.000255
Septage Yield (m3/day)	1997	11	7	76	35	86	40	35
	2005	0	13	0	32	82	38	37
	2010	0	9	0	30	0	0	39
	2020	0	10	0	0	0	0	0

Notes:
(1) Septage amounts are not included in the total because population density is less than 30 p.p.ha.

Table 6.3.8 - Septage Quantities by Environmental and Wastewater treatment zone (2/3)

Area		Nhue River Basin					Gia Lam			
Waste water treatment zone		T 6-1	T 6-2	T 7 (1)	T 8 (1)	Total	GT 1	GT 2	GT 3 (1)	Total
Environmental zone		Red River Right Bank South	Red River Right Bank North West	Sub-urban (Thanh Tri)	Sub-urban (Nhue West)		Gia Lam Urban Area	Gia Lam Urban Area (Yen View Town)	Sub-urban area(Gia Lam)	
Urban Population	1997	92,968	112,437	154,898	70,438	1,344,055	118,859	10,531	183,420	129,390
	2005	95,461	121,673	173,055	75,957	1,337,947	135,253	8,945	202,523	144,197
	2010	97,641	129,754	188,942	80,787	1,332,839	145,499	7,953	214,463	153,452
	2020	112,500	149,500	217,338	86,623	1,399,800	311,000	17,000	235,730	328,000
Population Density	2020	116.0	78.8	27.2	22.9		75.9	85	19	
Wastewater disposal system proposed		Large Scale centralized		On-site	On-site		Large Scale Centralized	Small Scale Centralized	On-site	
Population with septic tanks (not connected to public sewer system)	1997	92,968	112,437	154,898	70,438	1,344,055	118,859	10,531	183,420	129,390
	2005	95,461	121,673	173,055	75,957	1,008,701	135,253	8,945	202,523	144,197
	2010	97,641	129,754	188,942	80,787	531,804	145,499	7,953	214,463	153,452
	2020	0	0	217,338	86,623	40,267	0	0	235,730	0
Specific yield (m3/day/capita)		0.000255	0.000255	0.000255	0.000255	0.000255	0.000255	0.000255	0.000255	0.000255
Septage Yield (m3/day)	1997	24	29	39	18	343	30	3	47	33
	2005	24	31	44	19	257	34	2	52	37
	2010	25	33	48	21	136	37	2	55	39
	2020	0	0	55	22	10	0	0	60	0

Notes:
(1) Septage amounts are not included in the

Table 6.3.8 - Septage Quantities by Environmental and Wastewater treatment zone (3/3)

Area		Dong Anh						Sub-urban (Soc Son) [1]
Waste water treatment zone		DT 1	DT 2	DT 3	DT 4	DT 5 [1]	Total	
Environmental zone		Dong Anh Urban Area (Phuong Trach Center)	Dong Anh Urban Area (Co Loa-Red River Center)	Dong Anh Urban Area (North Tang Long & South Van Tri)	Dong Anh Urban Areas (others)	Sub-urban (Dong Anh)		
Urban Population	1997	5,058	6,827	27,650	74,382	120,253	113,917	233,166
	2005	23,538	24,218	50,365	139,164	136,518	237,285	260,492
	2010	35,088	35,088	64,562	179,652	146,683	314,390	277,571
	2020	75,000	75,000	138,000	384,000	166,742	672,000	301,489
Population Density	2020	136.4	113.6	65.4	73.8	17.9		10.2
Wastewater disposal system proposed		Small Scale Centralized	Small Scale Centralized	Large Scale Centralized	Community/ On-site	On-site		On-site
Population with septic tanks (not connected to public sewer system)	1997	5,058	6,827	27,650	74,382	120,253	113,917	233,166
	2005	23,538	24,218	10,635	83,886	136,518	142,277	260,492
	2010	35,088	35,088	0	89,826	146,683	160,002	277,571
	2020	75,000	75,000	0	192,000	166,742	342,000	301,489
Specific yield (m3/day/capita)		0.000255	0.000255	0.000255	0.000255	0.000255	0.000255	0.000255
Septage Yield (m3/day)	1997	1	2	7	19	31	29	59
	2005	6	6	3	21	35	36	66
	2010	9	9	0	23	37	41	71
	2020	19	19	0	49	43	87	77

Notes:
(1) Septage amounts are not included in the

Table 6.3.9 - Septage collection and disposal plan for Environmental Zones in Nhue River Basin)[1]

Year	Qty of septage m3/d	Collection managed by TUPWS			Not collected	Regulated Private Sector Services		Collection	Treatment
		m3/d	% of total	No. of trucks [2]	% of total	m3/d	% of total		
1999	343	75	22%	17	78%	-	0%		
2000	343	100	29%	13	71%	0	0%		
2001	343	125	36%	16	64%	0	0%	Replace existing trucks.	Domestic septage from Hanoi is treated temporarily at a new treatment facility near Gia Lam
2002	343	150	44%	19	56%	0	0%		
2003	342	175	51%	22	49%	0	0%		
2004	342	175	51%	22	49%	0	0%		
2005	257	175	68%	22	32%	0	0%	Increase collection capacity. Implement pricing strategy that encourages regular cleaning.	Sewage treatment plant for zone 2-1.
2006	225	175	78%	22	22%	0	0%		Domestic septage from Hanoi is co-treated with wastewater
2007	200	175	88%	22	13%	0	0%		
2008	175	160	91%	20	4%	9	5%		Sewage treatment plant for zone 4.
2009	150	130	87%	16	3%	15	10%		
2010	136	110	81%	14	4%	20	15%		Sewage treatment plant for zone 3.
2011	130	100	77%	13	3%	26	20%	Implement mandatory cleaning of septic tanks. Regulations are enforced. The role of the private sector increases.	
2012	115	80	70%	10	5%	29	25%		
2013	100	70	70%	9	5%	25	25%		
2014	90	65	72%	8	3%	23	25%		
2015	75	50	67%	6	3%	23	30%		Sewage treatment plant expansion for zone 2-1.
2016	60	35	58%	4	7%	21	35%		
2017	45	20	44%	3	11%	20	45%		
2018	30	-	0%	-	5%	29	95%	Quantities of septage from urban areas decreases as sewerage systems are developed. All collection provided by private sector	Smaller quantities of septage are co-treated at wastewater treatment plants.
2019	20	-	0%	-	5%	19	95%		
2020	10	-	0%	-	5%	10	95%		

(1) Sub-urban areas of Thanh Tri and Nhue West are excluded

(2) Assumed collection capacity per vehicle   1 truck = 5 m3 x 2 trips/day x 80% availability = 8 m3/day

Table 6.3.10 - Septage collection and disposal plan for environmental zones in Gia Lam [1]

Year	Qty of septage m3/d	Collection managed by TUPWS			Not Collected	Regulated Private Sector Services		Collection	Treatment
		m3/d	% of total	No. of trucks [2]	% of total	m3/d	% of total		
1999	33	5	15%	2	85%	0	0%	No improvements to collection capacity	Construct septage receiving and treatment facility. Treat domestic septage from Gia Lam, Hanoi and Dong Anh
2000	34	10	29%	1	71%	0	0%		
2001	35	15	43%	2	57%	0	0%		
2002	35	15	43%	2	57%	0	0%		
2003	36	15	42%	2	58%	0	0%		
2004	36	15	42%	2	58%	0	0%		
2005	37	20	54%	3	46%	0	0%	Increase collection capacity. Implement pricing strategy encourage regular cleaning.	Treat domestic septage from Gia Lam and Dong Anh at septage ponds.
2006	37	20	54%	3	46%	0	0%		
2007	38	20	53%	3	47%	0	0%		
2008	39	25	64%	4	36%	0	0%	Implement mandatory cleaning of septic tanks. Regulations are enforced. The role of the private sector increases.	
2009	39	25	64%	4	36%	0	0%		
2010	39	25	64%	4	31%	2	5%		
2011	42	30	71%	4	19%	4	10%		
2012	43	30	70%	4	15%	6	15%		
2013	45	30	67%	4	13%	9	20%		Construct large scale sewage treatment plant. Co-treat septage with wastewater. Abandon septage ponds.
2014	40	25	63%	4	13%	10	25%		
2015	35	20	57%	3	13%	11	30%		
2016	25	10	40%	2	10%	13	50%	quantities of septage from urban areas decreases as sewerage systems are developed	Construct small scale treatment plant for Yen Vien Town.
2017	15	5	33%	2	7%	9	60%		
2018	10	-	0%	2	5%	10	95%		
2019	5	-	0%	2	5%	5	95%		
2020	-	0	0%	-	5%	0	95%		

(1) excluding sub-urban areas

(2) Assumed collection capacity per vehicle 1 truck = 5 m3 x 2 trips/day x 80% availability = 8 m3/day

Table 6.3.11- Septage collection and disposal plan for environmental zones in Don Anh [1]

Year	Qty of septage m3/d	Collected by URENCO or HSDC			Not Collected	Regulated Private Sector Services		Collection	Treatment
		m3/d	% of total	No. of trucks [2]	% of total	m3/d	% of total		
1999	29	2	5%	2	95%	0	0%	Individual community based collection	Small community lagoons and land application in rural areas. Septage from urban developments treated at septage ponds in near Gia Lam.
2000	30	6	20%	2	80%	0	0%		
2001	32	8	25%	2	75%	0	0%		
2002	34	10	30%	2	70%	0	0%		
2003	36	13	35%	2	65%	0	0%		
2004	38	15	40%	2	60%	0	0%		
2005	36	16	45%	3	55%	0	0%		
2006	37	20	55%	3	45%	0	0%		Many small scale community systems are implemented in communities around industrial developments. Septage is treated at these wastewater treament plants
2007	38	23	60%	4	40%	0	0%		
2008	39	25	65%	4	35%	0	0%		
2009	40	28	70%	4	30%	0	0%		
2010	41	31	75%	5	20%	2	5%		
2011	45	33	73%	5	17%	3	10%	Organize area wide collection and disposal services.	
2012	50	35	70%	5	15%	5	15%		
2013	55	36	65%	5	15%	7	20%		
2014	60	36	60%	5	15%	9	25%		
2015	65	36	55%	5	15%	11	30%		
2016	70	35	50%	5	15%	12	35%		
2017	75	30	40%	5	15%	14	45%		
2018	80	24	30%	4	10%	14	60%		
2019	85	17	20%	3	10%	12	70%		
2020	87	-	0%	-	5%	0	95%		

(1) excluding sub-urban areas

(2) Assumed collection capacity per vehicle 1 truck = 5 m3 x 2 trips/day x 80% availability = 8 m3/day

Table 6.3.12 - Impact of septage discharges at Wastewater Treatment Plants

	Nhue River Basin 2005	2010
1 Volume collected for disposal per day (m3/day)	175	110
2 Septage loading		
a) Septage characteristics		
BOD mg/l	6,000	6,000
SS mg/l	15,000	15,000
b) loading		
BOD Kg/day	1,050	660
SS Kg/day	2,625	1,650
3 Plant Capacity (m3/day)		
- zone 2 treatment plant	75000	75000
- zone 4 treatment plant		70000
- zone 3 treatment plant		45000
	total	190000
4 Increase in BOD and SS loading caused by septage		
a) Influent wastewater characteristics		
BOD mg/l	312	305
SS mg/l	300	300
b) Plant BOD load without septage (mg/l)		
- zone 2 plant	23400	22875
- zone 4 plant		21350
- zone 3 plant		13725
c) Plant SS load without septage (mg/l)		
- zone 2 plant	22500	22500
- zone 4 plant		21000
- zone 3 plant		13500
d) Percentage of total septage received at each treatment plant		
- zone 2 plant	100%	39%
- zone 4 plant		37%
- zone 3 plant		24%
		100%
e) Increase in plant BOD loading per day with septage		
- zone 2 plant	4%	1%
- zone 4 plant		1%
- zone 3 plant		1%
f) Increase in plant SS loading per day with septage		
- zone 2 plant	12%	3%
- zone 4 plant		3%
- zone 3 plant		3%

5 Comments

Peaks day deliveries of up to 3 times the average can be expected.

