JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

PEOPLE'S COMMITTEE OF HO CHI MINH CITY (PCHCMC)
MINISTRY OF PLANNING AND INVESTMENT (MPI)
THE SOCIALIST REPUBLIC OF VIET NAM

THE STUDY ON URBAN DRAINAGE AND SEWERAGE SYSTEM FOR HO CHI MINH CITY IN THE SOCIALIST REPUBLIC OF VIET NAM

FINAL REPORT

MAIN REPORT

DECEMBER 1999

PACIFIC CONSULTANTS INTERNATIONAL

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Foreign Currency Exchange Rate Applied in this Report

Currency	Exchange Rate/US$
Vietnamese Dong (VND)	13,956
Japanese Yen (JPY)	113.39

(As of July, 1999)

PREFACE

In response to a request from the Government of the Socialist Republic of Viet Nam, the Government of Japan decided to conduct a master plan and a feasibility study on Urban Drainage and Sewerage System for Ho Chi Minh City in the Socialist Republic of Viet Nam and entrusted the study to Japan International Cooperation Agency (JICA).

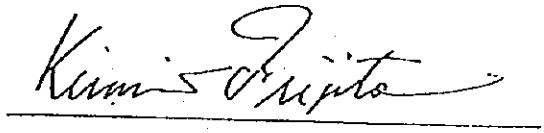
JICA selected and dispatched a study team headed by Mr. Ryuji Yanai, Pacific Consultants International (PCI) to Viet Nam, three times between July 1998 and December 1999. In addition, JICA set up an advisory committee headed by Mr. Kenji Tomizawa, Managing Director of Japan Sewer Collection System Maintenance Association, between July 1998 and December 1999, which examined the study from specialist and technical points of view.

The team held discussions with the officials concerned of the Government of Viet Nam and conducted field surveys at the study area. Upon returning to Japan, the team conducted further studies and prepared this final report.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relationship between our two countries.

Finally, I wish to express my sincere appreciation to the officials concerned of the Government of Viet Nam for their close cooperation extended to the team.

December, 1999



Kimio Fujita
President
Japan International Cooperation Agency

THE STUDY ON URBAN DRAINAGE AND SEWEARGE SYSTEM
FOR
HO CHI MINH CITY
IN
THE SOCIALIST REPUBLIC OF VIET NAM

December, 1999

Mr. Kimio Fujita
President
Japan International Cooperation Agency

LETTER OF TRANSMITTAL

Dear Sir,

We are pleased to submit to you the final report entitled "The Study on Urban Drainage and Sewerage System for Ho Chi Minh City in the Socialist Republic of Viet Nam". This report has been prepared by the Study Team in accordance with the contracts signed on 3 July 1998 and 13 May 1999 between the Japan International Cooperation Agency and the Pacific Consultants International.

The report examines the existing conditions of urban drainage and wastewater disposal in about 650 km^2 of Ho Chi Minh City and presents the results of master plan of urban drainage and sewerage system and feasibility study for priority projects concluded in the master plan.

The report consists of the Summary, Main Report, Supporting Report and Data Book. The Summary summarizes the results of all studies. The Main Report contains the existing conditions, the master plan, the feasibility study, and conclusions and recommendations. The Supporting Report includes technical details of contents of the Main Report. In addition, Data Book has been prepared and is submitted herewith.

All members of the Study Team wish to express grateful acknowledgement to the personnel of your Agency, Advisory Committee, Ministry of Foreign Affairs, Ministry of Construction and Embassy of Japan in Viet Nam, and also to officials and individuals of the Socialist Republic of Viet Nam for their assistance extended to the Study Team. The Study Team sincerely hopes that the results of the study will contribute to the improvement of urban drainage and sewerage system in the Socialist Republic of Viet Nam and that friendly relations of both countries be promoted further by this occasion.

Yours faithfully,

柳内龍三

Ryuji YANAI
Team Leader

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ABBREVIATIONS

1. ORGANIZATIONS

ADB	Asian Development Bank
CDM	Camp Dresser & MaKee International Inc.
CEC	City Environment Company
CITENCO	Ho Chi Minh City Environmental Company
DARD	Department of Agriculture and Rural Development]
DFP	Department of Finance-Pricing
DHI	Danish Hydraulics Institute
DOF	Department of Finance
DOSTE	Department of Science, Technology, and Environment
DPI	Department of Planning and Investment
DTPW	Department of Transport and Public Works
ENCO	Environmental Committee (renamed recently to the Environmental Management Section)
GOJ	Government of Japan
GOV	Government of Viet Nam
HCMC	Ho Chi Minh City
IDA	International Development Association
JICA	Japan International Cooperation Agency
JBIC	Japan Bank for International Cooperation (previous name: Overseas Economic Cooperation Fund: OECF)
MARD	Ministry of Agriculture and Rural Development
MOC	Ministry of Construction
MOF	Ministry of Finance
MOSTE	Ministry of Science, Technology, and Environment
MPI	Ministry of Planning and Investment
OECF	Overseas Economic Cooperation Fund (renamed to Japan Bank for International Cooperation: JBIC)
OWM	Office of Waterway Management
PC	People's Committee
PCHCMC	People's Committee of Ho Chi Minh City
PMU	Project Management Unit
SDC	Sewerage and Drainage Company
SOE	State Owned Enterprise
UDC	Urban Drainage Company
UPI	Urban Planning Institute
URENCO	urban Environment Company
USAID	United State International Assistance Department
WB	World Bank
WSC	Water Supply Company

2. TERMINOLOGY

ATP	Affordability to Pay	BOD	Biochemical Oxygen Demand
B/C	Benefit by Cost Ratio	cm	Centimeter
CIF	Cost, Insurance and Freight	COD	Chemical Oxygen Demand
DHWL	Design High Water Level	DLWL	Design Low Water Level
DO	Dissolved Oxygen	FC	Foreign Currency
EIRR	Economic Internal Rate of Return	FOB	Free on Board
FIRR	Financial Internal Rate of Return	GIS	Geographic Information System
GRDP	Gross Regional Domestic Products	GDP	Gross Domestic Products
ha	Hectare	HH/HHs	Household or Households
IDF	Intensity-Duration-Frequency	kg	Kilogram
km	Kilometer	km^2	Square kilometer
kw	Kilowatt	l	Litter
m	Meter	m/s	Meter per second
m^2	Square meter	m^3	Cubic meter
m^3/s	Cubic meter per second	mg	Milligram
mg/l	Milligram per litter	mm	Millimeter
LC	Local Currency	NLTN	Nhieu Loc Thi Nghe
NPV	Net Present Value	OM or O/M	Operation and Maintenance
s	Second	SCF	Standard Conversion Factor
SE	South East	SS	Suspended Solid
SAPROF	Special Assistance for Project Formation		
THBNDT	Tau Hu Ben Nghe Doi Te	THLG	Tan Hoa Lo Gom
TLBC	Thanh Long Binh chang	TQC	Total Quality Control
US$	United States Dollar	VND	Vietnamese Dong
¥	Japanese Yen	WTP	Willingness to Pay
%	Percent		

CHAPTER 1

INTRODUCTION

CHAPTER 1 INTRODUCTION

1.1 Background of the Study

Ho Chi Minh City (hereinafter referred to as "HCMC") located in the southern part of Viet Nam is the largest city of the nation as well as the socio-economic center in the southern region of the country. The city is also called to be a cultural, technical and scientific center and international trade metropolis. The national economy has been successfully grown due to the economic renovation since 1986, which is called "Doi Moi", resulting in a rapid urbanization and influx of population from rural areas to the city. The population of HCMC has doubled during the past 20 years from 2.5 million in 1975 to 5.0 million in 1996. According to the adjustment city development Master Plan prepared in 1998, its population in 2020 is projected to be approximately 10 million due to a continuous high population growth rate. The existing urbanized area (about 140 km^2), so called inner city area is therefore estimated to expand to about 430 km^2.

Infrastructure services of HCMC were considered to be fairly good within the country. Due to the current remarkable economic development and population increase of the city, the urbanized area was rapidly expanded without development of sufficient infrastructure, especially urban drainage and sewerage system. HCMC is prone to flooding due to its geographic feature with low ground elevation and high precipitation. The original urban drainage and sewerage system which was planned as the combined system had been constructed by French government in 1870s, and improved by the Government of United States from 1950s to 1975. However, the facilities had been designed for a population of 1.5 million. These facilities are mostly worn-out. Therefore, during the monsoon season, floods have been occurred several times in various parts of the city. In addition, domestic and industrial wastewater is directly discharged to water bodies, such as rivers, drainage canals and ponds due to the absence of any sewage treatment plant. Furthermore, illegally dumped domestic solid waste to the water bodies, unsatisfactory dredging of the drainage canals, and insufficient maintenance works for these canals aggravate remarkably the water pollution and bad odor. This deteriorated water quality condition much affects the people's sanitary environment. Considering the continuous rapid urbanization of the city, the water environment will be getting worse, if any countermeasures for environmental improvement are not implemented.

