3.2 Drainage Pipe System and Facilities

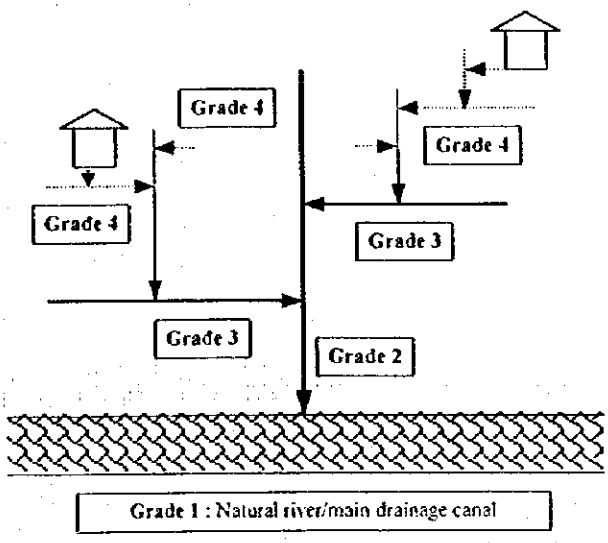
3.2.1 Combined Sewer System

First drainage pipe system was designed by French government and its construction was started in the beginning of the 1870s. Construction continued in stages since that time and centered on the old Saigon City area, in District 1 and 3. As reported in "Saigon Sewerage Feasibility Study" prepared by USAID and Ministry of Public Works (MPW), Vietnam in 1971, approximately 113 km length of main drainage pipe were installed in 1870s. Later, drainage pipe network was expanded to District 10 by American government in the 1960s. After the unification of the nation, the construction of drainage pipe network has continued since the early 1980s.

(1) Classification of Pipes

The existing drainage pipe network systems are classified into "3" Grades by UDC. The classification of "3" Grades was established to give priority in the drainage improvement and management plan. Definition of "3" Grades is described in the table and the schematic below. The definition is based on a hierarchy of branches of drainage pipe network but not the dimensions.

Classifi-cation	Definition
Grade 2 :	Main pipe receiving stormwater/wastewater from Grade 3 pipe and discharging directly into natural and main drainage channels (Grade 1).
Grade 3 :	Secondary pipe receiving stormwater/wastewater from Grade 4 pipe and discharging into Grade 2 pipe.
Grade 4 :	Tertiary pipe receiving stormwater/wastewater from houses and discharging into Grade 3 pipe.



The drainage pipes of Grade 2 and Grade 3 have been constructed by UDC and those of Grade 4 have been constructed by district offices.

(2) Cross-section of Pipes

In general, cross-sections of drainage pipe are classified into 3 types, which are horseshoe, circular and quadrilateral shaped ones. Furthermore, according to the typical cross-section, these are broken down into 12 types as presented in Fig. 3.5. At present, the cross-sections of Type-D and Type-F are employed for the drainage pipes by UDC and district offices respectively.

(3) Coverage Area and Length

Based on information provided by UPI among the 20 districts comprising the Study area, 17 districts are covered by combined drainage system partially or entirely. The total coverage area is approximately 62 km^2 (about 12 % of the entire study area) as presented in Fig. 3.6. The coverage ratio of District 1, 3 and 5, which are urban district, is estimated at 100 %. However, Binh Chanh district belonging to rural district is estimated at only 0.3 %.

The total length of the existing drainage pipes of Grade 2 and 3 managed by UDC and Grade 4 managed by each District in the study area is estimated at approximately 516 and 415 km respectively, as shown in the table below. Location of the main drainage pipes is shown in Fig. 3.7.

Length of Existing Drainage Pipe By Grade And District

Classification / District	Grade 2 (m)	Grade 3 (m)	Sub-total (Grade 2+3)(m)	Grade 4 (m)	Total (Grade 2+3+4)(m)
1			79,246	23,450	102,696
2			6,450	-	6,450
3	18,317	39891	58,208	40,780	98,988
4	10,000	9,540	19,540	39,430	58,970
5	12,580	17,934	30,514	23,330	53,844
6			34,561	47,880	82,441
7	4,830	1,780	6,610	-	6,610
8	10,651	10,539	21,190	39,730	60,920
9			-	-	-
10			67,470	38,140	105,610
11	7,199	27,350	34,549	3,430	37,979
Go Vap			38,808	7,300	46,108
Tan Binh			59,895	59,090	118,985
Binh Thanh	23,127	8,774	31,901	28,470	60,371
Phu Nhuan	13,543	7,677	21,220	48,110	69,330
Thu Duc			3,100	-	3,100
Binh Chanh			3,400	16,340	19,740
Total			516,662	415,480	932,142

(4) Condition of Outlets

These drainage pipe systems are finally discharging into near-by river/main canals (for example, the Saigon River, the Tau Hu-Ben Nghe, the Doi-Te and the Nhieu Loc-Thi Nghe canals). There are about 228 outlets along the river/main canals as listed below.

The majority of outlets are located along the Tau Hu-Ben Nghe canal. Those outlets are discharging wastewater collected from District 1, 3 and 10.

Number of Outlet by River and Canal

Rivers/Canals	Nos. of Outlet
Saigon R.	20
Tau Hu-Ben Nghe C.	80
Doi-Te C.	34
Nhieu Loc-Thi Nghe C.	47
Hang Bang C.	17
Tan Hoa-Lo Gom C.	27
Tham Luong-Ben Cat C.	3
Total	228

3.2.2 Hydraulic Evaluation of Existing Drainage Pipes

Discharge capacity of the existing main drainage pipes was estimated based on the collected longitudinal and cross sectional data of the drainage pipe, in addition to the supplementary survey data by the Team.

The existing drainage pipe systems are large and consist of complex networks. Furthermore the outlets of the drainage pipe system are affected by the tidal influences. Thus, for consideration of the drainage pipe network and the hydraulic condition of the outlet, MOUSE can be applied in modeling.

The evaluation for the discharge capacity of the existing main drainage pipe system has been carried out for the design rainfall of 3 year return period and the design flood water level of 2 year return period under the condition of existing land use. Design discharge was estimated by Rational formula. According to the calculation results, some main drainage system systems, which are shown in Fig. 3.8, will be required to increase their discharge capacities by installation of additional pipes or replacement.

TABLE 3.1 HYDRAULIC CHARACTERISTICS AND EXISTING DISCHARGE CAPACITY OF CANALS

Drainage Area	Canal No.	Name of Canal	Catchment Area (km2)	Length L (km)	Width B (m)	Depth H (m)	Flow Area A (m2)	Average Gradient I	Velocity V (m/s)	Discharge Cap. Q (m3/s)
C-Zone	C-C.1	Nhieu Loc - Thi Nghe Canal	31.668	9.376	16.0 - 65.5	1.5 - 7.5	14.8 - 250.6	0.00034 - 0.00201	0.47 - 1.73	7.0 - 430.0
	C-C.2	Rach Cau Son - Rach Tau Vam Tat	5.1400	2.259	46.0 - 58.0	2.3 - 3.6	90.6 - 102.2	0.00065	1.06 - 1.14	103.0 - 109.0
	C-C.3	Tan Hoa - Lo Gom Canal	20.224	7.773	8.0 - 63.0	1.1 - 4.2	8.4 - 210.4	0.00054 - 0.00082	0.51 - 1.45	3.0 - 304.0
	C-C.4	Tau Hu - Ben Nghe Canal	61.726	12.429	28.0 - 92.0	3.0 - 5.0	62.4 - 209.2	0.00008	0.24 - 0.58	21.0 - 96.0
	C-C.5	Doi - Te Canal		13.547	84.0 - 129.0	4.5 - 12.6	81.3 - 1,026	0.00033	0.62 - 2.12	50.0 - 2,175.0
N-Zone	C-N.1	Rach Ben Da - Rach Ba Hong	19.866	9.988	20.0 - 47.0	1.6 - 4.4	18.8 - 103.7	0.00023	0.41 - 0.72	8.0 - 75.0
	C-N.2	Rach Dai Han	34.649	9.698	5.0 - 12.0	0.6 - 2.2	3.6 - 17.4	0.00024	0.26 - 0.55	1.0 - 10.0
	C-N.3	Tham Luong - Ben Cat Canal	107.569	14.976	16.0 - 95.0	0.7 - 7.8	8.7 - 262.8	0.00035	0.42 - 1.30	3.0 - 335.0
	C-N.4	Rach 19 - 5	10.983	3.840	7.0 -11.0	1.0 - 2.2	3.9 - 12.8	0.00011	0.19 - 0.36	1.0 - 5.0
W-Zone	C-W.1	Rach Chua - Rach Nuoc Len	40.064	13.544	9.0 - 48.0	0.2 - 5.0	2.1 - 109.9	0.00014 -0.00040	0.25 - 1.52	1.0 - 73.0
	C-W.2	Ben Luc River	50.554	3.657	56.0 - 112.0	4.3 - 13.2	58.6 - 113.9	0.00033	1.02 - 1.61	123.0 - 1,012.0
	C-W.3	Can Giuoc River	72.908	4.188	100.0 - 190.0	4.3 - 11.6	535.1 - 662.1	0.00060	1.61 - 2.04	1,069.0 - 1,139.0
S-Zone	C-S.1	Rach Ba Lao	14.327	6.850	26.0 - 160.0	1.9 - 11.0	19.3 - 161.1	0.00013 - 0.00058	0.57 - 2.06	11.0 - 1,173.0
	C-S.2	Rach Xom Cui	6.334	7.349	44.0 - 75.0	2.3 - 10.0	70.3 -230.3	-0.00014 - 0.00110	-0.69 - 1.82	-105.0 - 367.0
	C-S.3	Rach Ong Lon - Kinh Cay Kho	13.701	8.390	75.0 - 120.0	6.6 - 9.3	301.5 - 673.4	-0.00020 - 0.00019	-1.31 - 0.98	-883.0 - 502.0
	C-S.4	Rach Tan - Rach Ca Cam - Rach Roi - Rach Tom - Muong Chuoi Canal	34.511	11.923	26.0 - 190.0	2.0 - 21.7	25.2 - 2,312.5	0.00027 - 0.00080	0.83 - 2.42	21.0 - 5,606.0
	C-S.5	Rach Cau Kinh	2.363	2.450	30.0 - 50.0	2.0 - 3.7	24.5 - 103.3	0.00161	1.02 - 1.85	25.0 - 191.0
	C-S.6	Rach AP3Phu My	2.232	2.422	8.0 - 45.0	1.6 - 4.7	6.3 - 132.8	0.00106 - 0.00233	1.15 - 1.90	7.0 - 252.0
NE-Zone	C-NE.1	Rach Ong Dau	3.321	3.856	17.6 - 28.7	1.5 - 3.0	15.9 - 49.3	0.00075	0.83 - 1.28	13.0 - 63.0
	C-NE.2	Rach Go Dua	9.486	3.549	34.0 - 54.0	3.3 - 5.6	65.8 - 154.6	0.00036	0.97 - 1.29	64.0 - 200.0
	C-NE.3	Rach Thu Duc	7.146	3.336	6.6 - 37.2	1.3 - 3.9	5.3 - 67.5	0.00147	1.05 - 1.85	6.0 - 125.0
	C-NE.4	R. Nhum - R. Cau - R. Go Gone	34.380	12.581	7.0 - 64.0	1.2 - 4.8	3.6 - 192.0	0.00029 - 0.00482	0.52 - 2.21	2.0 - 207.0
SE-Zone	C-SE.1	Rach Binh Khanh	1.977	2.457	33.0 - 54.0	2.9 - 6.8	55.7 - 204.2	0.00059	0.88 - 1.52	49.0 - 310.0
	C-SE.2	Rach Ca Tre Nho	2.596	2.203	16.0 - 42.0	1.1 - 5.4	10.7 - 119.4	0.00064 - 0.00163	0.89 - 2.48	10.0 - 296.0
	C-SE.3	Rach Da Do	1.918	3.672	30.1 - 39.5	3.3 - 4.0	49.6 - 70.7	0.00026	0.74 - 0.80	37.0 - 55.0
	C-SE.4	Rach Giong Ong To	7.803	5.614	20.0 - 58.0	2.7 - 5.4	31.1 - 191.3	0.00039 - 0.00065	0.76 - 1.67	24.0 - 320.0
	C-SE.5	Rach Muong	3.828	2.852	34.0 - 44.0	1.4 - 2.8	36.7 - 63.2	0.00211	1.62 - 2.23	59.0 - 141.0
	C-SE.6	Rach Ky Ha	5.104	5.399	20.0 - 46.0	1.7 - 3.8	23.6 - 95.9	0.0037 - 0.0097	0.80 - 1.01	23.0 - 86.0
	C-SE.7	Rach Chieu - Rach Kinh Ong Hong	15.050	6.752	51.0 - 97.2	1.9 - 8.4	120.6 - 396.6	0.00019 - 0.00025	0.76 - 1.04	95.0 - 399.0
	C-SE.8	R. Ong Cay - R. Ba Cua - R. Ong Kieu	11.328	6.993	19.0 - 70.0	1.9 - 6.9	27.8 - 210.2	0.00024	0.42 - 1.10	12.0 -205.0
	C-SE.9	Rach Tan - Rach Ong Nhieu	21.106	6.946	56.0 - 128.0	4.1 - 8.3	157.7 - 678.4	0.00057	1.37 - 2.05	216.0 - 1,393.0
	C-SE.10	Tac River	24.878	13.850	164.0 -214.2	6.9 - 11.0	827.5 - 1,646.7	0.00013 - 0.00046	1.10 - 2.36	1,342.0 - 3893.0