6 Conclusion

Treatment plants must be designed with extra capacity to treat high suspended solids and BOD loads from septage

investment cost for wastewater treatment plant includes 1% allowance for extra capacity

O&M costs include a 10% allowance for increased treatment costs

Table 6.3.13 - Estimate of Area Required for Gia Lam Septage Pond

		2005	2010	2020	
Maximum Quantity of Septage Collected					
Nhue River Basin	m3/d	175	110	10	
Gia Lam	m3/d	20	25	5	
Dong Anh	m3/d	16	31	87	
		211	166	102	
Design Temperature coldest month:	celcius	16	16	16	
Average Annual Rainfall	mm/year	1,674	1,674	1,674	
Average Annual Evaporation Rate	mm/year	984	984	984	
Net Rainfall	mm/year	691	691	691	
Septage BOD:	mg/l	6,000	6,000	6,000	600
1. Facultative pond					
a. daily BOD load (L, kg/d) is calculated from: L=.001 x Li x Q	kg/d	1,268	994	615	
b. permissible BOD surface loading at 16°C (Mara 1987)	kg/d	183	183	183	
c. facultative pond area = a/b	ha	6.9	5.4	3.4	
2. Hydraulic retention time					
d. Volume of septage	m3/d	211	166	102	
e. Volume due to net rainfall = c x net rainfall / 365	m3/d	131	103	64	
f. Volume of influent	m3/d	342	268	166	
g. Pond depth	m	1.2	1.2	1.2	
h. Retention time	days	243	243	243	

Table 6.3.14 - Annual Investment and Operating Costs for Septage Priority Project (1/2)

Septage Collection and Disposal in Nhue River Basin

	Unit	Priority project					Recurrent Costs						
		2000	2001	2002	2003	Total	2004	2005	2006	2007	2008	2009	2010
Quantity of Septage Generated	m3/d	343	343	343	342		342	257	225	200	175	150	136
Quantity of Septage Collected	m3/d	100	125	150	175		175	175	175	175	160	130	110
Septage collection and disposal													
vacuum trucks required 5m3	ea.	13	16	19	22		22	22	22	22	20	16	14
existing trucks from previous year	ea.	17	13	16	19		22	22	22	22	22	20	17
trucks retired	ea.	17	-	-	-		-	-	-	6	8	3	3
existing trucks this year	ea.	-	13	16	19		22	22	22	16	14	17	14
new trucks necessary	ea.	13	3	3	3		-	-	-	6	6	-	-
Cost													
Direct Cost	1000 USD	1,950	450	450	450		-	-	-	900	900	-	-
Engineering Services	1000 USD	98	23	23	23		-	-	-	45	45	-	-
Administration	1000 USD	59	14	14	14		-	-	-	27	27	-	-
Investment cost for vehicles	1000 USD	2,106	486	486	486	3,564	-	-	-	972	972	sub-total	1,944
Operating cost for vehicles	1000 USD	390	90	90	90		-	-	-	-	-56	-113	-75
Personnel for collection and disposal operations													
Manager	persons	1											
Drivers	persons	13	3	3	3		-	-	-	-	-2	-4	-2
Helpers	persons	13	3	3	3		-	-	-	-	-2	-4	-2
Mechanics	persons	2	1	1	1		-	-	-	-	-	-	-1
Mechanic apprentice	persons	2	1	1	1			-	-	-	-	-	-1
Staff costs for vehicles	1000 USD	21.7	5.6	5.6	5.6		-	-	-	-	-2.8	-5.6	-4.2
Annual operating costs	1000 USD	411.7	507.3	602.9	698.5		698.5	698.5	698.5	698.5	639.5	521.4	442.2
Approvals and inspection program													
vehicles	1000 USD	150.0	150.0	100.0	100.0								
computers	1000 USD	25.0	20.0	10.0	-								
Investment cost	1000 USD	175.0	170.0	110.0	100.0		-	-					
Personnel for approvals and inspection													
Manager	persons	1		-	-		-		-	-	-	-	-
Inspectors	persons	3	3	2	2					-	-	-	-
technicians		2	2	1									
data entry clerks		2	2	1									
incremental staff cost for approvals and inspection	1000 USD	5.6	4.9	2.8	1.4		-	-	-	-	-	-	-
Annual operating costs	1000 USD	5.6	10.5	13.3	14.7	-	14.7	14.7	14.7	14.7	14.7	14.7	14.7
Interim septage treatment lagoon													
land aquisition (10 ha)	1000 USD	2,500											
engineering	1000 USD	100	350										
direct construction	1000 USD			3,000									
admin	1000 USD			90									
contingency	1000 USD			604									
Investment cost	1000 USD	2,600	350	3,694	-	6,644	-						
Annual operation cost	1000 USD	-	-	-	20		20	20	20	20	20	20	20
Total costs													
Investment cost	1000 USD	4,881	1,006	4,290	586	10,763			-	972	972		
operating costs	1000 USD	417	518	616	733		733	733	733	733	674	556	477
Unit operating cost	USD /m3	11.4	11.3	11.3	11.5		11.5	11.5	11.5	11.5	11.5	11.7	11.9

Table 6.3.14 - Annual Investment and Operating Costs for Septage Priority Project (1/2)

Septage Collection and Disposal in Nhue River Basin

	Unit	Recurrent cost									
		2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Quantity of Septage Generated	m3/d	130	115	100	90	75	60	45	30	20	10
Quantity of Septage Collected	m3/d	100	80	70	65	50	35	20	-	-	-
Septage collection and disposal											
vacuum trucks required 5m3	ea.	13	10	9	8	6	4	3	-	-	-
existing trucks from previous year	ea.	14	13	13	13	13	7	4	3	-	-
trucks retired	ea.	1	-	-	-	6	3	1	3	-	-
existing trucks this year	ea.	13	13	13	13	7	4	3	-	-	-
new trucks necessary	ea.	-	-	-	-	-	-	-	-	-	-
Cost											
Direct Cost	1000 USD	-	-	-	-	-	-	-	-	-	-
Engineering Services	1000 USD	-	-	-	-	-	-	-	-	-	-
Administration	1000 USD	-	-	-	-	-	-	-	-	-	-
Investment cost for vehicles	1000 USD	-	-	-	-		-	-	-	-	
incremental operating cost for vehicles	1000 USD	-38	-75	-38	-19	-56	-56	-56	-75	-	-
Personnel for collection and disposal operations											
Manager	persons	-									
Drivers	persons	-	-2	-	-2	-	-2	-	-	-	-
Helpers	persons	-	-2	-	-2	-	-2	-	-	-	-
Mechanics	persons	-	-1	-	0	-	-1	-	-	-	-
Mechanic apprentice	persons	-	-1	-	0		-1	-	-	-	-
incremental staff costs for vehicles	1000 USD	-	-4.2	-	-2.8	-	-4.2	-	-	-	-
Annual operating costs	1000 USD	404.7	325.5	288.0	266.4	210.2	149.7	93.5	18.5	18.5	18.5
Approvals and Inspection program											
vehicles	1000 USD										
computers	1000 USD										
Investment cost	1000 USD										
Personnel for approvals and inspection											
Manager	persons	-		-	-	-		-	-	-	-
inspectors	persons	-	-2	-	-2				-	-2	-
technicians		-	-2	-	-2						
data entry clerks		-	-2	-	0						
incremental staff cost for approvals and inspection	1000 USD	-	-4.2	-	-2.8	-	-	-	-	-1	-
Annual operating costs	1000 USD	14.7	10.5	10.5	7.7	7.7	7.7	7.7	7.7	6.3	6.3
Interim septage treatment lagoon											
land aquisition (10 ha)	1000 USD	-									
engineering	1000 USD	0	-								
direct construction	1000 USD			-							
admin	1000 USD			-							
contingency	1000 USD			-							
Investment cost	1000 USD	-	-	-		-					
Annual operation cost	1000 USD	20	20	20	20	20	20	20	20	20	20
Total costs											
Annual investment cost	1000 USD	-	-	-	-			-	-	-	
operating costs	1000 USD	439	356	318	294	238	177	121	46	45	45
Unit operating cost	USD /m3	9.3	8.5	8.7	9.0	8.7	8.1	7.4	4.2	6.1	11.9

Table 6.3.15 - Annual Investment and Operating Costs for septage collection and disposal EMP study area (1/2)

	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Septage collection and disposal												
Quantity of Septage Generated	m3/d	407	410	412	414	416	330	299	276	253	229	216
Quantity of Septage Collected (Nhue River Basin)	m3/d	100	125	150	175	175	175	175	175	169	145	130
Quantity of Septage Collected (Gia Lam)	m3/d	10	15	15	15	15	20	20	20	25	45	27
Quantity of Septage Collected (Dong Anh)	m3/d	6	8	10	13	15	16	20	23	25	28	32
new trucks necessary (Nhue River Basin)	ea.	13	3	3	3	-	-	-		13		-
new trucks necessary (Gia Lam)	ea.	2					1			3		
new trucks necessary (Dong Anh)	ea.	2					1		1	2		1
total	ea.	17	3	3	3	-	2	-	1	18	-	1
Investment cost for vehicles	ea.	2,754	486	486	486	-	324	-	162	2,916	-	162
trucks in operation (Nhue River Basin)	ea.	13	16	19	22	22	22	22	22	20	16	14
trucks in operation (Gia Lam)	ea.	1	2	2	2	2	3	3	3	4	4	4
trucks in operation (Dong Anh)	ea.	2	2	2	2	2	3	3	4	4	4	5
total		16	20	23	26	26	28	28	29	28	24	23
Operating cost for vehicles	1000 USD	480	600	690	780	780	840	840	870	840	720	690
Personnel for collection and disposal operations												
Manager	persons	2	2	2	2	2	2	2	2	2	2	2
Drivers	persons	16	20	23	26	26	28	28	29	28	24	23
Helpers	persons	16	20	23	26	26	28	28	29	28	24	23
Mechanics	persons	4	5	6	7	7	7	7	7	7	6	6
Mechanic apprentice	persons	4	5	6	7	7	7	7	7	7	6	6
Staff costs for operating vehicles	1000 USD	29	36	42	47	47	50	50	52	50	43	42
Total annual operating cost for vehicles	1000 USD	509	636	732	827	827	890	890	922	890	763	732
Approvals and inspection program												
vehicles	1000 USD	150	300	400	500							
computers	1000 USD	25	45	55	55					50		
Investment cost	1000 USD	175	345	455	555					50		
Personnel for approvals and inspection												
Manager	persons	1	1	1	1	1	1	1	1	1	1	1
Inspectors	persons	3	6	8	10	10	10	10	10	10	10	10
technicians		2	4	5	5	5	5	5	5	5	5	5
data entry clerks		2	4	5	5	5	5	5	5	5	5	5
Total annual operating cost for approvals and inspection	1000 USD	8	15	19	21	21	21	21	21	21	21	21
Interim septage treatment lagoon												
land aquisition (10 ha)	1000 USD	2,500										
engineering	1000 USD	100	350									
direct construction	1000 USD			3,000								
admin	1000 USD			90								
contingency	1000 USD			604								
Investment cost	1000 USD	2,600	350	3,694	sub-total	6,644						
Annual operation cost	1000 USD	-	-	-	20	20	20	20	20	20	20	20
Cost of treating septage at wastewater treatment plants	1000 USD							18	18	17	15	13
Total costs												
Annual investment cost	1000 USD	5,529	1,181	4,635	1,041	6,644	324	-	162	2,966	-	162
Annual operating costs	1000 USD	517	651	751	868	868	931	949	981	948	819	786
Unit operating cost	USD /m3	12	12	12	12	12	12	12	12	12	10	11

Table 6.3.15 - Annual Investment and Operating Costs for septage collection and disposal EMP study area (2/2)

	Unit	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Septage collection and disposal											
Quantity of Septage Generated	m3/d	217	208	200	190	175	155	135	120	110	97
Quantity of Septage Collected (Nhue River Basin)	m3/d	126	109	95	88	73	56	40	29	19	10
Quantity of Septage Collected (Gia Lam)	m3/d	34	36	39	35	31	23	14	10	5	0
Quantity of Septage Collected (Dong Anh)	m3/d	36	40	43	45	46	47	44	38	29	-
new trucks necessary (Nhue River Basin)	ea.	-	-	-	-	-	-	-	-	-	-
new trucks necessary (Gia Lam)	ea.			1			1				
new trucks necessary (Dong Anh)	ea.			1		1					
Total		-	-	2	-	1	1	-	-	-	-
Investment cost for vehicles	ea.	-	-	324	-	162	162	-	-	-	-
trucks in operation (Nhue River Basin)	ea.	16	14	12	11	9	7	5	4	2	1
trucks in operation (Gia Lam)	ea.	4	5	5	4	4	3	2	1	1	0
trucks in operation (Dong Anh)	ea.	5	5	5	6	6	6	5	5	4	-
total		25	23	22	21	19	16	12	10	7	1
Annual operating cost for vehicles	1000 USD	736	695	663	628	561	472	367	287	197	37
Personnel for collection and disposal operations											
Manager	persons	2	2	2	2	2	2	2	2	2	1
Drivers	persons	25	23	22	21	19	16	12	10	7	1
Helpers	persons	25	23	22	21	19	16	12	10	7	1
Mechanics	persons	6	6	6	5	5	4	3	2	2	0
Mechanic apprentice	persons	6	6	6	5	5	4	3	2	2	0
Staff costs for operating vehicles	1000 USD	44	42	40	38	34	29	23	18	13	3
Total annual operating costs	1000 USD	781	737	703	666	595	500	389	305	210	39
Approvals and inspection program											
vehicles	1000 USD		400								150
computers	1000 USD			25							25
Investment cost	1000 USD		400	25	-	-	-	-	-	-	175
Personnel for approvals and inspection											
Manager	persons	1	1	1	1	1	1	1	1	1	1
Inspectors	persons	10	8	8	6	6	6	6	6	4	4
technicians		5	3	3	1	1	1	1	1	1	1
data entry clerks		5	3	3	3	3	3	3	3	2	2
Total annual operating cost for approvals and inspection	1000 USD	21	15	15	11	11	11	11	11	8	8
Interim septage treatment lagoon											
land aquisition (10 ha)	1000 USD	-									
engineering	1000 USD		-								
direct construction	1000 USD			-							
admin	1000 USD			-							
contingency	1000 USD			-							
Investment cost	1000 USD	-	-	-		-					
Annual operation cost	1000 USD	20	20	20	20	-	-	-	-	-	-
Cost of treating septage at wastewater treatment plants	1000 USD	13	11	10	9	15	13	10	8	5	1
Total costs											
Annual investment cost	1000 USD	-	400	349	-	162	162	-	-	-	175
operating costs	1000 USD	834	783	748	706	621	524	410	323	224	48
Unit operating cost	USD /m3	11	10	10	9	9	8	7	6	4	1

Table 6.3.16 Project Cost and Annual O&M Cost for Lake Conservation Project

(Project Cost) (Unit: US$1,000)