World Bank, Asian Developmental Bank and other donor countries are currently planning or implementing individual projects to improve the water environment of HCMC, but no comprehensive and systematic master plan (M/P) has been formulated.

To cope with the above situation, the Government of the Socialist Republic of Viet Nam (hereinafter referred to as "GOV") requested technical assistance for formulating the master plan and feasibility study on urban drainage and sewerage system in HCMC to the Government of Japan (hereinafter referred to as "GOJ").

In response to the request of GOV, GOJ decided to conduct the Study on Urban Drainage and Sewerage System for Ho Chi Minh City in the Socialist Republic of Vietnam (hereinafter referred to as " the Study") in accordance with the relevant laws and regulations in force in Japan.

The Japan International Cooperation Agency (hereinafter referred to as "JICA"), the official agency responsible for the implementation of technical cooperation programs of GOJ, has conducted the Study in close cooperation with the authorities concerned of GOV.

The People's Committee of Ho Chi Minh City (hereinafter referred to as "PCHCMC") has established Project Management Unit (hereinafter referred to as "PMU"), which acts as the technical and implementing counterpart and also as a coordinating body in relation with other relevant organizations for the smooth implementation of the Study.

In January 1998, JICA dispatched the Preparatory Study Team headed by Mr. Kenji Tomizawa to Viet Nam for the preliminary survey as well as discussions on the scope of work of the Study. The scope of work was agreed upon between the GOV and JICA on 19 January 1998.

1.2 Objective of the Study

The objectives of the study are:

(1) to formulate a Master Plan (M/P) targeting the year 2020 for urban drainage and sewerage system improvement in HCMC, and to identify the priority project(s),
(2) to conduct a Feasibility Study (F/S) on the priority project(s) identified in M/P, and
(3) to carry out technology transfer for the counterpart personnel of GOV in the course of the Study.

1.3 Study Area

The study area covers approximately 650 km^2 including the existing urbanized area of about 140 km^2 encompassing inner city area and the surrounding area of about 510 km^2, which is projected as an urbanized area in the year 2020. The study area is shown in Fig. 1.1.

1.4 Organization of the Study

JICA has entrusted the study to Pacific Consultants International, and the Study Team (hereinafter referred to as "Team"). The Team is composed of fifteen (15) experts listed, together with their designation, in Table 1.1. The member list of the Advisory Committee , organized by JICA to ensure the successful implementation and completion of the study, Member list of the Advisory Committee is given in Table 1.2.

The PCHCMC, the counterpart agency of the Study, established the Project Management Unit (hereinafter referred to as "PMU") which shall act as the technical and implementing counterpart for the Team. Steering Committee was organized by PCHCMC to coordinate with other

ministries and authorities concerned as well as to avoid duplication of any works. Members of Steering Committee and PMU are listed in Table 1.3 and 1.4 respectively.

1.5 Composition of Report

The report consists of five (5) volumes, Volume I: Executive Summary, Volume II: Main Report, Volume III: Supporting Report, Volume IV: Drawings and Volume V: Data Book.

TABLE 1.1 MEMBER LIST OF STUDY TEAM

No.	Name	Designation
1	Mr. Yanai Ryuji	: Team Leader
2	Mr. Tokumasu Toshiaki	: Deputy Team Leader/Urban Drainage Plan
3	Mr. Kondo Masami	: Deputy Team Leader/Sewerage Plan
4	Mr. Hassan M.M. Sabir	: Hydrology and Hydraulics
5	Mr. Katsuki Takaaki	: Facility Design (Urban Drainage)
6	Mr. Izawa Tetsuo	: Facility Design (Sewerage)
7	Dr. Sanjyai Arora	: Aquatic Environment
8	Dr. Nakazawa Nahoko	: Social Impact Analysis
9	Mr. Omura Takeshi	: Urban Plan and Land Use Plan
10	Mr. Ikeda Masayuki	: Topographic Survey
11	Mr. Kikuta Hiroshi	: Soil and Geology/Construction Plan/Cost Estimate
12	Mr. Ishimaru Toshikazu	: Operation and Maintenance (M/P Stage)
13	Mr. Abe Bogo	: Operation and Maintenance (F/S Stage)
14	Mr. Minakami Hiromasa	: Institution and Legal Aspect
15	Mr. Ishizuka Yoshiaki	: Economic and Financial Analysis
16	Mr. Niels Erik Jorgensen	: Advisor of Simulation Model, MOUSE (M/P Stage)
17	Mr. Alejandro E Lasarte	: Advisor of Simulation Model, MOUSE (F/S Stage)
18	Ms. Otsuka Atsuko	: Coordinator

TABLE 1.2 MEMBER LIST OF ADVISORY COMMITTEE

No.	Name	Designation
1	Mr. Tomizawa Kenji	: Chairman
2	Mr. Kato Kimimasa	: Member
3	Mr. Saito Katsuyoshi	: Member, JICA Coordinator: July 1998 - April 1999
4	Mr. Kuroki Taketo	: Member, JICA Coordinator: May 1999 - Present

TABLE 1.3 MEMBER LIST OF STEERING COMMITTEE (PSC)

No.	Name		Designation
1	Mr. Vu Hung Viet	:	Chairman, PSC and Vice Chairman, PCHCM
2	Mr. An Dzung	:	Vice Chairman, PSC and Vice Chief Architect & Director of Urban Planning Institute
3	Dr. Nguyen Ngoc Sinh	:	Member, PSC and Director of Environmental Department under Ministry of Science, Technology and Environment
4	Mr. Pham Van Nhiep	:	Member, PSC and Expert of Planning and Architecture Management Department
5	Mr. To Van Tuong	:	Member, PSC and Director of Sub-institute for Water Resources Planning
6	Mr. Tran Dung	:	Member, PSC and Expert of Infrastructure Department under Ministry of Planning and Investment
7	Dr. Nguyen Thien Nhan	:	Member, PSC and Director of Service of Science, Technology and Environment
8	Mr. Nguyen Khac Ngan	:	Member, PSC and Director of Agricultural and Rural Development Service
9	Ms. Phan Xuan Hoa	:	Member, PSC and Deputy Director of Planning and Investment Service
10	Mr. Tran Minh Dung	:	Member, PSC and Deputy Director of Service of Transportation and Public Works
11	Mr. Tran Chi Dung	:	Member, PSC and Deputy Director of Urban Planning Institute
12	Mr. Bui Van Thung	:	Member, PSC and Deputy Director of Financial Service
13	Ms. Nguyen Thi My Hanh	:	Member, PSC and Director of Investment Department
14	Mr. Pham Duc Hiep	:	Member, PSC and Director of Project Management Unit (PMU) : 15 Jul. 1998 - 9 Sep. 1998
15	Mr. Do Viet Dzung	:	Member, PSC and Director of Project Management Unit (PMU) : 4 Nov. 1998 - Present
16	Ms. Huynh Thu Ha	:	Member, PSC and Office Executive of PCHCM

TABLE 1.4 MEMBER LIST OF PROJECT MANAGEMENT UNIT (PMU)

No.	Name	Designation
1	Mr. Pham Duc Hiep	: Director of PMU: 15 Jul. 1998 - 9 Sep.1998
2	Mr. Do Viet Dzung	: Director of PMU: 4 Nov. 1998 - Present
3	Mr. Nguyen Tien Thanh	: Deputy Director of PMU
4	Ms. Duong Ngoc Hong	: Expert
5	Mr. Chau Minh Nhan	: Expert
6	Mr. Pham Van Phuoc	: Expert
7	Mr. Nguyen Nguyen Van Toan	: Expert
8	Mrs. Vo Thi Ngoc Hue	: Expert
9	Mrs. Truong Thi Kim Khanh	: Expert
10	Mrs. Nguyen Thu Phuong	: Expert and Interpreter
11	Mrs. Tran Pham Thi Phuong Thao	: Chief Accountant of PMU
12 - 16	Other five (5) members	

