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

SUPPORTING REPORT [VOLUME II]

DECEMBER 1999

PACIFIC CONSULTANTS INTERNATIONAL

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LIST OF SUPPORTING REPORT

[Volume I]

APPENDIX A: TOPOGRAPHY AND GEOLOGY

APPENDIX B: POPULATION AND LAND USE

APPENDIX C: METEOROLOGY AND HYDROLOGY

APPENDIX D: WATER QUALITY AND ENVIRONMENT

APPENDIX E: URBAN DRAINAGE IMPROVEMENT

[Volume II]

APPENDIX F: SEWERAGE DEVELOPMENT

APPENDIX G: OPERATION AND MAINTENANCE

APPENDIX H: ENVIRONMENTAL IMPACT ASSESSMENT

APPENDIX I: SOCIAL IMPACT SURVEY

APPENDIX J: CONSTRUCTION PLAN, COST ESTIMATE AND IMPLEMENTATION PROGRAM

APPENDIX K: ORGANIZATION AND LEGAL FRAMEWORK

APPENDIX L: ECONOMY AND FINANCE

ABBREVIATIONS

1. ORGANIZATIONS

ADB	Asian Development Bank
CDM	Camp Dresser & McKee 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
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
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
OWM	Office of Waterway Management
PC	People's Committee
PCHCMC	People's Committee of Ho Chi Minh City
PMU	Project Management Unit
SDC	Sewage 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
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	Liter
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 liter	mm	Millimeter
LC	Local Currency	NLTN	Nhieu Loc Thi Nghe
NPV	Net Present Value	O&M or O/M	Operation and Maintenance
s	Second	SCF	Standard Conversion Factor
SE	South East	SS	Suspended Solid
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		

APPENDIX F
SEWERAGE DEVELOPMENT

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

APPENDIX F SEWERAGE DEVELOPMENT

I. Master Plan Study

1. Pollution Load Generation

1.1 Unit Water Consumption

Based on the previous study of Master Plan on Sewerage System & Urban Sanitation Ho Chi Minh City (2010-2020) prepared by UPI, unit water consumption is estimated as follows.

Domestic Water Use

Area	Year 1997	Year 2020
Inner City Area	116 l/c/d	250 l/c/d
New Urbanized Area	91 l/c/d	180 l/c/d
Suburban Area	60 l/c/d	100 l/c/d

Water Use by Public Services and Small Industry

Area	Year 1997	Year 2020
Public Service	30 l/c/d	35 l/c/d
Small Industry	10 l/c/d	20 l/c/d
Watering Plants	5 l/c/d	10 l/c/d

Water consumption by armed forces, tourists and others are estimated at 12 % of domestic water consumption for the inner city area and 10 % for new urbanized area.

These figures are estimated based on the Water Supply General Planning in HCMC 2020 prepared by Water Supply Company.

Unit per capita water consumption for the inner city area and new urbanized area consists of domestic, public services, small industry, watering plants and armed forces, tourists and other uses. While, unit per capita water consumption in the suburban area consists of domestic, public services and watering plants only.

Unit per capita water consumption for this study is calculated as shown below.

Per Capita Unit Water Consumption

Area	Year 1997	Year 2020
Inner City Area	175 l/c/d	345 l/c/d
New Urbanized Area	145 l/c/d	263 l/c/d
Suburban Area	95 l/c/d	145 l/c/d

Water consumption in the industrial estate is estimated at 60 m^3/ha/d in 1997 and 80 m^3/ha/d in 2020.

1.2 Wastewater Generation

Wastewater generation is estimated by multiplying per capita unit water consumption by regional population. However, water consumption for watering plants of 5 l/c/d in 1997 and 10 l/c/d in 2020 are excluded from the wastewater volume.

Proposed unit per capita wastewater generation consisting of domestic, public services and small industries are as follows.

Unit Per Capita Wastewater Generation

Area	Year 1997	Year 2020
Inner City Area	170 l/c/d	335 l/c/d
New Urbanized Area	140 l/c/d	253 l/c/d
Suburban Area	90 l/c/d	135 l/c/d

Existing and future in 2020 wastewater generation by domestic, public services and small industries are estimated at 711,370 m^3/day and 2,071,050 m^3/day, respectively. Existing and future domestic wastewater generation by district are estimated in Table F.1.1

Wastewater generation from the industrial estates is assumed at 80 % of their water consumption.

1.3 Pollution Load Generation

Unit pollution load generation as BOD_5 is determined as follows.

Domestic Wastewater

Area	Year 1997	Year 2020
Inner City Area	40 g/c/d	60 g/c/d
New Urbanized Area	35 g/c/d	45 g/c/d
Suburban Area	25 g/c/d	35 g/c/d

Pollution load discharged from public services is assumed to be included in the domestic unit pollution load.

Existing and future pollution load generation as BOD_5 from domestic and public services in the Study Area are estimated to be 169,650 kg/day and 382,790 kg/day, respectively. Existing and future pollution load from industries are also estimated at 23,820 kg/day and 101,460 kg/day. Existing and future domestic pollution load generation in the study area are estimated in Table F.1.2.

2. Existing Sanitation and Sewerage Projects and Facilities

2.1 Existing On-site Sanitation

2.1.1 Domestic On-Site Sanitation

(1) General

Under the existing regulation in Viet Nam (Decree No.10, May 10,1954), human toilet waste should be treated by the appropriate septic tank before discharging the sewer and other public water bodies.

The existing domestic on-site sanitation facilities in the Study Area are used for the treatment of toilet waste only. The other domestic wastewater from kitchen, bathing and laundry are directly discharged to the sewers and public water bodies.