Cost Item	West Lake Phase II	Main City Lakes (14 Lakes)	Other City Lakes (50 Lakes)	Toatl
1) Construction Cost	27,000	8,000	12,000,000	12,035,000
a. Lake Conservation Works		1,344	12,000,000	12,001,344
b. Lake Sediments Dredging Works		6,240		6,240
c. Sewer & Dredging	10,000			10,000
d. Large scale Wastewater Treatment	7,000			7,000
e. Flushing Water Facilities	10,000			
2) Land Acquisition Cost	1,250	375	6,000,000	6,001,625
3) Engineering Services Cost (15 % of 1)	4,000	1,000	1,800,000	1,805,000
4) Administration Cost (3% of 1)	1,000	0	360,000	361,000
5) Sub-total	33,250	8,959	20,160,000	20,192,209
6) Physical Contingency (10% of 5)	3,000	1,000	2,016,000	2,020,000
Total	36,000	10,000	22,176,000	22,222,000

(Annual O&M Cost)

Cost Item	West Lake	Main City Lakes	Other City Lakes	Toatl
(US$1,000/year)				
1) Treatment Plant/Mechanical	205	8	60	273
2) Sewer System/Civil Facilities	61	3	30	94
Toatl	266	11	90	367

(Replacement cost)

25years after Construction	West Lake	Main City Lakes	Other City Lakes	Toatl
(US$)	6,833	269	2,000	9,102

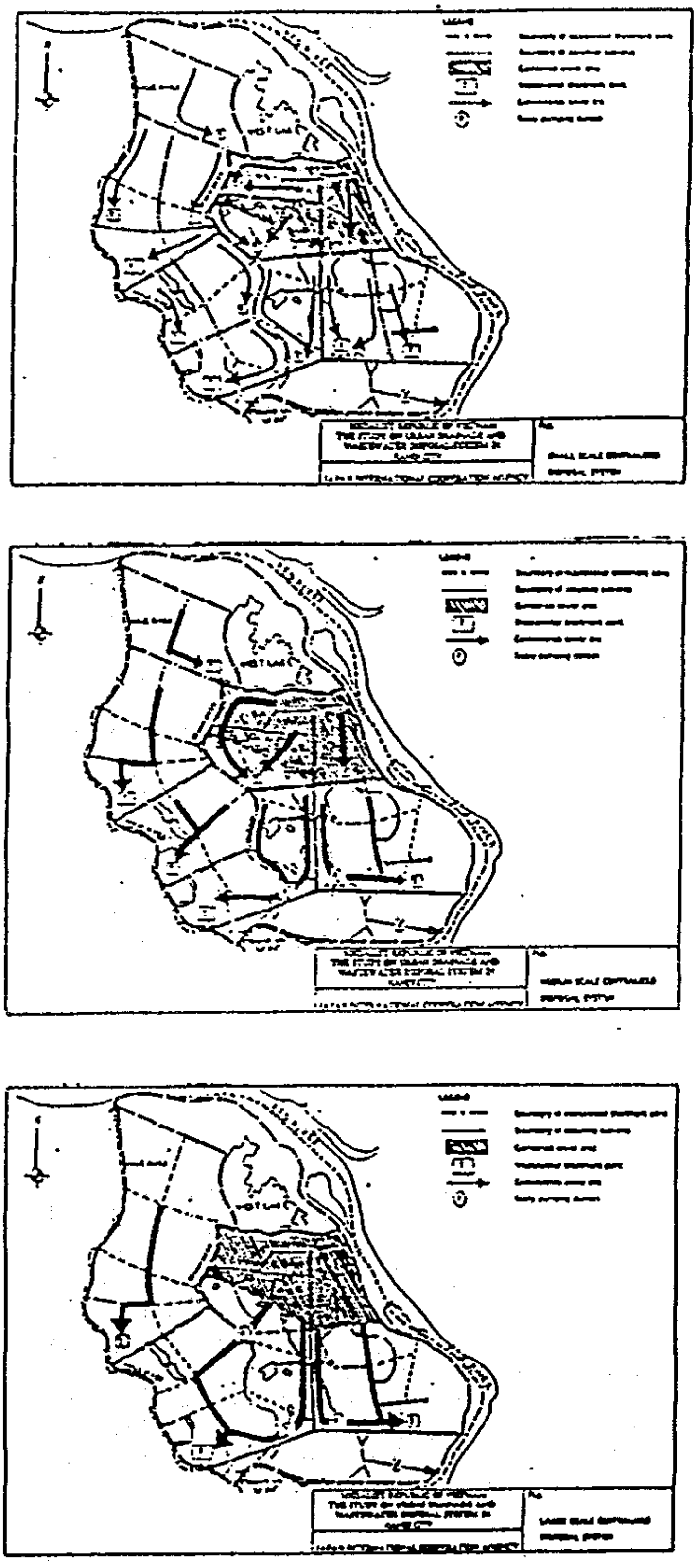


Figure 6.3.1

Schematic Wastewater Disposal System at Each Scale

JAPAN INTERNATIONAL COOPERATION AGENCY

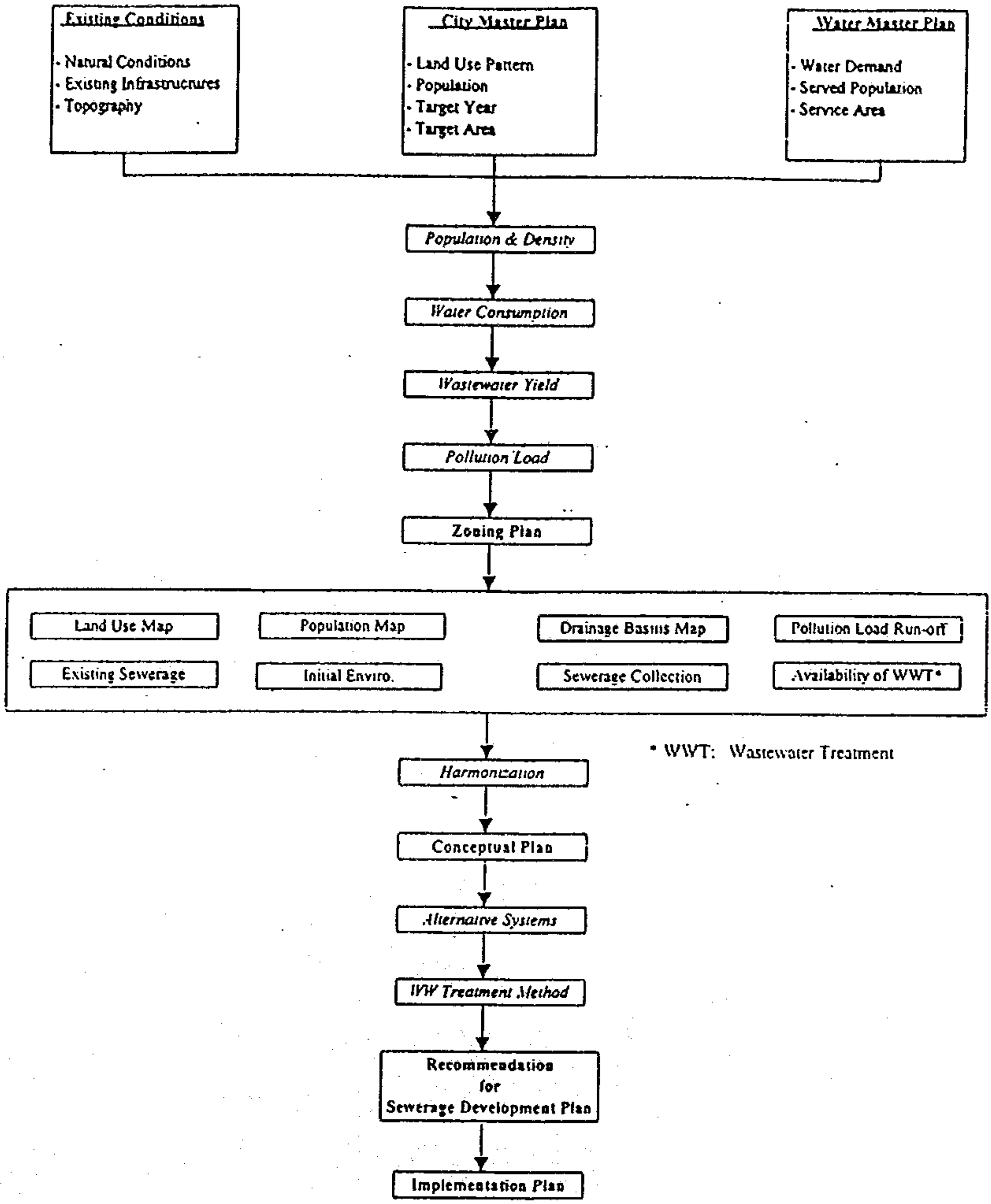
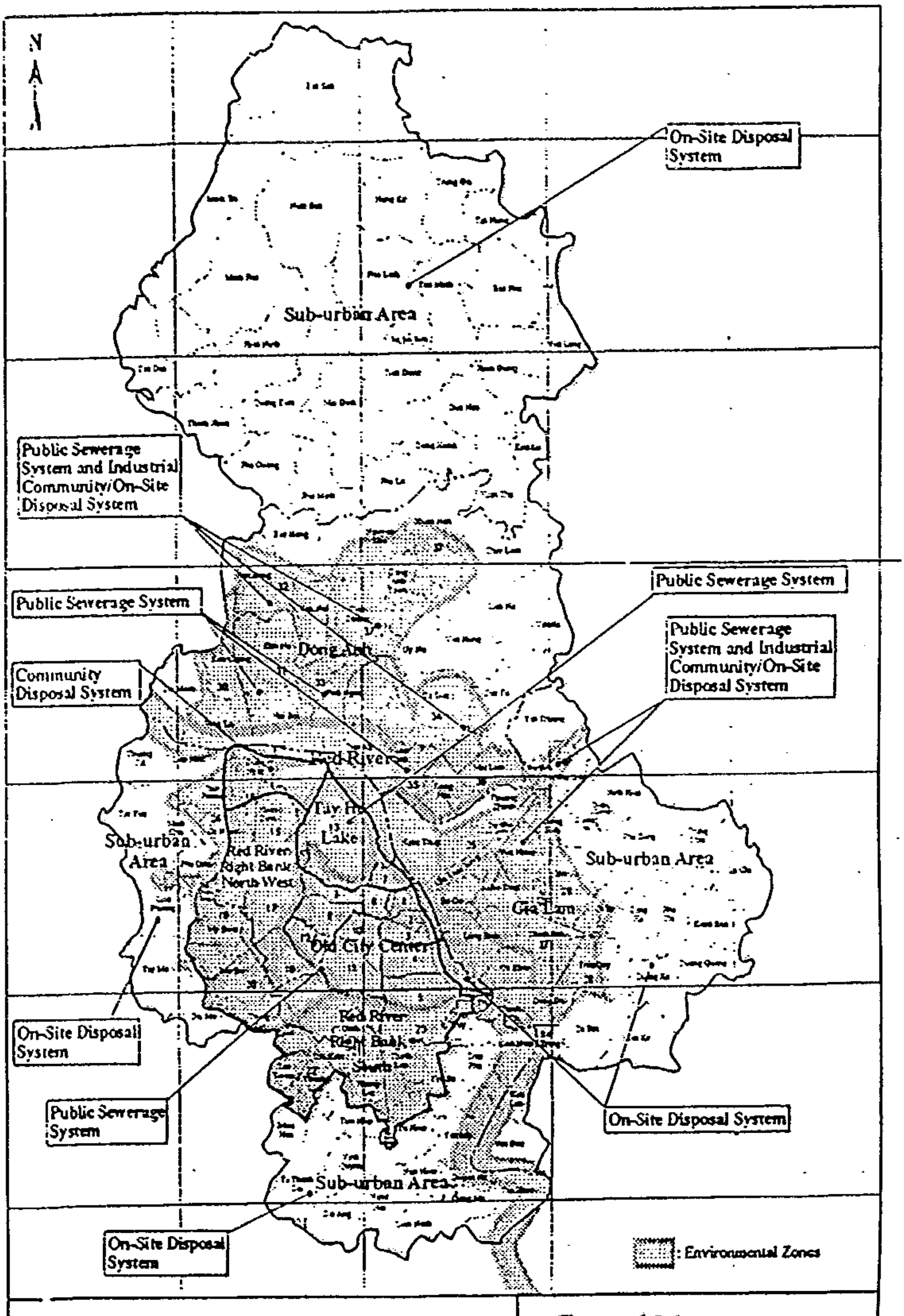
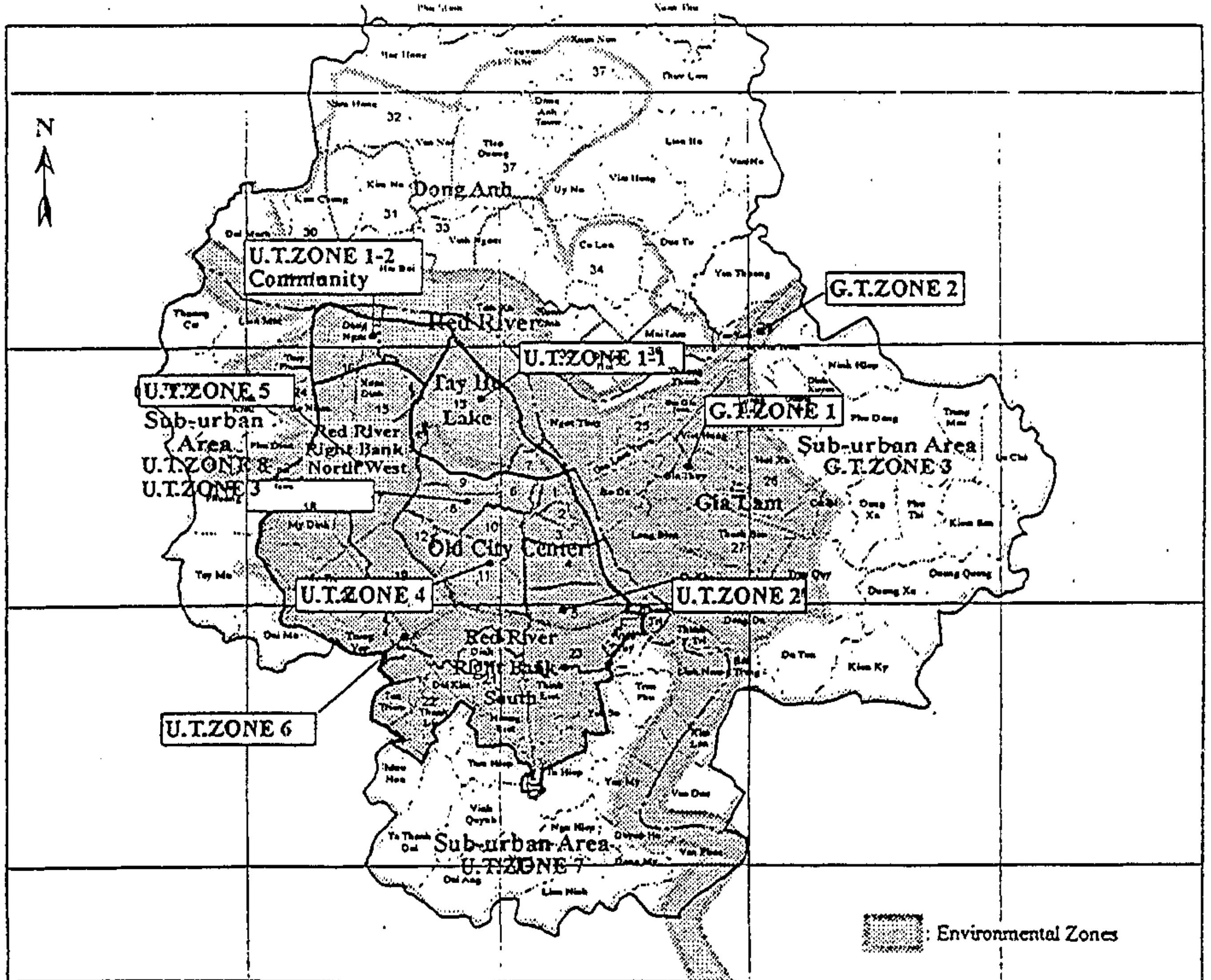


