Project for the Improvement of
Water Supply, Sewerage and Drainage System
in Yangon City

Final Report

Volume VI

Sewerage and Drainage System Mater Plan

Appendix

Appendix

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A. WATER QUALITY INVESTIGATION

1. OUTLINE OF WATER QUALITY INVESTIGATION

This water quality investigation consists of following 4 investigations;

- Water quality of Kandawgyi Lake and its pollution source
  Sampling and water quality investigation of Kandawgyi Lake water and wastewater of restaurant and drainage around Kandawgyi Lake are implemented.

- Water quality of YCDC public water bodies
  Sampling and water quality investigation of public water body which is managed by YCDC (i.e. drainage and river) are implemented.

- Functional assessment of existing WWTP
  Through the measurement of water quality (Inflow pit, Primary sedimentation tank, Aeration tank and Final settling tank) and characteristic of activated sludge, existing condition of WWTP is assessed.

- Water quality of industrial / hospital wastewater
  Sampling and water quality investigation of industrial wastewater (3 factories) and hospital wastewater (3 hospitals) are implemented.

2. SAMPLING POINT AND ANALYSIS ITEM

(1) Sampling point

Sampling point is listed below. Kandawgyi Lake (Lake water: 3 samples, Drainage: 3 samples and Restaurant: 3 samples), YCDC urban drainage: 6 samples, River: 8 samples, Factory: 3 samples, Hospital: 3 samples and WWTP (4 sampling points in WWTP), Total 34 sampling points.

Through this investigation, characteristic of water quality of Kandawgyi Lake, Drainage, River, Industrial / Hospital wastewater and WWTP are investigated.

This investigation is implemented 2 times, i.e. rainy season: 1 time and dry season: 1 time.

Table A.1 Sampling Point

No. of sample	Classification	Name of sampling point	Number of sample
WW - 1~3	Restaurants	Restaurant-A, B, C and D Rainy season: Restaurant- A, B and C Dry season: Restaurant- B, C and D	4
WW - 4~6	Factory	Factory-A, B and C	3
WW - 7~9	Hospital	Yangon General Hospital (Department of plastic, manila facial and oral surgery) Yangon General Hospital Yangon New General Hospital	3
WW - 10~21	WWTP	Inflow pit Primary sedimentation tank Aeration tank Final settling tank	12 (4 point× 3 times)
WW - 22~24	Kandawgyi Lake	Kandawgyi Lake (3 points)	3
WW - 25~27	Drainage	3 Drainage discharging into Kandawgyi Lake	3
WW - 28~35	River	Hlaing River Yangon River Bago River Nga Moe Yeik Creek Pu Zun Taung Creek	8
WW - 36~41	Drainage	Pauk Tar Chaung Yoe Gyi Chaung Thamaing Chaung Padauk Chaung Tbebyu Chaung Nat Chaung	6
Total (34 Sampling points)			42

(2) Analysis item

Analysis item is shown below. Water quality is to be analyzed with respect to 10 parameters, in case of WWTP (aeration tank) assessment is to be made for 7 items.

Table A.2 Analysis Item

Sample	Analysis item
Lake, Drainage, River and Waste water	Water temperature, pH, Suspended solid, COD_{Cr}, BOD, T-N, Ammonium nitrogen, Kjeldahl nitrogen, T-P and Electrical conductivity (EC)
Aeration tank	Water temperature, pH, Mixed liquor suspended solids (MLSS), Sludge volume (SV), Sludge volume index (SVI), Mixed liquor dissolved oxygen (MLDO), and EC

(3) Modification of investigation plan

From the preparatory investigation of sampling point, investigation plan was modified. Modification is described in following table.

Table A.3 List of Modification of Investigation Plan

Modification point	Initial plan	After modification	Reason of modification
Sampling point in WWTP	Side streams from sludge treatment plant	Cancelled	Sampling of side streams from sludge treatment plant is very difficult
Sampling point in Kandawgyi Lake	Restaurant and Hotel near Kandawgyi Lake	Sampling of Hotel discharge was canceled	There are 2 hotels near Kandawgyi Lake. However, one hotel was closed down. The other hotel discharges its wastewater to drainage, and doesn't discharge into Kandawgyi Lake. Therefore, sampling of hotel wastewater was cancelled.
Septic tank sampling	Inflow and outflow of septic tank	Cancelled	Human excreta in the investigation area are treated with septic tank. However, in many cases septic tank are buried (usually, can't access) and effluent is infiltrated with leaching cesspool. Therefore, it is assumed that septic tank effluent does not affect surface water quality.
Analysis item	13 items	14 items Addition of EC	River and drainage flow in Yangon city is strongly influenced by tidal fluctuation. To confirm the effect of tidal fluctuation, EC is added.
Sampling point		Addition of sampling point	Instead of the cancelled sampling point (WWTP and septic tank), river and drain (total 9 points) were added.

3. DETAIL INFORMATION OF SAMPLING POINT

Coordinates of sampling point and sampling date / time are shown below.

Table A.4 Information of Sampling Point

Sample No.	Sampling Point	Positional Information	Sampling	
			Date	Time
WW - 1	Restaurant -A (Dolphin) Rainy season	47 Q 197560E 1859594N	2012/9/13	12:00
WW - 2	Restaurant -B (Royal garden)	47 Q 197959E 1859546N	2012/9/13	15:05
			2013/3/22	14:23
WW - 3	Restaurant -C (Bangkok Kitchen)	47 Q 198168E 1859512N	2012/9/13	18:00
			2013/3/22	16:58
WW - 1	Restaurant –D (White Rice) Dry season	47 Q 198332E 1859379N	2013/3/21	14:00
WW - 4	Factory -A (PINYA MANUFACTURING Co., Ltd., Soft drink)	47 Q 187553E 1866155N	2012/9/19	12:25
			2013/3/12	11:14
WW - 5	Factory -B (FAME Pharmaceuticals, Medicine)	47 Q 187282E 1866568N	2012/9/19	12:55
			2013/3/12	12:30
WW - 6	Factory -C (Good Morning Co., Ltd. Bakery)	47 Q 185926E 1866878N	2012/9/19	13:15
			2013/3/12	12:04
WW - 7	Hospital-1 (Yangon General Hospital, Department of plastic, facial and oral surgery)	47 Q 196351E 1857378N	2012/9/18	11:35
			2013/3/6	11:15
WW - 8	Hospital-2 (Yangon General Hospital)	47 Q 196245E 1857320N	2012/9/18	11:55
			2013/3/6	10:42
WW - 9	Hospital-3 (Yangon New General Hospital (Japan Hospital))	47 Q 195735E 1857489N	2012/9/18	12:15
			2013/3/6	10:20
WW - 10	WWTP (Influent-1)	47 Q 200426E 1856019N	2012/9/14	10:54
			2013/3/22	11:19
WW - 11	WWTP (Influent -2)		2012/9/14	14:08

Sample No.	Sampling Point	Positional Information	Sampling	
			Date	Time
		(WWTP Office)	2013/3/22	16:16
WW - 12	WWTP (Influent -3)		2012/9/18	16:00
			2013/3/22	18:00
WW - 13	WWTP (Effluent of Primary Sedimentation Tank -1)		2012/9/14	11:00
			2013/3/22	11:27
WW - 14	WWTP (Effluent of Primary Sedimentation Tank -2)		2012/9/14	14:14
			2013/3/22	16:20
WW - 15	WWTP (Effluent of Primary Sedimentation Tank -3)		2012/9/18	16:10
			2013/3/22	18:15
WW - 16	WWTP (Aeration Tank-1)		2012/9/14	11:15
			2013/3/22	11:34
WW - 17	WWTP (Aeration Tank-2)		2012/9/14	14:33
			2013/3/22	16:40
WW - 18	WWTP (Aeration Tank-3)		2012/9/18	16:35
			2013/3/22	18:30
WW - 19	WWTP (Effluent of Final Sedimentation Tank -1)		2012/9/14	11:10
			2013/3/22	11:47
WW - 20	WWTP (Effluent of Final Sedimentation Tank -2)		2012/9/14	14:20
			2013/3/22	16:25
WW - 21	WWTP (Effluent of Final Sedimentation Tank -3)		2012/9/18	16:20
			2013/3/22	18:20
WW - 22	Kandawgyi Lake -1	47 Q 198010E 1859227N	2012/9/13	16:05
			2013/3/22	16:27
WW - 23	Kandawgyi Lake -2	47 Q 197660E 1859050N	2012/9/13	16:15
			2013/3/22	16:17
WW - 24	Kandawgyi Lake -3	47 Q 197396E 1859201N	2012/9/13	16:35
			2013/3/22	16:08
WW - 25	Kandawgyi Lake –Drainage canal	47 Q 197657E 1859587N	2012/9/13	11:45
			2013/3/22	15:41
WW - 26	Kandawgyi Lake -Drainage canal	47 Q 197134E 1859652N	2012/9/18	8:30
			2013/3/22	15:18
WW - 27	Kandawgyi Lake -Drainage canal	47 Q 198120E 1859581N	2012/9/18	8:45
			2013/3/22	14:42
WW - 28	River -1 (Hlaing River, Wartayar Village, upstream)	47 Q 184689E 1879702N	2012/9/20	12:00
			2013/3/7	11:46
WW - 29	River -2 (Hlaing River, midstream)	47 Q 192410E 1863250N	2012/9/20	14:20
			2013/3/7	10:22
WW - 30	River -3 (Hlaing River, downstream, Myanmar Industrial Port)	47 Q 194073E 1856740N	2012/9/20	15:10
			2013/3/7	09:51
WW - 31	River -4 (Yangon River, Near Bo Ta Htaung Pagoda)	47 Q 198562E 1855824N	2012/9/20	15:50
			2013/3/6	14:52
WW - 32	River -5 (Bago River, upstream)	47 Q 216735E 1871825N	2012/9/17	18:20
			2013/3/7	14:31
WW - 33	River -6 (Bago River, downstream, Near Thanlyin - Yangon Bridge)	47 Q 205651E 1859927N	2012/9/20	16:50
			2013/3/6	13:59
WW - 34	River -7 (Nga Moe Yeik Creek)	47 Q 206632E 1877475N	2012/9/19	8:35
			2013/3/7	14:02
WW - 35	River -8 (Pu Zun Taung Creek)	47 Q 199242E 1857450N	2012/9/20	17:25
			2013/3/6	14:35
WW - 36	YCDC Drainage Canal -1 (Pauk Tar Chaung)	47 Q 190860E 1868852N	2012/9/20	13:10
			2013/3/12	14:43
WW - 37	YCDC Drainage Canal -2 (Yoe Gyi Chaung)	47 Q 191584E 1867124N	2012/9/20	13:45
			2013/3/12	14:21

Sample No.	Sampling Point	Positional Information	Sampling	
			Date	Time
WW - 38	YCDC Drainage Canal -3 (Thamaing change)	47 Q 191759E 1865890N	2012/9/19	14:15
			2013/3/12	13:15
WW - 39	YCDC Drainage Canal -4 (Padauk Chaung)	47 Q 192248E 1864571N	2012/9/19	14:30
			2013/3/12	13:26
WW - 40	YCDC Drainage Canal -5 (Tbebyu Chaung)	47 Q 198134E 1858082N	2012/9/18	15:10
			2013/3/6	11:31
WW - 41	YCDC Drainage Canal -6 (Nat Chaung)	47 Q 199327E 1860842N	2012/9/18	15:30
			2013/3/6	12:03

(1) Sampling point of Kandawgyi Lake

Detailed location of Kandawgyi Lake sampling point is shown below;

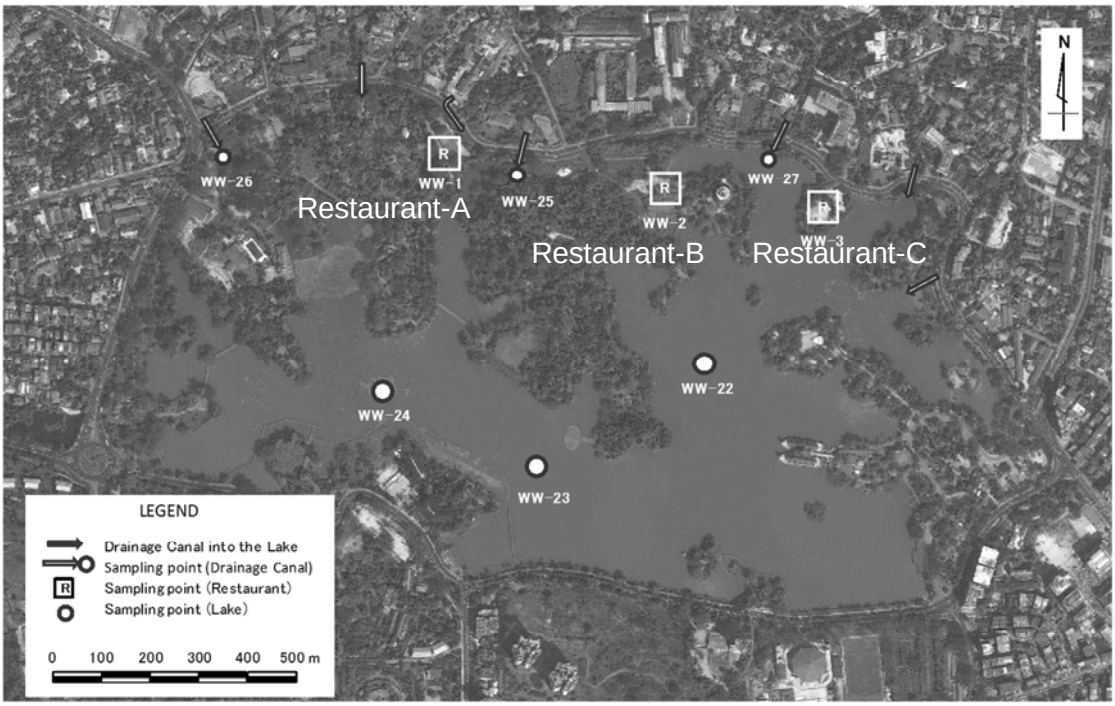


Figure A.1 Sampling Point of Kandawgyi Lake

Table A.5 Detailed Information of Restaurant Sampling Point

Name	General Description
WW-1 (Rainy season) Restaurant-A Dolphin (Myanmar and Chinese food)	Address: Nat Mouk Road, Bahan T/S, Tel: 01-542893, 01-546924 Respondent: U Paw San Number of Seats: 1,000 seats (maximum), 136 seats (daily average) Customers: number of customers per day is from 30 in June to September (minimum) to 1,000 in October to May (maximum) Business hour: from 6:00 to 22:00 Water Consumption: around 600 m^3/month (for July 2012) Treatment facilities: 2 chambers for filtration Sampling point: at chamber of filtration
WW-1 (Dry season)	Address: Opposite of Eye Special Hospital, Kandawgyi Park, Natmauk Rd.,01-556837

Name	General Description
Restaurant-D White Rice (Myanmar and Chinese food)	Respondent: Daw Yin Thida Win Number of Seats: Hall: 300 / Outside: 60 / Room: 50, Total: 410 seats Business hour: from 6:00 to 22:00 Water Consumption: 102m^3 / month (March 2013) Treatment facilities: Septic tank Sampling point: at drainage into lake
WW-2 Restaurant-B Royal Garden (Chinese food)	Address: Kan Pat Road, Bo Cho (2) Quarter, Bahan T/S, Tel: 01-546923, 01-546202 Respondent: U Htay Yin (G.M.) Number of Seats: 450 seats (maximum) for Receptions, and 260 seats for regular situation Customers: number of customers per day is from 40 to 50 customers in rainy season Business hour: from 6:30 to 14:15 and from 18:00 to 22:15 Water Consumption: around 1,000 m^3/month (for May and June 2012) and 1,200 m^3/month (for July 2012) Treatment facilities: Filtration Sampling point: at drainage into lake
WW-3 Restaurant-C Bangkok Kitchen (Thai food)	Address: Nat Mauk Road, Bahan T/S, Tel: 09-73013792, 01-548844 Respondent: U Aung Kyaw Lat (Supervisor) Number of Seats: 150 seats Customers: number of customers per day is from 50 to 100 customers Business hour: from 11:00 to 21:30 Water Consumption: 191 m^3/month (for August 2012) Treatment facilities: Septic Tank Sampling point: at drainage into lake

(2) Sampling point of hospital wastewater

Detailed information of hospital wastewater sampling point is shown below;

Table A.6 Detailed Information of Hospital Wastewater Sampling Point

WW-7 Hospital - A	Yangon General Hospital, Department of plastic, manila facial and oral surgery
WW-8 Hospital - B	Yangon General Hospital
WW-9 Hospital - C	Yangon New General Hospital (Japan Hospital)

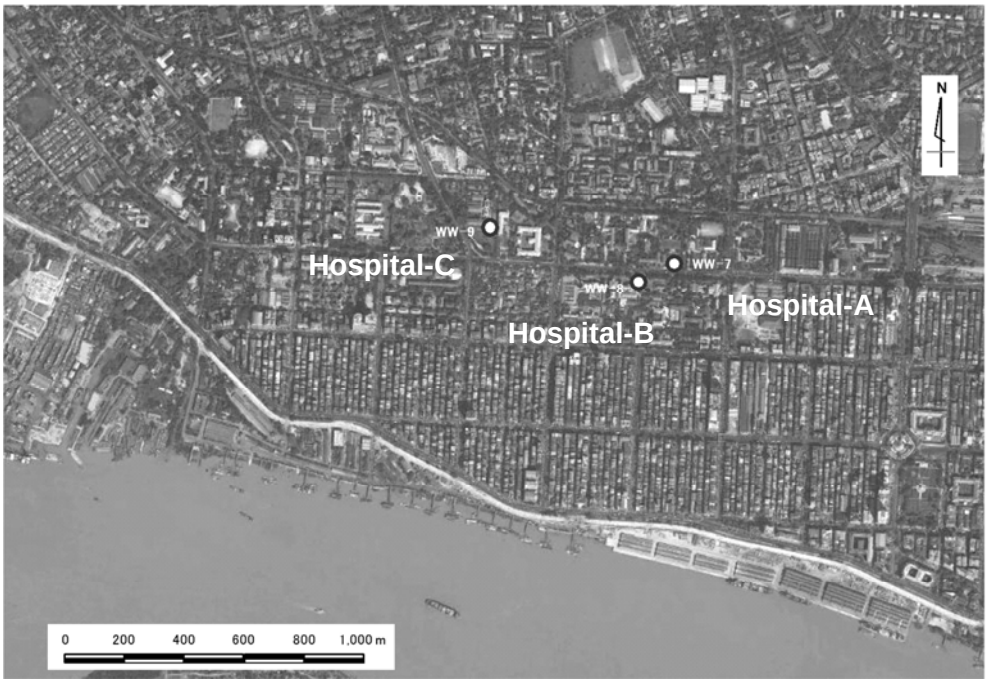


Figure A.2 Sampling Point of Hospital Wastewater

(3) Sampling point of industrial wastewater

Detailed information of industrial wastewater sampling point is shown below;

Table A.7 Detailed Information of Industrial Wastewater Sampling Point

Sample No. and Company name	General Description
WW-4 Factory-A PINYA MANUFACTURING Co., Ltd.	Address: No. 37/38, Ba Maw Ah Twin Wun Street, Zone (3), City of Industry, Hlaing Tharyar T/S, Tel: 01-685252, 09-5127988 Respondent: U Win Thein (Senior Plant Manager) Main products: Soft drink Number of workers: 150 person Working hours: from 8:00 to 17;00 Water consumption: 1,000 m^3/month from YCDC, and Six tube wells (with no record) Wastewater: roughly 35% of 1,000 m^3/month discharged Treatment facilities: No facilities
WW-5 Factory-B FAME Pharmaceuticals	Address: No. 20, Mingyi Maha Gaung Road, Zone (3), City of Industry, Hlaing Tharyar T/S Tel: 01-685083, 09-5003724 Respondent: U Tin Maung Aye (Director) Main products: Medicine (72 items) Number of workers: 323 person Working hours: from 8:00 to 17;00 Water consumption: 6,000 gallons/day from YCDC, and Six tube wells (with no record) Wastewater: wastewater is used for irrigation. Treatment facilities: Coagulation process and filtration
WW-6 Factory-C Good Morning	No reply Main products: Bakery

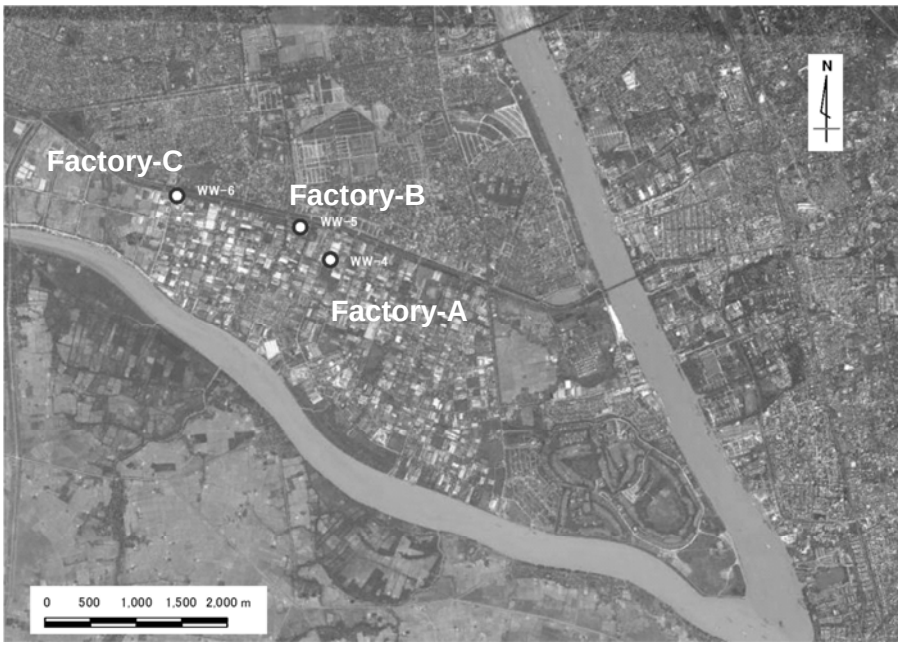


Figure A.3 Sampling Point of Industrial Wastewater

(4) Sampling point of river and drainage

Detailed information of river and drainage sampling point is shown below;

Table A.8 Detailed Information of River and Drainage Sampling Point

Sample No.	Location of Sampling Point
WW - 28	River -1 (Hlaing River, Wartayar Village, upstream)
WW - 29	River -2 (Hlaing River, midstream)
WW - 30	River -3 (Hlaing River, downstream, Myanmar Industrial Port)
WW - 31	River -4 (Yangon River, Near Bo Ta Htaung Pagoda)
WW - 32	River -5 (Bago River, upstream)
WW - 33	River -6 (Bago River, downstream, Near Thanlyin - Yangon Bridge)
WW - 34	River -7 (Nga Moe Yeik Creek)
WW - 35	River -8 (Pu Zun Taung Creek)
WW - 36	Drainage Canal -1 (Pauk Tar Chaung)
WW - 37	Drainage Canal -2 (Yoe Gyi Chaung)
WW - 38	Drainage Canal -3 (Thamaing Chaung)
WW - 39	Drainage Canal -4 (Padauk Chaung)
WW - 40	Drainage Canal -5 (Tbebyu Chaung)
WW - 41	Drainage Canal -6 (Nat Chaung)

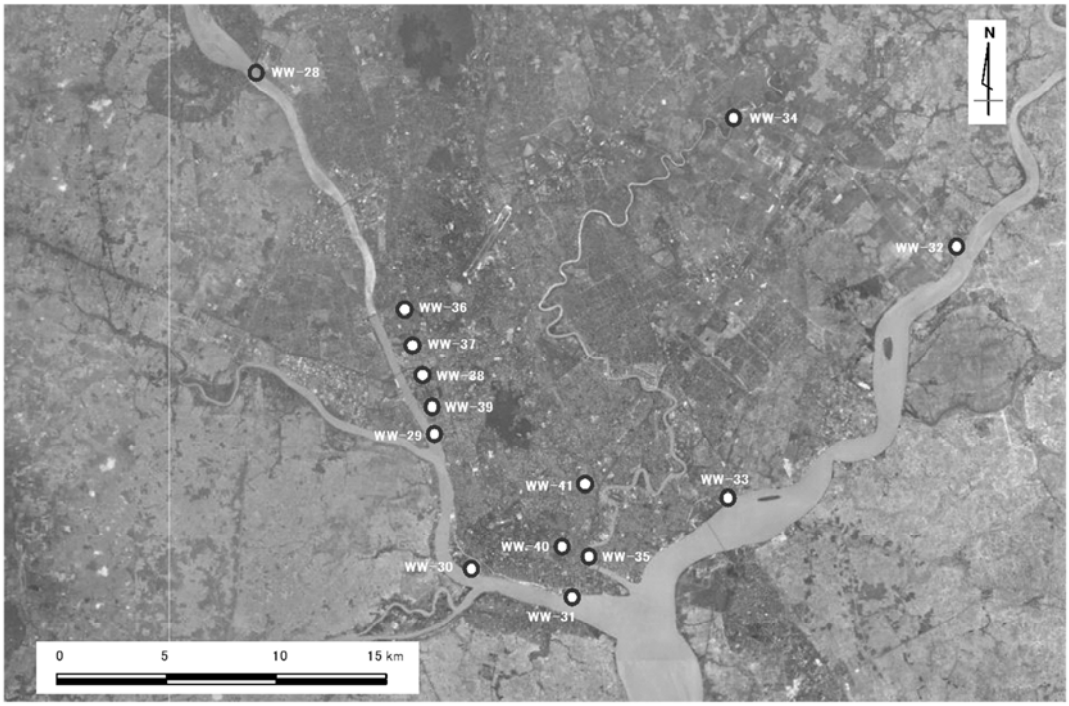


Figure A.4 Sampling Point of River and Drainage

(5) Sampling point of WWTP

Sampling point of WWTP is shown below.

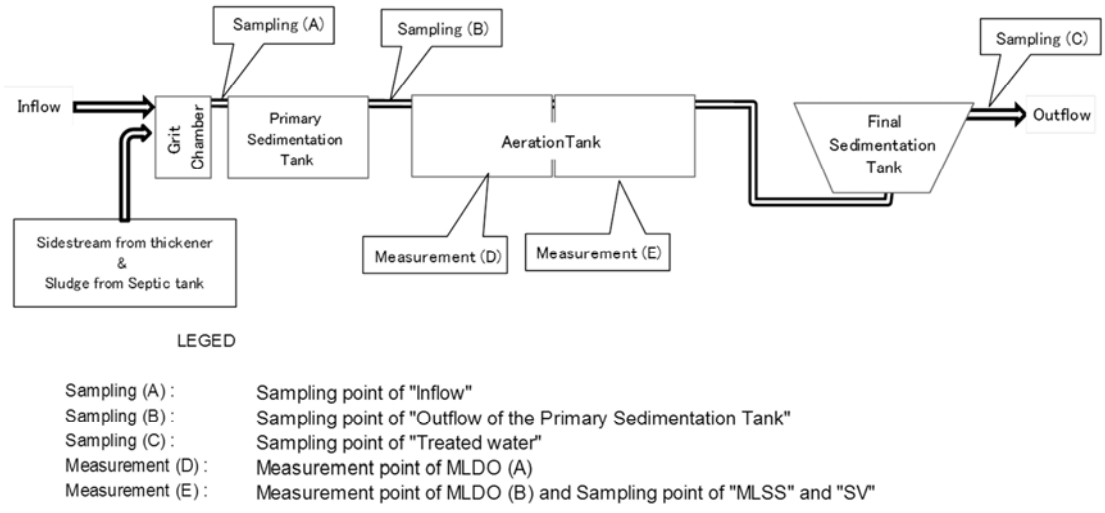


Figure A.5 Sampling Point of WWTP (1)

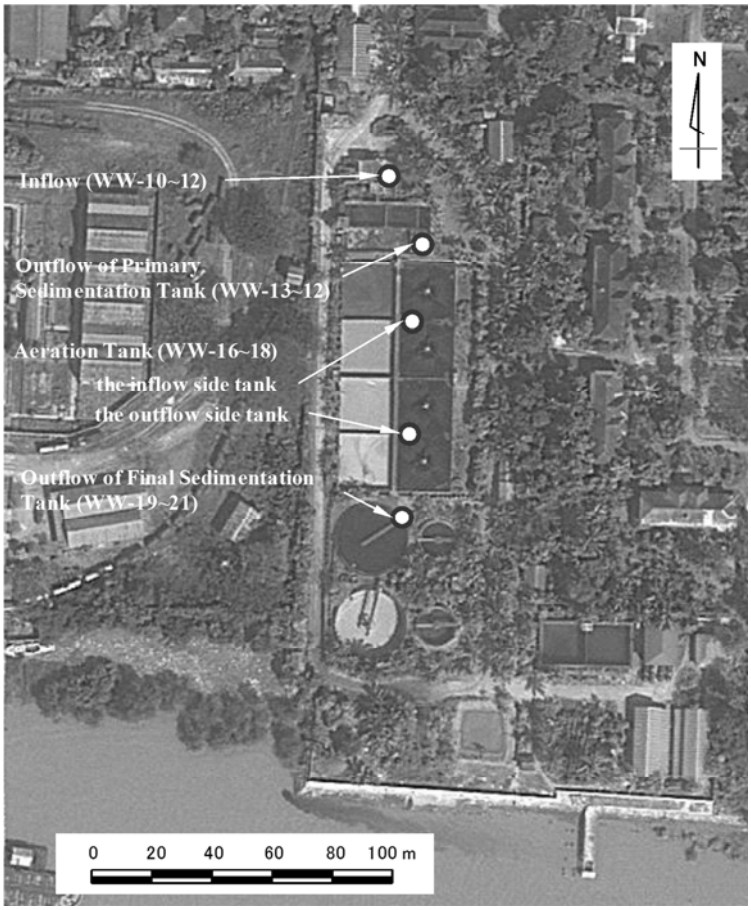


Figure A.6 Sampling Point of WWTP (2)

4. RESULT OF WATER QUALITY INVESTIGATION

Result of water quality analysis is shown below in table, and assessment of WWTP is shown in Figure A.7 and A.8.

Table A.9 Result of Water Quality Analysis, Rainy Season (1) Factory and Hospital

Parameter	Unit	Factory			Hospital		
		WW - 4	WW - 5	WW - 6	WW - 7	WW - 8	WW - 9
Air Temperature	^{o}C	36	34	36	33	33	33
Water Temperature	^{o}C	41.1	30.3	30.7	28.9	28.7	19.1
pH	-	11.5	7.7	7.0	8.4	6.8	7.5
Electrical Conductivity	μS/cm	4,100	950	500	720	230	600
Suspended Solid (SS)	mg/l	75	200	220	280	110	60
COD_{Cr}	mg/l	968	620	640	96	96	96
BOD	mg/l	630	510	510	21	60	12
T-N	mg/l	10.3	21.5	14.9	43.8	21.1	52.8
NH_4-N	mg/l	1.92	1.15	0.96	N.D.	N.D.	N.D.
TKN	mg/l	0.82	12.9	12.0	17.8	11.1	31.6
T-P	mg/l	0.17	1.19	0.29	0.61	0.19	1.23

Table A.10 Result of Water Quality Analysis, Rainy Season (2) WWTP

Parameter	Unit	Inflow			1st sedimentation tank effluent			Aeration tank			Final sedimentation tank effluent		
		WW - 10	WW - 11	WW - 12	WW - 13	WW - 14	WW - 15	WW - 16	WW - 17	WW - 18	WW - 19	WW - 20	WW - 21
Air Temperature	°C	31	28.5	31	30	28.5	31	30	28	31	30	28	31
Water Temperature	°C	28.7	28.5	29.0	28.7	28.3	29.2	28.5	28.2	29.4	28.2	28.0	29.2
pH	-	7.2	7.3	7.4	7.1	7.2	7.2	7.3	7.3	7.1	7.1	7.1	7.1
Electrical Conductivity	μS/cm	800	810	1,410	880	840	1,380	560	560	560	450	430	570
Suspended Solid (SS)	mg/l	1,180	1,652	1,820	998	1,468	1,200	-	-	-	160	142	295
COD_{Cr}	mg/l	1,280	2,560	960	480	960	640	-	-	-	32	32	32
BOD	mg/l	600	900	540	270	435	420	-	-	-	18	23	15
T-N	mg/l	131	97.0	214	122	84.6	370	-	-	-	15.2	16.4	17.4
NH_4-N	mg/l	2.50	2.69	2.88	2.88	2.69	2.30	-	-	-	0.96	0.77	1.34
TKN	mg/l	127	93.1	207	118	80.6	364	-	-	-	2.37	2.47	1.64
T-P	mg/l	8.48	12.5	13.1	9.68	12.5	12.3	-	-	-	8.31	8.44	8.21
MLSS	mg/l	-	-	-	-	-	-	6,400	5,450	6,250	-	-	-
SV	%	-	-	-	-	-	-	28.0	25.0	36.5	-	-	-
SVI	-	-	-	-	-	-	-	43.8	45.9	58.4	-	-	-
MLDO (First Tank)	mg/l	-	-	-	-	-	-	2.1	0.7	0.7	-	-	-
MLDO (Second Tank)	mg/l	-	-	-	-	-	-	3.4	1.8	1.8	-	-	-

Table A.11 Result of Water Quality Analysis, Rainy Season (3) Kandawgyi Lake

Parameter	Unit	Restaurant			Lake water			Drainage		
		WW - 1*	WW - 2	WW - 3	WW - 22	WW - 23	WW - 24	WW - 25	WW - 26	WW - 27
Air Temperature	^oC	31	31	30	31	31	31	35	31	32
Water Temperature	^oC	28.2	29.5	27.7	31.6	30.6	30.0	28.7	27.7	31.6
pH	-	6.0	7.5	6.9	9.5	9.2	9.2	6.7	7.3	7.1
Electrical Conductivity	µS/cm	250	570	124	132	129	143	195	240	125
Suspended Solid (SS)	mg/l	89	59	52	62	68	64	36	68	25
COD_{Cr}	mg/l	620	1280	928	96	160	160	192	64	160
BOD	mg/l	540	750	360	60	48	60	42	24	48
T-N	mg/l	68.8	13.9	13.0	2.17	1.98	1.69	4.53	4.03	3.03
NH_4-N	mg/l	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.19	0.13
TKN	mg/l	57.8	13.4	8.64	1.33	1.09	0.81	3.43	3.03	2.47
T-P	mg/l	10.2	1.67	0.94	0.13	0.13	0.14	0.35	0.13	0.19

*Restaurant-A (Dolphin)

Table A.12 Result of Water Quality Analysis, Rainy Season (4) River

Parameter	Unit	Hlaing River			Yangon River	Bago River		Nga Moe Yeik Creek	Pu Zun Taung Creek
		WW - 28	WW - 29	WW - 30	WW - 31	WW - 32	WW - 33	WW - 34	WW - 35
Air Temperature	^{o}C	32	36	33	32	28	30	33	29
Water Temperature	^{o}C	29.6	29.6	29.6	29.3	29.1	29.7	29.0	28.9
pH	-	7.6	7.7	7.6	7.6	7.3	7.5	7.0	7.7
Electrical Conductivity	µS/cm	124	133	130	128	70	135	68	135
Suspended Solid (SS)	mg/l	105	128	116	136	370	142	310	160
COD_{Cr}	mg/l	1280	2560	960	480	960	640	96	128
BOD	mg/l	600	900	540	270	435	420	27	50
T-N	mg/l	0.98	1.34	1.16	1.06	0.98	1.49	0.84	1.37
NH_4-N	mg/l	0.10	0.10	0.10	0.10	0.19	0.1	0.19	0.10
TKN	mg/l	0.48	0.50	0.50	0.44	0.48	0.69	0.33	0.66
T-P	mg/l	0.13	0.20	0.14	0.20	0.25	0.59	0.05	0.33

Table A.13 Result of Water Quality Analysis, Rainy Season (5) Drain

Parameter	Unit	Pauk Tar Chaung	Yoe Gyi Chaung	Thamaing Chaung	Padauk Chaung	Tbebyu Chaung	Nat Chaung
		WW - 36	WW - 37	WW - 38	WW - 39	WW - 40	WW - 41
Air Temperature	^oC	34	33.5	34.5	34	30	28.5
Water Temperature	^oC	29.0	29.9	30.1	29.9	28.8	28.0
pH	-	7.3	6.9	7.2	7.1	7.2	7.1
Electrical Conductivity	µS/cm	500	330	310	340	330	420
Suspended Solid (SS)	mg/l	480	510	130	186	58	44
COD_{Cr}	mg/l	192	128	96	160	224	224
BOD	mg/l	60	35	6	12	39	62
T-N	mg/l	17.8	22.5	8.73	5.42	19.3	10.8
NH_4-N	mg/l	2.69	2.50	0.38	0.57	0.28	0.19
TKN	mg/l	15.5	17.4	6.36	3.37	15.5	8.14
T-P	mg/l	1.41	1.78	0.30	0.54	1.22	1.03

Table A.14 Result of Water Quality Analysis, Dry Season (1) Factory and Hospital

Parameter	unit	Factory			Hospital		
		WW - 4	WW - 5	WW - 6	WW - 7	WW - 8	WW - 9
Air Temperature	^oC	40.5	36.5	36.5	34.5	34.5	35.5
Water Temperature	^oC	42.5	29.0	31.0	33.0	30.0	30.0
pH	-	7.81	6.94	5.61	5.4	7.00	7.33
Electrical Conductivity	µS/cm	7,740	1,200	2,370	270	240	1,290
Suspended Solid (SS)	mg/l	216	264	488	5	22	78
COD_{Cr}	mg/l	989	700	422	84	90	96
BOD	mg/l	540	492	200	18	36	21
T-N	mg/l	7.17	27.1	71.2	4.99	10.1	186
NH_4-N	mg/l	1.20	1.32	1.20	N.D.	N.D.	0.21
TKN	mg/l	1.27	24.6	62.6	1.67	6.45	176
T-P	mg/l	2.88	2.53	0.74	0.07	0.39	3.08