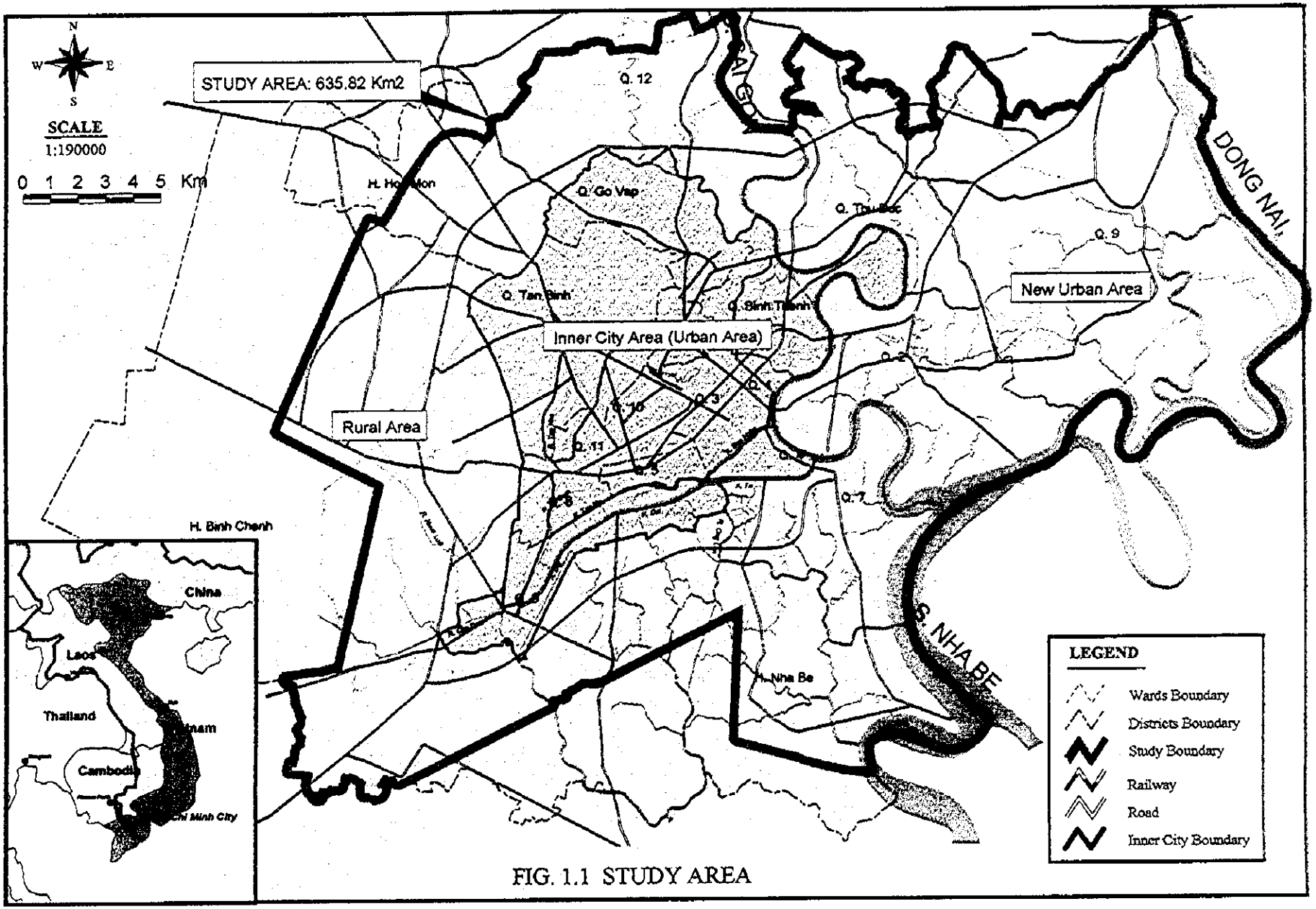

FIG. 1.1 STUDY AREA

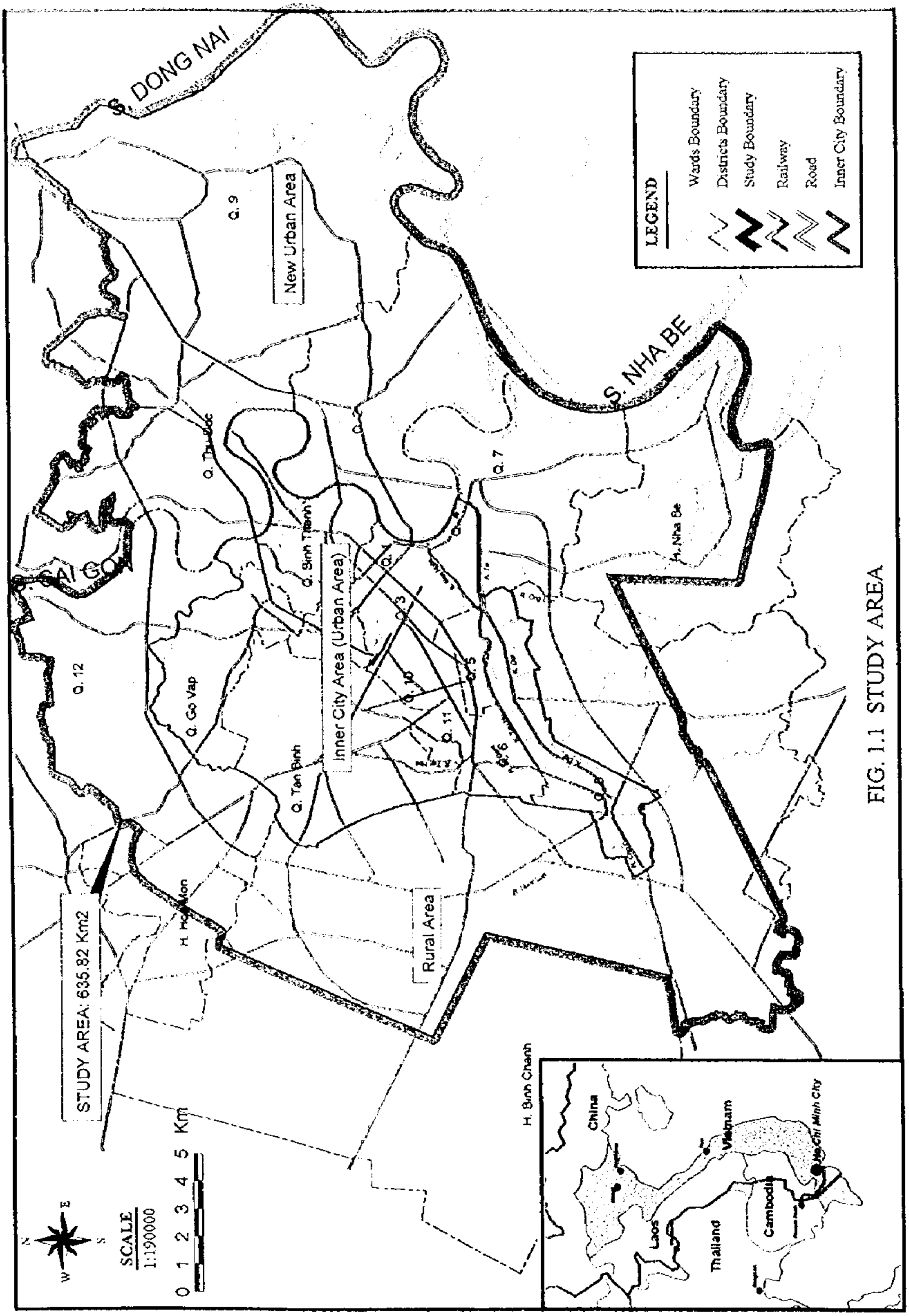

FIG. 1.1 STUDY AREA

CHAPTER 2

STUDY AREA

CHAPTER 2 STUDY AREA

2.1 Physical Condition

2.1.1 Topography

The Study Area with an area of about 650 km^2 is located from 10°40′ to 10°55′ of north latitude and from 106°35′ to 106°55′ of east longitude in the northeastern part of the Mekong Delta. The ground elevation ranges from about +0.5 to +30 m above MSL. The general ground slope of the area is from the north-northeast to the west-southwest. The regional topographic conditions are shown in Fig. 2.1 and summarized as follows:

(a) West Bank of the Saigon and Nha Be rivers

The west bank of Saigon and Nha Be rivers is classified into four (4) regions having different topographic characteristics. The western region is mostly low-lying area with its ground elevation varying from EL +0.7 to +1.0 m in Binh Chanh District. This region is mainly used as a paddy field. The central region is high land area including a hilly area of Hoc Mon (EL +8.0 to +10 m), Go Vap (EL +10 m) and the existing urban area (EL +2.0 to +8.0 m). This region including central parts of the city is mostly urbanized. The northern region along Saigon River is low land area with an elevation of EL +0.6 to +0.8 m, where paddy field is the predominant land use pattern. The southern region along the Nha Be River is mainly low-lying paddy field with an elevation of EL +0.6 to +1.2 m.