Figure 6.3.2 APPROACH OF SEWERAGE DEVELOPMENT PLAN



THE STUDY ON ENVIRONMENTAL IMPROVEMENT FOR HANOI CITY	Figure 6.3.3 Sewerage and Sanitation Development Plan
JAPAN INTERNATIONAL COOPERATION AGENCY	



THE STUDY ON ENVIRONMENTAL IMPROVEMENT FOR HANOI CITY	Figure 6.3.4
JAPAN INTERNATIONAL COOPERATION AGENCY	Sewerage and Sanitation Development Plan

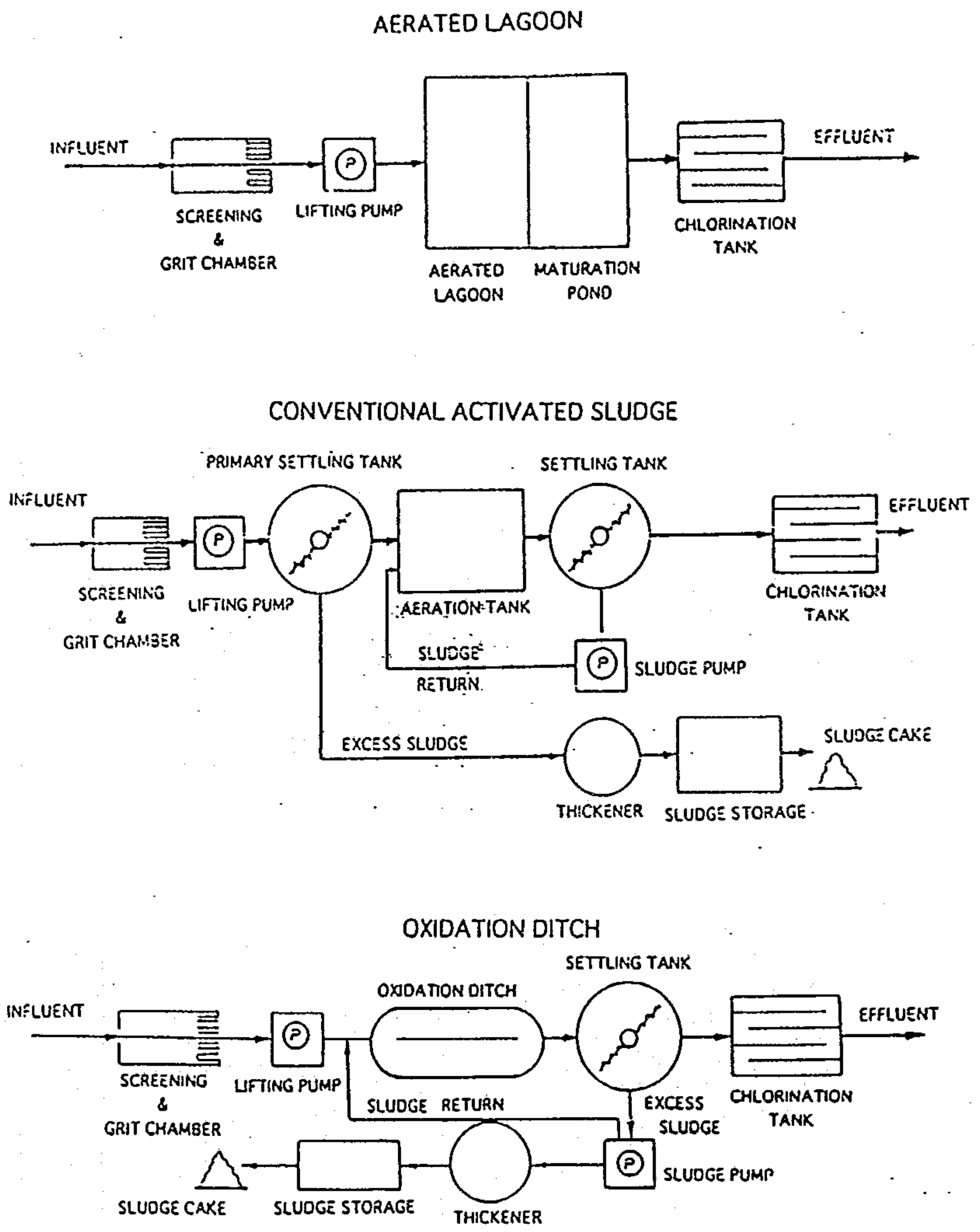
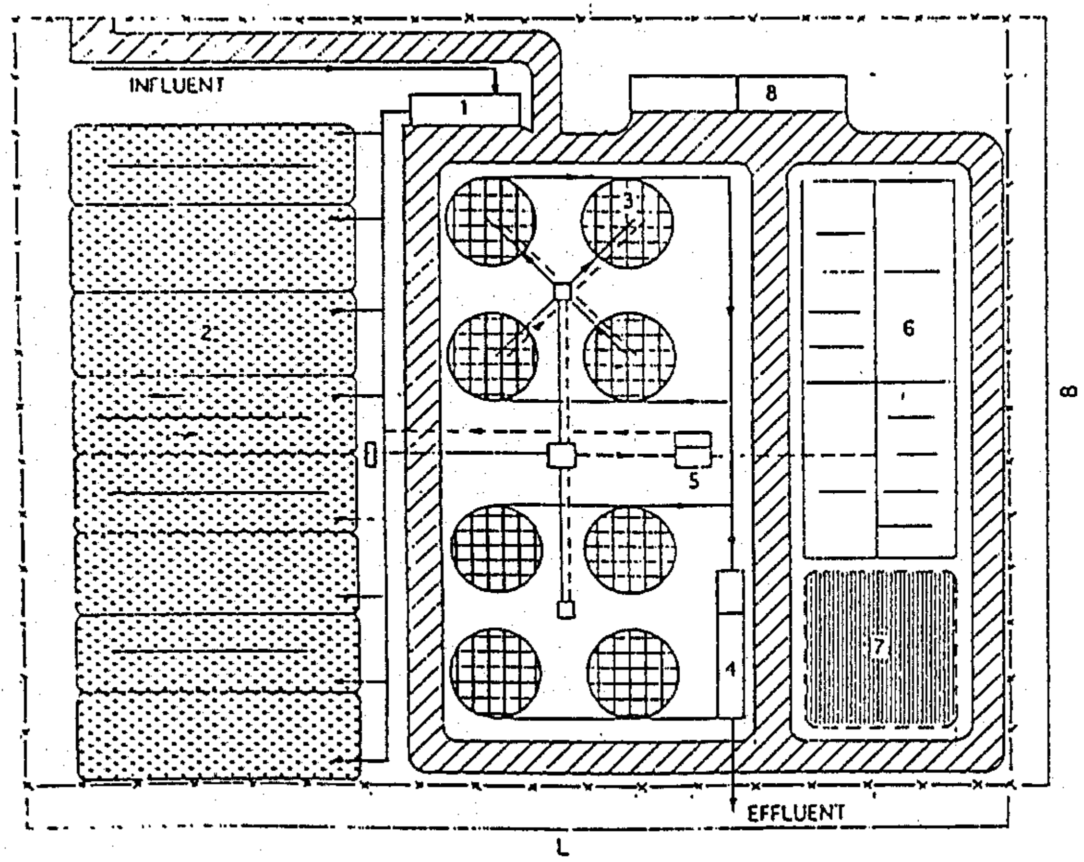


Figure 6.3.5

Typical Wastewater Treatment Methods

JAPAN INTERNATIONAL COOPERATION AGENCY



1.INLET FACILITIES AND FLOW MEASUREMENT
2. OXIDATION DITCHES
3. SETTLING TANKS
4. CHLORINATION CONTACT TANK
DOSING PUMPS AND STORAGE
5. SLUDGE PUMPING STATION
6.SLUDGE DRYING BEDS
7. SLUDGE STORAGE
8. ADMINISTRATIVE OFFICE AND LABORATORY

LEGEND

- ROAD
- FENCE
- FLOW PATH
- SLUDGE PIPES

JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 6.3.6 Schematic Layout for Oxidation Ditch

Figure 6.3.7 Implementation Schedule of Wastewater Disposal System

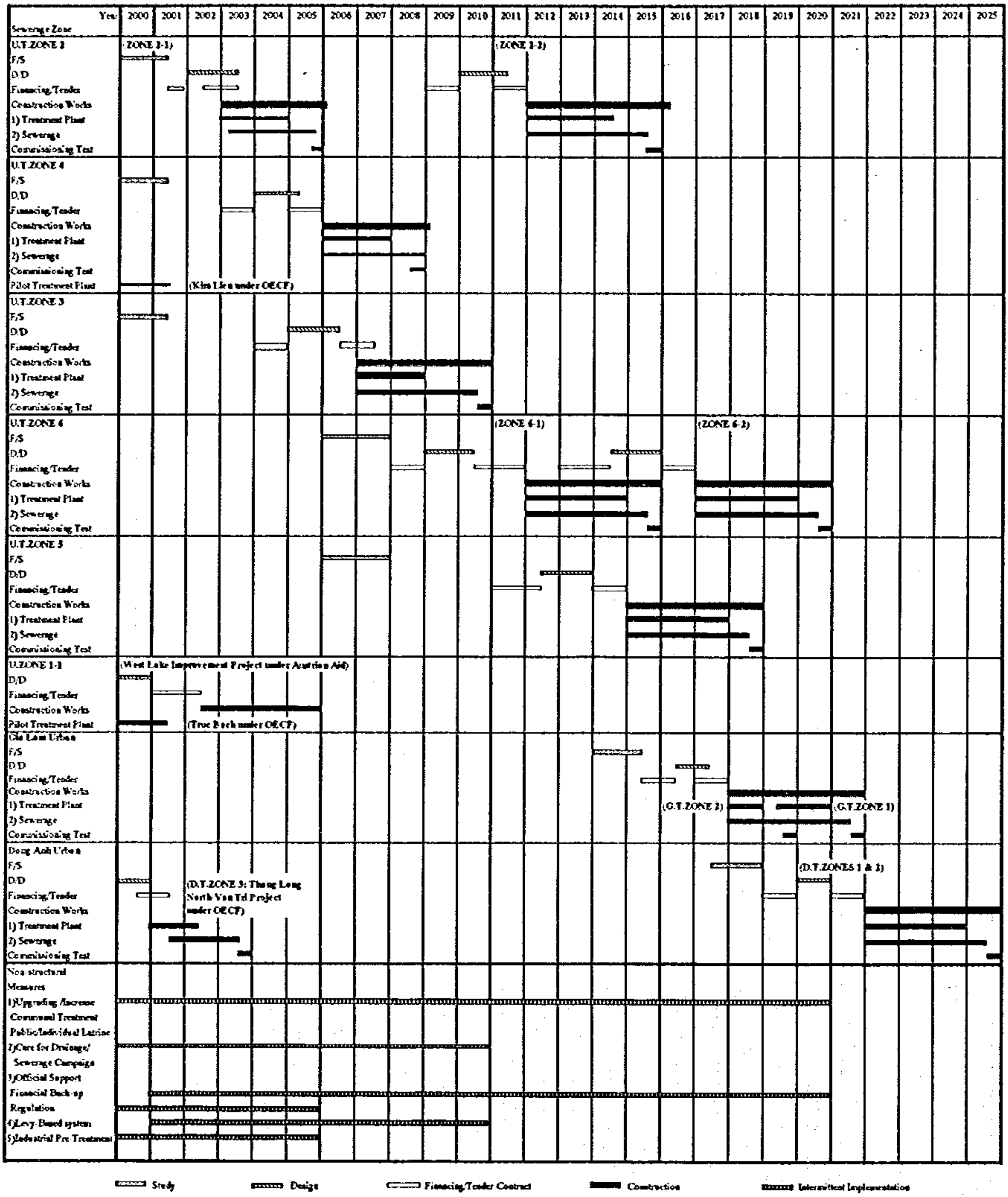


Figure 6.3.8 Disbursement Schedule of Wastewater Disposal Systems in Urban Area (1/4) (Unit: Million US$)