Table A.15 Result of Water Quality Analysis, Dry Season (2) WWTP

Parameter	unit	Inflow			1st sedimentation tank effluent			Aeration tank			Final sedimentation tank effluent		
		WW - 10	WW - 11	WW - 12	WW - 13	WW - 14	WW - 15	WW - 16	WW - 17	WW - 18	WW - 19	WW - 20	WW - 21
Air Temperature	^oC	36.5	37.0	35.0	36.5	37.0	35.0	36.5	37.0	35.0	36.5	37.0	34.0
Water Temperature	^oC	30.7	30.9	30.7	32.0	31.3	30.7	30.1	29.3	27.7	29.2	29.7	28.0
pH	-	7.55	7.37	7.35	7.24	7.28	7.15	7.33	7.40	7.44	7.19	7.18	7.20
EC	µS/cm	1,740	1,850	1,640	1,980	1,810	1,780	1,040	1,000	940	750	770	740
Suspended Solid (SS)	mg/l	936	1010	880	885	728	922	-	-	-	116	80	132
COD_{Cr}	mg/l	188	172	168	80	68	164	-	-	-	38	36	33
BOD	mg/l	82	64	90	30	30	76	-	-	-	16	20	20
T-N	mg/l	276	191	197	453	367	354	-	-	-	15.2	11.0	13.9
NH_4-N	mg/l	0.29	0.80	0.32	0.33	0.26	0.40	-	-	-	0.25	0.11	0.11
TKN	mg/l	273	187	195	451	366	351	-	-	-	7.46	4.16	7.74
T-P	mg/l	1.11	21.3	1.50	2.20	21.9	24.8	-	-	-	9.48	9.32	0.87
MLSS	mg/l	-	-	-	-	-	-	9,920	4,870	12,880	-	-	-
SV	%	-	-	-	-	-	-	89	90	91	-	-	-
SVI	-	-	-	-	-	-	-	90	185	71	-	-	-
MLDO	mg/l	-	-	-	-	-	-	0.45	0.00	0.32	-	-	-

Table A.16 Result of Water Quality Analysis, Dry Season (3) Kandawgyi Lake

Parameter	unit	Restaurant			Lake water			Drainage		
		WW - 1*	WW - 2	WW - 3	WW - 22	WW – 23	WW - 24	WW - 25	WW - 26	WW - 27
Air Temperature	^{o}C	36.5	35.5	34.0	35.0	35.0	34.0	34.0	34.0	37.0
Water Temperature	^{o}C	31.5	30.5	28.7	32.2	23.9	33.9	30.0	29.7	31.0
pH	-	5.42	6.69	8.00	11.09	11.06	10.96	7.06	7.12	7.19
Electrical Conductivity	µS/cm	480	810	210	270	230	290	290	610	350
Suspended Solid (SS)	mg/l	242	310	165	58	78	82	55	36	68
COD_{Cr}	mg/l	680	882	388	93	155	158	222	73	150
BOD	mg/l	270	372	184	52	50	68	88	30	44
T-N	mg/l	36.3	87.6	5.2	19.9	11.3	7.74	5.65	59.7	31.1
NH_4-N	mg/l	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
TKN	mg/l	25.1	25.1	4.96	19.5	10.9	7.46	4.81	55.6	28.5
T-P	mg/l	2.88	2.88	2.88	0.19	0.17	0.03	0.31	2.52	0.28

*Restaurant-D (White Rice)

Table A.17 Result of Water Quality Analysis, Dry Season (4) River

Parameter	unit	Hlaing river			Yangon River	Bago river		Nga Moe Yeik Creek	Pu Zun Taung Creek
		WW - 28	WW - 29	WW - 30	WW - 31	WW - 32	WW - 33	WW - 34	WW - 35
Air Temperature	^oC	36.5	34.0	33.0	31.5	32.5	33.5	38.0	31.0
Water Temperature	^oC	31.5	31.5	30.5	31.0	31.5	31.5	36.0	31.0
pH	-	7.93	7.90	7.74	7.58	7.59	7.58	7.16	7.54
Electrical Conductivity	µS/cm	890	3,330	6,640	163,100	8,990	14,580	160	14,450
Suspended Solid (SS)	mg/l	400	562	400	325	335	330	202	418
COD_{Cr}	mg/l	932	980	960	562	985	520	110	216
BOD	mg/l	520	520	436	280	362	364	50	88
T-N	mg/l	3.65	5.94	9.80	16.4	11.9	14.1	0.58	11.9
NH_4-N	mg/l	0.09	0.10	0.08	0.10	0.10	0.10	N.D.	0.10
TKN	mg/l	0.83	0.53	0.89	0.42	0.47	1.90	0.23	0.45
T-P	mg/l	0.54	0.08	0.18	0.10	0.17	2.82	0.03	0.05

Table A.18 Result of Water Quality Analysis, Dry Season (5) Drain

Parameter	unit	Pauk Tar Chaung	Yoe Gyi Chaung	Thamaing Chaung	Padauk Chaung	Tbebyu Chaung	Nat Chaung
		WW - 36	WW - 37	WW - 38	WW - 39	WW - 40	WW - 41
Air Temperature	^{o}C	34.5	38.1	35.0	34.5	36.5	35.5
Water Temperature	^{o}C	28.5	33.5	29.5	30.5	31.0	32.0
pH	-	7.18	6.68	7.09	7.17	6.85	6.89
Electrical Conductivity	µS/cm	920	1,250	520	1,450	460	550
Suspended Solid (SS)	mg/l	303	208	110	160	294	210
COD_{Cr}	mg/l	190	128	100	182	320	322
BOD	mg/l	60	40	28	52	96	58
T-N	mg/l	54.1	64.8	21.9	66.2	20.9	24.3
NH_4-N	mg/l	3.30	1.20	0.46	1.20	0.22	0.14
TKN	mg/l	46.6	57.4	16.7	50.5	18.4	22.9
T-P	mg/l	2.64	4.93	1.81	2.53	2.64	3.13

Kandawgyi Lake

Water quality data of Kandawgyi Lake water are shown below;

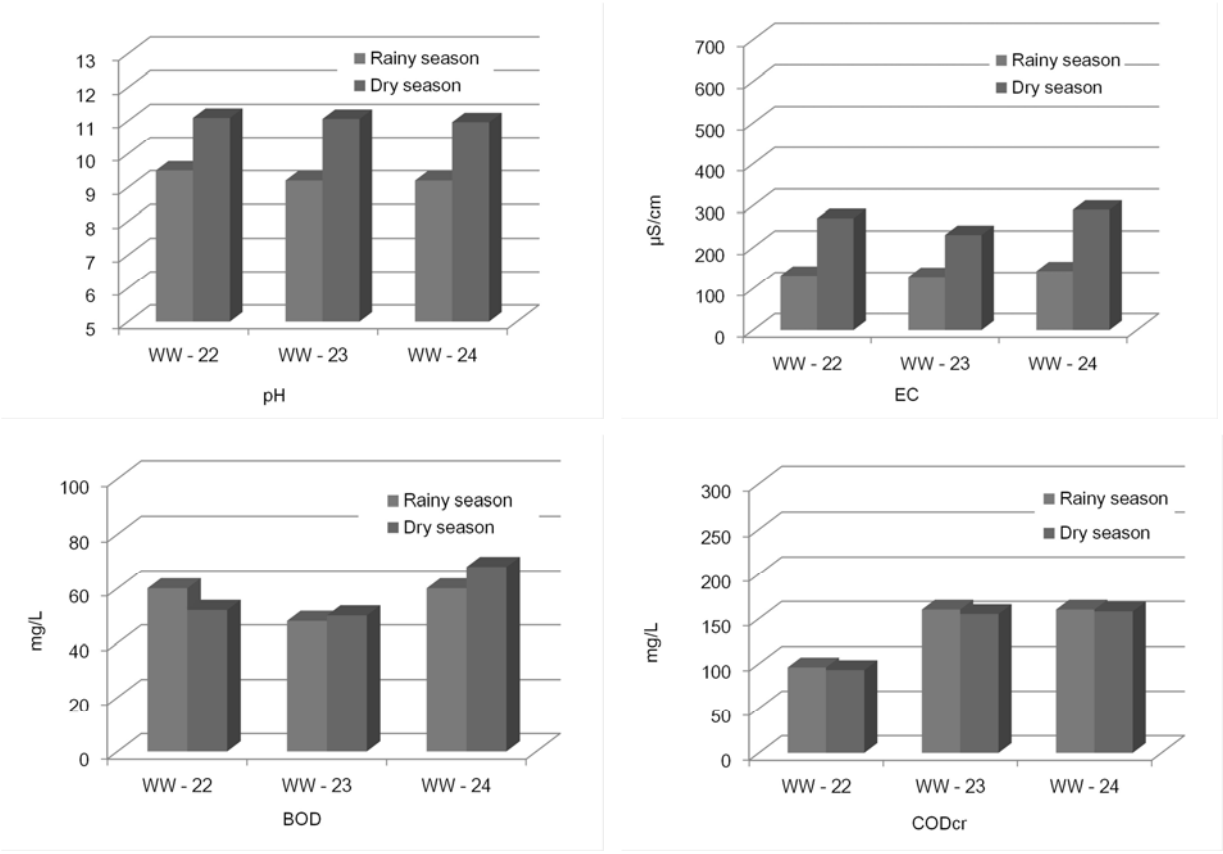


Figure A.7 Water Quality of Kandawgyi Lake Water (pH, EC, BOD, CODcr)

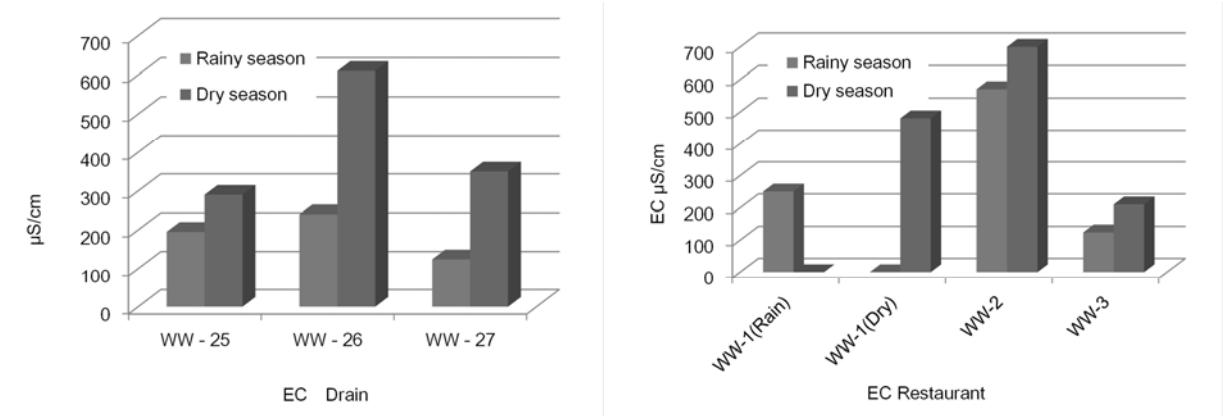


Figure A.8 Water Quality of Drain and Restaurant around Kandawgyi Lake (EC)

In Kandawgyi Lake water, both pH and EC of dry season are higher than those of rainy season. For the reason of high pH value in dry season, it is estimated that the photosynthesis of blue-green algae becomes more active than rainy season.

On the other hand, the reason of high pH in dry season is estimated to be the effect of drain and restaurant drainage which contain high EC substance.

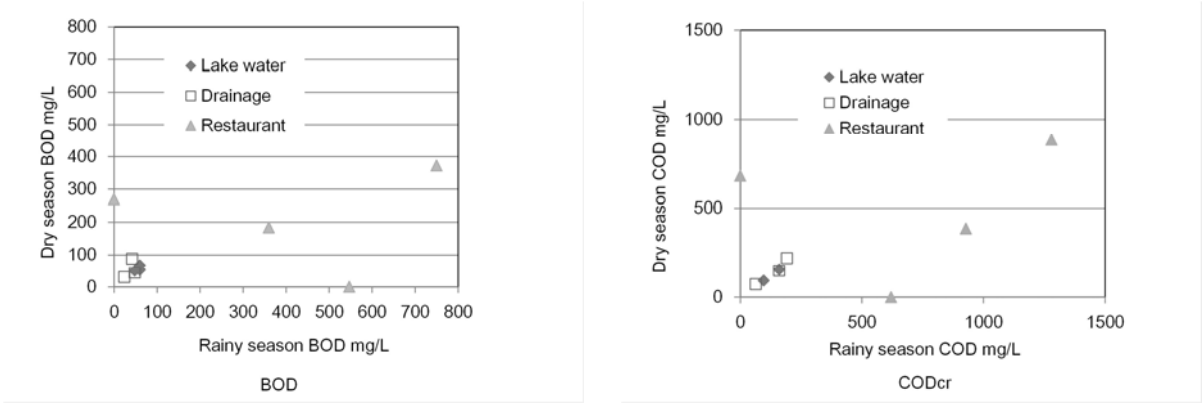


Figure A.9 Water Quality of Drain and Restaurant around Kandawgyi Lake (EC)

BOD of lake water in rainy season and dry season are similar. CODcr shows same tendency. However, both BOD and CODcr of lake water in the western part (WW-23 and WW-24) are higher than those of the eastern part (WW-22). Therefore, pollution of western part of the lake is progressing faster than eastern part.

Relationship of BOD of lake water, drain and restaurant drainage is shown in above figure. BOD values of drain and restaurant drainage are higher than lake water. Therefore, BOD pollution of lake water is effected by drain and restaurant drainage. Same tendency is observed in terms of CODcr.

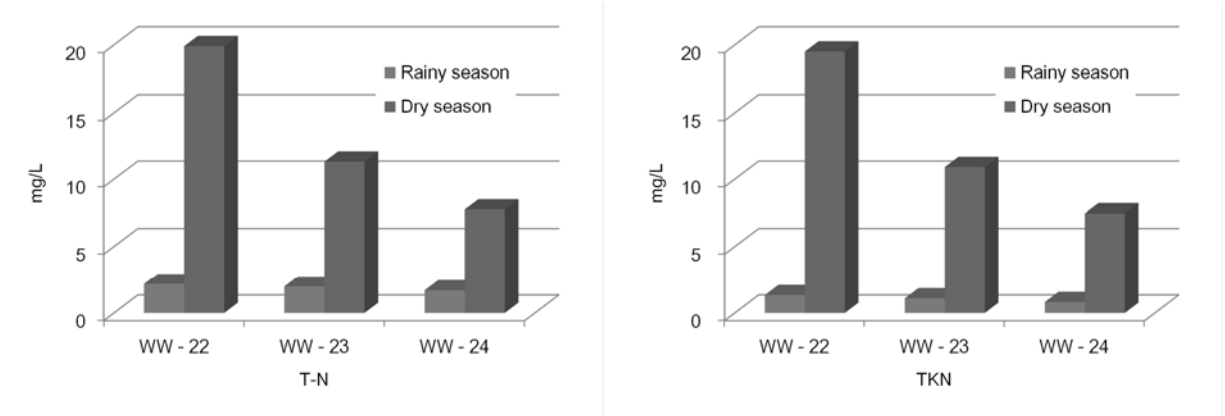


Figure A.10 Water Quality of Kandawgyi Lake Water (T-N, TKN)

T-N in dry season is higher than rainy season. The reason of this increase may be due to the progress of pollution or seasonal change. Major ingredient of T-N is TKN.

Relationship of T-N of lake water, drain and restaurant drainage shows that T-N in drain and restaurant drainage is higher than that in lake water.

Both T-N and TKN in eastern part of lake are higher than western part. There are many restaurants and cafes on the west bank of the lake. Therefore, the major source of this nitrogen pollution is attributed to the wastewater discharge from restaurant and café.

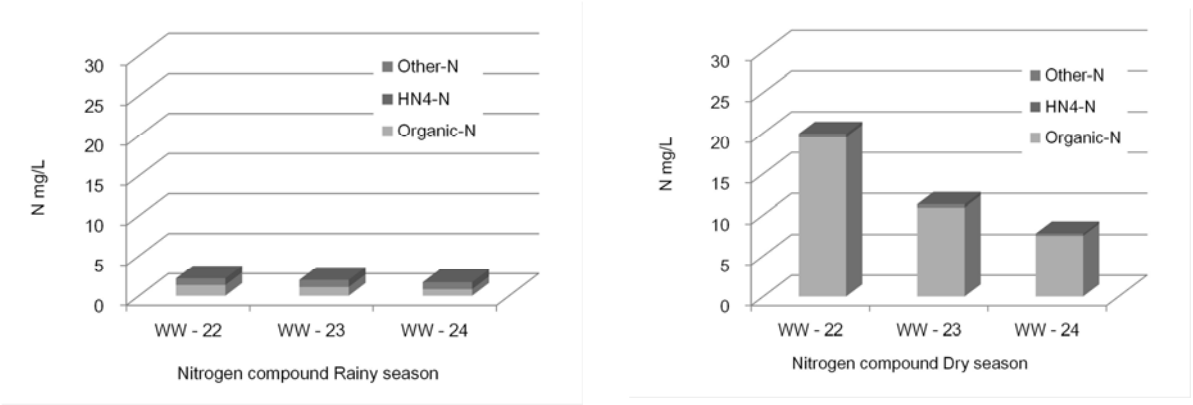


Figure A.11 Nitrogen Ingredients of Kandawgyi Lake Water

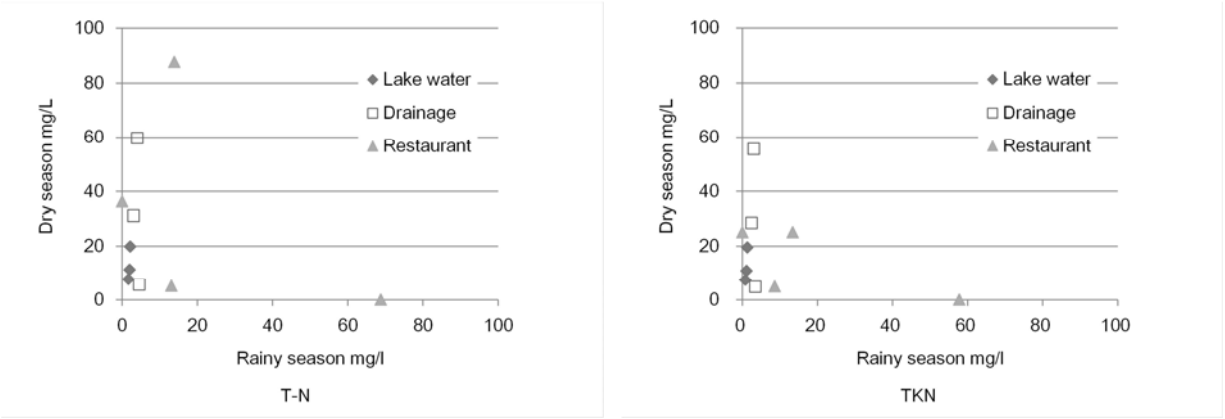


Figure A.12 Water Quality of Kandawgyi Lake Water, Drain and Restaurant Drainage (T-N, TKN)

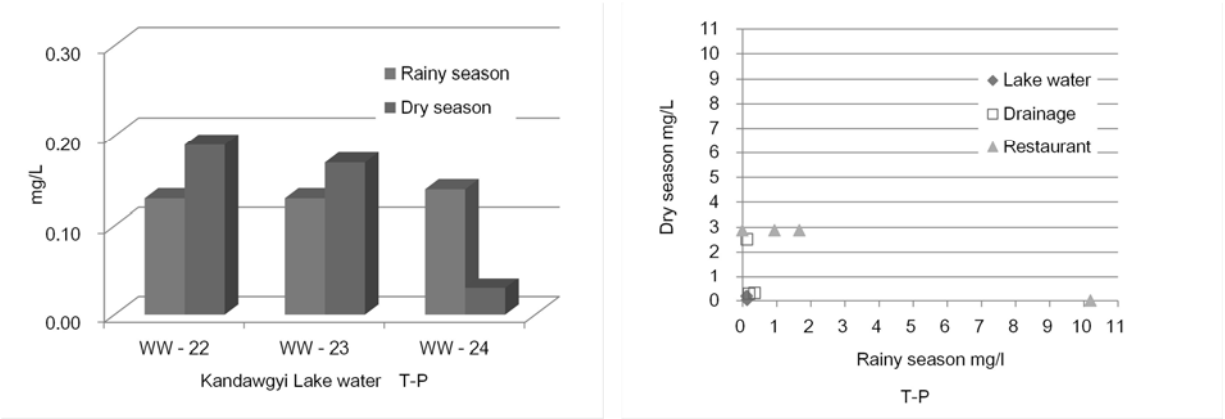


Figure A.13 Water Quality of Kandawgyi Lake Water (T-P)

In rainy season, T-P in lake water is near uniformity. However, in dry season, east part of lake water shows higher T-P. The reason of this difference may be due to the effect of lake water agitation by strong rainfall or release of lake water.
T-P in restaurant drainage shows higher value than that of lake water and drain. Therefore, major source of T-P is discharge from restaurant.

N/P ratio of Kandawgyi Lake water is shown below. N/P ratio in rainy season is 13 – 14, and in dry season it is 5 – 20.
Generally, N/P ratio > 16 means phosphorus is limiting factor for blue-algae growth. On the contrary, N/P ratio <16 means nitrogen is limiting factor.
In Kandawgyi Lake, nitrogen is limiting factor of blue-algae growth. However, it is possible that phosphorus becomes limiting factor by seasonal change or location.

Table A.19 N/P Ratio in Kandawgyi Lake Water

Location	Rainy season	Dry season
East	14	5
Central	15	5
West	13	20

Factory and Hospital

Water quality of Factory and Hospital drain is shown below;

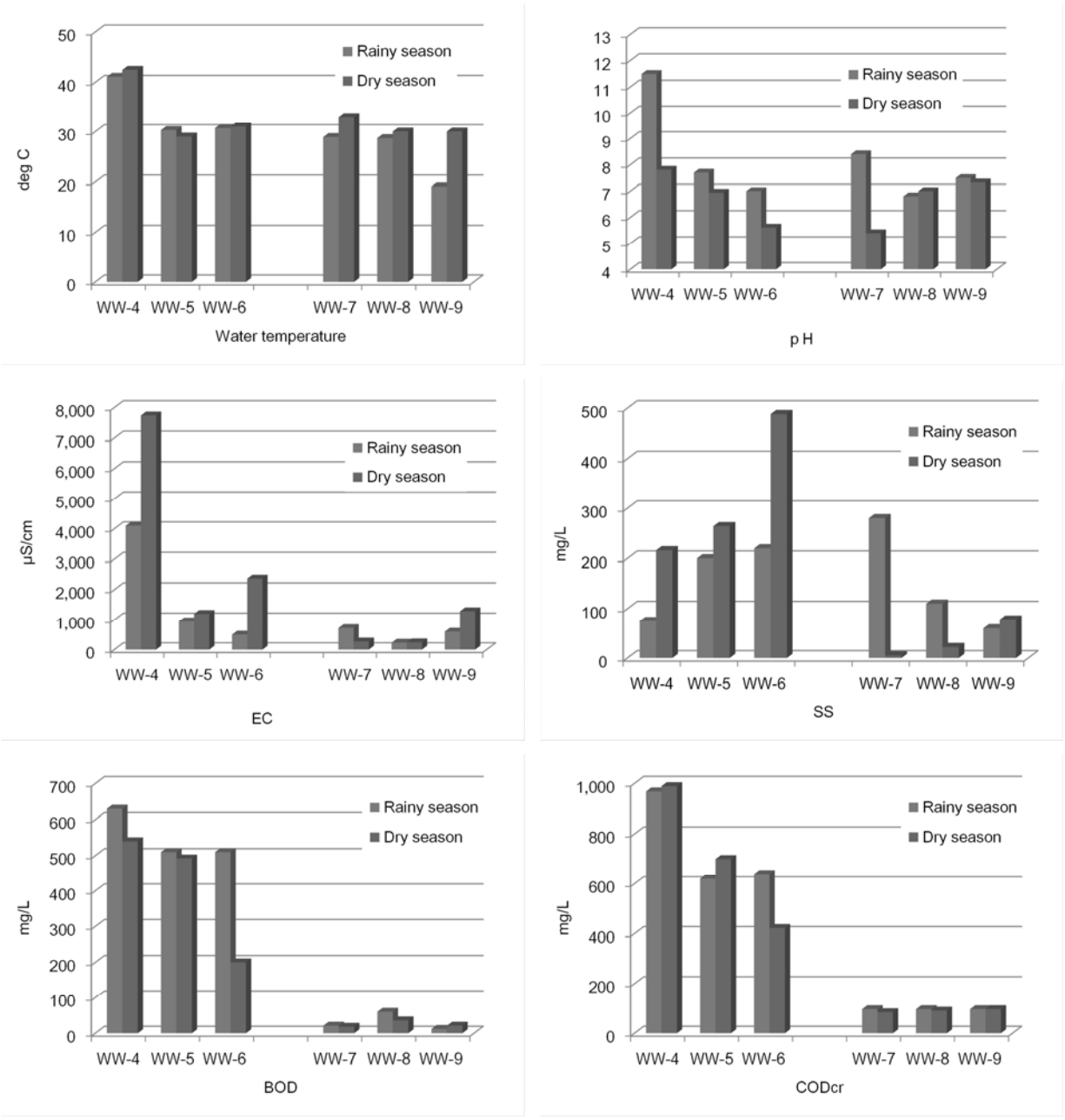


Figure A.14 Water Quality of Factory and Hospital Effluent (Water Temperature, pH, EC, SS, BOD, CODcr)

Water temperature of Beverage factory (WW-4) shows higher temperature than other wastewater. This wastewater shows higher pH in rainy season. Possible explanation of this difference is the difference in manufactured item.

WW-7 in dry season shows low pH. When water sampling was done, this hospital implemented surgical operation. Therefore, possible explanation of this pH decrease is due to discharge of medical material after surgical operation.

Industrial wastewater shows higher organic pollution (BOD and CODcr) than hospital wastewater.

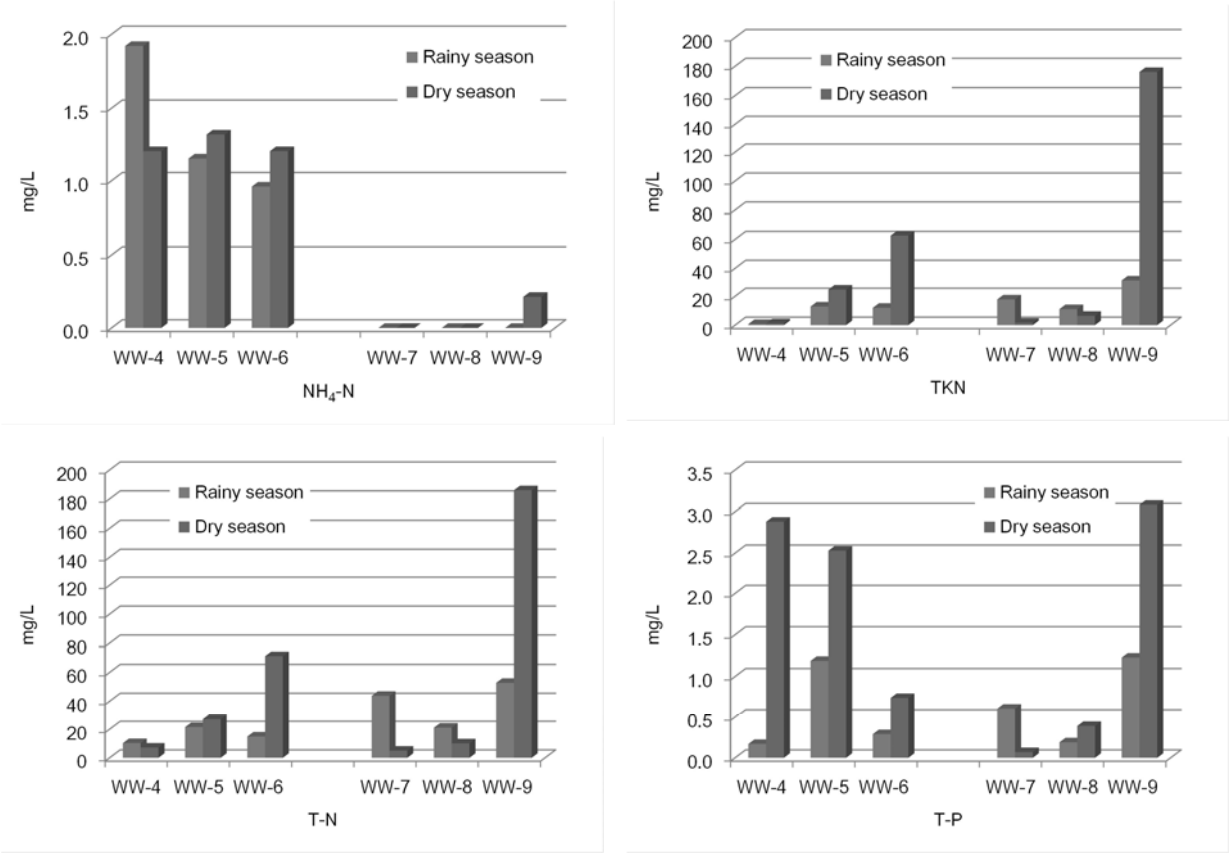


Figure A.15 Water Quality of Factory and Hospital Effluent (NH_4-N, TKN, T-N, T-P)

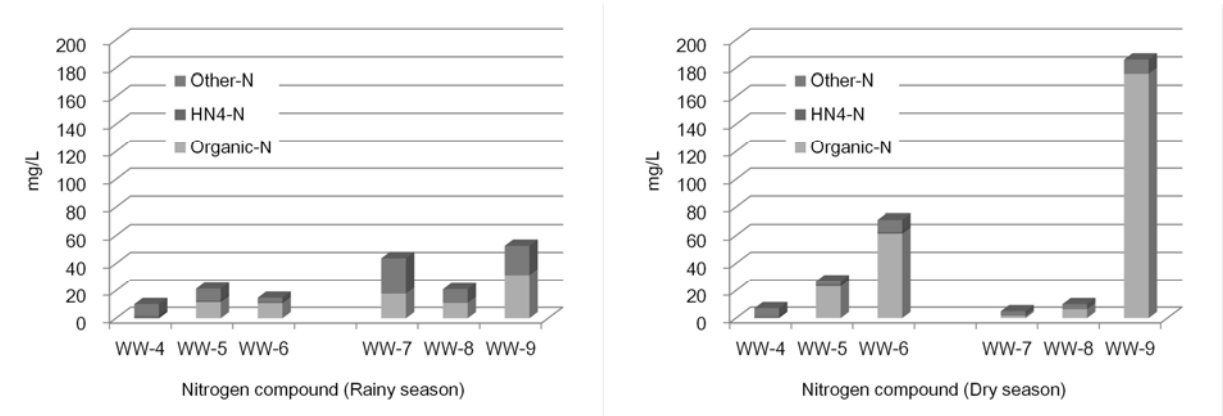


Figure A.16 Nitrogen Ingredients in Factory and Hospital Wastewater

Major nitrogen ingredient of beverage factory is other-nitrogen which is assumed inorganic nitrogen

compound. On the contrary, other factory (Pharmaceutical and Bread-making) and hospital wastewater contains organic-nitrogen.

Beverage factory and pharmaceutical factory show higher T-P than bread-making factory. In the beverage factory, usage of phosphorus containing sour agent is a possible reason. In the same way, usage of phosphorus containing agent may be possible reason of T-P in pharmaceutical wastewater.

Table A.20 Assessment of Wastewater Quality

Rainy season

Item	Limitation Value (Myanmar)	Factory A	Factory B	Factory C	Hospital A	Hospital B	Hospital C	Effluent standard (Japan)
pH	6 - 9.5	11.5	7.7	7	8.4	6.8	7.5	5.8-8.6
SS	200 mg/L	75	200	220	280	110	60	200 mg/L
BOD_5	20 - 60 mg/L	630	510	510	21	60	12	200 mg/L
CODcr	200 mg/L	968	620	640	96	96	96	160 mg/L (COD_{Mn})
T-N	Not decided	10.3	21.5	14.9	43.8	21.1	52.8	120 mg/L
T-P	Not decided	0.17	1.19	0.29	0.61	0.19	1.23	16 mg/L

Dry season

Item	Limitation Value (Myanmar)	Factory A	Factory B	Factory C	Hospital A	Hospital B	Hospital C	Effluent standard (Japan)
pH	6 - 9.5	7.81	6.94	5.61	5.4	7.0	7.33	5.8-8.6
SS	200 mg/L	216	264	488	5	22	78	200 mg/L
BOD_5	20 - 60 mg/L	540	492	200	18	36	21	200 mg/L
CODcr	200 mg/L	989	700	422	84	90	96	160 mg/L (COD_{Mn})
T-N	Not decided	7.17	27.1	71.2	4.99	10.1	186	120 mg/L
T-P	Not decided	2.88	2.53	0.74	0.07	0.39	3.08	16 mg/L

Wastewater quality is assessed on pH, SS, BOD, CODcr, T-N and T-P.

Both BOD and CODcr of Factory-A, -B and -C exceed limitation value of Myanmar. Among these 3 factories, Factory-A and Factory-C discharge their wastewater into river. Therefore, it is necessary to control these wastewater discharges via administrative guidance.

Limitation value of T-N and T-P is not decided in Myanmar. At present, T-N and T-P in factory wastewater does not exceed effluent standard of Japan.

Wastewater of hospital largely satisfies the limitation value of Myanmar. However, pH and SS of Hospital-A and T-N of Hospital-C exceed Japanese effluent standard.

However, when dialysis treatment and other high quality specialized medical treatment become popular in future, attention should be paid to characteristics of hospital wastewater.

River and Drainage

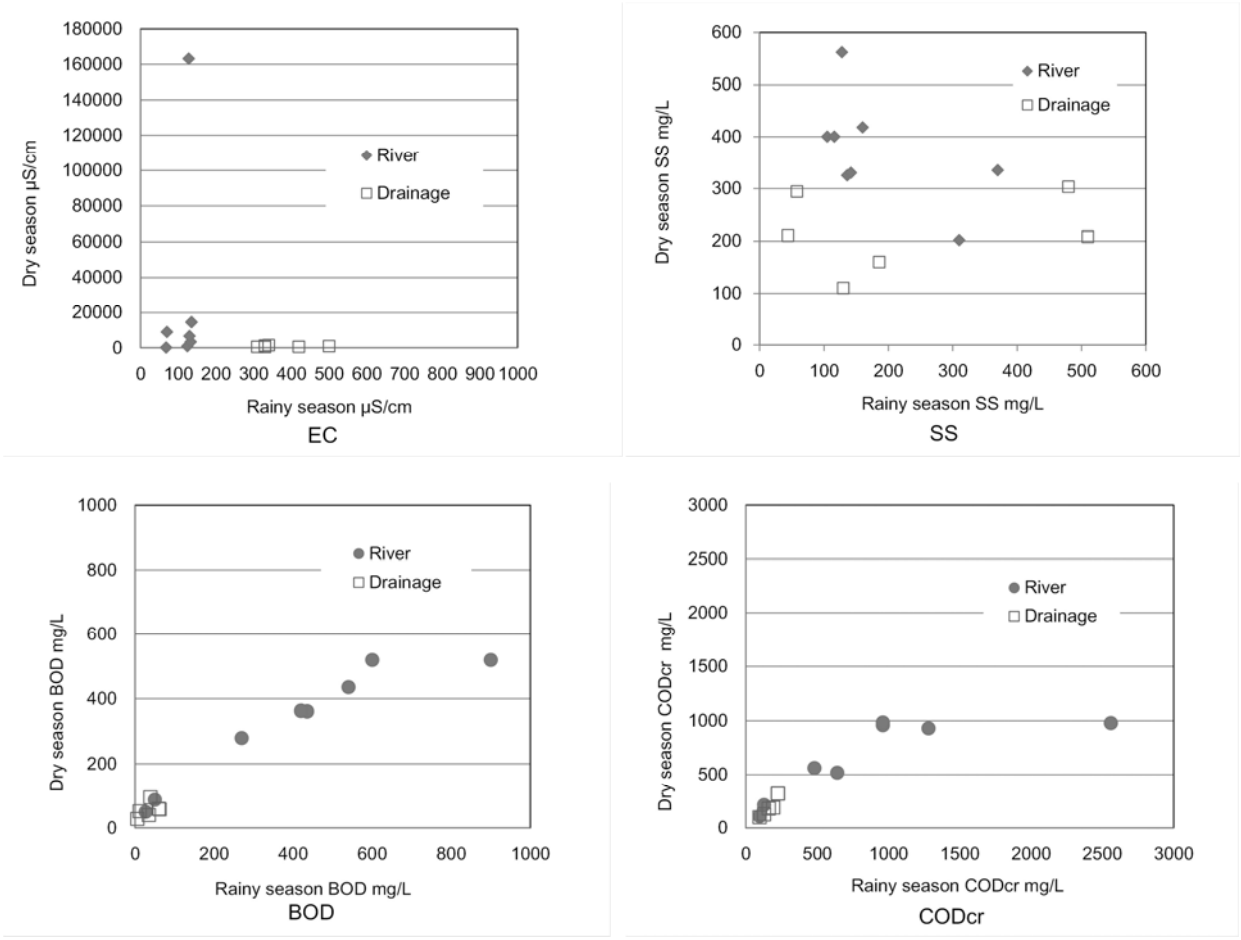


Figure A.17 Water Quality of River and Drainage (EC, SS, BOD, CODcr)

River water in dry season shows high EC value. Especially, downstream area shows higher EC value because of the effect of salt water intrusion. In the southern part of Yangon city, EC of Yangon River is: 163,000µS/cm, Downstream of Bago River the value is: 14,580µS/cm and Pu Zun Taung Creek, EC is: 14,450µS/cm.

On the other hand, EC and SS of drainage increase in rainy season. The possible explanation of this increase is the washout of deposit from branch drainage or road surface during rainy season.

BOD and CODcr in river are higher than those of drainage. Moreover, BOD and CODcr in rainy season are higher than dry season.
The reason of this increase is not clear, however, washout of deposit in drainage is considered as possible reason.