(b) East Bank of the Saigon River

This area consists of two regions, the north and south. The northern region is the high hilly land belonging to Thu Duc District with its ground elevation varying from EL +2.0 to +30.0 m. Recently, this region has being rapidly urbanized, due to the convenience of transport and the geographical advantage. The southern region is mostly low-lying area in District 2 and 9. The ground elevation of the area ranges from EL +0.6 to +1.5 m above MSL. This region has been developed mostly as a paddy field area protected by the dike from the flood of Saigon and Dong Nai rivers.

2.1.2 Geology

Ho Chi Minh City is located in the transitional part from the Northeastern Hills to the Mekong Delta. The geology in HCMC is composed of soils and rocks in Paleozoic and Cenozoic era. The Paleozoic rocks distribute at the northeastern hilly lands of HCMC. They are andesite, andesite tuff of Long Binh formation. The Cenozoic is composed of

Holocene, Pleistocene and Tertiary deposits. The Pleistocene deposits include Thu Duc and Cu Chi formation. Thu Duc formation is distributed along the hilly land with its ground elevation varying from EL +5 to +30 m in Thu Duc and District 9 at the northeastern area of HCMC. Cu Chi formation distributes on the continuous plain relief with its ground elevation from EL +2 to 10 m in Hoc Mon District at the north of HCMC and most of existing urbanized area. The Holocene deposits are distributed on the continuous plain relief with its ground elevation vary from EL +0.6 to +1.0 m in suburban low-lying area. Fig. 2.2 shows the geology of the study area.

According to the soil survey conducted through the Study, soil of the study area is consists of Holocene deposits, of which thickness varies from 2.5 to 35 m, covering Pleistocene deposit, of which thickness could not be confirmed because of the maximum boring depth of 50m. The thickness of Holocene deposits along the proposed intereceptor sewer is within 10 m in District 1, 4, and 5, however, it is more than 20 m in District 8. The Holocene deposits are composed of very soft, low or high plasticity organic clay, sandy clay (cohesive fine-grained soil) and very loose, loose clayey sand or silty clay. They have low bearing capacity in N-value varies from 0 to 2

The Pleistocene deposits are medium dense silty sand, sand or clayey sand (cohesiveness coarse-grained soil) and sometimes they are stiff sandy clay or clay.

2.1.3 Meteorology

HCM City is located in the tropical monsoon zone and its climatic characteristics are almost uniform temperature, high humidity, and heavy precipitation. Meteorological observation has been carried out at Tan Son Nhat station since 1915.

Heteorological characteristics of the study area as represented by Tan Son Nhat from 1976 to 1977 at station are shown in Fig. 2.3. The annual average temperature and relative humidity are 27.4 °C and 77.2 % respectively; Annual sunshine hour is 2,508 hours, which represents about 29 % time of a year. Annual average rainfall is 1,929 mm, of which about 93 % (1,788 mm) occurs during the rainy season starting from May to November with maximum monthly rainfall of 308 mm occurring in the month of August. Only about 7 % (141 mm) of annual rainfall occurs during the dry season from December to April.

2.2 Socio-economic Condition

2.2.1 Regional Economy

Vietnam uses a fiscal year system as same as the calendar year starting on 1st of January of a year and ending on 31st of December of the same year. Therefore, annual statistical data excerpted in this report are for one year from January to December in the same year.

Vietnamese domestic currency is "Dong" (hereinafter expressed as VND = Vietnamese Dong). In this report, the exchange rate of VND 13,956 per US$ and Japanese Yen 113.39 against US$ 1.00 are applied for project evaluation as a mid-rate as of the end of July 1999 unless otherwise cited.

In 1998, Gross Regional Domestic Product (GRDP or GDP) of HCMC grew to VND 62,623 billion at current market price at an average annual growth rate of 22.48 % since 1994, while the real annual growth rate was 12.80 % in average during the same period.

A difference between the 2 average annual growth rates at current market price and at 1994 constant price as mentioned above seems to be caused by rather high inflation rate of goods and services.

Per capita GDP at current market price amounted to VND 12,498,000 (equivalent to US$ 929.01) in 1998 at the average annual growth rate of 19.74 % since 1994, and the real growth rate was 10.27 % for the same period.

2.2.2 Financial Situation of Ho Chi Minh City

In Vietnam, even big cities such as Ha Noi or Ho Chi Minh and other provinces, don't have their own budget except for some little items. Sources of the Government revenue consist of the central Government owned companies, the Communist Party owned companies and institution of national defense, local administrative unit (as HCMC) owned companies, foreign investment sector companies, private sector companies and others.

Items of revenue consist of revenues on capital utilization, taxes on license, taxes on special sales, taxes on ordinary sales, taxes on profit, taxes on income (including personal income taxes), taxes on agriculture, taxes on housing and land use, fees on transportation, lottery, revenue on land use and rental, revenue on house sales, fees on registry, and others.

These are the central Governmental taxes, fees and revenues even though those companies and/or traders located in HCMC. HCMC gets a distributed amount of budget consisting of ordinary budget and some subsidies if necessary from the Government of Vietnam and these are the main sources of revenue for HCMC.

Revenue of HCMC consists of the ordinary budget from the central Government as mentioned above, revenue from individual traders and collectives, foreign investment sector companies, balance from the previous term, subsidies from the central Government, and others.

Therefore, almost all of these companies and/or traders should pay their taxes and fees and revenue in case of state owned companies additionally to HCMC. For example, the

Water Supply Company (WSC) of HCMC set a tariff for its water sales consisting of ordinary fee for the central Government and additional levy for HCMC.

In 1998, the scale of finances of HCMC amounted to VND 4,364 billion (equivalent to US$ 324 million) in revenue and VND 3,364 billion (US$ 250 million) in expenditure with their rise rates of 17 % and 24 % per annum since 1994 as summarized below:

Financial Statement of Ho Chi Minh City

(VND billion)

Revenue and Expenditure	1994	1995	1996	1997	1998	Average annual growth rate (%)
Revenue	2,319	2,625	2,959	3,849	4,364	17.13
Expenditure	1,421	1,633	1,803	3,021	3,364	24.03
Surplus/deficit	898	992	1,156	828	1,000	-

Source : Statistical Yearbook 1997/1998, Ho Chi Minh City Service of Culture and Information, January 1998/1999.

Among the revenue, sources, the category of "others" contributed quite high rate to the total revenue as 25 % in 1994 and 72 % in 1998 with increasing ratio of around 30 % per annum, but the statistical data issued by HCMC do not make it clear in detail. Expenditure of HCMC consists of 3 categories as (1) construction expenditure (capital expenditure for developing infrastructure and repairing), (2) ordinary expenditure (they call it as "frequent expenditure") and (3) others.

The construction expenditure has grown with a rate of around 54 % per annum since 1994 and it shares at 21 % and 50 % of the total amount of expenditure in 1994 and 1998 respectively.

There are several branch offices of the central Government located in HCMC, and they also have own construction budget for developing and repairing the infrastructure facilities in HCMC managed by the central Government like national road.

Therefore, whole amount of these 2 kinds of construction budget is for the total development and repairing the infrastructure facilities located in HCMC.

HCMC may have a lot of large scale projects. But it seems that those projects are financed by the above mentioned two categories of budgets as (1) subsidies to the City for construction expenditure from the central Government, and (2) direct budget of the central Government for construction expenditure for the City's development.

The ordinary expenditure consists of education expenditure, health expenditure, administration expenditure and subsidies to wards and communes and it shares at 65 % in 1994, 55 % in 1995, 54 % in 1996, 35 % in 1997 and 32 % in 1998 of the total expenditure.

2.2.3 Population

(1) Existing Population

The population of HCMC in the year 1997 was about 5 million as shown in

Table 2.1 The population is showing increasing trend. Inner city has about 3.5 million people, which accounts for about 70 % of the population of HCMC. New urban district has a population of about 0.6 million. The study area has additionall 0.26 million people from the communes of rural districts included in the study area. Hence total population of the study area is about 4.4 million, which is 88 % of the total population of HCMC.

Gross population density of each district in the inner city is shown in Table 2.1 and Fig. 2.4. Several wards in district 10 and 4 have population density higher than 1000 person per ha. In general, population density of the wards along the main canals Tau Hu - Ben Nghe, Doi - Te, Tan Hoa - Ong Buong - Lo Gom and Nhieu Loc - Thi Nghe is relatively higher than the other wards. The population density of outer city is still low mainly due to large area occupied by each ward and commune. Some wards/communes in the outer city have comparatively higher population density of the order of 100 person/ha. Linh Tay and Linh Dong wards in Thu Duc district, Phuoc Binh ward in district 9, An Khanh ward in district 2 and Tan Kieng, Tan Thuan Tay and Tan Qui wards in district 7 have population density varying from 100 - 160 person/ha.