TABLE 3.2 EVALUATION OF EXISTING DISCHARGE CAPACITY OF 27 CANAL SYSTEM

Zone	Catch-ment No.	Name of Catchment	Area (km^2) / Length (km)	Existing capasity & Design Runoff	Downstream Reaches	Middlestream Reaches	Upstream Reaches
C	C.1	Nhieu Loc - Thi Nghe	31.670	Existing Cap.	100 - 400	35 - 70	10 - 30
			9.376	Des. Runoff	150 - 170	140 -160	110 - 130
	C.2	R. Cau Son - R. Tau Vam Tat	5.140	Existing Cap.	100 -110	100 -110	100 -110
			2.259	Des. Runoff	50 - 75	40 - 50	25 - 40
	C.3	Tan Hoa - Lo Gom	20.220	Existing Cap.	10 - 100	5 - 40	5 - 20
			7.773	Des. Runoff	90 - 100	90 - 100	65 - 90
	C.4	Tau Hu - Ben Nghe and Doi - Te	41.500	Existing Cap.	1,200 - 1,500	600 -1,000	250 -700
			13.547	Des. Runoff	180 - 200	180 - 200	180 - 200
N	N.1	Rach Ben Da - Rach Ba Hong	19.870	Existing Cap.	40 - 80	10 - 40	5 - 10
			9.988	Des. Runoff	40 - 50	40 -50	30 - 40
	N.2	Tham Luong - Ben Cat Canal	107.569	Existing Cap.	40 -250	10 - 30	1 - 10
			24.674	Des. Runoff	100 - 150	30 - 100	10 - 30
W	W.1	Rach Chua - Rach Nuoc Len	72.910	Existing Cap.	10 -60	10 - 40	1 - 10
			13.544	Des. Runoff	40 -50	30 - 40	10 -30
S	S.1	R. Xom Cui - R. Ba Lao	14.330	Existing Cap.	400 - 1,000	50 - 400	20 - 50
			6.850	Des. Runoff	50 - 100	40 - 50	30 - 40
	S.2	R. Ong Lon - K. Cay Kho	15.660	Existing Cap.	300 - 230	250 - 400	400 - 500
			8.390	Des. Runoff	60 - 80	30 - 60	20 - 30
	S.3	R. Tan - R. Ca Cam - R. Roi - R. Tom - Muong Chuoi Canal	34.510	Existing Cap.	1,400 - 4,000	1,000 - 1,400	20 - 180
			11.923	Des. Runoff	150 - 190	40 -150	30 - 40
	S.4	R. Cau Kinh	2.360	Existing Cap.	25 - 180	10 - 25	5 - 10
			2.450	Des. Runoff	20 -40	10 - 20	5 - 10
	S.5	R. AP3 Phu My	2.230	Existing Cap.	150 - 250	80 - 150	10 - 80
			2.422	Des. Runoff	20 -40	10 - 20	5 - 10
NE	NE.1	R. Ong Dua	3.320	Existing Cap.	20 - 60	10 - 15	10 - 15
			3.856	Des. Runoff	20 - 25	10 - 20	10 - 20
	NE.2	R. Go Dua	9.530	Existing Cap.	110 - 160	80 - 110	50 - 80
			3.549	Des. Runoff	50 - 60	30 - 50	10 - 30
	NE.3	R. Thu Duc	7.150	Existing Cap.	10 - 100	5 - 10	5 - 10
			3.336	Des. Runoff	30 - 50	15 - 30	10 - 15
	NE.4	R. Truong Tho	2.650	Existing Cap.	10 - 20	5 - 10	5 - 10
			2.653	Des. Runoff	20 - 30	15 - 20	10 - 15
	NE.5	R. Nhum - R. Cau - R. Go Gone	34.380	Existing Cap.	40 - 150	10 - 20	5 - 10
			12.581	Des. Runoff	90 - 100	50 - 100	30 - 50
SE	SE.1	R. Binh Khanh	1.980	Existing Cap.	100 -300	40 - 300	20 - 40
			2.457	Des. Runoff	10 - 20	10 - 20	5 - 10
	SE.2	R. Ca Tre Nho	2.600	Existing Cap.	120 -140	120 - 250	10 - 50
			2.203	Des. Runoff	20 - 25	20 - 25	10 - 20
	SE.3	R. Da Do	1.920	Existing Cap.	30 - 50	20 - 30	10 - 20
			3.672	Des. Runoff	25 - 30	15 - 25	10 - 15
	SE.4	R. Giong Ong To	7.800	Existing Cap.	150 - 300	70 - 150	20 - 70
			5.614	Des. Runoff	40 - 60	30 - 40	20 - 30
	SE.5	R. Muong	3.830	Existing Cap.	50 - 130	40 - 50	20 - 40
			2.852	Des. Runoff	25 - 30	15 - 25	10 -15
	SE.6	R. Ky Ha	5.100	Existing Cap.	50 - 80	50 - 80	15 - 20
			5.399	Des. Runoff	25 - 30	20 - 25	15 - 20
	SE.7	R. Kinh Ong Hong - R. Chuiec	14.580	Existing Cap.	140 - 350	100 - 140	50 - 100
			6.752	Des. Runoff	60 - 65	50 - 60	40 - 50
	SE.8	R. Ong Cay - R. Ba Cua - R. Ong Kieu	11.330	Existing Cap.	110 - 150	80 - 150	50 - 100
			6.993	Des. Runoff	50 - 60	50 - 60	20 - 50
	SE.9	R. Tan - R. Ong Nhieu	21.110	Existing Cap.	250 - 1,200	200 - 250	100 - 200
			6.946	Des. Runoff	90 - 105	70 - 90	60 - 70
	SE.10	Tac River	24.880	Existing Cap.	700 - 1,200	700 - 1,200	700 - 1,200
			13.850	Des. Runoff	110 - 300	60 - 110	50 - 60

Note: 90 - 100 : It means the possible reaches to be improved.

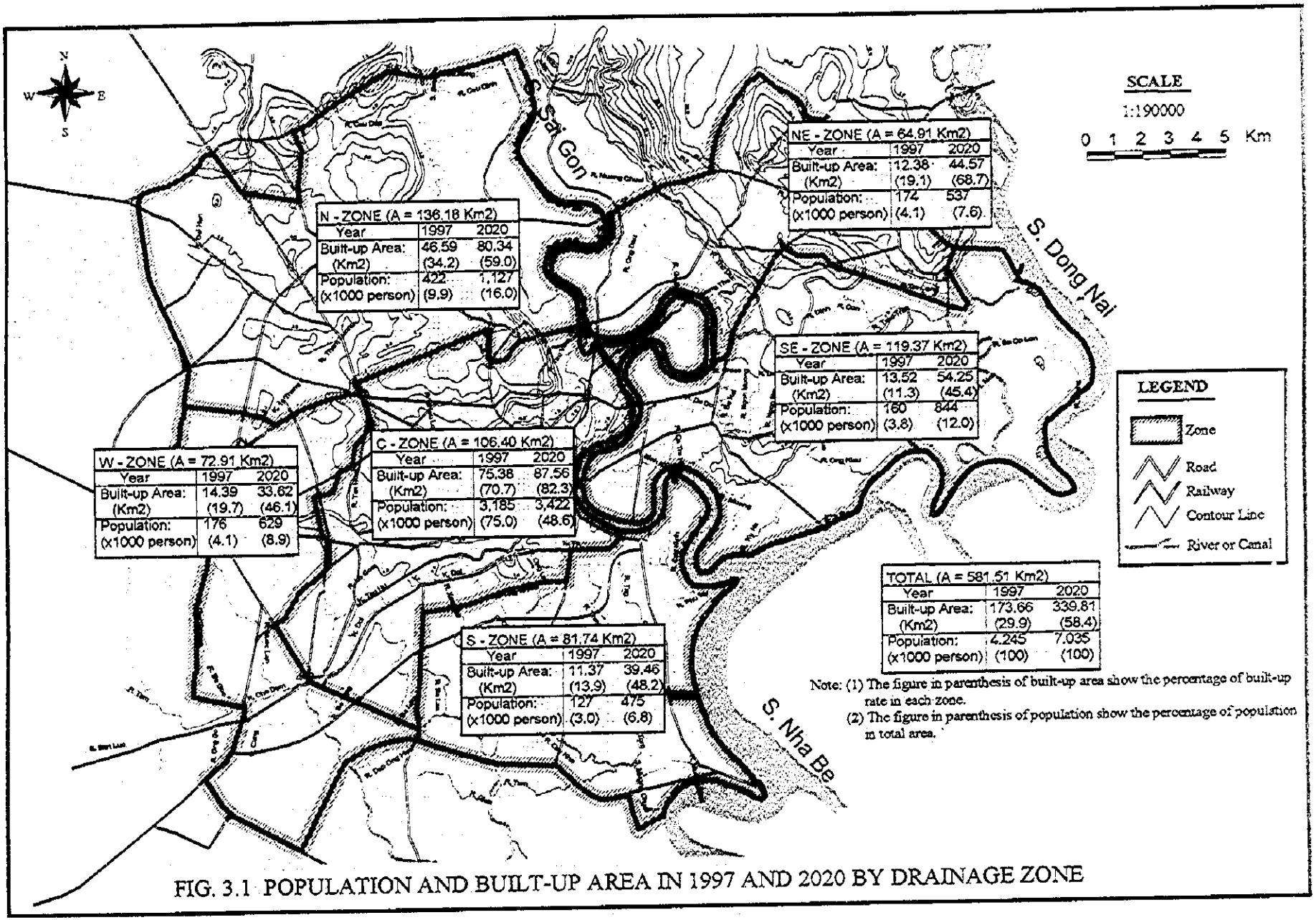
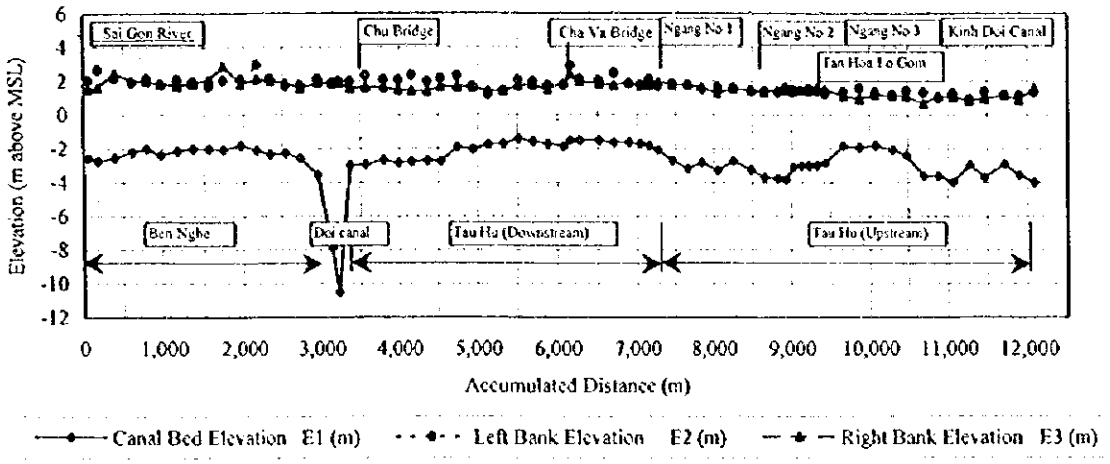
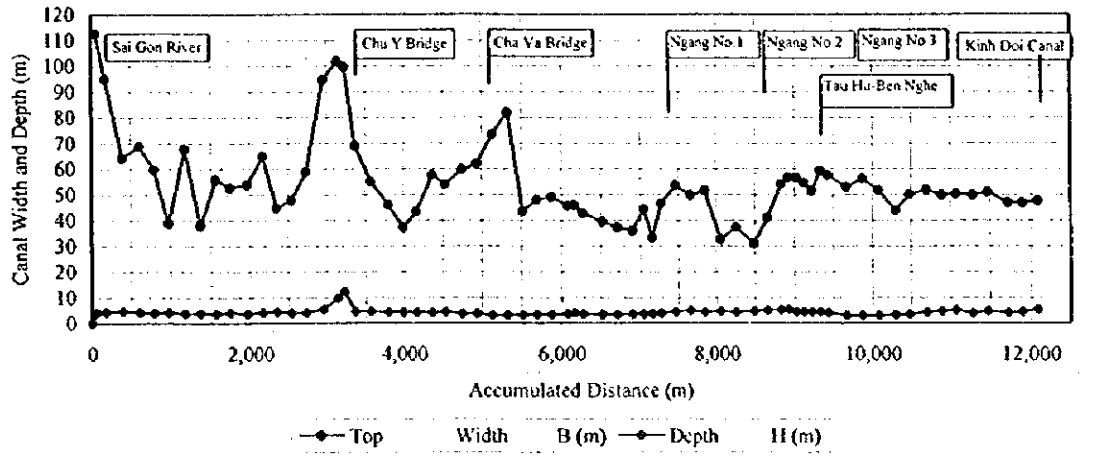