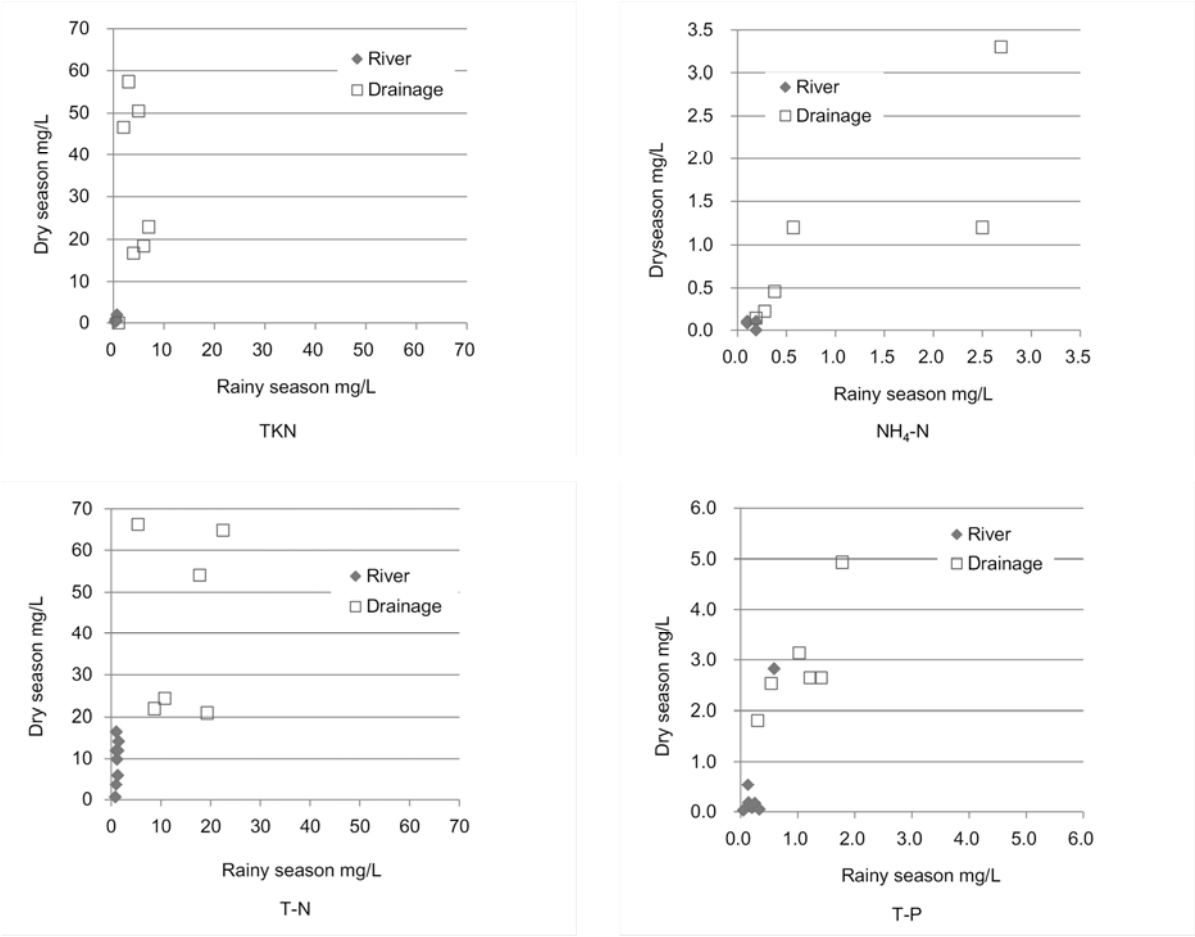


Figure A.18 Water Quality of River and Drainage (NH_4-N, TKN, T-N, T-P)

Drainage shows higher NH_4-N, TKN and T-N than river. Especially, Pauk Tar Chaung and Yoe Gyi Chaung show high NH_4-N concentration both in rainy season and dry season.

T-P shows same tendency, that is, drainage shows higher T-P than river. Similar to the observation of NH_4-N, Pauk Tar Chaung and Yoe Gyi Chaung show high T-P concentration.

From these observations, it is said that pollution of Pauk Tar Chaung and Yoe Gyi Chaung is serious compared to other drainage.

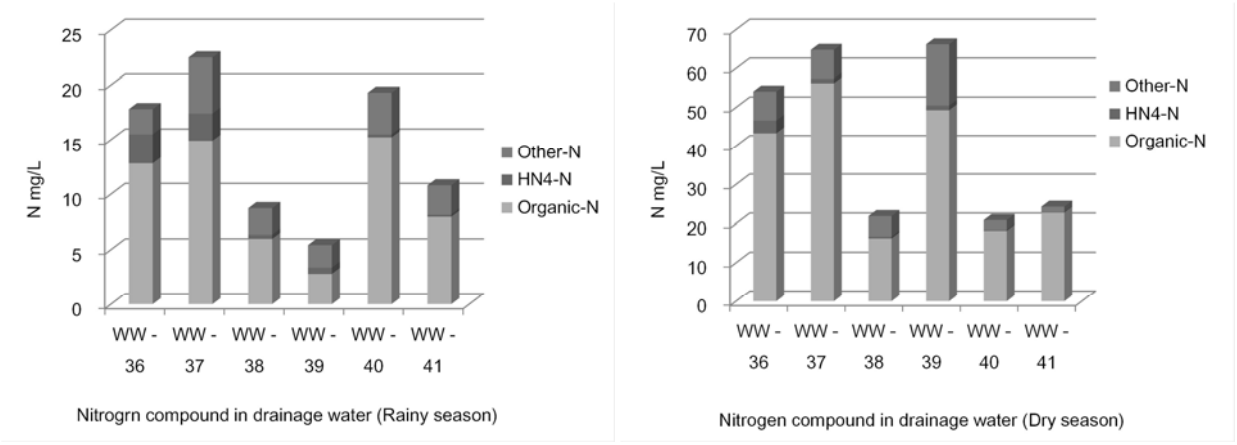


Figure A.19 Nitrogen Ingredients in Drainage

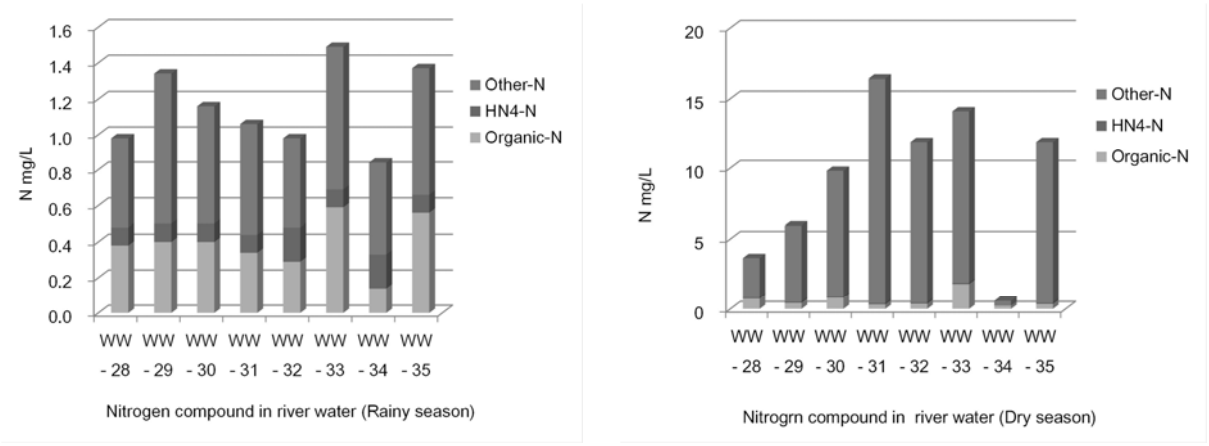


Figure A.20 Nitrogen Ingredients in Drainage

Above figures show the different of nitrogen ingredient of drainage water and river water. In drainage, major ingredient is Organic-N. Possible reason of this is that the major nitrogen source of drainage is domestic wastewater.

In river water, major ingredient of nitrogen is different in rainy season and dry season. In rainy season, major ingredient is organic-N and other-N. On the contrary, in dry season, other-N becomes dominant ingredient and NH_4-N is decreased.

In dry season, water temperature of river was 30.5 – 36.0 deg C (rainy season: 28.9 – 29.7 deg C). That is, it is assumed that this high water temperature in dry season activates nitrogen compound degradation (mineralization) in river water.

WWTP

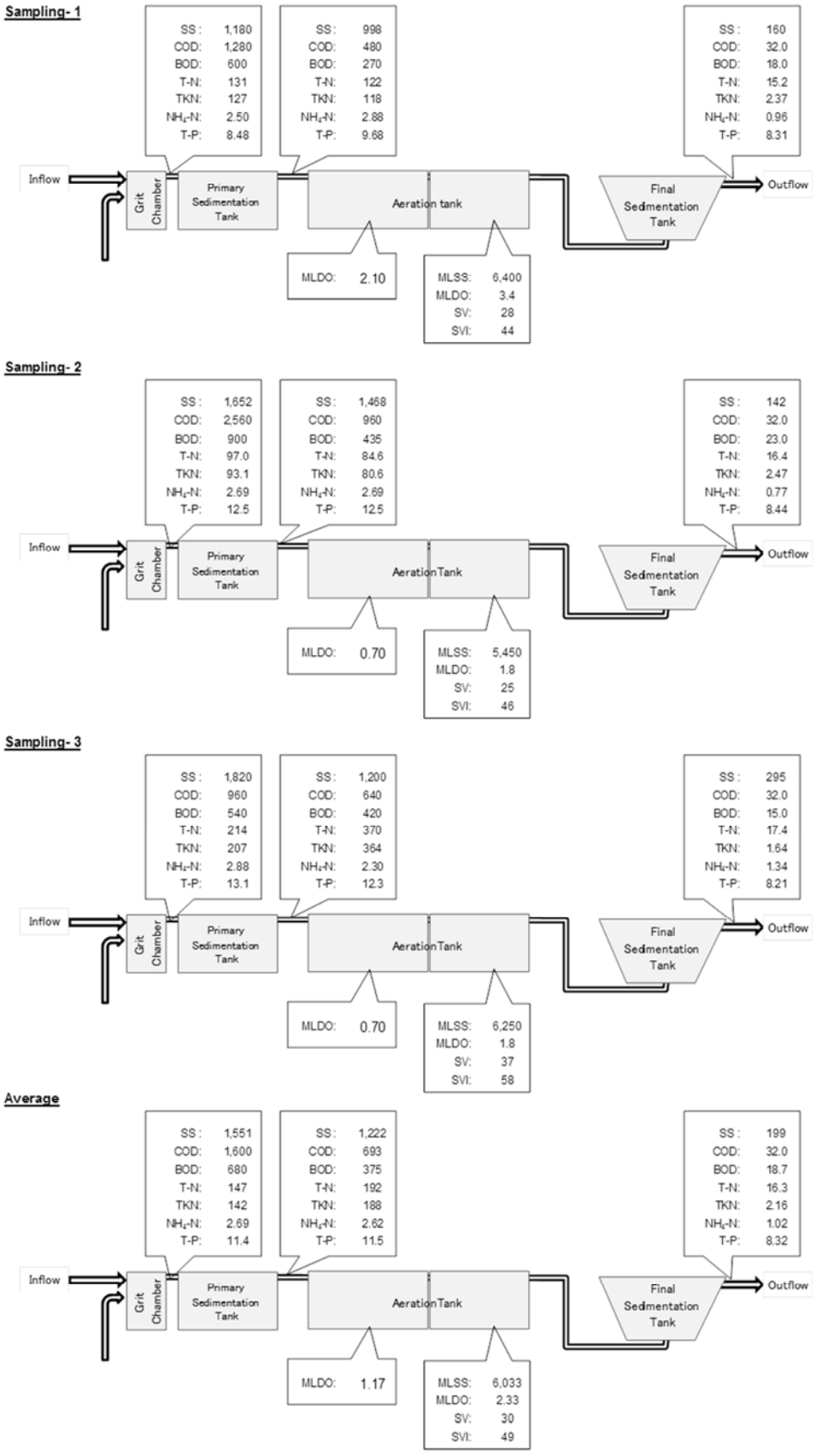


Figure A.21 Water Quality in WWTP Treatment Process (Rainy Season)

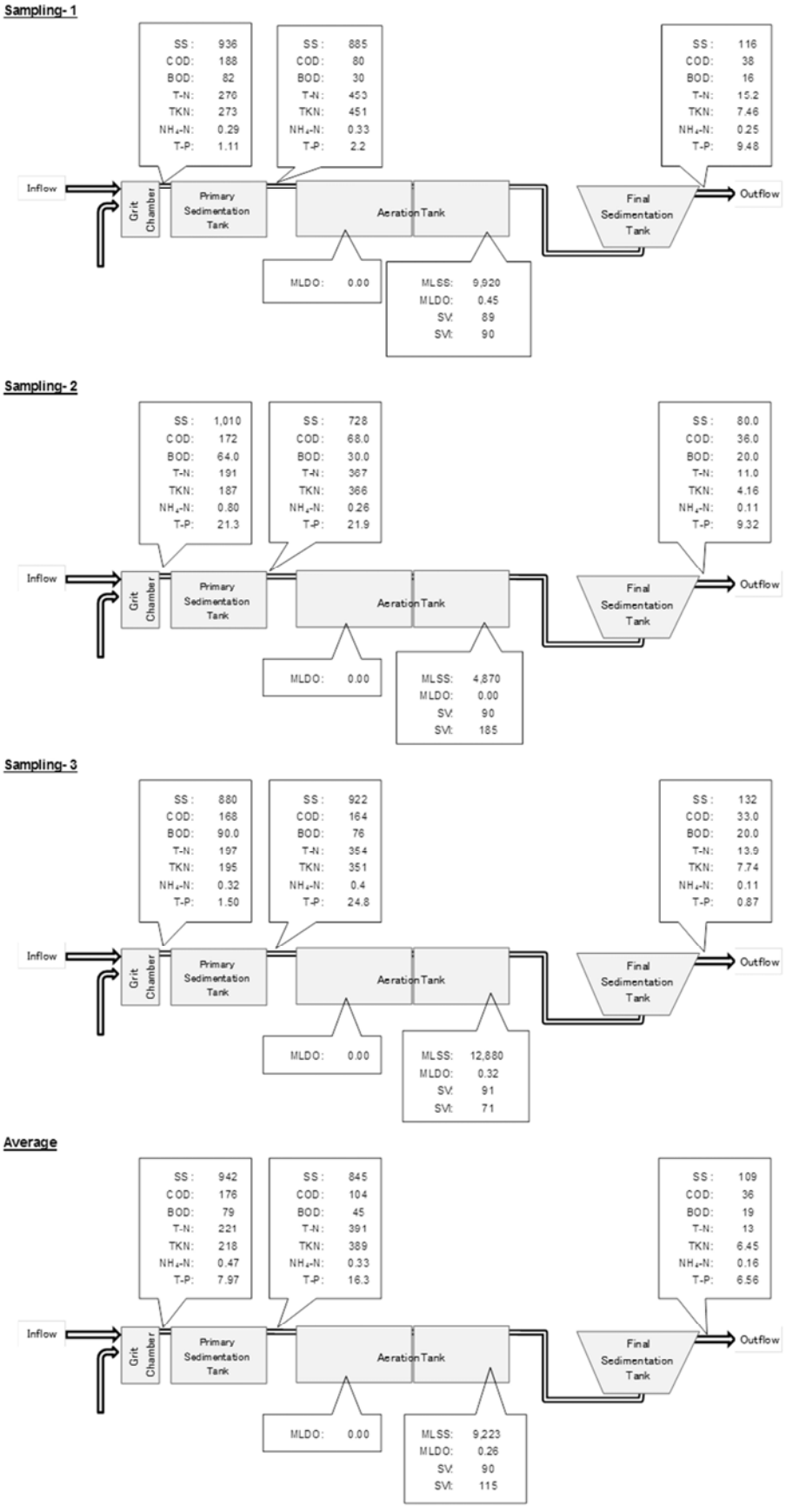


Figure A.22 Water Quality in WWTP Treatment Process (Dry Season)

Water quality changes in WWTP treatment process is shown below;

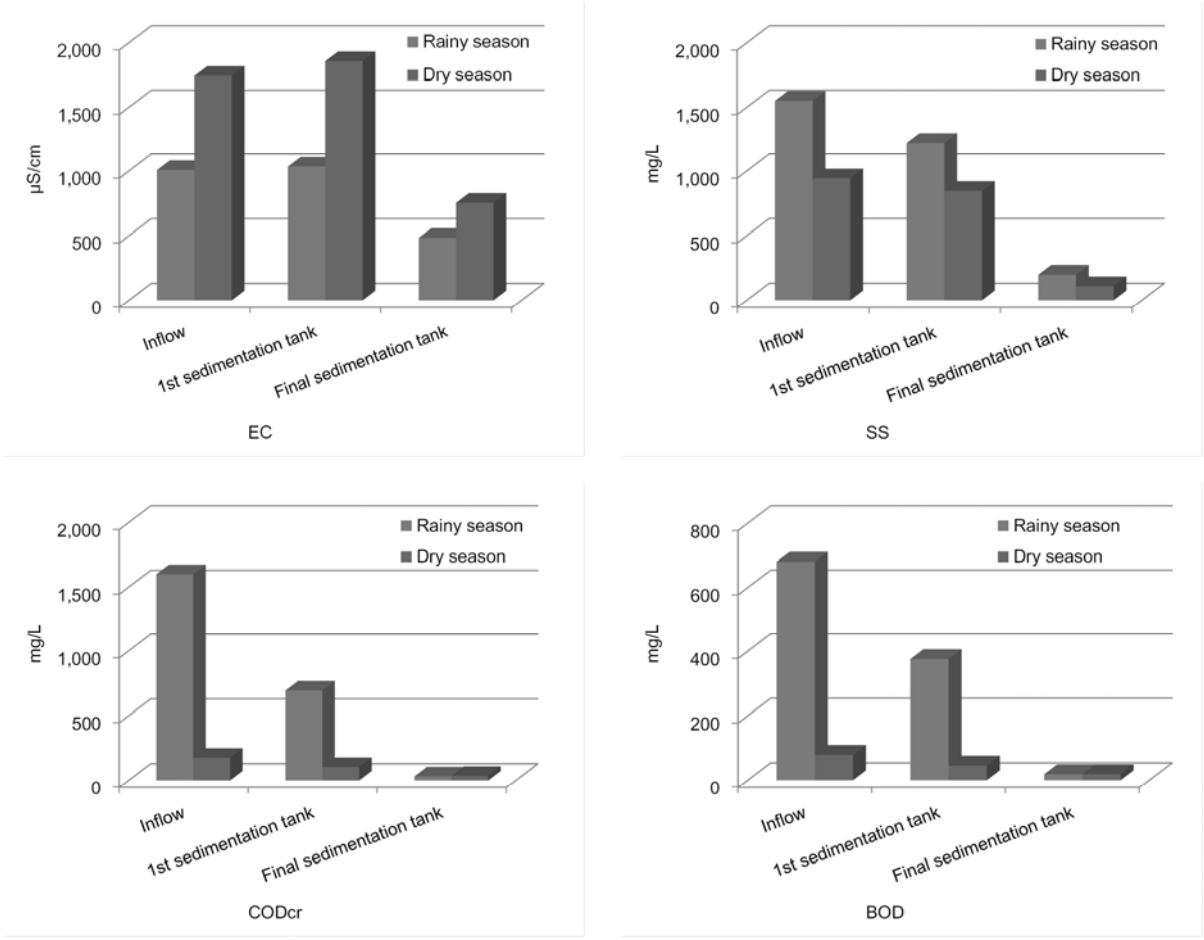


Figure A.23 Change of Water Quality in Treatment Process (EC, SS, CODcr, BOD)

BOD, CODcr and SS are removed in 1st sedimentation tank, and many of them are removed through aerobic tank and final sedimentation tank.

EC is reduced after aeration process and in final sedimentation tank.

BOD and CODcr in dry season is very low, however, trend of removal is same as in rainy season.

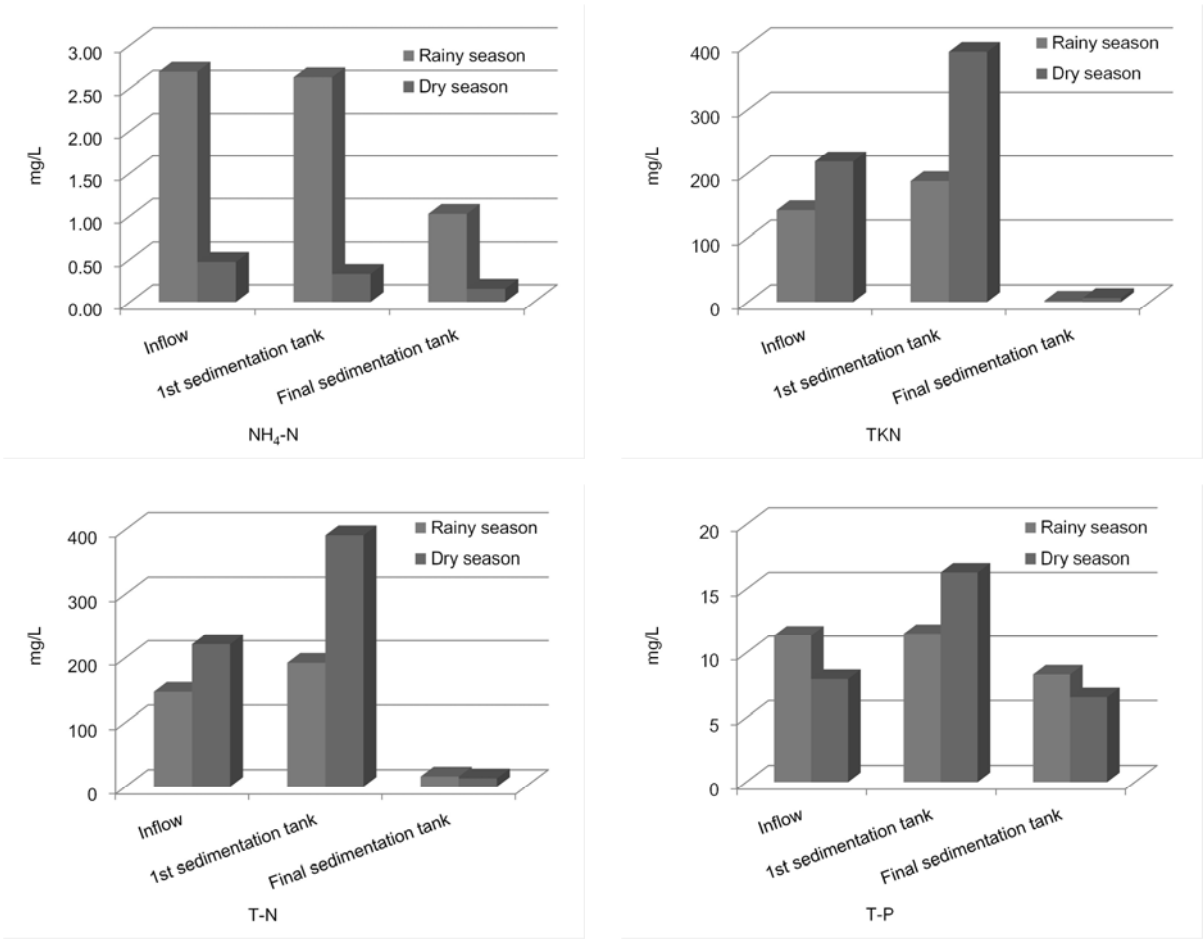


Figure A.24 Change of Water Quality in Treatment Process (HN_4-N, TKN, T-N, T-P)

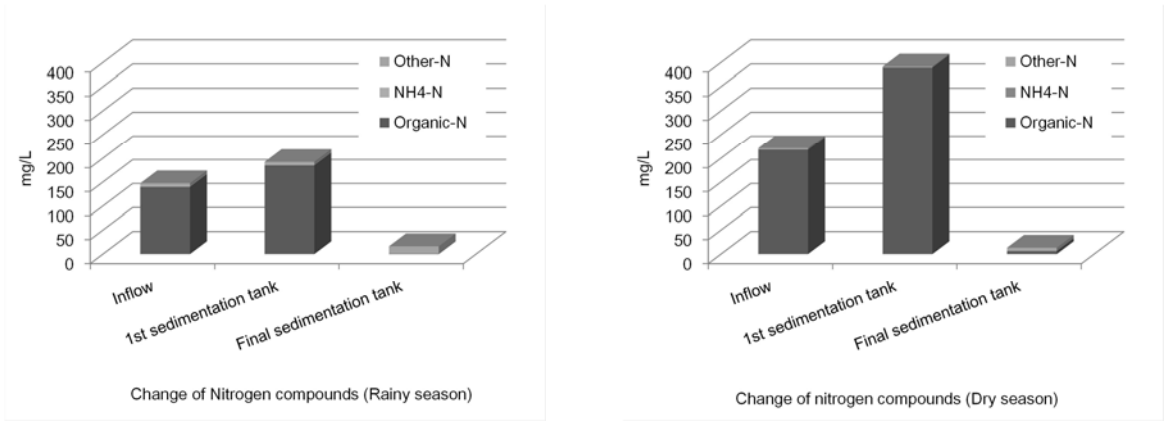


Figure A.25 Change of Nitrogen Compounds in Treatment Process

Change of HN4-N, TKN, T-N, T-P and nitrogen compounds in treatment process are shown above.

Major component of nitrogen compound in inflow water is organic-N. Many of these nitrogen compounds are removed through aerobic tank and final sedimentation tank.

T-P is removed through aerobic tank and final sedimentation tank. However, degree of T-P removal is smaller than nitrogen compounds.

Operating condition of WWTP

Operation condition of WWTP is as follows;

- Operating time of WWTP: 8 hours / day
- Operating time of aeration: Intermittent 2 hours (i.e. total aeration time is 4 hours / day)
- Capacity of WWTP: 14,775^{m3}/day
- Wastewater inflow: 2,300m^3/day

In spite of 4 hours / day of aeration time, rejection ratio of pollutants is high. Pollution removal ratio is shown in figure below.

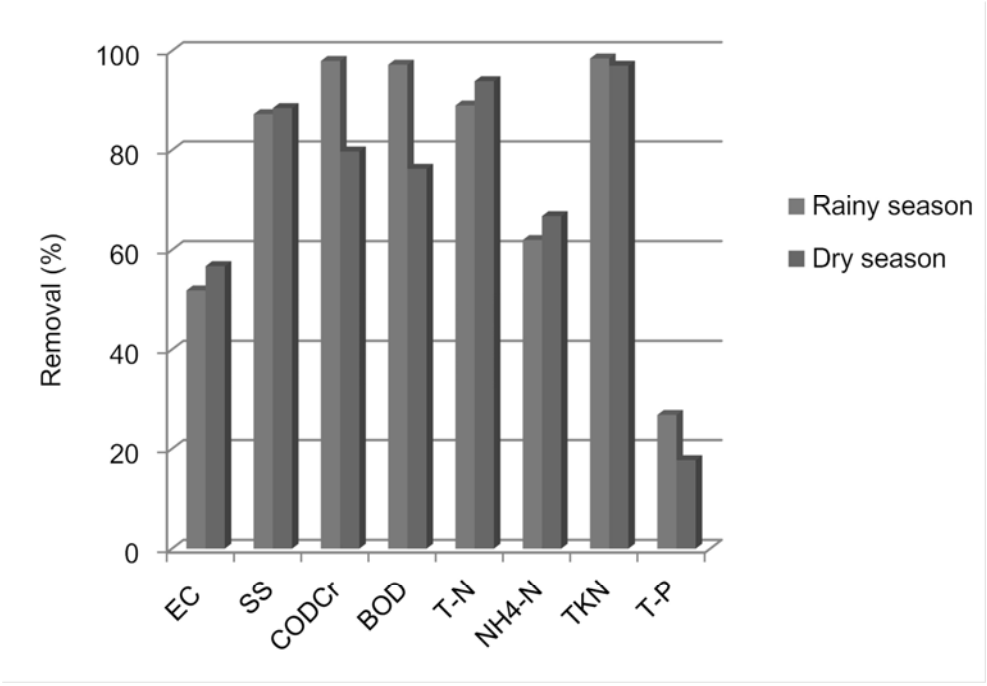


Figure A.26 Removal Ratio of Each Water Quality Items

Removal ratio of CODcr and BOD reduces in dry season. However, removal ratio of these items surpasses 70%.

T-N and TKN is removed more than 80%, and removal ratio of NH_4-N is around 60%. However, removal ratio of T-P remains around 20%.

In spite of insufficient condition of aerator operation, removal ratios of each water quality items are relatively high.

Possible explanations are as follows;

- The small volume of wastewater inflow below WWTP capacity causes longer retention time.
- Removal of BOD, COD and SS is accelerated by precipitation because of this longer retention time.
- Removal of T-N and T-P is accelerated by the intermittent aeration, because this operating condition has possibilities to bring anaerobic – anoxic – aerobic condition in aeration tank.

The table below shows condition of activated sludge.

Table A.21 Condition of Activated Sludge

Item	Rainy season	Dry season
MLSS (mg/L)	6,033	9,223
MLDO (mg/L)	2.33	0.26
SV_{30}	30	90
SVI	49	115

MLDO of dry season is very low (around 0.2mg/L) and aeration tank is nearly in anoxic condition. This anoxic condition is not intentionally created. Probably, this anoxic condition is created by long time discontinuation of aerator operation due to electricity supply failure.
MLSS is very high. Generally, MLSS of aeration tank is around 2,000 mg/L. According to the hearing survey, sludge withdraw pump of this WWTP is not working.
SV_{30} shows that sedimentation property of activated sludge becomes worse in dry season.

From these observations, it is assessed that this WWTP has a problem about activated sludge management.

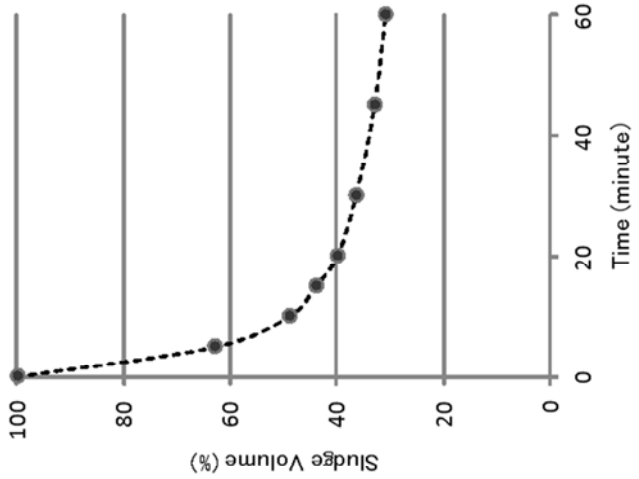
To improve the condition of WWTP, following reform measures are necessary.

- Refurbishment of sludge withdraw pump
- Installation of power generator to maintain continuous aeration
- Enhancement of laboratory in WWTP

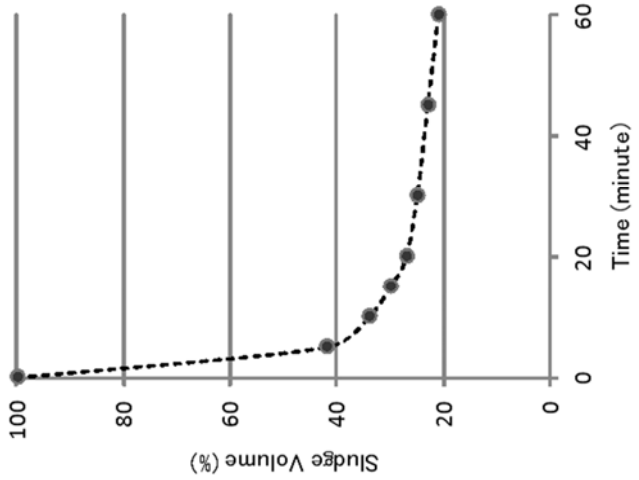
  At least, MLSS, MLDO, SV30 and effluent quality (BOD, SS and CODcr) have to be monitored.
- Improvement of skills of water quality analyst

  At least, water quality analyst has to obtain necessary water quality data using adequate analysis method.
- Improvement of skills of WWTP operator

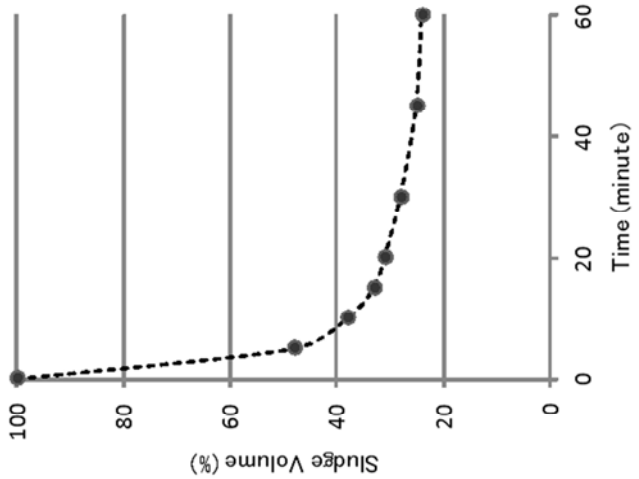
  At least, WWTP operator has to understand water quality change, and reflect them in WWTP operation.



Time (min.)	SV (%)
0	100
5	63
10	49
15	44
20	40
30	36.5
45	33
60	31

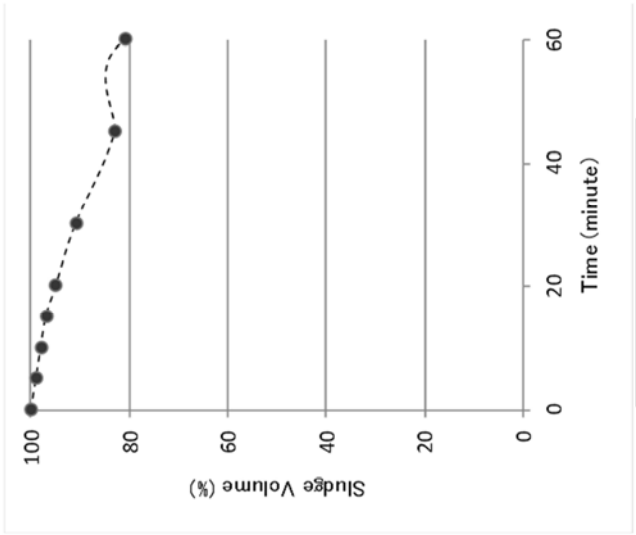


Time (min.)	SV (%)
0	100
5	42
10	34
15	30
20	27
30	25
45	23
60	21

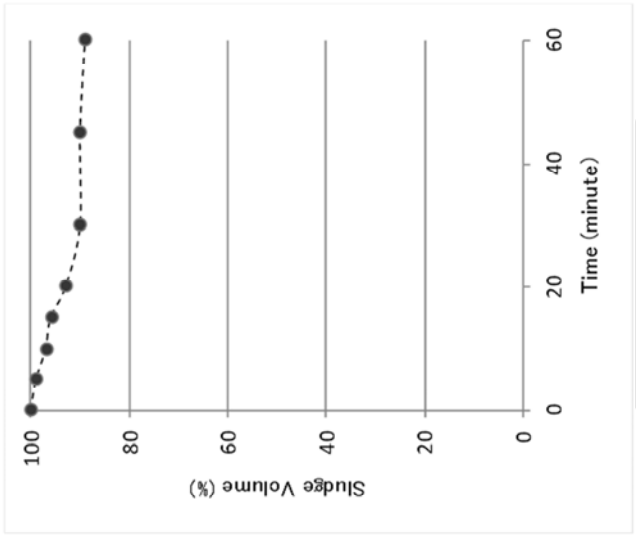


Time (min.)	SV (%)
0	100
5	48
10	38
15	33
20	31
30	28
45	25
60	24

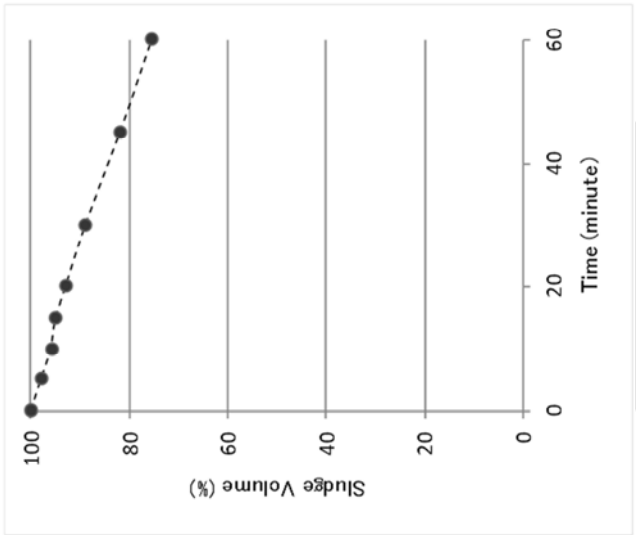
Figure A.27 Sludge Settling Property (Rainy season)



Time (min.)	SV (%)
0	100
5	99
10	98
15	97
20	95
30	91
45	83
60	81



Time (min.)	SV (%)
0	100
5	99
10	97
15	96
20	93
30	90
45	90
60	89



Time (min.)	SV (%)
0	100
5	98
10	96
15	95
20	93
30	89
45	82
60	75.5

Figure A.28 Sludge Settling Property (Rainy season)

B. COST ESTIMATION OF SEWERAGE WORKS

The project cost, implementation plan and the detailed operation and maintenance cost regarding sewerage works are shown in the following pages.