(2) Future Population of HCMC

According to the Master Plan 2020 of HCMC prepared by UPI, the population is expected to be about 10 million in the year 2020. The main policy of Master Plan is to distribute population between inner city and outer city more evenly. Government plan to settle the new residents as well as resettle people from the inner city to the suburban residential areas by providing employment opportunities. Regarding resettling residents from inner city to outer city, first target is the residents living along the canals particularly four main canals. In the year 2020, population in the inner city will decrease and population in outer city will increase considerably. The population projected in each district in the year 2020 is shown in Table 2.2 and distribution of population density is shown in Fig. 2.5. The population of each ward and commune is calculated following the trend of population increase rate and taking into account of future land use plan. For detailed explanation refer to Appendix B in Supporting Report.

2.2.4 Land Use

(1) Present Land Use

In the inner city, almost all the areas have already been built up as residential areas except some fringes in Go Vap, Binh Thanh, Tan Binh, District 6 and 8. Some agricultural areas can still be found on the border of the inner city and the outer city. These agricultural lands may also be developed in the near future. There are two major commercial and service areas; District 1 and between District 5 and 6. Ben Nghe ward facing the Saigon River in district 1 is the largest commercial and also tourist attraction of HCMC. Binh Tay market in China Town is the other commercial area.

Another tendency is to locate the industries along the canal. The main reason is that shipping is the main mode of transporting goods. Along Tau Hu - Ben Nghe canal in district 8, 5, 4 and 1 there exists major industrial zone. Another major industrial zone is along Tan Hoa - Lo Gom Canal in district 6 and Tan Binh. The other major industrial areas are located on the canals in Binh Thanh and the area along the Cach Mang Thang Tam street to Au Co street through the north and south in Tan Binh. Open spaces are not adequate for resident as the inner city has very few parks and green areas. Existing land use pattern of the inner city is shown in Fig. 2.6.

In Outer City, majority of land is being used for agricultural purpose. Residential areas in outer city in comparison to inner city are more scattered except around the district centers. There are three major industrial areas. One is on provincial road No. 15 connecting to the southern area through district 7 and Nha Be. This is known as Tan Thuan Export Processing zone located on the peninsula of Tan Thuan ward in district 7. The second is along Ha Noi Highway through district 2, 9 and Thu Duc. The third is along the National Road No.1 from Binh Chanh to district 12 and Thu Duc. Present Land use pattern of the outer city is shown in Fig. 2.7.

(2) Future Land Use

Some agricultural lands found at present in the fringes of inner city will also be built up in future. The old residential quarters would be redeveloped particularly in the district's center to improve living environment and enhance tourism. The existing major commercial/service areas in Ben Nghe and around Ben Thanh market will be improved and intensified as a city center. Green belts or parks are planned on the Saigon river side and along some canals. However it will require relocation program for the residents living along the canals.

In An Khanh, Thu Thiem and An Loi Dong wards of district 2 located on the farther shore of Saigon River from Ben Nghe ward, the new business center is planned to be developed. If the bridges are constructed over the Saigon River, the development potentials of this area will be much higher. The other district centers and commercial/service areas are planned especially on adjoining areas of the inner city. In particular Thu Duc is planned to develop over almost the whole area. Future land use pattern of the outer city is shown in Fig. 2.8.

2.3 Hydrology

2.3.1 River and Canal Network

In and around the study area, there are three big rivers, Saigon, Dong Nai and Nha Be rivers. The catchment area, length and existing discharge capacity of these rivers are summarized in the table below:

Name of River	Length (m)	Catchment Area (km^2)	Existing Discharge Capacity (m^3/s)
Saigon	200	5,400	2,200 at Thu Duc Mot
Dong Nai	270	23,000	6,200 at confluence with Saigon River
Nha Be	40	40,700	-

These rivers are always affected by the tidal influence of South China Sea. The difference between HWL and LWL near HCMC varies from 2.7 to 3.3 m. Recently, three reservoirs of Dau Tieng, Tri An and Thac Mo reservoirs have been constructed at the upstream basin of Saigon and Dong Nai rivers. Since these reservoirs have increased reliably safety of the lower reaches of both rivers up to almost 20-year frequency discharge, the study area has little possibility to have a big flood from both rivers. Therefore, a continuous dike system along the rivers as a flood control facility for these rivers will not be considered in this study except a polder dike system, which likely protects the limited urbanized area from flood of these surrounding rivers.

The Study area consisting of 6 drainage zones is composed of 27 main canal networks with total length of more than 310 km as shown in Fig. 2.9. Major canal systems are summarized below:

No.	Name of Canal Network	Zone	Length (km)	Catchment Area (km^2)	Name of Districts covered
1	Tan Hoa - Lo Gom	C	7.7	20.22	6, 8, 11, and Tan Binh
2	Tau Hu - Ben Nghe -	C	12.2	61.73	4, 5, 6, 7, 8, 11, and Bin Chang
	Doi - Te		13.6		
3	Nhieu Loc - Thi Nghe	C	31.7	9.40	1, 3, 10, Phu Nhuan, Tan Binh, Binh Thanh, Go Vap
4	Tham Luong - Ben Cat	N	107.6	14.98	Hoc Mon, Go Vap, 12, Tan Binh, Binh Chang
5	R. Chua - R. Nhoc Len	W	40.1	13.54	8, Binh Chang
6	R. Tan - R. Ca Cam - R. Roi - R. Tom - Muong Chuoi	S	34.5	11.92	7 and Nha Be
7	R. Cau - R. Go Cong	NE	34.4	12.58	9 and Thu Duc
8	R. Tan - R. Ong Nhieu	SE	21.1	6.95	9

According to the field investigation, most of the canals in the inner city area have been narrowed due to the encroachment by illegal houses and buildings. These canals include Nhieu Loc - Thi Nghe, Tan Hoa - Lo Gom, Tau Hu - Ben Nghe - Doi - Te and Tham Luong - Ben Cat canals, of which beds have been shallowed by much garbage, waste disposal, debris and organic materials dumped from houses and buildings along the canal. On the other hand, the present conditions of the canals in surrounding areas such as a natural canal or manmade irrigation canal, particularly in the agricultural land, are relatively good.

2.3.2 Rainfall

Rainfall data has been collected from 7 stations located in and around the Study area. They are at: Tan Son Nhat, Hoc Mon, Le Minh Xuan, Binh Chanh, Nha Be, Ha Tien and Long Son. Among them, Tan Son Nhat is the only automatic rain gauging station where short duration rainfall data is available. Annual total rainfall at Tan Son Nhat station is 1,929 mm. Seasonal rainfall amounts to 1,788 and 18 mm during the wet (May - November) and dry (January - March) seasons respectively. Maximum and minimum rainfalls occur in August (308 mm) and February (2 mm) respectively.

(1) Intensity-Duration-Frequency (IDF) Curves

Existing IDF curves prepared by Hydrological Sub-Institute, HCMC (KTTV, using 1933 - 1989 data) and Ministry of Construction, Hanoi (MOC, using 1953 - 1983 data) have been updated using the data collected from 1952 - 1997. Probability analysis on annual maximum rainfalls ranging from 15 minutes up to 24 hours has been carried out using Gumbel's distribution method and is presented in Table 2.3. Probable rainfall intensities for 5 and 10 year return

periods are estimated to be 80 and 91 mm/hr respectively, which are almost same values as that of other East Asian countries. Probable daily rainfall depths for 5 and 10 year return periods are estimated to be 114 and 128 mm respectively.

To facilitate runoff analysis, the best fit IDF curves with Kimijima or Wenzel type equations have been proposed and is presented in Fig. 2.10. Two sets of equations have been proposed: one set for rainfall within 3 hours and another set for rainfall from more than 3 to 24 hours.

(2) Design Rainfall Hyetographs

From mass curve analysis on 10 recent high daily rainfall events, frontal type rainfall pattern with 6 hour duration has been proposed as design rainfall hyetographs for pump drainage plan. To be on conservative side, total amount of rainfall in 6 hours has been taken to be equal to daily rainfall. Proposed design rainfall hyetograph for 5 year return period is shown in Fig. 2.11.

(3) Areal Reduction Factor

The existing areal reduction factor values specified by MOC has been updated based on analysis of point rainfall. To facilitate runoff analysis, the best fitted areal reduction factor curve with polynomial type equation has been proposed and is shown in Fig. 2.12.

2.3.3 Water Level Analysis

Water level data has been collected from 5 stations located on rivers flowing through and around the study area. They are at: Phu An, Nha Be, Thu Dau Mot, Bien Hoa and Ben Luc. High and low water levels are observed during October-January and February-August respectively. Highest and lowest water levels are observed in October and June-July respectively.