FIG. 3.1 POPULATION AND BUILT-UP AREA IN 1997 AND 2020 BY DRAINAGE ZONE

LONGITUDINAL PROFILE



CANAL WIDTH AND DEPTH



DISCHARGE CAPACITY

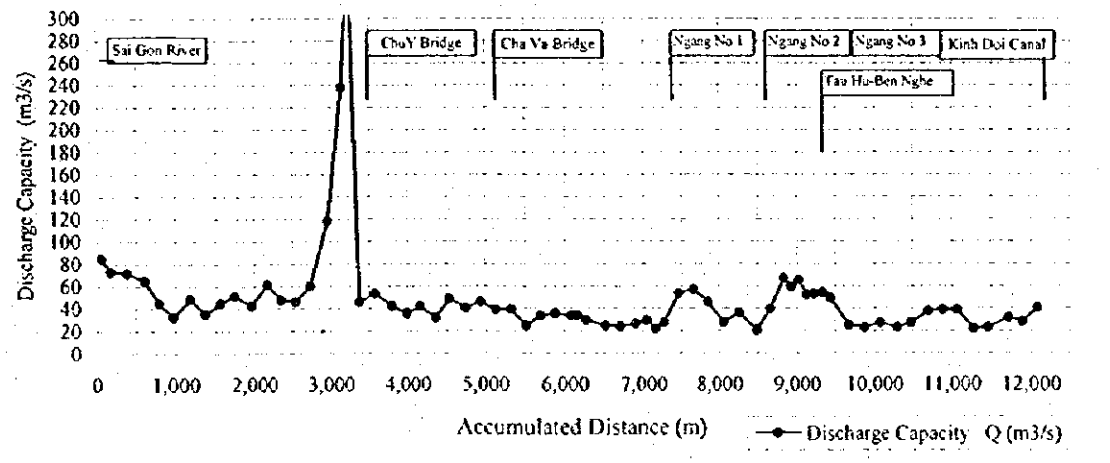
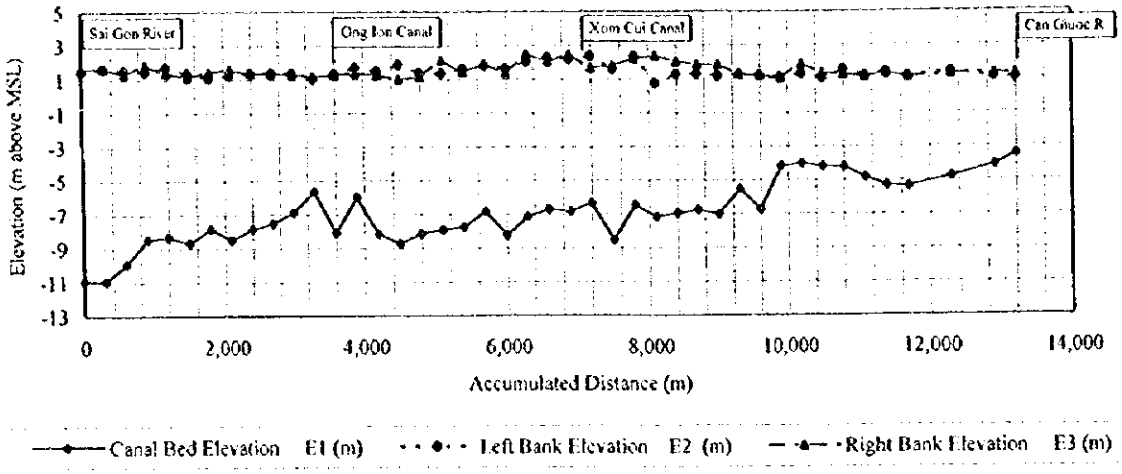
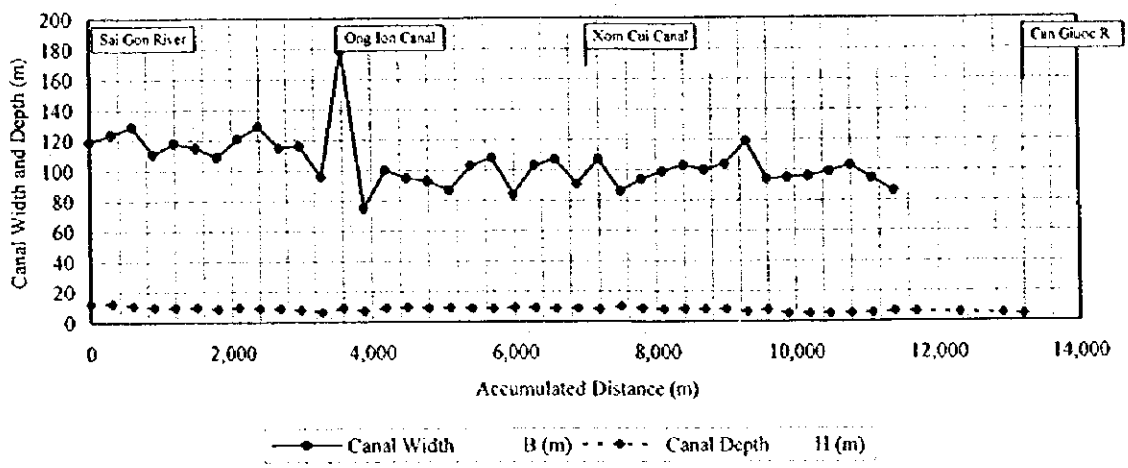


FIG. 3.2 (1/2) HYDRAULIC CHARACTERISTIC AND DISCHARGE CAPACITY OF EXISTING TAU HU - BEN NGHE CANAL

PROFILE



CANAL WIDTH AND DEPTH



DISCHARGE CAPACITY

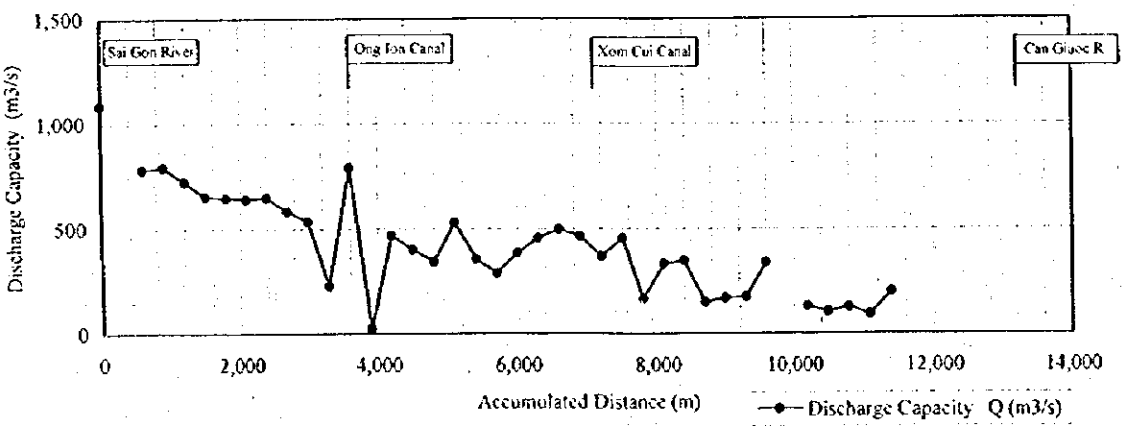


FIG. 3.2 (2/2) HYDRAULIC CHARACTERISTIC AND DISCHARGE CAPACITY OF EXISTING DOI - TE CANAL

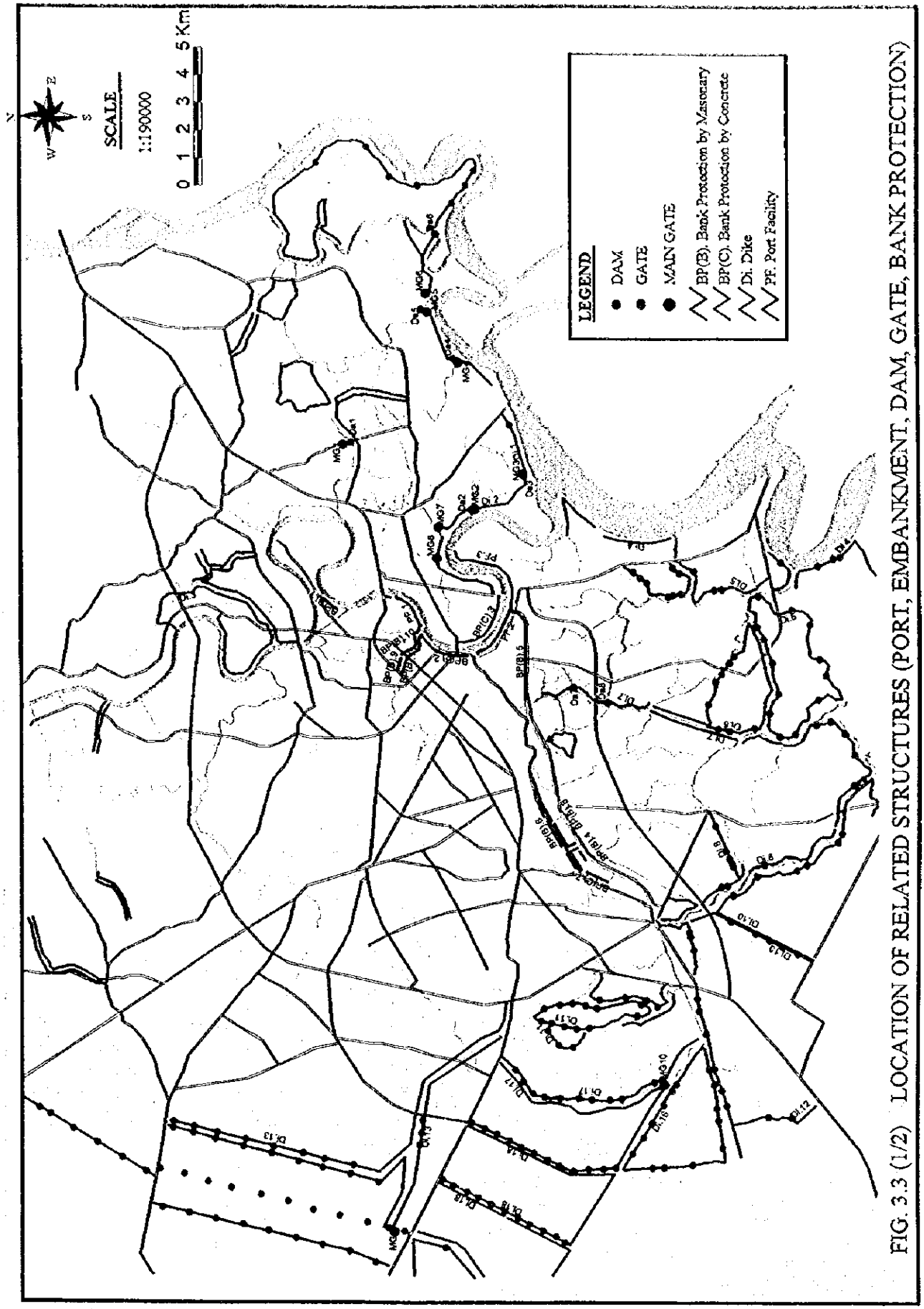


FIG. 3.3 (1/2) LOCATION OF RELATED STRUCTURES (PORT, EMBANKMENT, DAM, GATE, BANK PROTECTION)

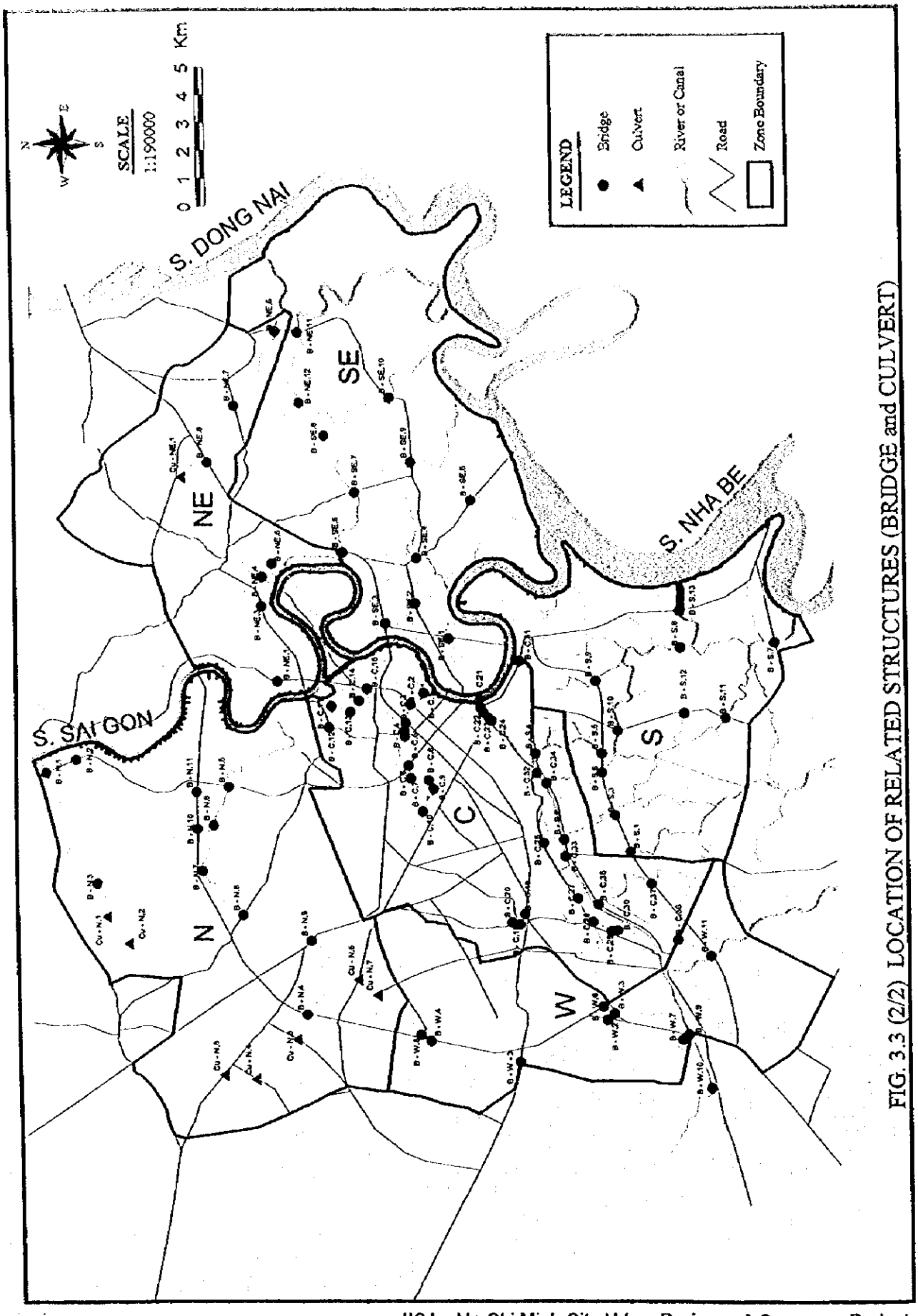
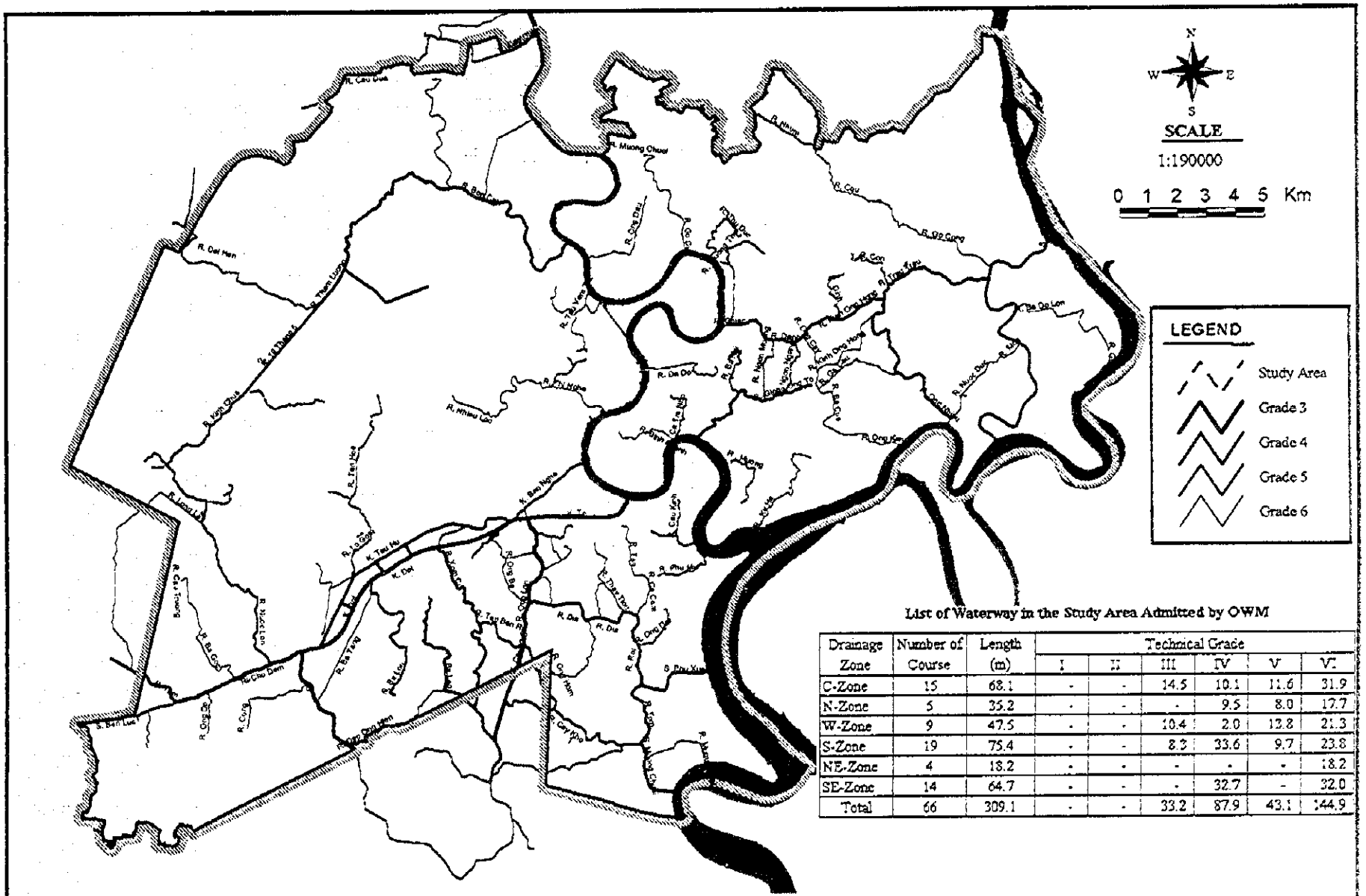


