2.6.2 Problems of Relocation and Resettlement

(1) Government Side

(a) Legal Land User

The difficulties encountered are in moving households with land use rights. Legal land users have the right to be compensated by the present law/regulation. However, many of these households feel that the unit price of compensation for their land is below the market rate and it takes long time for negotiation.

(b) Illegal Houses/Land Users

The number of illegal house and land user in the whole city has not been officially investigated yet. Additionally, illegal residents have not been compensated in relocation under the existing regulatory framework and this causes hindrance of smooth relocation negotiation.

(c) Price of Apartment Unit

Over pricing of apartments is another hindrance for relocation program. Also, the design of apartment is not usually appropriate from the point of family structure, income level, income sources, etc.

(d) High Percentage of Relocatees who sell their Units of Apartment in Resettlement Sites

The authority considers this attitude of the relocatees are based on the following two factors; (a) since the unit price is lower than the market price, relocatees sell at the higher price than that they bought and get money, and (b) after resettlement, living condition is getting better and they look for the much better housing. Based on the interview and observation, however, the most possible reason is likely that the amount of repayment makes a large economic burden to the relocatees and their living becomes difficult.

(e) Limited Budget and Manpower for Relocation/Resettlement

People's opinions should be heard and compensation amount should be calculated and negotiated considerately with the targeted inhabitants. This requires enough budget and government staff in charge with technical knowledge.

(2) Inhabitants Side

(a) Loss of Income Base and Decrease of Income

The relocation of households and their businesses may have a major impact on the income situation and the basis of businesses. When maintaining the original job after relocation, households will be faced with an increase in transportation costs and travel time to their places of work. In some cases, this may lead to giving up the income generating activity. Also, informal businesses will be affected by relocation, in particular, when the relocates cannot maintain their former client and suppliers' networks in the resettlement sites.

(b) Increase of Costs of Living in the Resettlement Site

Households in the new resettlement sites have to pay service charges such as water, electricity and garbage collection, repayment for housing units, possibly higher transportation costs, etc. Some of these expenditures may not have been paid at all by a part of the households in their original locations. This incurs additional financial burden due to high interest rates and loan service conditions.

(c) Change of Life

While government prefers apartment construction for resettlement to other options of relocation such as land and row houses, it is likely that people prefer to be provided with land and build their houses by themselves. Standardized apartments and rented houses are not preferable according to their traditional living style. Also, sometimes the previous community is split in some places and their cooperation system is broken. This may cause the uneasy of the relocatees in new resettlement sites and the unstable relationship between new relocatees and the already existing inhabitants.

2.6.3 Policies and related Regulations

(1) National Policy

Though many laws, decrees and regulations have been issued since 1992 (Constitution issued), the policy and legal framework for relocation is not fully coherent and transparent. Decree No. 90/CP was displaced by Decree No. 22/ND-CP issued in 24 April 1998. Decree No. 22 is the base for determination of area to be cleared for national and public purposes. According to this decree, all transportation and infrastructure projects allow government to acquire appropriate land. The new decree highlights further compensation entitlements and subsidies compared to the previous one. The higher prices for urban land is set and the definition of land for public use is broadened. The policy

of compensation of the all projects is unified to avoid complaints by the inhabitants and the degree of compensation becomes higher. Presently, however, according to this decree, a growing number of people still cannot be classified as legal and are thus not entitled to compensation arrangements.

Relocation policy largely takes the form of compensation policy in the above legal framework. However, it is significant that not much attention is paid to enactment of regulations concerning a minimization of relocation and socio-economic aspects of the affected people and businesses. Compensation costs of land and property are based on minimum and maximum prices as specified in Decree No. 87/CP. Provinces and cities governed by central government are allowed to set their own land values according to the local conditions, as they fall within the limited ranges.

(2) HCMC Policy

The relocation in HCMC aims at 3 objectives as follows.

(a) Clearance of encroached houses on and along canals that obstruct living environment, security and waterway transport
(b) Urban rehabilitation
(c) Reduction of population pressure in inner city residential areas

It is important to note that current government policy in respect of all canal residents within the city is that all structures and households living on and along the canal within a boundary of 20 m from the existing bank (called as "the technical boundary") will be removed and structures within another 20 m (termed as "the redevelopment boundary") will also be subject to clearance (depending on the detail design and funding of the project).

The general policies to the relocated households are;

(a) For those who look for accommodation by themselves

- Compensated and subsidized once by cash
- Given favorable conditions for re-immigration to their previous area and different district or province

(b) For those who register at new apartments prepared by the government

- Compensated for clearance and subsidized for relocation
- Allowed to buy in or rent an apartment unit
- Exempted from land use tax, registration fee of new house and land transfer fee

- Supported for vocational training and put priority on employment service for cases who register at new apartment block at industrial area of the district
- Supported for the low income people for 3-6 months to have a stable life in resettlement area, such as living cost, education cost, medical care, service of social workers and privilege for job training
- Supported for necessary formalities on permanent residential registration

Households who want to buy an apartment prepared by the government, can choose one of the following 3 options regarding the cost of apartment; (i) Payment of the entire cost at a time with 10% discount, (ii) Payment at least 30% of total price at the first and the remainder paid every 3 months within 1 year with 2% discount, (iii) Payment within 10 years, each year of which pays 1/10 of the remainder, equivalent to 99.99% pure gold at the moment of debt and payment.

2.6.4 Organization related to Relocation/Resettlement

Under Decision No. 4964/QD-UB-VX (1998), PC of HCMC has established a Steering Committee for Urban Planning, Compensation and Resettlement. The main tasks of Steering Committee are to coordinate compensation and resettlement activities including consultation, advice, monitoring for compensation and relocation of district level, and enforce HCMC policy.

PC of HCMC decides lands to be confiscated, and has the overall responsibility for determining the compensation plan, setting its own land values within the broad national range. District PC is responsible for confirming the land and structure areas affected and the entitlements to compensation working in coordination with the Department of Land & Housing. Also, PC of district has authority to draw up and determine specific compensation rates. The Chairperson of PC of district is entitled to issue a decision for the establishment of Project Management Unit (PMU) for Clearance and Compensation of each project when there is a decision of PC of HCMC for land acquisition and clearance of houses in the district.

During the last couple of years, People's Councils have tended to increase their role in the local operation of decrees. This council is particularly relevant to relocation where national regulation requires that they be specified in the local context. Also, the Council can receive people's complaints including those related to relocation and try to solve them.

Most of works concerned with relocation and resettlement is handled by Department of Land & Housing. This department is responsible for coordinating the relocation plan at city level. This includes planning, funding and arranging transfers of funds, and

providing technical support to the district. This department handles the City Housing Development Fund whose source mainly comes from the sale of state-owned housing and are used for supporting relocation.

Urban Planning Institute (UPI) conducts research on urban planning, being responsible for setting the boundaries for relocation, and proposes projects to Chief Architect's Office that manages projects. Department for Labor and War Invalids, Social Affairs, a part of the Steering Committee, is mainly concerned with implementing the policy of resettlement to New Economic Zones. The social aspects of the inhabitants in resettlement sites should be covered mainly by this department, but this activities have not been implemented yet. Also, Department of Education is responsible for the school registration, transfer of school children during the construction of new school, of children after relocation.

Key issues regarding the organizations related to relocation/resettlement are,

(a) Coordination between organizations is problematic and not functional,
(b) There is a considerable difference in capacity between different districts, and
(c) The issue of rehabilitation of relocatees is not actively taken up by any organization, though its importance is recognized.

2.6.5 Compensation

Compensation will be provided in cash, by land or by house according to Decree No. 22. Scope of compensation is;

(a) Loss of the whole area of confiscated lands stated in Decree No. 22
(b) Loss of properties on confiscated land, including infrastructure
(c) Subsidizing people and factories that have to be relocated
(d) Paying fees to confiscated land-owners who have to change their jobs
(e) Paying the cost of site clearing, moving and allowance

Those who are entitled to compensation for loss of properties on confiscated lands must be legal owners of those properties. Illegal households are not entitled to compensation other than receiving a one way removal fee or support in moving to the New Economic Zone. The minimum and maximum price range established under Decree No. 87/CP is used as the basis for assessment of compensation by provincial/city authorities. PC of HCMC is responsible for creating a compensation plan and the compensation rates that will be paid within national guidelines. Major projects require special legislation. The compensation frame is based on the Decision No. 4755/QD-UB-QLDT of PC of HCMC and other circulars under this Decision. Individuals using land illegally after 15 October 1993 will receive no assistance. Allowance for moving, transition and subsistence are limited to permanent residents.

Compensation amounts are based on the 3 criteria; that is, (i) Purpose of resettlement, (ii) Legal status of the inhabitants, and (iii) Standard, quality and status of land and house. In Decision No. 05/UB-QLDT, PC of HCMC has further specified the prices of urban land in HCMCHCMC. Decision N0. 6337/QD-UB-QLDT regulates additional basis for compensation for land and houses located on and along canals or rivers and areas of huts in HCMC.

Table 2.1 Population Changes of HCMC

No.	Year / District/ Ward, Commune	Total Area (sq.km)	1979 (Census) Population	1979 (Census) Density (p/ha)	1989 (Census) Population	1989 (Census) Density (p/ha)	1994 Population	1994 Density (p/ha)	1995 Population	1995 Density (p/ha)	1996 Population	1996 Density (p/ha)	1997 Population	1997 Density (p/ha)
Total HCMC		**2,093.7**	**3,293,146**	**16**	**3,924,435**	**19**	**4,649,387**	**22**	**4,764,671**	**23**	**4,880,435**	**23**	**4,989,703**	**24**
Inner City		**140.3**	**2,352,813**	**168**	**2,796,229**	**199**	**3,306,609**	**236**	**3,386,488**	**241**	**3,466,891**	**247**	**3,541,040**	**252**
(1)	Quan 1	7.6	222,760	293	252,263	332	264,859	348	271,292	357	277,115	365	282,063	371
(2)	Quan 3	4.8	213,545	445	238,943	498	244,358	509	249,964	521	255,637	533	260,418	543
(3)	Quan 4	4.0	141,748	354	179,933	450	207,655	519	212,370	531	216,628	542	220,650	552
(4)	Quan 5	4.1	192,081	468	213,720	521	237,084	578	242,274	591	246,965	602	251,387	613
(5)	Quan 6	7.0	175,789	251	213,353	305	264,198	377	269,897	386	275,262	393	280,336	400
(6)	Quan 8	18.8	213,470	114	254,702	135	326,362	174	333,572	177	340,546	181	347,090	185
(7)	Quan10	5.7	207,842	365	229,621	403	256,924	451	262,290	460	267,070	469	271,593	476
(8)	Quan11	5.0	199,302	399	225,264	451	244,358	489	249,958	500	255,220	510	260,159	520
(9)	Go Vap	19.2	127,934	67	162,534	85	217,576	113	223,166	116	229,291	119	234,966	122
(10)	Tan Binh	38.5	264,315	69	333,834	87	466,232	121	480,278	125	496,810	129	512,185	133
(11)	Binh Thanh	20.5	249,640	122	321,246	157	388,196	189	397,872	194	408,173	199	417,739	204
(12)	Phu Nhuan	5.1	144,387	283	170,816	335	188,807	370	193,555	380	198,174	389	202,454	397
Outer City		**1,953.4**	**940,333**	**5**	**1,128,206**	**6**	**1,342,778**	**7**	**1,378,183**	**7**	**1,413,544**	**7**	**1,448,663**	**7**
(13)	Hoc Mon	109.5	208,035	13	243,963	15	289,538	18	297,377	18	305,420	19	185,871	17
(14)	Quan12	52.5	-	-	-	-	-	-	-	-	-	-	127,459	24
(15)	Thu Duc	48.0	239,078	11	297,161	14	354,802	17	364,734	17	375,202	18	171,165	36
(16)	Quan 2	50.2	-	-	-	-	-	-	-	-	-	-	95,219	19
(17)	Quan 9	113.1	-	-	-	-	-	-	-	-	-	-	119,446	11
(18)	Binh Chanh	303.3	164,935	5	201,284	7	244,684	8	251,081	8	257,496	8	263,883	9
(19)	Nha Be	98.4	97,450	7	122,250	9	149,585	11	153,564	11	157,522	12	63,041	6
(20)	Quan 7	35.9	-	-	-	-	-	-	-	-	-	-	98,380	27
(21)	Huyen Cu Chi	428.5	191,614	4	214,266	5	250,727	6	256,631	6	261,881	6	267,026	6
(22)	Can Gio	714.0	39,221	1	49,282	1	53,442	1	54,796	1	56,023	1	57,173	1

Source: Statistical Office of HCM

Table 2.2 The Balance Between Existing Population and Frame For Year 2020

Area	Year / District/ Ward, Commune		Total Area (sq.km)	1997			2020		Annual Increase Rate
				Population	Density (p/ha)	Household	Population	Density (p/ha)	
	Total HCMC		**2,093.7**	**4,989,703**	**24**	**988,281**	**10,400,000**	**50**	**3.24%**
S. A.	**Inner City Total**		**140.3**	**3,541,040**	**252**	**707,055**	**4,000,000**	**285**	**0.53%**
	(1)	Quan 1	7.6	282,063	371	62,169	270,000	355	-0.19%
	(2)	Quan 3	4.8	260,418	543	57,536	250,000	521	-0.18%
	(3)	Quan 4	4.0	220,650	552	40,831	210,000	525	-0.21%
	(4)	Quan 5	4.1	251,387	613	51,023	220,000	537	-0.58%
	(5)	Quan 6	7.0	280,336	400	52,689	300,000	429	0.30%
	(6)	Quan 8	18.8	347,090	185	64,463	430,000	229	0.94%
	(7)	Quan10	5.7	271,593	476	56,326	270,000	474	-0.03%
	(8)	Quan11	5.0	260,159	520	50,006	250,000	500	-0.17%
	(9)	Go Vap	19.2	234,966	122	43,640	450,000	234	2.87%
	(10)	Tan Binh	38.5	512,185	133	102,092	600,000	156	0.69%
	(11)	Binh Thanh	20.5	417,739	204	83,958	520,000	254	0.96%
	(12)	Phu Nhuan	5.1	202,454	397	42,322	230,000	451	0.56%
S.A.	**New Urban Area**		**299.7**	**611,669**	**20**	**122,080**	**2,450,000**	**82**	**6.22%**
	(13)	Quan12	52.5	127,459	24	25,933	500,000	95	6.12%
	(14)	Thu Duc	48.0	171,165	36	33,416	550,000	115	5.21%
	(15)	Quan 2	50.2	95,219	19	19,043	650,000	129	8.71%
	(16)	Quan 9	113.1	119,446	11	23,582	400,000	35	5.40%
	(17)	Quan 7	35.9	98,380	27	20,105	350,000	97	5.67%
Partially	**Rural Area**		**511.2**	**512,795**	**10**	**96,495**	**2,350,000**	**46**	**6.84%**
S.A.	(18)	Hoc Mon	109.5	185,871	17	34,397	650,000	59	5.59%
	(19)	Binh Chanh	303.3	263,883	9	50,406	1,300,000	43	7.18%
	(20)	Nha Be	98.4	63,041	6	11,693	400,000	41	8.36%
Out of	**Rural Area**		**1,142.5**	**324,199**	**3**	**62,651**	**1,600,000**	**14**	**7.19%**
S.A.	(21)	Huyen Cu Chi	428.5	267,026	6	53,032	900,000	21	5.42%
	(22)	Can Gio	714.0	57,173	1	9,619	700,000	10	11.51%

Source: Statistical Office of HCMC, Master Plan 2020 of UPI

Note: "S.A." means Study Area

TABLE 2.3 PROBABLE MAXIMUM RAINFALL DEPTHS AT TAN SON NHAT

Unit : mm

Time (minutes)	Probable Rainfall Depths for Different Return Periods											
	1-Yr.	1.5-Yr.	2-Yr.	3-Yr.	5-Yr.	10-Yr.	20-Yr.	25-Yr.	30-Yr.	50-Yr.	70-Yr.	100-Yr.
15	18.82	27.70	30.06	32.80	35.86	39.70	43.39	44.56	45.51	48.16	49.90	51.74
30	24.91	41.74	46.21	51.42	57.21	64.50	71.49	73.71	75.51	80.53	83.83	87.31
45	31.94	53.15	58.78	65.34	72.64	81.82	90.63	93.42	95.69	102.03	106.18	110.57
60	33.39	57.72	64.18	71.71	80.09	90.62	100.73	103.93	106.54	113.81	118.57	123.61
90	34.92	62.64	70.00	78.57	88.12	100.12	111.63	115.28	118.25	126.53	131.96	137.70
120	35.65	64.74	72.72	82.00	92.34	105.33	117.79	121.75	124.96	133.92	139.80	146.01
180	37.12	67.75	75.88	85.36	95.91	109.17	121.88	125.92	129.20	138.34	144.34	150.68
360	47.26	77.89	83.72	90.50	98.06	111.42	124.22	128.29	131.60	140.81	146.85	153.24
daily	51.09	83.58	92.22	102.27	113.47	127.54	141.03	145.31	148.80	158.50	164.86	171.59