Based on the survey data on the existing service level of sanitary facilities in each district conducted by the Center for City Preventive Medication in 1997, the existing toilets are classified into five (5) types; (1) individual toilet with standard septic tank, (2) individual toilet with non standard septic tank, (3) individual toilet with leaching pit, (4) canal hang-on toilet, (5) public toilet. Individual toilet with standard type of septic tank means the one with septic tank has three chambers and the effluent is discharged to the sewers and/or public water bodies. While, individual toilet with non-standard septic tank means the one with septic tank has one or two chambers only. Toilet with leaching pit includes pit latrine and privy discharging human waste directly into underground or canals. Hang-on toilet is located on rivers and canals and toilet waste is discharged directly to public water bodies.

The PMU and the JICA Study Team conducted a questionnaire survey for about 1,000 families to establish the existing conditions of the on-site sanitation facilities. The results are now under evaluating.

(2) Service Level

Based on the data prepared by the Center for City Preventive Medication, the existing population ratio in terms of service level of on-site sanitation facilities in each District of the Study Area is provided in Table F.2.1.

Population of 52.66% in the Study Area have individual toilet with standard septic tank, 24.97 % have toilet with non standard septic tank, 8.40% use hang-on toilet along rivers and canals, and 0.03% use toilet with leaching pit. However, 4.77% of population still do not have any access to the toilet facilities. Remaining about 9.0% of population is supposed to use the public toilet.

(3) Public Toilet

The existing public toilets were constructed mainly by Urban Environmental Company of PC HCMC. The operation and maintenance of the public toilets are entrusted to the local authority or local community.

All districts in the Study Area have public toilets. Along with their respective total number of public toilets and seats and the average per capita service charge are given in Table F.2.2. The total numbers of the existing public toilets in the Study Area is to be 135. The districts having the highest distribution of public toilets of 19 numbers, are Districts 1 and 3. And the lowest of 1 unit is found in District Go Vap and District 9. The total numbers of public toilet seats are at 1,323 with the highest distribution of 202 in District 1 and the lowest of 4 in District 9.

Public toilets are constructed at markets and bus stations, along main streets and residential area with high population density. Location of the existing public toilet is shown in Fig. F.2.1.

2.2 Desludging and Treatment

2.2.1 General

Urban Environmental Companies of Ho Chi Minh City and Urban Public Work Company of each District are the organization responsible for cleaning and transportation of sludge of septic tanks in the Study Area, in addition to its major function of solid waste management. Septic tank of individual toilet and public toilet are cleaned on request and removed sludge be transported to the treatment site by the companies.

Urban Environmental Company has one (1) team of septic tank cleaning consisting of three (3) vacuum trucks with a capacity of 5 m^3 (1 unit) and 2 m^3 (2 units).

2.2.2 Desludging

The requests for desludging is accepted both by telephone and direct visit to the office.

The charge of desludging by the Urban Environmental Company is VND 150,000 for 2 m^3 capacity of truck and VND 250,000 for 5 m^3 capacity of truck. The sludge cleaning charge also subjects to the distance from the company. Urban Environmental Company collects the sludge of about 4,000 m^3 per annum. Total of about 100 units of vacuum truck are now operating in Ho Chi Minh City.

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

2.2.3 Sludge Treatment

Sludge treatment is managed by the private company with 15 workers at Tan Binh district. The principle of treatment is sedimentation, anaerobic digestion and composting.

The treatment plant is located at the agricultural area in Tan Binh district along Tan Ky – Tan Quy road. The treatment capacity of about 500 m^3/day can treat 70 % of desludged sludge in Ho Chi Minh City with an area of about 1 ha. Sludge is treated in the sedimentation pond for 3 to 4 days and digested under the anaerobic condition for 2 weeks. Digested sludge is composted for 5 to 6 months mixed with husk of beans and sawdust. The effluent from the sludge treatment plant is discharged to Tham Luong canal with no treatment. The company manages the sludge treatment plant by selling the compost about 5,000 ton/year at the price of 80,000 to 90,000 VND/ton. The company does not charge any fee of sludge treatment.

The existing on-site sanitation facilities in the Study Area are used for the treatment of toilet waste only. The other domestic wastewater from kitchen, bathing and laundry are directly discharged to the sewer and/or public water bodies.

2.3 Relevant Studies on Sewerage Development

2.3.1 Improvement and Construction of Nhieu Loc – Thi Nghe Canal

Proposed Sewerage Development System

Interceptor system along Nhieu Loc – Thi Nghe canal is proposed to collect wastewater.

Two (2) treatment plants are proposed at Van Thanh and Mieu canal with treatment capacity of 114,920 m^3/d and 192,922 m^3/d respectively.

Estimated project cost is as follows:

Collection system	:	8.5 million US$
Treatment Plant	:	36.8 million US$
Total	:	45.3 million US$

2.3.2 Improvement, Construction and Rehabilitation of Tan Hoa–Ong Buong – Lo Gom Canal

Proposed Sewerage Development System

Interceptor system with pumping station at Ong Buong bridge is proposed to collect wastewater and to transfer to wastewater treatment plant at Phu Dinh. Proposed treatment capacity is 112,600 m^3/d. Activated sludge system is proposed as a treatment method.

Construction cost is estimated as follows:

Interceptor and sewer	:	63.4 billion VND
Pumping Station	:	69.1 billion VND
Treatment Plant	:	275.7 billion VND
Total	:	408.2 billion VND

2.3.3 Improvement, Construction and Rehabilitation of Tau Hu – Doi – Te Canals

Proposed Sewerage Development System

Interceptor system along the canals is proposed to collect wastewater. Two (2) treatment plants are proposed at Phu Dinh and Ong Nho with treatment capacities of 125,000 m^3/d and 200,000 m^3/d respectively.