FIG. 3.3 (2/2) LOCATION OF RELATED STRUCTURES (BRIDGE and CULVERT)



List of Waterway in the Study Area Admitted by OWM

Drainage Zone	Number of Course	Length (m)	Technical Grade					
			I	II	III	IV	V	VI
C-Zone	15	68.1	-	-	14.5	10.1	11.6	31.9
N-Zone	5	35.2	-	-	-	9.5	8.0	17.7
W-Zone	9	47.5	-	-	10.4	2.0	12.8	21.3
S-Zone	19	75.4	-	-	8.3	33.6	9.7	23.8
NE-Zone	4	18.2	-	-	-	-	-	18.2
SE-Zone	14	64.7	-	-	-	32.7	-	32.0
Total	66	309.1	-	-	33.2	87.9	43.1	144.9

FIG. 3.4 NAVIGABLE CANALS IN THE STUDY AREA

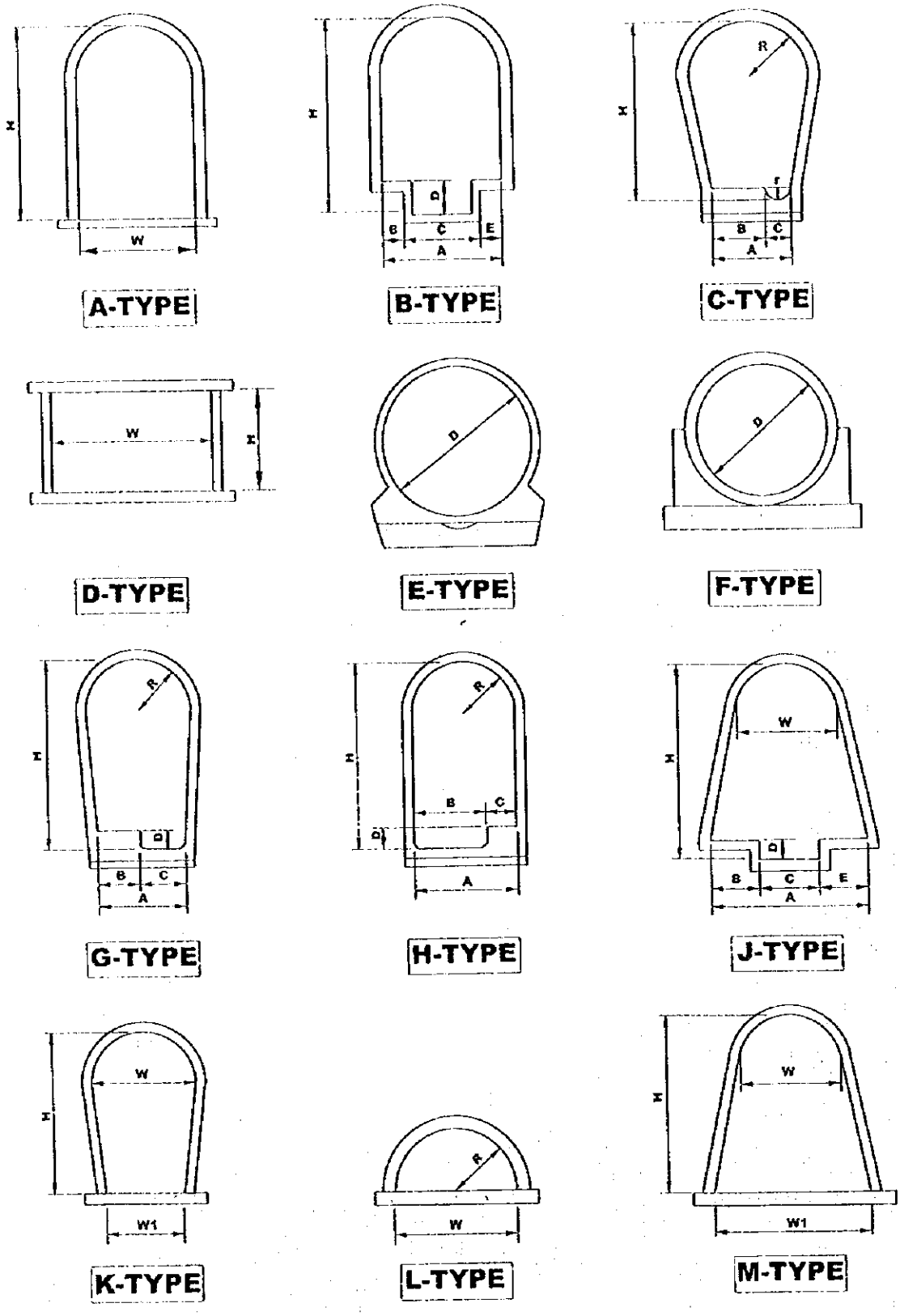


FIG. 3.5 TYPICAL CROSS-SECTION OF EXISTINGDRAINAGE PIPE

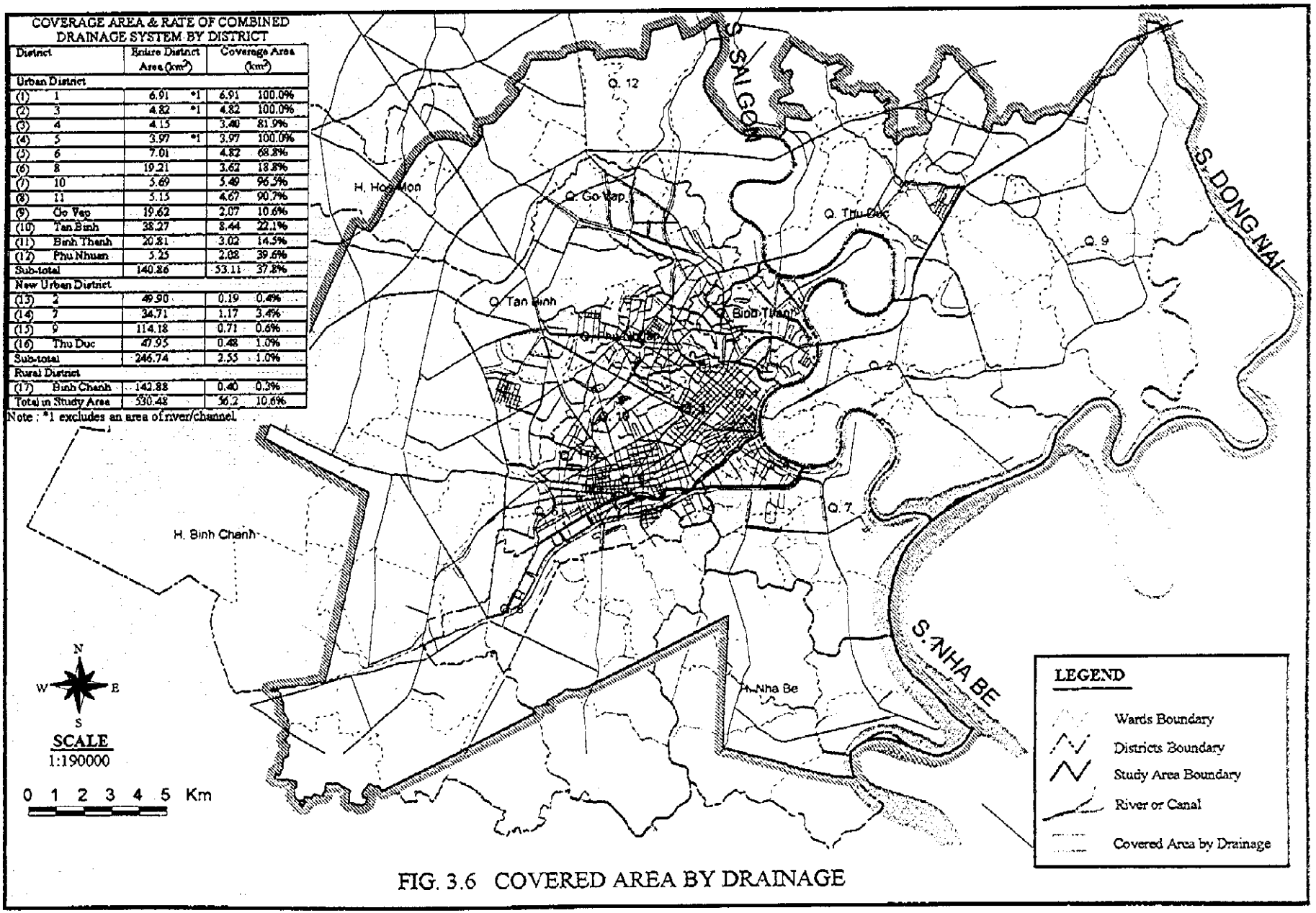


FIG. 3.6 COVERED AREA BY DRAINAGE

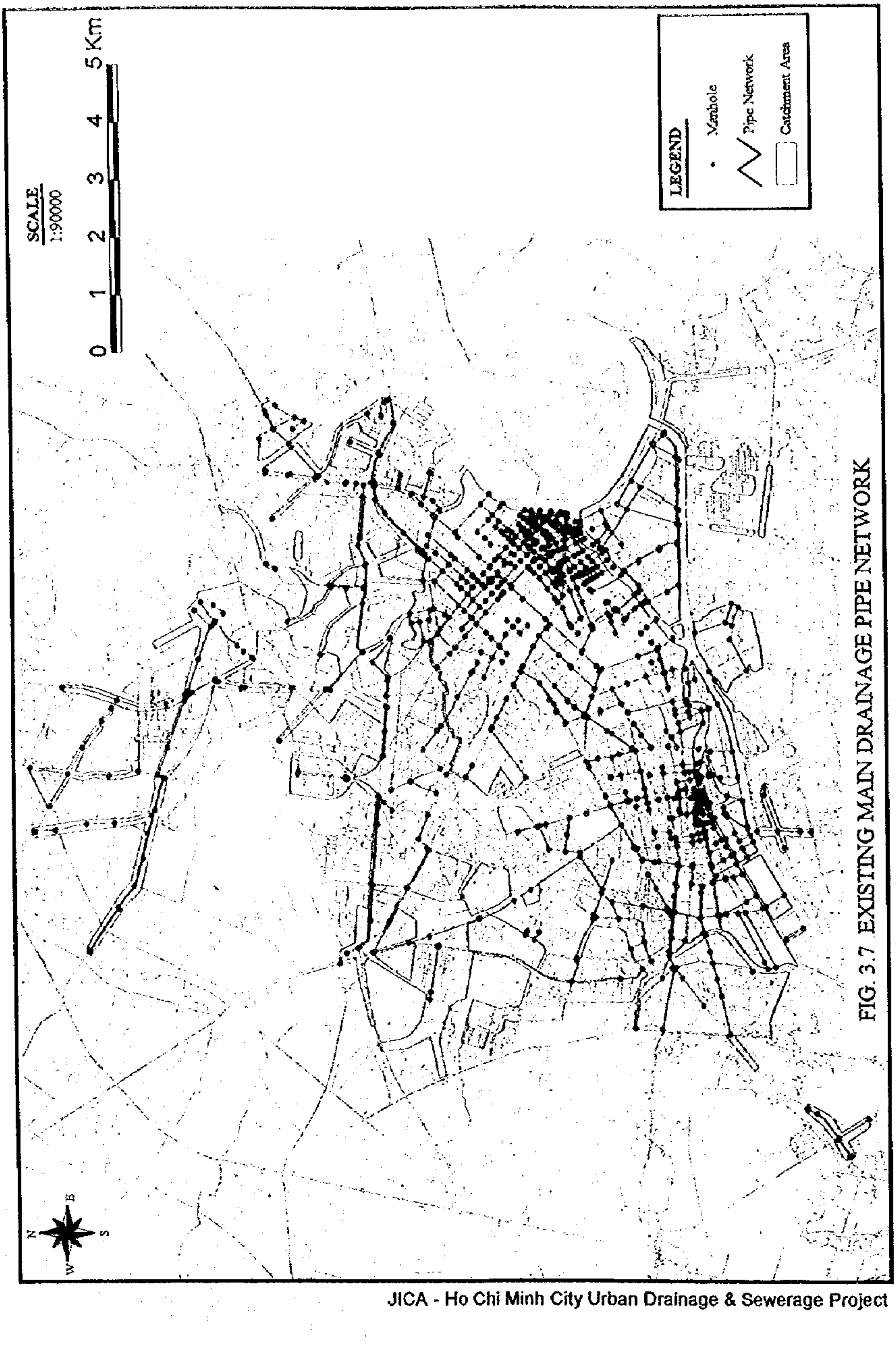


FIG. 3.7 EXISTING MAIN DRAINAGE PIPE NETWORK

CHAPTER 4

EXISTING SEWERAGE AND SANITATION SYSTEM AND FACILITIES

CHAPTER 4 EXISTING SEWERAGE AND SANITATION SYSTEM AND FACILITIES

4.1 On-Site Sanitation System

Based on the data prepared by the Center for City Preventive Medication, about 4.77 % of population do not have any access to the toilet facilities. About 9 % of population is supposed to use public toilet. The existing public toilets have been constructed mainly by Urban Environmental Company of PC HCMC. The operation and maintenance of the public toilets are entrusted to the local authority or local community. At present there are 135 public toilets in the study area. Public toilets are constructed at markets and bus stations, along main streets and residential area with high population density. Location of the existing public toilet is shown in Fig. 4.1. District 1 and 3 each have 19 public toilets, highest among the all districts.