(1) Longitudinal Water Level Profiles

Longitudinal water level profiles along the rivers have been investigated. To facilitate application of water level for design purpose, 4 reaches along with southern boundaries have been identified which are:

- Reach 1 : Mouth of Ba Hong canal to mouth of Doi-Te canal.
- Reach 2 : Mouth of Doi-Te canal to mouth of Muong Chuoi river.
- Reach 3 : Saigon-Nha Be rivers confluence to Tac-Dong Nai rivers confluence.
- Reach 4 : Mouth of Doi-Te canal to mouth of Ba Goc canal.
- Southern Boundaries : Southern boundaries of Ba Goc and Ba Lao canals.

(2) Design Water Levels

Considering coincidence of high rainfall event with high water level, design flood level (DFL) is defined as average of monthly maximum water level during August-November. Proposed design flood levels for different reaches along with other reference water levels are presented in Table 2.4. Design flood levels for Reach 1, 2, 3, 4 and southern boundaries are proposed to be EL. +1.32, +1.39, +1.47, +1.32 and +1.39 m respectively.

(3) Dynamic Water Levels

For applying in hydrodynamic simulation, design 24 hour dynamic water level variation has been proposed for different reaches. Fig. 2.13 shows the proposed dynamic water level variation corresponding to design flood levels for different reaches.

2.3.4 Flood Run-off Analysis

Flood runoff analysis using Rational method has been carried out to calculate design discharges of the canal improvement. Existing flow capacities of the canals have been initially evaluated using Manning's steady flow formula. Then, based on the design discharges and water levels, canal improvement plan has been proposed. The proposed canal improvement plan has been finally evaluated by hydrodynamic simulation of the inter-connected canal network applying unsteady river flow modeling software called "MIKE 11" in order to justify the initial canal improvement plan. Design discharges of the canals are presented in Table 2.5. Runoff calculation points along the canals is shown in Fig. 2.14.

2.4 Flood and Flood Damages

2.4.1 Flood Condition

(1) Current Floods

HCMC has been affected by serious floods several times during the rainy season from June to November and the high tide season from September to January in every year. Recently, two typical floods have attacked the city.

First is 1994 flood, occurred on 28 July 1994. The daily rainfall recorded on that day is 162.2 mm, corresponding to almost 5 year return period. According to the flood survey results conducted in an ADB project, the inundation area was estimated at 128.7 ha occupying 0.9 % of the inner city area of 140 km^2 and 1.75 % of urban area in 1994. Inundation depth was 25 cm in average and 37 cm in maximum for a rainfall duration of 5 to 8 hours. Affected population was

counted at almost 45,000 equivalent to 6,430 households.

Second is 1996 flood. It lasted for one month starting from mid October to mid. November 1996. The main reason of the flood was combination of the highest water levels of Vam Co, Saigon and Dong Nai rivers within current 40 years (+1.50 m above MSL) and relatively heavy rainfall in central and surrounding areas. Flood waters from Van Co and Nha Be rivers overflowed into HCMC have caused a large inundated area of more than 15,000 ha with a depth of 0.3 - 1.0 m in Cu Chi, Hoc Mon, Binh Chang and Nha Be districts. Many areas in the inner city have also seriously flooded, of which inundation depth has been recorded from 0.3 m to 0.5 m.

(2) Causes of Flood

HCMC has suffered serious floods several times during not only the rainy season (June and November) but also high tide season (September to January) in every year. Floods resulting from various complex causes are classified roughly into three (3) types. First is the external flood type due to the high water levels of surrounding rivers/canals affected by tidal influence. During the high tide season, this type flood has habitually occurred in low-lying areas including the expected future development areas. Second is the internal flood type occurring in relatively high land area resulting from the heavy rainstorm and insufficient drainage network system. Typical flood of this type occurred on 28 July 1994 flood (5 year frequency flood, daily rainfall: 162.2 mm), which has affected the central parts of HCMC. Third is mixed type flood occurred in the intermediate land in combination with the above two (2) reasons. This type flood has typically occurred in the western and southern parts of HCMC for one month from mid. October to mid. November 1996.

(3) Flood Condition

Flood condition of the study area has been investigated based on the current flood data and information from the agencies and districts concerned and supplemental flood survey conducted by the Team.

Flood area is estimate at 34.61 km^2 in built-up area (20 % of the area) and 230.3 km^2 in agricultural land (56 % of the area) as shown in Fig. 2.15. Flood depth of frequent and the biggest flood corresponding to 10 year flood range from 20 to 60 cm (35 cm in average) and 20 to 100 cm (40 cm in average) respectively. Duration of both floods range from 1.0 to 24 hours, however average duration is estimated at 6.5 hours for frequent flood and 7.7 hours for the biggest flood. The flood condition by drainage zone is shown in Table 2.6.

(4) Flood Vulnerable Population

At present, total 1.18 million people, 27.7 % of existing population of the study area is affected from the flood, of which 856 thousand peoples are in the built-up areas. It is anticipated that these vulnerable population will be increased to about 2.5 million peoples (35.2 % of future population) in total, of which 1,100 thousand peoples are projected population for future urbanized areas located in low-lying area. Present and future vulnerable population by drainage zone is shown in Table 2.7.

2.4.2 Flood Damages

Flood damages are classified into the following two (2) categories consisting of several kinds of losses:

(a) Direct damages

- Building loss: residential, commercial, industrial and institutional buildings
- Indoor movable loss: furniture, stored good and materials in the above buildings
- Public facilities loss: infrastructures
- Agriculture production loss

(b) Indirect damages

- Business suspension loss for commercial activity
- Income loss of workers due to inundation
- Medical cost to be burned by people living in the project area with bad environmental condition in case of without the project

(1) Direct Damage

(a) Damages to Buildings and Their Indoor Movables

Land use in the inundated area is classified by four types as (1) commercial area, (2) residential area, (3) industrial and/or institutional area, and (4) green area in the Flood Damage Survey with respective inundated duration and inundated depth in district basis.

The inundated duration and inundated depths are both consisting of minimum and maximum ones. Here, it is assumed that the minimum ones are for annual flood (1 year flood) and the maximum ones for 10 year flood

in flood scale for making clear return periods of the flood.

For estimation of damages, damageable value (= value of assets to be damaged) by each land use classification is firstly estimated dividing it between buildings and indoor movables by the inundated area on district basis.

Then, damages are estimated by the inundated area in each District using the damage rates corresponding to the inundated depth of buildings and indoor movables. Accordingly, the resulted damages are to be on district basis. In this case, relationships between damage rates and inundation depths are based on a method usually applied for the similar projects.

Inundated areas of districts belonging to each zone are already clear. Using these data on inundated areas of districts belonging to each zone, the above said district based damages are converted into zone based damages.

Target year of the Project is set as the year 2020, so damages in 2020 are estimated based on extrapolation using the population projection.

(b) Agricultural Damages

Damages to agricultural crops represented by paddy are estimated based on unit yield and unit farm gate price of paddy according to statistical data multiplying the damage rates by flooding condition in inundation duration (days) and inundated depths, and by its growing stage.

In this case, relationships among damage rates, inundated duration, inundated depths and growing stage of paddy are based on a method used in the similar projects developed in Japan.

It is assumed that the agricultural area will be decreased in the future because of urbanization. Therefore, damages to agricultural crops will also be come smaller than present ones.

(c) Damages to Public Facilities

Damages to public facilities represented by roads are estimated based on the information on annual expenditure of Ho Chi Minh City of rehabilitation for roads destroyed due to inundation, gotten from an authorities concerned.

Following table shows a summary of the annual average direct damages:

Direct Damages for the Whole Project Area

(million VND)

Kind of Damages	Damages by urbanized situation	
	At present	In 2020
Buildings and Indoor Movables	672,995	1,112,933
Public Facilities	6,730	13,632
Agricultural Crops	27,998	14,339

The annual average direct flood damages are shown in Table 2.8.

(2) Indirect Damages

(a) Business Suspension Losses

If an inundation is occurred, small scale retailers located in the inundated area should be suspended their businesses. Damages consist of direct damages to their stored goods and losses of expected profits due to suspension of their business. These kinds of damages and/or losses are classified as an indirect damage caused by inundation usually called as "business suspension losses".

The business suspension losses are estimated based on average daily sales amount per shop multiplying the number of shops in inundated area and suspended days. The average daily sales amount is estimated by the statistical data. Number of shops consisting of households engaged in private trading and services is estimated based on the result of the Flood Damage Survey by District, and suspended days are estimated based on the inundation duration.