TABLE 2.4 REFERENCE WATER LEVELS

Unit: EL. m (Mui Nai)

Reach	Reference Water Levels					
	Recoreded Historical Highest WL	High Water Level (HWL)	Design Flood Level (DFL)	Mean Water Level (MWL)	Low Water Level (LWL)	Recorded Historical Lowest WL
Reach 1	1.56	1.45	1.32	0.23	-2.11	-2.40
Reach 2	1.75	1.52	1.39	0.27	-2.12	-2.42
Reach 3	1.94	1.61	1.47	0.54	-1.78	-2.04
Reach 4	1.56	1.45	1.32	0.23	-2.11	-2.40
Southern Boundaries	1.75	1.52	1.39	0.27	-2.12	-2.42

Criteria for Refernce Water Levels

Highest WL : Recorded historical maximum water level
HWL = High Water Level : Average of annual maximum water levels
DFL = Design Flood Level : Average of monthly maximum water levels for the months August to November
MWL = Mean Water Level : Average of daily mean water levels
LWL = Low Water Level : Average of annual minimum water levels
Lowest WL : Recorded historical minimum water level

TABLE 2.5 (1/2) DESIGN DISCHARGES OF THE CANALS BY RATIONAL METHOD

Drainage Area	Catchment ID	Catchment Area (km2)	Canal ID	Canal Name	Canal Area (km2)	Runoff Point ID	Runoff Point Area (km2)	Runoff Coefficient	Segment's Flow Length (km)	Segment's Flow Velocity (m/s)	Time of Concentration (minutes)	Rainfall Intensity 5-Yr. R.P. (mm/hr)	Rainfall Intensity 10-Yr. R.P. (mm/hr)	Areal Reduction Factor	Design Discharge 5-Yr. R.P. (m3/s)	Design Discharge 10-Yr. R.P. (m3/s)
Northern Zone	-	19.87	C-N.1	Rach Ben Da - Rach Ba Hong *	19.87	N.1.A	3.33	0.51	1.07	0.35	101	54.9	61.5	0.99	35	
						N.1.B	9.93	0.55	2.78	0.35	233	24.5	26.8	0.97	36	
						N.1.C	14.17	0.52	2.04	0.50	301	19.1	20.8	0.96	37	
						N.1.D	19.87	0.51	3.61	0.50	421	13.9	15.2	0.94	37	
	N.2	107.57	C-N.2	Rach Dai Han **	34.65	N.2.A	11.67	0.48	0.97	0.70	124	46.0	51.5	0.96	69	
						N.2.B	18.10	0.47	1.68	0.70	163	35.4	39.4	0.94	78	
						N.2.C	29.33	0.50	4.09	0.60	277	20.7	22.6	0.91	78	
						N.2.D1	34.65	0.52	2.49	0.40	381	15.3	16.7	0.90	78	
			C-N.4	Kinh 19 Thang *	10.98	N.2.D2	10.98	0.63	3.34	0.30	379	15.4	16.8	0.96	28	
			C-N.3	Kinh Tham Luong	107.57	N.2.E	56.82	0.57	1.56	0.35	455	13.0	14.2	0.86	99	108
						N.2.F	64.30	0.58	2.25	0.35	562	10.7	11.7	0.84	99	108
						N.2.G1	78.22	0.59	4.37	0.35	770	8.1	8.9	0.83	99	108
			C-N.5	Rach Ben Cat	11.86	N.2.G2	6.32	0.49	3.10	0.30	295	19.5	21.3	0.98	16	
						N.2.G1	11.86	0.53	2.49	0.35	413	14.2	15.5	0.96	24	
			C-N.3	Kinh Tham Luong	107.57	N.2.H	95.79	0.59	1.57	0.35	845	7.4	8.2	0.81	99	108
						N.2.I	100.68	0.59	2.50	0.35	964	6.6	7.3	0.81	99	108
						N.2.J	107.57	0.60	2.61	0.35	1088	5.9	6.6	0.81	99	108
Central Zone	-	31.67	C-C.1	Rach Nhieu Loc - Rach Thi Nghe	31.67	C.1.A	7.54	0.76	0.55	1.30	78	67.2	75.4	0.98	104	117
						C.1.B	11.09	0.76	2.14	0.70	129	44.2	49.4	0.96	104	117
						C.1.C	16.96	0.77	1.77	0.70	171	33.8	37.6	0.95	116	129
						C.1.D	24.54	0.76	2.32	0.70	227	25.2	27.5	0.93	121	131
						C.1.E	31.67	0.76	2.15	0.70	278	20.7	22.5	0.91	126	137
	C.2	5.14	C-C.2	Rach Cau Son - Rach Tau Vam Tat	5.14	C.2.A	5.14	0.78	2.09	0.40	116	48.5	54.3	0.98	53	
	-	20.22	C-C.3	Rach Tan Hoa - Rach Le Gom	14.35	C.3.A	5.86	0.79	2.26	1.40	72	71.1	79.8	0.98	90	
						C.3.B	10.58	0.74	1.97	1.20	100	55.4	62.1	0.97	117	
						C.3.C1	14.35	0.76	2.84	0.60	179	32.5	36.1	0.95	117	
				Rach Ruot Ngua	5.88	C.3.C2	5.88	0.69	1.50	0.40	135	42.6	47.6	0.98	47	
	-	41.50	C-C.5	Kinh Doi - Kinh Te	61.73	C.4.A1	1.84	0.85	3.34	0.40	154	37.4	41.7	0.99	16	18
			C-C.6	Rch Ba Tang	2.88	C.4.A2	2.88	0.67	3.33	0.40	227	25.2	27.5	0.99	13	
			C-C.7	Rach Ba Lon	6.52	C.4.A3	3.41	0.62	2.56	0.40	160	30.1	33.0	0.99	18	
						C.4.A4	6.52	0.58	3.18	0.40	344	16.8	18.3	0.98	18	
						C.4.B	36.71	0.71	2.02	0.40	369	15.8	17.2	0.90	117	131
			C-C.5	Kinh Doi - Kinh Te	61.73	C.4.C	44.22	0.71	1.40	0.40	427	13.8	15.0	0.88	117	131
						C.4.D	50.86	0.71	1.97	0.40	509	11.7	12.8	0.87	117	131
						C.4.E	61.73	0.71	4.25	0.40	687	8.9	9.8	0.85	117	131
Western Zone	W.1	72.91	C-W.1	Rach Tan Phu	9.68	W.1.A	9.68	0.66	2.60	0.50	154	37.5	41.8	0.97	65	
				Kinh Chua - Rach Nuoc Len ***	43.26	W.1.B	14.81	0.59	2.05	0.40	239	23.9	26.1	0.95	65	72
						W.1.C1	19.55	0.55	4.11	0.40	411	14.3	15.6	0.94	65	72
						W.1.C2	8.62	0.52	2.20	0.30	211	27.2	29.7	0.97	33	
						W.1.D1	36.36	0.57	4.49	0.40	598	10.1	11.1	0.90	65	72
			C-W.2	Rach Nhanh	3.20	W.1.D2	3.20	0.69	2.07	0.30	167	34.7	38.7	0.99	21	
			C-W.1	Rach Chua - Rach Nuoc Len	43.26	W.1.E1	43.26	0.58	2.72	0.40	711	8.7	9.5	0.88	65	72
			C-W.3	Rach Cai Truong - Rach Ba Goc	6.04	W.1.E2	6.04	0.44	4.90	0.30	346	16.8	18.3	0.98	12	
						W.1.E3	7.02	0.50	1.36	0.40	402	14.5	15.9	0.98	14	15
				Song Ben Luc	50.55	W.1.F	50.55	0.57	1.18	0.40	760	8.2	9.0	0.87	65	72
						W.1.G	59.41	0.57	1.85	0.40	837	7.5	8.3	0.85	65	72
			C-W.5	Song Can Guoc	72.91	W.1.H	72.91	0.56	1.76	0.40	910	7.0	7.7	0.83	65	72

*: Canal improvement plan for Rach Ben Da - Ba Hong has been proposed considering inundation in the upper two reaches. The design discharges shown in this table represent discharges under inundation condition.

**: Canal improvement plan for Rach Dai han has been proposed considering inundation. Design (5-year) discharges through main channel at runoff points N.2.A, N.2.B, N.2.C and N.2.D1 are 7, 11, 19 and 24 m3/s respectively.
The design discharges along Rach Daihan, as shown in this table represent total discharges through main channel and flood plain at different runoff points, under inundation condition.

***: Canal improvement plan for Kinh Chua has been proposed considering inundation. Design (5-year) discharges through main channel for lengths of 0.35 and 3.11 km along reaches W.1.B and W.1.C1 are 12 and 14 m3/s respectively.
The design discharges along Kinh Chua (runoff points W.1.B and W.1.C1), as shown in this table represent total discharges through main channel and flood plain, under inundation condition.

TABLE 2.5 (2/2) DESIGN DISCHARGES OF THE CANALS BY RATIONAL METHOD

Drainage Area	Catchment ID	Catchment Area (km2)	Canal ID	Canal Name	Canal Area (km2)	Runoff Point ID	Runoff Point Area (km2)	Runoff Coefficient	Segment's Flow Length (km)	Segment's Flow Velocity (m/s)	Time of Concentration (minutes)	Rainfall Intensity 5-Yr. R.P. (mm/hr)	Rainfall Intensity 10-Yr. R.P. (mm/hr)	Areal Reduction Factor	Design Discharge 5-Yr. R.P. (m3/s)	Design Discharge 10-Yr. R.P (m3/s)
Southern Zone						S.1.A	2.68	0.57	2.54	0.40	137	41.8	46.7	0.99	18	
						S.1.B1	6.72	0.53	2.51	0.40	242	23.7	25.8	0.98	23	
						S.1.B2	4.38	0.55	4.00	0.40	217	26.3	28.7	0.99	17	
						S.1.B3	6.33	0.52	2.06	0.40	303	19.0	20.7	0.98	17	
			C-S.1	Rach Ba Lao	14.33	S.1.C	14.33	0.52	1.39	0.40	342	16.9	18.4	0.95	34	
	S.2	15.66	C-S.3	Rach Ong Lon - Kinh Cay Kho	13.70	S.2.A1	2.40	0.48	2.02	0.40	158	36.6	40.8	0.99	12	
			C-S.4	Rach Ong Bay	1.96	S.2.A2	1.96	0.59	1.90	0.40	150	38.4	42.9	0.99	12	
					13.70	S.2.B	7.21	0.52	1.51	0.40	218	26.2	28.6	0.98	26	
						S.2.C	15.66	0.53	3.39	0.40	359	16.2	17.6	0.95	36	
					34.51	S.3.A	2.17	0.71	1.57	0.40	123	46.1	51.5	0.99	20	22
						S.3.B1	4.49	0.73	2.43	0.40	225	25.5	27.8	0.99	23	25
			C-S.6	Rach Thay Tieu	4.79	S.3.B2	4.79	0.74	3.12	0.40	198	29.0	31.7	0.98	28	
			C-S.7	Rach Dia	5.75	S.3.B3	5.75	0.56	3.58	0.40	292	19.7	21.5	0.98	17	
				Rach Roi - Rach Tom - Song Muong Chuoi	34.51	S.3.C	19.33	0.65	2.60	0.40	333	17.4	18.9	0.94	57	62
						S.3.D1	23.68	0.65	2.63	0.40	442	13.3	14.5	0.93	57	62
			C-S.8	Phuoc Khien River	6.45	S.3.D2	6.45	0.54	3.41	0.40	259	22.2	24.1	0.98	21	
			C-S.5	Rach Roi - Rach Tom - Song Muong Chuoi	34.51	S.3.E	34.51	0.63	7.41	0.40	543	11.1	12.1	0.90	64	69
	S.4	2.36	C-S.9	Rach Cau Kinh	2.36	S.4.A	2.36	0.67	1.92	0.40	133	43.1	46.2	0.99	19	
	S.5	2.23	C-S.10	Rach AP3 Phu My	2.23	S.5.A	2.23	0.60	1.86	0.40	116	48.5	54.3	0.99	18	
North-Eastern Zone	NE.1	3.32	C-NE.1	Rach Ong Dau	3.32	NE.1.A	3.32	0.57	3.58	0.40	170	34.0	37.9	0.99	18	
	NE.2	9.53	C-NE.2	Rach Go Dua	9.53	NE.2.A	4.78	0.68	2.57	0.40	172	33.6	37.4	0.98	30	
						NE.2.B	9.53	0.65	2.20	0.40	264	21.7	23.7	0.97	36	
	NE.3	7.15	C-NE.3	Rach Thu Duc	7.15	NE.3.A	7.15	0.64	3.14	0.40	161	35.8	39.9	0.98	44	
	NE.4	2.65	C-NE.4	Rach Truong Tho	2.65	NE.4.A	2.65	0.73	2.17	0.40	143	40.2	44.9	0.99	21	
	NE.5	34.38	C-NE.5	Rach Nhum - Rach Cau - Rach Go Cong *	34.38	NE.5.A1	10.12	0.42	3.35	2.33	69	0.0	82.4	0.97	83	93
						NE.5.A2	4.72	0.46	2.34	2.90	62	0.0	89.2	0.98	47	53
						NE.5.B	17.99	0.45	1.70	1.84	85	60.2	71.0	0.94	133	149
						NE.5.C	28.17	0.45	2.83	0.77	146	39.5	44.1	0.92	133	149
						NE.5.D1	34.38	0.45	4.44	0.32	378	15.4	16.8	0.90	133	149
South-Eastern Zone	SE.1	1.98	C-SE.1	Rach Binh Khanh	1.98	SE.1.A	1.98	0.50	2.32	0.40	128	44.7	50.0	0.99	12	
	SE.2	2.60	C-SE.2	Rach Ca Tre Nho	2.60	SE.2.A	2.60	0.65	2.08	0.40	118	48.1	53.8	0.99	22	
	SE.3	1.92	C-SE.3	Rach Da Do	1.92	SE.3.A	1.92	0.80	2.50	0.40	205	27.9	30.5	0.99	12	
	SE.4	7.80	C-SE.4	Rach Giong Ong To	7.80	SE.4.A	5.40	0.43	3.41	0.40	200	28.6	31.3	0.98	18	
						SE.4.B	7.80	0.44	2.05	0.40	285	20.2	21.9	0.97	19	
	SE.5	3.83	C-SE.5	Rach Muong	3.83	SE.5.A	3.83	0.65	1.11	0.40	173	33.6	37.3	0.99	23	
	SE.6	5.10	C-SE.6	Rach Ky Ha	5.10	SE.6.A	5.10	0.80	4.39	0.40	263	21.8	23.7	0.98	24	
	SE.7	14.58	C-SE.7	Rach Chiec - Rach Kinh Ong Hong	14.58	SE.7.A	8.39	0.56	1.50	0.60	191	30.0	32.8	0.97	38	
						SE.7.B	14.58	0.55	3.20	0.40	325	17.8	19.4	0.95	38	
	SE.8	11.33	C-SE.8	Rach Ong Cay - Rach Ba Cua - Rach Ong Kieu	11.33	SE.8.A	2.77	0.46	1.95	0.40	164	35.3	39.3	0.99	12	
						SE.8.B	11.33	0.53	4.12	0.40	336	17.2	18.8	0.96	27	
	SE.9	21.11	C-SE.9	Rach Tan - Rach Ong Nhieu	21.11	SE.9.A	7.46	0.65	2.47	0.40	147	39.1	43.6	0.98	51	
						SE.9.B	13.73	0.57	4.24	0.40	324	17.8	19.4	0.96	51	
						SE.9.C	21.11	0.56	2.83	0.40	442	13.3	14.6	0.94	51	
	SE.10	24.88	C-SE.11	Tac River		SE.10.A	7.57	0.43	3.62	0.40	265	21.6	23.6	0.98	19	21
						SE.10.B	19.00	0.52	4.08	0.00	435	13.5	14.7	0.94	35	38
						SE.10.C	59.26	0.54	2.41	0.40	458	12.9	14.1	0.85	133	149

* Canal improvement plan for Rach Go Cong has been proposed considering construction of on-site storage ponds to reduce peak runoff due to rapid urbanization such that discharges under existing landuse condition can be kept. The design discharges along Rach Go Cong shown in this table represent discharges under existing landuse condition.