4.1.1 Existing Sanitation Facilities

Under the existing regulation in Viet Nam (Decree No. 10, May 10, 1954), human toilet waste should be treated by the appropriate septic tank before discharging to the sewer and other public water bodies. As a result about 55 - 65 % of population has septic tank laid under their houses. These septic tanks partially treat wastewater only from toilet and other domestic wastewater from kitchen, bathing and laundry are directly discharged to the sewers and public water bodies. Based on the data provided by the Center for City Preventive Medication in 1997, the existing sanitation facilities are classified into five (5) types:

- individual toilet with standard septic tank
- individual toilet with non standard septic tank
- individual toilet with leaching pit
- canal hang-on toilet,
- public toilet.

The details of population covered by these on-site sanitation facilities in each District of the study area are provided in Table 4.1. Septic tanks are the only means of wastewater treatment in the study area. It can be summarized that about 35 - 45 % of population discharge domestic wastewater to rivers/canals directly or indirectly without any treatment and remaining 55 - 65 % discharge partially treated black water (wastewater from toilet) and untreated gray water to the rivers/canals. As a result water quality of canals is similar to that of wastewater.

4.2 Desludging and Treatment

Urban Environmental Companies of Ho Chi Minh City and Urban Public Work Company of each District are the organization responsible for cleaning and transportation of sludge of septic tanks in the Study Area, in addition to its major function of solid waste management. Septic tank of individual toilet and public toilet are cleaned on request. The requests for desludging is accepted both by telephone and direct visit to the office. Urban Environmental Company has one (1) vacuum truck with a capacity of 5 m3 (1 unit) and two (2) vacuum trucks of 2 m3 capacity. For desludging, Urban Environmental Company charges VND 150,000 and VND 250,000 for 2 m3 and 5 m3 respectively. On an average Urban Environmental Company collects 4,000 m3 of sludge per annum. At present about 100 units of vacuum truck are operating in Ho Chi Minh City.

The frequency of desludging of residential units varies from a few months to even up to ten years or more, and is considered to be dependent on the quality of construction and maintenance with respect to the storm water intrusion into the septic tank, and the level of ground water table.

Sludge treatment is carried out by private company in Tan Binh district. Sludge is treated in the stabilization pond for 3 - 4 days and after anaerobic digestion of 2 weeks sludge is composted for 5 to 6 months. The effluent from sludge treatment is discharged to Tham Luong canal without any treatment. The private company can sell compost about 5,000 ton/year by which they can recover the cost of sludge treatment.

Table 4.1 EXISTING SERVICE POPULATION RATIO BY SANITATION FACILITY

DISTRICT	EXISTING	NUMBER OF	TOILET WITH STANDARD S/T		TOILET WITH UNSTANDARD S/T		LEACHING PIT		HANG-ON TOILET		NO FACILITY	
	POPULATION	HOUSEHOLD	NUM. OF HH	%	NUM.OF HH	%	NUM.OF HH	%	NUM.OF HH	%	NUM.OF HH	%
1	280,063	31,628	28,525	90.19	0	0.00	0	0.00	1,607	5.08	70	0.22
3	260,418	32,261	20,210	62.65	8,502	26.35	0	0.00	1,666	5.16	922	2.86
4	220,650	33,156	17,556	52.95	1,056	3.18	0	0.00	3,356	10.12	5,708	17.22
5	251,387	28,471	26,519	93.14	1,420	4.99	0	0.00	264	0.93	una	una
6	280,336	27,830	7,069	25.40	13,784	49.53	0	0.00	4,250	15.27	2,077	7.46
8	347,090	42,715	25,489	59.67	0	0.00	0	0.00	7,411	17.35	una	una
10	271,593	35,118	34,969	99.58	0	0.00	una	una	149	0.42	una	una
11	260,159	35,878	34,808	97.02	0	0.00	0	0.00	556	1.55	514	1.43
GO VAP	234,966	27,375	9,548	34.88	15,397	56.24	17	0.06	192	0.70	2,239	8.18
TAN BINH	512,185	59,047	15,381	26.05	42,346	71.72	10	0.02	1,608	2.72	648	1.10
BINH THANH	417,739	56,467	44,544	78.89	1,678	2.97	0	0.00	3,377	5.98	una	una
PHU NHUAN	202,454	28,853	27,348	94.78	0	0.00	0	0.00	204	0.71	una	una
12	127,459	una	una	una	una	una	una	una	una	una	una	una
HOC MON	185,817	54,206	0	0.00	21,414	39.50	una	una	14,000	25.83	6,331	11.68
THU DUC	171,165	27,164	0	0.00	26,626	98.02	una	una	una	una	una	una
2	95,219	14,478	7,631	52.71	473	3.27	143	0.99	1,990	13.74	una	una
9	119,446	una	una	una	una	una	una	una	una	una	una	una
7	98,380	una	una	una	una	una	una	una	una	una	una	una
BINH CHANH	263,883	44,152	5,197	11.77	11,804	26.73	0	0.00	8,010	18.14	9,122	20.66
Total	4,600,409	578,799	304,794	52.66	144,500	24.97	170	0.03	48,640	8.40	27,631	4.77

Source: Center for City Preventive Medication, 1997

Note : una : unavailable

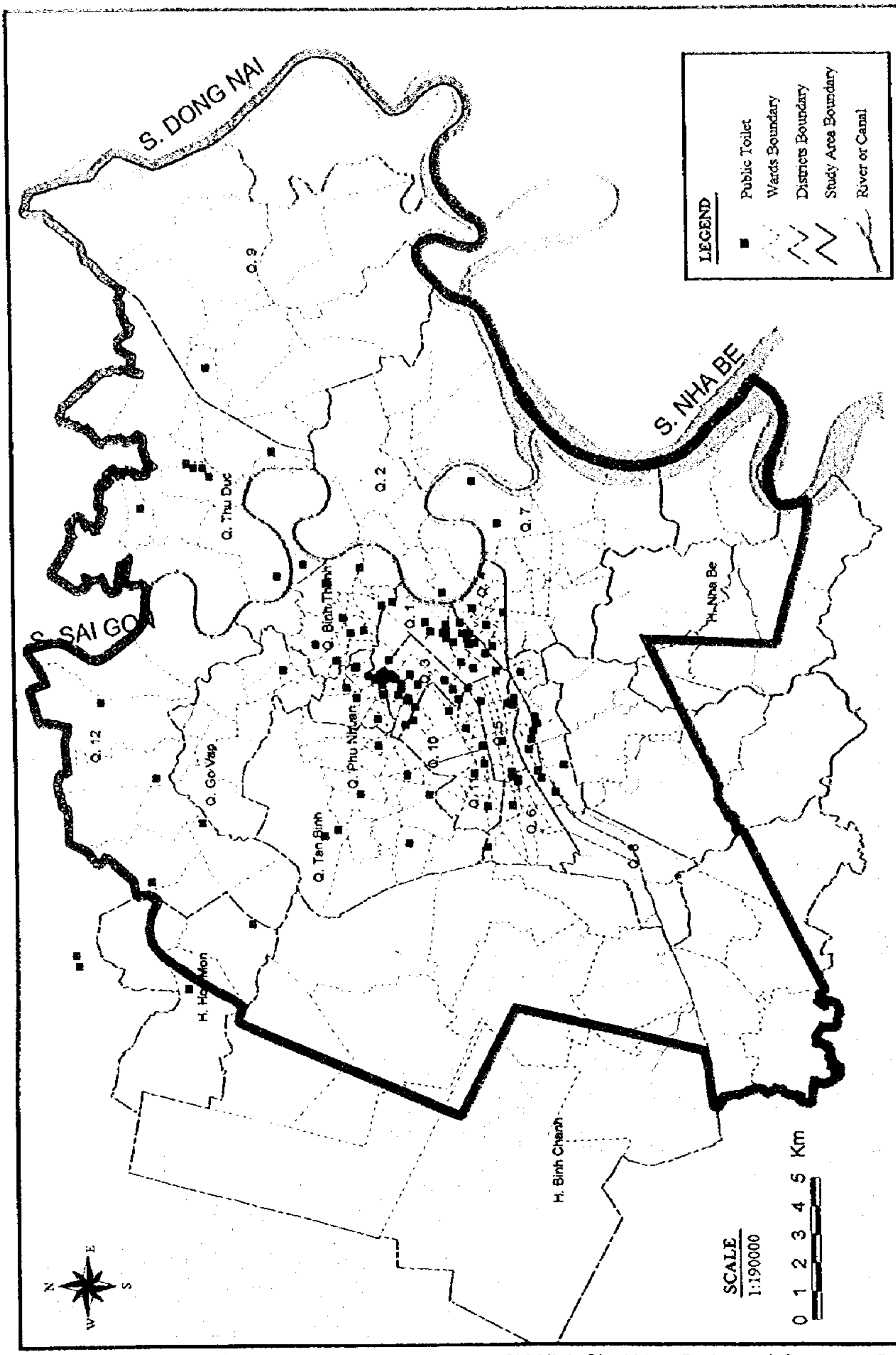


FIG. 4.1 DISTRIBUTIONN OF PUBLIC TOILET

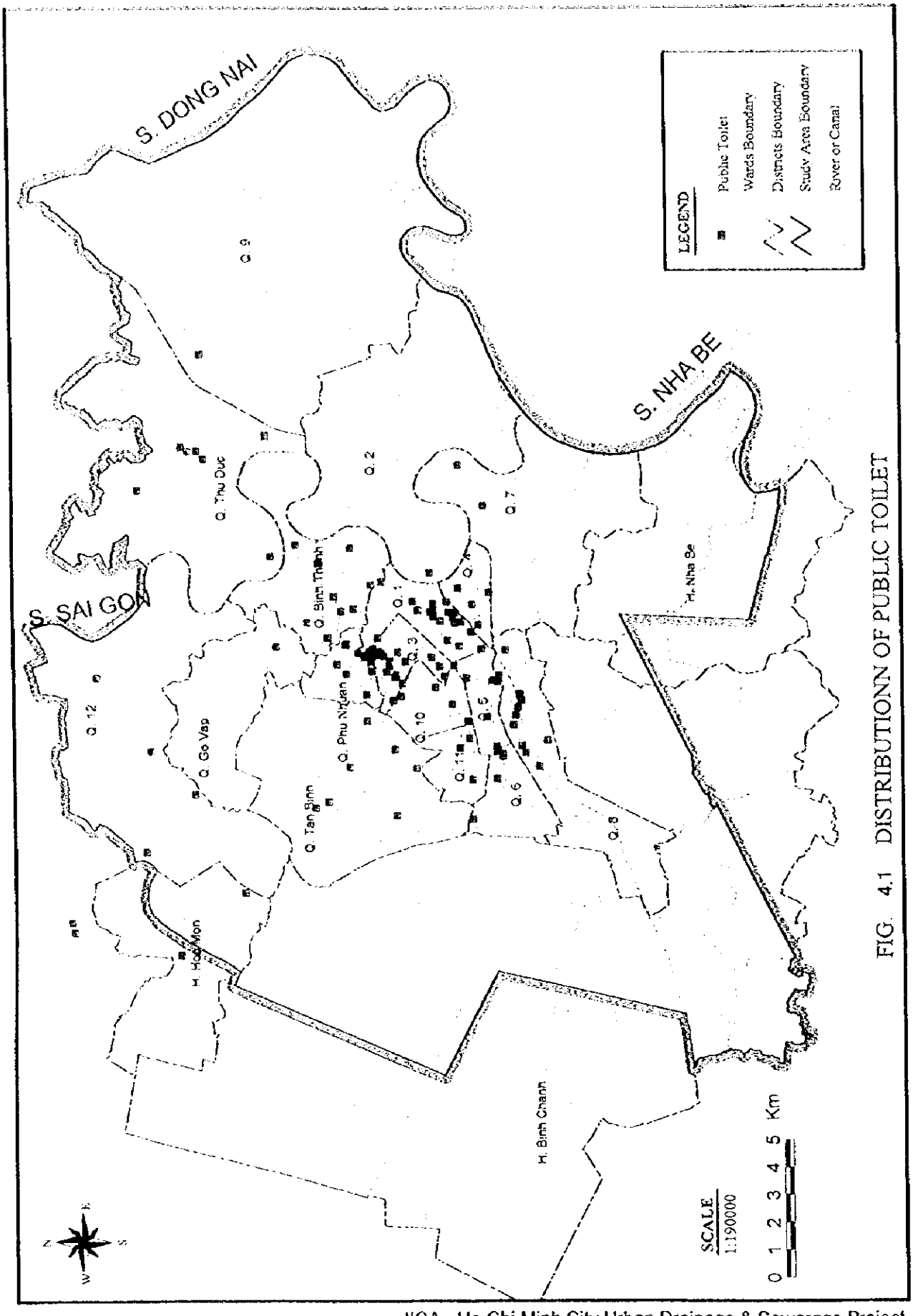


FIG. 4.1 DISTRIBUTIONN OF PUBLIC TOILET

CHAPTER 5

RELEVANT STUDIES AND ONGOING PROJECT

CHAPTER 5 RELEVANT STUDIES AND ONGOING PROJECTS

5.1 Feasibility Study and Preliminary Design on Ho Chi Minh City Sewerage Project

This project has been funded by International Development Association (IDA) and the Japanese Grant Fund and involves preparation of feasibility study for sewerage system of Nhieu Loc Thi Nhge (NLTN) Basin in the HCM City.