For estimation of suspended days, it is assumed that the business suspension days are 1 day and 1.5 days in case of average flood duration of less than 8 hours, and more than 8 hours respectively.

(b) Income Losses of Workers Due to Inundation

Personal income losses should also be counted as a loss due to inundation. If a flooding is occurred, and this flooding is bigger than some specified scale, some workers or labors can not come to their working places, so that their income will be decreased. Even their salaries or wages are not deducted from their fixed amount of salaries or wages, owners of shops, offices or such working places should pay the salaries or wages to their employees without any productive activities made by their employees. These are also

the other kind of business suspension losses named as "Income Losses of Workers".

For estimation of these income losses of workers, population in the inundated area, number of workers or labors in these areas and their income level per day should be cleared first. Among them, population in the inundated areas is already compiled by District. And, average number of working persons per HH has been cleared from the Social Survey. An average income per labor in urban area and agricultural area are estimated based on the statistical data.

(c) Medical Cost to be Saved

The Project is a combined project of improvement of urban drainage systems and improvement of sewerage systems in Ho Chi Minh City, so that it may contribute to improve the people's living environment.

If living environment will be improved by these kind of projects, some of water borne diseases may be decreased and, people's burden for medical cost or fees, or some amount of budget to use for hospitals may be decreased too. In other words, in case of without the Project, some medical costs are burdens to people living in the Project area and the Ho Chi Minh City. These costs are also classified also as the indirect damages called as "Medical Cost to be Saved".

The medical cost to be saved consists of such two kinds as (i) income losses of patient and (ii) other medical costs.

i) Income Losses of Patients

Number of patients, effect rate (%) of the Project to improve the living environment, average daily income per patient, and days to visit hospitals or days to stay at hospitals are the factors for estimation of income losses of patients. Average number of patients per year are estimated based on the information from the Health Department of Ho Chi Minh City, multiplying effect rate of the Project which is usually used for similar projects.

Days to visit to or to stay at hospitals are estimated based on the information from the Health Department, and the same amount of average daily income in case of estimation for "Income Losses of Workers" is applied for estimation of income losses of patients.

ii) Other Medical Cost to be Saved

Annual average subsidy, annual average amount to be paid from the medical insurance, and annual average medical cost collected from patients are estimated based on the information from the Health Department. The medical cost to be saved can be estimated based on the said total cost multiplying the suffering rate of water borne disease and effect rate of the Project mentioned above. In this case, the applied suffering rate of water borne disease is based on that used in similar project in developing countries.

d) Navigation Cost to be Saved

After excavation of Tau Hu - Be Nghe Canals, a lot of consignors save their cost for navigation due to improvement of quay facilities so that waiting time for loading and/or unloading becomes to decrease. In other words, in case of without the Project, most of the consignors should pay extra fees and/or charges for inland waterway transportation to the firms of ship owners to use ships and/or boats. This is also a kind of indirect damages/losses called as "the Navigation Cost to be Saved".

The navigation cost to be saved is estimated based on hourly navigation cost multiplying by share rate of ships/boats registered to use the Canal and total in the Ho Chi Minh City, decreased waiting time (hours), daily workable hours, and annual workable days.

The hourly navigation cost is estimated based on gross output of inland waterway transportation reported in the Statistical Yearbook of the City divided by annual workable hours. The share rate of ships/boats registered to use the Canal and total in the City is estimated based on an information from the Waterway Management Office belonging to the Department of Transportation and Public Works, Ho Chi Minh City.

The decreased waiting time (hours) has already been cleared in "Pre-Feasibility Study on Improvement, Construction and Rehabilitation of Tau Hu - Doi - Te Canals". It is assumed that daily workable hours and annual workable days are 12 hours and 365 days respectively.

Following table shows a summary of the annual average indirect damages:.

Annual Average Indirect Damages/Losses for the Whole Project Area

(million VND)

Kind of damages/losses	Amount of damages/losses by urbanized situation	
	At present	In 2020
Business suspension losses	83,073	94,081
Income losses of workers	27,083	74,095
Medical cost to be saved	16,105	31,180
Navigation cost to be saved	10,789	18,157

The annual average indirect flood damages are shown in Table 2.8.

2.5 Environmental Conditions

2.5.1 Water Environment

(1) Water Quality of Rivers

Water quality of Dong Nai river at Hoa An (water supply intake) is also getting affected from the discharges of upstream basin. Water quality survey conducted during this study, of which locations are illustrated in Fig. 2.16, shows that BOD varies between 5 – 9 mg/l. According to Vietnamese standard TCVN 5942-1995, BOD of surface water being used for domestic water supply should be less than 4 mg/l. Survey showed that Fecal coliforms also exceeded the limit in dry season especially during low tide. Table 2.9 shows water quality of major rivers during high tide and low tide for rainy season and early dry season.

Water quality of Saigon river is deteriorating. Average BOD of Saigon river at Nha Rong was as high as 16 mg/l in the year 1997 compared with 10 mg/l in the year 1993. Water quality survey conucted during this study reveals that the level of pollution in the upstream reaches of Saigon is low, however is quite high at Nha Rong after receiving wastewater from Tau Hu - Ben Nghe canal and Doi - Te canal. BOD at Tan Tuan reach was found to vary from 30 to 75 mg/l. Fecal coliforms were also about 1.1 E +07 MPN/100ml. Concentration of pollutants in Saigon river is higher than the prescribed maximum limit for domestic use/other uses. Saigon river is an important source of aquatic products. If organic pollution is not controlled, DO in Saigon river will be depleted further making it impossible for fish and other aquatic organisms to survive. The less tolerant migratory fish are unlikely to survive if DO is less than 4 mg/l.

Water qualiy at Nha Be is improved compared with Saigon river. DO is increased to 7 - 7.8 mg/l. Nha Be is subjected to tidal influences and salinity intrusion and is not a suitable source for drinking water supply. However it is important to maintain low organic pollution so as to maintain ecology of the river.

(2) Water Quality of Canals

Table 2.10 shows water quality of major canals (refer to Fig. 2.16) during high tide and low tide for rainy season and early dry season.

Tan Hoa - Lo Gom receives untreated wastewater of district Tan Binh, 11, 6, 8 and Binh Chanh. District Tan Binh, 11 and 6. These districts have high number of industries in the study area. Hence pollution due to industrial wastewater is severe in this canal. Organic and fecal contamination is severe in Tan Hoa Lo Gom canal. DO is completely depleted in the canal and BOD varies from 300 - 500 mg/l. At high tide dilution takes place. Due to tidal influence the wastewater in the down stream of Tan Hoa - Lo Gom is diluted as water from Can Giuoc river goes into the canal but upstream of the canal is stagnant for many days in the canal. The solids in the wastewater keep on accumulating in the canal. The canal is in anaerobic phase and emanates bad smell of CH_4 and H_2S. Fecal coliforms are 1.5 E+05 - 1.5 E+06 MPN/100ml exceeding the permissible concentration in the surface water. Heavy metal concentration is still below the maximum allowable concentration as prescribed in Standard TCVN 5942- 1995.

Water quality of Tau Hu - Doi - Te - Ben Nghe is also not much different from Tan Hoa - Lo Gom Canal. Besides district 1, 4, 5, 6, 7 and 8 Tau Hu canal System receives wastewater from Tan Hoa Canal system also. Tau Hu at Y bridge is more polluted than Te at Tan Tuan. Due to intrusion of water from Saigon river during high tide dilution of Canal Te helps in improving the water quality at Tan Tuan. DO varies between 0 - 4 mg/l and BOD between 100 - 250 mg/l. At high tide due to dilution water quality is improved. Fecal coliforms vary between 1.5 E+04 - 5.7 E+05 MPN/100 ml. It has led to spread of infectious diseases. The sludge at the bottom is not only a result of pollution but also adds to a continuous release of pollutants to the water and air. Further sludge accumulation is disturbing the hydraulic drainage system of the canal and if dredging of sludge is not carried out it may lead to flooding and spreading of infectious diseases. Heavy metal concentration is still below the maximum allowable concentration as prescribed in Standard TCVN 5942 - 1995.

Nhieu loc - Thi Nghe is also affected by tide. With semi diurnal tidal influence, the tide does not go fully down once it rises, so in the upper parts pollutants are received and accumulated and do not move away. DO at Cong Ly bridge is almost 0 mg/l and BOD is 120 - 210 mg/l but water quality is slightly improved at the BA Son bridge near Saigon river. During high tide at Ba Son bridge DO is about 6 mg/l and BOD is less than 20 mg/l. Fecal coliforms at Cong Ly bridge, during low tide in dry season are 1.5 E+05 MPN/100ml. Heavy metal concentration is still below the maximum allowable concentration as prescribed in Vietnamese Standards. Domestic wastewater is the main source of pollution for Nhieu Loc canal. Wastewater from Hospitals is another source of pollution.