Construction cost is as follows :

Collection system	:	9.5 million US$
Treatment Plant	:	50.2 million US$
Total	:	59.7 million US$

The study area of each project and proposed treatment plant sites are shown in Fig. F.2.2.

3. Sanitation and Sewerage Development Plan

3.1 Zoning of On-site Sanitation and Sewerage System Development

3.1.1 General

Major water pollution sources of the Study Area are domestic, commercial & institutional and industrial wastewater.

Eighty seven percent (87%) of the toilet wastewater of domestic origin in the Study Area is treated by standardized & non standardized septic tanks and leaching system. Effluent from the septic tank is discharged to the sewer and public water bodies. While, the remaining 13% is directly discharged into canals and ponds with no treatment.

All the domestic gray water (wastewater from kitchen, laundry and bathing) of the Study Area is directly discharged into combined sewer and public water bodies with no treatment.

For treatment of the domestic wastewater, the following three (3) systems are considered to be appropriate.

On-site Treatment System

Septic Tank with anaerobic up-flow filter :treat both toilet wastewater and gray water

Package Treatment Plant with contact aeration tank (Joka-sou)
: treat both toilet wastewater and gray water

Sewerage system : treat both toilet wastewater and gray water

Layout of the above two (2) on-site treatment systems are shown in Figs. F.3.1 and F.3.2

Among the above three (3) systems, the most suitable one shall be applied, depending on the local conditions of the Study Area.

Commercial and institutional wastewater will be treated by the same systems as domestic wastewater. This is because their sources are widely distributed over the Study Area along with domestic sources and the wastewater quality is similar to that of domestic wastewater.

However, industrial wastewater will be treated by individually by on-site treatment system, in principle, as their sources are concentrated to some specific locations with varying wastewater quality on the type of industry.

3.1.2 Required Wastewater Treatment Level

(1) Target River Water Quality

The target river water quality of the Study Area is determined based on the existing river water use and environmental river water quality standards.

The major rivers and canals in the Study Area are classified into two (2) classes, water supply sources and other uses. Only the upper stream of Dong Nai river is used for water supply sources of Ho Chi Minh City. While, other rivers and canals are used only for navigation, drainage and agricultural uses.

Based on the Vietnamese standard on the maximum permissible concentration of pollutants in surface water (TCVN 5942-1995), the water quality of the rivers and canals in the Study Area is specified as follows:

River and Canal	Water Quality Standard (BOD_5 mg/l)
Upper Stream of Dong Nai River	less than 4
Other Rivers and Canals	less than 25

(2) Required Wastewater Treatment Level

Vietnamese government stipulated the discharge of industrial wastewater quality standards (TCVN5945-1995) in 1995. The details are shown in Table D.6.5, Appendix D.

According to the standards, all industrial wastewater should be treated to the appropriate level before discharging the specified water bodies as follows:

Rivers and Canals	Discharged Industrial Wastewater Quality (BOD_5 mg/l)
Upper Stream of Dong Nai River	less than 20
Other Rivers and Canals	less than 50

The effluent water from the wastewater treatment plant is regarded as the industrial wastewater. Then, the required wastewater treatment level is proposed to be less than 50 mg/l of BOD_5 for the Urgent Stage. While, for the Master Plan in 2020, the required wastewater treatment level is easily expected to be graded up. In the light of this fact, the required wastewater treatment level for the Master Plan stage, 20 mg/l of BOD_5 is proposed. Other parameters of the treated wastewater quality also follow the same standards (TCVN5945-1995).

3.1.3 Wastewater Treatment System

As mentioned above, three (3) systems are considered to treat the domestic wastewater for the future development areas. Based on the population density and required treatment level, the most appropriate system is selected with the following conditions:

Design Effluent Water Quality:	50 mg/l of BOD_5 for the Urgent Stage
	:	20 mg/l of BOD_5 for the Master Plan Stage
On-site Treatment System	:	Septic Tank with up-flow filter for the Urgent Stage
	:	Jouka-sou for the Master Plan Stage
Sewerage System	:	Separate system for collection of wastewater with pump
	:	Modified Activated Sludge System for the Urgent Stage
	:	Conventional Activated Sludge system for the Master Plan Stage

Unit cost of the Sewerage System varies according to magnitude of service area and its population density. While unit cost of the On-site Sanitation System is relatively constant.

The comparison study for selection of the optimum wastewater treatment system, 10 different population density areas of ranging from 29 person/ha to 481 person/ha are selected. The project cost, consisting of construction cost and O/M cost for 30 years of above mentioned three (3) systems are compared.

(1) Selection of Areas and Population Density

Based on the regional distribution of the future population density in each ward, the wards with same population density range are summing up and make the following 10 different population density groups. The construction cost and O/M cost for On-site sanitation system and sewerage system of each population density area are estimated based on the following assumption.

	Population density (person/ha)	Population (person)	Area (ha)	Wastewater (m^3/d)
Case 1	29	548,726	18,747	111,001
Case 2	75	1,180,671	15,828	249,969
Case 3	118	370,357	3,135	88,915
Case 4	169	486,932	2,878	110,154
Case 5	218	457,138	2,092	100,563
Case 6	274	122,806	448	31,070
Case 7	330	133,352	404	33,738
Case 8	362	94,015	260	26,349
Case 9	413	57,367	139	14,542
Case 10	481	39,908	83	10,097

(2) Cost Estimation of Sewerage System

Sewerage System consists of ;

1) Wastewater treatment plant
2) Sewer net work
3) Pumping station

In this comparative study, the construction costs are estimated by using the formulas for designing sewerage works in Japan, " Outline of Financial Model in Sewerage Works, Japan Sewerage Works Association, 1985" with the following revisions:

- Estimated costs are modified as a present value by deflation factor.
- Deference of unit cost between Japan and Viet Nam are
  - as for wastewater treatment plant : 4.41 : 1
  - as for sewer network and pumping station : 6.14 : 1
- No. of regional pumping station : 1station/400ha
- Main sewer density (m/ha) is assumed as 70 % of that in Japan (refer to the Study in Jakarta)
- Exchange rate : US$ 1 = VND 13,800
  US$ 1 = Yen 120

O/M costs are estimated by using the formulas for designing sewerage works in Japan, "Outline of Financial Model in Sewerage Works, Japan Sewerage Works Association, 1985" with the following modifications:

- Estimated O/M cost are modified as a present value by deflation factor.
- Deference of unit costs of labor, electricity and chemicals between Japan and Vietnam are assumed as 3.5:1.