The study area is 33.2 km^2 and has a population of 989,676 persons. The future population is predicted as 1,073,000 for 2015. The basin is served by combined sewer system. The sewer coverage of basin is non-uniform. The existing wastewater flow in 1997 is estimated to be about 183,000 m^3/d and 245,00 m^3/d for dry and wet weather respectively. Projected wastewater for the year 2030 is 503,000 m^3/d and 564,000 m^3/d for dry and wet weather respectively. The existing BOD load is estimated at 35,000 kg/d and projected load varies from 52,000 to 115,000 kg/d. Only 55 % of existing population is served with septic tank. Wastewater from drainage system is discharged to Nhieu Loc Thi Nghe canal without any treatment. Water quality of Nhieu Loc Thi Nghe is same as that of wastewater with BOD varying from 100 to 250 mg/l. Besides, deteriorating environment flooding of the basin is another major problem. Simulation of the 2 year storm carried out in the study indicated that one third of the storm flow can not be conveyed by the existing drains, and goes into flooding of the streets and properties.

The study has identified number of improvements required for urban drainage and sewerage system of Nhieu Loc Thi Nghe basin, as listed below:

- replacement, enlargement, reinforcement or rehabilitation of storm drains
- improvement of flood channel along the NLTN canal
- improvements on tributaries of the NLTN canal
- wastewater collection within the NLTN flood plain
- wastewater interceptor along the NLTN canal
- wastewater treatment and disposal

After studying various options for the above mentioned improvements the study has proposed following facilities for Phase I:

- Drainage improvements, consisting primarily of new large box culverts placed in streets, to reduce flooding and overflows of combined storm water and sewage onto the streets

- An NLTN flood channel, to reduce flooding within the NLTN flood plain and to prevent backup and surcharging of flows in the improved drainage system. Tide gates in the walls of the flood channel, at low points within the flood plain, are

proposed to prevent flooding by high tides or backwater effects in the flood channel during severe storms

- NLTN wastewater interceptor, to improve canal water quality by intercepting dry-weather wastewater flows at CSOs (combined sewer overflows) along the canal.

- A preliminary treatment plant containing fine screens and pumps with a hydraulic capacity of 64,000 m^3/hr, to remove wastewater from the NLTN interceptor and discharge it through an outfall to the Saigon River.

- An instrumentation and control system to bleed flows from the NLTN flood channel into the NLTN interceptor, to maintain water quality in the canal by replacing polluted urban runoff and combined sewer overflows into the canal with cleaner water from the Saigon river.

The facilities, which are deferred or not included in Phase I, are as follows:

- A biological treatment plant to be located outside the NLTN basin, which is expected to become affordable by the year 2020. The treatment plant should be built in phases, initially to a capacity of 400,000 m^3/d and expanded to a capacity of 800,000 m^3/d in year 2030.

- Wastewater collection and interception within NLTN flood plain and flood channels on two NLTN tributaries are deferred.

- Existing bridges crossing the NLTN canal may obstruct flood flows in the proposed flood channel. Replacement or modifications of bridges would occur over a period of years, as funds become available.

The estimated capital cost of Phase I facilities is US$ 148.89 million. Recommended complementary programs are estimated to cost US$ 28.25 million. The estimated capital cost of deferred facilities is US$ 222.55 million.

Project Management Unit (PMU) of NLTN project is now preparing preliminary design of facilities.

5.2 Canal Tan Hoa-Lo Gom Sanitation and Urban Upgrading Project

The project has been funded by Belgium Government and aims to improve the quality of life in Tan Hoa-Lo Gom (THLG) Basin by reducing the pollution and by increasing environmental and urban development related to economic and community development activity. The project also aims to strengthen the capacity of the local communities and the city institutions dealing with related problems of the THLG Canal.

The project area is 19km^2 comprising of Tan Binh district, District 11 and 6. Present population is about 500,000 inhabitants.

Project management Unit (PMU) has completed data collection and design phase is underway which will be followed by implementation phase. The findings are briefly discussed below.

The project is articulated around 7 strategies: solid waste collection, canal maintenance and reshaping, wastewater treatment, institutional strengthening, awareness raising and community participation, town planning and socio economic support.

Improvement of solid waste management is proposed based on the concept of Small Transfer Station (STS). The STS will replace the rendezvous points and the large transfer station. The optimum network of STS should cover an area with maximum radius of 1 km. Primary collection is proposed to be reorganized by creating a cooperative working under the management of the ward authorities.

For improvement of THLG canal regular canal cleaning from solid waste, dredging and embankment is proposed. PMU is studying the option of enlarging the canal to reduce flooding problem. Vertical embankments are proposed so as to reduce the number of houses that need to be relocated.

THLG canal receives not only domestic wastewater but also industrial wastewater from the industries located in Tan Binh District. As a result THLG canal is the most polluted canal in HCMC. Appropriate sewerage system and strict enforcement of industrial effluent standards are the only way to improve wastewater management in THLG basin. Series of Stabilization Ponds are proposed as the appropriate treatment process.

5.3 Hang Bang Canal Area Rehabilitation Project

The project is one component of HCMC Environmental Improvement Project assisted by Asian Development Bank (ADB). The study involves preparation of feasibility study on rehabilitation of the sewers and drains in Hang Bang catchment area.

The project covers area of 3.8 km^2 from districts 5, 6 and 11. It has an estimated population of 240,000 people. Growth rate in this area is expected to remain below average (4 to 5 % of growth rate is predicted for HCM City) as this area is already overcrowded. A network of combined sewers, with a total length of about 33 km serves Hang Bang drainage area. All these sewers drain untreated wastewater to Hang Bang canal. The canal is heavily polluted with BOD of about 300 mg/l and coliforms of the order of 5 E + 07 MPN/100ml. The canal has been illegally encroached by the people and has severely affected the hydraulic capacity of canal. This has led to backup of floodwaters in the upstream combined sewers during period of high rainfall.

It is reported in the study that sewerage and drainage system of the area can no longer cope with the storm water runoff from even moderate rainfall. As a result the combined sewage, a mixture of raw sewage, septic tank effluent and storm water runoff backs up in the sewers and floods roads and houses. Besides causing disruption of economic and social activities, the polluted water poses a serious public health hazard. Therefore there is an urgent need to rehabilitate the combined sewerage and drainage system. Following three alternatives have been reported:

- replacing the Hang Bang Canal with a closed combined sewer
- dredging the Hang Bang canal and restore the open channel as the main collector to convey the drainage to Tan Hoa and Tau Hu canal
- extending the sewers that drain to Hang Bang Canal so as to enable them to discharge directly into Tau Hu canal.

The Project Management Unit (PMU) is evaluating these three alternatives. The project cost is estimated at $ 26.2 million. The foreign exchange cost is estimated at $ 3.6 million while local currency cost is estimated at $ 22.6 million.

Besides above mentioned projects, Department of Transportation and Public Works (DOTPW) has also carried out pre feasibility studies for major canals in the HCM city.

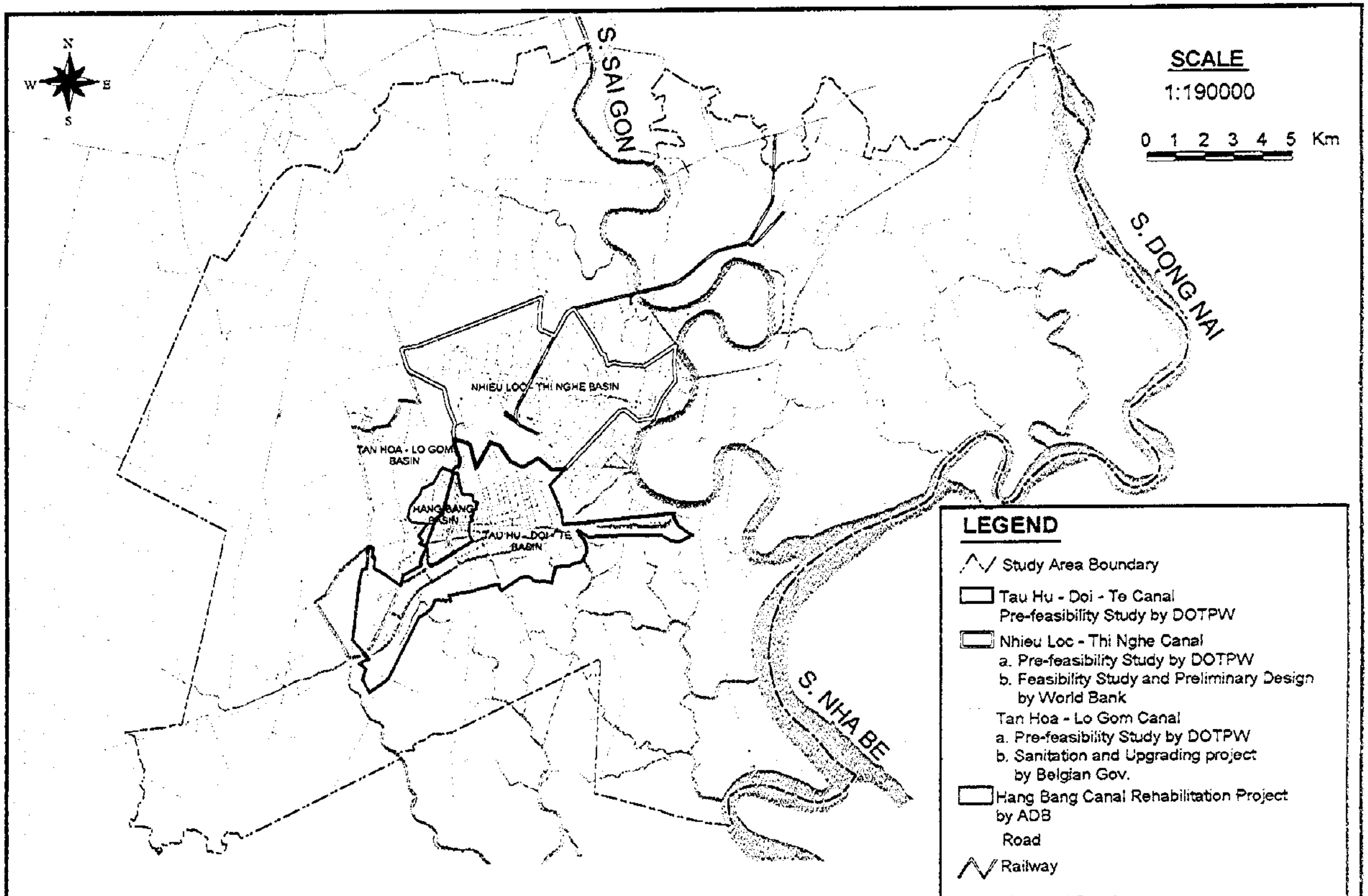


FIG. 5.1 LOCATION OF RELEVANT STUDY AND PROJECT

CHAPTER 6

MASTER PLAN OF URBAN DRAINAGE IMPROVEMENT

CHAPTER 6 MASTER PLAN OF URBAN DRAINAGE IMPROVEMENT

6.1 Planning Concept and Design Scale

The target year of the Urban Drainage Master Plan (M/P) is set at 2020 on the premise that the proposed project implementation will be taken up at least 20 years. Consequently, all plans are to be prepared to meet the demands of population and land use in the target year 2020.

As shown in Fig. 6.1, the study area is broadly classified into the following four (4) areas:

(a) Area A : Existing urbanized area with a combined sewerage system (inner city area)
(b) Area B : Existing urbanized area with a channel drainage system (inner city area and a part of surrounding area)
(c) Area C : Projected future urbanized area (a part of surrounding area)
(d) Area D : Area to be preserved as agricultural land, green and open space (a part of surrounding areas)

Considering the rapid urbanization in the study area and flood damage situation in these urbanized areas, the integrated urban drainage measures shown in Fig. 6.2 are proposed in this M/P, to minimize the project cost and to facilitate the smooth implementation of the project. As shown in Figs. 6.3 and 6.4, basic policy for selecting measures in the above each area is as follows:

(a) For Area A and B : Storm water is to be drained as soon as possible by the structural measures in order to decrease the existing flood losses.
(b) For Area C : Flood damages are to be minimized by the combination of structural and non-structural measures.
(c) For Area D : Rainwater storage potential is to be preserved by non-structural measures

Design scale of the urban drainage facilities is generally applied to meet 2 to 10 year frequency floods. Most of the capitals and major cities in developing countries of Southeast Asia employ the almost same design scale as 2 to 10-year return period.

Design Scale for Urban Drainage in Asian Countries

Name of Country and City	Population ($x10^3$ person)	Design Scale(Frequency)		Remarks
		Sewer Line	Canal	
Japan, Tokyo	12,000	3	7 - 30	capital
Philippine, Manila	6,500	5	10	capital
Thailand, Bangkok	5,000	2	5	capital
Indonesia, Jakarta	8,000	5	10	capital
Bangladesh, Dacca	5,000	5	5	capital
Viet Nam, Ha Noi	2,200	5	10	capital

In HCMC, 1 to 3-year and 5-year frequency flood have been applied for the design of sewer line (Grade 2, 3 and 4) and the canal (Grade 1) respectively. Considering that HCMC is the largest city of the nation as well as the socio-economic center in the southern region of the country, the design scale is proposed as follows:

Design Scale for Drainage Facilities

Urban Drainage facility	Catchment Area (km^2)	Design Flood (year return period)
Sewer Line (Grade 3,4)	-	2
Sewer Line (Grade 2)	-	3
Canal (Grade 1)	less than 30	5
Canal (Grade 1)	more than 30	10
Drainage Pumping Station	-	5

Note: Design flood of 10-year return period is to be applied only for the trunk reaches.