Sewerage Zone / Item	Total	Year 2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
ZONE 2-1		(F/S)																									
1) Construction Cost	51.288			0.000	16.706	20.515	14.066																				
a. Treatment Plant	32.242				12.897	12.897	6.448																				
b. Sewerage	19.046				3.809	7.618	7.618																				
2) Land Acquisition Cost	2.505				1.670	0.835																					
3) Engineering Service Cost	7.693			3.077	1.539	1.539	1.539																				
4) Administration Cost	1.539			0.257	0.513	0.513	0.257																				
5) Physical Contingency	6.303			0.333	2.043	2.340	1.586																				
Total	69.328			3.667	22.471	25.742	17.448																				
ZONE 4		(F/S)																									
1) Construction Cost	28.669					0	0	12.63	14.33	1.702																	
a. Treatment Plant	21.861							10.93	10.93																		
b. Sewerage	6.808							1.702	3.404	1.702																	
2) Land Acquisition Cost	11.419						5.710	5.710																			
3) Engineering Service Cost	4.300					1.229	1.229	0.614	0.614	0.614																	
4) Administration Cost	0.86					0.123	0.123	0.246	0.246	0.123																	
5) Physical Contingency	4.525					0.270	1.412	3.840	3.039	0.488																	
Total	49.773					1.622	8.473	23.042	18.233	2.927																	
ZONE 3		(F/S)																									
1) Construction Cost	64.113						0.000	0.000	24.161	28.109	7.895	3.948															
a. Treatment Plant	40.427								20.214	20.214																	
b. Sewerage	23.686								3.948	7.895	7.895	3.948															
2) Land Acquisition Cost	15.200							7.600	7.600																		
3) Engineering Service Cost	9.617						2.404	2.404	1.202	1.202	1.202	1.202															
4) Administration Cost	1.923						0.240	0.240	0.481	0.481	0.240	0.240															
5) Physical Contingency	9.085						0.264	1.024	3.344	2.979	0.934	0.539															
Total	99.938						2.909	11.269	36.788	32.771	10.272	5.929															

Figure 6.3.8 Disbursement Schedule of Wastewater Disposal Systems in Urban Area (2/4) (Unit: Million US$)

ZONE 2-2																											
1) Construction Cost	39.294											0.000	0.000	10.536	14.237	10.820	3.701										
a. Treatment Plant	17.086													6.834	6.834	3.417											
b. Sewerage	22.208													3.701	7.403	7.403	3.701										
2) Land Acquisition Cost	1.253												0.627	0.627													
3) Engineering Service Cost	5.894											1.474	1.474	0.737	0.737	0.737	0.737										
4) Administration Cost	1.179											0.147	0.147	0.295	0.295	0.147	0.147										
5) Physical Contingency	4.762											0.162	0.225	1.219	1.527	1.170	0.459										
Total	52.382											1.783	2.472	13.413	16.795	12.874	5.044										
ZONE 6-1								(F/S)																			
1) Construction Cost	29.188										0.000	0.000	0.000	8.585	10.792	7.603	2.207										
a. Treatment Plant	15.944													6.378	6.378	3.189											
b. Sewerage	13.244													2.207	4.415	4.415	2.207										
2) Land Acquisition Cost	0.728												0.364	0.364													
3) Engineering Service Cost	4.378										0.973	0.973	0.486	0.486	0.486	0.486	0.486										
4) Administration Cost	0.876										0.088	0.088	0.088	0.175	0.175	0.175	0.088										
5) Physical Contingency	3.517										0.106	0.106	0.094	0.961	1.145	0.827	0.278										
Total	38.687										1.167	1.167	1.032	10.572	12.599	9.092	3.060										
ZONE 5								(F/S)																			
1) Construction Cost	64.043													0.000	0.000	0.000	16.895	23.125	17.793	6.230							
a. Treatment Plant	26.662																10.665	10.665	5.332								
b. Sewerage	37.381																6.230	12.460	12.460	6.230							
2) Land Acquisition Cost	2.755															1.378	1.378										
3) Engineering Service Cost	9.606													2.135	2.135	1.067	1.067	1.067	1.067	1.067							
4) Administration Cost	1.921													0.192	0.192	0.192	0.384	0.384	0.384	0.192							
5) Physical Contingency	7.833													0.233	0.233	0.264	1.972	2.458	1.924	0.749							
Total	86.158													2.559	2.559	2.901	21.696	27.034	21.169	8.239							

Figure 6.3.8 Disbursement Schedule of Wastewater Disposal Systems in Urban Area (3/4) (Unit: Million US$)

ZONE 6-2								(F/S)																		
1) Construction Cost	57.175															0.000	0.000	0.000	14.919	20.598	15.978	5.679					
a. Treatment Plant	23.100																		9.240	9.240	4.620						
b. Sewerage	34.075																		5.679	11.358	11.358	5.679					
2) Land Acquisition Cost	1.029																	0.515	0.515								
3) Engineering Service Cost	8.576															1.906	1.906	0.953	0.953	0.953	0.953	0.953					
4) Administration Cost	1.715															0.172	0.172	0.172	0.343	0.343	0.343	0.172					
5) Physical Contingency	6.850															0.208	0.208	0.164	1.673	2.189	1.727	0.680					
Total	75.345															2.285	2.285	1.803	18.403	24.084	19.002	7.484					
G.T.ZONE 1																(F/S)											
1) Construction Cost	10.692																	0.000	0.000	10.150	45.195	45.195	10.150				
a. Treatment Plant	49.789																				24.895	24.895					
b. Sewerage	60.903																			10.150	20.301	20.301	10.150				
2) Land Acquisition Cost	2.250																		1.125	1.125							
3) Engineering Service Cost	16.604																	4.151	4.151	2.076	2.076	2.076	2.076				
4) Administration Cost	3.321																	0.415	0.415	0.830	0.830	0.415	0.415				
5) Physical Contingency	13.287																	0.457	0.569	1.418	4.810	4.769	1.264				
Total	46.154																	5.023	6.260	15.599	52.911	52.455	3.905				
G.T.ZONE 2																(F/S)											
1) Construction Cost	9.180																	0.000	0.000	6.880	2.300	0.000	0.000				
a. Treatment Plant	4.580																			4.580							
b. Sewerage	4.600																			2.300	2.300						
2) Land Acquisition Cost	0.500																	0.250	0.250								
3) Engineering Service Cost	1.377																	0.551	0.275	0.275	0.275						
4) Administration Cost	0.275																	0.046	0.046	0.092	0.069						
5) Physical Contingency	1.133																	0.085	0.057	0.725	0.264						
Total	12.465																	0.931	0.628	7.972	2.909	0.000	0.000				

Figure 6.3.8 Disbursement Schedule of Wastewater Disposal Systems in Urban Area (4/4) (Unit: Million US$)

Item	Total	Schedule						
D.T.ZONE 1		(F/S)						
1) Construction Cost	26.432		0.000	0.000	2.094	11.122	11.122	2.094
a. Treatment Plant	13.868					6.934	6.934	
b. Sewerage	12.564				2.094	4.188	4.188	2.094
2) Land Acquisition Cost	1.000			0.500	0.500			
3) Engineering Service Cost	3.965		0.991	0.991	0.496	0.496	0.496	0.496
4) Administration Cost	0.793		0.099	0.099	0.198	0.198	0.099	0.099
5) Physical Contingency	3.219		0.109	0.159	0.329	1.182	1.172	0.269
Total	35.409		1.199	1.749	3.617	12.997	12.888	2.958
D.T.ZONE 2		(F/S)						
1) Construction Cost	28.813		0.000	0.000	2.491	11.916	11.916	2.491
a. Treatment Plant	13.868					6.934	6.934	
b. Sewerage	14.945				2.491	4.982	4.982	2.491
2) Land Acquisition Cost	1.000			0.500	0.500			
3) Engineering Service Cost	4.322		1.081	1.081	0.540	0.540	0.540	0.540
4) Administration Cost	0.864		0.108	0.108	0.216	0.216	0.108	0.108
5) Physical Contingency	3.500		0.119	0.169	0.375	1.267	1.256	0.314
Total	38.499		1.307	1.857	4.122	13.939	13.820	3.453

Figure 6.3.9 Implementation Schedule of Lake Conservation Projects

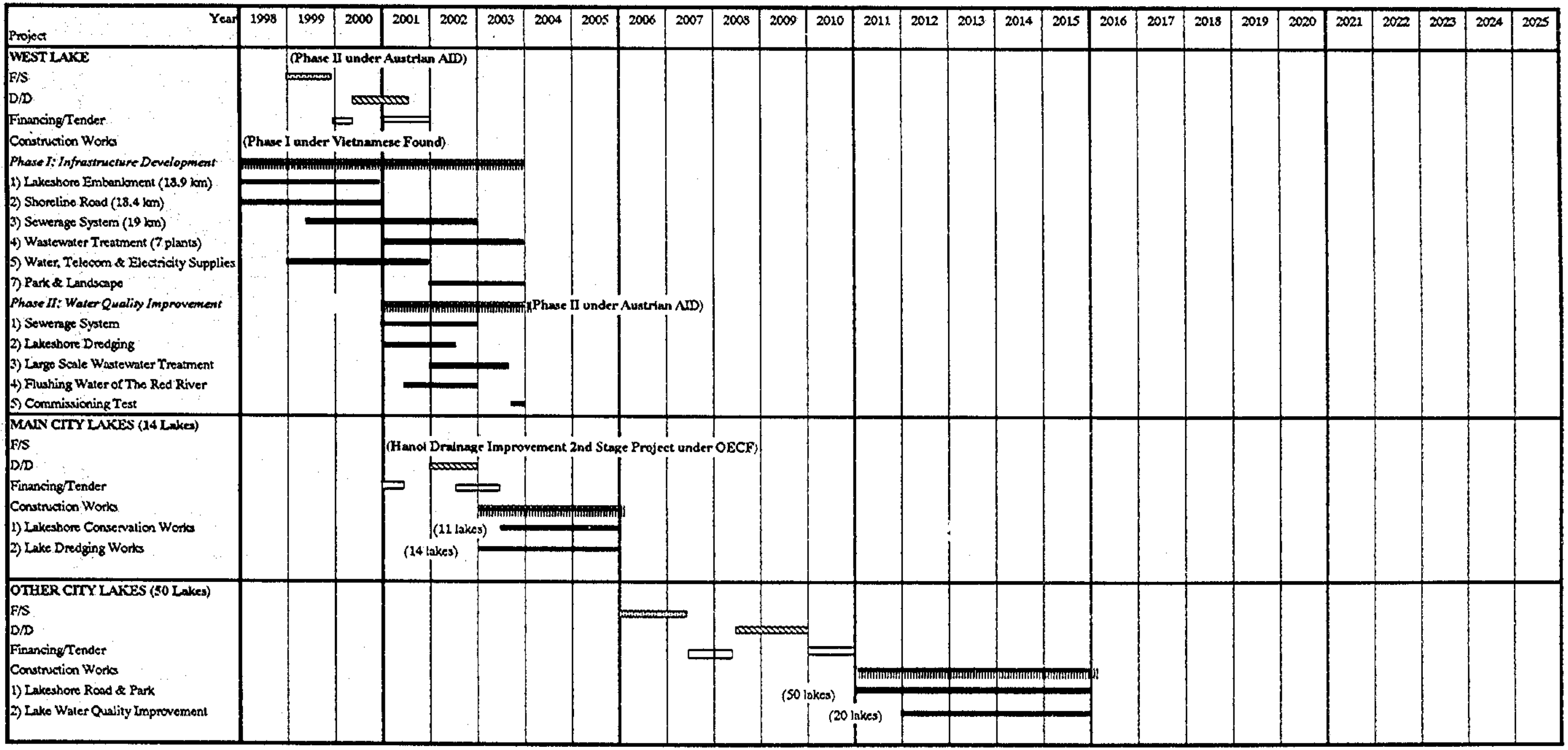
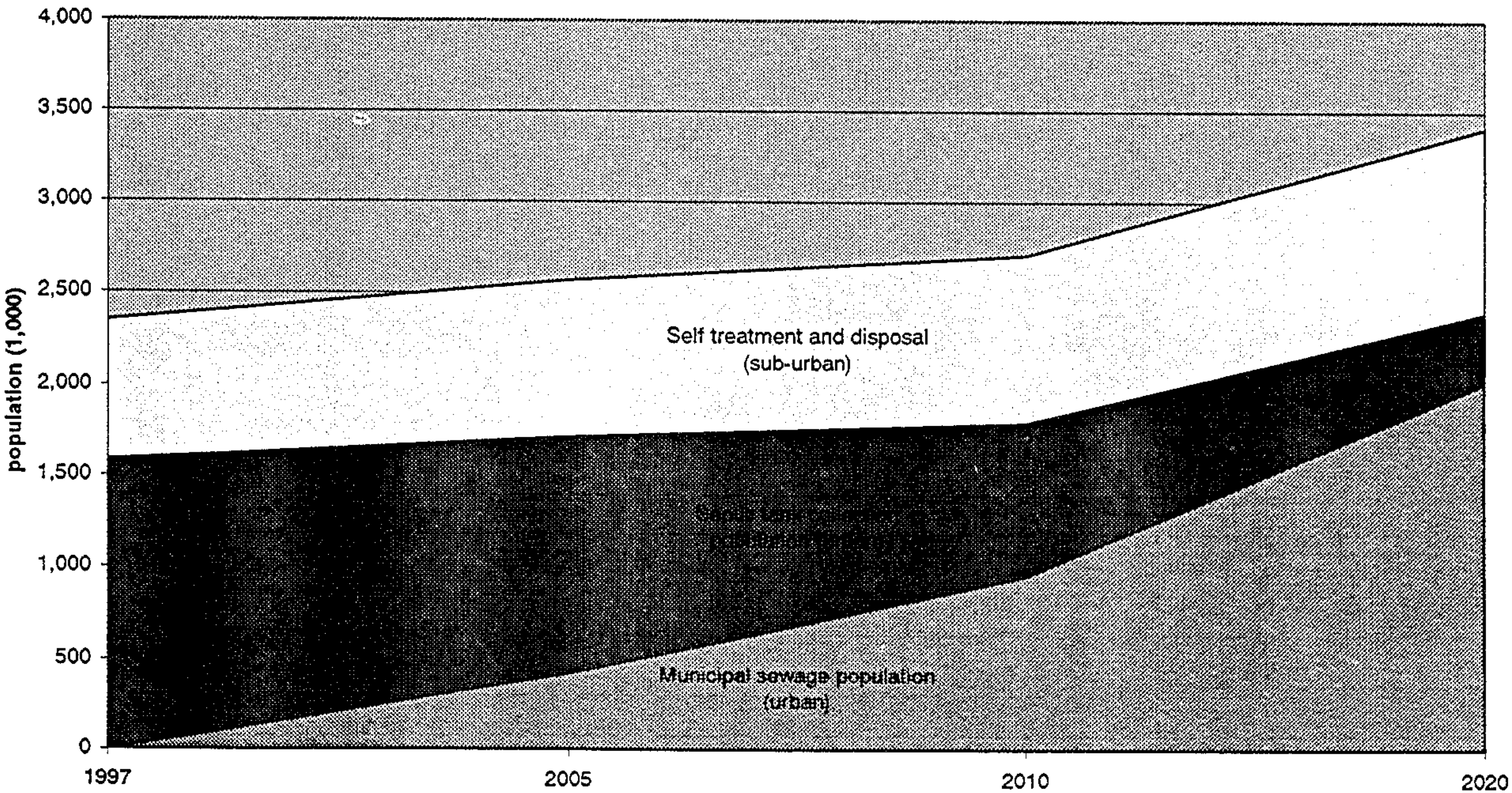