The estimated construction and annual O/M costs of Sewerage System for the 10 cases in both conditions of required water quality of 50 mg/l and 20 mg/l in terms of BOD_5 are

shown in Table F.3.1.

(3) Cost Estimation of On-site Sanitation System

On-site Sanitation System consists of;

1) On-site treatment system
2) Sludge treatment plant

Construction cost of on-site sanitation system and sludge treatment plant are estimated with following conditions;

Required treated water quality	BOD_5 : 50 mg/l	BOD_5 : 20 mg/l
Type of Septic Tank	With anaerobic up-flow filter	With contact acration
Purchase Cost [a] (USD of treatment capacity for 5 persons)	596	1,192
Installation Cost [b] (USD)	20 % of purchase cost	10 % of purchase cost
Sludge treatment plant construction cost (USD/person)	1/3 of construction of wastewater treatment plant [c]	1/3 of construction of wastewater treatment plant [c]

(Remarks) :

a) Referred to the cost in Malaysia
b) Cost for connecting to the discharge water body
c) The assumption was made by the following reasons:
   - The ratio of construction cost for Sludge Treatment Plant and Wastewater treatment plant is 1:4.
   - However, the auxiliary facilities such as the parking lot, car-washing lot, smell protection, etc. are required for the Sludge Treatment Plant.
   - Then the construction cost of sludge treatment plant is assumed as 1/3 of that of wastewater treatment plant.

The estimated of O/M costs of On-site Sanitation System are shown in below;

Required treated water quality	BOD_5 : 50 mg/L	BOD_5 : 20 mg/L
Type of Septic Tank	With anaerobic up-flow filter	With contact aeration
Power (USD/5person/year)	Ignored [a]	22.2 [b]
Chemical (USD/5person/year)	2.5 [c]	2.5 [c]
Cleaning tank (USD/5person/year)	8.5 [d]	8.5 [d]
O/M cost of sludge treatment plant (USD/person/year)	0.7 of O/M cost for WWTP	0.7 of O/M cost for WWTP

(Remarks)

a) Due to anaerobic up-flow filter
b) Required power is 35 WH/5persons for contact aeration and power supply charge is 1,000 VND/kW
c) For disinfection, bleaching solid of 5g/m^3 with effective chlorine of 60 %. The cost of bleaching solid is estimated at 10,000 VND/kg.

d) Per capita unit sludge generation is assumed at 0.04 m^3/person/year. The cleaning of septic tank is assumed twice per year by two labors with 3 hours working time.

The estimated construction and annual O/M costs of on-site sanitation system for the 10 cases in both conditions of required water quality of 50 mg/l and 20 mg/l in terms of BOD_5 are shown in Table F.3.2.

(4) Conclusion

The project cost consisting of construction cost and O/M cost with 30 years operation period is adopted for the comparative study. The estimation of present value of 30 years O/M cost, discount rate of 10 % per annum is assumed.

The project costs of both on-site sanitation system and sewerage system are compared in Table F.3.3 and Fig. F.3.3.

As evidence from above table and figures, the following facts are disclosed.

In the Urgent Stage with required treated water quality of 50 mg/l in terms of BOD_5:

On-site sanitation system is much economical than sewerage system for all study area.

On-site sanitation system of septic tank with anaerobic up-flow filter is proposed for the new urbanized area and suburban areas.

In the Master Plan Stage with required treated water quality of 20 mg/l in terms of BOD_5:

Sewerage system is more economical than on-site sanitation system for the area with population density of more than 200 person/ha.

Sewerage system is proposed as wastewater treatment in wards with population density of more than 200 person/ha. While, on-site sanitation system (septic tank with contact aeration) will be proposed for wards with population density of less than 200 person/ha.

3.1.4 Zoning

(1) Division of the Study Area by Population Density

The following two (2) areas defined in the previous section 3.1.3 ; Area A and Area B are delineated as shown in Fig. F.3.4.

Area A : with a population density of less than 200 person/ha in 2020
Area B : with a population density of more than 200 person/ha in 2020

Area A covers a total area of 519.69 km^2 located in the fringes of the Study Area. The population of this area in the year 2020 is estimated to be 3,205,047.

Area B covers a total area of 109.53 km^2. The population in the year 2020 is estimated to be 4,225,938.

Average population densities of these two (2) areas in the year of 2020 are estimated to be 62 person/ha in Area A and 386 person/ha in Area B.

(2) Sewerage Development Area - Area B

Sewerage development area is delineated based on the following criteria.

(i) Wards with a population density of more than 200 person/ha will be included in the sewerage development area, in principle. However, wards in which the locations are isolated from other high population density areas, separated by canals and main roads and wards where large industrial developments are expected, will be excluded.