TABLE 2.6 FLOOD CONDITIONS BY ZONE AND CATCHMENT AREA

Zone	Catchment		Flood Condition								
			Flood Area (km^2)			Flood Depth (cm)			Flood Duration (hr)		
	No.	Area (km2)	Built-up Area	Agricultural Land	Total	Built-up Area			Built-up Area		
						Min.	Abe.	Max.	Min.	Abe.	Max.
C-Zone	C.1	31.85	4.809	0	4.809	33.0	37.5	42.0	6.6	7.0	7.3
	C.2	5.14	1.805	0	1.805	27.0	33.5	40.0	2.2	3.0	3.8
	C.3	20.22	4.454	0	4.454	28.0	35.5	43.0	10.6	11.2	11.8
	C.4	41.32	6.186	9.218	15.404	28.0	40.0	52.0	2.0	6.1	10.2
	C.a	4.91	3.727	0	3.727	58.0	68.5	79.0	2.1	4.0	5.9
	C.b	1.29	0.222	0	0.222	33.0	42.5	52.0	2.2	3.1	4.0
	C.c	1.68	0	0	0	-	-	-	-	-	-
	Sub-total	106.41	21.203	9.218	30.421	34.4	43.0	51.6	4.9	6.7	8.5
N-Zone	N.1	19.87	0	2.315	2.315	-	-	-	-	-	-
	N.2	107.57	7.463	21.034	28.497	26.0	26.0	26.0	4.3	4.3	4.3
	N.a	8.75	0	7.707	7.707	-	-	-	-	-	-
	Sub-total	136.19	7.463	31.056	38.519	26.0	26.0	26.0	4.3	4.3	4.3
W-Zone	W.1	72.91	2.739	31.903	34.642	22.0	22.5	23.0	10.9	10.9	10.9
	Sub-total	72.91	2.739	31.903	34.642	22.0	22.5	23.0	10.9	10.9	10.9
S-Zone	S.1	7.99	0	11.285	11.285	-	-	-	-	-	-
	S.2	8.29	0	10.534	10.534	-	-	-	-	-	-
	S.3	48.21	1.460	27.300	28.760	21.0	30.0	39.0	2.6	4.4	6.1
	S.4	2.36	0	0	0	-	-	-	-	-	-
	S.5	2.23	0.068	0.912	0.98	20.0	25.0	30.0	3.0	3.5	4.0
	S.a	3.46	0	0	0	-	-	-	-	-	-
	S.b	3.86	0.278	3.400	3.678	20.0	25.0	30.0	3.0	3.5	4.0
	S.c	5.33	0	5.253	5.253	-	-	-	-	-	-
	Sub-total	81.74	1.806	58.684	60.49	20.8	0.9	1.1	0.2	8.5	9.2
NE-Zone	NE.1	3.32	0	3.262	3.262	-	-	-	-	-	-
	NE.2	9.53	0	6.375	6.375	-	-	-	-	-	-
	NE.3	7.14	0	0	0	-	-	-	-	-	-
	NE.4	2.65	0	0	0	-	-	-	-	-	-
	NE.5	34.38	0	2.798	2.798	-	-	-	-	-	-
	NE.a	3.76	0	3.680	3.680	-	-	-	-	-	-
	NE.b	2.50	0	0.257	0.257	-	-	-	-	-	-
	NE.c	1.62	0	0	0	-	-	-	-	-	-
	Sub-total	64.91	0	16.372	16.372	-	-	-	-	-	-
SE-Zone	SE.1	1.98	0	1.557	1.557	-	-	-	-	-	-
	SE.2	2.60	0.123	0.856	0.979	20.0	35.0	50.0	12.0	12.0	12.0
	SE.3	1.92	0	0	0	-	-	-	-	-	-
	SE.4	7.80	0.223	5.154	5.377	20.0	20.0	20.0	1.0	1.0	1.0
	SE.5	3.83	0	2.810	2.81	-	-	-	-	-	-
	SE.6	5.11	0	3.247	3.247	-	-	-	-	-	-
	SE.7	14.58	0	8.184	8.184	-	-	-	-	-	-
	SE.8	11.33	0	8.896	8.896	-	-	-	-	-	-
	SE.9	21.11	0	15.822	15.822	-	-	-	-	-	-
	SE.10	24.88	0	22.018	22.018	-	-	-	-	-	-
	SE.a	3.67	0.518	0	0.518	27.0	34.5	42.0	2.7	3.1	3.5
	SE.b	5.16	0.542	2.417	2.959	20.0	25.0	30.0	4.0	5.0	6.0
	SE.c	1.82	0	1.236	1.236	-	-	-	-	-	-
	SE.d	1.30	0	0.201	0.201	-	-	-	-	-	-
	SE.e	2.77	0	2.624	2.624	-	-	-	-	-	-
	SE.f	9.53	0	8.416	8.416	-	-	-	-	-	-
	Sub-total	119.36	1.406	83.438	84.844	22.6	28.6	34.6	3.7	4.3	4.8
Total		581.51	34.617	230.671	265.288	30.4	34.9	40.5	4.9	6.5	7.7

Note: Agricultural lands in N, S, NE and SE zones have been suffered from the flood of the Saigon, Dong Nai and Nha Be rivers in high tide season due to the insufficient dyke system. Average flood depth ranges from 0.5 to 0.8 m. Flood duration in S zone is mostly every day in high tide season. However, that in N, NE and SE zones is more than one week. Especially, N zone is inundated during the embankment along the Saigon River will be damaged by erosion.

TABLE 2.7 PRESENT AND FUTURE VULNERABLE POPULATION BY CATCHMENT AREA

Zone	Catchment	Flood Area (km^2)			Flood Vulnerable Population					
		Built-up Area	Agricultural Land	Total	Built-up Area		Agricultural Land		Total	
					1997	2020	1997	2020	1997	2020
C-Zone	C.1	4.809	0	4.809	195,629	219,281	0	0	195,629	219,281
	C.2	1.805	0	1.805	33,081	46,084	0	0	33,081	46,084
	C.3	4.454	0	4.454	157,552	171,003	0	0	157,552	171,003
	C.4	6.186	9.218	15.404	314,210	315,553	19,723	67,070	363,933	382,623
	C.a	3.727	0	3.727	9,839	18,947	0	0	9,839	18,947
	C.b	0.222	0	0.222	2,880	3,826	0	0	2,880	3,826
	Sub-total	21.203	9.218	30.421	743,191	774,694	19,723	67,070	762,914	841,764
N-Zone	N.1	0	2.315	2.315	0	0	2,728	18,612	2,728	18,612
	N.2	7.463	21.034	28.497	54,758	115,567	69,565	216,250	124,323	331,817
	N.a	0	7.707	7.707	0	0	10,181	58,030	10,181	58,030
	Sub-total	7.463	31.056	38.519	54,758	115,567	82,474	292,892	137,232	408,459
W-Zone	W.1	2.739	31.903	34.642	35,236	44,773	38,989	243,813	74,225	288,586
	Sub-total	2.739	31.903	34.642	35,236	44,773	38,989	243,813	74,225	288,586
S-Zone	S.1	0	11.285	11.285	0	0	9,458	72,952	9,458	72,952
	S.2	0	10.534	10.534	0	0	11,995	46,364	11,995	46,364
	S.3	1.460	27.300	28.760	15,567	39,076	26,754	116,257	42,321	155,333
	S.5	0.068	0.912	0.98	84	348	1,115	4,503	1,199	4,851
	S.b	0.278	3.400	3.678	320	1,909	3,947	21,044	4,267	22,953
	S.c	0	5.253	5.253	0	0	9,717	15,479	9,717	15,479
	Sub-total	1.806	58.684	60.49	15,971	41,333	62,986	276,599	78,957	317,932
NE-Zone	NE.1	0	3.262	3.262	0	0	7,814	30,295	7,814	30,295
	NE.2	0	6.375	6.375	0	0	24,057	81,682	24,057	81,682
	NE.5	0	2.798	2.798	0	0	2,855	6,437	2,855	6,437
	NE.a	0	3.680	3.680	0	0	7,141	29,702	7,141	29,702
	NE.b	0	0.257	0.257	0	0	681	2,560	681	2,560
	Sub-total	0	16.372	16.372	0	0	42,548	150,676	42,548	150,676
SE-Zone	SE.1	0	1.557	1.557	0	0	6,156	35,327	6,156	35,327
	SE.2	0.123	0.856	0.979	590	4,729	2,316	12,596	2,906	17,325
	SE.4	0.223	5.154	5.377	1,106	3,462	8,088	51,565	9,194	55,027
	SE.5	0	2.81	2.81	0	0	2,078	26,296	2,078	26,296
	SE.6	0	3.247	3.247	0	0	2,522	22,091	2,522	22,091
	SE.7	0	8.184	8.184	0	0	14,386	55,571	14,386	55,571
	SE.8	0	8.896	8.896	0	0	8,470	27,788	8,470	27,788
	SE.9	0	15.822	15.822	0	0	11,178	55,350	11,178	55,350
	SE.10	0	22.018	22.018	0	0	10,235	55,681	10,235	55,681
	SE.a	0.518	0	0.518	805	10,452	0	0	805	10,452
	SE.b	0.542	2.417	2.959	4,242	17,154	7,240	59,788	11,482	76,942
	SE.c	0	1.236	1.236	0	0	884	11,526	884	11,526
	SE.d	0	0.201	0.201	0	0	174	657	174	657
	SE.e	0	2.624	2.624	0	0	931	9,471	931	9,471
	SE.f	0	8.416	8.416	0	0	2,150	8,781	2,150	8,781
	Sub-total	1.406	83.438	84.844	6,743	35,797	76,808	432,488	83,551	468,285
Total		**34.617**	**230.671**	**265.288**	**855,899**	**1,012,164**	**323,528**	**1,463,538**	**1,179,427**	**2,475,702**

TABLE 2.8 AVERAGE ANNUAL FLOOD DAMAGES BY DRAINAGE ZONE

Zone	Direct damages			Indirect damages/losses		
	Kind of damages	At present	In future	Kind of damages	At present	In future
C-Zone	Buildings and movables	362,728	435,398	Business suspension losses	73,638	76,626
	Public facilities	3,248	4,294	Income losses of workers	12,537	13,559
	Agricultural crops (paddy)	514	257	Medical cost to be saved	10,729	11,693
				Navigation cost to be saved	10,789	18,157
	Total	366,490	439,949	Total	96,904	101,878
N-Zone	Buildings and movables	213,984	268,463	Business suspension losses	3,822	7,723
	Public facilities	2,571	3,776	Income losses of workers	2,584	9,389
	Agricultural crops (paddy)	1,586	1,133	Medical cost to be saved	1,803	5,015
				Navigation cost to be saved	0	0
	Total	218,141	273,371	Total	8,209	22,127
W-Zone	Buildings and movables	40,497	115,990	Business suspension losses	4,071	5,144
	Public facilities	420	1,542	Income losses of workers	1,659	5,967
	Agricultural crops (paddy)	0	0	Medical cost to be saved	990	3,448
				Navigation cost to be saved	0	0
	Total	40,917	117,531	Total	6,720	14,559
S-Zone	Buildings and movables	33,644	113,877	Business suspension losses	1,219	2,959
	Public facilities	277	1,470	Income losses of workers	1,769	6,862
	Agricultural crops (paddy)	5,141	2,571	Medical cost to be saved	1,008	3,779
				Navigation cost to be saved	0	0
	Total	39,062	117,918	Total	3,996	13,600
NE-Zone	Buildings and movables	0	61,899	Business suspension losses	0	0
	Public facilities	0	920	Income losses of workers	3,200	10,732
	Agricultural crops (paddy)	3,702	1,851	Medical cost to be saved	519	1,742
				Navigation cost to be saved	0	0
	Total	3,702	64,670	Total	3,719	12,474
SE-Zone	Buildings and movables	22,142	117,306	Business suspension losses	322	1,628
	Public facilities	215	1,630	Income losses of workers	5,334	27,586
	Agricultural crops (paddy)	17,055	8,527	Medical cost to be saved	1,056	5,503
				Navigation cost to be saved	0	0
	Total	39,412	127,463	Total	6,712	34,717
Whole study area	Buildings and movables	672,995	1,112,933	Business suspension losses	83,072	94,080
	Public facilities	6,731	13,632	Income losses of workers	27,083	74,095
	Agricultural crops (paddy)	27,998	14,339	Medical cost to be saved	16,105	31,180
				Navigation cost to be saved	10,789	18,157
	Total	707,724	1,140,904	Total	126,260	199,355

Table 2.9 Water Quality of Main Canals/Rivers in Praing and Dry Seasons (1/2)

Parameter	Tan Hoa - Lo Gom Canal		Tau Hu - Doi - Te Canal		Ben Nghe at Khanh Hoi Bridge		Nhieu Loc - Thi Nghe Canal	
	Tan Hoa at Tan Hoa Street		Tau Hu at Y Bridge				Thi Nghe at Ba Son Bridge	
	High Tide	Low Tide	High Tide	Low Tide	High Tide	Low Tide	High Tide	Low Tide
Temperature, C	28.4 (28.5)	30.0 (32.0)	28.4 (26.3)	29.9 (28.0)	27.9 (26.0)	29.9 (28.5)	28.5 (26.8)	29.8 (27.2)
PH	5.9 (6.3)	5.8 (6.3)	6.7 (6.8)	6.6 (6.8)	6.1 (6.7)	6.4 (6.9)	6.2 (6.4)	6.5 (6.9)
DO, mg/l	0.0 (0.0)	0.0 (0.0)	2.8 (4.6)	0.0 (1.9)	2.6 (3.4)	0.2 (0.6)	5.8 (5.7)	0.0 (3.2)
Conductivity, mS/m	104.0 (118.0)	125.0 (139.2)	306.0 (41.0)	331.0 (64.0)	38.0 (30.0)	214.0 (57.0)	24.0 (12.4)	52.0 (53.3)
BOD5, mg/l	326.0 (409.0)	536.0 (500.0)	151.0 (84.0)	251.0 (124.0)	81.0 (50.0)	157.0 (104.0)	14.0 (13.0)	174.0 (48.0)
COD, mg/l	1456.0 (780.0)	988.0 (1178.0)	249.0 (125.0)	400.0 (200.0)	200.0 (98.0)	211.0 (176.0)	28.0 (40.0)	234.0 (86.0)
Total Solids, mg/l	1420.0 (54.0)	272.0 (420.0)	70.0 (67.0)	216.0 (92.0)	11.0 (33.0)	41.0 (38.0)	23.0 (14.0)	76.0 (25.0)
Total Nitrogen (T-N), mg/l	38.2 (32.3)	46.2 (41.0)	2.0 (1.9)	11.2 (3.1)	1.6 (1.5)	10.4 (8.0)	1.4 (1.2)	13.2 (8.9)
Total Phosphorus (T-P), mg/l	2.0 (5.9)	2.9 (16.1)	0.1 (1.1)	0.6 (2.5)	0.1 (1.6)	0.9 (6.2)	0.1 (0.7)	1.3 (1.3)
Total Coliform, MPN/100 ml	1.10E+07 (2.10E+06)	1.50E+07 (1.10E+07)	1.50E+06 (1.10E+06)	2.10E+06 (1.50E+06)	9.00E+02 (1.10E+06)	9.30E+03 (1.10E+06)	9.30E+04 (2.10E+05)	1.10E+07 (1.10E+06)
Fecal Coliform, MPN/100ml	1.50E+06 (2.00E+05)	2.10E+05 (2.00E+05)	9.30E+04 (2.00E+04)	2.10E+05 (5.70E+05)	2.10E+02 (5.70E+04)	5.70E+03 (1.50E+05)	4.00E+02 (2.10E+04)	4.30E+04 (9.30E+04)
$SO_4^{(-2)}$, mg/l	32.4 (61.9)	46.0 (63.4)	81.1 (25.0)	97.4 (43.1)	26.9 (19.0)	317.3 (22.1)	18.3 (16.3)	12.8 (15.8)
Chloride (Cl^-), mg/l	117.5 (153.3)	159.1 (181.1)	769.6 (78.0)	782.1 (120.6)	123.1 (49.0)	520.4 (74.3)	54.7 (17.4)	81.7 (63.1)
Cadmium, µg/l	<1 (0.0)	<1 (0.0)	<1 (2.9)	<1 (2.1)	2.7 (3.7)	3.8 (4.1)	1.3 (2.6)	1.5 (3.1)
Lead, µg/l	2.6 (<2)	5 (<2)	<2 (<2)	<2 (<2)	<2 (<2)	2.2 (<2)	<2 (<2)	2.2 (<2)
Hexavelent Chromium Cr^{6+}, µg/l	<0.04 (<0.04)	<0.04 (<0.04)	<0.04 (<0.04)	<0.04 (<0.04)	<0.04 (<0.04)	<0.04 (<0.04)	<0.04 (<0.04)	<0.04 (<0.04)
Arsenic (As), µg/l	1.8 (1.8)	2.1 (2.1)	0.9 (0.9)	0.3 (0.3)	0.6 (0.6)	2.8 (2.8)	<0.2 (<0.2)	2.0 (2.0)
Total Mercury (Hg), µg/l	<2.5 (<2.5)	<2.5 (<2.5)	<2.5 (<2.5)	<2.5 (<2.5)	<2.5 (<2.5)	<2.5 (<2.5)	<2.5 (<2.5)	<2.5 (<2.5)