Table B.1 Implementation Plan of Sewerage works

Sewerage Zone	Components		Year																													
			2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
C1	F/S			■																												
	Preparation of Fund				■	■																										
	WWTP	DD					■																									
		Construction						■	■																							
	Sewer Network	DD					■																									
		Construction						■	■																							
W1	F/S					■																										
	Preparation of Fund						■	■																								
	WWTP	DD							■																							
		Construction								■	■																					
	Sewer Network	DD					■	■	■	■																						
		Construction						■	■	■	■																					
C2+E1	F/S										■																					
	Preparation of Fund											■	■																			
	WWTP	DD												■					■					■					■			
		Construction													■	■				■	■				■	■				■	■	
	Sewer Network	DD												■	■	■	■	■	■	■	■	■	■	■	■	■	■					
		Construction													■	■	■	■	■	■	■	■	■	■	■	■	■	■					
W2	F/S									■																						
	Preparation of Fund										■	■																				
	WWTP	DD												■																		
		Construction													■	■																	
	Sewer Network	DD									■	■	■	■	■																	
		Construction										■	■	■	■	■																	
N1	F/S																	■														
	Preparation of Fund																		■	■												
	WWTP	DD																						■								
		Construction																							■	■						
	Sewer Network	DD																	■	■	■	■	■	■	■							
		Construction																		■	■	■	■	■	■	■							
E3	F/S																															
	Preparation of Fund																				■	■										
	WWTP	DD																						■					■			
		Construction																							■	■					■	■
	Sewer Network	DD																			■	■	■	■	■	■	■	■	■	■		
		Construction																				■	■	■	■	■	■	■	■	■	■	■

■ Implementation period

Table B.2 Project Cost of Sewerage Works (Case That Separate System is Adopted in All Sewerage Zones)

Non-disclosure Information

Table B.3 Unit Cost of Waste Water Treatment Plant (Case That Separate System is Adopted in All Sewerage Zones)

Non-disclosure Information

Table B.4 Project Cost of Sewerage Works (Cost for Each Sewerage Zone (Case That Separate System is Adopted in C1, W1 and a Part of C2, and Interceptor System with Primary Treatment is Adopted in the Others)

Non-disclosure Information

Table B.5 Unit Cost of Waste Water Treatment Plant (Cost for Each Sewerage Zone (Case That Separate System is Adopted in C1, W1 and a Part of C2, and Interceptor System is Adopted in the Others)

Non-disclosure Information

Table B.6 Project Cost of Sewerage Works (Cost for Each Sewerage Zone (Case That Separate System is Adopted in C1, W1 and a Part of C2, and Interceptor System with Secondary Treatment is Adopted in the Others)

Non-disclosure Information

Table B.7 Calculation of No. of Apartments by Each Township

Township	Area (ha)	C1		C2		E1		W1		W2		N1		E3	
		% of served township in C1	area (ha)	% of served township in C2	area (ha)	% of served township in E1	area (ha)	% of served township in W1	area (ha)	% of served township in W2	area (ha)	% of served township in N2	area (ha)	% of served township in E3	area (ha)
Pabedan	62	100.0%	62												
Kyauktada	70	100.0%	70												
Botahtaung	260	100.0%	260												
Pazundaung	107	100.0%	107												
Bahan	847			83.2%	705			16.8%	142						
Tarmwe	499			100.0%	499										
Mingalar Taung Nyunt	494			100.0%	494										
Yankin	479			100.0%	479										
Thingangyun	1,312			100.0%	1312										
Mayangone	2,588			69.2%	1791					30.8%	797				
South Okkalapa	822			100.0%	822										
Latha	60							100.0%	60						
Lanmadaw	131							100.0%	131						
Ahlone	338							100.0%	338						
Kyee Myin Daing	457							39.8%	182						
Sanchaung	240							100.0%	240						
Dagon	489							100.0%	489						
Kamaryut	647							11.1%	72	88.9%	575				
Hlaing	984									100.0%	984				
Insein	3,163											100.0%	3163		
North Okkalapa	2,766					100.0%	2766								
North Dagon	2,418					100.0%	2418								
Dawbon	311													100.0%	311
Thaketa	1,356													100.0%	1356
South Dagon	3,751													100.0%	3751
Total (ha)	24,651	Total area of C1	499	Total area of C2	6102	Total area of E2	5184	Total area of W1	1654	Total area of W2	2356	Total area of N1	3163	Total area of E3	5418
				Total area of C2 and E1	11286										
Design pop.			178,000		1,902,000				483,000		350,000		377,000		921,000
No. of households (all)			28,254		163,231		138,674		76,667		55,556		59,841		146,190
Total No. of household in each township		3 Pabedan	3511	11 Bahan	18859	23 North Okkalapa	73992	11 Bahan	6582	20 Mayangone	18794	21 Insein	59,841	15 Dawbon	8391
		4 Kyauktada	3963	12 Tarmwe	13348	30 North Dagon	64682	1 Latha	2781	16 Kamaryut	13559			25 Thaketa	36588
		5 Botahtaung	14722	13 Mingalar Taung Nyunt	13215			2 Lanmadaw	6072	17 Hlaing	23203			31 South Dagon	101211
		6 Pazundaung	6058	18 Yankin	12813			7 Ahlone	15667						
				19 Thingangyun	35097			8 Kyee Myin Daing	8436						
				20 Mayangone	47910			9 Sanchaung	11125						
				24 South Okkalapa	21989			10 Dagon	22666						
								16 Kamaryut	3338						
		Total	28,254	Total	163,231	Total	138,674	Total	76,667	Total	55,556	Total	59,841	Total	146,190
% of apartment in each township		3 Pabedan	95.5%	11 Bahan	44.2%	23 North Okkalapa	1.2%	11 Bahan	44.2%	20 Mayangone	13.9%	21 Insein	1.7%	15 Dawbon	3.7%
Source: result of socio-economic survey		4 Kyauktada	94.6%	12 Tarmwe	76.6%	30 North Dagon	7.8%	1 Latha	88.1%	16 Kamaryut	59.9%			25 Thaketa	3.9%
		5 Botahtaung	72.8%	13 Mingalar Taung Nyunt	73.8%			2 Lanmadaw	74.0%	17 Hlaing	33.0%			31 South Dagon	0.7%
		6 Pazundaung	79.4%	18 Yankin	39.6%			7 Ahlone	83.5%						
				19 Thingangyun	13.6%			8 Kyee Myin Daing	27.7%						
				20 Mayangone	13.9%			9 Sanchaung	67.6%						
				24 South Okkalapa	0.0%			10 Dagon	48.7%						
								16 Kamaryut	59.9%						
No. of households in apartment		3 Pabedan	3,351	11 Bahan	8,330	23 North Okkalapa	905	11 Bahan	2,907	20 Mayangone	2,621	21 Insein	1,012	15 Dawbon	308
		4 Kyauktada	3,749	12 Tarmwe	10,223	30 North Dagon	5,070	1 Latha	2,449	16 Kamaryut	8,116			25 Thaketa	1,443
		5 Botahtaung	10,720	13 Mingalar Taung Nyunt	9,757			2 Lanmadaw	4,491	17 Hlaing	7,645			31 South Dagon	682
		6 Pazundaung	4,812	18 Yankin	5,070			7 Ahlone	13,085						
				19 Thingangyun	4,772			8 Kyee Myin Daing	2,339						
				20 Mayangone	6,682			9 Sanchaung	7,521						
				24 South Okkalapa	0			10 Dagon	11,042						
								16 Kamaryut	1,998						
		Sub total	22,632	Sub total	44,834	Sub total	5,975	Sub total	45,832	Sub total	18,382	Sub total	1,012	Sub total	2,433
No. of HC for apartment 30 households/apartment	30		754		1494		199		1528		613		34		81
No. of HC for detached house			5,622		118,397		132,699		30,835		37,174		58,829		143,757
Total no of HC			6,376		119,891		132,898		32,363		37,787		58,863		143,838
				C1+E1	252,789										
				C1(50%)	59,946										

Table B.8 Operation and Maintenance Cost for Each Sewerage Zone (Case That Separate System is Adopted in all Sewerage Zones)

(Unit: Mil. JPY/year)

Items	C1	C2&E1	W1	W2	E3	N1	Total
Salary	3.5	7.1	5.9	5.9	5.9	4.6	32.9
Electricity	24.4	260.5	64.3	44.5	92.6	49.2	535.5
Maintenance(Spare parts)	20.5	202.5	52.7	43.4	68.6	43.4	431.1
Sludge cake	7.5	80.5	19.9	13.7	28.6	15.2	165.4
Chemical	28.4	302.4	74.6	51.6	107.6	57.2	621.8
Sewer	4.3	24.0	7.5	10.6	21.0	12.9	80.3
Other cost	1.7	17.1	4.3	3.2	6.1	3.4	35.8
Total	90.3	894	229	173	330	186	1,902.8

*: The total OM cost of C1 with the capacity of 70,200m^3/d

Table B.9 Operation and Maintenance (Cost for Each Sewerage Zone (Case That Separate System is Adopted in C1, W1 and a Part of C2, and Interceptor System with Primary Treatment is Adopted in the Others)

(Unit: Mil. JPY/year)

Items	C1	C2&E1	W1	W2	E3	N1	Total
Salary	3.5	6.6	5.9	5.4	5.4	4.2	31.0
Electricity	24.4	161.6	64.3	19.3	40.1	21.3	331.0
Maintenance(Spare parts)	20.5	83.7	52.7	19.2	28.8	19.2	224.1
Sludge cake	7.5	56.2	19.9	7.6	15.7	8.4	115.3
Chemical	28.4	230.1	74.6	18.2	38.0	20.2	409.5
Sewer	4.3	7.4	7.5	0.0	0.0	0.0	19.2
Other cost	1.7	10.8	4.3	1.4	2.6	1.5	22.3
Total	90.3	556	229	71	131	75	1,152.4

Table B.10 Operation and Maintenance (Cost for Each Sewerage Zone (Case That Separate System is Adopted in C1, W1 and a Part of C2, and Interceptor System with Secondary Treatment is Adopted in the Others)

Items	C1	C2&E1	W1	W2	E3	N1	Total
Salary	3.5	6.6	5.9	5.4	5.4	4.2	31.0
Electricity	24.4	260.5	64.3	44.5	92.6	49.2	535.5
Maintenance(Spare parts)	20.5	202.5	52.7	43.4	68.6	43.4	431.1
Sludge cake	7.5	80.5	19.9	13.7	28.6	15.2	165.4
Chemical	28.4	302.4	74.6	51.6	107.6	57.2	621.8
Sewer	4.3	7.4	7.5	0.0	0.0	0.0	19.2
Other cost	1.7	17.1	4.3	3.2	6.1	3.4	35.8
Total	90.3	877	229	162	309	173	1,839.8

C. FINANCIAL SIMULATION

Table C.1 Sewerage Financial Simulation 1
Separate/Secondary Treatment (Capital Subsidy 80% Annual Tariff Increase 3.9%)

Non-disclosure Information

Table C.2 Sewerage Financial Simulation 2
Interceptor/Secondary Treatment (Capital Subsidy 80% Annual Tariff Increase 2.7%)

Non-disclosure Information

Table C.3 Sewerage Financial Simulation 3
Interceptor/Primary Treatment (Capital Subsidy 80% Annual Tariff Increase 1.7%)

Non-disclosure Information

Table C.4 Sewerage Financial Simulation 4
Separate/Secondary Treatment (Capital Subsidy 60% Annual Tariff Increase 5.0%)

Non-disclosure Information

Table C.5 Sewerage Financial Simulation 5
Interceptor/Secondary Treatment (Capital Subsidy 60% Annual Tariff Increase 3.9%)

Non-disclosure Information

Table C.6 Sewerage Financial Simulation 6
Interceptor/Primary Treatment (Capital Subsidy 60% Annual Tariff Increase 3.0%)

Non-disclosure Information

Table C.7 Sewerage Financial Simulation 7
Separate/Secondary Treatment (Capital Subsidy 40% Annual Tariff Increase 5.9%)

Non-disclosure Information

Table C.8 Sewerage Financial Simulation 8
Interceptor/Secondary Treatment (Capital Subsidy 40% Annual Tariff Increase 4.9%)

Non-disclosure Information

Table C.9 Sewerage Financial Simulation 9
Interceptor/Primary Treatment (Capital Subsidy 40% Annual Tariff Increase 4.0%)

Non-disclosure Information

Table C.10 Sewerage Financial Simulation 10
Separate/Secondary Treatment (Capital Subsidy 0% Annual Tariff Increase 7.3%)

Non-disclosure Information

Table C.11 Sewerage Financial Simulation 11
Interceptor/Secondary Treatment (Capital Subsidy 0% Annual Tariff Increase 6.3%)

Non-disclosure Information

Table C.12 Sewerage Financial Simulation 12
Interceptor/Primary Treatment (Capital Subsidy 0% Annual Tariff Increase 5.4%)

Non-disclosure Information

D. DRAINAGE FACILITIES PLAN

Table D.1 Evaluation of Flow Capacity for Existing Major Drainage Channels

	Design Flow (5 year Return Period) (m3/s)	Slope (‰)	Target channel for Evaluation	Capacity Check				Evaluation	Remarks
				Section at Bridge		Section at Channel			
				Capacity (m3/s)	Check	Capacity (m3/s)	Check		
Line-1_B	35.433	3.700	No1-4	57.858	OK	56.506	OK	OK	
Line-2_B	47.298	2.540	No2-2	12.136	NG	15.933	NG	NG	
Line-2_C	51.643	2.290	No2-3	6.213	NG	3.813	NG	NG	
Line-3_B	16.377	3.970	No3-1	2.417	NG	2.332	NG	NG	
Line-3_C	22.924	2.540	No3-2	32.559	OK	-	-	Confirmation of height at either bank is necessary	Height of either bank is low
Line-4_D	45.641	0.110	No4-3	17.897	NG	17.897	NG	NG	Sueveyed at only Channel section
Line-5_B	92.000	2.330	No5-3	47.492	NG	-	-	NG	Height of right side bank is low
Line-5_C	91.840	1.380	No5-5	29.189	NG	17.421	NG	NG	
Line-8_B	40.456	3.180	No8-4	84.404	OK	46.328	OK	OK	
Line-9_B	34.023	3.260	No9-4	14.120	NG	26.280	NG	NG	
Line-10_B	43.459	4.070	No10-5	41.264	NG	51.325	OK	Modification of the bridge is	
Line-11_B	89.348	2.180	No11-4	21.926	NG	-	-	NG	Sueveyed at only Section at bridge
Line-11_A	89.348	3.230	No11-4	72.518	NG	-	-	NG	Height of left side bank is low
Line-12_B	17.985	-0.030	No12-3	#NUM!	OK?	#NUM!	OK?	OK?	
Line-12_C	21.457	2.430	No12-4	37.669	OK	20.121	NG	NG	
Line-15_B	53.835	1.590	No15-4	6.291	NG	3.989	NG	NG	
Line-15_C	53.835	2.060	No15-4	29.176	NG	-	-	NG	Height of right side bank is low
Line-15_D	61.887	1.220	No15-5	47.932	NG	41.870	NG	NG	
Line-16_B	31.037	0.370	No16-1	1.749	NG	2.009	NG	NG	
Line-16_C	67.790	0.580	No16-3	23.755	NG	-	-	NG	Height of right side bank is low
Line-16_D	74.681	0.930	No16-4	22.212	NG	30.584	NG	NG	
Line-18_B	115.412	3.960	No18-3	83.424	NG	44.279	NG	NG	
Line-18_C	115.412	2.010	No18-3	291.745	OK	488.918	OK	OK	
Line-19_D	25.782	3.710	No19-4	105.657	OK	53.370	OK	OK	
Line-20_B	35.013	0.500	No20-2	19.015	NG	5.059	NG	NG	
Line-21_C	55.810	1.130	No21-6	27.914	NG	-	-	NG	Height of right side bank is low
Line-22_B	36.869	-0.750	No22-3	#NUM!	OK?	-	-	Confirmation of height at right side bank is necessary	Height of right side bank is low

Note: Capacity check is based on the cross section survey.

Table D.2 Flow Calculation Sheets for Improvement of Major Drainage Channels (1/3)

	L	Total A	ti	t2	T	I	C	ratio over total catchment	A	Discharge	Dimension	Slope	Velocity	Flow Capacity
	(m)	(ha)	(min) inlet	(min) traveling	(min) total	(mm/h)			(ha)	(m3/s)		(-)	(m/s)	(m3/s)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)				
No1-1	600	318.5	20	5.0	25.0	117.1	0.5	0.3	95.6	15.5	4.50 x 2.25	0.00050	1.795	16.354
No1-2	640	318.5		5.3	30.3	102.4	0.5	0.5	159.3	22.6	5.50 x 2.75	0.00040	1.835	24.979
No1-3	770	318.5		6.4	36.7	89.5	0.5	0.7	223.0	27.7	6.00 x 3.00	0.00037	1.870	30.298
No1-4	760	318.5		6.3	43.0	80.1	0.5	1.0	318.5	35.4	6.50 x 3.25	0.00034	1.891	35.954
Total	2,770													
No2-1	800	517.0	25	6.7	31.7	99.2	0.5	0.5	258.5	35.6	6.50 x 3.25	0.00034	1.891	35.954
No2-2	300	517.0		2.5	34.2	94.1	0.5	0.7	361.9	47.3	7.50 x 3.75	0.00030	1.954	49.465
No2-3	280	517.0		2.3	36.5	89.9	0.5	0.8	413.6	51.6	8.00 x 4.00	0.00028	1.971	56.762
No2-4	1,230	517.0		10.3	46.8	75.5	0.5	1.0	517.0	54.2	8.00 x 4.00	0.00028	1.971	56.762
Total	2,610													
No3-1	560	213.0	15	4.7	19.7	138.4	0.5	0.4	85.2	16.4	4.50 x 2.25	0.00055	1.882	17.152
No3-2	890	213.0		7.4	27.1	110.7	0.5	0.7	149.1	22.9	5.50 x 2.75	0.00050	2.052	27.927
No3-3	1,010	213.0		8.4	35.5	91.6	0.5	1.0	213.0	27.1	5.50 x 2.75	0.00050	2.052	27.927
Total	2,460													
No4-1	260	404.7	25	2.2	27.2	110.4	0.5	0.5	202.4	31.0	6.00 x 3.00	0.00040	1.945	31.502
No4-2	800	404.7		6.7	33.9	94.7	0.5	0.7	283.3	37.3	6.50 x 3.25	0.00040	2.051	38.998
No4-3	990	404.7		8.3	42.2	81.2	0.5	1.0	404.7	45.6	7.00 x 3.50	0.00040	2.155	47.519
Total	2,050													
No6-1	290	1151.6	30	2.4	32.4	97.7	0.5	0.4	460.6	62.5	8.50 x 4.25	0.00025	1.939	63.047
No6-2	420	1151.6		3.5	35.9	90.9	0.5	0.5	575.8	72.7	9.00 x 4.50	0.00025	2.014	73.427
No6-3	540	1151.6		4.5	40.4	83.7	0.5	0.6	691.0	80.3	9.50 x 4.75	0.00025	2.088	84.815
Total	1,250													
No5-1	470	1151.6	20	3.9	23.9	120.9	0.5	0.1	115.2	19.3	5.00 x 2.50	0.00040	1.722	19.373
No5-2	930	1151.6		7.8	31.7	99.2	0.5	0.2	172.7	23.8	5.50 x 2.75	0.00040	1.835	24.979
No5-3	1,170	1151.6		9.8	50.2	71.9	0.5	0.8	921.3	92.0	9.50 x 4.75	0.00030	2.288	92.911
No5-4	780	1151.6		6.5	56.7	66.0	0.5	0.9	978.9	89.7	9.50 x 4.75	0.00030	2.288	92.911
No5-5	340	1151.6		2.8	59.5	63.8	0.5	0.9	1,036.4	91.8	9.50 x 4.75	0.00030	2.288	92.911
No.5-6	720	1151.6		6.0	65.5	59.7	0.5	1.0	1,151.6	95.5	10.00 x 5.00	0.00030	2.367	106.529
Total	4,410													
No7-1	180	317.9	20	1.5	21.5	130.2	0.5	0.4	127.2	23.0	5.50 x 2.75	0.00035	1.716	23.366
No 7-2	160	317.9		1.3	22.8	124.9	0.5	0.5	159.0	27.6	6.00 x 3.00	0.00035	1.819	29.468
No7-3	620	317.9		5.2	28.0	108.2	0.5	0.8	254.3	38.2	7.00 x 3.50	0.00030	1.866	41.153
No7-4	530	317.9		4.4	32.4	97.7	0.5	1.0	317.9	43.1	7.50 x 3.75	0.00030	1.954	49.465
Total	1,490													
No8-1	860	343.9	20	7.2	27.2	110.4	0.5	0.3	103.2	15.8	4.50 x 2.25	0.00050	1.795	16.354
No8-2	320	343.9		2.7	29.9	103.3	0.5	0.5	172.0	24.7	5.50 x 2.75	0.00040	1.835	24.979
No8-3	360	343.9		3.0	32.9	96.7	0.5	0.7	240.7	32.3	6.50 x 3.25	0.00034	1.891	35.954
No8-4	820	343.9		6.8	39.7	84.7	0.5	1.0	343.9	40.5	7.00 x 3.50	0.00032	1.928	42.502
Total	2,360													
No9-1	520	316.9	30	4.3	34.3	93.9	0.5	0.65	206.0	26.9	5.50 x 2.75	0.00050	2.052	27.927
No9-2	370	316.9		3.1	37.4	88.4	0.5	0.7	221.8	27.2	5.50 x 2.75	0.00050	2.052	27.927
No9-3	490	316.9		4.1	41.5	82.2	0.5	0.8	253.5	28.9	6.00 x 3.00	0.00050	2.174	35.221
No9-4	460	316.9		3.8	45.3	77.3	0.5	1.0	316.9	34.0	6.00 x 3.00	0.00050	2.174	35.221
Total	1,840													

Table D.3 Flow Calculation Sheets for Improvement of Major Drainage Channels (2/3)

	L	Total A	ti	t2	T	I	C	ratio over total catchment	A	Discharge	Dimension	Slope	Velocity	Flow Capacity
	(m)	(ha)	(min) inlet	(min) traveling	(min) total	(mm/h)			(ha)	(m3/s)		(-)	(m/s)	(m3/s)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)				
No10-1	300	273.9	20	2.5	22.5	126.1	0.6	0.2	54.8	11.5	4.00 x 2.00	0.00050	1.659	11.946
No10-2	300	273.9		2.5	25.0	117.1	0.6	0.4	109.6	21.4	5.00 x 2.50	0.00050	1.925	21.659
No10-3	290	273.9		2.4	27.4	109.9	0.6	0.5	137.0	25.1	5.50 x 2.75	0.00045	1.946	26.494
No10-4	240	273.9		2.0	29.4	104.6	0.6	0.6	164.3	28.6	6.00 x 3.00	0.00045	2.063	33.413
No10-5	500	273.9		4.2	33.6	95.2	0.6	1.0	273.9	43.5	7.00 x 3.50	0.00040	2.155	47.519
Total	1,630													
No11-1	580	779.2	25	4.8	29.8	103.6	0.6	0.5	389.6	67.3	8.50 x 4.25	0.00030	2.124	69.064
No11-2	910	779.2		7.6	37.4	88.4	0.6	0.7	545.4	80.4	9.00 x 4.50	0.00030	2.207	80.436
No11-3	700	779.2		5.8	43.2	79.9	0.6	0.8	623.4	83.0	9.50 x 4.75	0.00030	2.288	92.911
No11-4	1,230	779.2		10.3	53.5	68.8	0.6	1.0	779.2	89.3	9.50 x 4.75	0.00030	2.288	92.911
	3,420													
No12-1	360	128.1	20	3.0	23.0	124.2	0.6	0.4	51.2	10.6	3.50 x 1.75	0.00085	1.979	10.909
No12-2	400	128.1		3.3	26.3	113.1	0.6	0.6	76.9	14.5	4.00 x 2.00	0.00075	2.032	14.631
No12-3	330	128.1		2.8	29.1	105.3	0.6	0.8	102.5	18.0	4.50 x 2.25	0.00065	2.046	18.647
No12-4	240	128.1		2.0	31.1	100.5	0.6	1.0	128.1	21.5	5.00 x 2.50	0.00060	2.109	23.727
Total	1,330													
No14-1	510	466.1	30	4.3	34.3	93.9	0.6	0.4	186.4	29.2	5.50 x 2.75	0.00055	2.152	29.290
No14-2	510	466.1		4.3	38.6	86.4	0.6	0.5	233.1	33.6	6.00 x 3.00	0.00050	2.174	35.221
No14-3	320	466.1		2.7	41.3	82.4	0.6	0.6	279.7	38.4	6.50 x 3.25	0.00045	2.176	41.363
	1,340													
No13-1	360	466.1	20	3.0	23.0	124.2	0.6	0.2	93.2	19.3	5.00 x 2.50	0.00040	1.722	19.373
No13-2	560	466.1		4.7	27.7	109.0	0.6	0.3	116.5	21.2	5.50 x 2.75	0.00040	1.835	24.979
No13-3	480	466.1		4.0	31.7	99.2	0.6	0.3	139.8	23.1	5.50 x 2.75	0.00040	1.835	24.979
No13-4	400	466.1		3.3	44.6	78.1	0.6	1.0	466.1	60.7	8.00 x 4.00	0.00035	2.204	63.462
Total	1,800													
No15-1	470	698.1	30	3.9	33.9	94.7	0.6	0.4	279.2	44.1	7.00 x 3.50	0.00035	2.016	44.450
No15-2	640	698.1		5.3	39.2	85.5	0.6	0.5	349.1	49.7	8.00 x 4.00	0.00030	2.040	58.755
No15-3	730	698.1		6.1	45.3	77.3	0.6	0.6	418.9	54.0	8.00 x 4.00	0.00030	2.040	58.755
No15-4	1,350	698.1		11.3	56.6	66.1	0.6	0.7	488.7	53.8	8.00 x 4.00	0.00030	2.040	58.755
No15-5	1,180	698.1		9.8	66.4	59.1	0.6	0.9	628.3	61.9	8.50 x 4.25	0.00030	2.124	69.064
No15-6	370	698.1		3.1	69.5	57.3	0.6	1.0	698.1	66.7	8.50 x 4.25	0.00030	2.124	69.064
Total	4,740													
No16-1	630	801.3	20	5.3	25.3	116.2	0.6	0.2	160.3	31.0	6.00 x 3.00	0.00040	1.945	31.502
No16-2	690	801.3		5.8	31.1	100.5	0.6	0.4	320.5	53.7	8.00 x 4.00	0.00030	2.040	58.755
No16-3	1,040	801.3		8.7	39.8	84.6	0.6	0.6	480.8	67.8	8.50 x 4.25	0.00030	2.124	69.064
No16-4	1,500	801.3		12.5	52.3	69.9	0.6	0.8	641.0	74.7	9.00 x 4.50	0.00030	2.207	80.436
No16-5	510	801.3		4.3	56.6	66.1	0.6	1.0	801.3	88.3	9.50 x 4.75	0.00030	2.288	92.911
Total	4,370													

Table D.4 Flow Calculation Sheets for Improvement of Major Drainage Channels (3/3)

	L	Total A	ti	t2	T	I	C	ratio over total catchment	A	Discharge	Dimension	Slope	Velocity	Flow Capacity
	(m)	(ha)	(min) inlet	(min) traveling	(min) total	(mm/h)			(ha)	(m3/s)		(-)	(m/s)	(m3/s)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)				
No17-1	1,120	1433.1	30	9.3	39.3	85.3	0.6	0.3	429.9	61.1	8.00 x 4.00	0.00035	2.204	63.462
Total	1,120													
No18-1	900	1433.1	25	7.5	46.8	75.5	0.6	0.3	429.9	54.1	8.00 x 4.00	0.00028	1.971	56.762
No18-2	450	1433.1		3.8	50.6	71.5	0.6	0.4	573.2	68.3	9.00 x 4.50	0.00025	2.014	73.427
No18-3	1,660	1433.1		13.8	64.4	60.4	0.6	0.8	1,146.5	115.4	11.50 x 5.75	0.00020	2.122	126.265
No18-4	220	1433.1		1.8	66.2	59.2	0.6	1.0	1,433.1	141.4	12.00 x 6.00	0.00020	2.183	141.440
Total	3,230													
No19-1	360	230.2	20	3.0	23.0	124.2	0.4	0.3	69.1	9.5	3.50 x 1.75	0.00065	1.731	9.540
No19-2	410	230.2		3.4	26.4	112.8	0.4	0.4	92.1	11.5	4.00 x 2.00	0.00055	1.740	12.529
No19-3	400	230.2		3.3	29.7	103.8	0.4	0.8	184.2	21.2	5.00 x 2.50	0.00050	1.925	21.659
No19-4	150	230.2		1.3	31.0	100.8	0.4	1.0	230.2	25.8	5.50 x 2.75	0.00045	1.946	26.494
Total	1,320													
No20-1	540	620.8	30	4.5	34.5	93.5	0.4	0.2	124.2	12.9	4.00 x 2.00	0.00060	1.818	13.086
No20-2	640	620.8		5.3	39.8	84.6	0.4	0.6	372.5	35.0	6.50 x 3.25	0.00035	1.919	36.479
No20-3	810	620.8		6.8	46.6	75.8	0.4	1.0	620.8	52.3	7.50 x 3.75	0.00035	2.111	53.428
Total	1,990													
No21-1	1,040	759.9	30	8.7	38.7	86.3	0.4	0.3	228.0	21.9	5.00 x 2.50	0.00055	2.019	22.717
No21-2	670	759.9		5.6	44.3	78.5	0.4	0.4	266.0	23.2	5.50 x 2.75	0.00050	2.052	27.927
No21-3	960	759.9	30	8.0	38.0	87.4	0.4	0.2	152.0	14.8	4.50 x 2.25	0.00050	1.795	16.354
No21-4	330	759.9		2.8	40.8	83.1	0.4	0.3	228.0	21.0	5.00 x 2.50	0.00050	1.925	21.659
No21-5	1,180	759.9		9.8	54.1	68.2	0.4	0.8	607.9	46.1	7.00 x 3.50	0.00040	2.155	47.519
No21-6	300	759.9		2.5	56.6	66.1	0.4	1.0	759.9	55.8	7.50 x 3.75	0.00040	2.256	57.117
Total	4,480													
(No22-1	2,800	1525.6	50	23.3	73.3	55.2	0.4	0.4	610.2	37.4	6.50 x 3.25	0.00045	2.176	41.363
No22-2	1,710	1525.6		14.3	87.6	48.7	0.4	0.5	686.5	37.1	6.50 x 3.25	0.00045	2.176	41.363
No22-3	1,830	1525.6		15.3	102.9	43.5	0.4	0.5	762.8	36.9	6.50 x 3.25	0.00045	2.176	41.363
No22-4	1,670	1525.6	30	13.9	43.9	79.0	0.4	0.3	457.7	40.2	6.50 x 3.25	0.00045	2.176	41.363
No22-4	550	1525.6		4.6	107.5	42.2	0.4	0.9	1,373.0	64.4	8.50 x 4.25	0.00035	2.294	74.598
No22-4	450	1525.6		3.8	111.3	41.2	0.4	1.0	1,525.6	69.8	8.50 x 4.25	0.00035	2.294	74.598
	9,010													

Table D.5 Flow Calculation Sheets for Improvement of Major Drainage Channels in CBD

	L	Total A	ti	t2	T	I	C	ratio over total catchment	A	Discharge	Dimension	Slope	Velocity	Flow Capacity
	(m)	(ha)	(min) inlet	(min) traveling	(min) total	(mm/h)			(ha)	(m3/s)		(−)	(m/s)	(m3/s)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)				
G−1	295.2	14.2	5	2.5	7.5	272.1	0.8	1.0	14.2	8.6	2.20 x 2.20	0.00105	1.978	8.618
G−2	348.5	15.9	5	2.9	7.9	262.4	0.8	1.0	15.9	9.3	2.40 x 2.40	0.00095	1.994	10.338
G−3	386.9	18.6	5	3.2	8.2	255.6	0.8	1.0	18.6	10.6	2.60 x 2.60	0.00085	1.990	12.106
G−4	637.0	37.6	5	5.3	10.3	217.9	0.8	1.0	37.6	18.2	3.20 x 3.20	0.00065	1.998	18.417
G−5	889.3	41.8	5	7.4	12.4	191.4	0.8	1.0	41.8	17.8	3.20 x 3.20	0.00065	1.998	18.417
G−6	1,220.1	48.4	5	10.2	15.2	166.0	0.8	1.0	48.4	17.9	3.20 x 3.20	0.00065	1.998	18.417
G−7	984.1	19.9	5	8.2	13.2	183.2	0.8	1.0	19.9	8.1	2.20 x 2.20	0.00105	1.978	8.618
G−8	1,009.9	34.7	5	8.4	13.4	181.3	0.8	1.0	34.7	14.0	2.80 x 2.80	0.00080	2.028	14.311
G−9	1,164.2	29.0	5	9.7	14.7	169.9	0.8	1.0	29.0	10.9	2.60 x 2.60	0.00085	1.990	12.106
G−10	1,223.1	54.1	5	10.2	15.2	166.0	0.8	1.0	54.1	20.0	3.40 x 3.40	0.00060	1.999	20.799
G−11	1,134.2	40.4	5	9.5	14.5	171.5	0.8	1.0	40.4	15.4	3.00 x 3.00	0.00070	1.986	16.090
G−12	1,209.6	38.9	5	10.1	15.1	166.7	0.8	1.0	38.9	14.4	3.00 x 3.00	0.00070	1.986	16.090
G−13	1,033.5	75.0	5	8.6	13.6	179.4	0.8	1.0	75.0	29.9	4.40 x 4.40	0.00045	2.056	35.824
G−14	520.0	49.5	5	4.3	9.3	234.1	0.8	1.0	49.5	25.8	4.40 x 4.40	0.00045	2.056	35.824
G−15	632.3	37.5	5	5.3	10.3	217.9	0.8	1.0	37.5	18.2	3.20 x 3.20	0.00065	1.998	18.417
Total	12,688													

Average velocity: 2.0m/s(assumption)

Table D.6 Flow Calculation Sheets for Storage Pipe（Inlet to Pumping Station）in CBD (1/2)

		Drainage District		Treatment District		Rainfall Intensity			Runoff Coefficient	Inlet Time										Unit sewage Design Flow per ha	
						I=1,115/(t^0.7)			0.80	5										(Hourly Maximum) (m3/sec·ha)	
Pipe No.	Inlet Pipe	Area (A)		Converted Area (A×C)		Length		Concentration Time	Design Flow					Design Sewer							Remarks
									Stormwater			Snitary Sewage	Others	Total	Section	Slope	Velocity	Flow	Invert Level	G.L.	Earth Cover
		Each	Total	Each	Total	Each	Total		Runoff Coefficient (C)	Per ha	Flow								Start / End	Start / End	Start / End
		ha	ha	ha	ha	m	m	min		m3/sec	m3/sec	m3/sec	m3/sec	m3/sec	mm	‰	m/sec	m3/sec	m	m	m
																					Gate Pump:200m3/min = 3.30 m3/s
G-1		14.20	14.20	11.36	11.36	295	295	7.5	0.80	0.6047	8.587			8.587	□ 2,200× 2,200	1.05	1.978	8.616			
B-1			14.20	0.00	11.36	236	531	9.5	0.80	0.5125	7.278			7.278	○ 3,000	1.00	2.008	14.195			
to B-2																					
G-2		15.90	15.90	12.72	12.72	349	349	7.9	0.80	0.5831	9.271			9.271	□ 2,400× 2,400	0.95	1.994	10.337			
B-2	B-1		30.10	0.00	24.08	384	918	12.7	0.80	0.4182	12.588			12.588	○ 3,000	1.00	2.008	14.195			
to B-3																					
G-3		18.60	18.60	14.88	14.88	387	387	8.2	0.80	0.5681	10.567			10.567	□ 2,600× 2,600	0.85	1.990	12.107			
B-3	B-2		48.70	0.00	38.96	468	1383	16.4	0.80	0.3497	17.030			17.030	○ 3,250	1.00	2.118	17.571			
to B-4																					
G-4		37.60	37.60	30.08	30.08	637	637	10.3	0.80	0.4843	18.210			18.210	□ 3,200× 3,200	0.65	1.998	18.414			Gate Pump 6.80 ha
B-4	B-3		79.50	0.00	63.64	428	1808	19.4	0.80	0.3111	24.732			24.732	○ 3,750	1.00	2.330	25.735			Cut off 6.80 ha
to B-5																					
G-5		41.80	41.80	33.44	33.44	889	889	12.4	0.80	0.4253	17.778			17.778	□ 3,200× 3,200	0.65	1.998	18.414			Gate Pump 7.80 ha
B-5	B-4		113.50	0.00	90.88	332	2140	21.7	0.80	0.2877	32.654			32.654	○ 4,250	0.90	2.403	34.069			Cut off 7.80 ha
to B-6																					
G-6		48.40	48.40	38.72	38.72	1220	1220	15.2	0.80	0.3688	17.880			17.880	□ 3,200× 3,200	0.65	1.998	18.414			Gate Pump 8.90 ha
B-6	B-5		153.00	0.00	122.50	356	2496	24.1	0.80	0.2673	40.897			40.897	○ 4,750	0.80	2.440	43.239			Cut off 8.90 ha
to B-7																					
G-7		19.90	19.90	15.92	15.92	984	984	13.3	0.80	0.4049	8.068			8.068	□ 2,200× 2,200	1.05	1.978	8.616			Gate Pump 8.10 ha
B-7	B-6		164.80	0.00	131.92	268	2761	25.9	0.80	0.2541	41.876			41.876	○ 4,750	0.80	2.440	43.239			Cut off 8.10 ha
to B-8																					
G-8		34.70	34.70	27.76	27.76	1010	1010	13.3	0.80	0.4049	14.050			14.050	□ 2,800× 2,800	0.80	2.028	14.310			
B-8	B-7		199.50	0.00	159.68	296	3057	27.9	0.80	0.2412	48.119			48.119	○ 5,000	0.80	2.525	49.578			
to B-9																					
G-9		29.00	29.00	23.20	23.20	1164	1164	14.8	0.80	0.3787	10.898			10.898	□ 2,600× 2,600	0.85	1.990	12.107			
B-9	B-8		228.50	0.00	182.88	288	3348	29.7	0.80	0.2306	52.738			52.738	○ 5,250	0.80	2.608	56.459			
to B-10																					
G-10		54.10	54.10	43.28	43.28	1223	1223	15.2	0.80	0.3688	19.952			19.952	□ 3,400× 3,400	0.60	1.999	20.796			Gate Pump 8.90 ha
B-10	B-9		273.70	0.00	219.06	304	3649	31.6	0.80	0.2210	60.488			60.488	○ 5,500	0.80	2.690	63.909			Cut off 8.90 ha
to B-11																					
G-11		40.40	40.40	32.32	32.32	1134	1134	14.5	0.80	0.3812	15.400			15.400	□ 3,000× 3,000	0.70	1.966	16.067			Gate Pump 8.70 ha
B-11	B-10		305.40	0.00	244.38	294	3943	33.4	0.80	0.2126	64.928			64.928	○ 5,750	0.80	2.771	71.955			Cut off 8.70 ha
to B-12																					
G-12		38.90	38.90	31.12	31.12	1210	1210	15.2	0.80	0.3688	14.346			14.346	□ 3,000× 3,000	0.70	1.966	16.067			
B-12	B-11		344.30	0.00	275.50	293	4236	35.2	0.80	0.2049	70.547			70.547	○ 5,750	0.80	2.771	71.955			
to B-13																					
G-13		75.00	75.00	60.00	60.00	1034	1034	13.4	0.80	0.4028	30.210			30.210	□ 4,400× 4,400	0.45	2.056	35.824			
B-13	B-12		419.30	0.00	335.50	500	4736	38.0	0.80	0.1947	81.428			81.428	○ 6,250	0.80	2.930	89.892			Area storaged by Pipe 223.63 ha
to Pumping St.																					
Pumping St.														38.00							
				※Refer to capacity calculation of Stormwater storage pipe.																		
		Total Length of Storage pipe		4,441 m		⇒Volume of Storage pipe(Dia 6250mm)excluding flow capacity is 68,000m3.															