6.2 Alternative Study

6.2.1 Utilization of Low-lying Agricultural Land as Natural Retarding Basin

Dai Han and Tham Lung - Ben Cat canals in North zone are expected to have a large scale improvement due to rapid increase of flood run-off caused by development. In order to prepare more economical canal improvement plan, the following alternatives are considered.

(a) Alternative 1-I : Dai Han and Tham Luong - Ben Cat canals are to be improved on 5 and 10-year return period flood respectively without any flood

(b) Alternative 1-II : Dai Han canal is to be improved on 5-year return period with an allowable inundation and Tham Luong - Ben Cat canal is to be improved on 10-year return period without any flood

If the low-lying paddy fields along Dai Han canal can practically be used as a natural retarding basin with an allowable inundation (area: within 10% of the basin, depth: 0.3-0.4 m and duration: within one day), it was found that about 75% of peak run-off can be decreased as shown in Fig. 6.5. It is found that Alternative 1-II is more economical than Alternative 1-I as a result of cost comparison.

Utilization of low-lying paddy field as a natural retarding basin is applicable for Ben Da - Ba Hong basin in N-zone and R. Cua - R. Nuoc Len basin in W-zone.

6.2.2 Drainage System for Newly Urbanized area in Low Land

Vast low-lying paddy fields in W, S and SE zones would be widely developed as a residential, institutional and industrial area. UPI has prepared a guideline that a land development in low-lying area shall be filled up to EL +2.0 m to easily maintain a separated gravity discharge system from a technical and economical viewpoints. In order to confirm the justification of UPI guideline, the following alternative study has been made.

(a) Alternative 3- I : Low land is to be filled up more than 2.0 m above MSL and the gravity discharge system is applied for urban drainage.
(b) Alternative 3-II : Low land is to be protected from the external flood by a polder dike and pump drainage system is employed for urban drainage.

Cost comparison led Alternative 3-I is recommendable. Because it was found that the cost of Alternative 3-II including its O/M cost during the project life of 50 years was estimated at 1.6 - 3 times of that of Alternative 3-I as shown in Fig. 6.6. This justification was confirmed by the same study for Long Truong development plan with an area of about 9.0 km^2 in SE zone.

However, for some low-lying mostly developed areas situated on the fringe of C zone, land filling to apply the gravity discharge system will be difficult due to a large number of relocation of the existing houses and buildings. Pump drainage system by a polder dike has to employ for these areas regardless of its little wasteful system.

6.2.3 Drainage System for Newly Urbanized Area in High Land

Almost 50 % of agricultural land in Thu Duc area (NE.3, 4 and 5 basins of about 44 km^2) situated on high land of NE zone would be rapidly developed as residential, institutional and industrial areas. These developments will increase a flood run-off and flood risk to the downstream low-lying areas as shown in Fig. 6.7. The following countermeasure alternatives for flood run-off increased due to urbanization in NE. 5 catchment area of 34.38 km^2 has been studied.

(a) Alternative 4-I : Increased flood run-off is to be met by the improvement of Rach Nhum - Rach Cau - Rach Go Gong canals

(b) Alternative 4-II : Canal improvement is designed on the existing conditions and increased flood run-off is to be met by onsite detention pond.

The construction costs of the alternatives are given below:

Cost Comparison of Alternatives 4-I And 4-II

(Unit: Billion VND)

Item	Alternative 4-I	Alternative 4-II
1. Canal Improvement	629.7	506.9
(1) Construction Cost	(615.8)	(497.3)
(2) Land Acquisition Cost	(13.8)	(9.6)
2. Onsite Detention Pond	-	75.6
(1) Construction Cost	-	(70.8)
(2) Land Acquisition Cost	-	(4.8)
Total Cost	629.7	582.4

Note: Specific storage requirement of onsite detention pond is estimated at 17,000 m^3/km^2 based on the increased run-off coefficient of 0.12 due to urbanization.

Alternative 4-II is recommended because of lower construction cost than Alternative 4-I. This means that PCHCMC will require to provide some regulation and management organization on new development in high land that any developers shall construct the required onsite detention pond to control the flood run-off increased due to their activity. This conclusion is able to apply for the new development in NE.3(R. Thu Duc) and NE. 4 (R. Truong Tho) basins.

6.3 Proposed Optimum Plan

6.3.1 Outline of Proposed Optimum Plan by Drainage Zone (refer to Fig. 6.8)

(1) C-Zone

At present, C zone is overcrowded with a population of about 3.19 million. Flood areas are estimated at 21.2 km^2 equivalent to almost 60 % of total flood area (34.6 km^2). For C zone drainage improvement, it is proposed to collect storm water as much as possible and to drain to the surrounding rivers as soon as possible by the structural measures:

(a) Rehabilitation and construction of drainage pipes (Grade 2,3,and 4)

(b) Canal improvement for Nhieu Loc - Thi Nghe, Tan Hoa - Lo Gom and Tau Hu - Ben Nghe canals

(c) Drainage improvement for low-lying areas (Thanh Da and Ben Me Coc) by pump drainage system consisting of dike, pumping station with retarding pond, canal improvement, and drainage pipe facilities

It is recommended that these measures are to be implemented as a short term program taking into account of urgency of the drainage improvement works of C zone.

(2) N-Zone

N zone having a population of 422,000 has suffered from the flood with an area of 7.5 km^2 (about 21% of the total flood area). This zone is projected to increase in about 2.6 times population and to expand into about 1.7 times development area in 2020. For the drainage improvement of N zone, the following combination with structural and non-structural measures is proposed.

(a) Practical utilization of low-lying paddy fields as a natural retarding basin and land use regulation for these areas
(b) Rehabilitation and construction of secondary/tertiary drainage channels, drains and pipes in the right bank basin of Tham Luong - Ben Cat canal
(c) Canal improvement for Tham Luong - Ben Cat and Ben Da - Ba Hong canals
(d) Construction of secondary/tertiary drainage channel and drain for the left bank basin of Tham Luong - Ben Cat canal and Ben Da - Ba Hong basin

It is recommended that the above item (a) & (b), and (c) & (d) are to be implemented as the short and mid. term program respectively, considering the present and future urbanization and flood conditions in N zone.

(3) W-Zone

Population, future developments and flood area in built-up one in West zone are about 50 % of those in N zone. The proposed measures are almost same as that of N zone.

(a) Utilization of low-lying paddy fields as a natural retarding basin and land use regulation for these areas
(b) Construction and rehabilitation of secondary/tertiary drainage channel, drain and pipe improvement in the eastern region neighboring C zone
(c) Canal improvement for R. Cua - R. Nuoc Len and other canals
(d) Construction of secondary/tertiary drainage facilities in new development areas

It is recommended that the above item (a) & (b), and (c) & (d) are to be executed

as the short and mid. term program. Because the urbanization and flood condition in W zone is almost same as that of N zone.

(4) S-Zone

About 110,000 peoples are living in the existing built-up area of 11.37 km^2, which is mostly southern parts of Doi - Te canal. However, Saigon South Development Project will change the land use from the southern low-lying agricultural land to residential, institutional and industrial park. The following structural and non-structural measures are proposed.

(a) Preservation of land along the existing rivers/canals and land use regulation of low-lying paddy field
(b) Construction of secondary/tertiary drainage channel, drain and pipe in the existing built-up area
(c) Partial improvement of main canals
(d) Construction of secondary/tertiary drainage facilities in newly developed areas

The above items (a) & (b), and (c) & (d) are recommended to implement in short term and mid. or long term programs respectively. Because the Saigon South Development Project expects private investment for its implementation.

(5) NE-Zone

Almost 120,000 peoples are living in Thu Duc region, of which built-up area is about 7 % of a total one in the study area. Up to 2020, about 21 km^2 of high land agricultural area (about 50 % of Thu Duc region) is expected to develop as a residential, institutional, industrial and recreation/refresh area. Some parts have been developed and it is feared to increase the flood risk for the downstream low lands. The proposed measures consisting of structural and non-structural measures are as follows:

(a) Land use and flood control regulations for high land development: (construction of onsite detention pond by developers)
(b) Land use regulation for low-lying agricultural land and preservation for future requirement of land along the existing canals
(c) Rehabilitation of secondary/tertiary drainage facilities in existing urbanized areas
(d) Canal improvement in adjustment with the urbanization
(e) Construction of secondary/tertiary drainage facilities in newly developed areas

It is recommended that the above items (a), (b) & (c), and (d) & (e) are to be

executed in short tem and mid. or long term program respectively in view of the flood condition and economy of non-structural measures.

(6) SE-Zone

The present population of about 160 thousand and urbanized area of about 13.0 km^2 in SE zone is almost the same situation as that of NE zone, however topography and land use of SE zone is prominently different because of almost all low flat paddy field. However, inland low-lying areas of about 31 km^2 is projected to develop up to 2020 as a residential, institutional and industrial areas, which is equivalent to 2.3 times of the existing developed area. Accordingly, following structural and nonstructural measures is proposed.

(a) Land use regulation for low-lying paddy field and preservation for future land requirement along the existing canals
(b) Rehabilitation of secondary/tertiary drainage facilities in existing urbanized areas
(c) Canal improvement in adjustment with the urbanization
(d) Construction of secondary/tertiary drainage facilities in newly developed areas

The above items (a) & (b), and (c) & (d) are proposed to implement in short and mid. or long term program. Because the new development in SE zone is expected to start relatively early period, but it takes much time to be fully developed.

6.3.2 Canal Improvement

The optimum improvement plan for 27 canal systems was formulated based on their design discharges shown in Figs. 6.9 (1/3) to (3/3) and the following concept:

(a) Main canals with a catchment area of more than 30 km^2 are proposed to improve for 10-year frequency flood. However, the objective canals in suburban area are to be improved in two (2) stages from the economical viewpoint, 5-year return period canal improvement in first stage and 10-year return period one in second stage as a long-term plan. Main canals in the inner city and having a basin of less than 30 km^2 are to be improved at one stage.

(b) Tau Hu canal and the downstream reaches of Tan Hoa - Lo Gom in C zone have to be improved based on the water transportation requirement proposed in the pre-feasibility study conducted by DTPW. The other canal improvements have to be planned based on the drainage requirement to minimize the project cost.

(c) O/M road with width of 5.0 m is to be constructed along both banks to minimize total project cost, in spite of the following O/M road standard prepared MOC,

- city area: 5.0 m in width (new development area: 10.0 m in width)
- suburban area: 10.0 m in width (new development area: 20.0 m in width)

(d) The water surface gradient is to be proposed as the same existing ground slope as possible and the canal bed is to be paralleled with the proposed water surface gradient.

(e) Considering a design discharge, topography, development situation and difficulty of land acquisition/house compensation, the following five (5) types of canal cross sections shown in Fig. 6.10 are proposed.

- Type A : This type will be applied in case that the existing discharge capacity is bigger than the design one. No improvement works are executed except the construction of O/M road. Reformation of the bank and a grass/sod slope protection will be implemented.

- Type B : This type forms trapezoidal shape with 1:2 slope lined by grass/sod. This type will be mainly applicable for the canal improvement in suburban area, where land acquisition is relatively not difficult.

- Type C : This type forms trapezoidal shape with 1:1 to 1:1.5 slope lined by stone masonry. This type will be applied in the existing urbanized areas where expected lands can be acquired without much problem.

- Type D : This type forms trapezoidal shape with 1:0.5 slope or rectangular shape protected by the reinforced retaining wall. This type will be employed in the existing urbanized area, where land acquisition is expected to be rather difficult.

- Type E : This is a reinforced concrete box culvert. This type will be applied at the road crossing if the bridge construction is more expensive than this. This type is also employed for the improvement of upstream reaches, which is expected to be covered by the project.

(f) In case the existing bridge length is shorter than the proposed canal width, reconstruction of the bridge is proposed. No rehabilitation of the existing bridge is proposed due to lack of detailed structural data and information.

Tables 6.1(1/4) to (4/4) and Figs. 6.11 (1/2) and (2/2) show the proposed optimum canal improvement plan. The proposed canal improvement length and number of the proposed box culvert/bridge construction by zone are summarized in the table below:

Bill of Quantities by Drainage Zone

Item / Zone	C	N	W	S	NE	SN	Total
Type A (km)	18.29	0	16.02	52.81	0	41.28	128.40
Type B (km)	3.89	42.52	20.24	5.68	25.99	8.00	106.32
Type C (km)	28.92	14.86	9.91	0	14.66	0	68.35
Type D (km)	4.23	0	0	0	0	0	4.23
Sub-total (km)	55.33	57.38	46.17	58.49	40.65	49.28	307.30
Type E (place)	0	4	0	0	0	0	4
Bridge (place)	4	7	3	0	5	0	19

Note: Bill of quantities for the canal improvements by zone are shown in Table 6.2.