Table 2.10 Water Quality of Main Canals/Rivers in Praing and Dry Seasons (2/2)

Parameter	Tham Luong - Vam Thuat Canal		Nhoe Len at An Lac Brigde		Saigon River		Dong Nai River	
	Tham Luong at Cho Cau Bridge				At Thanh Da		At Hoa An Bridge	
	High Tide	Low Tide	High Tide	Low Tide	High Tide	Low Tide	High Tide	Low Tide
Temperature, C	28.2 (28.0)	30.1 (27.9)	28.7 (26.9)	30.2 (27.9)	28.3 (26.9)	29.9 (27.5)	27.7 (27.0)	30.1 (29.0)
PH	6.5 (6.5)	6.6 (6.7)	6.8 (6.7)	6.7 (6.7)	6.1 (6.3)	5.9 (6.2)	6.7 (7.0)	6.6 (7.0)
DO, mg/l	0.7 (3.5)	1.0 (2.9)	3.7 (5.6)	2.4 (3.3)	2.8 (6.8)	3.8 (7.0)	6.5 (6.2)	6.9 (6.0)
Conductivity, mS/m	30.0 (22.8)	27.0 (31.0)	373.0 (59.0)	316.0 (54.0)	22.9 (10.3)	13.8 (9.4)	3.7 (3.8)	3.5 (4.3)
BOD5, mg/l	152.0 (71.0)	181.0 (93.0)	47.0 (25.0)	67.0 (38.0)	58 (19.0)	61 (29.0)	7 (5.0)	8 (9.0)
COD, mg/l	310.0 (148.0)	240.0 (175.0)	106.0 (65.0)	157.0 (84.0)	144 (39.0)	135 (45.0)	16 (43.0)	11 (42.0)
Total Solids, mg/l	32.0 (12.0)	98.0 (46.0)	201.0 (62.0)	372.0 (168.0)	32 (38.0)	69 (26.0)	31 (94.0)	60 (60.0)
Total Nitrogen (T-N), mg/l	4.8 (1.1)	2.0 (1.3)	2.6 (1.3)	2.9 (2.7)	1.4 (1.3)	1.3 (0.9)	0.8 (0.3)	0.9 (0.3)
Total Phosphorus (T-P), mg/l	0.6 (1.5)	0.2 (1.8)	0.07 (0.9)	0.09 (2.1)	0.09 (0.4)	0.06 (0.6)	0.05 (0.2)	0.06 (0.2)
Total Coliform, MPN/100 ml	1.10E+07 (1.10E+06)	1.50E+07 (2.10E+06)	1.10E+07 (1.10E+07)	1.20E+07 (2.10E+06)	9.30E+04 (1.50E+05)	1.10E+07 (1.10E+07)	2.10E+04 (1.50E+05)	2.10E+03 (2.10E+06)
Fecal Coliform, MPN/100ml	1.50E+06 (7.00E+03)	2.10E+06 (9.30E+05)	2.10E+06 (1.10E+05)	2.10E+06 (2.10E+05)	7.00E+02 (2.00E+04)	1.50E+04 (4.60E+06)	1.50E+03 (2.10E+04)	9.00E+02 (9.30E+05)
$SO_4^{(-2)}$, mg/l	21.4 (15.1)	19.0 (37.4)	127.2 (42.1)	121.9 (37.9)	23.5 (15.1)	12.9 (15.4)	3.1 (1.8)	6.3 (1.2)
Chloride (Cl^-), mg/l	33.7 (30.1)	26.6 (31.2)	998.1 (136.8)	574.4 (104.6)	38.5 (13.8)	17.7 (11.5)	1.7 (3.8)	1.7 (3.4)
Cadmium, µg/l	<1 (4.6)	<1 (3.6)	3.2 (3.5)	<1 (4.3)	2.8 (3.7)	1.6 (4.1)	2.7 (2.2)	1.8 (2.8)
Lead, µg/l	4.2 (2.3)	<2 (<2)	<2 (<2)	<2 (<2)	<2 (<2)	<2 (<2)	<2 (<2)	2.3 (4)
Hexavelent Chromium Cr^{6+}, µg/l	<0.04 (<0.04)	<0.04 (<0.04)	<0.04 (<0.04)	<0.04 (<0.04)	<0.04 (<0.04)	<0.04 (<0.04)	<0.04 (<0.04)	<0.04 (<0.04)
Arsenic (As), µg/l	0.9 (0.9)	0.6 (0.6)	0.6 (0.6)	<0.2 (<0.2)	<0.2 (<0.2)	0.9 (0.9)	<0.2 (<0.2)	1.1 (1.1)
Total Mercury (Hg), µg/l	<2.5 (<2.5)	<2.5 (<2.5)	<2.5 (<2.5)	<2.5 (<2.5)	<2.5 (<2.5)	<2.5 (<2.5)	<2.5 (<2.5)	<2.5 (<2.5)

Table 2.11 Bed Characteristics of Rivers and Canals

Palameter / Name of River and Canal Location	Aluminium (Al) mg/kg	Copper (Cu) mg/kg	Cadmium (Cd) mg/kg	Lead (Pb) mg/kg	Mercury (Hg) mg/kg	A-Mercury (R_2HG) mg/kg	Chromium (Cr) mg/kg	Zinc (Zn) mg/kg	Cyanide (Cn) mg/kg	Arsenic (As) mg/kg	Total P (P) mg/kg	PCB (PCB)
1. Saigon River												
1.1 Ba Thon	81,000	75.52	0.37	44.91	0.81	< 0.01	108.39	194.37	< 0.005	15.44	1,000	19.77
1.2 Thanh Da	53,000	39.82	0.32	56.92	1.31	< 0.01	111.39	502.72	< 0.005	15.54	1,300	65.53
1.3 Tan Thuan	61,000	23.91	2.71	48.71	0.72	< 0.01	112.88	187.52	< 0.005	13.94	410	21.87
2. Dong Nai River												
2.1 Hoa An Br.	79,000	46.11	2.62	44.11	0.41	< 0.01	154.03	98.49	< 0.005	10.27	370	129.33
3. Tan Hoa - Lo Gom Canal												
3.1 Tan Hoa St.	59,000	51.37	1.98	178.80	1.01	< 0.01	234.47	2,140.99	0.014	22.11	1,500	537.21
3.2 Tran Van Kieu St.	53,000	147.02	1.33	112.80	0.85	< 0.01	335.80	1,840.69	0.018	15.48	2,300	642.60
4. Tham Luong - Van Thuat Canal												
4.1 Cho Cau Bridge	94,700	41.82	2.29	47.26	12.56	< 0.01	141.21	332.46	< 0.005	9.59	620	226.22
4.2 Ben Phan Bridge	111,000	20.63	0.41	58.46	0.61	< 0.01	111.17	295.35	< 0.005	15.55	1,700	35.07
4.3 Van Thuat	116,000	32.81	0.38	45.49	0.12	< 0.01	95.81	102.72	< 0.005	14.16	310	116.20
5. Nhieu Loc - Thi Nghe Canal												
5.1 Ba Son Bridge	61,000	114.62	0.32	57.71	0.71	< 0.01	77.26	218.24	< 0.005	17.83	530	131.05
5.2 Cong Ly Bridge	74,000	210.01	1.99	119.60	2.21	< 0.01	148.72	2,306.59	< 0.005	15.85	3,200	920.59
6. Tau Hu - Doi - Te Canal												
6.1 Y Bridge	68,000	158.91	2.63	81.56	0.42	< 0.01	125.35	389.61	< 0.005	12.81	210	38.00
6.2 Nhi Thien Duong	108,000	100.64	2.45	62.91	1.62	< 0.01	171.18	694.97	< 0.005	12.95	690	539.50
6.3 Tan Thuan Bridge	79,000	34.68	0.32	65.91	1.22	< 0.01	99.71	322.27	< 0.005	12.06	1,100	47.74
7. Ben Nghe Canal												
7.1 Khanh Hoi Bridge	102,000	65.61	0.37	57.32	1.32	< 0.01	130.61	1,303.45	< 0.005	15.01	1,000	73.89
8. Ong Lon Canal												
8.1 Ong Lon	123,000	96.56	4.32	62.73	1.07	< 0.01	156.16	852.29	< 0.005	15.11	230	86.00
9. Vinh Binh Canal												
9.1 Vinh Binh Bridge	95,000	49.12	3.51	43.02	0.32	< 0.01	86.69	146.46	< 0.005	10.91	370	43.54
10. Nuoc Len												
10.1 An Loc Bridge	99,000	34.04	2.11	57.42	0.69	< 0.01	116.26	256.96	< 0.005	12.28	1,000	26.73
11.Ben Luc River												
11.1 Ben Luc	97,000	43.32	2.21	84.58	1.11	< 0.01	104.96	7,181.42	< 0.005	14.71	670	44.10
12. Suoi Cai												
12.1 Linh Trung Ward	97,000	57.63	2.71	65.39	0.25	< 0.01	47.15	137.86	< 0.005	3.93	160	86.24

TABLE 2.12 REGULATION STANDARDS FOR HEAVY METALS IN THE SEDIMENTS TO BE USED ON LAND OR FOR AGRICULTURAL PURPOSE

Parameter	Japanese Standard*	EU Directive#	Netherlands Standard#	Italy Standard#
Cu (mg/kg)		1000-1750	75	1000
Cd (mg/kg)	5	20-40	1.25	20
Pb (mg/kg)		750-1200	100	750
Hg (mg/kg)	2	16-25	0.75	10
Cr (mg/kg)			75	
Zn (mg/kg)			300	2500
As (mg/kg)	50			

* to be used for agricultural purpose, # to be used on land

TABLE 2.13 SUMMARY OF GROUND WATER WELLS BEING MANAGED BY DEPT. OF INDUSTRY

District	No. of Wells			Capacity (m3/d)				
	Total	N2	Q I-III	Total	N2	Q I-III	Industrial	Domestic
Q 1	45	1	44	9,326.00	450.00	8,786.00	8,601.00	635.00
Q 2	478	209	269	2,418.00	1813.70	604.50	1,638.00	780.00
Q 3	1,615		1615	5,301.00		5,301.00	2,756.00	2,545.00
Q 4	19	8	11	570.00	369.00	201.00	539.00	31.00
Q 5	18	2	16	765.00	120.00	645.00	120.00	645.00
Q 6	539	331	208	7,325.00	6,677.00	648.00	5,259.00	2,066.00
Q 7	85	70	15	1,032,90	990.50	42.40	30.00	1,002.90
Q 8	258	233	25	5,741.00	5,428.00	313.00	4,473.00	1,268.00
Q 9	732	51	681	9,912,30	8,930.70	981.60	8,957.50	954.80
Q 10	1,970	4	1,966	14,480.00	5,960.00	8,520.00	10,954.00	3,526.00
Q 11	2,513	203	2,310	25,934.00	4,276.00	21,658.00	16,146.00	9,788.00
Q 12	3,827	348	3,479	20,036.00	13,900.20	6,135.80	11,854,90	8.181.10
Thu Duc	3,741	2,527	1,214	36,076,20	25,373.40	10,702.80	25,421,50	10,654.70
Go Vap	11,955	8	11,947	33,081.00	1,890.00	31191.00	17,007.00	16,074.00
Tan Binh	27,216	806	26,410	172,789.00	81,496.00	91,293.00	124,301.00	48.488.00
Phu Nhuan	4,445	10	4,435	7,486.00	318.00	7,168.00	2,092.00	5,394.00
Binh Thanh	2,192	49	2,143	11,983.00	612.00	11,371.00	7,523.00	4,460.00
Hoc Mon	6,719	207	6,512	33,676.00	4,548.00	29,128.00	8,584,10	25,091.90
Binh Chanh	9,308	6008	3,300	60,498.00	46,338.00	14,160.00	34,264.00	26,234.00
Nha Be	493	493		2,011,10	2,011.10		670.00	1341.10

QI-III Pleistocen aquifer: < 10 m deep, N2B Pliocen aquifer: 50 – 160 m deep, N2A Plitocen aquifer: 110 – 210 m deep

TABLE 2.14 WATER QUALITY OF GROUNDWATER WELLS IN HCM CIT

District	Depth	pH	Cl (mg/l)	Fe (mg/l)	NO3 (mg/l)
1	4 –50	5.9		0.45-1.80	7.40 - 23.82
2	4 –30	5.37	87.80	0.07	
3	40 – 50	4.2 - 6.5		rack	
4	30 –100				
5	43 – 180	4.5 – 6.3		9.33	1.27
6	40 – 157	5.4 – 7.7	2 - 108	0.15 – 1.78	0.09 – 0.48
7	40 – 70	4.7 – 8.4	187.89 – 470.54	6.45 – 31.47	0.30 – 0.35
8	80 – 200	4.4 – 8.12	14.04 – 669.90	0.2 – 75.70	0.20 – 2.31
9	40 - 60	4.3 – 7.1	7.09 - 53.82	0. 00 - 0.24	0.33 – 355.00
10	112 – 200	6.6		0.92	
11	50 – 104	4.2 – 8.2	17.55 - 221	0.03 – 11.35	0.01 – 0.04
12	60 – 99	4.5 – 6.8	11.700– 146.25	0.08 – 3.91	0.10 - 33
Thuû Nöùc	35 – 95	4.5 – 8.5	152 - 760.50	0.02 – 3.65	0.00 – 15.55
Goo Vaáp	69 – 81	3.8 –8.2	5.80 – 107.00	0.07 – 0.59	0.10 – 18.10
Taân Binh	40 – 180	4.1 – 7.3	1 – 80	0.04 – 13.70	0.02 – 16.13
Phu Nhuan	34 – 42	5.7 – 7.9	11.34 - 21.45	0.06 – 0.80	2.54
Bình Thaïnh	60 – 100	4.1 – 6.6	75 – 198.90	0.60 – 0.65	16.67 – 42.80
Bình Chaùnh	80 – 248	1.7 – 8.6	10.00 – 140.21	0.20 – 7.03	0.00 – 1.94
Nhao Beo	193	6.2 – 7.7			

TABLE 2.15 INCIDENCE OF WATER-BORNE DISEASES FOR DIFFERENT DISTRICTS

Name of District	Year 1993 Total Population: 3,988,000		Year 1994 Total Population: 4,055,680		Year 1995 Total Population: 4,386,837		Year 1996 Total Population: 4,257,111		Year 1997 Total Population: 4,479,633	
	Cases	Cases/ 100000	Cases	Cases/ 100000	Cases	Cases/ 100000	Cases	Cases/ 100000	Cases	Cases/ 100000
Q1	241	6.04	114	2.81	522	11.90	423	9.94	455	10.16
Q2									75	1.67
Q3	255	6.39	123	3.03	329	7.50	283	6.65	354	7.90
Q4	190	4.76	66	1.63	295	6.72	284	6.67	365	8.15
Q5	233	5.84	137	3.38	630	14.36	456	10.71	615	13.73
Q6	290	7.27	270	6.66	678	15.46	495	11.63	712	15.89
Q7									93	2.08
Q8	262	6.57	163	4.02	1312	29.91	971	22.81	1427	31.86
Q9									118	2.63
Q10	315	7.90	162	3.99	400	9.12	301	7.07	348	7.77
Q11	250	6.27	127	3.13	313	7.13	220	5.17	292	6.52
Q12										
Go Vap	151	3.79	80	4.19	184	4.19	163	3.83	273	6.09
Tan Binh	450	11.28	290	12.70	557	12.70	456	10.71	529	11.81
Binh Thanh	473	11.86	258	11.51	505	11.51	445	10.45	545	12.17
Phu Nhuan	160	4.01	89	5.22	229	5.22	137	3.22	228	5.09
Thu Duc	451	11.31	335	9.99	483	9.99	316	7.42	414	9.24
H. Binh Chanh	109	2.73	93	7.32	321	7.32	237	7.68	381	8.51
H. Nha Be	136	3.41	40	8.55	375	8.55	398	9.35	69	1.54