(ii) Wards in the new developed districts, especially in District Thu Duc, District 9, 2 and 12, their net population density which is population divided by inhabitable area, is more than 200 person/ha will be included in the sewerage development area. Such wards are:

District Thu Duc : Binh Chieu, Tam Phu, Binh Thoi, Hiep Binh chanh, Hiep Binh Phuoc, Linh Chieu, Linh dong, Linh Tay, Linh Trung, Tam Binh, Tam Phu, Truong Tho
District 9 : Hiep Phu, Tang Nhon Phu A, Tang Nhon Phu B, Phuoc Binh, phuoc Long A, Phuoc Long B
District 2 : Thao Dien, Binh Trung Dong, Binh Trung Tay, Cat Lai, Thanh My Loi
District 12 : Hiep Thanh, Tan Thoi Hiep, Tan Thoi Nhat, Tan chanh Hiep, Trung My tay, Dong Hung Thuan

(iii) Wards surrounded by or located in the vicinity of other high population density areas and wards in which the combined sewer is already installed will be included even when their population density is lower than 200 person/ha. Such wards are:

Ben Nghe in D.1, Ward 6 in D.3, Wards 1 and 18 in D. 4, Wards 11, 12 in D. 5, Ward 10 in D. 6, Tan Thuan in D. 7, Ward 5 in D. 8, wards 12 and 14 in D. 10, Ward

9 in D. Phu Nhuan, Wards 2, 4, 12, 14, 16, 19, 20 in D. Tan Binh, Wards 13, 22 in D. Binh Thanh, and Ward 5 in D. Go Vap.

Based on the above criteria, the sewerage development area and population in the year 2020 are as follows.

Area	:	189.78 km^2 or 30 % of the Study Area
Population in 2020	:	5,774,748 or 78 % of the Study Area

Sewerage development area is delineated in Fig. F.3.5.

(3) On-site Treatment System Development Area - Area A

Wards with a population density of less than 200 person/ha will be included in principle. However, among the 22 wards will be relocated as the sewerage development area.

The delineated on-site treatment system development area is shown in Fig.F.3.5.

The total Number of Wards covered, and their area and population in the year 2020 are as follows.

Area	:	439.44 km^2 or 70 % of the Study Area
Population in 2020	:	1,656,237 or 22 % of the Study Area

4. Potential Sites of Wastewater Treatment Plants

4.1 Concept of Site Selection

Potential sites of wastewater treatment plants are the ones possessing the following characteristics:

(1) Sites where the wastewater from service area could be collected mostly by gravity, in other words, the site of natural drainage.
(2) Sites are spacious enough to construct the treatment facilities and other auxiliaries.
(3) Sites where the environmental impact to the surroundings by the operation of the facilities is not very significant.
(4) Green area and open space in the future land use plan (Land Use Master Plan for Ho Chi Minh City 2020)

4.2 Significance of Treatment Plant Sites

The Saigon Sewerage Feasibility Study conducted by American Consultants in 1971 nominated nine potential sites for wastewater treatment plants for west area of Saigon

river and one for east area of Saigon river. While, only one potential site at the location of about 2 km southwest of the confluence of Saigon river and Dong Nai river was selected as the treatment plant site of west area of Saigon river. After that, PC HCM made a Master Plan on Sewerage System and Urban Sanitation in 1993 and is now adjusting it to the Land Use Master Plan of Ho Chi Minh City in 2020. The Master Plan proposed the four (4) treatment plant sites; Hiep Phuoc Industrial and Residential area in Nha Be District (about 12 km south of inner city area), Can Giuoc area in Binh Chanh District (along canal Rach Can Guoc), Vinh Loc Industrial area in Binh Chanh district, and Catlai Industrial and Residential area in District 2.

Department of Transportation and Public Works of PCHCM has conducted the pre-feasibility studies on environmental improvement project for some main canals in the inner city area. There are (1) Tau Hu – Doi Te Project, (2) Tan Hoa Lo Gom Project and (3) Nhieu Loc – Thi Nghe Project.

The proposed locations of treatment plants by above mentioned projects are shown in Table F.4.1 and Fig. F.4.1.

Accordingly, this Master Plan will subdivide the sewerage area into realistic size along with the existing on-going projects and the priority of implementation for sewerage development. This has much bearing effort will be made to identify as much alternative sites as possible for sitting potential treatment plants.

4.3 Potential Identified Sites

Potential treatment plant sites identified by the PMU and the JICA Study Team through site reconnaissance are shown in Table. F.4.2 and Fig.F.4.2.

This identification was made based on the above concept of site selection.

Site 1. : Site 1 is located southern part of Saigon south in Binh Chanh district. The site is enclosed by Tac Ben Ro canal and Cay Kho Canal. The existing and future land use condition is agricultural area. Available space for construction of treatment plant is expected to be 70 ha with an existing unit land price of 38,600 VND/m^2.

Site 2.: Site 2 is located in Tan Binh District. The site is enclosed by Tan Ky – Tan Quy Str., May 19 Canal and Binh Long Str. The site belongs to government property. This site will be preserved as green area in future. Available area is about 60 ha.

Site 3. : Site 3 is located in Binh Chanh District. The site is enclosed by Le Minh Xuan Str. and Ba Goc Canal. The existing and future land use conditions are

agriculture area. Available space is about 160 ha with an existing unit land price of 38,600 VND/m^2.

Site 4. : Site 4 is located Nha Be district. The north and west sides of the site 6 are enclosed by Roi Canal. The existing and future land use condition is agricultural area. Available area for treatment plant construction is about 150 ha with an existing unit land price of 26,000 VND/m^2.

Site 5. : Site 5 is located along Saigon River in District 2. The site is enclosed by Luong Dinh Cua Str., Giong Ong To River and Saigon River. The existing land use condition is agricultural area and it will be preserved as green area in future. Available land space is 15 ha with an existing unit land price is at 19,300 VND/m^2.

Site 6. : Site 6 is located near by Ben Do Nho River and Ben Do Lon River in District 9. The existing land use condition is agricultural area and it will be preserved as green area in future. The available area is about 90 ha with an existing unit land price of 19,300 VND/m^2.