Figure 6.3.10 Disbursement Schedule of Lake Conservation Project

(Unit:Million US$)

Item	Total	Year 1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
West Lake Phase II			(F/S: under Austrian AID)																										
1) Construction Cost	27.000			0.000	10.000	13.500	3.500																						
a. Sewer & Dredging	10.000				6.667	3.333																							
b. Large scale Wastewater Treatment	7.000					3.500	3.500																						
c. Flushing Water Facilities	10.000				3.333	6.667																							
2) Land Acquisition Cost	1.250			0.833	0.417																								
3) Engineering Service Cost	4.050			1.350	1.350	0.675	0.675																						
4) Administration Cost	0.810			0.116	0.231	0.231	0.231																						
5) Physical Contingency	3.311			0.230	1.200	1.441	0.441																						
Sub-Total	36.421			2.529	13.198	15.847	4.847																						
Main City Lakes						(2nd Stage Project under OECF)																							
1) Construction Cost	7.584					0	2.416	2.752	2.232																				
a. Lake Conservation Works (11 Lakes)	1.344						0.336	0.672	0.672																				
b. Lake Sediments Dredging Works (14 Lakes)	6.240						2.080	2.080	1.560																				
2) Land Acquisition Cost	0.375					0.188	0.188																						
3) Engineering Service Cost	1.138					0.325	0.325	0.325	0.325																				
4) Administration Cost	0.228					0.033	0.033	0.033	0.033																				
5) Physical Contingency	0.933					0.055	0.296	0.311	0.259																				
Sub-Total	10.258					0.601	3.258	3.421	2.849																				
Other City Lakes										(F/S)																			
1) Construction Cost	12.000											0.000	0.000	0.000	2.000	2.500	2.500	2.500	2.500										
a. Lakeshore Road & Park	10.000														2.000	2.000	2.000	2.000	2.000										
b. Lake Water Quality Improvement	2.000															0.500	0.500	0.500	0.500										
2) Land Acquisition Cost	6.000													3.000	3.000														
3) Engineering Service Cost	1.800											0.300	0.600	0.150	0.150	0.150	0.150	0.150	0.150										
4) Administration Cost	0.360											0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045										
5) Physical Contingency	2.016											0.035	0.065	0.320	0.520	0.270	0.270	0.270	0.270										
Sub-Total	22.176											0.380	0.710	3.515	5.715	2.965	2.965	2.965	2.965										

Figure 6.3.11 -Trends in planned septage collection and municipal sewage population (Total Study Area)



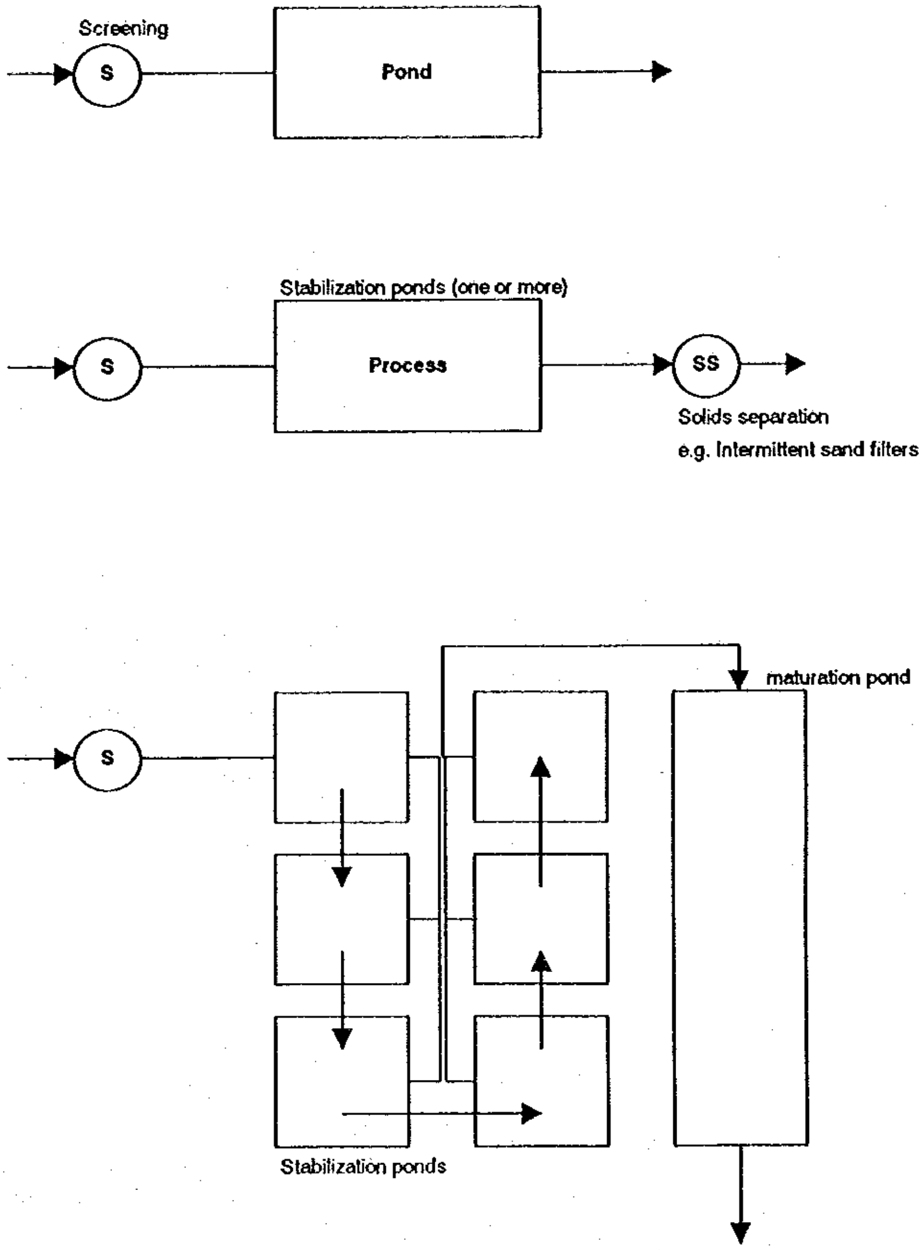
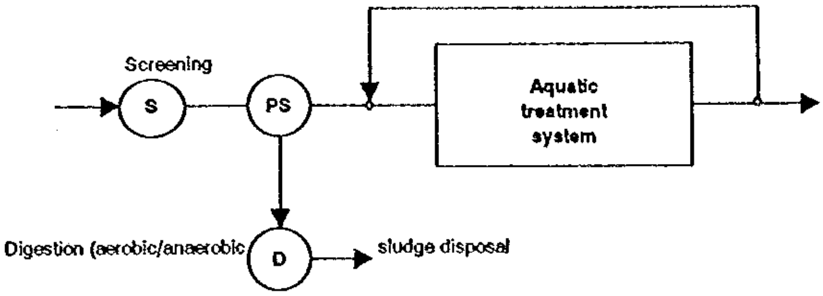
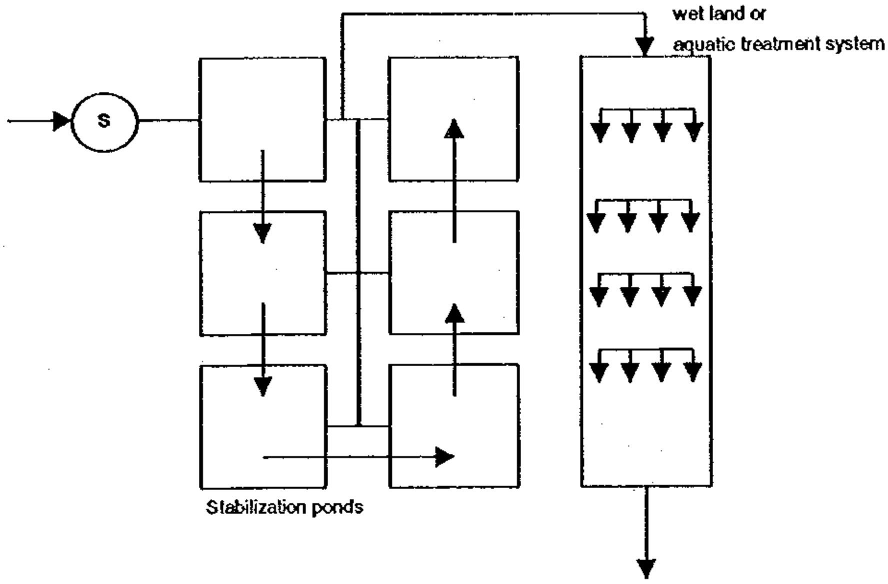


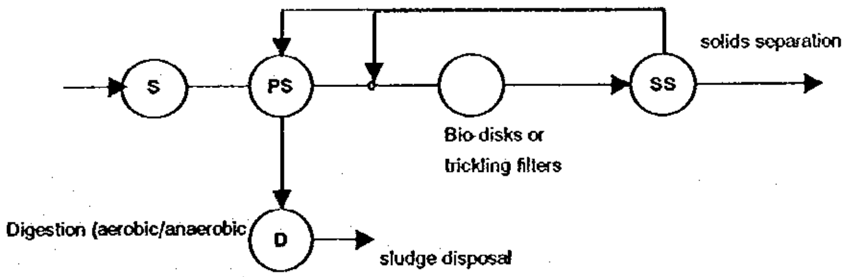
Figure 6.3.12 - Typical Flow Schematic for Septage Waste Stabilization Ponds



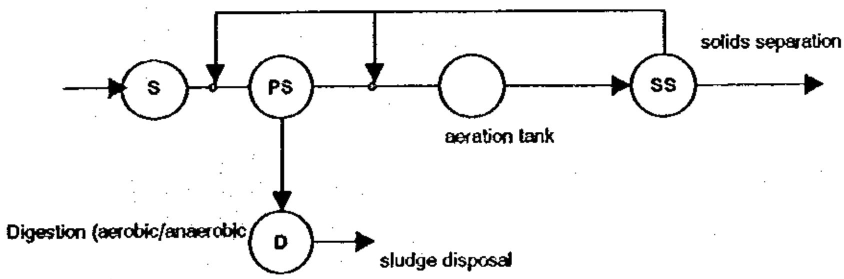
a) Aquatic treatment system (ATS)



b) Stabilization ponds with wet land or aquatic treatment system



c) Bio-disks or trickling filters treatment process



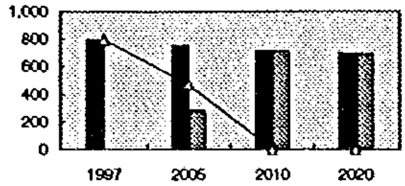
d) Activated sludge treatment process

Figure 6.3.13 - Flow Schematic for Typical Small Septage Treatment Facilities

Figure 6.3.14 - Transition of planned septage collection population and municipal sewage population