TABLE 2.16 LAWS, REGULATIONS AND STANDARDS ON ENVIRONMENTAL PROTECTION

Name of the Laws, Regulations and Ordinance	Year Enacted	Remarks
Law on Environmental Protection	1993	Requires EIA report for new activities/projects affecting the Environment be submitted to State Management Agency for environmental protection for appraisal
TCVN 5942 – 1995 Water Quality : Surface Water Quality Standards	1995	Specifies parameters and their maximum allowable concentrations in surface water
TCVN 5943 – 1995 Water Quality : Coastal Water Quality Standards	1995	Specifies parameters and their maximum allowable concentrations in coastal water
TCVN 5944 – 1995 Water Quality : Ground Water Quality Standards	1995	Specifies parameters and their maximum allowable concentrations in ground water
TCVN 5945 – 1995 Effluent Standards : Industrial Wastewater Discharges	1995	Specifies pollutants and their maximum allowable concentrations in Industrial wastewater to be discharged to public water bodies
TCVN 5937 – 1995 Air Quality : Ambient Air Quality Standards	1995	Specifies maximum allowable concentrations for the common pollutants in ambient air.
TCVN 5938 – 1995 Air Quality : Maximum Allowable Concentrations of Hazardous Substances and Dusts	1995	Specifies maximum allowable concentrations of hazardous substances in ambient air including inorganic and organic toxic substances
TCVN 5939 – 1995 Air Quality : Industrial Emission Standards for inorganic substances and Dusts	1995	Specifies maximum allowable concentrations of inorganic substances in industrial emissions discharged to the atmosphere
TCVN 5940 – 1995 Air Quality : Industrial Emission Standards for organic substances	1995	Specifies maximum allowable concentrations of organic substances in industrial emissions discharged to the atmosphere
TCVN 5941 – 1995 Soil Quality : Maximum Allowable Limits of Pesticides Residues in the Soil	1995	Specifies maximum allowable limits of pesticide residues in the soil

TABLE 2.17 MAXIMUM PERMISSIBLE CONCENTRATION OF POLLUTANTS IN SURFACE WATER (TCVN 5942 – 1995)

No.	Parameter	Unit	Maximum Permissible Concentration	
			A	B
1	pH		6.0 – 8.0	5.5 – 9.0
2	BOD_5 (20°C)	mg/l	< 4	< 25
3	COD	mg/l	< 10	< 35
4	Dissolved Oxygen	mg/l	> 6	> 2
5	Suspended Solids	mg/l	20	80
6	Arsenic	mg/l	0.05	0.10
7	Barium	mg/l	1	4
8	Cadmium	mg/l	0.01	0.02
9	Lead	mg/l	0.05	0.10
10	Chromium (Hexavalent)	mg/l	0.05	0.05
11	Chromium (Trivalent)	mg/l	0.1	1
12	Copper	mg/l	0.1	1
13	Zinc	mg/l	1	2
14	Manganese	mg/l	0.1	0.8
15	Nickel	mg/l	0.1	1
16	Iron	mg/l	1	2
17	Mercury	mg/l	0.001	0.002
18	Tin	mg/l	1	2
19	Ammonia (as N)	mg/l	0.05	1
20	Fluoride	mg/l	1	1.5
21	Nitrate (as N)	mg/l	10	15
22	Nitrite (as N)	mg/l	0.01	0.05
23	Cynaide	mg/l	0.01	0.05
24	Phenol Compounds	mg/l	0.001	0.02
25	Oil and Grease	mg/l	Not detectable	0.3
26	Detergent	mg/l	0.5	0.5
27	Coliform	MPN/100 ml	5000	10000
28	Total Pesticides (except DDT)	mg/l	0.15	0.15
29	DDT	mg/l	0.01	0.01
30	Gross alpha activity	Bq/l	0.1	0.1
31	Gross beta activity	Bq/l	1.0	1.0

Note

- Values in the Column A are applied to the surface water being used as a source of domestic water supply with appropriate treatment
- Values in the Column B are applied to the surface water being used for the purposes other than domestic water supply

TABLE 2.18 MAXIMUM PERMISSIBLE CONCENTRATION OF POLLUTANTS FOR THE DISCHARGE OF INDUSTRIAL WASTEWATER (TCVN 5945 - 1995)

No.	Parameter	Unit	Maximum Permissible Concentration		
			A	B	C
1	Temperature	OC	40	40	45
2	PH		6 – 9	5.5 – 9	5 – 9
3	BOD_5 (20°C)	mg/l	20	50	100
4	COD	mg/l	50	100	400
5	Suspended Solids	mg/l	50	100	200
6	Arsenic	mg/l	0.05	0.1	0.5
7	Cadmium	mg/l	0.01	0.02	0.5
8	Lead	mg/l	0.1	0.5	1
9	Residual Chlorine	mg/l	1	2	2
10	Chromium (VI)	mg/l	0.05	0.1	0.5
11	Chromium (III)	mg/l	0.2	1	2
12	Mineral Oil and Fat	mg/l	Not detectable	1	5
13	Animal-vegetable Fat and Oil	mg/l	5	10	30
14	Copper	mg/l	0.2	1	5
15	Zinc	mg/l	1	2	5
16	Manganese	mg/l	0.2	1	5
17	Nickel	mg/l	1	1	2
18	Organic Phosphorus	mg/l	0.2	0.5	1
19	Total Phosphorus	mg/l	4	6	8
20	Iron	mg/l	1	5	10
21	Tetrachloroethylene	mg/l	0.02	0.1	0.1
22	Tin	mg/l	0.2	1	5
23	Mercury	mg/l	0.005	0.005	0.01
24	Total Nitrogen	mg/l	30	60	60
25	Trichloroethylene	mg/l	0.05	0.3	0.3
26	Ammonia (as N)	mg/l	0.1	1	10
27	Fluoride	mg/l	1	2	5
28	Phenol	mg/l	0.001	0.05	1
29	Sulfide	mg/l	0.2	0.5	1
30	Cyanide	mg/l	0.05	0.1	0.2
31	Coliform	MPN/100ml	5000	10000	-
32	Gross alpha activity	Bq/l	0.1	0.1	-
33	Gross beta activity	Bq/l	1.0	1.0	-

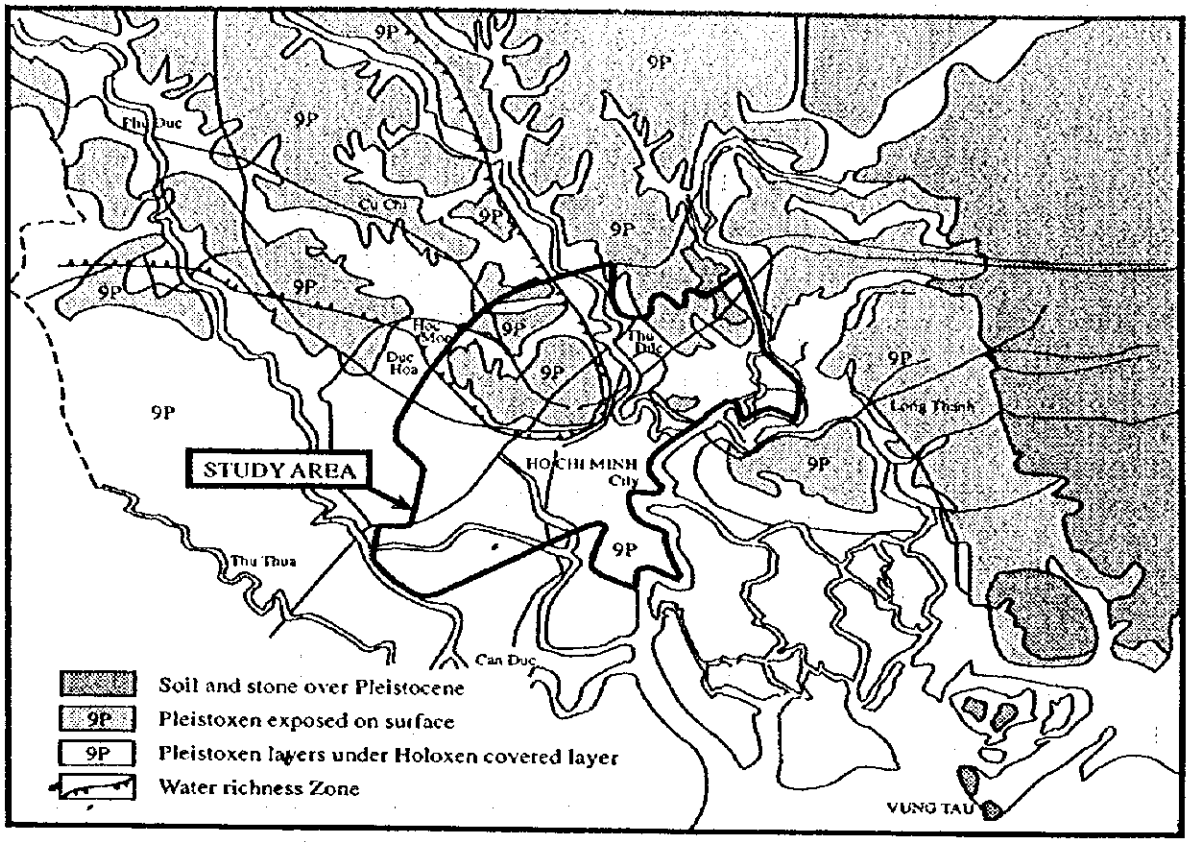
Note

- Industrial wastewaters containing the values of parameters and concentration pf substances which are equal to or lower than the values specified in the column A can be discharged into the water bodies being used as source of domestic water supply.
- Industrial wastewaters containing the values of parameters and concentration of substances which are lower than or equal to those specified in the column B can be discharged only into those water bodies being used for navigation, irrigation, aquatic breeding and cultivation etc.
- Industrial wastewaters containing the values of parameters and concentration of substances which are greater than those specifiedin the Column B but not exceeding those specified in column C can be discharged only into specific waterbodies permitted by authorized agencies.
- Industrial wastewaters containing the values of parameters and concentration of substances which are greater than those specified in the column C shall not be discharged into surroundings.

FIG. 2.1 TOPOGRAPHY OF THE STUDY AREA

JICA - Ho Chi Minh City Urban Drainage & Sewerage Project

FIG. 2.1 TOPOGRAPHY OF THE STUDY AREA



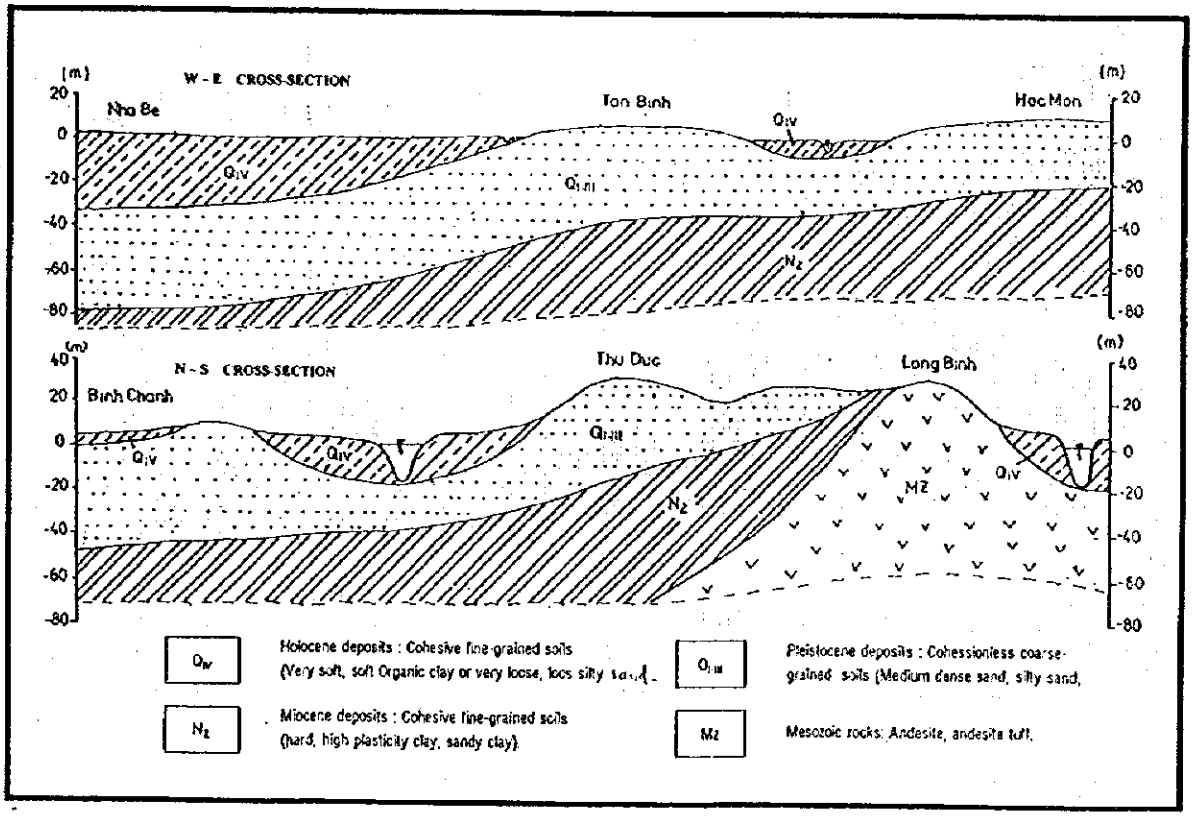
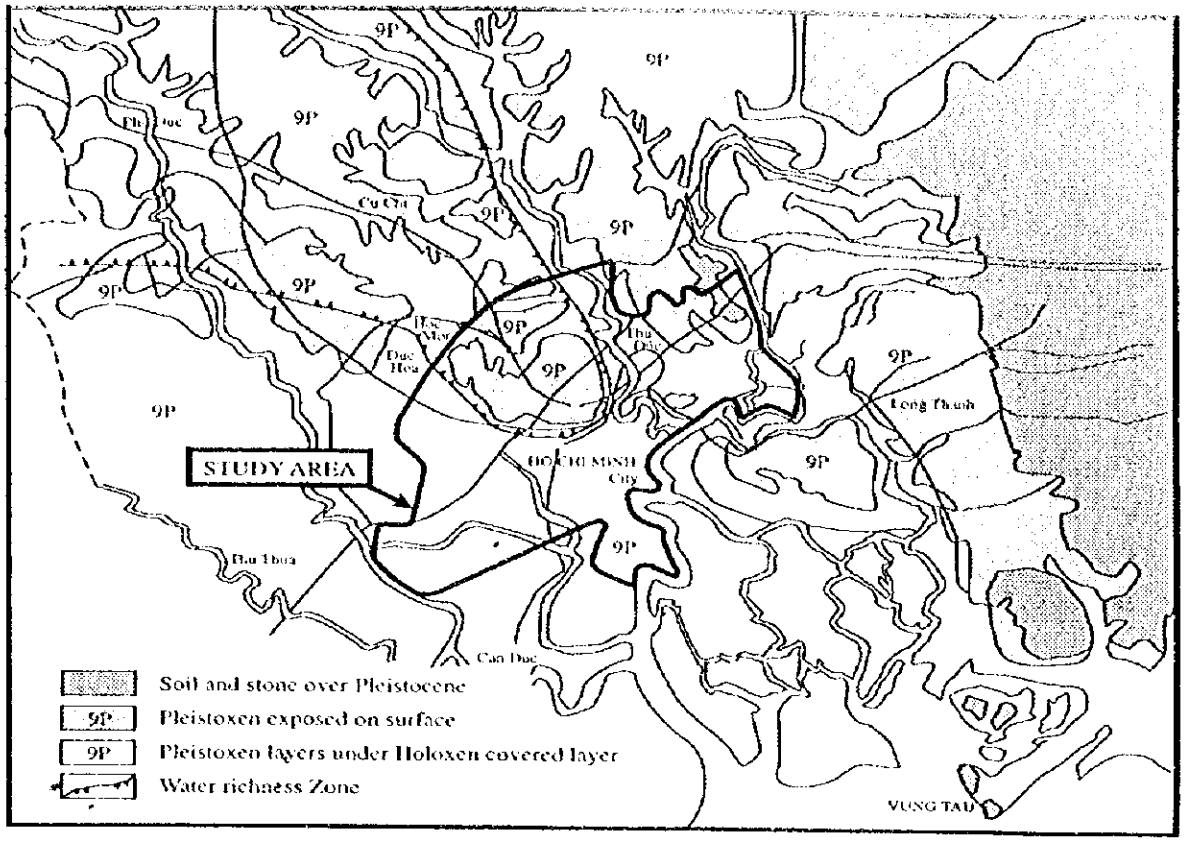