Site 7. : Site 7 is located along Saigon River in District 2. The site is enclosed by Luong Dinh Cua Str., Giong Ong To River and Saigon River. The existing land use condition is agricultural area and it will be preserved as green area in future. Available land space is 15 ha with an existing unit land price of 19,300 VND/m^2.

Site 8. : Site 8 is located along Saigon river in District 12. The site is enclosed by saugon river and Vam Thuat river. The existing land use condition agricultural area and it will be preserved as green space in future. Available land space is about 15 ha with an existing unit land cost of 19,300 VND/m^2.

5. Alternative Studies of Sewerage Development System

5.1 General

The objective sewerage development area for the year 2020 covers 18,978 ha located in the inner city area and new developed districts of Thu Duc, District 2, 9 and 12 as determined in the previous Section 3.1.4. Principally, the objective sewerage development area is divided into two zones of West and East by Saigon River. The West Zone consists of inner city area and new developed districts of 12 and 7. The East Zone consists of new developed districts of Thu Duc, 2 and 9.

The population and wastewater discharge of the each sewerage zone in the year 2020 are estimated as follows:

Sewerage Zone	Population	Wastewater Discharge (m^3/day)
West Zone	4,478,248	1,441,337
East Zone	1,296,500	328,015
Total	5,774,748	1,769,352

Further more, the objective sewerage development area is classified into two (2) by sewerage condition. One is existing combined sewer system covering area of the inner city area and the other is the new developed districts without any sewerage system. The sewerage development area in the inner city area, almost 50% of the objective sewerage development area is covered by the existing combined sewer networks.

Based on the conditions as mentioned above, the following alternative systems are considered for the evaluation of sewerage development in the objective area.

(1) Individual Small Scale Treatment System
The objective area will be divided into several 10 zones. The wastewater of the objective area will be treated individually for each zone.

(2) Two Large Scale and Two Small Scale Treatment System

Individual small scale sewerage systems in the inner city area where the wastewater is collected by combined system are integrated into one (1) large scale sewerage system. Four (4) small scale sewerage systems in East Zone with separate wastewater collection system are also integrated into one (1) large scale system. The remaining two (2) small scale sewerage systems in Districts 12 and 7 are proposed as an independent sewerage system with separate wastewater collection system.

5.2 Individual Small Scale Treatment System

5.2.1 Proposed System

(1) Division of Sewerage Development Area

The objective area of 18,978 ha is divided into 10 sewerage zones, based on existing on-going sewerage project, administrative boundary, topographic conditions, river and canal networks, road networks and available potential treatment plant sites. The divided sewerage zones are shown in Fig. F.5.1.

The area of the divided sewerage zone ranges from 583 ha to 3,935 ha, with an average of 1,898 ha. The area, population and population density of the respective sewerage zones are shown in Table F.5.1.

(2) Design Wastewater Discharge

Design wastewater discharge of the whole objective area is 1,769,352 m^3/day on daily average basis in 2020. Its break-down by sewerage zone is shown in Table F.5.2.

(3) Sewage Collection System

(a) Inner City Area

Proposed sewerage system will cover the area of 10,942 ha in the inner city area. This occupies about 78 % of the total inner city area. The existing combined sewer covers the inner city area of 5,331 ha with the total length of 932,142 m. Based on the existing sewer collection system, combined sewer system is proposed for collection of wastewater in the inner city area.

The wastewater discharged from above mentioned inner city area of 5,331 ha is collected and discharged by the combined sewer to rivers/canals near by. Interceptor sewer along the rivers/canals is proposed to intercept the wastewater collected by the combined sewer before discharging. The area with no existing sewer system, combined sewer system connecting the interceptor sewer is proposed.

The proposed sewer line consisting of interceptor and conveyance sewer classified by their function and diameter has a total length of 112,170 m. Its break-down by sewer type is shown below. The tertiary, secondary and main sewer in combined sewage collection area are proposed in Urban Drainage Improvement Sector.

Sewer Type	Diameter (mm)	Length (m)
Interceptor Sewer	ϕ 500 – ϕ 2,500	92,444
Conveyance Sewer	ϕ 1,600 – ϕ 3,000	19,726
Total		112,170

Sewer length in the respective sewerage zones is shown in Table F.5.3.

(b) New Developed Districts

Proposed sewerage system covers the area of 8,036 ha in new developed districts of Thu Duc, 2,9,7 and 12. The existing combined sewer system covers only 255 ha in the proposed sewerage development area. Then, the existing combined sewer system is ignored for this alternative study.

The more environmentally superior wastewater collection system of separate system is proposed for new developed districts.

The proposed sewer line networks in the new developed districts is estimated at 1,233,681 m. The break-down by sewer type is shown below.

Sewer Type	Diameter (mm)	Length (m)
Secondary & Tertiary	ϕ 150 – ϕ 500	372,432
Main	ϕ 600 – ϕ 1,300	858,350
Conveyance	ϕ 1,100	2,899
Total		1,233,681

Sewer length in the respective sewerage zones is shown in Table F.5.3.

(4) Wastewater Treatment Plant

Nine (9) wastewater treatment plant sites are proposed to treat the wastewater of the 10 sewerage zones. Wastewater discharged from both sewerage zones of NL-TN and THBNDT is treated at the same location in District Binh Chanh enclosed by Tac Ben Ro and Ong Lon rivers. Remaining eight (8) sewerage zones have their own treatment plant. Location of the treatment plant is shown in Fig. F.5.1.

Conventional activated sludge system is applied as the treatment system in this alternative study.

(5) Estimated Costs

(a) Construction Cost

Total construction cost for all 10 sewerage zones is estimated at VND 21,713.8 billion at 1999 price, the break-down is shown as below.