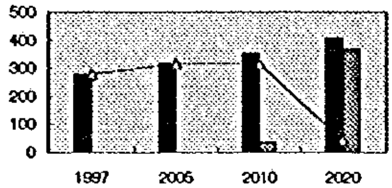
Zone 1 - Old City Center

	Pop (000's)	sewer	septic
1997	793	0	793
2005	750	280	470
2010	712	712	0
2020	690	690	0



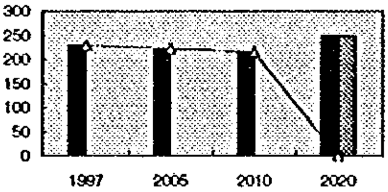
Zone 2 - Red River Right Bank North West

	Pop (000's)	sewer	septic
1997	277	0	277
2005	317	0	317
2010	352	35	317
2020	406	365	40



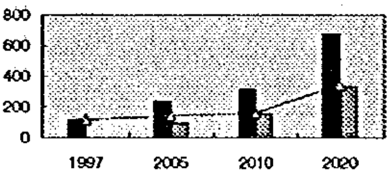
Zone 3- Red River Right Bank South

	Pop (000's)	sewer	septic
1997	229	0	229
2005	221	0	221
2010	215	0	215
2020	248	248	0



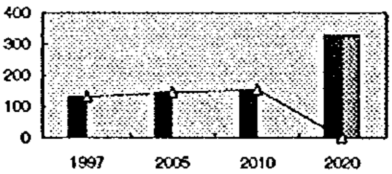
Zone 4 - Dong Anh Urban Area

	Pop (000's)	sewer	septic
1997	114	0	114
2005	237	95	142
2010	314	154	160
2020	672	330	342



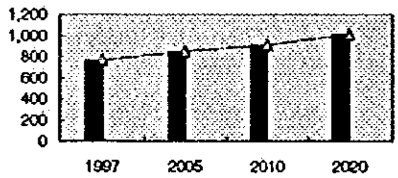
Zone 5 - Gia Lam Urban Area

	Pop (000's)	sewer	septic
1997	129	0	129
2005	144	0	144
2010	153	0	153
2020	328	328	0



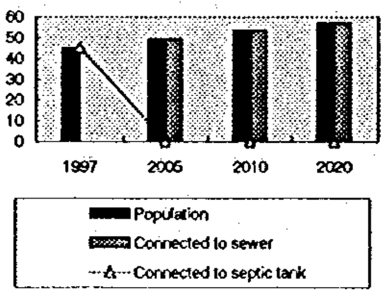
Zone 6 - Sub-urban

	Pop (000's)	sewer	septic
1997	762	0	762
2005	849	0	849
2010	908	0	908
2020	1,008	0	1,008



Zone 7 - Ho Tay

	Pop (000's)	sewer	septic
1997	45	0	45
2005	49	49	0
2010	54	54	0
2020	57	57	0



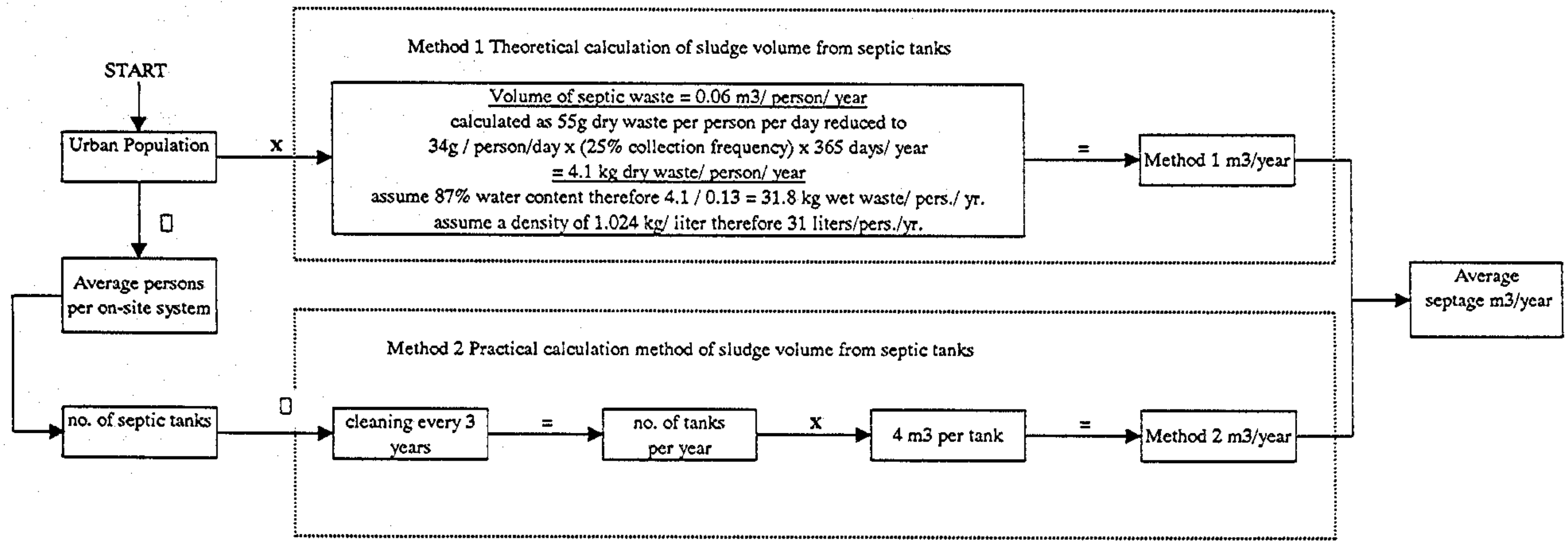


Figure 6.3.15 - Sludge volume estimating method

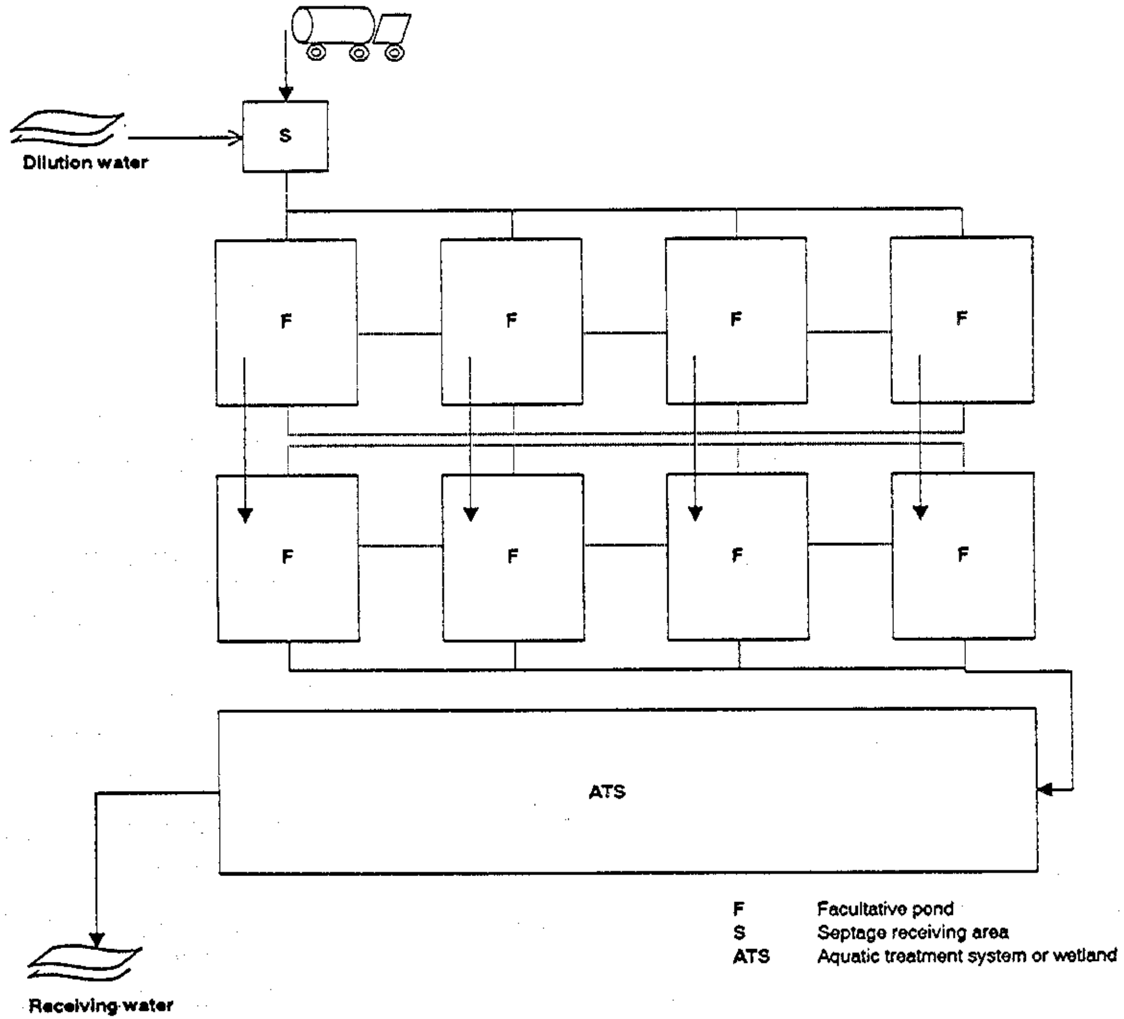
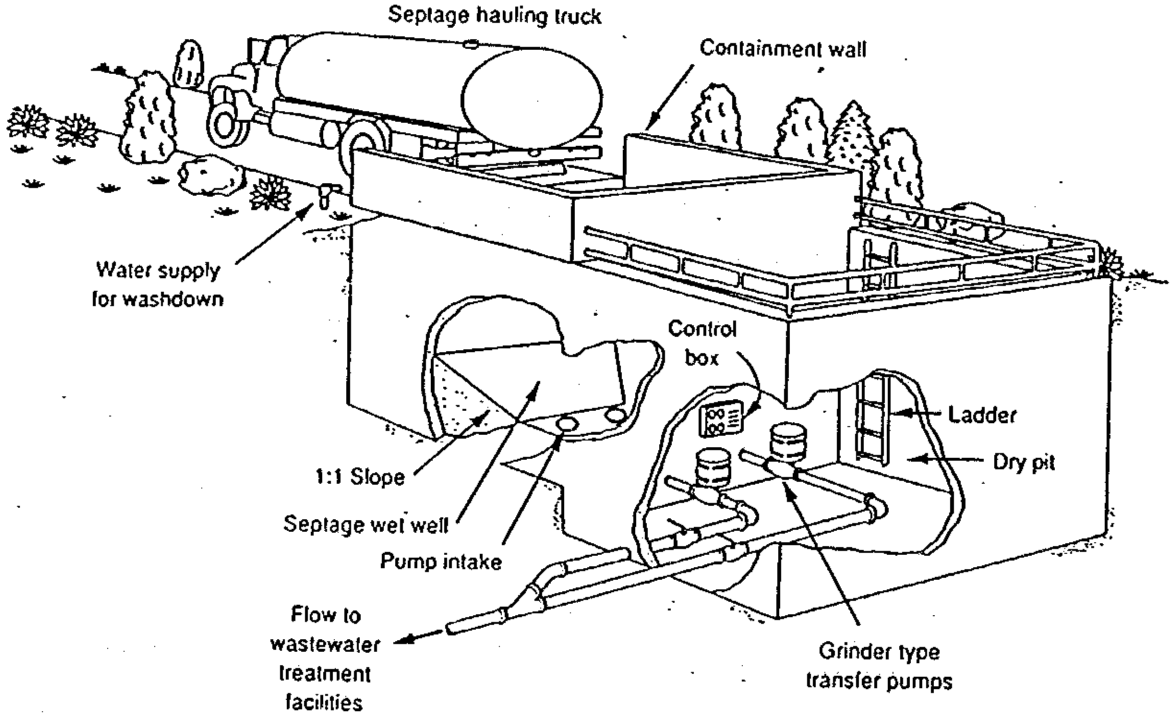


Figure 6.3.16 - Conceptual Septage Treatment Facility



THE STUDY ON ENVIRONMENTAL IMPROVEMENT FOR HANOI CITY	Figure 6.3.17 Typical Septage Receiving Facility
JAPAN INTERNATIONAL COOPERATION AGENCY	

6.4 Strategies and Measures for Achieving a Clean Air Environment

6.4.1 Basic Concept for Plan Formulation

(1) Basic Concept

Based on the results of the evaluation of the present air quality and future air quality for the years 2010 and 2020, and in order to attain the proposed air quality targets as mentioned in section 5.1.3, several countermeasures will have to be implemented for each type of emission source. The major sources of pollution in Hanoi are as shown below.

- Domestic Emissions
- Industrial Emissions
- Motor Vehicle Emissions

The importance of these emissions will increase in the future. This section presents some countermeasures for domestic, industrial and transportation sources of air pollutants. A summary of proposed countermeasures are shown below.