Figure 2.2 GEOLOGY OF HO CHI MINH CITY



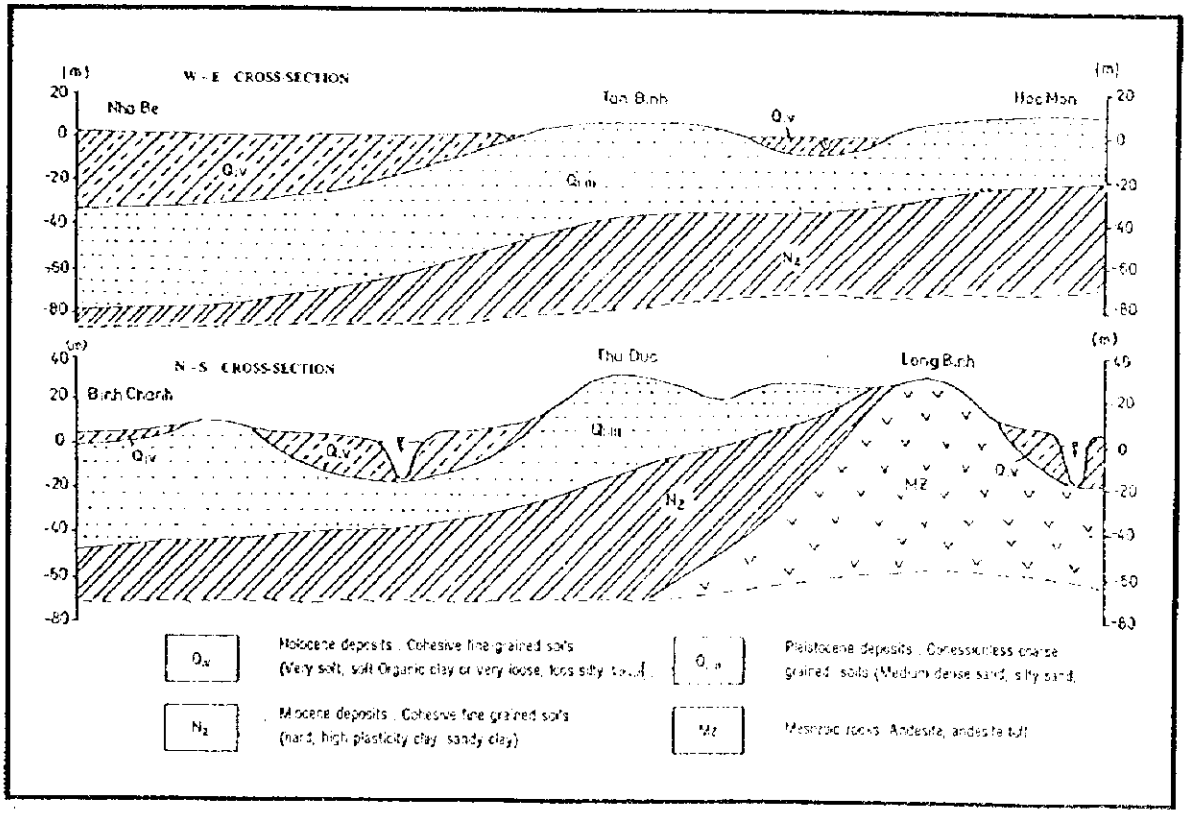
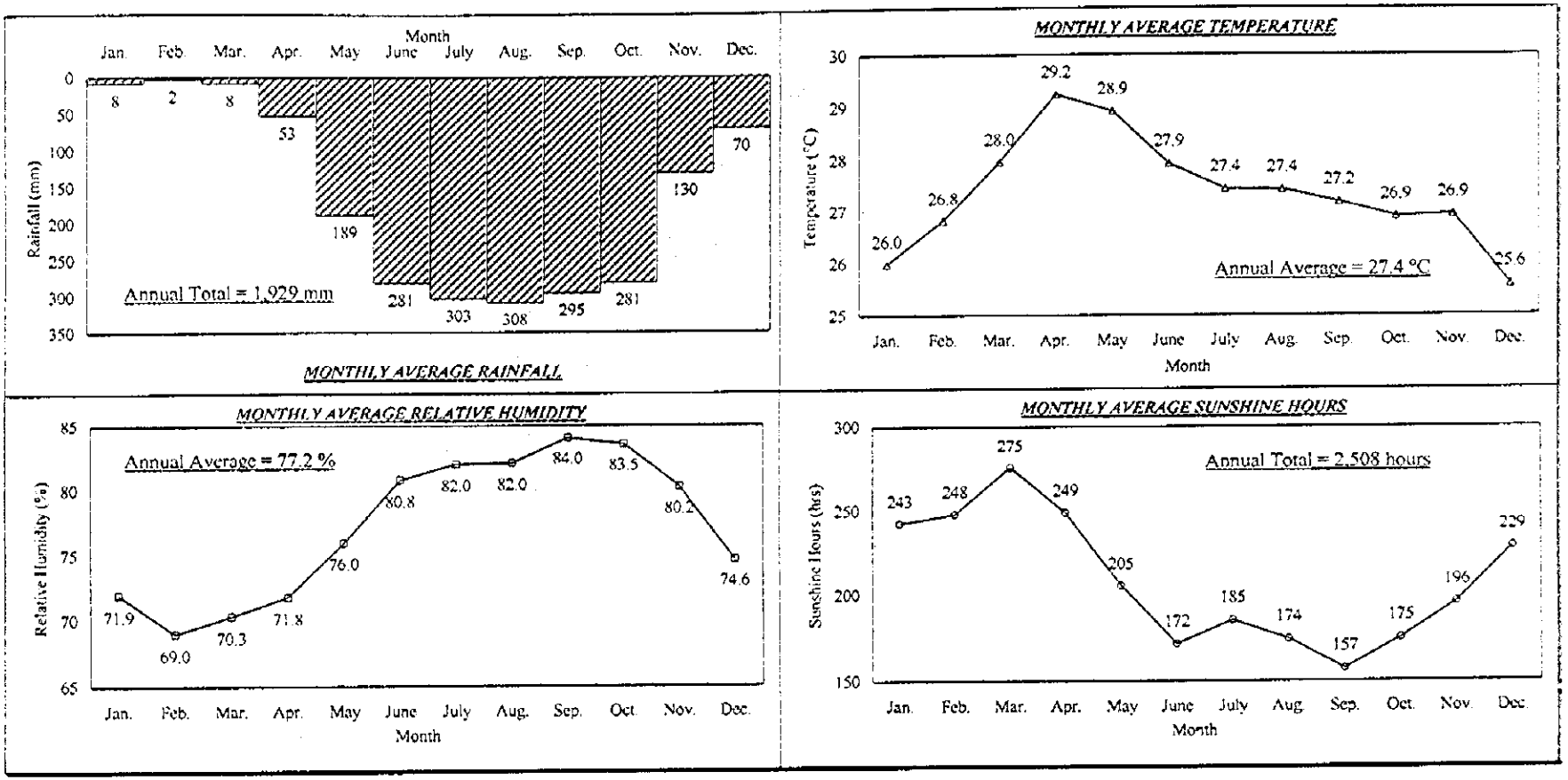


Figure 2.2 GEOLOGY OF HO CHI MINH CITY



Data : From 1976 to 1997 at Tan Son Nhat

Data Source : Ho Chi Minh City Statistical Office

FIG. 2.3 METEOROLOGICAL CONDITIONS OF HO CHI MINH CITY

FIG. 2.4 REGIONAL DISTRIBUTION OF POPULATION DENSITY BY WARD (EXISTING - 1997)

FIG. 2.5 REGIONAL DISTRIBUTION OF POPULATION DENSITY BY WARD (FUTURE - 2020)