Tham Luong - Vam Thuat has been severely polluted by industrial wastewater. More than 150 industries discharge untreated wastewater. DO is almost depleted in this canal. BOD varies from 100 - 200 mg/l. Fecal coliforms vary between 1.5 E+04 - 2.1 E+06 MPN/100ml. Heavy metal concentration is still below the maximum allowable concentration as prescribed in Standard TCVN 5942 - 1995.

In short as mentioned above, all most all the canals are severely polluted. In some cases water quality has been worsened by the effect of semi diurnal tide. DO is zero in all the canals making it virtually impossible for fauna to survive. Fecal contamination is severe which has already resulted in spreading of water-borne diseases such as diarrhea, typhoid, and dysentery. Sludge is under going anaerobic degradation and emanate offensive odor. The canal banks have been illegally encroached by squatters damaging the landscape of city center. Sludge has been accumulating and most of the canals have not been dredged for long time. Filling of the canals disturbs the hydraulic drainage system and may cause flooding which will enhance the spread of infectious diseases. In future toxic compounds discharged to canals from untreated industrial wastewater may cause health hazards such as cancer, skin diseases etc.

(3) Characteristics of Bed Sediments of Rivers and Canals

The solids in the drainage from the study area settles at the bed of canal to form sludge. Further influence of tide has resulted wastewater to be stagnant in some reaches of canal. Hence solids have been accumulating and most of the canals have not been dredged for long time. Sludge is a source of continuous release of organic pollutants and nutrients. Anaerobic decomposition of the sludge has resulted in the foul odour along the canals.

In this study heavy metal content of the sediments were analyzed in the laboratory. Table 2.11 shows the concentration of heavy metals in the dried sludge in the rivers and canals respectively. Although sampling was done at selected locations shown in Fig. 2.16 only once but the results clearly show that all most all the canals contain heavy metals. Tham Luong Vam Thuat canal has Hg as high as 12.56 mg/kg. Tan Hoa Lo Gom canal has 179 mg/kg of Pb and 336 mg/kg of Cr in the sediments. Nhieu Loc Thi Nghe has 2.21 mg/kg of Hg, 210 mg/kg of Cu and 2307 mg/kg of Zn in the sediments. Ong Ion canal has 4.32 mg/kg of Cd and Ben Luc canal has 7,182 mg/kg of Zn in the sediments.

Table 2.12 shows regulation standards for heavy metals in the sediments to be used on land or to be used for agricultural purpose. Netherlands heavy metal limits are the most stringent and accordingly sediments of most of the canals can not be used on land. Tham Luong Vam Thuat and Nhieu loc Thi Nghe can not pass Japanese standards for Hg. It can be concluded that industrial wastewater is polluting the sediments in the canals however situation is not so alarming at this

moment. It is recommended that industrial effluent standards should be strictly enforced. Further it is time now to set standards in Vietnam for the heavy metals in the sludge to be disposed on the land.

(4) Ground Water Quality

Besides rivers, Groundwater is the main water source for domestic and industrial purpose. Groundwater is extracted from both shallow and deeper aquifers throughout the HCM city. Table 2.13 summarizes the details of these ground water wells. Outside the urban center groundwater is the primary source of drinking water supply, particularly in the northern half of the city, which includes Thu Duc, Go Vap, Tan Binh, Hoc Mon and Binh Chanh District. Table 2.14 shows groundwater quality. Only limited parameters are analyzed for groundwater quality. High acidity is the major problem in these wells. High salinity is also reported in some groundwater wells of District 8 and Thu Duc. Iron content is more than permissible value for all the wells in district 7 and some wells of district 8, 11 and Tan Binh. Concentration of nitrate is higher in some wells of district 9. Although Fecal contamination is not measured. But problem of fecal pollution in Plesistocen aquifers (less than 10 m deep) has been reported. Water quality analyzed for certain ground wells during EIA survey also showed high concentration of E Coliform. Refer to Appendix H in Supporting Report for more details.

(5) Major Source of Pollution

(a) Domestic Source

Except from the partial treatment of toilet wastes in some areas of the study area, there is no treatment of wastewater. As a result sewage is one of the major source of pollution for the canals.

(b) Industrial Source

The main pollutant source other than domestic wastewater is industries. Ho Chi Minh City has roughly 28,000 industries, the vast majority of which are household industries located mainly within residential areas of the urban districts. There are about 700 medium and a large scale industries, about 500, of which are located in urban districts. Most of these industries are concentrated in District 6, 11, Tan Binh and Thu Duc. A survey of industrial pollution in HCMC was conducted by DOSTE in 1994 and 1996. Data shows that most of the industries lack treatment facilities and only few have primary sedimentation/septic tanks. As a result untreated wastewater with not only organic impurities but also containing toxic or hazardous material is discharged into public sewers or public water bodies. Specially, Tham

Luong, Vam Thuat, Tan Hoa-Lo Gom and Suoi Cai canals are polluted by industrial wastewater. For more details refer to Appendix D in Supporting Report.

DOSTE is responsible for monitoring the quality of industrial effluent being discharged to public water bodies. Serious efforts are being made to control industrial pollution of canals. In future DOSTE plans to implement strict monitoring system with more authority to District Environmental Officer.

2.5.2 Public Health Conditions

As discussed earlier, there is practically no treatment of wastewater in the Ho Chi Minh City and untreated wastewater is discharged into canals. All the canals are severly polluted and many slum setteled along the canals are using this polluted water for many purposes. These unhygenic conditions have led to break down of many water borne diseases.

Table 2.15 shows that District 8, 6 and 5 which are along the canals Tau Hu-Ben Nghe, Doi-Te and Lo Gom have much higher incidences of water borne diseases. In the year 1997, there were about 1427 cases of water borne diseases only in district 8, which is almost 3 times compared with other districts. The deteriorating water environment has increased the cases of water borne diseases in the past years. There is no clear trend available since 1993, but overall cases of water borne diseases in 1997 are more than 1.8 times that of in 1993. Diarrhoea and Dysentry are the major waterborne diseases prevalent in the study area. In the year 1997, 73cases/100,000 of Diarrhoea were reported in the study area.

2.5.3 Law, Regulation and Standards on Water Pollution Control

Table 2.16 shows the laws, regulations and standards related to environmental protection. Among these, Law on Environmental Protection (1993), Water Quality Standards and Effluent Standards are directly related to this study and are discussed below in detail.

(1) Law on Environmental Protection

This Law requires EIA report for new activities/projects affecting the Environment be submitted to National Environmental Agency (NEA) for appraisal. According to this law the Department of science, Technology and Environment (DOSTE) shall be responsible to the people's committees of provinces and cities directly under the Central Government, for environmental protection in their localities. Organizations, individuals engaged in production, business and other activities that cause environmental degradation, environmental pollution, environmental incidents must implement remedial measures as

specified by the local people's committees and by the NEA for environmental protection and shall be liable for damages according to regulations by the law.

(2) Water Quality Standards

Water Quality Standards are established to control the quality of surface water, coastal water and ground water. The objectives of these standards are protection of human health and conservation of the living environment. In TCVN 5942 - 1995, various parameters and their maximum allowable concentrations in surface water are prescribed as shown in Table 2.17. In TCVN 5943 - 1995, various parameters and their maximum allowable concentrations in coastal water. TCVN 5944 - 1995 specifies parameter and their maximum allowable concentrations in Ground water.

(3) Effluent Standards

TCVN 5945 - 1995 standard is applied to control the quality of industrial wastewater before being discharged into water body. This standard specifies the parameters and their maximum allowable concentration in the Industrial wastewater as shown in Table 2.18. More stringent limits are imposed in case industrial effluent is to be discharged to water bodies being used for domestic water supply as shown in column A of Table 2.18. Industrial wastewater having concentration of pollutants more than those described in column C can not be discharged to water bodies. TCXD 188 - 1996 specifies the parameters and their maximum allowable concentration in the urban effluents.

2.6 Relocation and Resettlement

2.6.1 Present Situation of Relocation and Resettlement

Over 36,000 households are living on and along the canals. Among them, 11,346 houses with 285,000 people are encroached on and along canals making slum area, occupy 664,289 m^2, which are mostly temporary houses without electricity and water supply services. All these slum areas on and along the canal in HCMC are expected to be cleared off.

On-going projects including relocation are usually related to canal improvement and infrastructure development/improvement. Initially no land for resettlement was reserved in the Master Plan for HCMC, but with increasing relocation demands, provisions have now been made. Throughout HCMC suitable sites for relocation have been identified, but there is a dominance of sites in the outskirts of HCMC.