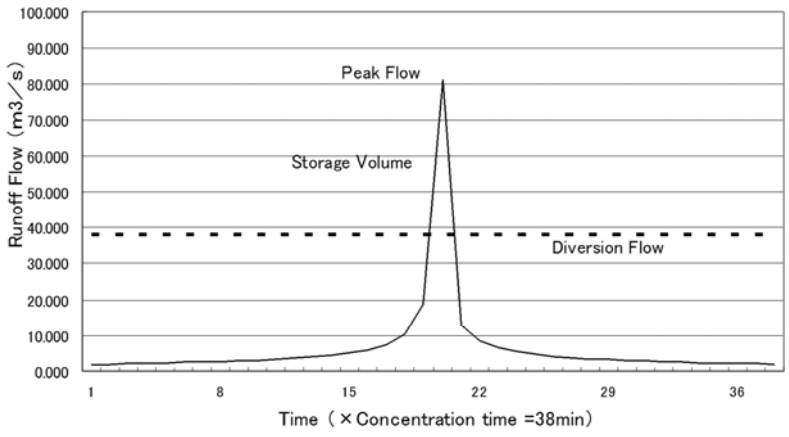
Table D.7 Flow Calculation Sheets for Storage Pipe（Inlet to Pumping Station）in CBD (2/2)

■Capacity calculation of Storage Pipe (Considering Gate Pump Capacity)

5 Return Period-year　　Whole CBD Point

Concentration time 38.00 min　　Peak Flow 81.42143 m3/s = 4,885 m3/min
Time Mesh 38.00 min　　Drainage Area 419.300 ha
Downstream Flow Capacity 38.00 m3/s(Coapacity of Pumping St.)
Runoff Coefficient 0.8　　Required Storage Volume 65,733 m3 < 68,000 m3

NO.		Time t(min)	Rainfall Intensity I(mm/h)	hyeto graph i(mm/h)	Order	hyeto on central concentrated type i(mm/h)	i(mm/h)	hydro graph (m3/s)	Downstream Flow Capacity (m3/s)	Diversion Volume (m3/s)	Storage Volume (m3)
1	38.0	00:38:00	87.38	87.38	38	2.07	2.07	1.932	38.000	0.000	0.00
2	76.0	01:16:00	53.79	20.20	36	2.15	2.15	2.008	38.000	0.000	0.00
3	114.0	01:54:00	40.50	13.92	34	2.24	2.24	2.091	38.000	0.000	0.00
4	152.0	02:32:00	33.11	10.95	32	2.34	2.34	2.183	38.000	0.000	0.00
5	190.0	03:10:00	28.32	9.17	30	2.45	2.45	2.286	38.000	0.000	0.00
6	228.0	03:48:00	24.93	7.96	28	2.58	2.58	2.401	38.000	0.000	0.00
7	266.0	04:26:00	22.38	7.08	26	2.72	2.72	2.531	38.000	0.000	0.00
8	304.0	05:04:00	20.38	6.40	24	2.88	2.88	2.680	38.000	0.000	0.00
9	342.0	05:42:00	18.77	5.86	22	3.06	3.06	2.852	38.000	0.000	0.00
10	380.0	06:20:00	17.44	5.42	20	3.28	3.28	3.054	38.000	0.000	0.00
11	418.0	06:58:00	16.31	5.06	18	3.54	3.54	3.295	38.000	0.000	0.00
12	456.0	07:36:00	15.35	4.74	16	3.85	3.85	3.587	38.000	0.000	0.00
13	494.0	08:14:00	14.51	4.48	14	4.24	4.24	3.951	38.000	0.000	0.00
14	532.0	08:52:00	13.78	4.24	12	4.74	4.74	4.421	38.000	0.000	0.00
15	570.0	09:30:00	13.13	4.03	10	5.42	5.42	5.055	38.000	0.000	0.00
16	608.0	10:08:00	12.55	3.85	8	6.40	6.40	5.966	38.000	0.000	0.00
17	646.0	10:46:00	12.03	3.68	6	7.96	7.96	7.419	38.000	0.000	0.00
18	684.0	11:24:00	11.55	3.54	4	10.95	10.95	10.204	38.000	0.000	0.00
19	722.0	12:02:00	11.12	3.40	2	20.20	20.20	18.820	38.000	0.000	34,334.40
20	760.0	12:40:00	10.73	3.28	1	87.38	87.38	81.421	38.000	43.421	31,398.20
21	798.0	13:18:00	10.37	3.17	3	13.92	13.92	12.966	38.000	0.000	0.00
22	836.0	13:56:00	10.04	3.06	5	9.17	9.17	8.544	38.000	0.000	0.00
23	874.0	14:34:00	9.73	2.97	7	7.08	7.08	6.597	38.000	0.000	0.00
24	912.0	15:12:00	9.45	2.88	9	5.86	5.86	5.465	38.000	0.000	0.00
25	950.0	15:50:00	9.18	2.79	11	5.06	5.06	4.712	38.000	0.000	0.00
26	988.0	16:28:00	8.93	2.72	13	4.48	4.48	4.170	38.000	0.000	0.00
27	1,026.0	17:06:00	8.70	2.64	15	4.03	4.03	3.758	38.000	0.000	0.00
28	1,064.0	17:44:00	8.48	2.58	17	3.68	3.68	3.433	38.000	0.000	0.00
29	1,102.0	18:22:00	8.27	2.51	19	3.40	3.40	3.169	38.000	0.000	0.00
30	1,140.0	19:00:00	8.08	2.45	21	3.17	3.17	2.949	38.000	0.000	0.00
31	1,178.0	19:38:00	7.90	2.40	23	2.97	2.97	2.763	38.000	0.000	0.00
32	1,216.0	20:16:00	7.72	2.34	25	2.79	2.79	2.603	38.000	0.000	0.00
33	1,254.0	20:54:00	7.56	2.29	27	2.64	2.64	2.464	38.000	0.000	0.00
34	1,292.0	21:32:00	7.40	2.24	29	2.51	2.51	2.341	38.000	0.000	0.00
35	1,330.0	22:10:00	7.25	2.20	31	2.40	2.40	2.233	38.000	0.000	0.00
36	1,368.0	22:48:00	7.11	2.15	33	2.29	2.29	2.136	38.000	0.000	0.00
37	1,406.0	23:26:00	6.98	2.11	35	2.20	2.20	2.048	38.000	0.000	0.00
38	1,444.0	00:04:00	6.85	2.07	37	2.11	2.11	1.969	38.000	0.000	0.00



E. COST ESTIMATION OF DRAINAGE WORKS

The project cost and the detailed operation and maintenance cost regarding drainage works are shown in the following pages.

Table E.1 Detailed Project Cost of Drainage Works (CBD)

Non-disclosure Information

Table E.2 Summary of Project Cost of Drainage Works

Non-disclosure Information

Table E.3 Detailed Project Cost of Drainage Works（No.1~22）

Non-disclosure Information

Table E.4 Operation and Maintenance Cost of Drainage Works

Unit: USD/year

Items	Total
Salary	276,408
Electricity	2,380,572
Maintenance(Spare parts)	5,151,560
Other cost	156,171
Total	7,964,711
Total (Except for electricity)	

Unit: Mil. JPY/year

Items	Total
Salary	23.4
Electricity	201.5
Maintenance(Spare parts)	436.0
Other cost	13.2
Total	674.1
Total (Except for electricity)	459.4

F. WASTEWATER GENERATION BY TOWNSHIPS AND SEWERAGE ZONES

Daily Average Wastewater (m^3/day), 2040 (including infiltration)

Code	Township	Wastewater	Sewerage Zone														Out of S.Z.
			CI	C2	W1	W2	W3	W4	N1	N2	N3	E1	E2	E3	E4	S1	
1	Latha	11,975			11,975												
2	Lanmadaw	15,688			15,688												
3	Pabedan	13,127	13,127														
4	Kyauktada	12,268	12,268														
5	Botahtaung	18,958	18,958														
6	Pazundaung	19,922	19,922														
7	Ahlone	26,127			26,127												
8	Kyee Myin Daing	44,210			44,210		0										
9	Sanchaung	38,458			38,458												
10	Dagon	20,803			20,803												
11	Bahan	44,235		36,045	8,190												
12	Tarmwe	70,695		70,695													
13	Mingalar Taung Nyunt	59,702		59,702													
14	Seikkan	971															971
15	Dawbon	27,025												27,025			
16	Kamaryut	33,815			3,763	30,052											
17	Hlaing	47,287				47,287											
18	Yankin	46,750		46,750													
19	Thingangyun	93,297		93,297													
20	Mayangone	111,963		72,303		39,660											
21	Insein	129,633							129,633								
22	Mingalardon	294,693								294,693							
23	North Okkalapa	167,617										167,617					
24	South Okkalapa	73,755		73,755													
25	Thaketa	82,670												82,670			
26	Dala	127,409														127,409	
27	Seikgyikhanaungto	14,512					14,512										
28	Shwe Pyi Thar	100,416									100,416						
29	Hlaing Tharyar	191,809						191,809									
30	North Dagon	65,335										65,335					
31	South Dagon	134,154												134,154			
32	East Dagon	269,207											269,207				
33	Dagon Seikkan	77,827													77,827		
YCDC Sub-total		2,486,312	64,275	452,548	169,214	116,999	14,512	191,809	129,633	294,693	100,416	232,952	269,207	243,849	77,827	127,409	971
34	Kyauktan	19,949															19,949
35	Thanlyin	161,690															161,690
36	Hlaegu	69,381															69,381
37	Hmawbi	71,712															71,712
38	Htantapin	51,632															51,632
39	Twantay	43,014															43,014
Out of YCDC Sub-total		417,378	0	0	0	0	0	0	0	0	0	0	0	0	0	0	417,378
Total		2,903,690	64,275	452,548	169,214	116,999	14,512	191,809	129,633	294,693	100,416	232,952	269,207	243,849	77,827	127,409	418,349

Daily Maximum Wastewater (m^3/day), 2040 (including infiltration)

Code	Township	Wastewater	Sewerage Zone														Out of S.Z.
			CI	C2	W1	W2	W3	W4	N1	N2	N3	E1	E2	E3	E4	S1	
1	Latha	13,113			13,113												
2	Lanmadaw	17,126			17,126												
3	Pabedan	14,379	14,379														
4	Kyauktada	13,428	13,428														
5	Botahtaung	20,596	20,596														
6	Pazundaung	21,810	21,810														
7	Ahlone	28,411			28,411												
8	Kyee Myin Daing	48,179			0		0										
9	Sanchaung	42,065			42,065												
10	Dagon	22,419			22,419												
11	Bahan	47,892		0	0												
12	Tarmwe	77,266		77,266													
13	Mingalar Taung Nyunt	65,194		65,194													
14	Seikkan	1,046															1,046
15	Dawbon	29,433												29,433			
16	Kamaryut	36,559			0	0											
17	Hlaing	51,091				51,091											
18	Yankin	50,947		50,947													
19	Thingangyun	101,418		101,418													
20	Mayangone	120,909		0		0											
21	Insein	139,691							139,691								
22	Mingalardon	317,362								317,362							
23	North Okkalapa	181,733										181,733					
24	South Okkalapa	80,335		80,335													
25	Thaketa	89,677												89,677			
26	Dala	137,210														137,210	
27	Seikgyikhanaungto	15,628					15,628										
28	Shwe Pyi Thar	108,140									108,140						
29	Hlaing Tharyar	206,563						206,563									
30	North Dagon	70,361										70,361					
31	South Dagon	144,473												144,473			
32	East Dagon	289,915											289,915				
33	Dagon Seikkan	83,814													83,814		
YCDC Sub-total		2,688,179	70,213	375,159	123,133	51,091	15,628	206,563	139,691	317,362	108,140	252,094	289,915	263,583	83,814	137,210	1,046
34	Kyauktan	21,483															21,483
35	Thanlyin	174,128															174,128
36	Hlaegu	74,718															74,718
37	Hmawbi	77,228															77,228
38	Htantapin	55,604															55,604
39	Twantay	46,323															46,323
Out of YCDC Sub-total		449,484	0	0	0	0	0	0	0	0	0	0	0	0	0	0	449,484
Total		3,137,663	70,213	375,159	123,133	51,091	15,628	206,563	139,691	317,362	108,140	252,094	289,915	263,583	83,814	137,210	450,530

Hourly Maximum Wastewater (m^3/day), 2040 (including infiltration)

Code	Township	Wastewater	Sewerage Zone														Out of S.Z.
			CI	C2	W1	W2	W3	W4	N1	N2	N3	E1	E2	E3	E4	S1	
1	Latha	19,369			19,369												
2	Lanmadaw	25,034			25,034												
3	Pabedan	21,263	21,263														
4	Kyauktada	19,807	19,807														
5	Botahtaung	29,604	29,604														
6	Pazundaung	32,195	32,195														
7	Ahlone	40,971			40,971												
8	Kyee Myin Daing	70,009			70,009		0										
9	Sanchaung	61,902			61,902												
10	Dagon	31,309			31,309												
11	Bahan	68,002		55,413	12,590												
12	Tarmwe	113,403		113,403													
13	Mingalar Taung Nyunt	95,401		95,401													
14	Seikkan	1,457															1,457
15	Dawbon	42,674												42,674			
16	Kamaryut	51,648			5,748	45,900											
17	Hlaing	72,011				72,011											
18	Yankin	74,031		74,031													
19	Thingangyun	146,082		146,082													
20	Mayangone	170,114		109,856		60,258											
21	Insein	195,012							195,012								
22	Mingalardon	442,040								442,040							
23	North Okkalapa	259,369										259,369					
24	South Okkalapa	116,522		116,522													
25	Thaketa	128,216												128,216			
26	Dala	191,114														191,114	
27	Seikgyikhanaungto	21,768					21,768										
28	Shwe Pyi Thar	150,624									150,624						
29	Hlaing Tharyar	287,713						287,713									
30	North Dagon	98,003										98,003					
31	South Dagon	201,230												201,230			
32	East Dagon	403,810											403,810				
33	Dagon Seikkan	116,741													116,741		
YCDC Sub-total		3,798,444	102,869	710,707	266,931	178,169	21,768	287,713	195,012	442,040	150,624	357,372	403,810	372,120	116,741	191,114	1,457
34	Kyauktan	29,923															29,923
35	Thanlyin	242,535															242,535
36	Hlaegu	104,072															104,072
37	Hmawbi	107,568															107,568
38	Htantapin	77,448															77,448
39	Twantay	64,522															64,522
Out of YCDC Sub-total		626,067	0	0	0	0	0	0	0	0	0	0	0	0	0	0	626,067
Total		4,424,511	102,869	710,707	266,931	178,169	21,768	287,713	195,012	442,040	150,624	357,372	403,810	372,120	116,741	191,114	627,524

Infiltration (m^3/day), 2040

Code	Township	Infiltration	Sewerage Zone														Out of S.Z.
			CI	C2	W1	W2	W3	W4	N1	N2	N3	E1	E2	E3	E4	S1	
1	Latha	600			600												
2	Lanmadaw	1,310			1,310												
3	Pabedan	610	610														
4	Kyauktada	670	670														
5	Botahtaung	2,580	2,580														
6	Pazundaung	1,040	1,040														
7	Ahlone	3,290			3,290												
8	Kyee Myin Daing	4,520			4,520		0										
9	Sanchaung	2,390			2,390												
10	Dagon	4,640			4,640												
11	Bahan	7,670		6,250	1,420												
12	Tarmwe	4,990		4,990													
13	Mingalar Taung Nyunt	4,780		4,780													
14	Seikkan	224															224
15	Dawbon	2,950												2,950			
16	Kamaryut	6,380			710	5,670											
17	Hlaing	9,250				9,250											
18	Yankin	4,780		4,780													
19	Thingangyun	12,090		12,090													
20	Mayangone	22,500		14,530		7,970											
21	Insein	29,050							29,050								
22	Mingalardon	68,006								68,006							
23	North Okkalapa	26,460										26,460					
24	South Okkalapa	7,960		7,960													
25	Thaketa	12,600												12,600			
26	Dala	29,402														29,402	
27	Seikgyikhanaungto	3,349					3,349										
28	Shwe Pyi Thar	23,173									23,173						
29	Hlaing Tharyar	44,264						44,264									
30	North Dagon	15,077										15,077					
31	South Dagon	30,959												30,959			
32	East Dagon	62,125											62,125				
33	Dagon Seikkan	17,960													17,960		
YCDC Sub-total		467,648	4,900	55,380	18,880	22,890	3,349	44,264	29,050	68,006	23,173	41,537	62,125	46,509	17,960	29,402	224
34	Kyauktan	4,604															4,604
35	Thanlyin	37,313															37,313
36	Hlaegu	16,011															16,011
37	Hmawbi	16,549															16,549
38	Htantapin	11,915															11,915
39	Twantay	9,926															9,926
Out of YCDC Sub-total		96,318	0	0	0	0	0	0	0	0	0	0	0	0	0	0	96,318
Total		563,966	4,900	55,380	18,880	22,890	3,349	44,264	29,050	68,006	23,173	41,537	62,125	46,509	17,960	29,402	96,542

G. HOUSEHOLDS INTERVIEW SURVEY

Table G.1 Q55 Access to Toilet Facility

	Access to Toilet Facility					
	No Toilet	Pit Latrine	Pour-flush Toilet	Flush Toilet	No Answer	**Total**
No.	64	1,105	8,315	584	1	**10,069**
%	0.6%	11.0%	82.6%	5.8%	0.0%	**100.0%**

Table G.2 Q56 Sanitation Treatment by Type of Water

		Sanitation Treatment by Type of Water				
		Sewerage System	Septic Tank	No Treatment	No Answer	**Total**
Number	Black Water	938	4,344	4,786	1	**10,069**
	Gray Water	1,359	2,705	6,001	4	**10,069**
% of Total	Black Water	9.3%	43.1%	47.5%	0.0%	**100.0%**
	Gray Water	13.5%	26.9%	59.6%	0.0%	**100.0%**

Table G.3 Q57 Assessment on Sanitary Condition

	Assessment on Sanitary Condition						
	Very Bad	Bad	So-so	Good	Very Good	No Answer	**Total**
No.	155	1,759	1,495	6,565	93	2	**10,069**
%	1.5%	17.5%	14.8%	65.2%	0.9%	0.0%	**100.0%**

Table G.4 Q58 Frequency of Problem, for responses answered "Very Bad" or "Bad" or "So-so" in Q57

		Frequency of Problem				
		Always	Sometimes	No Problem	No Answer	**Total**
Number	Offensive Odor (Bad Smell)	758	2,147	489	15	**3,409**
	Pipe Clogging	346	1,250	1,795	18	**3,409**
	Overflow of Wastewater	516	1,510	1,366	17	**3,409**
% of Total	Offensive Odor (Bad Smell)	22.2%	63.0%	14.3%	0.4%	**100.0%**
	Pipe Clogging	10.1%	36.7%	52.7%	0.5%	**100.0%**
	Overflow of Wastewater	15.1%	44.3%	40.1%	0.5%	**100.0%**

Table G.5 Q59 Acceptance of Black Water Use

	Acceptance of Black Water Use				
	Direct Use is Acceptable	Utilization with Composting (Appropriate Non-bacterial Treatment) is Acceptable	Hard to Accept	No Answer	**Total**
No.	646	6,604	2,817	2	**10,069**
%	6.4%	65.6%	28.0%	0.0%	**100.0%**

Table G.6 Q60 Willingness to Pay for Sanitation

	Willingness to Pay for Sanitation								
	Less than 500	501 ~ 1,000	1,001 ~ 2,000	2,001 ~ 3,000	3,001 ~ 5,000	5,001 ~ 7,000	More than 7,000	No Answer	**Total**
No.	4,378	2,687	990	585	403	65	960	1	**10,069**
%	43.5%	26.7%	9.8%	5.8%	4.0%	0.6%	9.5%	0.0%	**100.0%**

Table G.7 Q61a Access to Drainage

	Access to Drainage			
	Yes	No	No Answer	**Total**
No.	8,590	1,478	1	**10,069**
%	85.3%	14.7%	0.0%	**100.0%**

Table G.8 Q61b Assessment on Drainage Control, for Responses Answered "Yes" in Q61a

	Assessment on Drainage Condition						
	Very Bad	Bad	So-so	Good	Very Good	No Answer	**Total**
No.	316	2,283	1,658	4,292	30	11	**8,590**
%	3.7%	26.6%	19.3%	50.0%	0.3%	0.1%	**100.0%**

Table G.9 Q62 Assessment on Odor of Drainage

	Assessment on Odor of Drainage						
	Very Bad	Bad	So-so	Good	Very Good	No Answer	**Total**
No.	268	2,250	1,640	5,749	42	120	**10,069**
%	2.7%	22.3%	16.3%	57.1%	0.4%	1.2%	**100.0%**

Table G.10 Q63 Frequency of Odor of Drainage, for Responses Answered "Very Bad" or "Bad" or "So-so" in Q62

	Frequency of Odor of Drainage							
	1 Time per Month	1 Time per 3 Month	1 Time per Half Year	Every Time when It Floods	Rarely	Never	No Answer	**Total**
No.	775	162	178	2,037	970	15	21	**4,158**
%	18.6%	3.9%	4.3%	49.0%	23.3%	0.4%	0.5%	**100.0%**

Table G.11 Q64 Organization in Charge for Cleaning

	Organization in Charge for Cleaning					
	Cleaning Crew from YCDC	Cleaning Crew Hired by Yourself	Residents in Your Community	None	No Answer	**Total**
No.	1,033	781	6,421	1,823	11	**10,069**
%	10.3%	7.8%	63.8%	18.1%	0.1%	**100.0%**

Table G.12 Q65 Frequency of Flooding of Drainage

	Frequency of Flooding of Drainage							
	Every Month	Every Year	Every 2 Years	Every 10 Years	More than 10 Years	Never Experienced	No Answer	**Total**
No.	124	4,191	234	48	47	5,422	3	**10,069**
%	1.2%	41.6%	2.3%	0.5%	0.5%	53.8%	0.0%	**100.0%**

Table G.13 Q66 Level of Flooding, Except for responses Answered "Never" in Q65

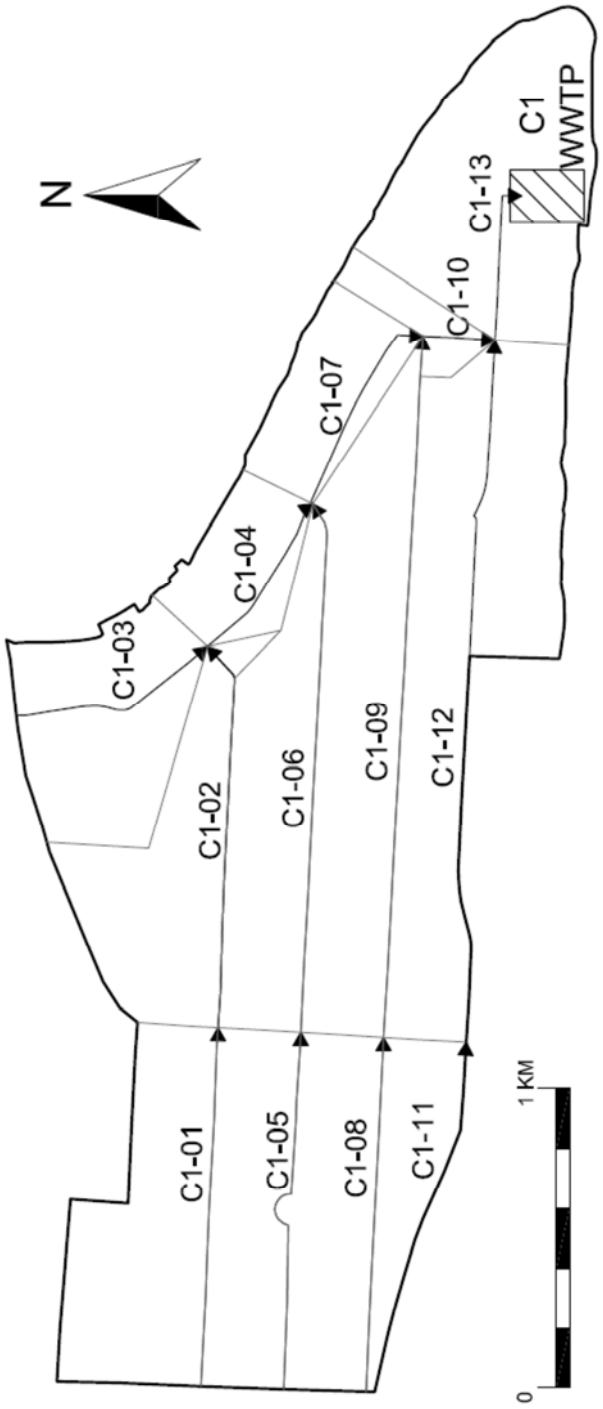
		Level of Flooding												
		Water Level						Duration of the Flood						
		Up to Ankles	Up to Knees	Up to Waist	More than Waist	No Answer	**Total**	Less than Half Day	Half Day ~ 1 Day	More than 1 ~ 3 Days	More than 3 ~ 5 Days	More than 6 Days	No Answer	**Total**
No.	Normal Flooding	2,421	1,904	175	23	121	**4,644**	2,722	805	462	215	315	125	**4,644**
	The most serious flooding in the past	165	363	136	43	3,937	**4,644**	283	170	86	35	129	3,941	**4,644**
%	Normal Flooding	52.1%	41.0%	3.8%	0.5%	2.6%	**100.0%**	58.6%	17.3%	9.9%	4.6%	6.8%	2.7%	**100.0%**
	The most serious flooding in the past	3.6%	7.8%	2.9%	0.9%	84.8%	**100.0%**	6.1%	3.7%	1.9%	0.8%	2.8%	84.9%	**100.0%**

		Level of Flooding											
		Inundation Speed						Flow Velocity					
		Very Fast (Within a Few Minutes)	Fast (Within One Hour)	Slow (Within a Few Hours)	Very Slow	No Answer	**Total**	Very Fast	Fast	Slow	Very Slow	No Answer	**Total**
No.	Normal Flooding	692	2,791	968	70	123	**4,644**	469	1,696	2,023	329	127	**4,644**
	The most serious flooding in the past	110	408	167	16	3,943	**4,644**	52	211	340	99	3,942	**4,644**
%	Normal Flooding	14.9%	60.1%	20.8%	1.5%	2.6%	**100.0%**	10.1%	36.5%	43.6%	7.1%	2.7%	**100.0%**
	The most serious flooding in the past	2.4%	8.8%	3.6%	0.3%	84.9%	**100.0%**	1.1%	4.5%	7.3%	2.1%	84.9%	**100.0%**

Table G.14 Q67 Willingness to Pay for Drainage

	Willingness to Pay for Drainage								
	Less than 500	501 ~ 1,000	1,001 ~ 2,000	2,001 ~ 3,000	3,001 ~ 5,000	5,001 ~ 7,000	More than 7,000	No Answer	**Total**
No.	4,627	2,801	936	490	277	39	898	1	**10,069**
%	46.0%	27.8%	9.3%	4.9%	2.8%	0.4%	8.9%	0.0%	**100.0%**

H. FLOW CALCULATION OF TRUNK MAINS



Source: JICA Study Team

Figure H.1 Layout Plan of Trunk Main, C1 Sewerage Zone

Table H.1 Flow Calculation of Trunk Main, C1 Sewerage Zone (1/2)

Flow Calculation C1

P 1

Wastewater unit flow per ha: 0.00244336m3/sec/ha

Pipe No.	Lower Pipe No.	Drainage Area		Length		Stormwater Runoff				Sanitary Wastewater			Others		TOTAL	Design Sewer Pipe							Remarks
		Each	Total	Each	Longest	Rainfall per ha	Coversion Area Each	Coversion Area Total	Stormwater	Population Each	Population Total	Wastewater	Each	Total		Dia.	Gradient	Velocity	Flow	G.L.	Invert	Covering	
		ha	ha	m	m	m3/sec/ha	ha	ha	m3/sec			m3/sec	m3/sec	m3/sec	m3/sec	mm	‰	m/sec	m3/sec	M	M	m	
C1-1		4530	4530	1200	1201							01107			01107	⊙ 600	160	0869	02456	520 550	2050 -0113	250 496	
C1-2	C1-4	4030	8560	1308	2509							02092			02092	⊙ 700	140	0900	03465	550 420	-0213 -2306	496 575	
C1-3		3870	3870	709	709							00946			00946	⊙ 600	160	0869	02456	480 420	1650 0374	250 318	
C1-4	C1-7	1820	14250	602	3111							03482			03482	⊙ 900	110	0944	06004	420 430	-2506 -3291	573 662	
C1-5		3250	3250	1249	1250							00794			00794	⊙ 500	200	0860	01689	460 460	1558 -1179	250 524	
C1-6		4030	7280	1778	3028							01779			01779	⊙ 700	140	0900	03465	460 430	-1379 -4203	522 775	
C1-7	C 1-10	2160	23690	724	3836							05788			05788	⊙ 1100	090	0976	09274	430 360	-4603 -5334	772 775	
C1-8		3390	3390	1185	1186							00828			00828	⊙ 500	200	0860	01689	420 500	1158 -1438	250 590	
C1-9		5970	9360	2546	3532							02287			02287	⊙ 700	140	0900	03465	500 360	-1638 -5384	588 823	
C 1-10	C 1-13	800	33850	241	4077							08271			08271	⊙ 1350	080	1055	15096	360 390	-6034 -6248	818 870	
C 1-11		2010	2010	1218	1219							00491			00491	⊙ 400	260	0845	01062	430 520	2865 -0617	400 538	
C 1-12		8160	10170	2362	3581							02485			02485	⊙ 800	120	0911	04581	520 390	-1017 -4310	535 734	

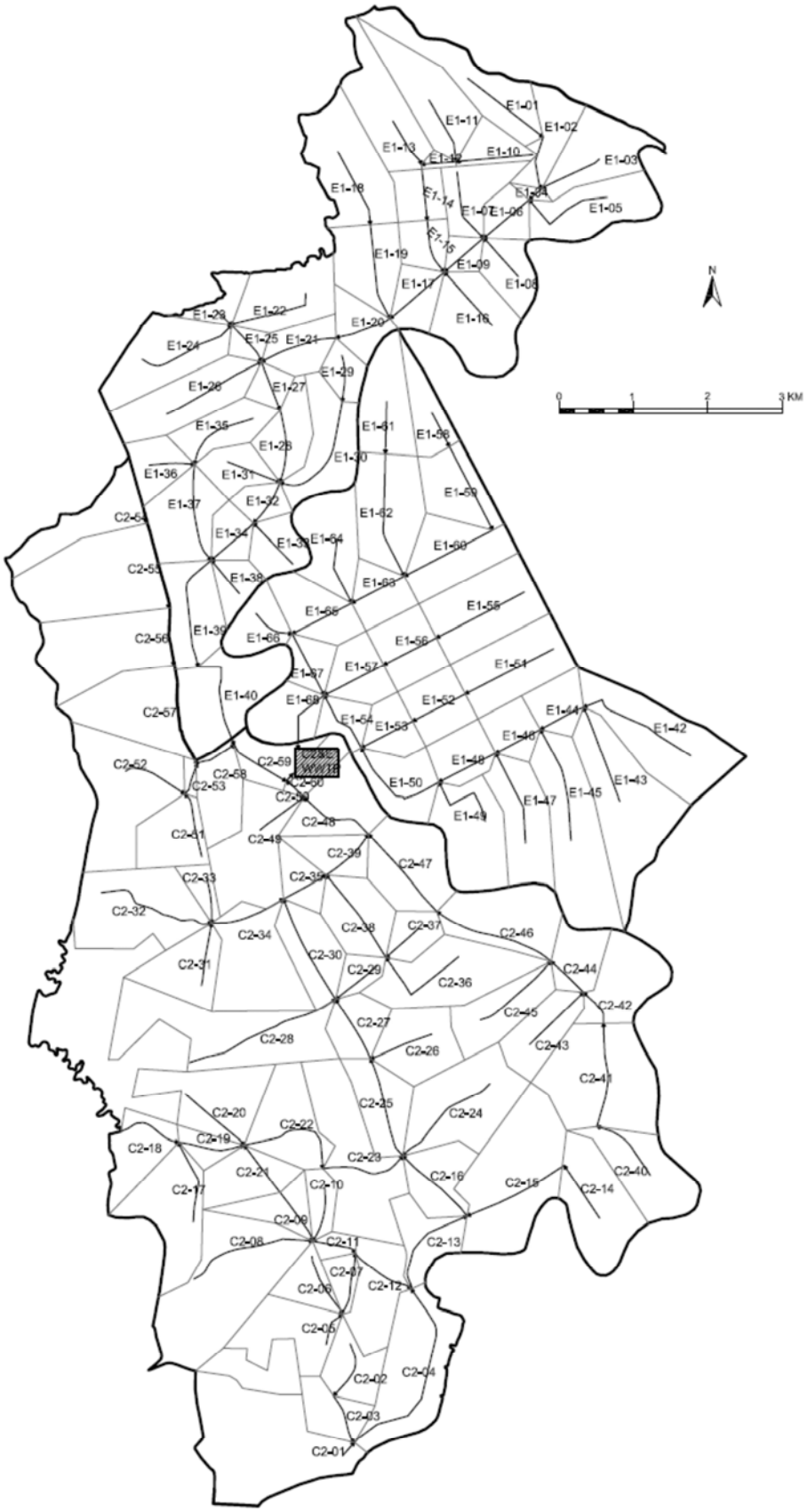
Table H.1 Flow Calculation of Trunk Main, C1 Sewerage Zone (2/2)

Flow Calculation C1

P 2

Wastewater unit flow per ha: 0.002443 36m3/sec/ha

Pipe No.	Lower Pipe No.	Drainage Area		Length			Stormwater Runoff					Sanitary Wastewater				Others		TOTAL	Design Sewer Pipe							Remarks
		Each	Total	Each	Longest		Rainfall per ha		Coversion Area		Stormwater		Population		Wastewater	Each	Total		Dia.	Gra-dient	Velocity	Flow	G.L.	Invert	Cove-ring	
									Each	Total			Each	Total												
		ha	ha	m	m		m3/sec/ha		ha	ha	m3/sec				m3/sec	m3/sec	m3/sec	m3/sec	mm	‰	m/sec	m3/sec	M	M	m	
C 1-13		5860	49880	549	4626										12187			12187	1500	070	1058	18702	390 550	-6398 -6842	869 1073	



Source: JICA Study Team

Figure H.2 Layout Plan of Trunk Main, C2+E1 Sewerage Zone

Table H.2 Flow Calculation of Trunk Main, C2+E1 Sewerage Zone (1/12)

Flow Calculation C2&E1

P 1

Wastewater unit flow per ha: 0.00146080m3/sec/ha

Pipe No.	Lower Pipe No.	Drainage Area		Length		Stormwater Runoff				Sanitary Wastewater				Others		TOTAL	Design Sewer Pipe							Remarks
		Each	Total	Each	Longest	Rainfall per ha		Coversion Area		Stormwater	Population		Wastewater	Each	Total		Dia.	Gradient	Velocity	Flow	G.L.	Invert	Covering	
								Each	Total		Each	Total												
		ha	ha	m	m	m3/sec/ha		ha	ha	m3/sec			m3/sec	m3/sec	m3/sec	m3/sec	mm	‰	m/sec	m3/sec	M	M	m	
C 2-02		6020	6020	823	823								00879			00879	⊙ 600	160	0869	02456	830 780	4650 3176	300 397	
C 2-03	C 2-04	5340	11360	703	1526								01659			01659	⊙ 700	140	0900	03465	780 470	3076 0942	397 300	
C 2-01		24860	24860	100	100								03632			03632	⊙ 900	110	0944	06004	300 470	-0975 -1085	300 481	
C 2-04	C 2-13	17250	53470	2722	4248								07811			07811	⊙ 1350	080	1055	15096	470 710	-1535 -0979	478 973	
C 2-08	C 2-11	23890	23890	1778	1779								03490			03490	⊙ 900	110	0944	06004	1600 840	11712 4425	331 300	
C 2-09	C 2-11	4980	4980	780	781								00727			00727	⊙ 500	200	0860	01689	870 840	5158 4458	300 440	
C 2-10		3120	3120	756	757								00456			00456	⊙ 400	260	0845	01062	800 840	6565 4397	300 357	
C 2-11	C 2-12	1640	33630	615	2394								04913			04913	⊙ 1000	100	0965	07582	840 430	2958 0218	436 300	
C 2-06	C 2-07	4430	4430	893	894								00647			00647	⊙ 450	230	0860	01367	850 880	7012 4740	300 357	
C 2-05		9910	9910	490	491								01389			01389	⊙ 700	140	0900	03465	1270 880	8299 5042	364 300	

Table H.2 Flow Calculation of Trunk Main, C2+E1 Sewerage Zone (2/12)