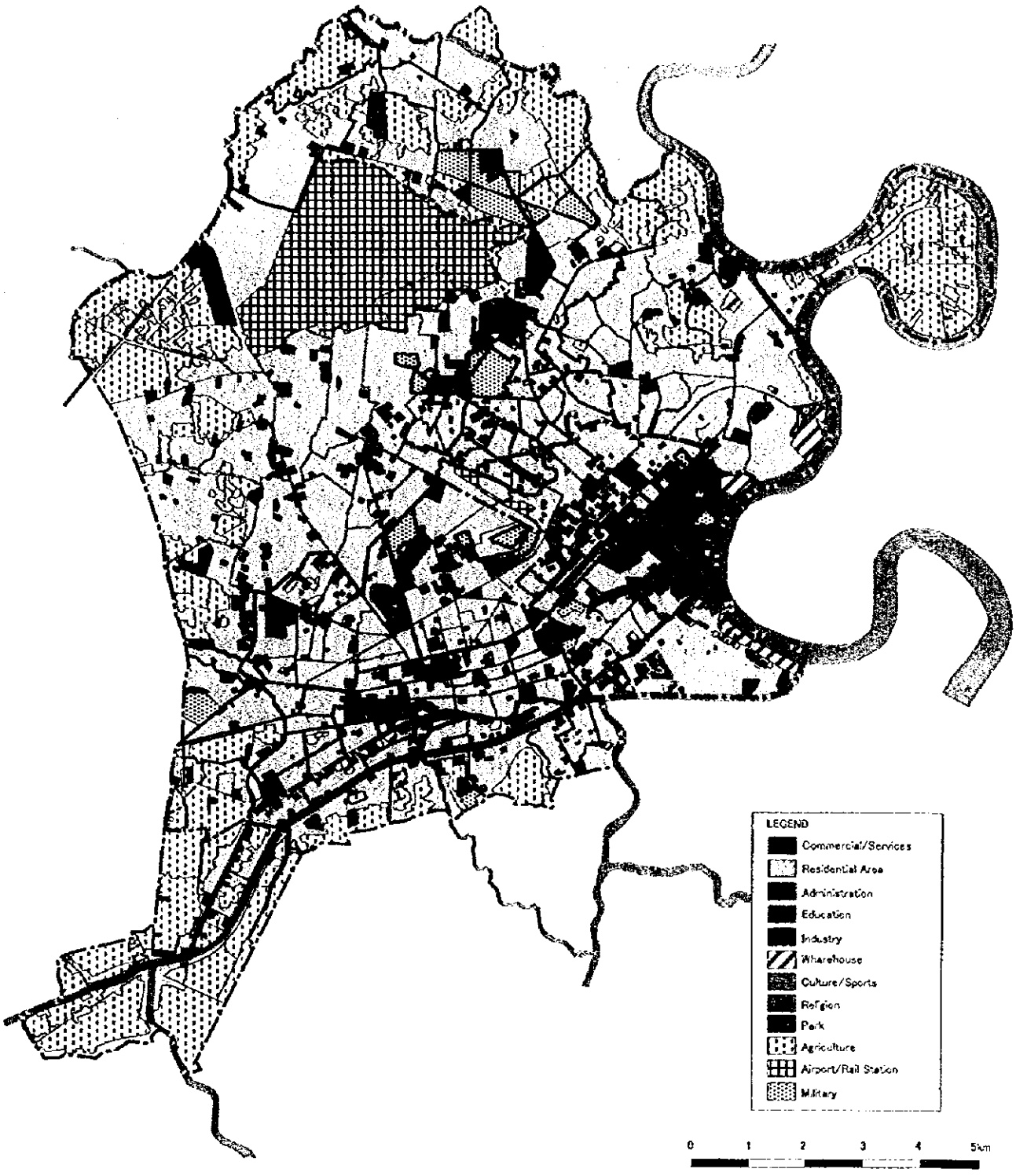


FIG. 2.6 EXISTING LAND USE OF INNER CITY

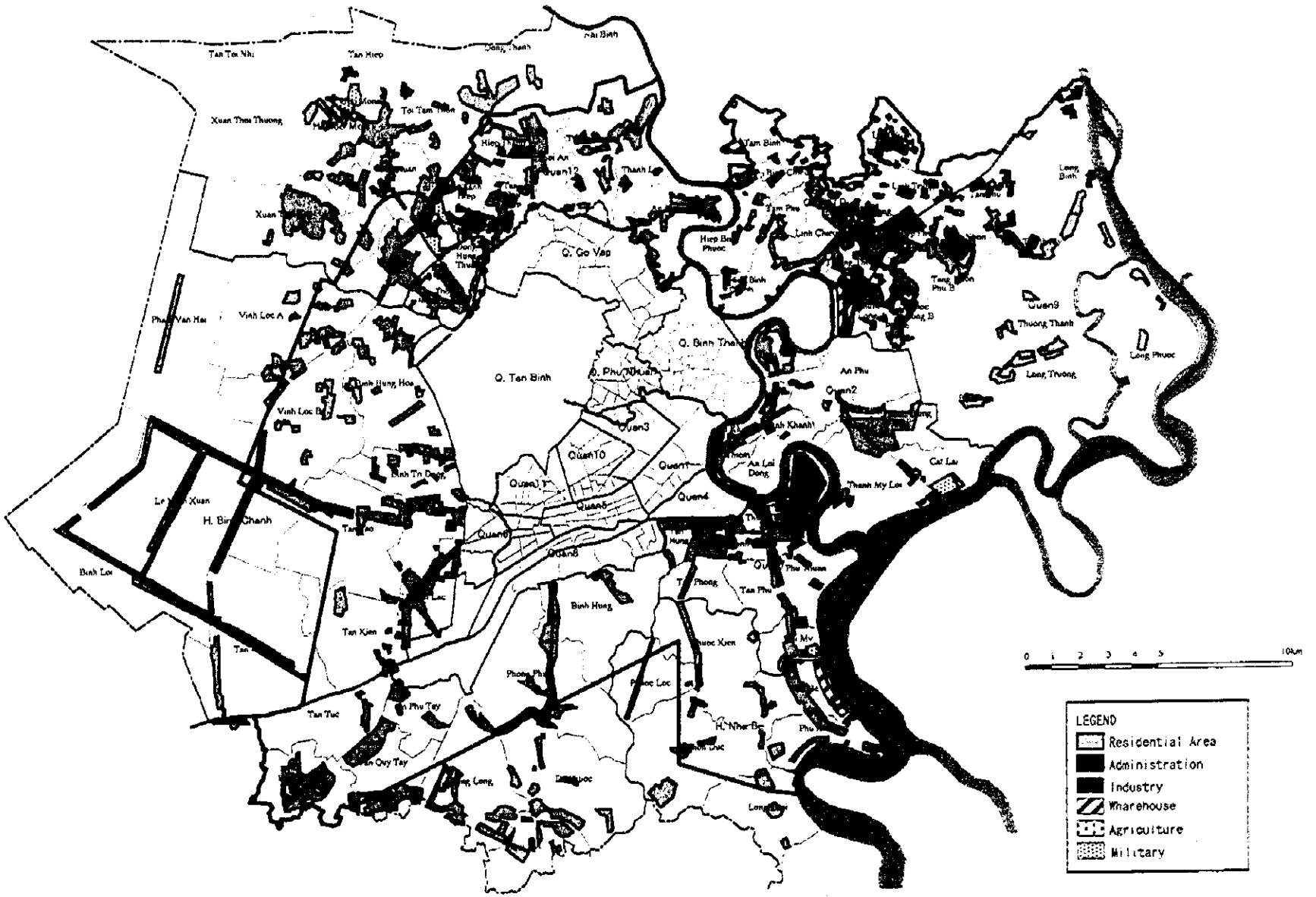


Fig. 2.7 Existing Land Use of Outer City

Fig. 2.7 Existing Land Use of Outer City

Fig. 2.8 FUTURE LAND USE OF THE STUDY AREA

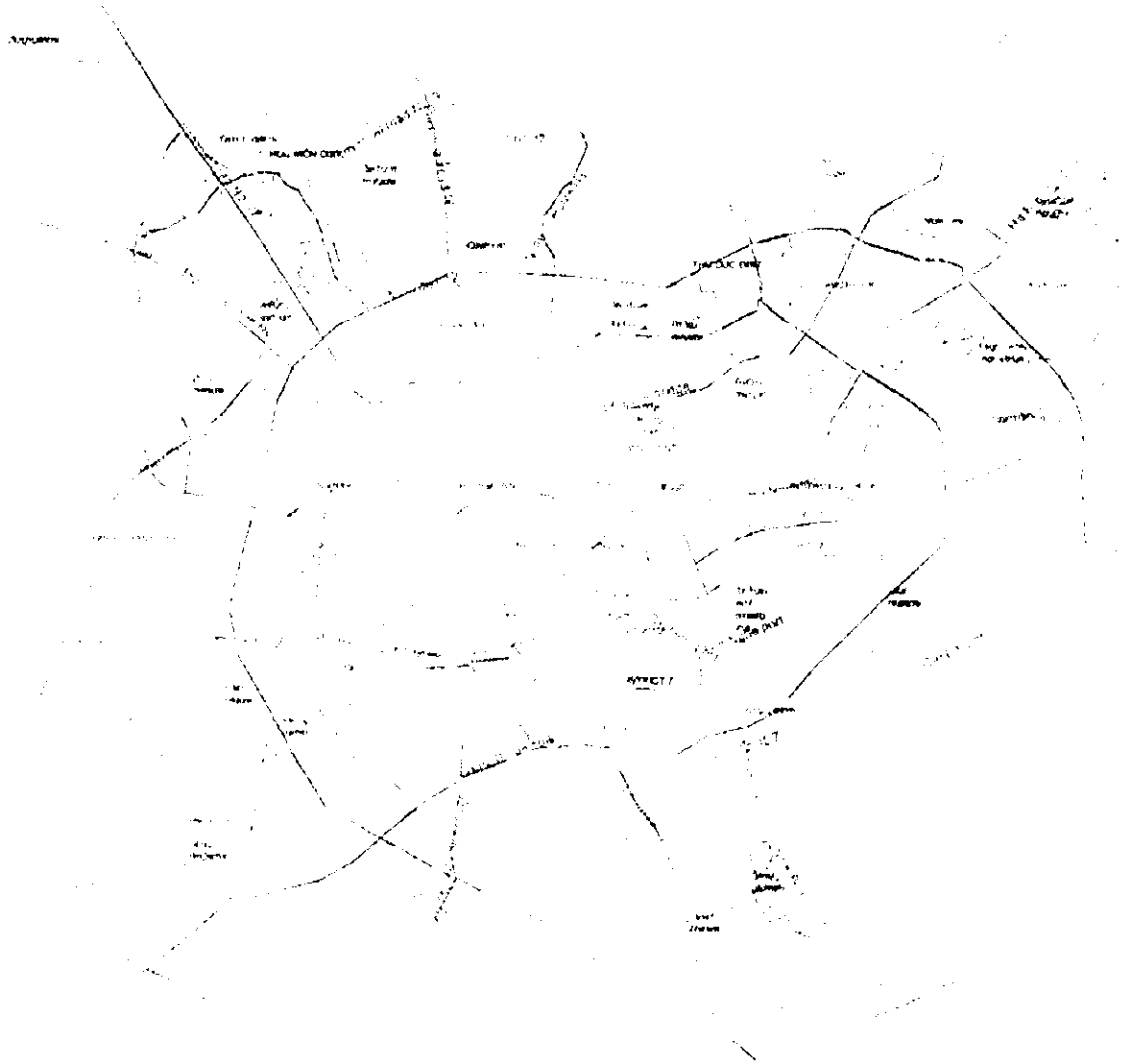
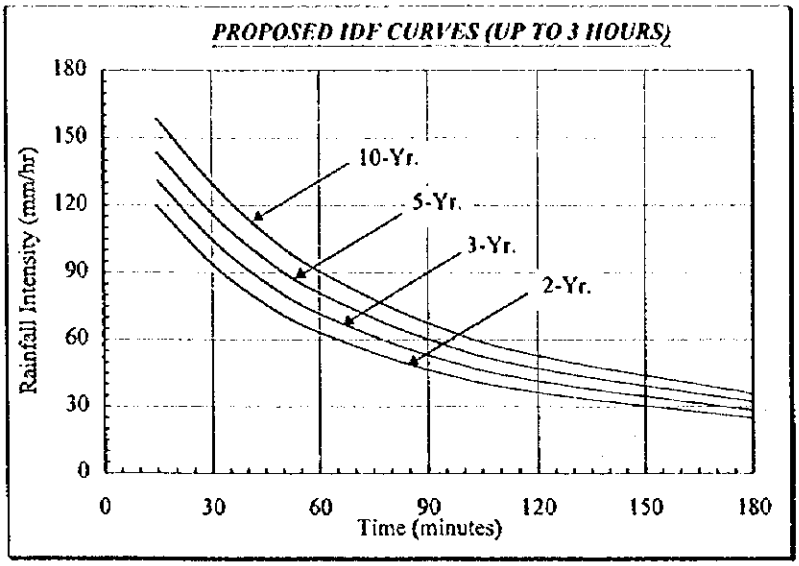


FIG. 2.9 CANAL SYSTEM BY DRAIANGE ZONE

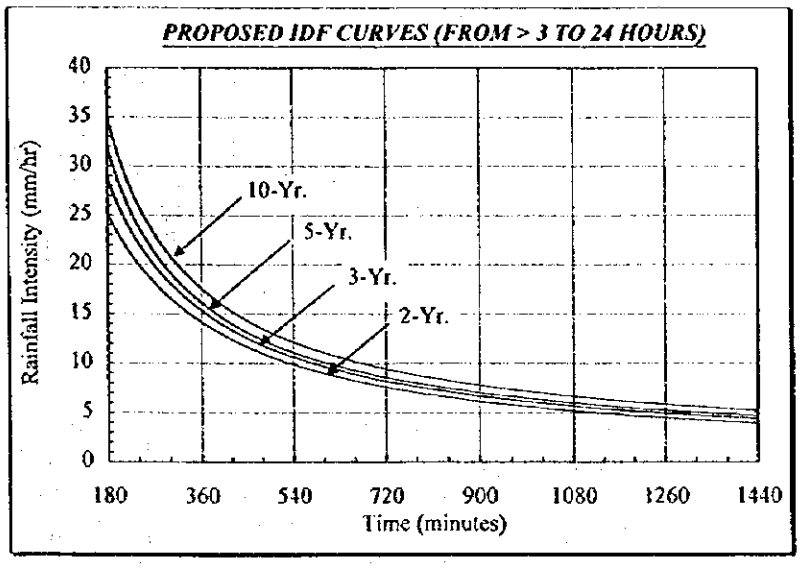


Proposed Equations

$$I = \frac{b}{t^n + a}$$

I = Rainfall Intensity, mm/hr
t = Duration, minutes

Return Period (Years)	Parameter		
	b	n	a
1	3,055	1.04	24
1.5	10,633	1.15	74
2	13,567	1.18	89
3	17,439	1.20	107
5	22,294	1.22	128
10	29,125	1.25	154
20	36,410	1.27	179
25	38,836	1.28	186
30	40,861	1.28	192
50	46,733	1.29	209
70	50,683	1.30	220
100	54,976	1.31	231



Proposed Equations

$$I = \frac{b}{t^n + a}$$

I = Rainfall Intensity, mm/hr
t = Duration, minutes

Return Period (Years)	Parameter		
	b	n	a
1	515,400	1.68	35,184
1.5	7,372	1.05	94
2	5,858	1.00	53
3	3,269	0.91	1
5	2,024	0.84	-15
10	1,669	0.80	-16
20	1,229	0.75	-17
25	1,305	0.75	-17
30	1,073	0.72	-17
50	886	0.69	-17
70	872	0.68	-16
100	875	0.68	-16