6.3.3 Pump Drainage Improvement

As described before, gravity discharge system by land filling is the most economical drainage measure for the development of low lands in the study area. However, for some low-lying areas located on the fringe of C zone, which have being developed, the pump drainage system is to be applied due to the difficulty of relocation to filling up. Three (3) low catchment areas in C zones were proposed to employ it as shown in Fig. 6.12. In order to minimize the pump drainage cost, it has been planned to make small pump capacity in association with a retarding pond. The proposed pump drainage plan is as follows:

The Proposed Pump Drainage Plan

Location / Item	Than Da	Ben Me Coc (1)	Ben Me Coc (2)
Drainage Area (km^2)	0.495	0.709	0.460
Pump Capacity (m^3/s)	1.1	1.5	1.0
Retarding Pond Capacity (m^3)	22,900	33,000	21,400
Storage Capacity of Canal and Drainage Pipe (m^3)	11,100	15,900	10,300
Water Gate (W x H x unit)	2.0 x 2.0 x 1	2.5 x 2.5 x 1	2.0 x 2.0 x 1
New Dike Construction (m)	200	4,200	3,400
Rehabilitation of Existing Dike (m)	1,200	0	0
Construction & Rehabilitation of Drainage Pipe (km^2)	0.495	0.709	0.460

6.3.4 On-site Detention Pond

For new developments of the high land in three (3) catchment areas (NE.3, NE.4 and NE.5) located on Thu Duc region in NE zone, any developer has to construct a detention pond to regulate the increased flood run-off. The specific and total storage requirements of the detention pond in these areas are estimated at 17,000 - 19,000 m^3/km^2 and 50,000 - 530,000 m^3 respectively. Since no concrete development plan is now prepared, assuming that the storage capacity of one detention pond will be 30,000 - 40,000 m^3/pond, the required number of the ponds for each catchment area is estimated at 4, 2 and 12 ponds as shown in the table below:

Onsite Detention Pond Plan in Thu Duc Region

Item \ Drainage Zone		NE.3	NE.4	NE.5
Drainage Area (km^2)		7.15	2.65	34.38
Development Area (km^2)	1997	2.39	1.50	5.13
	2020	6.25	2.48	21.46
	Difference	3.86	0.98	16.33
Run-off Coefficient (C)	1997	0.50	0.57	0.45
	2020	0.64	0.73	0.57
	Difference	0.14	0.16	0.12
Specific Storage Requirement of Detention Pond (Vs) (x 1,000 m^3/km^2)		17.2	19.0	15.3
Total Storage Requirement of Detention Pond (V = Vs x A) (x 1,000 m^3)		123.0	50.5	526.1
Proposed Typical Capacity of Onsite Detention Pond (Vt) (x 1000 m^3)		31.0	25.5	44.4
Propose Number of Onsite Detention Pond (N = V/Vt) (place)		4	2	12

6.3.5 Drainage Pipe and Channel Improvement

The principal of drainage development plan is to utilize the existing combined sewer network to minimize the investment cost and allocate the budget effectively. According to the survey of existing combined sewer system, most of the system is still functioning well. The development plan of drainage pipe and channel systems to mitigate flooding also takes into account the factors consisting of sewerage development plan, existing combined sewer area and existing/future land use.

Consequently, respective countermeasures are proposed for four (4) area types, which are classified in the forgone section, as shown in the table below and in Fig. 6.13.

Drainage Pipe/Channel System Development Plan

Area Type	Factor					Proposed Countermeasures
	Sewerage Development Area	Sewerage Collection System	Existing Combined Sewer Area	Land Use		
				Existing	Future	
(A)	Yes	Combined	Fully covered	Urbanized Area	Urbanized Area	Rehabilitation ofexisting main/ secondary/tertiary combined sewer
(B)-1	Yes	Combined	Partially covered	Rural/Urbanized Area	Urbanized Area	Installation additional main/ secondary/tertiary combined sewer
(B)-2	Yes	Separate	Not Exist	Rural/Urbanized Area	Urbanized Area	Mostly installation open channel for new urbanized part, Partially installation of sewer pipe for existing urbanized part
(C)	No	-	Not Exist	Rural/Urbanized Area	Urbanized Area	Mostly installation open channel for new urbanized part, Partially installation of sewer pipe for existing urbanized part ditto
(D)	No	-	Not Exist	Rural Area	Rural Area	Utilize existing natural drainage system

Based on the above-mentioned criteria of the delineation, the length of the proposed drainage pipe/channel is estimated as shown in the table below. Assumption of the estimation is based on the existing condition of drainage system in District 1, which has been fully covered by drainage system.

Estimated Length of Drainage Pipe/Channel

Drainage Zone		Length of Proposed Drainage Pipe/Channel (m)					
Zone Name	Area (ha)	Rehabilitation of Existing Sewer	Main Combined Sewer	Secondary /Tertiary Combined Sewer	Stormwater Sewer	Open Channel	Total
C-Zone	10,641	15,181	375,846	162,528	11,792	214,400	779,747
N-Zone	13,620	-	265,179	114,672	59,697	1,085,400	1,524,948
W-Zone	7,291	-	53,280	23,040	19,536	355,200	451,056
S-Zone	8,174	-	149,073	64,464	33,836	615,200	862,573
NE-Zone	6,491	-	255,855	110,640	35,354	642,800	1,044,649
SE-Zone	11,936	-	294,261	127,248	47,146	857,200	1,325,855
Total	58,153	15,181	1,393,494	602,592	207,361	3,770,200	5,988,828

Note : The length of drainage pipe per area are assumed as follows;
Main Combined Pipe :111 m/ha
Secondary/Tertiary Combined Pipe:48 m/ha
Stormwater Sewer :11 m/ha
Open Channel :100 m/ha x both side of road

6.4 Proposed Non-structural Measures

According to the city development master plan in 2020, the present population of about 4.3 million in the study area is projected at about 7 million in 2020. Consequently the existing built-up area of about 170 km^2 will be expanded at about 340 km^2. Urbanization of high land in N and NE zones and low-lying agricultural land in W, S and SE zones will increase the amount of flood run-off and peak discharge, resulting in expansion of flood risk to the surrounding areas. Since structural measures will take much investment and time in rapidly urbanizing city of HCM, it is recommended to employ the comprehensive urban drainage plan including non-structural measures. The proposed non-structural measures are as follows:

(a) Identification and publication of flood-prone area

Inundation map is the essential tool for the publication of information on floods. This serves as a guide for stabilizing the living conditions of the peoples and future development, resulting in mitigation on flood damages.

(b) Preservation of low-lying agricultural land in surrounding areas

A large scale filling-up of the low-lying paddy fields for land development will impact instantly to deteriorate the surrounding drainage condition and bring the necessity of much investment for drainage improvement by structural measures. So, it is proposed to preserve these low lands for land development as much as possible and utilize these areas as a natural retarding basin. PCHCMC has to prepare an appropriate guideline of land use regulation for low-lying areas and to provide the administrative organization as a practical implementation agency.

(c) Preservation of future land requirement of canal improvement

A large scale of land acquisition (total area: 4.49 km^2) will be required for the future canal improvement consisting of widening/deepening, bank protection work and O/M road construction. It is proposed to preserve the future land requirement for canal improvement as fast as possible to reduce the cost and time for the land acquisition and house compensation. PCHCMC will need to prepare an appropriate guideline and to strengthen the organization in order to strictly control and regulate these future required land.

(d) Flood proofing measures in flood-prone area

PCHCMC shall provide guidance to the residents, who are living in flood-prone areas, that houses/buildings shall provide individual flood proofing measures such as a partial land fill, flood-proof wall, piloti style house, etc. to mitigate the flood damage by themselves. Because it will be necessary to take much time to

complete the drainage improvement works.

(e) Flood control regulation for new development in high land

New developments in high lands, such as Hoc Mon district in N-zone and Thu Duc district in NE-zone, will increase the flood risk in downstream low-lying areas and the cost of canal improvement. So, these developers shall construct a retarding pond to regulate flood run-off increased by the new development. PCHCMC shall prepare a regulation law of flood control for new development in high land and establish an organization having technical development, investigation and inspection sections.

(f) Strengthening of the existing flood forecasting and warning system

Establishment of sufficient hydro-meteorological monitoring system is necessary to mitigate a flood damage in the city. The existing monitoring system managed by Southern Region Hydro Meteorological Center (SRHMC) is proposed to improve as follows:

- Manual rain gauge of six stations in and around the study area shall be replaced by an automatic one.
- Water level station network for inland main rivers/canals shall be established.

(g) Strengthening of the existing standing office for flood prevention

The branch office of Water Management and Flood Prevention/Fighting was established in Department of Agriculture and Rural Development in 1996 as a standing office to support the Steering Committee of Flood and Storm Prevention in PCHCMC. Organization of this office shall be strengthened to carry out sufficiently its function and responsibilities including the smooth implementation of the proposed non-structural measures.

6.5 Project Cost

6.5.1 Basic Conditions of Cost Estimate

The project cost and operation and maintenance cost are estimated based on the following basic conditions:

(a) The project cost consists of (i) construction cost, (ii) administration cost, (iii) land acquisition and house compensation cost, (iv) engineering cost and (v) physical contingency. The price contingency is excluded from this estimation.

(b) All base costs are estimated under the economic conditions in February 1999.

(c) The exchange rate of foreign currencies are applied as follows:

US$ 1.00 = Yen 111.1= VND 13,332

(d) Imported tax for machinery, equipment and materials to be imported are excluded.

(e) Annual O/M cost is assumed at 0.3% of the construction cost for canal, onsite detention pond and drainage pipe and 0.5% of the construction cost for pumping station.

6.5.2 Estimated Cost

Total project cost is estimated at 16,423 billion VND. The estimated project cost by zone is shown in the table below:

Project Cost

(unit: Billion VND)

Cost \ Zone	C	N	W	S	NE	SE	Total
1. Construction	3,856.4	2,649.1	1,243.7	883.4	1,559.6	1,031.2	11,223.4
(1) Canal Imp.	(894.0)	(786.1)	(540.1)	(272.4)	(648.8)	(179.8)	(3,321.2)
(2) Pump Drainage	(262.1)	(0)	(0)	(0)	(0)	(0)	(262.1)
(3) Onsite De-Pond	(0)	(0)	(0)	(0)	(272.4)	(0)	(272.4)
(4) Exist. Sewer Imp.	(118.4)	(0)	(0)	(0)	(0)	(0)	(118.4)
(5) Comb. Sewer Imp.	(2,369.0)	(785.0)	(350.8)	(0)	(0)	(0)	(3,504.8)
(6) Storm Sewer Imp.	(212.9)	(1,078.1)	(352.8)	(611.0)	(638.4)	(851.4)	(3,744.5)
2. Land Acq./House C.	1,386.2	631.3	250.5	183.6	235.6	181.7	2,869.0
3. Administration	157.3	98.4	44.8	32.0	53.9	36.4	422.8
4. Engineering	269.9	185.4	87.1	61.8	109.2	72.2	785.9
5. Contingency	385.6	264.9	124.4	88.3	156.0	103.1	1,122.3
Total	6,055.5	3,829.3	1,750.5	1,249.1	2,114.3	1,424.6	16,423.3

Note: 1. Administration cost is assumed at 3 % of a total cost of construction and land acquisition/house compensation.
2. Engineering costs is assumed at 7 % of the construction cost.
3. Physical contingency cost is assumed at 10 % of the construction cost.

Total annual operation and maintenance cost is estimated at 33.8 billion VND. Annual O/M cost by zone is as follows:

Operation and Maintenance Cost

(unit: Billion VND)

Cost Zone	C	N	W	S	NE	SE	Total
O/M Cost	12.1	7.9	3.7	2.7	4.7	3.1	33.8

6.6 Economic Project Evaluation

6.6.1 Economic Benefit

An economic analysis appraises the project in terms of a national and/or a regional socio- economy by comparing and measuring its economic costs and benefits. In other words, economic analysis evaluates the degree of economic impacts of the project that would bring about in the national and/or regional socio-economy.

Damages and/or losses estimated in previous Chapter are to be regarded as economic benefits in case of with the Urban Drainage System Improvement Works. In this case, such damages as to buildings/indoor movables and to agricultural crops estimated by flood scale should firstly be converted into the average annual flood damages by calculation of probability.

For estimation of the economic benefit in future urbanized situation in 2020, distribution level of the Project to the urbanization of each Zone is to be taken into account for direct benefits. Following Table shows a summary of benefits by Zone consisting of direct and indirect ones at base year and in 2020 respectively.

Zone	Annual average benefit (billion VND)			
	Direct benefit		Indirect benefit	
	Base year	2020	Base year	2020
C Zone	366.5	439.9	107.7	120.0
N Zone	218.1	273.4	8.2	22.1
W Zone	40.9	117.5	6.7	14.6
S Zone	39.1	117.9	4.0	13.6
NE Zone	3.7	64.7	3.7	12.5
SE Zone	39.4	127.5	6.7	34.7
Whole area	707.7	1140.9	137.0	217.5

6.6.2 Economic Cost

A project cost consists of foreign currency portion and local currency portion.

Foreign Currency Portion

Using the financial construction cost estimated by Cost Estimator, economic cost of the Project is estimated. In this study, the net construction cost includes labour cost, costs for materials and equipment. For the foreign currency portion, these costs for labour, materials and equipment are estimated in either Cost Insurance Freight (CIF) price. These international prices are assumed to reflect economic cost directly.

Local Currency Portion

Because it is presumed that local markets in developing countries are distorted by price controls and other regulations, prices in the domestic markets do not reflect economic scarcity of goods and services. This means that the prices can not be used to identify economic costs of local procurement and have to be converted into economic prices. In economic analysis of a project, conversion factors are used to convert the costs in domestic markets into economic costs of a project.

Using export and import statistics, a standard conversion factor (SCF) is estimated at a rate of 0.90195. The SCF converts the domestic commodity prices into the economic prices that can be assumed to reflect the economic scarcity of the local equipment and materials.

However, the SCF is applied to only tradable goods. The economic cost of non-tradable goods and services has to be separately evaluated. Conversion factors of land, skilled and non-skilled labours are respectively estimated.

Economic wage of unskilled laborers to be employed for the construction works is assumed to be 70 % of the actual market wage, taking of the employment opportunity of laborers in the study area.

Economic cost of land compensation including other compensation cost such as the cost for removal of houses is assumed to be 100 % of the financial cost, taking account of the opportunity cost of land use.

Total Economic Cost

Following table shows a summary of economic construction cost estimates by Zone from the financial cost together with operation and maintenance cost (OM cost) and replacement cost.

(unit: Billion VND)

Zone Cost	C Zone	N Zone	W Zone	S Zone	NE Zone	SE Zone	Whole project area
Financial cost	6,055.5	3,828.4	1,750.4	1,249.5	2,144.6	1,424.2	16,452.6
Economic cost	5,028.9	3,122.9	1,419.6	1,013.8	1,699.2	1,132.2	13,416.6
Economic cost							
OM	10.0	6.4	3.0	2.2	3.8	2.5	27.9
Replacement	104.5	0.0	0.0	0.0	0.0	0.0	104.5