Flow Calculation C2&E1

P 2

Wastewater unit flow per ha: 0.00146080m3/sec/ha

Pipe No.	Lower Pipe No.	Drainage Area		Length		Stormwater Runoff				Sanitary Wastewater				Others		TOTAL	Design Sewer Pipe							Remarks
		Each	Total	Each	Longest	Rainfall per ha	Coversion Area Each	Coversion Area Total	Stormwater	Population Each	Population Total	Wastewater	Each	Total		Dia.	Gradient	Velocity	Flow	G.L.	Invert	Covering		
		ha	ha	m	m	m3/sec/ha	ha	ha	m3/sec			m3/sec	m3/sec	m3/sec	m3/sec	mm	‰	m/sec	m3/sec	M	M	m		
C 2-07		2570	16510	849	1743							02412			02412	⊙ 800	120	0911	04581	880	4390	354		
																				430	0434	300		
C 2-12		9070	59210	914	3308							08649			08649	⊙ 1350	080	1055	15096	430	-0153	300		
																				710	-1001	665		
C 2-13	C 2-16	6080	119360	1429	5678							17436			17436	⊙ 1650	070	1128	24115	710	-4379	971		
																				540	-3519	915		
C 2-14		13370	13370	864	864							01953			01953	⊙ 700	140	0900	03465	640	2642	300		
																				660	1275	457		
C 2-15		21380	34750	1486	2351							05076			05076	⊙ 1100	090	0976	09274	660	0875	454		
																				540	-0645	486		
C 2-16	C 2-25	7200	161310	1196	6875							23564			23564	⊙ 1800	070	1195	30412	540	-5669	914		
																				490	-6608	958		
C 2-17	C 2-19	12600	12600	1149	1149							01841			01841	⊙ 700	140	0900	03465	2500	20526	372		
																				1480	11042	300		
C 2-18		7250	7250	868	869							01059			01059	⊙ 600	160	0869	02456	1430	10650	300		
																				1480	9103	505		
C 2-19	C 2-22	2660	22510	905	2054							03288			03288	⊙ 900	110	0944	06004	1480	8803	502		
																				770	3725	300		
C 2-20	C 2-22	12020	12020	1056	1057							01756			01756	⊙ 700	140	0900	03465	1260	8531	331		
																				770	3942	300		
C 2-21		7140	7140	786	786							01043			01043	⊙ 600	160	0869	02456	870	5050	300		
																				770	3654	340		

Table H.2 Flow Calculation of Trunk Main, C2+E1 Sewerage Zone (3/12)

Flow Calculation C2&E1

P 3

Wastewater unit flow per ha: 0.00146080m3/sec/ha

Pipe No.	Lower Pipe No.	Drainage Area		Length		Stormwater Runoff					Sanitary Wastewater				Others		TOTAL	Design Sewer Pipe							Remarks
		Each	Total	Each	Longest	Rainfall per ha		Coversion Area		Stormwater	Population		Wastewater		Each	Total		Dia.	Gradient	Velocity	Flow	G.L.	Invert	Covering	
								Each	Total		Each	Total													
		ha	ha	m	m	m3/sec/ha		ha	ha	m3/sec			m3/sec		m3/sec	m3/sec	m3/sec	mm	‰	m/sec	m3/sec	M	M	m	
C 2-22		10250	51920	1510	3565								07584				07584	⊙ 1200	090	1034	11696	770	3054	335	
																						900	1490	622	
C 2-23	C 2-25	18030	69950	1183	4749								10218				10218	⊙ 1500	070	1058	18702	900	1190	620	
																						490	0218	307	
C 2-24		15280	15280	1552	1553								02232				02232	⊙ 700	140	0900	03465	720	3434	301	
																						490	0957	319	
C 2-25	C 2-27	7980	254520	1394	8269								37180				37180	⊙ 2200	070	1366	31934	490	-7008	955	
																						520	-8102	1094	
C 2-26		9380	9380	890	890								01370				01370	⊙ 700	140	0900	03465	560	1842	300	
																						520	0439	400	
C 2-27	C 2-30	5660	269560	935	9205								39377				39377	⊙ 2200	070	1366	31934	520	-8122	1096	
																						330	-8857	980	
C 2-28	C 2-30	20740	20740	2166	2167								03030				03030	⊙ 800	120	0911	04581	1260	8429	331	
																						330	-0566	300	
C 2-29		2590	2590	722	723								00378				00378	⊙ 350	280	0802	00772	350	2118	900	
																						330	-0081	300	
C 2-30	C 2-35	8170	301060	1535	10740								43979				43979	⊙ 2400	070	1448	65497	330	-9057	978	
																						350	-10269	1119	
C 2-32	C 2-34	16410	16410	1656	1657								02397				02397	⊙ 800	120	0911	04581	2430	16786	365	
																						830	4434	300	

Table H.2 Flow Calculation of Trunk Main, C2+E1 Sewerage Zone (4/12)

Flow Calculation C2&E1

P 4

Wastewater unit flow per ha: 0.00146080m3/sec/ha

Pipe No.	Lower Pipe No.	Drainage Area		Length		Stormwater Runoff				Sanitary Wastewater				Others		TOTAL	Design Sewer Pipe							Remarks
		Each	Total	Each	Longest	Rainfall per ha		Coversion Area		Stormwater	Population		Wastewater	Each	Total		Dia.	Gradient	Velocity	Flow	G.L.	Invert	Covering	
								Each	Total		Each	Total												
		ha	ha	m	m	m3/sec/ha		ha	ha	m3/sec			m3/sec	m3/sec	m3/sec	m3/sec	mm	‰	m/sec	m3/sec	M	M	m	
C 2-31	C 2-34	8030	8030	855	855								01173			01173	⊙ 600	160	0869	02456	930 830	5650 4122	300 353	
C 2-33		2380	2380	624	624								00348			00348	⊙ 350	280	0802	00772	1580 830	13778 6918	764 700	
C 2-34		14440	41260	1043	2700								06027			06027	⊙ 1100	090	0976	09274	830 350	3560 -0688	355 300	
C 2-35	C 2-39	3960	346280	660	11401								50585			50585	⊙ 2400	070	1448	65497	350 330	-10289 -10813	1121 1154	
C 2-36	C 2-38	14460	14460	1427	1427								02112			02112	⊙ 700	140	0900	03465	450 320	0742 -1532	300 397	
C 2-37		3960	3960	571	572								00578			00578	⊙ 450	230	0860	01367	470 320	3189 1712	702 600	
C 2-38		8420	26840	1384	2812								03921			03921	⊙ 900	110	0944	06004	320 330	-1732 -3518	396 584	
C 2-39	C 2-48	4990	378110	805	12207								55234			55234	⊙ 2600	070	1527	81081	330 460	-11013 -11658	1152 1347	
C 2-40		10820	10820	1008	1008								01581			01581	⊙ 700	140	0900	03465	680 750	3042 1433	300 531	
C 2-41		19330	30150	1418	2426								04404			04404	⊙ 1000	100	0965	07582	750 570	1133 -0562	529 518	
C 2-42	C 2-44	9790	39940	532	2959								05834			05834	⊙ 1100	090	0976	09274	570 630	-0662 -1202	517 631	

Table H.2 Flow Calculation of Trunk Main, C2+E1 Sewerage Zone (5/12)

Flow Calculation C2&E1

P 5

Wastewater unit flow per ha: 0.00146080m3/min/ha

Pipe No.	Lower Pipe No.	Drainage Area		Length		Stormwater Runoff				Sanitary Wastewater				Others		TOTAL	Design Sewer Pipe							Remarks
		Each	Total	Each	Longest	Rainfall per ha	Coversion Area Each	Coversion Area Total	Stormwater	Population Each	Population Total	Wastewater	Each	Total		Dia.	Gradient	Velocity	Flow	G.L.	Invert	Covering	
		ha	ha	m	m	m3/sec/ha	ha	ha	m3/sec			m3/sec	m3/sec	m3/sec	m3/sec	mm	‰	m/sec	m3/sec	M	M	m	
C 2-43		7310	7310	1015	1016							01068			01068	⊙ 600	160	0869	02456	680 630	3150 1322	300 433	
C 2-44	C 2-46	5650	52900	607	3566							07728			07728	⊙ 1200	090	1034	11696	630 630	-1302 -1927	631 693	
C 2-45		8650	8650	1251	1252							01264			01264	⊙ 700	140	0900	03465	560 630	1842 -0153	300 570	
C 2-46		12450	74000	1700	5266							10810			10810	⊙ 1500	070	1058	18702	630 470	-2227 -3635	692 672	
C 2-47		11930	85930	1400	6666							12553			12553	⊙ 1650	070	1128	24115	470 460	-3785 -4909	672 774	
C 2-48	C 2-50	9070	473110	1060	13267							69112			69112	⊙ 2800	070	1604	98797	460 360	-11858 -12702	1345 1330	
C 2-49		13170	13170	738	739							01924			01924	⊙ 700	140	0900	03465	280 360	-0958 -2130	300 497	
C 2-50	C 2-60	3380	489650	322	13590							71530			71530	⊙ 2800	070	1604	98797	360 400	-12722 -12968	1332 1396	
E1-1		11800	11800	1283	1284							01035			01035	⊙ 600	160	0869	02456	410 490	0450 -0845	300 610	
E1-2	E1-4	6130	17930	738	2022							01573			01573	⊙ 700	140	0900	03465	490 470	-1945 -3118	609 706	
E1-3		10010	10010	875	876							00878			00878	⊙ 600	160	0869	02456	410 470	0450 -1113	300 516	
E1-4	E1-6	650	28590	228	2251							02508			02508	⊙ 800	120	0911	04581	470 520	-3218 -3531	705 787	

Table H.2 Flow Calculation of Trunk Main, C2+E1 Sewerage Zone (6/12)

Flow Calculation C2&E1

P 6

Wastewater unit flow per ha: 0.00146080m3/sec/ha

Pipe No.	Lower Pipe No.	Drainage Area		Length		Stormwater Runoff				Sanitary Wastewater				Others		TOTAL	Design Sewer Pipe							Remarks
		Each	Total	Each	Longest	Rainfall per ha	Coversion Area		Stormwater	Population		Wastewater	Each	Total		Dia.	Gradient	Velocity	Flow	G.L.	Invert	Covering	
							Each	Total		Each	Total												
		ha	ha	m	m	m3/sec/ha	ha	ha	m3/sec			m3/sec	m3/sec	m3/sec	m3/sec	m3/sec	mm	‰	m/sec	m3/sec	M	M	m	
E1-5		10780	10780	1317	1318							00946			00946	⊙ 600	160	0869	02456	540 520	1750 -0624	300 517	
E1-6	E1-9	3870	43240	806	3057							03794			03794	⊙ 900	110	0944	06004	520 560	-3631 -4682	786 931	
E1-7	E1-9	6800	6800	1013	1013							00597			00597	⊙ 450	230	0860	01367	460 560	3112 0515	400 460	
E1-8		5590	5590	698	699							00490			00490	⊙ 400	260	0845	01062	620 560	4765 2766	400 240	
E1-9	E 1-17	2230	57860	699	3757							05077			05077	⊙ 1100	090	0976	09274	560 560	-4882 -9592	929 1000	
E 1-10	E 1-12	3980	3980	1043	1043							00349			00349	⊙ 350	280	0802	00772	490 460	3518 0332	400 389	
E 1-11		11370	11370	918	919							00998			00998	⊙ 600	160	0869	02456	430 460	0650 -0999	300 495	
E 1-12	E 1-14	750	16100	469	1512							01413			01413	⊙ 700	140	0900	03465	460 460	-1099 -1834	494 568	
E 1-13		11300	11300	711	712							00991			00991	⊙ 600	160	0869	02456	590 460	2230 0950	302 300	
E 1-14		4940	31940	755	2268							02802			02802	⊙ 800	120	0911	04581	460 430	-1934 -2978	567 641	

Table H.2 Flow Calculation of Trunk Main, C2+E1 Sewerage Zone (7/12)

Flow Calculation C2&E1

P 7

Wastewater unit flow per ha: 0.00146080m3/sec/ha

Pipe No.	Lower Pipe No.	Drainage Area		Length		Stormwater Runoff				Sanitary Wastewater				Others		TOTAL	Design Sewer Pipe							Remarks
		Each	Total	Each	Longest	Rainfall per ha	Coversion Area Each	Coversion Area Total	Stormwater	Population Each	Population Total	Wastewater	Each	Total		Dia.	Gradient	Velocity	Flow	G.L.	Invert	Covering	
		ha	ha	m	m	m3/sec/ha	ha	ha	m3/sec			m3/sec	m3/sec	m3/sec	m3/sec	mm	‰	m/sec	m3/sec	M	M	m	
E 1-15	E 1-17	4110	36050	764	3032							03163			03163	⊙ 900	110	0944	06004	430	-3078	640	
																				560	-4058	868	
E 1-16		12110	12110	962	962							01063			01063	⊙ 600	160	0869	02456	580	2150	300	
																				560	0429	452	
E 1-17	E 1-20	4770	110790	962	4719							09721			09721	⊙ 1350	080	1055	15096	560	-5842	999	
																				440	-6732	968	
E 1-18		14530	14530	1092	1092							01275			01275	⊙ 700	140	0900	03465	460	0842	300	
																				490	-0887	503	
E 1-19		9050	23580	1309	2402							02069			02069	⊙ 700	140	0900	03465	490	-0907	505	
																				440	-3000	664	
E 1-20		4910	139280	781	5500							12220			12220	⊙ 1500	070	1058	18702	440	-6882	967	
																				540	-7528	1132	
E 1-21	E 1-27	5600	144880	1068	6569							12712			12712	⊙ 1650	070	1128	24115	540	-7678	1131	
																				540	-8528	1216	
E 1-24	E 1-25	12580	12580	1387	1388							01104			01104	⊙ 600	160	0869	02456	500	1350	300	
																				590	-1136	639	
E 1-22	E 1-25	10130	10130	1213	1213							00889			00889	⊙ 600	160	0869	02456	590	0250	300	
																				590	-1928	718	
E 1-23		3140	3140	292	293							00276			00276	⊙ 300	300	0974	00689	590	4591	400	
																				590	3651	694	
E 1-25	E 1-27	2000	27850	645	2033							02444			02444	⊙ 1100	090	0976	09274	590	-2428	714	
																				540	-3088	730	

Table H.2 Flow Calculation of Trunk Main, C2+E1 Sewerage Zone (8/12)

Flow Calculation C2&E1

P 8

Wastewater unit flow per ha: 0.00146080m3/sec/ha

Pipe No.	Lower Pipe No.	Drainage Area Each	Drainage Area Total	Length Each	Length Longest	Stormwater Runoff Rainfall per ha	Stormwater Runoff Coversion Area Each	Stormwater Runoff Coversion Area Total	Stormwater Runoff Stormwater	Sanitary Wastewater Population Each	Sanitary Wastewater Population Total	Sanitary Wastewater Wastewater	Others Each	Others Total	TOTAL	Design Sewer Pipe Dia.	Gradient	Velocity	Flow	G.L.	Invert	Covering	Remarks
		ha	ha	m	m	m3/sec/ha	ha	ha	m3/sec			m3/sec	m3/sec	m3/sec	m3/sec	mm	‰	m/sec	m3/sec	M	M	m	
E 1-26		11550	11550	1462	1462							01013			01013	⊙ 600	160	0869	02456	560 540	1950 -0669	300 542	
E 1-27		2570	186850	699	7269							16394			16394	⊙ 1650	070	1128	24115	540 540	-8548 -9096	1218 1273	
E 1-28	E 1-32	6650	193500	996	8265							16978			16978	⊙ 1650	070	1128	24115	540 470	-9116 -9892	1275 1282	
E 1-29		3360	3360	626	627							00295			00295	⊙ 300	300	0974	00689	540 510	4091 2051	700 274	
E 1-30	E 1-32	10560	13920	1612	2240							01221			01221	⊙ 600	160	0869	02456	510 470	1450 -1453	300 550	
E 1-31		4820	4820	763	763							00423			00423	⊙ 400	260	0845	01062	340 470	1965 -0215	700 448	
E 1-32	E 1-34	3040	215280	665	8930							18889			18889	⊙ 1650	070	1128	24115	470 410	-9912 -10436	1284 1277	
E 1-33		5080	5080	763	763							00446			00446	⊙ 400	260	0845	01062	380 410	2365 0185	900 348	
E 1-34	E 1-39	3580	223940	756	9687							19648			19648	⊙ 1800	070	1195	30412	410 390	-10586 -11074	1276 1315	
E 1-35	E 1-37	6480	6480	1081	1081							00569			00569	⊙ 450	230	0860	01367	410 480	2612 -0158	600 447	

Table H.2 Flow Calculation of Trunk Main, C2+E1 Sewerage Zone (9/12)

Flow Calculation C2&E1

P 9

Wastewater unit flow per ha: 0.00146080m3/sec/ha

Pipe No.	Lower Pipe No.	Drainage Area		Length		Stormwater Runoff				Sanitary Wastewater				Others		TOTAL	Design Sewer Pipe							Remarks
		Each	Total	Each	Longest	Rainfall per ha	Coversion Area Each	Coversion Area Total	Stormwater	Population Each	Population Total	Wastewater	Each	Total		Dia.	Gradient	Velocity	Flow	G.L.	Invert	Covering	
		ha	ha	m	m	m3/sec/ha	ha	ha	m3/sec			m3/sec	m3/sec	m3/sec	m3/sec	mm	‰	m/sec	m3/sec	M	M	m	
E 1-36		4980	4980	616	617							00437			00437	⊙ 400	260	0845	01062	340 480	1965 0203	700 416	
E 1-37	E 1-39	9660	21120	1349	2431							01853			01853	⊙ 700	140	0900	03465	480 390	-0408 -2557	445 570	
E 1-38		3700	3700	589	590							00325			00325	⊙ 300	300	0974	00689	440 390	3091 1183	700 341	
E 1-39		9610	258370	1604	11291							22669			22669	⊙ 1800	070	1195	30412	390 420	-11194 -12479	1317 1475	
E 1-40	C 2-59	14400	272770	1400	12692							23933			23933	⊙ 1800	070	1195	30412	420 410	-12499 -13623	1477 1580	
C 2-54		9050	9050	175	175							01322			01322	⊙ 700	140	0900	03465	720 670	3314 2942	313 300	
C 2-55		19140	28190	1185	1360							04118			04118	⊙ 1000	100	0965	07582	670 670	2618 1211	300 441	
C 2-56		15350	43540	785	2145							06360			06360	⊙ 1200	090	1034	11696	670 590	1011 0203	439 440	
C 2-57	C 2-58	12810	56350	1408	3554							08232			08232	⊙ 1350	080	1055	15096	590 480	0053 -1256	439 460	
C 2-52	C 2-53	17940	17940	902	903							02621			02621	⊙ 800	120	0911	04581	1880 1380	14542 9934	339 300	
C 2-51		7470	7470	897	897							01091			01091	⊙ 600	160	0869	02456	1530 1380	11643 10043	301 311	
C 2-53		830	26240	447	1350							03833			03833	⊙ 900	110	0944	06004	1380 480	8123 0825	470 300	

Table H.2 Flow Calculation of Trunk Main, C2+E1 Sewerage Zone (10/12)

Flow Calculation C2&E1

P 10

Wastewater unit flow per ha: 0.00146080m3/sec/ha

Pipe No.	Lower Pipe No.	Drainage Area		Length		Stormwater Runoff				Sanitary Wastewater				Others		TOTAL	Design Sewer Pipe							Remarks
		Each	Total	Each	Longest	Rainfall per ha	Coversion Area Each	Coversion Area Total	Stormwater	Population Each	Population Total	Wastewater	Each	Total		Dia.	Gradient	Velocity	Flow	G.L.	Invert	Covering	
		ha	ha	m	m	m3/sec/ha	ha	ha	m3/sec			m3/sec	m3/sec	m3/sec	m3/sec	mm	‰	m/sec	m3/sec	M	M	m	
C 2-58		6980	89570	567	4121							13084			13084	⊙ 1650	070	4128	24115	480	-1556	459	
																				410	-1992	432	
C 2-59		5510	367850	870	13562							37822			37822	⊙ 2200	070	4366	51934	410	-14023	1576	
																				400	-14713	1635	
C 2-60	C2-W WTP		857510	150	13740							109352			109352	⊙ 3200	070	4754	141055	400	-15713	1629	
																				400	-15818	1640	
E 1-42	E 1-44	16860	16860	1709	1710							01479			01479	⊙ 700	140	0900	03465	570	1942	300	
																				600	-0792	603	
E 1-43		18710	18710	1357	1358							01642			01642	⊙ 700	140	0900	03465	680	3042	300	
																				600	0879	436	
E 1-44	E 1-46	4910	40480	657	2367							03552			03552	⊙ 900	110	0944	06004	600	-0992	602	
																				550	-1833	636	
E 1-45		18410	18410	1582	1582							01615			01615	⊙ 700	140	0900	03465	600	2242	300	
																				550	-0266	501	
E 1-46	E 1-48	4590	63480	682	3050							05570			05570	⊙ 1100	090	0976	09274	550	-2033	635	
																				500	-2728	654	
E 1-47		10820	10820	1304	1304							00949			00949	⊙ 600	160	0869	02456	600	2350	300	
																				500	0005	435	
E 1-48	E 1-50	5400	79700	861	3912							06993			06993	⊙ 1200	090	4034	11696	500	-2828	653	
																				530	-3702	771	
E 1-49		12150	12150	1114	1115							01066			01066	⊙ 600	160	0869	02456	560	1950	300	
																				530	-0057	471	

Table H.2 Flow Calculation of Trunk Main, C2+E1 Sewerage Zone (11/12)

Flow Calculation C2&E1

P 11

Wastewater unit flow per ha: 0.00146080m3/sec/ha

Pipe No.	Lower Pipe No.	Drainage Area		Length		Stormwater Runoff				Sanitary Wastewater				Others		TOTAL	Design Sewer Pipe							Remarks
		Each	Total	Each	Longest	Rainfall per ha		Coversion Area		Stormwater	Population		Wastewater	Each	Total		Dia.	Gradient	Velocity	Flow	G.L.	Invert	Covering	
								Each	Total		Each	Total												
		ha	ha	m	m	m3/sec/ha		ha	ha	m3/sec			m3/sec	m3/sec	m3/sec	m3/sec	mm	‰	m/sec	m3/sec	M	M	m	
E 1-50	E 1-54	7900	99750	1454	5366								08752			08752	⊙ 1350	080	1055	15096	530	-3852	770	
																					450	-5192	824	
E 1-51		12370	12370	1342	1343								01085			01085	⊙ 600	160	0869	02456	560	1950	300	
																					520	-0452	500	
E 1-52		6600	18970	800	2144								01664			01664	⊙ 700	140	0900	03465	520	-0552	499	
																					480	-1836	588	
E 1-53		4730	23700	781	2925								02079			02079	⊙ 700	140	0900	03465	480	-1856	590	
																					450	-3092	683	
E 1-54	E 1-68	3630	127080	895	6262								11150			11150	⊙ 1500	070	1058	18702	450	-5342	823	
																					390	-6072	836	
E 1-58		5990	5990	518	518								00490			00490	⊙ 400	260	0845	01062	490	3465	100	
																					540	2000	297	
E 1-59		8170	13760	1270	1788								01207			01207	⊙ 600	160	0869	02456	540	1750	300	
																					490	-0518	477	
E 1-60	E 1-63	10560	24320	1342	3131								02134			02134	⊙ 700	140	0900	03465	490	-0618	476	
																					350	-2754	550	
E 1-61		9650	9650	708	708								00847			00847	⊙ 600	160	0869	02456	460	0950	300	
																					460	-0326	428	
E 1-62		12750	22400	1719	2428								01965			01965	⊙ 700	140	0900	03465	460	-0426	427	
																					350	-3179	592	
E 1-63	E 1-65	5380	52100	801	3932								04571			04571	⊙ 1000	100	0965	07582	350	-3479	590	
																					350	-4440	686	
E 1-64		9870	9870	926	927								00866			00866	⊙ 600	160	0869	02456	450	0850	300	
																					350	-0810	366	

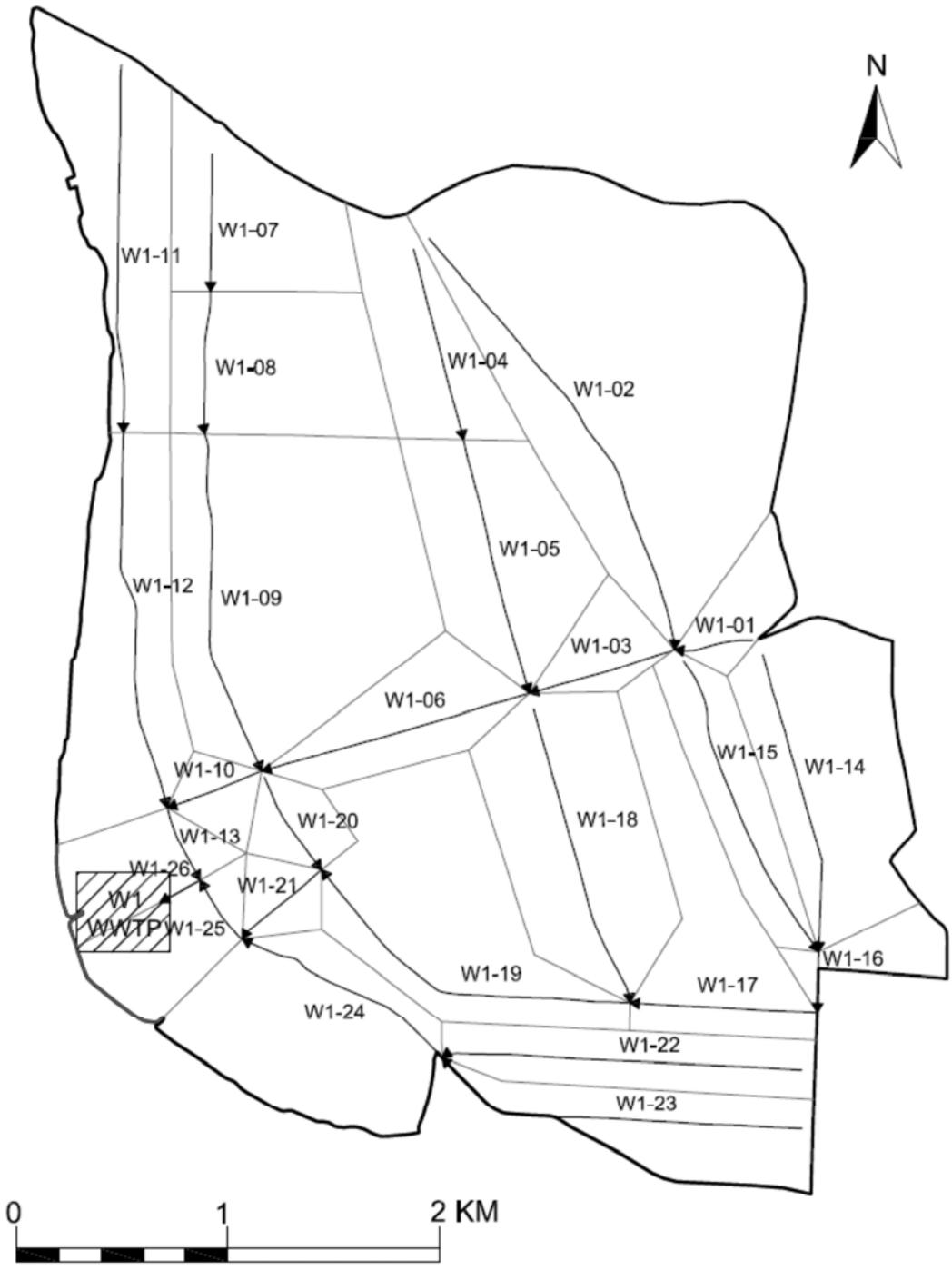
Table H.2 Flow Calculation of Trunk Main, C2+E1 Sewerage Zone (12/12)

Flow Calculation C2&E1

P 12

Wastewater unit flow per ha: 0.00146080m3/sec/ha

Pipe No.	Lower Pipe No.	Drainage Area		Length		Stormwater Runoff				Sanitary Wastewater				Others		TOTAL	Design Sewer Pipe							Remarks
		Each	Total	Each	Longest	Rainfall per ha	Coversion Area Each	Coversion Area Total	Stormwater	Population Each	Population Total	Wastewater	Each	Total			Dia.	Gradient	Velocity	Flow	G.L.	Invert	Covering	
		ha	ha	m	m	m3/sec/ha	ha	ha	m3/sec			m3/sec	m3/sec	m3/sec	m3/sec	m3/sec	mm	‰	m/sec	m3/sec	M	M	m	
E 1-65	E 1-67	7740	69310	905	4838							06116				06116	⊙ 1100	090	0976	09274	350	-5540	685	
																					400	-5472	828	
E 1-66		5670	5670	590	590							00497				00497	⊙ 400	260	0845	01062	460	3165	700	
																					400	1490	208	
E 1-67	E 1-68	3800	79180	944	5782							06947				06947	⊙ 1200	090	4034	11696	400	-5572	828	
																					390	-6540	915	
E 1-55		13960	13960	1340	1341							01225				01225	⊙ 600	160	0869	02456	540	1750	300	
																					390	-0652	390	
E 1-56		7390	21350	801	2143							01873				01873	⊙ 700	140	0900	03465	390	-0752	389	
																					390	-2036	518	
E 1-57		6080	27430	901	3044							02407				02407	⊙ 800	120	0911	04581	390	-2136	517	
																					390	-3396	643	
E 1-68		6480	240170	800	7062							21073				21073	⊙ 1800	070	5195	30412	390	-7140	911	
																					400	-7760	983	



Source: JICA Study Team

Figure H.3 Layout Plan of Trunk Main, W1 Sewerage Zone

Table H.3 Flow Calculation of Trunk Main, W1 Sewerage Zone (1/3)

Flow Calculation W1

P 1

Wastewater unit flow per ha: 0.00181620m3/sec/ha

Pipe No.	Lower Pipe No.	Drainage Area		Length		Stormwater Runoff				Sanitary Wastewater				Others		TOTAL	Design Sewer Pipe							Remarks
		Each	Total	Each	Longest	Rainfall per ha	Coversion Area		Stormwater	Population		Wastewater	Each	Total			Dia.	Gradient	Velocity	Flow	G.L.	Invert	Covering	
							Each	Total		Each	Total													
		ha	ha	m	m	m3/sec/ha	ha	ha	m3/sec			m3/sec	m3/sec	m3/sec	m3/sec	m3/sec	mm	‰	m/sec	m3/sec	M	M	m	
W 1-15	W 1-16	4190	4190	1534	1534							00761				00761	⊙ 500	200	0860	01689	2110	17056	350	
																					1000	6458	300	
W 1-14		9350	9350	1446	1447							01698				01698	⊙ 700	140	0900	03465	2380	19257	379	
																					1000	8242	300	
W 1-16		1720	15260	286	1820							02772				02772	⊙ 800	120	0911	04581	1000	5415	372	
																					750	3634	300	
W 1-17	W 1-19	6990	22250	886	2707							04041				04041	⊙ 1000	100	0965	07582	750	3418	300	
																					950	2376	604	
W 1-18		9810	9810	1468	1468							01782				01782	⊙ 700	140	0900	03465	1580	11759	328	
																					950	5742	300	
W 1-19	W 1-21	10610	42670	1706	4413							07750				07750	⊙ 1200	090	1034	11696	950	2176	603	
																					400	-0295	300	
W 1-20		1630	1630	518	518							00296				00296	⊙ 300	300	0974	00689	610	4713	408	
																					400	2691	100	
W 1-21	W 1-25	1280	45580	499	4912							08278				08278	⊙ 1350	080	1055	15096	400	-0453	300	
																					410	-0913	356	
W 1-23	W 1-24	5220	5220	1807	1808							00948				00948	⊙ 600	160	0869	02456	260	-1050	300	
																					370	-4300	735	
W 1-22		4750	4750	1705	1705							00863				00863	⊙ 600	160	0869	02456	340	-0250	300	
																					370	-3327	638	
W 1-24		8720	18690	1115	2923							03394				03394	⊙ 900	110	0944	06004	370	-4600	733	
																					410	-6045	917	

Table H.3 Flow Calculation of Trunk Main, W1 Sewerage Zone (2/3)

Flow Calculation W1

P 2

Wastewater unit flow per ha: 0.00181620m3/sec/ha

Pipe No.	Lower Pipe No.	Drainage Area Each	Drainage Area Total	Length Each	Length Longest	Stormwater Runoff Rainfall per ha	Stormwater Runoff Coversion Area Each	Stormwater Runoff Coversion Area Total	Stormwater Runoff Stormwater	Sanitary Wastewater Population Each	Sanitary Wastewater Population Total	Sanitary Wastewater Wastewater	Others Each	Others Total	TOTAL	Design Sewer Pipe Dia.	Gradient	Velocity	Flow	G.L.	Invert	Covering	Remarks
		ha	ha	m	m	m3/sec/ha	ha	ha	m3/sec			m3/sec	m3/sec	m3/sec	m3/sec	mm	‰	m/sec	m3/sec	M	M	m	
W 1-25	W 1-26	3380	67650	343	5256							12287			12287	⊙ 1500	070	1058	18702	410	-6645	913	
																				520	-6925	1051	
W1-2	W1-3	26210	26210	2304	2305							04760			04760	⊙ 1000	100	0965	07582	2360	19518	300	
																				2460	16753	677	
W1-1		2090	2090	376	376							00380			00380	⊙ 350	280	0802	00772	2860	26727	649	
																				2460	23218	500	
W1-3	W1-6	2000	30300	718	3023							05503			05503	⊙ 1100	090	0976	09274	2460	16653	676	
																				1650	12312	300	
W1-4		4970	4970	929	929							00903			00903	⊙ 600	160	0869	02456	2260	18069	388	
																				1230	8650	300	
W1-5		7580	12550	1239	2169							02279			02279	⊙ 700	140	0900	03465	1230	8542	300	
																				1650	6561	918	
W1-6	W 1-10	4440	47290	1317	4340							08589			08589	⊙ 1350	080	1055	15096	1650	5911	914	
																				610	1647	300	
W1-7		5820	5820	648	649							01057			01057	⊙ 600	160	0869	02456	1420	10550	300	
																				1410	9394	406	
W1-8		6910	12730	678	1328							02312			02312	⊙ 800	120	0911	04581	1410	9194	404	
																				810	4234	300	
W1-9		16560	29290	1647	2975							05320			05320	⊙ 1100	090	0976	09274	810	3865	305	
																				610	1912	300	
W 1-10	W 1-13	1330	77910	477	4818							14150			14150	⊙ 1650	070	1128	24115	610	0841	349	
																				430	-0470	300	

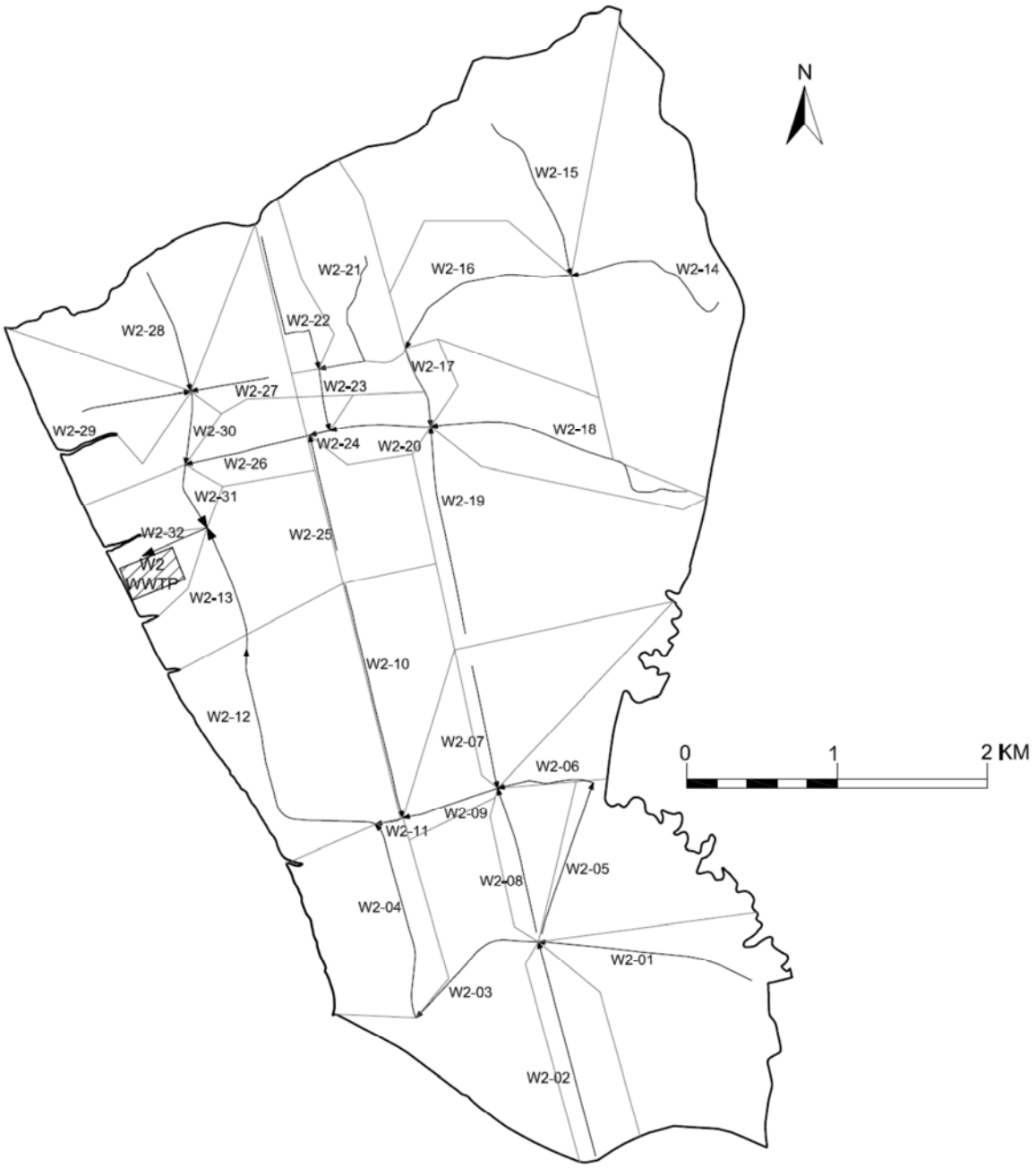
Table H.3 Flow Calculation of Trunk Main, W1 Sewerage Zone (3/3)

Flow Calculation W1

P 3

Wastewater unit flow per ha: 0.00181620m3/sec/ha

Pipe No.	Lower Pipe No.	Drainage Area		Length			Stormwater Runoff					Sanitary Wastewater				Others		TOTAL	Design Sewer Pipe							Remarks
		Each	Total	Each	Longest		Rainfall per ha		Coversion Area		Stormwater		Population		Wastewater	Each	Total		Dia.	Gradient	Velocity	Flow	G.L.	Invert	Covering	
									Each	Total			Each	Total												
		ha	ha	m	m		m3/sec/ha		ha	ha	m3/sec				m3/sec	m3/sec	m3/sec	m3/sec	mm	‰	m/sec	m3/sec	M	M	m	
W 1-11		7940	7940	1737	1738										01442			01442	⊙ 700	140	0900	03465	600 880	2242 -0529	300 857	
W 1-12		8660	16600	1808	3547										03015			03015	⊙ 800	120	0911	04581	880 430	-0629 -3155	856 659	
W 1-13		3210	97720	380	5199										17748			17748	⊙ 1650	070	1128	24115	430 520	-4005 -4291	654 772	
W 1-26			165370	216	5472										30034			30034	⊙ 2000	070	1282	40278	520 410	-7425 -7597	1048 955	