Data : 1952 - 1997

FIG. 2.10 PROPOSED IDF CURVES WITH EQUATIONS

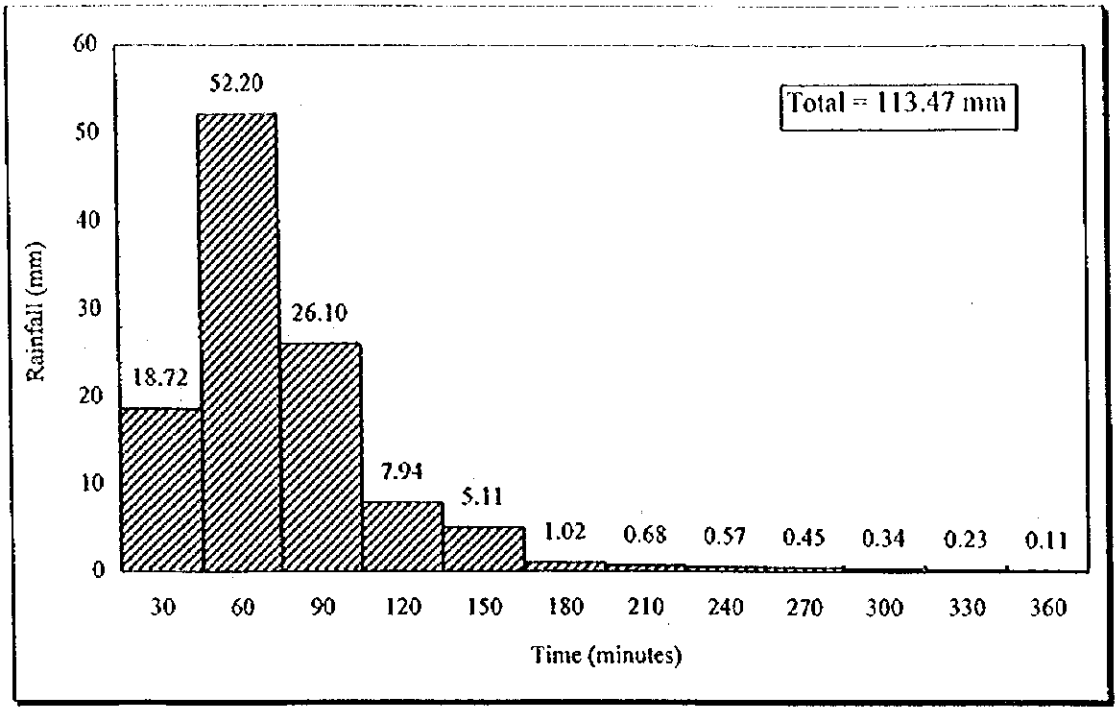


FIG. 2.11 PROPOSED 5-YEAR DESIGN RAINFALL HYETOGRAPH

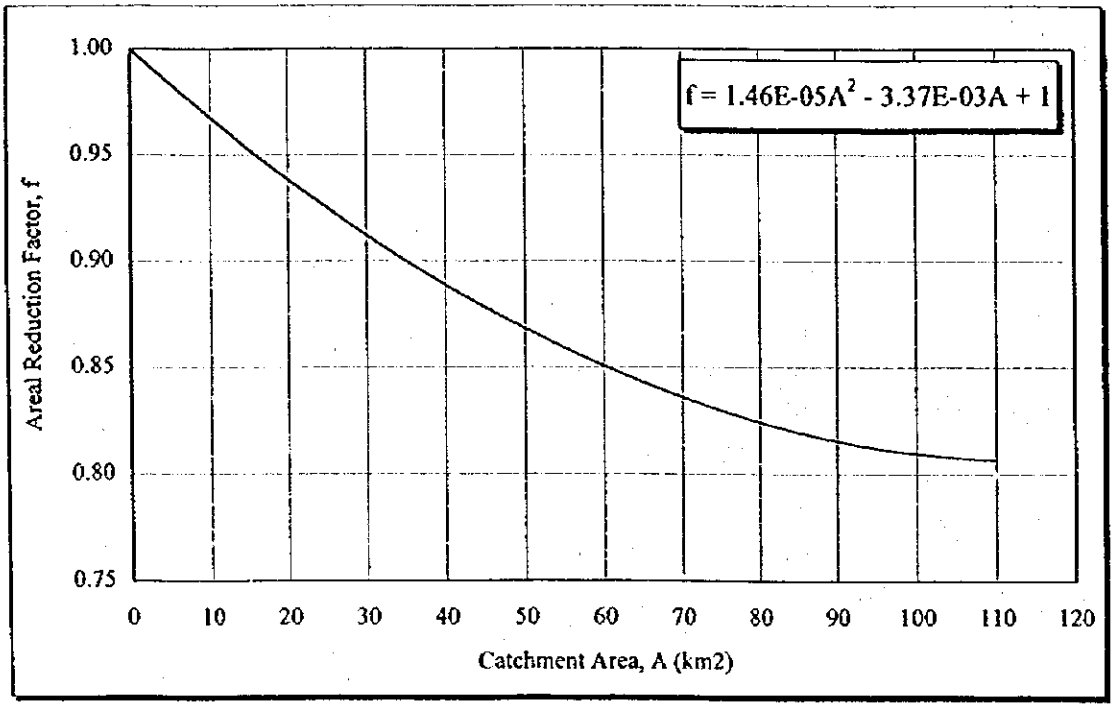


FIG. 2.12 PROPOSED AREAL REDUCTION FACTOR CURVE

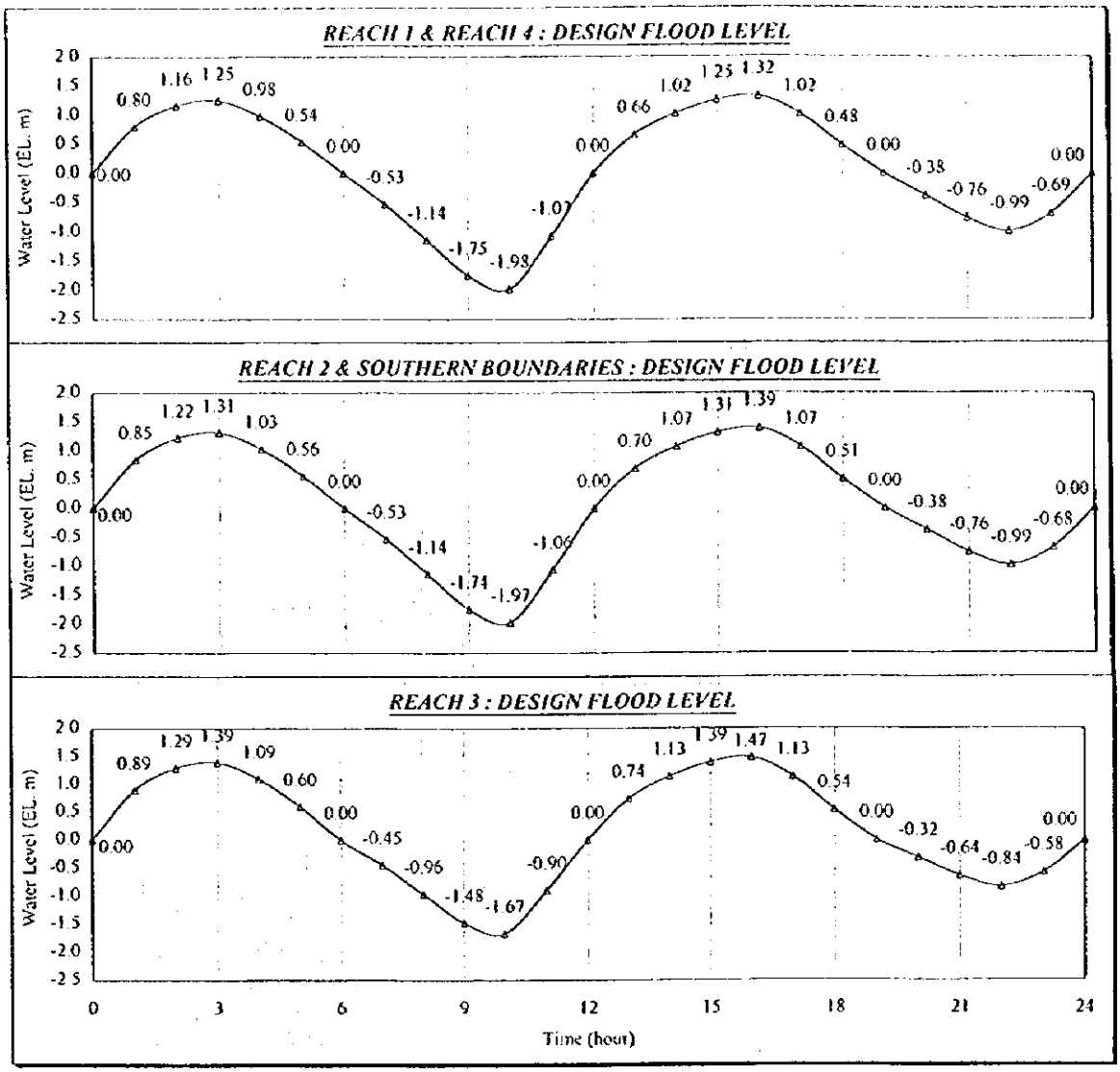


FIG. 2.13 DYNAMIC WATER LEVEL PROFILES

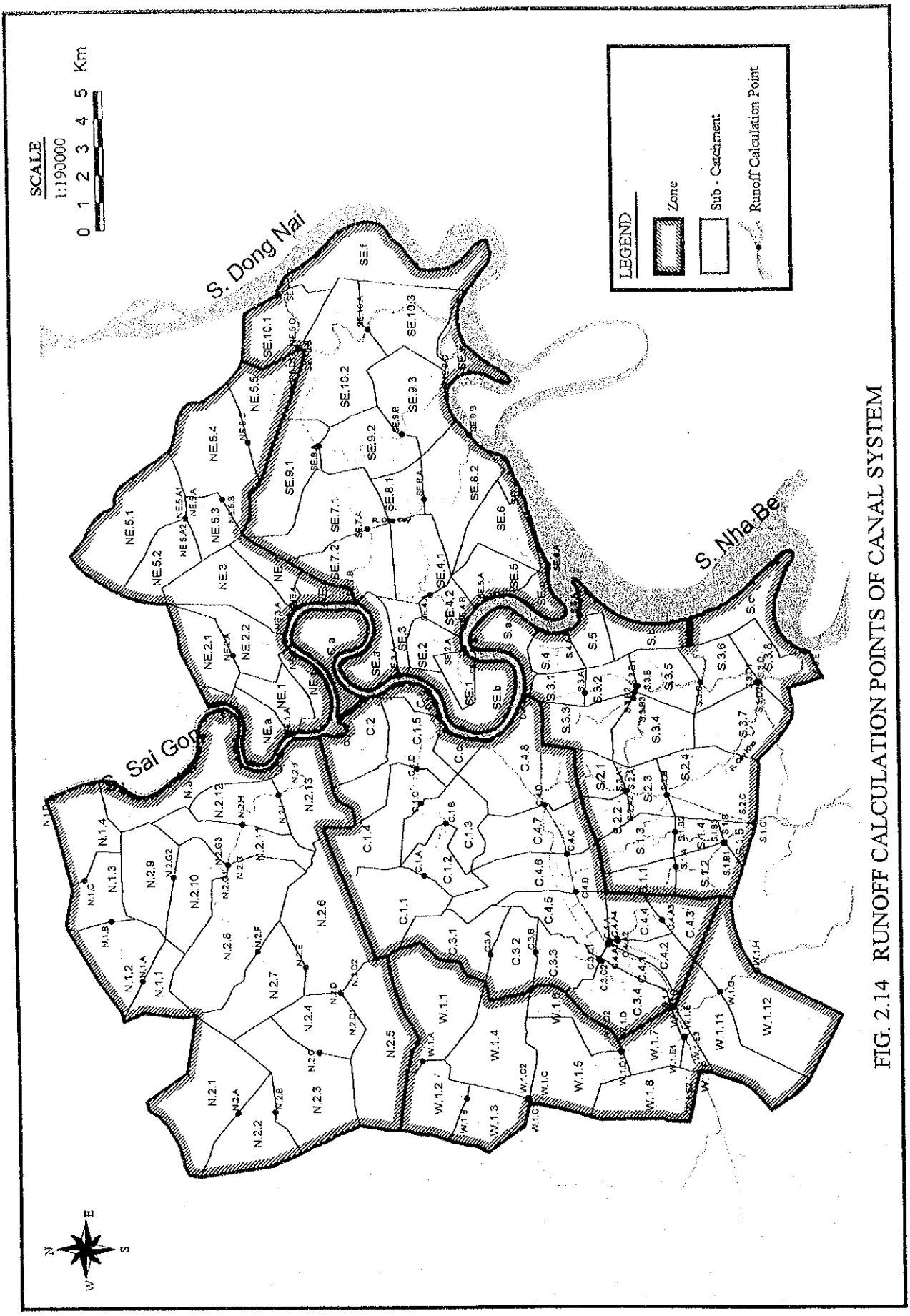


FIG. 2.14 RUNOFF CALCULATION POINTS OF CANAL SYSTEM

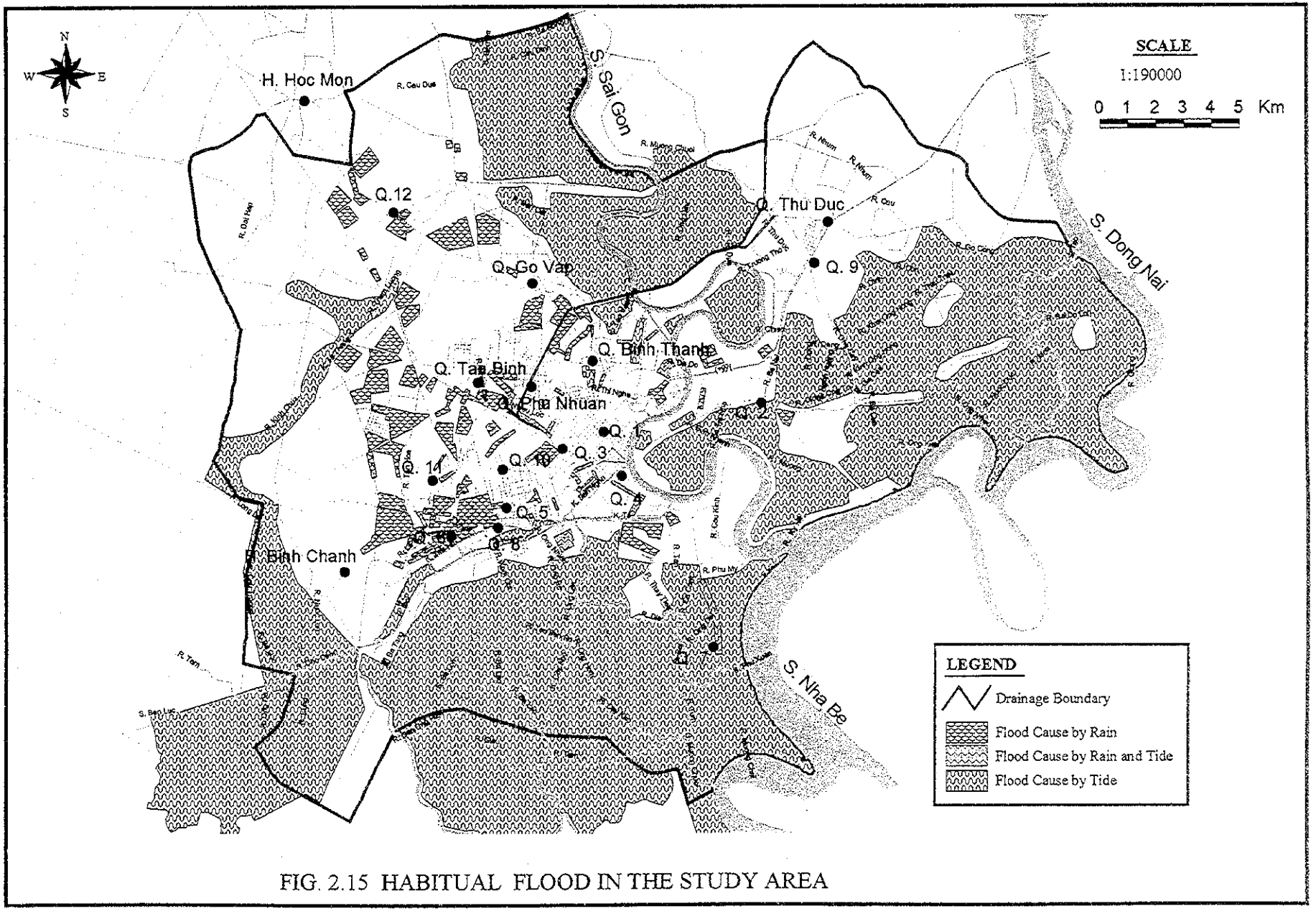


FIG. 2.15 HABITUAL FLOOD IN THE STUDY AREA

FIG. 2.16 LOCATION OF MONITORING STATION

CHAPTER 3

EXISTING URBAN DRAINAGE SYSTEM AND FACILITIES

CHAPTER 3 EXISTING URBAN DRAINAGE SYSTEM AND FACILITIES

3.1 Canal System and Facilities

3.1.1 Drainage Zone

The study area is divided into six drainage zones based on the topographical condition, existing urban drainage system, and the present and future urbanization scale. Fig. 3.1 shows six drainage zones in the study area including their present and future population and built up area. Summary of each drainage zone is mentioned below:

(1) Central city drainage zone (C-zone)

The main canals of this drainage zone are Nhieu Loc - Thi Nghe, Tan Hoa - Lo Gom, Tau Hu - Ben Nghe and Doi - Te. This zone covers the entire central part of the city. The combined sewer network system was built in 1980s by the French Government, which consists of trunk sewer of about 93 km and secondary sewer of more than 930 km. These sewers drain the collected rainwater and wastewater into the above main canals through more than 93 outlets. These canals finally discharge into Saigon River.

(2) Northern city drainage zone (N-zone)

The main canals of this zone are Tham Luong - Ben Cat, Rach Dai Han, Rach Ben Da - Ba Hong. This zone covers northern suburban area. In this drainage zone only Go Vap district has sewer along the right bank of Tham Luong - Ben Cat canal and other areas have no sewer network yet. The storm water collected by few sewer pipes, ditches and channels drain directly into above mentioned main canals, which are connected with Saigon River.

(3) Western city drainage zone (W-zone)

The main canals of this drainage zone are Chua, Nuoc Len, Ben Luc, and Can Guioc. This zone covers low lying area along canal Chua and Nuoc Len. This drainage zone has no sewerage system except some pipes, which have been recently constructed for newly urbanized areas in Binh Chanh. The storm water and wastewater is collected through ditches and channels and drain into Ben Luc and Can Guioc rivers which finally discharge to Nha Be River.

(4) Southern city drainage zone (S-zone)

The main canals in this drainage zone are as Ba Lao, Xom Cui, Ong Lon, Cay Kho, Dia, Muong Chuoi. This zone is naturally low lying area with dense canal

networks and has been developed as an agricultural land mainly. In recent years this zone has seen several economic developments by the foreign investors. Rainwater and wastewater is collected by natural small canals and discharged to above mentioned canals and finally to Nha Be River.

(4) North-Eastern city drainage zone (NE-zone)

The main canals in this zone are Go Dua, Nhum, Cau and Go Gong. This zone mainly consists of agricultural land and has been sometimes flooded due to backwater from Saigon River during high tide due to insufficient dike system along the river. This zone has practically no sewerage system. Storm water and wastewater collected through the above canals is discharged directly into Saigon and Dong Nai rivers.

(5) South-Eastern city drainage zone (SE-zone)

This zone has dense canal network and main canals are as Chiec, Ong Hong, Kieu, Ong Nhieu, Trau Trau and Tac River. This zone also mainly consists of agricultural land and residential areas are being developed recently. This zone has no sewer pipes but very dense canal network system. Storm water and wastewater collected by ditches and channels are drained to the above canals/rivers. These canals then discharge into Saigon and Dong Nai rivers.

3.1.2 Objective Canals and Existing Discharge Capacity

The study area consisting of six drainage zones has 27 major and 16 small canal network systems. Most of the canals in the inner city including Nieu Loc - Thi Nghe, Tan Hoa - Lo Gom, Tau Hu - Ben Nghe, Tham Lung - Ben Cat canals, etc. have been narrowed, due to the encroachment of illegal house and building. These canal beds have also been shallowed by garbage, waste disposal and soil deposit disposed from houses along the canal. These problems are one of a primary factor of inundation. On the other hand, the present conditions of the canal located in surrounding areas are relatively good as a natural canal or manmade irrigation canal.

Based on the collected longitudinal and cross sectional data, field reconnaissance and supplementary surveys conducted during this study, hydraulic characteristics of canals are summarized in Table 3.1. Hydraulic characteristics of major canals are illustrated in Fig. 3.2. According to the preliminary hydraulic evaluation of the discharge capacities of 27 canal systems, they have the lowest velocity from 0.3 to 0.4 m/s at the high tide of three rivers, Saigon, Dong Nai and Nha Be. Consequently, as shown in Table 3.2, it is evaluated that discharge capacities of almost all canals in C, N, W and NE zones are smaller than that of 5 or 10 year flood run-off and are to be increased by widening and deepening works. For most of the canals in S and SE zones, it is not found out the necessity of canal improvement works to increase their flow capacity, because of their

high dense canal network and enough flow capacities.

3.1.3 Related Structure

Related structures such as port facility, dike, bank protection, bridge and culverts are shown in Fig. 3.3. Three river ports are provided along the Saigon River to protect the landslide land from flooding of the Saigon River. Dike system consists of embankment, earth dam and water gate along the rivers/canals in and around the study area. Embankment along the Saigon, Dong Nai and some canals in Nha Be and Binh Chanh district have been damaged, eroded and collapsed and are not working properly, which is main cause of the external flood in low-lying areas during high tide season. The study area has eight dams, six are in district 2 and 9 and two are in district 7. Except two dams constructed at Rach Bang and Rach Dia others are in good condition. Two major gates; An Ha and Kenh C constructed in Binh Chanh are being properly operated and maintained. District 2 and 9 have eight main gates. Total length of bank protection provided is about 17.2 km along Saigon River and other canals such as Doi, Te and Ben Nghe. Box culverts are provided on the crossings of roads and canals. Existing capacity of these culverts is not enough and need to be improved.

3.1.4 Waterway Transportation

Waterway transportation system in HCMC consists of more than 1,200 km navigable rivers, canals and channels. At present, over millions of tons of import and export goods are annually transported through the big rivers. The national waterways connected with HCMC and Mekong delta provinces are serving to transport the domestic products and agricultural goods of 4 to 5 million tons per year. The domestic products including construction materials (sand, stone, brick, timber, etc.) of about dozens million tons are also transported by canals and channels. It is forecasted that the needs of the waterway transport in future will not decrease considering the densely developed canal and river network system in HCMC.

The Department of Transport and Public Works (DTPW), HCMC is responsible for the administration of traffic and waterway transport within the city. Out of total section of 970 km rivers and canals, about 736 km sections are managed as the navigable course by Office of Waterway Management (OWM) and the remaining 234 km sections are managed by Urban Drainage Company (UDC) as the urban drainage facilities.

In the Study area, there are 66 navigable rivers and canals with a total length of 309.1 km as mentioned in the table below and their location are shown in Fig. 3.4.

Drainage Zone	Number of Courses	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	13.8	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

Note: The waterways are classified into six grades on the requirements of navigation.

Recent rapid urbanization, motorization and lack of sufficient management for watercourse in HCMC have made the following problems for navigation:

(a) Some rivers and canals have been filled up and replaced to the covered sewer lines.
(b) The river and canal widths have been reduced due to the encroachment of the illegal houses and structures, the number of which is counted at almost 25,000 structures for about 70 km waterway within the inner city
(c) Due to poor garbage collection system, people's habitual action and lack of social morality, some rivers and canals have been dumped by garbage, refuse and waste disposal. These result in block for navigation and pollute the river water.

OWM undertakes periodical dredging projects for several canals in the city to maintain the required canal cross section for city drainage and inland navigation of ships and boats. The recent dredging projects are listed as below:

- Nhieu Loc - Thin Nghe canal: 250,000 m^3
- Ngang No. 2 and Ngang No. 3 canal: 60,000 m^3
- Lo Gom canal:170,000 m^3

In future OWM is planning to undertake following canal dredging works:

- Ben Nghe (Grade 5), Tah Hu (Grade 4) and Lo Gom (Grade 6) canal: 800,000 m^3
- Te canal (Grade 3): 100,000 m^3
- Vanh Dai Trong (Grade 4) canal: 1,000,000 m^3
- Trao Trao and Chiec (Grade 4) canals: 600,000 m^3
- Giong Ong To (Grade 4) canal: 600,000 m^3