(Unit: Billion VND)

House Connection	354.6
Collection Sewer Networks	1,451.9
Pumping Station	2,148.8
Treatment Plant	7,006.4
Land Acquisition	52.5
Sub-total	11,014.2
New Developed Districts	
House Connection	468.2
Collection Sewer Networks	5,671.4
Pumping Station	590.5
Treatment Plant	3,949.1
Land Acquisition	20.4
Sub-total	10,699.6
Total	21,713.8

Construction cost of one (1) sewerage zone in the inner city area ranges from VND

1.3 billion to VND 4.2 billion with an average of VND 2.8 billion. While, construction cost in new developed districts ranges from VND 0.9 billion to VND 2.8 billion with an average of VND 1.8 billion.

(b) Operation and Maintenance Cost

Operation and maintenance (O&M) cost of the collection system includes costs for cleaning and repairing. Annual O&M cost is assumed at 0.3% of the construction cost.

O&M cost of the pumping station consists of electricity charge, repairing cost and personal expenditure. Annual O&M cost is estimated by using the following formula.

$$Mp = 24.2 \times Qp^{0.69}$$

Mp : Annual O/M cost (Million VND/annum) of Pumping Station
Qp : Design Wastewater Volume in m^3/min.

O&M cost of the treatment plant covers costs for electricity charge, chemical cost, material cost, repairing cost, personnel expenditure and etc. The annual O&M cost is estimated by using the following formula.

$$Mt = 267.41 \times Qt^{0.697}$$

Mt : Annual O/M cost (million VND/annum) of Treatment Plant
Qt : Design Wastewater Volume in 1,000 m^3/day

Total annual O&M cost of the 10 sewerage zones is estimated to be VND 137.8 billion at 1999 price.

5.3 Two Large Scale and Two Small Scale Treatment System

5.3.1 Proposed System

(1) Division of Sewerage Development Area

The objective area of 18,978 ha is divided into four (4) sewerage systems. Four (4) individual small scale sewerage systems in the inner city area are integrated into one (1) large scale system. Four (4) small scale sewerage systems in the East Zone are also integrated into one (1) large scale sewerage system. The remaining two (2) small scale sewerage systems in West Zone of SW and SS are developed independently. The area of each sewerage system is 10,942 ha of inner sewerage system, 5,166 ha of East Sewerage

system, 1,315 ha of SW and 1,555 ha of SS. The population and population density of the four (4) sewerage systems are shown in Table F.5.4.

(3) Design Wastewater Discharge

The dry weather design wastewater discharge including groundwater infiltration of the four (4) sewerage zones are 1,386,000 m^3/day of inner city zone, 361,000 m^3/day of East zone, 111,000 m^3/day of SW and 89,000 m^3/day of SS. The wet weather design wastewater discharge of the inner city zone is to be 3,779,000 m^3/day.

(4) Sewage Collection System

Combined system is proposed for the inner city sewerage zone. While the separate system is proposed for East sewerage zone, SW and SS in the new developed districts. The proposed sewage collection system is in fact the integrated one of the four (4) combined collection systems of the individual small scale sewerage system in the inner city area dealt with in the forgone section of 5.2.

The proposed collection and conveyance sewers in the four (4) sewerage zones is at 1,339,099 m. Its break-down is as shown below.

Sewer Type	Diameter (mm)	Length (m)
Secondary & Tertiary	ϕ 150 – ϕ 500	372,432
Main	ϕ 500 – ϕ 1,400	858,350
Interceptor	ϕ 500 – ϕ 4,500	103,705
Conveyance	ϕ 4,500	4,612
Total		1,339,099

Sewer pipe length in the respective sewerage zones is shown in Table F.5.5.

(5) Wastewater Treatment Plant

The wastewater from the four (4) sewerage zones are proposed to be treated by conventional activated sludge system independently. Location of the treatment plant is shown in Fig. F.5.2. Treatment plant of the inner city zone is proposed to be located at the same place as the THLG sewerage system in the individual small scale system. This treatment plant site has sufficient area to treat the whole wastewater discharged from the inner city zone. Treatment plant for East zone is located at the same place as SN-I sewerage system in the individual small scale sewerage system. And treatment plants for SW and SS are also same location as proposed in the individual small scale sewerage system.

(6) Estimated Costs

(a) Construction Cost

Total construction cost for the four (4) sewerage zones is estimated at VND 23,370.2 billion at 1998 price, the break-down is as shown below.

(Unit: Billion VND)

Item	Construction Cost
House Connection	822.2
Collection System	5,671.4
Pumping Station	3,058.1
Interceptor & Conveyance Sewer	4,276.4
Treatment Plant	9,490.1
Land Acquisition	52.0
Total	23,370.2

(b) Operation and Maintenance Cost

Total annual O&M cost of this system is estimated at VND 146.0 billion at 1999 price, and the break-down is as shown below.

(Unit: Billion VND)

Item	Construction Cost
Collection System	17.4
Pumping Station	22.9
Interceptor & Conveyance Sewer	12.6
Treatment Plant	93.1
Total	146.0

5.4 Comparative Evaluation

5.4.1 General

The construction and O&M costs of the two (2) alternative systems are compared as follows.

Alternative	Construction (Billion VND)	Annual O&M (Billion VND)
Individual Small Scale	21,713.8	137.8
Two Large and Two Small Scale	23,307.2	146.0

Construction cost for individual small scale system is lower than that of the two large and two small scale system. Annual O&M cost for the individual small scale system is

also lower than that of the two large and two small scale system.