Source: JICA Study Team

Figure H.4 Layout Plan of Trunk Main, W2 Sewerage Zone

Table H.4 Flow Calculation of Trunk Main, W2 Sewerage Zone (1/3)

Flow Calculation W2

P 1

Wastewater unit flow per ha: 0.00101682m3/sec/ha

Pipe No.	Lower Pipe No.	Drainage Area		Length		Stormwater Runoff				Sanitary Wastewater				Others		TOTAL	Design Sewer Pipe							Remarks
		Each	Total	Each	Longest	Rainfall per ha	Coversion Area Each	Coversion Area Total	Stormwater	Population Each	Population Total	Wastewater	Each	Total		Dia.	Gradient	Velocity	Flow	G.L.	Invert	Covering		
		ha	ha	m	m	m3/sec/ha	ha	ha	m3/sec			m3/sec	m3/sec	m3/sec	m3/sec	mm	‰	m/sec	m3/sec	M	M	m		
W2-2	W2-3	5750	5750	1478	1478							00585			00585	⊙ 450	330	0860	01367	2350	21787	523		
																				1560	14112	400		
W2-1		15950	15950	1457	1457							01622			01622	⊙ 700	140	0900	03465	1920	15338	310		
																				1560	11842	300		
W2-3		14740	36440	1029	2507							03705			03705	⊙ 900	110	0944	06004	1560	10792	383		
																				530	1325	300		
W2-4	W 2-11	9620	46060	1343	3850							04683			04683	⊙ 1000	100	0965	07582	530	1218	300		
																				450	-0386	380		
W2-5		9120	9120	1068	1068							00927			00927	⊙ 600	160	0869	02456	1530	11214	344		
																				880	5150	300		
W2-6	W2-9	4380	13500	648	1716							01373			01373	⊙ 700	140	0900	03465	880	4557	349		
																				450	0742	300		
W2-8	W2-9	3850	3850	997	997							00391			00391	⊙ 400	260	0845	01062	1440	12443	452		
																				450	3065	400		
W2-7		7730	7730	830	830							00786			00786	⊙ 500	200	0860	01689	870	4876	328		
																				450	0958	300		
W2-9	W 2-11	3570	28650	663	2379							02913			02913	⊙ 800	120	0911	04581	450	0634	300		
																				450	-0284	392		
W 2-10		7090	7090	1599	1599							00721			00721	⊙ 500	200	0860	01689	470	1158	300		
																				450	-2343	630		
W 2-11			81800	192	4042							08318			08318	⊙ 1350	080	1055	15096	450	-3193	624		
																				450	-3367	641		

Table H.4 Flow Calculation of Trunk Main, W2 Sewerage Zone (2/3)

Flow Calculation W2

P 2

Wastewater unit flow per ha: 0.00101682m3/sec/ha

Pipe No.	Lower Pipe No.	Drainage Area		Length			Stormwater Runoff					Sanitary Wastewater				Others		TOTAL	Design Sewer Pipe							Remarks
		Each	Total	Each	Longest		Rainfall per ha		Coversion Area		Stormwater		Population		Wastewater	Each	Total		Dia.	Gradient	Velocity	Flow	G.L.	Invert	Covering	
									Each	Total			Each	Total												
		ha	ha	m	m		m3/sec/ha		ha	ha	m3/sec				m3/sec	m3/sec	m3/sec	m3/sec	mm	‰	m/sec	m3/sec	M	M	m	
W 2-12		16400	98300	1759	5801										09985			09985	⊙ 1350	080	1055	15096	450 500	-3387 -5011	643 856	
W 2-13	W 2-32	9860	108060	862	6663										10988			10988	⊙ 1500	070	1058	18702	500 540	-5161 -5866	855 965	
W 2-15	W 2-16	17360	17360	1185	1185										01765			01765	⊙ 700	140	0900	03465	1040 960	6642 4767	300 408	
W 2-14		22360	22360	1164	1164										02274			02274	⊙ 700	140	0900	03465	2220 960	17528 5842	391 300	
W 2-16		10470	50190	1320	2505										05103			05103	⊙ 1100	090	0976	09274	960 730	4367 3019	405 309	
W 2-17	W 2-20	1010	51200	556	3061										05206			05206	⊙ 1100	090	0976	09274	730 670	2999 2439	311 307	
W 2-18	W 2-20	8620	8620	1881	1881										00876			00876	⊙ 600	160	0869	02456	1590 670	11924 3050	333 300	
W 2-19		17240	17240	1402	1402										01753			01753	⊙ 700	140	0900	03465	790 670	4142 1898	300 404	
W 2-20	W 2-24	2730	79790	675	3736										08113			08113	⊙ 1350	080	1055	15096	670 560	1248 0628	400 352	
W 2-22	W 2-23	2730	2730	1096	1096										00278			00278	⊙ 300	300	0974	00689	660 540	5291 1727	400 336	

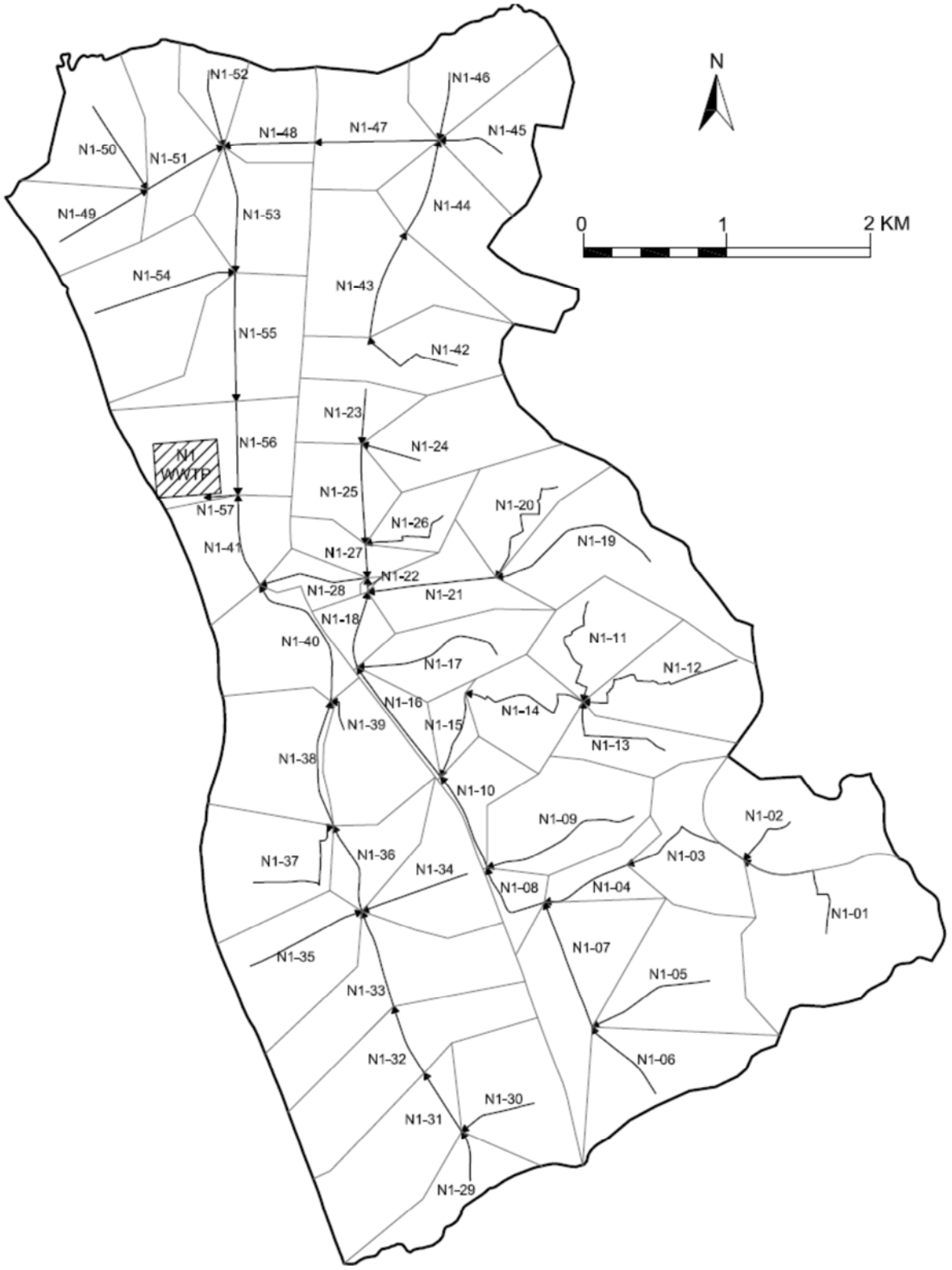
Table H.4 Flow Calculation of Trunk Main, W2 Sewerage Zone (3/3)

Flow Calculation W2

P 3

Wastewater unit flow per ha: 0.00101682m3/sec/ha

Pipe No.	Lower Pipe No.	Drainage Area Each	Drainage Area Total	Length Each	Length Longest	Stormwater Runoff: Rainfall per ha	Coversion Area Each	Coversion Area Total	Stormwater	Sanitary Wastewater: Population Each	Population Total	Wastewater	Others Each	Others Total	TOTAL	Design Sewer Pipe: Dia.	Gradient	Velocity	Flow	G.L.	Invert	Covering	Remarks
		ha	ha	m	m	m3/sec/ha	ha	ha	m3/sec			m3/sec	m3/sec	m3/sec	m3/sec	mm	‰	m/sec	m3/sec	M	M	m	
W 2-21		6780	6780	1073	1073							00689			00689	⊙ 500	200	0860	01689	1230 540	8226 1858	343 300	
W 2-23		1690	11200	416	1512							01139			01139	⊙ 1100	090	0976	09274	540 560	0927 0512	329 390	
W 2-24	W 2-26	670	91660	139	3875							09320			09320	⊙ 1350	080	1055	15096	560 500	0262 0151	389 340	
W 2-25		5330	5330	787	787							00542			00542	⊙ 450	230	0860	01367	490 500	3412 1406	400 311	
W 2-26	W 2-31	3630	100620	848	4723							10231			10231	⊙ 1500	070	1058	18702	500 450	0001 -0693	339 358	
W 2-28	W 2-30	8270	8270	849	849							00841			00841	⊙ 500	200	0860	01689	450 450	0958 -0903	300 486	
W 2-29	W 2-30	5600	5600	735	735							00569			00569	⊙ 450	230	0860	01367	480 450	3312 1442	400 257	
W 2-27		4450	4450	523	523							00452			00452	⊙ 400	260	0845	01062	530 450	3865 2387	400 468	
W 2-30		3060	21380	492	1341							02174			02174	⊙ 700	140	0900	03465	450 450	-1103 -1873	485 362	
W 2-31		3060	125060	468	5191							12716			12716	⊙ 1650	070	1128	24115	450 540	-2823 -3190	355 682	
W 2-32		2500	235620	470	7133							23958			23958	⊙ 1800	070	1195	30412	540 450	-6166 -6536	964 911	



Source: JICA Study Team

Figure H.5 Layout Plan of Trunk Main, N1 Sewerage Zone

Table H.5 Flow Calculation of Trunk Main, N1 Sewerage Zone (1/6)

Flow Calculation N1

P 1

Wastewater unit flow per ha: 0.0005181m3/sec/ha

Pipe No.	Lower Pipe No.	Drainage Area		Length		Stormwater Runoff				Sanitary Wastewater				Others		TOTAL	Design Sewer Pipe							Remarks
		Each	Total	Each	Longest	Rainfall per ha	Coversion Area Each	Coversion Area Total	Stormwater	Population Each	Population Total	Wastewater	Each	Total		Dia.	Gradient	Velocity	Flow	G.L.	Invert	Covering	
		ha	ha	m	m	m3/sec/ha	ha	ha	m3/sec			m3/sec	m3/sec	m3/sec	m3/sec	mm	‰	m/sec	m3/sec	M	M	m	
N1-1	N1-3	12940	12940	1035	1036							00753			00753	⊙ 500	200	0860	01689	1460 1820	11058 8790	300 887	
N1-2		8010	8010	445	446							00466			00466	⊙ 400	260	0845	01062	1640 1820	14965 13708	300 406	
N1-3		5860	26810	981	2018							01560			01560	⊙ 700	140	0900	03465	1820 1330	8590 7040	885 550	
N1-4		2560	29370	645	2663							01709			01709	⊙ 700	140	0900	03465	1330 980	7020 5997	552 305	
N1-5	N1-7	8040	37410	901	3565							02177			02177	⊙ 700	140	0900	03465	980 880	5977 4537	307 351	
N1-6		6680	6680	651	651							00389			00389	⊙ 400	260	0845	01062	1750 880	15287 7365	578 700	
N1-7		8400	52490	934	4499							03054			03054	⊙ 800	420	0911	04581	880 1460	4437 3137	350 1060	
N1-8	N 1-10	1630	54120	603	5103							03149			03149	⊙ 900	210	0944	06004	1460 1180	3037 2252	1059 857	
N1-9		7590	7590	1125	1126							00442			00442	⊙ 400	260	0845	01062	1610 1180	14579 10365	309 700	
N 1-10	N 1-16	2640	64350	719	5822							03744			03744	⊙ 900	210	0944	06004	1180 1010	2232 1300	859 783	
N 1-12	N 1-14	6970	6970	1296	1296							00406			00406	⊙ 400	260	0845	01062	1690 1070	15308 9265	416 700	

Table H.5 Flow Calculation of Trunk Main, N1 Sewerage Zone (2/6)

Flow Calculation N1

P 2

Wastewater unit flow per ha: 0.00058181m3/sec/ha

Pipe No.	Lower Pipe No.	Drainage Area		Length		Stormwater Runoff				Sanitary Wastewater			Others		TOTAL	Design Sewer Pipe							Remarks
		Each	Total	Each	Longest	Rainfall per ha	Coversion Area Each	Coversion Area Total	Stormwater	Population Each	Population Total	Wastewater	Each	Total		Dia.	Gradient	Velocity	Flow	G.L.	Invert	Covering	
		ha	ha	m	m	m3/sec/ha	ha	ha	m3/sec			m3/sec	m3/sec	m3/sec	m3/sec	mm	‰	m/sec	m3/sec	M	M	m	
N 1-11	N 1-14	5360	5360	902	903							00312			00312	⊙ 300	300	0974	00689	1600 1070	14492 9391	720 900	
N 1-13		3580	3580	829	830							00208			00208	⊙ 250	320	0891	00437	1750 1070	15897 9442	635 900	
N 1-14		4420	20330	1027	2324							01183			01183	⊙ 1100	090	0976	09274	1070 1470	6512 5468	300 804	
N 1-15		1490	21820	622	2946							01270			01270	⊙ 1100	090	0976	09274	1470 1010	5448 4308	806 410	
N 1-16	N 1-18	1600	87770	962	6785							05107			05107	⊙ 1100	090	0976	09274	1010 770	5100 0112	781 640	
N 1-17		5360	5360	1082	1082							00312			00312	⊙ 300	300	0974	00689	1660 770	14914 6391	638 900	
N 1-18	N 1-22	1860	94990	543	7328							05527			05527	⊙ 1100	090	0976	09274	770 730	0092 -0456	642 657	
N 1-19	N 1-21	10160	10160	1283	1283							00591			00591	⊙ 450	230	0860	01367	1630 1010	14632 8612	718 900	
N 1-20		5130	5130	954	954							00298			00298	⊙ 300	300	0974	00689	1410 1010	12704 8791	609 900	
N 1-21		4720	20010	901	2185							01164			01164	⊙ 1100	090	0976	09274	1010 730	9628 3112	328 300	
N 1-22	N 1-28	100	115100	98	7426							06697			06697	⊙ 1200	090	1034	11696	730 720	-0556 -0645	656 655	

Table H.5 Flow Calculation of Trunk Main, N1 Sewerage Zone (3/6)

Flow Calculation N1

P 3

Wastewater unit flow per ha: 0.0005818 m3/sec/ha

Pipe No.	Lower Pipe No.	Drainage Area		Length			Stormwater Runoff				Sanitary Wastewater				Others		TOTAL	Design Sewer Pipe							Remarks
		Each	Total	Each	Longest		Rainfall per ha		Coversion Area		Stormwater		Population		Wastewater	Each	Total		Dia.	Gradient	Velocity	Flow	G.L.	Invert	Covering	
									Each	Total			Each	Total												
		ha	ha	m	m		m3/sec/ha		ha	ha	m3/sec				m3/sec	m3/sec	m3/sec	m3/sec	mm	%	m/sec	m3/sec	M	M	m	
N 1-24	N 1-25	6310	6310	423	423										00390			00390	⊙ 400	260	0845	01062	1670	14264	200	
																							960	8165	400	
N 1-23		3290	3290	385	386										00191			00191	⊙ 250	320	0891	00437	1070	9442	200	
																							960	8106	224	
N 1-25	N 1-27	4060	14060	700	1124										00818			00818	⊙ 700	440	0900	03465	960	5752	309	
																							790	4142	300	
N 1-26		2580	2580	675	676										00150			00150	⊙ 250	320	0891	00437	1730	15318	172	
																							790	6642	400	
N 1-27		2280	18920	236	1361										01101			01101	⊙ 700	440	0900	03465	790	4019	312	
																							720	3442	300	
N 1-28	N 1-41	1820	135840	770	8197										07903			07903	⊙ 1350	080	1055	15096	720	-0795	654	
																							570	-1513	576	
N 1-30	N 1-31	7060	7060	553	553										00411			00411	⊙ 400	260	0845	01062	620	4765	400	
																							670	3186	308	
N 1-29		3850	3850	356	356										00224			00224	⊙ 300	300	0974	00689	580	4491	400	
																							670	3341	305	
N 1-31		7760	18670	486	1040										01086			01086	⊙ 1100	090	0976	09274	670	2486	303	
																							670	1990	352	
N 1-32		8990	27660	515	1555										01609			01609	⊙ 1100	090	0976	09274	670	1970	354	
																							760	1446	497	
N 1-33	N 1-36	9590	37250	703	2259										02167			02167	⊙ 1100	090	0976	09274	760	1426	499	
																							800	0711	610	

Table H.5 Flow Calculation of Trunk Main, N1 Sewerage Zone (4/6)

Flow Calculation N1 P 4

Wastewater unit flow per ha: 0.0005818m3/sec/ha

Pipe No.	Lower Pipe No.	Drainage Area		Length		Stormwater Runoff				Sanitary Wastewater				Others		TOTAL	Design Sewer Pipe							Remarks
		Each	Total	Each	Longest	Rainfall per ha	Coversion Area Each	Coversion Area Total	Stormwater	Population Each	Population Total	Wastewater	Each	Total		Dia.	Gradient	Velocity	Flow	G.L.	Invert	Covering	
		ha	ha	m	m	m3/sec/ha	ha	ha	m3/sec			m3/sec	m3/sec	m3/sec	m3/sec	mm	‰	m/sec	m3/sec	M	M	m	
N 1-35	N 1-36	7050	7050	869	870							00410			00410	⊙ 400	260	0845	01062	620 800	4765 2290	500 528	
N 1-34		5690	5690	779	780							00331			00331	⊙ 300	300	0974	00689	1040 800	9086 6543	501 515	
N 1-36	N 1-38	3490	53480	651	2910							03112			03112	⊙ 1100	090	0976	09274	800 910	0691 0026	612 289	
N 1-37		7050	7050	953	954							00410			00410	⊙ 400	260	0845	01062	610 910	4665 1943	500 672	
N 1-38	N 1-40	7130	67660	907	3817							03937			03937	⊙ 1100	090	0976	09274	910 690	0006 -0932	791 664	
N 1-39		5480	5480	258	259							00319			00319	⊙ 300	300	0974	00689	790 690	6535 5591	506 500	
N 1-40		5950	79090	1071	4888							04602			04602	⊙ 1100	090	0976	09274	690 570	-0952 -2060	666 657	
N 1-41	N 1-57	5430	220360	668	8865							12821			12821	⊙ 1650	070	1128	24115	570 480	-2610 -3138	654 617	
N 1-42		6950	6950	743	743							00381			00381	⊙ 350	280	0802	00772	2080 930	18477 7918	594 500	
N 1-43		9270	15820	783	1527							00920			00920	⊙ 600	460	0869	02456	930 620	9419 3550	323 300	
N 1-44	N 1-47	7780	23600	692	2220							01373			01373	⊙ 700	240	0900	03465	620 630	2442 1350	300 419	

Table H.5 Flow Calculation of Trunk Main, N1 Sewerage Zone (5/6)

Flow Calculation N1

P 5

Wastewater unit flow per ha: 0.0005818 m3/sec/ha

Pipe No.	Lower Pipe No.	Drainage Area		Length		Stormwater Runoff				Sanitary Wastewater				Others		TOTAL	Design Sewer Pipe							Remarks
		Each	Total	Each	Longest	Rainfall per ha	Coversion Area Each	Coversion Area Total	Stormwater	Population Each	Population Total	Wastewater	Each	Total		Dia.	Gradient	Velocity	Flow	G.L.	Invert	Covering		
		ha	ha	m	m	m3/sec/ha	ha	ha	m3/sec			m3/sec	m3/sec	m3/sec	m3/sec	mm	‰	m/sec	m3/sec	M	M	m		
N 1-46	N 1-47	5750	5750	480	481							00335			00335	⊙ 300	300	0974	00689	620	4891	500		
																				630	3330	266		
N 1-45		5970	5970	475	475							00324			00324	⊙ 300	300	0974	00689	870	7252	614		
																				630	4991	500		
N 1-47		6320	41240	866	3086							02399			02399	⊙ 1100	090	0976	09274	630	0950	416		
																				410	-0088	300		
N 1-48	N 1-53	4080	45320	638	3725							02637			02637	⊙ 1100	090	0976	09274	410	-0108	302		
																				350	-0763	308		
N 1-49	N 1-51	4740	4740	713	713							00276			00276	⊙ 300	300	0974	00689	400	2691	500		
																				290	0370	222		
N 1-50		5860	5860	693	694							00341			00341	⊙ 300	300	0974	00689	290	1591	500		
																				290	-0668	326		
N 1-51	N 1-53	5620	16220	610	1323							00944			00944	⊙ 600	060	0869	02456	290	-0968	322		
																				350	-2062	491		
N 1-52		2320	2320	549	549							00135			00135	⊙ 250	320	0891	00437	340	2142	500		
																				350	0243	300		
N 1-53	N 1-55	6050	69910	893	4619							04067			04067	⊙ 1100	090	0976	09274	550	-2562	487		
																				370	-3466	598		
N 1-54		9770	9770	1023	1023							00568			00568	⊙ 450	230	0860	01367	430	2812	500		
																				370	0200	301		
N 1-55		7890	87970	899	5519							05095			05095	⊙ 1100	090	0976	09274	370	-3486	600		
																				400	-4396	721		

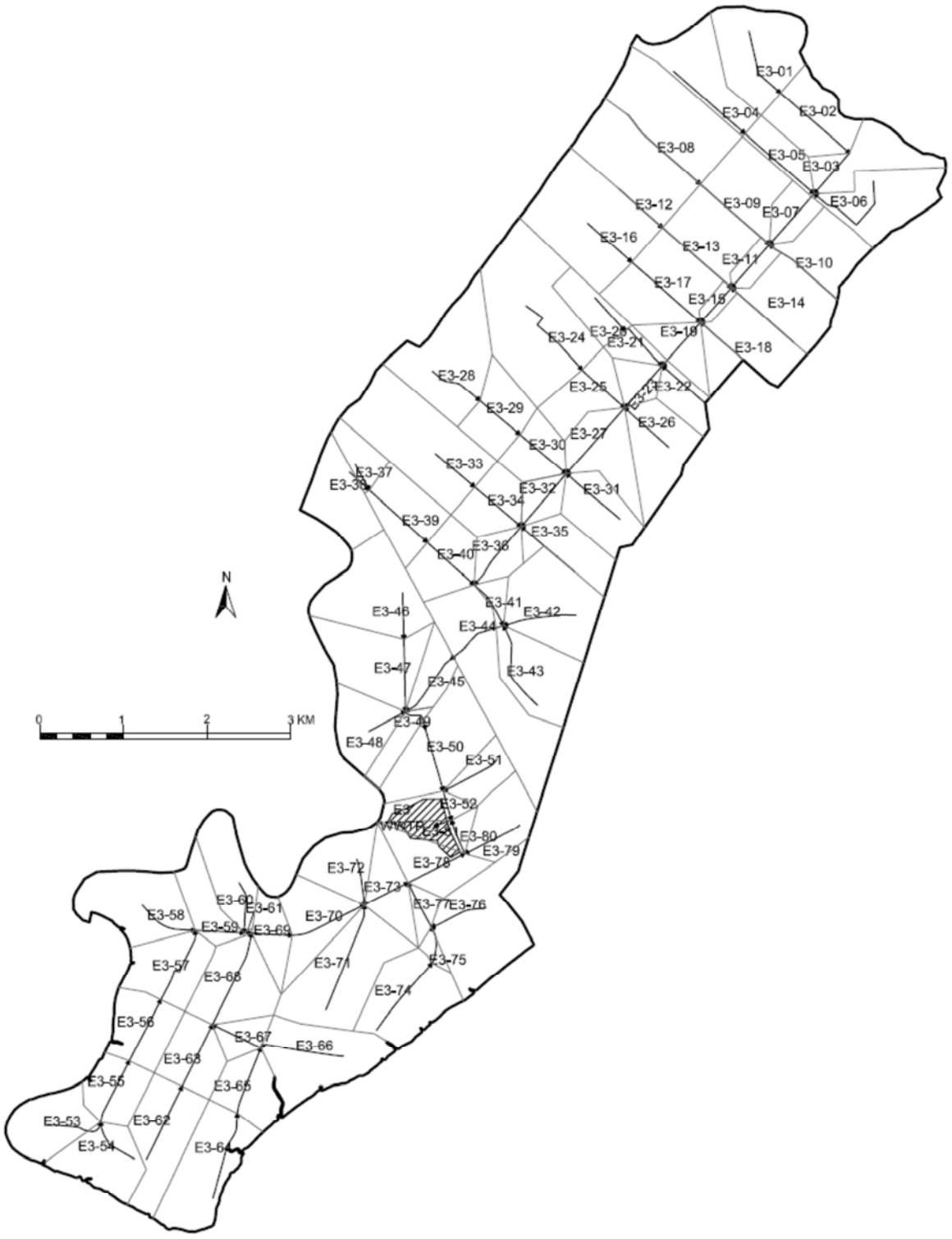
Table H.5 Flow Calculation of Trunk Main, N1 Sewerage Zone (6/6)

Flow Calculation N1

P 6

Wastewater unit flow per ha: 0.0005818l/m3/sec/ha

Pipe No.	Lower Pipe No.	Drainage Area		Length		Stormwater Runoff				Sanitary Wastewater				Others		TOTAL	Design Sewer Pipe							Remarks
		Each	Total	Each	Longest	Rainfall per ha	Coversion Area Each	Coversion Area Total	Stormwater	Population Each	Population Total	Wastewater	Each	Total		Dia.	Gradient	Velocity	Flow	G.L.	Invert	Covering	
		ha	ha	m	m	m3/sec/ha	ha	ha	m3/sec			m3/sec	m3/sec	m3/sec	m3/sec	mm	‰	m/sec	m3/sec	M	M	m	
N 1-56		8370	95940	655	6174							05582			05582	⊙ 1100	090	0976	09274	480	-5086	870	
																				400	-4416	723	
N 1-57			316300	235	9101							18403			18403	⊙ 1650	070	1128	24115	480	-5636	867	
																				400	-5820	805	



Source: JICA Study Team

Figure H.6 Layout Plan of Trunk Main, E3 Sewerage Zone

Table H.6 Flow Calculation of Trunk Main, E3 Sewerage Zone (1/8)

Flow Calculation E3

P 1

Wastewater unit flow per ha: 0.00084595m3/sec/ha

Pipe No.	Lower Pipe No.	Drainage Area		Length		Stormwater Runoff				Sanitary Wastewater				Others		TOTAL	Design Sewer Pipe							Remarks
		Each	Total	Each	Longest	Rainfall per ha	Coversion Area Each	Coversion Area Total	Stormwater	Population Each	Population Total	Wastewater	Each	Total		Dia.	Gradient	Velocity	Flow	G.L.	Invert	Covering	
		ha	ha	m	m	m3/sec/ha	ha	ha	m3/sec			m3/sec	m3/sec	m3/sec	m3/sec	mm	‰	m/sec	m3/sec	M	M	m	
E3-1		10920	10920	869	869							00924			00924	⊙ 600	160	0869	02456	770	4050	300	
																				770	3496	455	
E3-2		7550	18470	1092	1962							01562			01562	⊙ 700	140	0900	03465	770	3396	455	
																				730	0666	588	
E3-3	E3-7	6800	25270	664	2627							02138			02138	⊙ 700	140	0900	03465	730	0646	590	
																				690	-0405	655	
E3-4		7850	7850	1137	1138							00664			00664	⊙ 450	230	0860	01367	790	6412	400	
																				730	3488	332	
E3-5	E3-7	3370	11220	1095	2234							00949			00949	⊙ 600	160	0869	02456	730	3338	331	
																				690	1388	486	
E3-6		8850	8850	1239	1239							00749			00749	⊙ 500	200	0860	01689	690	3358	300	
																				690	0635	572	
E3-7	E 3-11	3080	48420	808	3435							04096			04096	⊙ 1000	100	0965	07582	690	-0705	652	
																				650	-1675	709	
E3-8		12650	12650	1210	1211							01070			01070	⊙ 600	160	0869	02456	790	4250	300	
																				630	2072	358	
E3-9	E 3-11	7040	19690	1096	2307							01666			01666	⊙ 700	140	0900	03465	630	1972	357	
																				650	0242	550	
E 3-10		6290	6290	1050	1050							00532			00532	⊙ 450	230	0860	01367	590	4412	300	
																				650	1717	430	
E 3-11	E 3-15	1980	76380	688	4124							06461			06461	⊙ 1200	090	1034	11696	650	-1875	708	
																				540	-2575	668	

Table H.6 Flow Calculation of Trunk Main, E3 Sewerage Zone (2/8)

Flow Calculation E3

P 2

Wastewater unit flow per ha: 0.00084595m3/sec/ha

Pipe No.	Lower Pipe No.	Drainage Area		Length		Stormwater Runoff					Sanitary Wastewater				Others		TOTAL	Design Sewer Pipe							Remarks
		Each	Total	Each	Longest	Rainfall per ha		Coversion Area		Stormwater		Population		Wastewater	Each	Total		Dia.	Gradient	Velocity	Flow	G.L.	Invert	Covering	
								Each	Total			Each	Total												
		ha	ha	m	m	m3/sec/ha		ha	ha	m3/sec				m3/sec	m3/sec	m3/sec	m3/sec	mm	‰	m/sec	m3/sec	M	M	m	
E 3-12		11070	11070	706	706									00936			00936	⊙ 600	160	0869	02456	750	3841	301	
																						630	3573	308	
E 3-13	E 3-15	7060	18130	1096	1802									01534			01534	⊙ 700	140	0900	03465	630	3473	307	
																						540	0743	390	
E 3-14		7820	7820	997	997									00662			00662	⊙ 450	230	0860	01367	650	5012	400	
																						540	3455	346	
E 3-15	E 3-19	1120	103450	556	4680									08751			08751	⊙ 1350	080	1055	15096	540	-2725	667	
																						570	-3229	748	
E 3-16		15800	15800	707	708									01337			01337	⊙ 700	140	0900	03465	650	3716	303	
																						630	3542	300	
E 3-17	E 3-19	10600	26400	1094	1802									02233			02233	⊙ 700	140	0900	03465	630	3522	302	
																						570	0793	415	
E 3-18		6540	6540	994	994									00553			00553	⊙ 450	230	0860	01367	680	5312	400	
																						570	2770	244	
E 3-19	E 3-23	4050	140440	692	5372									11881			11881	⊙ 1500	070	1058	18702	570	-3379	747	
																						520	-3944	753	
E 3-20		3880	3880	541	541									00328			00328	⊙ 300	300	0974	00689	630	4991	400	
																						560	3228	206	
E 3-21	E 3-23	1960	5840	541	1082									00494			00494	⊙ 400	260	0845	01062	560	3128	204	
																						520	1581	318	
E 3-22		3220	3220	683	683									00272			00272	⊙ 300	300	0974	00689	520	3891	400	
																						520	1660	323	

Table H.6 Flow Calculation of Trunk Main, E3 Sewerage Zone (3/8)

Flow Calculation E3

P 3

Wastewater unit flow per ha: 0.00084595m3/sec/ha

Pipe No.	Lower Pipe No.	Drainage Area		Length			Stormwater Runoff				Sanitary Wastewater				Others		TOTAL	Design Sewer Pipe							Remarks
		Each	Total	Each	Longest		Rainfall per ha		Coversion Area		Stormwater		Population		Wastewater	Each	Total		Dia.	Gra-dient	Velocity	Flow	G.L.	Invert	Cove-ring	
									Each	Total			Each	Total												
		ha	ha	m	m		m3/sec/ha		ha	ha	m3/sec				m3/sec	m3/sec	m3/sec	m3/sec	mm	‰	m/sec	m3/sec	M	M	m	
E 3-23	E 3-27	2560	152060	677	6049										12864			12864	⊙ 1650	070	1128	24115	520 580	-8094 -4629	752 866	
E 3-24		19530	19530	1118	1119										01652			01652	⊙ 700	140	0900	03465	630 600	2542 0761	300 448	
E 3-25	E 3-27	5550	25080	683	1803										02122			02122	⊙ 700	140	0900	03465	600 580	0741 -0338	450 538	
E 3-26		8020	8020	708	708										00678			00678	⊙ 450	230	0860	01367	900 580	3512 1702	700 361	
E 3-27	E 3-32	7050	192210	1053	7103										16260			16260	⊙ 1650	070	1128	24115	580 640	-4649 -5487	868 1012	
E 3-28		12310	12310	689	690										01041			01041	⊙ 600	160	0869	02456	630 690	2650 1424	300 483	
E 3-29		6040	18350	625	1315										01552			01552	⊙ 700	140	0900	03465	690 620	1324 0329	482 511	
E 3-30	E 3-32	4510	22860	725	2040										01934			01934	⊙ 700	140	0900	03465	620 640	0309 -0846	513 649	
E 3-31		6390	6390	844	845										00541			00541	⊙ 450	230	0860	01367	730 640	5812 3648	600 226	
E 3-32	E 3-36	2570	224030	832	7935										18952			18952	⊙ 1650	070	1128	24115	640 640	-9507 -6172	1014 1080	
E 3-33		15600	15600	619	619										01320			01320	⊙ 700	140	0900	03465	660 620	2842 1854	300 359	

Table H.6 Flow Calculation of Trunk Main, E3 Sewerage Zone (4/8)

Flow Calculation E3

P 4

Wastewater unit flow per ha: 0.00084595m3/min/ha

Pipe No.	Lower Pipe No.	Drainage Area Each	Drainage Area Total	Length Each	Length Longest	Stormwater Runoff Rainfall per ha	Stormwater Runoff Coversion Area Each	Stormwater Runoff Coversion Area Total	Stormwater Runoff Stormwater	Sanitary Wastewater Population Each	Sanitary Wastewater Population Total	Sanitary Wastewater Wastewater	Others Each	Others Total	TOTAL	Design Sewer Pipe Dia.	Gradient	Velocity	Flow	G.L.	Invert	Covering	Remarks
		ha	ha	m	m	m3/sec/ha	ha	ha	m3/sec			m3/sec	m3/sec	m3/sec	m3/sec	mm	‰	m/sec	m3/sec	M	M	m	
E 3-34	E 3-36	5100	20700	729	1349							01751			01751	⊙ 700	140	0900	03465	620	1834	361	
																				640	0670	497	
E 3-35		5490	5490	844	844							00464			00464	⊙ 400	260	0845	01062	650	5065	100	
																				640	2651	331	
E 3-36	E 3-41	3220	253440	898	8834							21440			21440	⊙ 1800	070	1195	30412	640	-6322	1080	
																				630	-7032	1141	
E 3-37	E 3-39	2850	2850	352	352							00241			00241	⊙ 300	300	0974	00689	630	4991	100	
																				680	3856	264	
E 3-38		6960	6960	323	323							00589			00589	⊙ 450	230	0860	01367	650	5012	100	
																				680	4187	213	
E 3-39		6690	16500	931	1284							01396			01396	⊙ 1100	090	0976	09274	680	2612	300	
																				650	1652	366	
E 3-40		5850	22350	755	2040							01891			01891	⊙ 1100	090	0976	09274	650	1632	368	
																				630	0854	426	
E 3-41	E 3-44	1320	277110	612	9447							23442			23442	⊙ 1800	070	1195	30412	630	-7052	1143	
																				730	-7540	1291	
E 3-43	E 3-44	8110	8110	1102	1102							00686			00686	⊙ 500	200	0860	01689	720	3658	300	
																				730	1230	553	
E 3-42		10920	10920	878	879							00924			00924	⊙ 600	160	0869	02456	610	3450	300	
																				730	0885	577	
E 3-44		14640	310780	764	10211							26290			26290	⊙ 2000	070	1282	40278	730	-7740	1290	
																				680	-8336	1299	

Table H.6 Flow Calculation of Trunk Main, E3 Sewerage Zone (5/8)