Direct Measures for Achieving a Clean Air Environment

Sector of activity	Strategies and Measures
Domestic	Promotion of gas for cooking in households
	Gradual elimination of coal/wood used as fuel in the urban areas
Industry	Promotion of cleaner production (including energy conservation) in existing and new facilities
	Development of process-specific air emission standards
	Increase air emission regulation compliance by inspection and stack measurements
	Promotion of use of cleaner fuels (gas, low sulfur fuel oil) instead of coal and high sulfur fuel oil
	Adequate stack design (height) to avoid excessive pollutant concentration in ambient air even if emission are within standards
Transportation	Unleaded gasoline
	Low sulfur diesel (500 ppm) and gasoline (100 ppm)
	Emission regulations for new motor vehicles (for example: Japan, EEC standards for automobiles and trucks; Taiwan or Japan standards for motorcycles). Unleaded gasoline is a prerequisite to this measure.
	Inspection and maintenance programs for motorcycles

Countermeasures for mobile source air emissions are not only direct measures but also indirect measures. Indirect measures are usually aiming at solve traffic congestion problems, while direct measures affect the emission at the source.

Indirect Measures for Achieving Clean Air Environment

Sector of activity	Strategies and Measures
Transportation	Construction of road infrastructure (improvements to existing network and construction of ring roads) to improve traffic flow
	Better public bus system, with low emission buses for routes in the central urban area
	Improvements to traffic flow by better signalling
	Two-wheeler policy: to avoid traffic congestion and minimize construction of infrastructure
	Major improvement to street cleaning activities (water flushing, vacuum and sweeping)
	Improvement to road network to eliminate unpaved areas on the side of urban roadways

Higher than standard ambient air TSP concentrations were identified as the major actual and future air quality problem in Hanoi. For other pollutants (CO, NO_x, SO_2 and PM10), the situation is estimated to be acceptable in most areas of Hanoi. Measures should, therefore, aim at reducing TSP emissions in the future and to limit the growth of the loads of the other pollutants.

(2) Direct Countermeasures

1) Domestic emissions

Domestic emissions do not contribute greatly to total atmospheric pollution. In a "do nothing" case and with further industrial development and increase in traffic, the relative contribution of domestic emissions to atmospheric load will decrease. However, in lower income high population density residential areas, the use of coal (especially the cheap "pressed coal cylinder") for cooking contributes to deterioration of air quality, especially in the morning when households start up their coal burning units. The use of coal causes much more indoor air problems than general air quality problems. In fact, some studies in Hanoi show that CO concentrations in kitchens and houses using coal can reach levels up to 55 mg/m^3, about 8 times the maximum estimated CO hourly concentration for general air quality in Hanoi.

A major switching from coal to electricity or natural or petroleum gas will evidently improve air quality in a neighborhood but the main benefits will certainly be better indoor air quality and less exposure to toxic gas for people who cook with coal.

With future economic development and family income increases that follow, it is believed that people who can afford it will switch naturally from coal to gas. For the moment, it seems that the main obstacle to use gas instead of coal is the procurement cost of the gas burner or cooker. In order to promote the use of gas over coal, the price of gas must be competitive, especially for lower income families. Banning the use of coal in the city center is probably too drastic a measure unless other measures are put in place to help low income families. A first step would be to eliminate gradually the "pressed coal cylinder" by industrially processed coal There is actually no governmental program such as special loans or discount prices to help families in the procurement of a gas burners.

The main objective is to reduce the use of coal and wood in the Old City Center area from 62% to 5% of households. In the rural areas, the needed reduction would be much less.

2) Industrial emissions

Globally, industrial emissions from fuel combustion could increase by a factor of 5 to 6 between 1997 and 2020 if no reduction measures are implemented. This estimated increase is based on the assumption that new industries emit the same amount of pollutants per unit of production than the old ones and that none of the existing plants will reduce their emissions.

A large number of existing facilities that submitted EIA reports have identified some measures to be implemented to reduce air emissions. The challenge will be to implement them.

Measures to be applied to industries can be divided into the following categories: emission reduction and increased diffusion.

(a) Increased diffusion or increasing stack heights

Increased diffusion, by increasing stack height, does not greatly change the contribution of a specific source to general air quality in Hanoi, but can make major changes in the vicinity of a specific industry. Even with increasing stack height within the limits of "good engineering practice stack height" to minimize impacts on air quality, a specific point source must still meet the air emission standards. "Good engineering practice stack height" is usually defined, following US-EPA, as the greater of either 2.5 times the height of surrounding buildings or 65 meters.

Some sources in Hanoi should probably increase stack height even if they meet the emission standards. In the EIA process for existing and new facilities, air dispersion modeling can be used as a tool to establish the required stack height to minimize air quality impacts in the vicinity of a source.

(b) Development of process-specific air emission standards

The actual air emission regulations for TSP, CO, NOx and SO2 are general and apply to all types of source, regardless of the type of process. Process-specific emission standards by type of industry should be developed and adopted, starting with different standards for NOx and TSP for different fuels (gas, fuel oil, coil) and firing capacity of combustion devices. An opacity standard for combustion devices can easily be implemented to assure that combustion is efficient and complete. Enforcement of such an opacity standard can be performed by visual inspection of the plume ("Standard Test Method for Relative Density of Black Smoke (Ringelmann Method)" - ASTM-D3211) and does not require stack sampling.

(c) Increasing source compliance testing for major sources

(d) Promotion of cleaner production and cleaner fuels

Restrictions on fuel sulfur content in the urban areas or specific industrial zones if needed.

Insisting on the implementation of the Best Available Technique Not Entailing Excessive Costs for new sources or upgrading of old factories, even if other techniques can meet the emission standards. For example, low-NOx burners for large combustion devices firing fuel oil.

3) Motor vehicle emissions

For motor vehicles, the major contributor for all contaminants in the urban area, emission reduction will be required for CO, NOx, SO_2 and lead in the future.

Most of the countermeasures proposed here are under the responsibility of various National Ministries or Agencies. Countermeasures related to fuel specification and new vehicle regulations are usually implemented at the national level.

(a) Unleaded gasoline

Even if estimation of future general air quality does not predict higher than standard lead concentration in ambient air, unleaded gasoline should be introduced for two main reasons:

- unleaded gasoline is prerequisite for introduction of end-of-pipe pollution control devices such as oxidation catalytic converters and 3-way catalytic converters used to control CO, NOx and HC from gasoline motor vehicles. These will have to be introduced in the future.
- even if lead concentrations are generally below standard in Hanoi, there is no level for which no effects can be detected.

(b) Low sulfur diesel and gasoline

Actual sulfur specification for diesel fuel is 0.5% (5000 ppm) in Vietnam. Most developing countries have already or will in the future adopt a low sulfur diesel regulation ranging from 500 ppm to as low as 50 ppm in several years. For gasoline in Vietnam, there is no specification for sulfur and the sulfur content is probably between 500 and 1000 ppm or even more. Many countries have already adopted or propose sulfur specifications for gasoline around 100 ppm. Beside reducing sulfur dioxide emissions, these measures also aim at improving efficiency of end-of-pipe pollution control devices and reducing emissions of contaminants that contribute to fine particulate matter (PM10 and PM2.5).

(c) Emission regulations for new motor vehicles

Introduction of more stringent regulations for all classes of motor vehicles such as oxidation catalytic converters to control CO and HC emissions from motorcycles and 3-way catalytic converters used to control CO, NOx and HC from cars. These regulations will require the introduction of unleaded gasoline required for the pollution control devices for motor vehicles. These regulations could reduce CO and HC from motorcycles by up to 80-90%. Based on the estimates for future pollution loads, they would be required sooner for motorcycles since they contribute the most to CO emissions. It takes many years before these measures are fully effective because in the first years the share of new vehicles in the fleet is not important enough.

Applying existing emission regulation in Europe or Japan (or Taiwan for motorcycles) for new vehicles would probably be quite simple since most of vehicle manufacturers already can meet those standards. Adopting more stringent standards existing elsewhere would not cause too much pressure on manufacturers since the technical solutions already exist, but would require some plant updating for vehicles manufactured or assembled in Vietnam.

(d) Inspection and maintenance programs for motorcycles

The actual inspection of air emissions on a regular basis should be expanded to include motorcycles. Based on the present and future estimates of air emissions from mobile sources, motorcycles are now and will remain the main source of carbon monoxide and possibly of hydrocarbons into the atmosphere in Hanoi. Also, the number of motorcycles continues to increase rapidly and eventually a large proportion of the fleet will be composed of old vehicles that generate several times the amount of contaminants than new vehicles. This program would ensure that old vehicles emit reasonable amounts of contaminants and would keep off the street vehicles that cannot meet the standards. To implement this measure, the actual testing center in Hanoi (Department of Transport) would have to be expanded or new centers would have to be constructed. DOSTE, MOSTE, and the Ministry of Transport are currently reviewing a project for inspection of motorcycles. Preliminary proposals were rejected because too many motorcycles would have to be taken off the street.

An inspection program for motorcycles could probably reduce CO emissions by 30% to 40%.

Indirect measures were discussed in the "Urban Transport Master Plan for Hanoi City" sponsored by JICA in 1997. The Master Plan estimated that the improvements to the road network and public transport system could reduce air emissions by up to 25%. Indirect measures aim at solving the traffic congestion problem and contribute to reducing emissions from motor vehicles.

Construction of road infrastructure:

- Construction of ring roads to permit reduction in traffic in the central area.
- Improvement to the general road network will avoid traffic congestion and reduce the emissions related to stop-and-go traffic.
- Better public bus system, with low emission buses for routes in the central urban area.
- Improvements to traffic flow by better signaling.
- Two-wheeler policy: to avoid traffic congestion and minimize construction of infrastructures.

Public mass transport system: this measure was studied in the JICA urban transport study, but the conclusion was that the benefit/cost ratio was not high enough, so it was not considered in the Master Plan for Urban Transport.

Road dust (1): Road dust due to traffic was identified as one of the major sources of TSP in Hanoi. High silt (fine material) on paved roads of Hanoi is the main parameter to control.

Road dust (2): The two main types of techniques to control paved road silt loads:

preventive controls: controls that attempt to prevent material from being deposited onto the surface. Regulations requiring the covering of loads in trucks or the paving of access areas to unpaved lots or construction sites are examples of prevention measures. Also, many side roads (space between the road and the buildings) in Hanoi are not paved.

mitigative controls: controls that attempt to remove from the travel lanes any material that has been deposited. Vacuum sweeping, water flushing and broom sweeping and flushing are mitigative measures. Current activities by URENCO includ water flushing on a regular basis on the main roads of the urban area. Flushing pushes the material to the side of the road, but a large part of it stays on a relatively wide band on the external part of the roadway, allowing the material to be blown into the air when a large vehicle passes by. Vacuum sweeping should also be considered to remove fine material from the side of the street.

6.4.2 Institutional and Regulatory Measures

(1) Setting Appropriate Standards for Air Quality

1) Ambient Air Quality

The Air Quality-Ambient Air Quality Standards (TCVN 5937-1995) is set up for conservation of air quality. Compared with the WHO Standard, the level of the standard is quite reasonable, except for TSP. The standard for TSP is quite hard to maintain in urban areas. The Study Team proposes easing of the standard of TSP.

2) Effluent Standards

The Air Quality – Maximum Allowable Concentration of Hazardous Substances in Ambient Air (TCVN 5938-1995) was set up to control emission levels to protect air quality. Every industrial factory is required to prepare suitable facilities to meet the standard. Vehicles which do not meet the standard are not allowed to be used. The level of the standard seems to be reasonable.

(2) Reinforcement of Regulations and Law Enforcement

The overall approach to industrial air pollution control is similar to that for water pollution. The five-fold approach is:

- setting appropriate emission standards for all industrial facilities
- development of compliance agreements to bring existing industrial facilities into full compliance with standards
- establishment of more punitive systems for enforcement
- instituting a system of air pollution charges for industrial facilities
- use existing and new EIA regulations on existing industrial facilities to force new investments in pollution control measures

Many of the strategies and measures proposed to control air pollution resulting from transportation will require new regulations. The proposed programs include:

- introduction of regulations to force use of unleaded gasoline
- setting standards for sulphur content in diesel fuel and gasoline
- emission regulations for new motor vehicles
- inspection and maintenance programs for motorcycles

It is likely that these regulations will have to be developed at the national level. Although, it is possible the Hanoi City could develop it own regulations on inspection and maintenance programs for motor cycles.

1) Short-term measures: By 2005

(a) Measures against Industry Related Air Pollution

In short term, the following measures will be undertaken:

- to develop of emission standards for facilities
- to review administrative penalties for violation of pollution control laws
- to complete pollution abatement plans based on EIA for all existing facilities
- to strengthen inspection capability to ensure compliance

(b) Measures against Domestic Air Pollution

No regulatory measures are proposed.

(c) Measures against Traffic Air Pollution

In the short term, measures will be undertaken to implement:

- inspection and maintenance programs for motorcycles

2) Mid-term measures: By 2010

(a) Measures against Industry Related Air Pollution

In the mid-term, the following measures will be undertaken:

- the institution of air pollution charges for all major facilities

(b) Measures against Domestic Air Pollution

No regulatory measures are proposed.

(c) Measures against Traffic Air Pollution

In the mid-term measures will be undertaken for:

- setting standards for sulphur content in diesel fuel and gasoline
- establishing emission regulations for new motor vehicles

3) Long term measures: By 2020

(a) Measures against Industry Related Air Pollution

In long term measures will be taken for the:

- completion of pollution abatement programs for all facilities

(b) Measures against Domestic Air Pollution

No measures proposed.

(c) Measures against Traffic Air Pollution

In long term measures will be taken for the:

- introduction of regulations to force use of unleaded gasoline.