Flow Calculation E3

P 5

Wastewater unit flow per ha: 0.00084595m3/sec/ha

Pipe No.	Lower Pipe No.	Drainage Area		Length		Stormwater Runoff					Sanitary Wastewater				Others		TOTAL	Design Sewer Pipe							Remarks
		Each	Total	Each	Longest	Rainfall per ha		Coversion Area		Stormwater	Population		Wastewater		Each	Total		Dia.	Gradient	Velocity	Flow	G.L.	Invert	Covering	
								Each	Total		Each	Total													
		ha	ha	m	m	m3/sec/ha		ha	ha	m3/sec			m3/sec		m3/sec	m3/sec	m3/sec	mm	‰	m/sec	m3/sec	M	M	m	
E 3-45	E 3-49	3.400	31.4180	846	1105.8								2.6578				2.6578	⊙ 2000	0.70	1.282	4.0278	6.80	-8.356	13.01	
																						7.60	-9.031	14.49	
E 3-46		11.310	11.310	564	565								0.0957				0.0957	⊙ 600	1.60	0.869	0.2456	6.50	2.850	3.00	
																						6.80	1.845	4.31	
E 3-47	E 3-49	9.550	20.860	865	1430								0.1765				0.1765	⊙ 700	1.40	0.900	0.3465	6.80	1.745	4.30	
																						7.60	0.371	6.47	
E 3-48		5.720	5.720	498	499								0.0484				0.0484	⊙ 400	2.60	0.845	0.1062	7.90	6.465	1.00	
																						7.60	5.049	2.12	
E 3-49		2.550	34.3310	376	1143.4								2.9042				2.9042	⊙ 2000	0.70	1.282	4.0278	7.60	-9.051	14.51	
																						7.20	-9.335	14.39	
E 3-50	E 3-52	10.990	35.4390	773	1220.8								2.9972				2.9972	⊙ 2000	0.70	1.282	4.0278	7.20	-9.355	14.41	
																						7.00	-9.955	14.81	
E 3-51		3.530	3.530	751	751								0.0299				0.0299	⊙ 300	3.00	0.974	0.0689	7.20	5.891	1.00	
																						7.00	3.436	3.26	
E 3-52	E 3-81	3.050	36.0880	358	1256.7								3.0529				3.0529	⊙ 2000	0.70	1.282	4.0278	7.00	-9.975	14.83	
																						7.20	-10.247	15.30	
E 3-53	E 3-55	6.800	6.800	720	721								0.0575				0.0575	⊙ 450	2.30	0.860	0.1367	5.80	4.312	1.00	
																						5.80	3.473	2.84	
E 3-54		6.960	6.960	645	645								0.0589				0.0589	⊙ 450	2.30	0.860	0.1367	6.60	5.112	1.00	
																						5.80	3.468	2.84	
E 3-55		6.340	20.100	812	1533								1.700				1.700	⊙ 700	1.40	0.900	0.3465	5.80	2.042	3.00	
																						3.90	0.748	4.39	

Table H.6 Flow Calculation of Trunk Main, E3 Sewerage Zone (6/8)

Flow Calculation E3

P 6

Wastewater unit flow per ha: 0.00084595m3/sec/ha

Pipe No.	Lower Pipe No.	Drainage Area		Length		Stormwater Runoff					Sanitary Wastewater				Others		TOTAL	Design Sewer Pipe							Remarks
		Each	Total	Each	Longest	Rainfall per ha		Coversion Area		Stormwater	Population		Wastewater		Each	Total		Dia.	Gra-dient	Velocity	Flow	G.L.	Invert	Cove-ring	
								Each	Total		Each	Total													
		ha	ha	m	m	m3/sec/ha		ha	ha	m3/sec			m3/sec		m3/sec	m3/sec	m3/sec	mm	‰	m/sec	m3/sec	M	M	m	
E 3-56		7110	27210	829	2362								02302				02302	⊙ 700	140	0900	03465	590 650	0728 -0594	441 634	
E 3-57	E 3-59	7110	34320	988	3351								02903				02903	⊙ 800	120	0911	04581	650 680	-0694 -2064	633 800	
E 3-58		9640	9640	743	743								00815				00815	⊙ 500	300	0860	01689	730 680	3758 2130	300 413	
E 3-59	E 3-61	4510	48470	586	3937								04100				04100	⊙ 1000	100	0965	07582	680 660	-2264 -2952	798 847	
E 3-60		6430	6430	626	627								00544				00544	⊙ 450	230	0860	01367	620 660	4712 3111	300 300	
E 3-61	E 3-69	050	54950	276	4213								04648				04648	⊙ 1000	100	0965	07582	660 640	-2972 -3288	849 861	
E 3-64		10450	10450	1071	1072								00884				00884	⊙ 600	160	0869	02456	640 640	2750 0834	300 492	
E 3-65	E 3-67	5450	15900	453	1525								01345				01345	⊙ 700	140	0900	03465	640 690	0734 0019	491 612	
E 3-66		10940	10940	1016	1016								00925				00925	⊙ 600	160	0869	02456	780 690	4150 2323	300 393	
E 3-67	E 3-68	2560	29400	644	2169								02487				02487	⊙ 800	120	0911	04581	690 620	-0081 -0977	612 631	
E 3-62		9290	9290	975	975								00786				00786	⊙ 500	200	0860	01689	520 360	1658 -0472	300 353	

Table H.6 Flow Calculation of Trunk Main, E3 Sewerage Zone (7/8)

Flow Calculation E3

P 7

Wastewater unit flow per ha: 0.00084595m3/sec/ha

Pipe No.	Lower Pipe No.	Drainage Area		Length		Stormwater Runoff					Sanitary Wastewater				Others		TOTAL	Design Sewer Pipe							Remarks
		Each	Total	Each	Longest	Rainfall per ha		Coversion Area		Stormwater	Population		Wastewater		Each	Total		Dia.	Gra-dient	Velocity	Flow	G.L.	Invert	Cove-ring	
								Each	Total		Each	Total													
		ha	ha	m	m	m3/sec/ha		ha	ha	m3/sec			m3/sec		m3/sec	m3/sec	m3/sec	mm	‰	m/sec	m3/sec	M	M	m	
E 3-63		5700	14990	827	1802								01268				01268	⊙ 700	140	0900	03465	560 620	-0672 -1993	551 744	
E 3-68		8460	52850	1202	3372								04471				04471	⊙ 1000	100	0965	07582	620 640	-2293 -3742	741 906	
E 3-69		3670	111470	484	4697								09430				09430	⊙ 1350	080	0955	15096	640 710	-4092 -4540	904 1019	
E 3-70	E 3-73	6900	118370	943	5641								10014				10014	⊙ 1350	080	0955	15096	710 770	-4560 -5436	1021 1168	
E 3-71	E 3-73	12760	12760	1352	1352								01079				01079	⊙ 600	160	0869	02456	600 770	2350 -0079	300 713	
E 3-72		5740	5740	556	556								00486				00486	⊙ 400	260	0845	01062	690 770	5465 3877	600 339	
E 3-73	E 3-78	4830	141700	587	6229								11987				11987	⊙ 1500	070	1058	18702	770 710	-9586 -6058	1867 1155	
E 3-74		9560	9560	1047	1047								00809				00809	⊙ 500	200	0860	01689	720 800	3658 1367	300 609	
E 3-75	E 3-77	860	10420	453	1501								00881				00881	⊙ 600	160	0869	02456	800 670	1267 0462	608 559	
E 3-76		12640	12640	702	702								01069				01069	⊙ 600	160	0869	02456	720 670	3550 2290	300 376	
E 3-77		1650	24720	600	2101								02091				02091	⊙ 700	140	0900	03465	670 710	0362 -0598	558 694	
E 3-78	E 3-80	5830	172250	759	5988								14571				14571	⊙ 1650	070	1128	24115	710 750	-6208 -6800	1154 1253	

Table H.6 Flow Calculation of Trunk Main, E3 Sewerage Zone (8/8)

Flow Calculation E3

P 8

Wastewater unit flow per ha: 0.00084595m3/sec/ha

Pipe No.	Lower Pipe No.	Drainage Area		Length			Stormwater Runoff					Sanitary Wastewater				Others		TOTAL	Design Sewer Pipe							Remarks
		Each	Total	Each	Longest		Rainfall per ha		Coversion Area		Stormwater		Population		Wastewater	Each	Total		Dia.	Gra-dient	Velocity	Flow	G.L.	Invert	Cove-ring	
									Each	Total			Each	Total												
		ha	ha	m	m		m3/sec/ha		ha	ha	m3/sec				m3/sec	m3/sec	m3/sec	m3/sec	mm	‰	m/sec	m3/sec	M	M	m	
E 3-79		5920	5920	743	743										00501			00501	⊙ 400	260	0845	01062	700	5565	600	
																							750	3454	361	
E 3-80		2750	180920	437	7426										15305			15305	⊙ 1650	070	1128	24115	750	-6820	1255	
																							720	-7166	1260	
E 3-81			541800	216	12783										45834			45834	⊙ 2400	070	1448	65497	720	-10647	1527	
																							690	-10819	1514	

I. DESIGN CALCULATION OF WWTP

Table I.1 Design Calculation of C1 WWTP (1/16)

1 BASIC CONDITIONS

1-1 Basic Items

(1) Name : **C1 WWTP**

(2) Land Area : Approximately xxxx ha

(3) Ground Level (Elevatio : + 4.50 m

(4) Inlet Pipe Invert Level : - 6.80 m

(5) Pipe Diameter : 1,500 mm

(6) Land Use : —

(7) Collection System : ~~Combined System~~ Separate System

(8) Treatment Process : Conventional Activated Sludge Process

(9) Effluent Point : Yangon River

(10) Water Level at the Effluent Poi :
High water leve = 3.70 m
Low water leve = — m

(11) Target Year : 2020 (F/S Stage)
2040 (M/P Stage)

1-2 Service Area and Design Population

(1) Service Area : 499 ha

(2) Design Population

Item		Year 2020	Year 2040
Design Population	person	-	178,000

Table I.1 Design Calculation of C1 WWTP (2/16)

1-3 Design Sewage Flow

(Year 2020)

Item	m^3/day	m^3/hr	m^3/min	m^3/sec
Maximum Daily Flow		0.0	0.00	0.000
Maximum Hourly Flow	0	0.0	0.00	0.000

(Year 2040)

Item	m^3/day	m^3/hr	m^3/min	m^3/sec
Maximum Daily Flow	70,200	2,925.0	48.75	0.813
Maximum Hourly Flow	102,900	4,287.5	71.46	1.191

1-4 Design Sewage Quality

Item	BOD	SS	T-N	Coli-group	Oil&Greese
	(mg/l)	(mg/l)	(mg/l)	(MPN/cm^3)	(mg/l)
Influent	200	180	-	-	-
Effluent	20	30	-	3,000	5

1-5 Process Flow Diagram

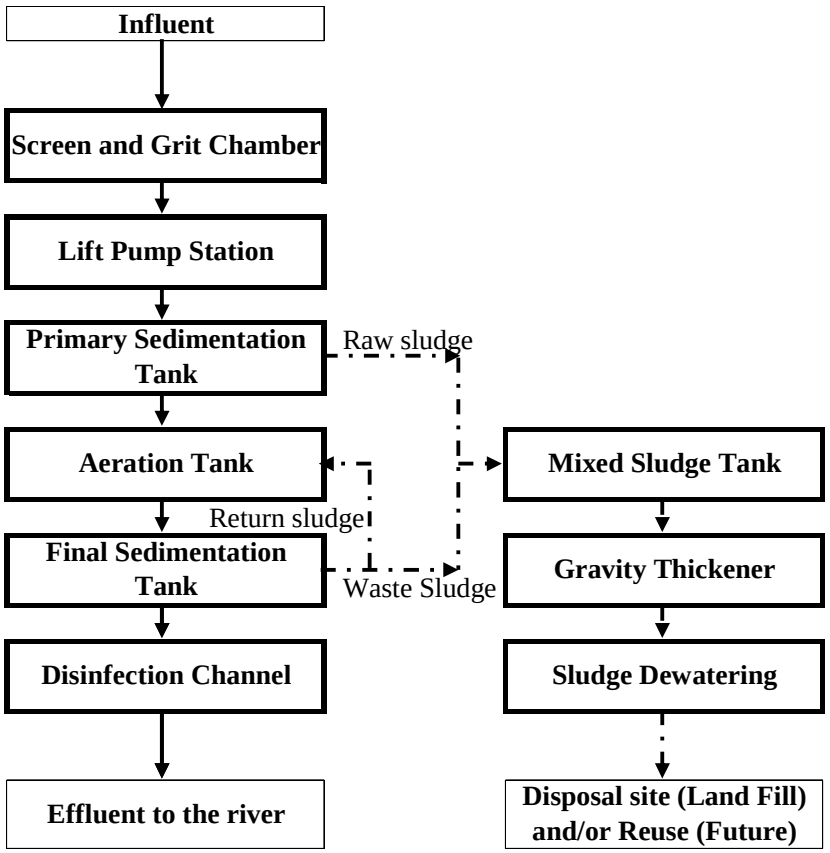


Table I.1 Design Calculation of C1 WWTP (3/16)

1.6 Design Criteria

ITEMS	UNIT	Formula or Value	Application
1 Grit Chamber (For Maximum Hourly Flow)			
(1) Hydraulic Load	$m^3/m^2/day$	1,800	1,800
(2) Average Velocity	m/sec	0.3	0.3
2 Primary Sedimentation Tank (For Maximum Daily Flow)			
(1) Hydraulic Load	$m^3/m^2/day$	35.0-70.0	50
(2) Settling Time (Ref.)	hour	1.5	1.5
(3) Water Depth	m	2.5-4.0	3.5
(4) Weir Loading	$m^3/m/day$	250	250
3 Aeration Tank (For Maximum Daily Flow)			
(1) Hydraulic Retention Time (HRT)	hour	6 - 8	6.0
(2) MLSS Concentration	mg/l	1,500 -2,000	2,000
(3) BOD-SS Load (Reference only)	kg/kg/day	0.2 - 0.4	-
4 Final Sedimentation Tank (For Maximum Daily Flow)			
(1) Hydraulic Load	$m^3/m^2/day$	20.0-30.0	25
(2) Settling Time (Ref.)	hour	3.0-4.0	-
(3) Water Depth	m	2.5-4.0	3.5
(4) Weir Loading	$m^3/m/day$	150	150
5 Disinfection Tank (For Maximum Daily Flow)			
(1) Retention (Chlorination) Time	min	15	15
6 Gravity Thickener (For Maximum Daily Flow)			
(1) Solids Loading	$kg/m^2/day$	60-90	75
(2) Water Depth	m		4.0

Table I.1 Design Calculation of C1 WWTP (4/16)

2 CAPACITY CALCULATION

2-1 Grit Chamber

Item	Sign	Unit	Calculation	F/S	M/P
Type	-	-	Parallel Flow Type		
Design Sewage Flow	Q1	m^3/day			102,900
(Maximum Hourly Flow)	Q2	m^3/sec			1.191
Water Surface Load	WSL	m^3/m^2/day			1,800
Required Surface Area	RSA	m^2	Q1/WSL		57.17
Basin Number	BN	basin			4
Average Velocity	AV	m/sec			0.3
Depth	H	m			0.9
Width	W1	m	Q2/(AV×H×BN)		1.10
Therefore	W2	m			1.1
Length	L1	m	RSA/(W2×BN)		12.99
Therefore	L2	m			13.0
Dimension (Width)	W	m			**1.1**
(Jength)	L	m	L2		**13.0**
(Depth)	H	m	H		**0.90**
(Basin Number)	N	basin			**4**
(Check)					
Water Surface Load		m^3/m^2/day	Q1/(W×L×N)		1,799
Average Velocity		m/sec	Q2/(W×H×N)		0.301

2-2 Lift Pump Station

Item	Sign	Unit	Calculation	F/S	M/P
Type	-	-	Vertical shaft Volute type mixed flow pump		
Design Sewage Flow	Q1	m^3/min	Peak Flow		71.46
Pump Unit -1 Number	UN1	unit	including 1 stand-by		4
Discharge per Unit	DU1	m^3/min	Q1/UN1		23.82
Pump Diameter(V=1.5~3.0m/s	D1	mm	$146\times(DU1/1.5\sim3.0)^{0.5}$		411 ~582
Therefore	D1	mm			500

Table I.1 Design Calculation of C1 WWTP (5/16)

2-3 Primary Sedimentation Tank

(1) Existing

Item	Sign	Unit	Calculation	F/S	M/P
Type	-	-	Parallel Flow Type		
Design Sewage Flow	Q1	m^3/day			20,000
(Maximum Daily Flow)	Q2	m^3/hr			833.3
Basin Number	BN	basin			2
Hydraulic Load	HL	m^3/m^2/day			50.0
Required Surface Area	A1	m^2	Q1/HL		400
	A2	m^2/basin	A1/BN		200
Width	W1	m	3.0m~4.0m, Max5.0m		7.3
Length	L1	m	A2/W1		27.40
Therefore	L2	m			27.4
Water Depth	WD	m			3.7
Overflow Weir Load	OWL	m^3/m/day			250
Required Weir Length	WL1	m/basin	Q1/(BN×OWL)		40.00
Therefore	WL2	m/basin			40.0
Dimension (Width)	W	m			**7.3**
(Depth)	D	m			**3.7**
(Length)	L	m			**27.4**
(Basin Number)	N	basin			**2**
(Check)					
Hydraulic Load	HL	m^3/m^2/day	Q1/(N×W×L)		50.00
Retention(Settling) Time	T	hour	(N×W×D×L)/Q2		1.75
Overflow Weir Load	OWL	m^3/m/day	Q1/(N×WL2)		250.00

Table I.1 Design Calculation of C1 WWTP (6/16)

Continuing Primary Sedimentation Tank
(2) Proposed-1

Item	Sign	Unit	Calculation	F/S	M/P
Type	-	-	Parallel Flow Type		
Design Sewage Flow	Q1	m^3/day			25,400
(Maximum Daily Flow)	Q2	m^3/hr			1,058.3
Basin Number	BN	basin			6
Hydraulic Load	HL	m^3/m^2/day			50.0
Required Surface Area	A1	m^2	Q1/HL		508
	A2	m^2/basin	A1/BN		85
Width	W1	m	3.0m~4.0m, Max5.0m		3.5
Length	L1	m	A2/W1		24.19
Therefore	L2	m			24.0
Water Depth	WD	m			3.0
Overflow Weir Load	OWL	m^3/m/day			250
Required Weir Length	WL1	m/basin	Q1/(BN×OWL)		16.93
Therefore	WL2	m/basin			17.0
Dimension (Width)	W	m			**3.5**
(Depth)	D	m			**3.0**
(Length)	L	m			**24.0**
(Basin Number)	N	basin			**6**
(Check)					
Hydraulic Load	HL	m^3/m^2/day	Q1/(N×W×L)		50.40
Retention(Settling) Time	T	hour	(N×W×D×L)/Q2		1.43
Overflow Weir Load	OWL	m^3/m/day	Q1/(N×WL2)		249.02

Table I.1 Design Calculation of C1 WWTP (7/16)

Continuing Primary Sedimentation Tank
(3) Proposed-2

Item	Sign	Unit	Calculation	F/S	M/P
Type	-	-	Parallel Flow Type		
Design Sewage Flow	Q1	m^3/day			24,800
(Maximum Daily Flow)	Q2	m^3/hr			1,033.3
Basin Number	BN	basin			4
Hydraulic Load	HL	m^3/m^2/day			50.0
Required Surface Area	A1	m^2	Q1/HL		496
	A2	m^2/basin	A1/BN		124
Width	W1	m	3.0m~4.0m, Max5.0m		5.8
Length	L1	m	A2/W1		21.38
Therefore	L2	m			21.5
Water Depth	WD	m			3.0
Overflow Weir Load	OWL	m^3/m/day			250
Required Weir Length	WL1	m/basin	Q1/(BN×OWL)		24.80
Therefore	WL2	m/basin			25.0
Dimension (Width)	W	m			**5.8**
(Depth)	D	m			**3.0**
(Length)	L	m			**21.5**
(Basin Number)	N	basin			**4**
(Check)					
Hydraulic Load	HL	m^3/m^2/day	Q1/(N×W×L)		49.72
Retention(Settling) Time	T	hour	(N×W×D×L)/Q2		1.45
Overflow Weir Load	OWL	m^3/m/day	Q1/(N×WL2)		248.00

Table I.1 Design Calculation of C1 WWTP (8/16)

2-4 Aeration Tank

(1) Existing

Item	Sign	Unit	Calculation	F/S	M/P
Type	-	-	Multi-tank Complete mixing Type		
Design Sewage Flow	Q1	m^3/day			45,400
(Maximum Daily Flow)	Q2	m^3/hr			1,891.7
Hydraulic Retention Time	HRT	hr			6.0
Basin Number	BN	basin			2
Required Volume per basin	RV	m^3/basin	Q2×RT/BN		5,675
Width	W	m	1~2H		18.6
Water Depth	H	m	4.0m~6.0m		4.1
Length	L1	m	RV/(W×H)		74.4
Therefore	L2	m			74.4
Dimension (Width)	W	m			**18.6**
(Depth)	H	m			**4.1**
(Length)	L	m			**74.4**
(Basin Number)	N	basin			**2**
(Check)					
Hydraulic Retention Time	HRT	hour	W×H×L×N/Q2		6.0
BOD-SS load	BSS_L	kgBOD/kgSS/d	(Q1×BODin)/(W×H×L×N×Xa)		0.24
BOD_{in} : Inflow BOD Concentration			120 mg/L (Removal Rate in PST : 40%)		
Xa : MLSS Concentration			2,000 mg/L		
Aerobic Sludge Retention Time	ASRT	day	HRT/24×Xa / (a×S-BODin + b×SSin - c×HRT/24×Xa) =		4.738
$S\text{-}BOD_{ir}$: Inflow S-BOD Concentration			80 mg/L (S-BOD[Solved BOD]=BODin×0.6		
SS_{in} : Inflow SS Concentration			90 mg/L (Removal Rate in PST : 50%)		
a : Sludge converting ratio of solved BOI			0.5 mgMLSS/mgBOD (0.4~0.6)		
b : Sludge converting ratio of SS			0.95 mgMLSS/mgSS (0.9~1.0)		
c : Sludge reduction ratio caused by endogenous respiration			0.04 (1/day)(0.03~0.05)		
Effluent Quality (C-BOD)	EQ	mg/L	$10.42\times A\text{-}SRT^{(-0.519)}$ (15~20℃)		4.648
Water Temperature			20 ℃		
Effluent Water Quality (C=BOD Maximum)			EQ×3 20mg/l >		14
					-OK-

Table I.1 Design Calculation of C1 WWTP (9/16)

Continuing Aeration Tank
(2) Proposed

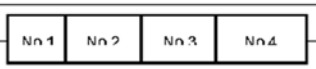
Item	Sign	Unit	Calculation	F/S	M/P
Type	-	-	Multi-tank Complete mixing Type		
Design Sewage Flow	Q1	m^3/day			24,800
(Maximum Daily Flow)	Q2	m^3/hr			1,033.3
Hydraulic Retention Time	HRT	hr			6.0
Basin Number	BN	basin			2
Required Volume per basin	RV	m^3/basin	Q2×RT/BN		3,100
Width	W	m	1~2H		12.0
Water Depth	H	m	4.0m~6.0m		5.5
Length	L1	m	RV/(W×H)		47.0
Therefore	L2	m			48.2
Dimension (Width)	W	m			**12.0**
(Depth)	H	m			**5.5**
(Length)	L	m			**48.2**
(Basin Number)	N	basin			**2**
(Check)					
Hydraulic Retention Time	HRT	hour	W×H×L×N/Q2		6.2
BOD-SS load	BSS_L	kgBOD/kgSS/d	(Q1×BODin)/(W×H×L×N×Xa)		0.23
BOD_{in} : Inflow BOD Concentration			120 mg/L (Removal Rate in PST : 40%)		
Xa : MLSS Concentration			2,000 mg/L		
Aerobic Sludge Retention Time	ASRT	day	HRT/24×Xa / (a×S-BODin + b×SSin - c×HRT/24×Xa) =		4.888
$S\text{-}BOD_{ir}$: Inflow S-BOD Concentration			80 mg/L (S-BOD[Solved BOD]=BODin×0.6		
SS_{in} : Inflow SS Concentration			90 mg/L (Removal Rate in PST : 50%)		
a : Sludge converting ratio of solved BOI			0.5 mgMLSS/mgBOD (0.4~0.6)		
b : Sludge converting ratio of SS			0.95 mgMLSS/mgSS (0.9~1.0)		
c : Sludge reduction ratio caused by endogenous respiration			0.04 (1/day)(0.03~0.05)		
Effluent Quality (C-BOD)	EQ	mg/L	$10.42\times A\text{-}SRT^{(-0.519)}$ (15~20℃)		4.573
Water Temperature			20 ℃		
Effluent Water Quality (C=BOD Maximum)			EQ×3 20mg/l >		14
					-OK-
			1 : 1.5 : 1.5 : 2.25		
Partition of Aeration Tank					
Total Length of Tank	TL	m			48.2
No.1 Tank Length	L1	m	TL×1/(1+1.5+1.5+2.25)		7.7
No.2 Tank Length	L2	m	TL×1.5/(1+1.5+1.5+2.25)		11.6
No.3 Tank Length	L3	m	TL×1.5/(1+1.5+1.5+2.25)		11.6
No.4 Tank Length	L4	m	TL×2.25/(1+1.5+1.5+2.25)		17.4
			Total		**48.3**

Table I.1 Design Calculation of C1 WWTP (10/16)

2-5 Final Sedimentation Tank

(1) Existing

Item	Sign	Unit	Calculation	F/S	M/P
Type	-	-	Radial flow circular type		
Design Sewage Flow	Q1	m^3/day			20,600
(Maximum Daily Flow)	Q2	m^3/hr			858.3
Basin Number	BN	basin			2
Hydraulic Load	HL	m^3/m^2/day			25.0
Required Surface Area	A1	m^2	Q1/HL		824
	A2	m^2/basin	A1/BN		412
Water Depth	WD	m			3.5
Diameter	D1	m	$(4\times A2/3.14)^{0.5}$		22.91
Therefore	D2	m			22.9
Overflow Weir Load	OWL	m^3/m/day			150
Required Weir Length	WL1	m/basin	Q1/(BN×OWL)		68.67
Therefore	WL2	m/basin			69.0
Dimension (Diameter)	D	m	D2		**22.9**
(Depth)	H	m	WD		**3.5**
(Basin Number)	N	basin	BN		**2**
(Check)					
Hydraulic Load	HL	m^3/m^2/day	$4\times Q1/(D^2\times 3.14\times N)$		25.02
Retention(Settling) Time	T	hour	$D^2\times\pi\times H\times N/(4\times Q2)$		3.36
Overflow Weir Load	OWL	m^3/m/day	Q1/(N×WL2)		149.28

Table I.1 Design Calculation of C1 WWTP (11/16)

Continuing Final Sedimentation Tank
(2) Proposed-1

Item	Sign	Unit	Calculation	F/S	M/P
Type	-	-	Radial flow circular type		
Design Sewage Flow	Q1	m^3/day			24,800
(Maximum Daily Flow)	Q2	m^3/hr			1,033.3
Basin Number	BN	basin			2
Hydraulic Load	HL	m^3/m^2/day			25.0
Required Surface Area	A1	m^2	Q1/HL		992
	A2	m^2/basin	A1/BN		496
Water Depth	WD	m			4
Diameter	D1	m	$(4\times A2/3.14)^{0.5}$		25.14
Therefore	D2	m			25.5
Overflow Weir Load	OWL	m^3/m/day			150
Required Weir Length	WL1	m/basin	Q1/(BN×OWL)		82.67
Therefore	WL2	m/basin			83.0
Dimension (Diameter)	D	m	D2		**25.5**
(Depth)	H	m	WD		**4.0**
(Basin Number)	N	basin	BN		**2**
(Check)					
Hydraulic Load	HL	m^3/m^2/day	$4\times Q1/(D^2\times 3.14\times N)$		24.29
Retention(Settling) Time	T	hour	$D^2\times\pi\times H\times N/(4\times Q2)$		3.95
Overflow Weir Load	OWL	m^3/m/day	Q1/(N×WL2)		149.40

Table I.1 Design Calculation of C1 WWTP (12/16)

Continuing Final Sedimentation Tank
(3) Proposed-2

Item	Sign	Unit	Calculation	F/S	M/P
Type	-	-	Parallel Flow Type		
Design Sewage Flow	Q1	m^3/day			24,800
(Maximum Daily Flow)	Q2	m^3/hr			1,033.3
Basin Number	BN	basin			4
Hydraulic Load	HL	m^3/m^2/day			25.0
Required Surface Area	A1	m^2	Q1/HL		992
	A2	m^2/basin	A1/BN		248
Width	W1	m	3.0m~4.0m, Max5.0m		5.8
Length	L1	m	A2/W1		42.76
Therefore	L2	m			43.5
Water Depth	WD	m			3.5
Overflow Weir Load	OWL	m^3/m/day			150
Required Weir Length	WL1	m/basin	Q1/(BN×OWL)		41.33
Therefore	WL2	m/basin			41.5
Dimension (Width)	W	m			**5.8**
(Depth)	D	m			**3.5**
(Length)	L	m			**43.5**
(Basin Number)	N	basin			**4**
(Check)					
Hydraulic Load	HL	m^3/m^2/day	Q1/(N×W×L)		24.57
Retention(Settling) Time	T	hour	(N×W×D×L)/Q2		3.42
Overflow Weir Load	OWL	m^3/m/day	Q1/(N×WL2)		149.40

Table I.1 Design Calculation of C1 WWTP (13/16)

2-6 Disinfection Channel

(1) Proposed

Item	Sign	Unit	Calculation	F/S	M/P
Type	-	-	Chlorination		
Design Sewage Flow	Q1	m^3/day			70,200
(Maximum Daily Flow)	Q2	m^3/min			48.75
Retention(Chlorination) Time	RT	min			15.0
Required Volume	RV	m^3	Q2×RT		731
Width of channel	W	m			2.5
Depth of channel	H	m			2.0
Pass Number	PN	pass			6
Length of channel	L1	m/pass	RV/(W×H×PN)		24.4
Therefore	L2	m/pass			24.5
Dimension (Width)	W	m			**2.5**
(Depth)	H	m			**2.0**
(Length)	L	m/pass			**24.5**
(Pass Number)	N	pass			**6**
(Check)					
Retention(Chlorination) Time	RT	min	(W×H×L×PN)/Q2		15.1

Table I.1 Design Calculation of C1 WWTP (14/16)

2-7 Sludge Thickening Tank

Item	Sign	Unit	Calculation	F/S	M/P
Type	-	-	Gravity Thickener (Radial Flow Circular Type)		
Generated Sludge Solids	GS	t-DS/day	Refer to Mass Balance Cal.		12.32
Generated Sludge Volume	GSV	m^3/day	Refer to Mass Balance Cal.		1,503
Solid Matter Load	SML	kg/m^2/day			75
Required Surface Area	SA	m^2	$(GS\times10^3)/SML$		164.3
Water Depth	H	m			4.1
Basin Number	BN	basin			2
Required Tank Diameter	TD1	m	$(SA\times4/(3.14\times BN))^{0.5}$		10.23
Therefore	TD2	m			10.5
Dimension (Diameter)	D	m/basin			**10.5**
(Depth)	H	m			**4.1**
(Basin Number)	BN	basin			**2**
(Check)					
Solid Matter Load	SML	kg/m^2/day	$GS\times10^3/(3.14\times D^2/4)\times BN$		71.2
Sludge Thickened Time	T	hr	$(3.14\times D^2/4)\times H\times BN\times24/GSV$		11.3

2-8 Sludge Dewatering

Item	Sign	Unit	Calculation	F/S	M/P
Type	-	-	Mechanical Dewatering (Screw Press Type)		
Thickened Sludge Solids	TS	t-DS/day	Refer to Material Balance		11.201
Unit Number	UN	Unit			4
Operating Day	OD	day(/week)			5.0
Operating Time	OT	hr/day			10.0
Required Dewatering Capacity	DC	kg/hr/unit	$TS\times10^3\times7/(OD\times OT\times UN)$		392.0
Solids Loading	Q_{100}	kg-ds/hr/φ100			3.0
Screnn Diameter	SD1	mm	$100\times(DC/Q_{100})\text{^}(1/2.2)$		916.0
Therefore	SD2	mm			800
Dimension (unit)	UN	Unit			**4**
(Screen Diameter)	SD	mm			**800**
(Check)					
Dewatering Capacity	DC	kg/hr/unit	$(SD/100)\text{^}2.2\times Q_{100}$		291.0
Operating Time	OT	hour/day	$TS\times10^3/(DC\times(UN-1))*(7/OT$		13.5

Table I.1 Design Calculation of C1 WWTP (15/16)

Material Balance Calculation (Primary and Secondary Sedimentation Tank + Thickening Tank + Mechanical Dewatering)

Table-1 Input Data

1. Calculation Manner		1	1:Premise that the quality of supernatants are same level removed with inlet sewage 2:Premise that the entire supernatants are removed at treatment process
2. Selection of Treatment Efficiency		2	1:Total Removal Ratio 2:Outlet Water Quality(input 1or2)
In case of 1 : input data		90	(%)
In case of 2 : input data		30	(mg/l)
3. Excess Sludge Generation		1	1:Consideration of Solid Matter Only 2:Consideration of Converting of Solved BOD (input 1or2)
In case of 1:Input data (Sludge generation)		100	Sludge generation ratio per removal SS(%)
In case of 2:Input data	a		T2=Q2*S2=(a*S_{BOD}+b*S1-c*θ*XA)*Q1/10^6 ' '(Excess sludge generation formula)
	b		a:Converting ratio of solved BOD(mgMLSS/mgBOD)
	c		b:Converting ratio of SS(mgMLSS/mgSS)
	SBOD		c:Sludge reduction ratio caused by endogenous respiration of activated sludge(1/day)
	XA		Sboo:Solved BOD quality at inlet to reactor
	θ		XA:MLSS concentration(mg/l)
			θ:Hydraulic retention time(day)

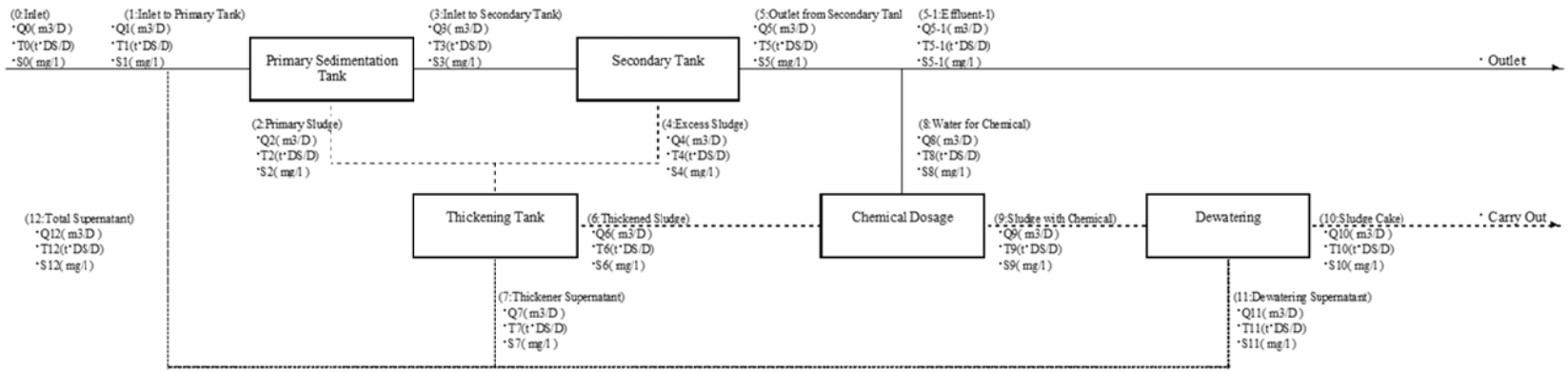
Table-2 Basic Conditions

Water Flow and Quality		Sludge Moisture and Recovery Ratio				Chemical Conditions for Dewatering	
*Inlet flow : Q0(m3/D)	70200	*Primary sludge moisture ratio : W1(%)	98.5	*Removal ratio in primary tank : A2(%)	50.0	*Chemical dosage : A5(%)	1.0
*Inlet quality : S0(mg/l)	180	*Excess sludge moisture ratio : W2(%)	99.5	*Recovery ratio in sludge thickener : A3(%)	90.0	*Chemical dissolve concentration : A6(%)	0.2
*Total removal ratio : A1(%)	-	*Thickened sludge moisture ratio : W3(%)	98.0	*Recovery ratio in dewatering : A4(%)	95.0		
*Effluent quality: St(mg/l)	30.0	*Dewatered sludge moisture ratio : W4(%)	80.0				
*Sludge generation ratio per removal SS : Si(%)	100.0						

Table-3 Material Balance Calculation

	0	1	2	3	4	5	6	7	8	9	10	11	12			5-1		
Q(m3/day)	70,200	71,705	481	71,224	1,022	70,202	554	948	55	610	53	557	1,505			70,147		
T (t*DS/day)	12.636	14.428	7.214	7.214	5.108	2.106	11.090	1.232	0.111	11.201	10.641	0.560	1.792			1.995		
S (mg/l)	180	201	15,000	101	5,000	30	20,000	1,300	2,000	18,364	200,000	1,006	1,191			30		
X (Ti/T0*100)	100	114.2	57.1	57.1	40.4	16.7	87.8	9.8	0.9	88.6	84.2	4.4	14.2			15.8		

Figure-1 Material Balance Model



Calculation Formula

*Q0=Input Data *T0=Q0*S0*10^(-6) *S0=Input Data	*Q3=Q1-Q2 *T3=T1*(100-A2)/100 *S3=T3*10^6/Q3	*Q6=T4*100/(100-W3) *T6=(T2+T4)*A3/100 *S6=10^6*(100-W3)/100	*Q9=Q6+Q8 *T9=T6+T8 *S9=T9*10^6/Q9	*Q12=Q7+Q11 *T12=T7+T11 *S11=T11*10^6/Q11	*Q5-1=Q5-Q8 *T5-1=T5-T8 *S5-1=S5
*Q1=Q0+Q13 *T1=T0+T13 *S1=T1*10^6/Q1	*Q4=(Q3*ST-T3*10^6)/(ST-S4)*T4/(T3-T5) *T4=((T1-T5)*Si/100)-T2 *S4=10^6*(100-W2)/100	*Q7=(Q2+Q4)-Q6 *T7=(T2+T4)-T6 *S7=T7*10^6/Q7	*Q10=T10*100/(100-W4) *T10=T9*A4/100 *S10=10^6*(100-W4)/100		
*Q2=T2*100/(100-W1) *T2=T1-T3 *S2=10^6*(100-W1)/100	*Q5=(T3*10^6-Q3*S4)/(ST-S4) *T5=Q5*ST/10^6 *S5=St	*Q8=T6*A5/A6 *T8=Q8*S8/10^6 *S8=10^4*A6	*Q11=Q9-Q10 *T11=T9-T10 *S11=T11*10^6/Q11		

Table I.1 Design Calculation of C1 WWTP (16/16)

Material Balance Sheet