6. Proposed Sewerage Development Plan

6.1 Sewerage Development Zone

The proposed sewerage development area covers 18,978 ha in the inner city of 10,942 ha and new developed districts of 8,036 ha with future population of 3,760,248 and 2,014,500 respectively in 2020. The area is divided into nine (9) zones, as the optimum plan. From the individual small scale treatment system, Saigon East I and II are integrated into one (1) from the capacity of treatment plant and its available site. For each of these zones, an independent sewerage development plan will be prepared as mentioned in the foregone section 5.2. (See Fig. F.6.1) The respective zones covers the whole or part of those Districts as shown below, according to zone name.

Zone	District
Tham Long – Ben Cat (TLBC)	Binh Thanh, Go Vap
Nhieu Loc – Thi Nghe (NLTN)	1, 3, 10, Binh Thanh, Go Vap, Phu Nhuan, Tan Binh
Tan Hoa – Lo Gom (THLG)	6, 8, 11, Tan Binh
Tau Hu – Ben Nghe – Doi – Te (THBNDT)	1, 3, 4, 5, 6, 8, 10, 11, Tan Binh
Saigon West (SW)	12
Saigon South (SS)	7
Saigon North I (SN-I)	Thu Duc
Saigon North II (SN-II)	9
Saigon East (SE)	2

The area of the respective zones are shown in Table F.6.1.

The population of each zone is estimated by summing up the population of the Ward covers by its zone. For population data of Districts, refer to Appendix B, Table B.5. The zone population in 2020 ranges from 196,500 in SN-II zone to 1,390,282 in THBNDT zone. Its population density in the inner city area is in the range of 237 person/ha in TLBC and 454 person/ha in THBNDT with an average of 344 person/ha. The population density of new developed districts are adopted as net population density which is estimated by future population divided by the inhabitable area consisting of residential area, commercial and institutional area. The net population density of sewerage development areas in new developed districts ranges from 191 person/ha of SN-II to 396 person/ha of SE with an average of 294 person/ha.

The land use of each zone is estimated by summing up the land use of the included Wards. The land use patterns of the respective zones in 2020 are shown in Table F.6.2.

6.2 Design Wastewater Generation

6.2.1 Domestic Wastewater Generation

In this Study, domestic wastewater consists of domestic, commercial, institutional and small industrial wastewater. The domestic wastewater generation of each zone is estimated by multiplying future population by respective unit wastewater generation. The total wastewater generation of the sewerage development area in 2020 is estimated at 1,769,563 m^3/day. Its break-down into the respective zones is shown as below.

Sewerage Zone	Design Wastewater Generation (m^3/day)
TLBC	118,877
NLTN	455,456
THLG	219,606
THBNDT	465,744
SW	100,694
SS	80,960
SN-I	126,500
SN-II	49,715
SE	151,800
TOTAL	1,769,352

6.2.2 Industrial Wastewater Generation

In this Study, industrial wastewater discharged from the industrial estates is proposed to be treated independently at the each industrial estate. The industrial wastewater discharged from the industrial estates is not treated by the sewage treatment plant proposed in this Study. However, industrial wastewater discharged from small home factories located in the residential area is collected and treated along with domestic wastewater.

6.3 Wastewater Collection System

6.3.1 General

There are two (2) types of wastewater collection system. One is separate system and another is combined system. Separate system collects only wastewater excluding storm water. While, combined system collects storm water along with wastewater.

In this Study Area, existing combined system covers an area of 5,331 ha of the inner city area. From the economical point of view, existing combined system should be utilized effectively. Therefore, combined wastewater collection system is applied for the inner city area.

While, the sewerage development area in the new developed districts with no existing sewerage system, the separate system is proposed from the following technical, environmental and economical viewpoints.

- Separate system has less possibility of pollutants getting accumulated than combined system.
- When it rains, the combined sewerage system causes pollution in the receiving water due to the overflow of untreated wastewater.
- Only separate system can keep sanitary wastes out of rivers and storm drains and can reduce pollution of surface water bodies.
- The area can be managed storm water drainage by ditches and/or open channels, separate sewerage system is more economical than combined system.

6.3.2 Inner City Area

The existing combined sewer covers 5,331 ha of the inner city sewerage development area as shown in Fig. F.6.2. Both toilet waste and gray water from this area is discharged to rivers/canals near by through the existing combined sewer without any treatment. The wastewater from the remaining inner city area of 5,661 ha, 51 % of toilet waste is treated by the on-site septic tank, while gray water is discharged into the ground and/or small canals directly.

In the existing combined sewer developed area, the interceptor sewer along the rivers/canals will be installed to intercept all wastewater before discharging to the rivers/canals in the dry season. And in the rainy season, 1.4 times of dry weather flow of diluted by storm water will be intercepted before discharging. While, the excessive diluted wastewater is discharged to the rivers/canals near by with no treatment.

The area with no existing combined sewer system, the combined sewer consisting of house connection, tertiary, secondary, main sewers and interceptor sewer will be proposed.

Collected wastewater by interceptor sewer will be transferred to the treatment plant through pumping stations and conveyance sewer.

6.3.3 New Developed Districts

Separate system is applied for the sewage collection area in the new developed districts. This system collects only wastewater consisting of toilet waste and gray water. Storm water will be discharged by open ditches/channels separately from wastewater.

6.3.4 Design Criteria

(1) Hourly Peak Flow Factor :

Hourly peak flow factor was decided 1.4 times of daily average domestic wastewater generation from the Water Supply Master Plan by Water Supply Company in HCMC.

(2) Groundwater Infiltration :

Groundwater infiltration was decided 10 % of daily average domestic wastewater generation with references of the cases in Japan and other Asian countries such as Indonesia.

(3) Interceptor Capacity : Hourly peak flow plus groundwater infiltration

Based on the annual rainfall data at Tan Son Nhat Airport in 1997, pollution load reduction efficiency in respective interceptor capacities of 1.4 and 3.0 times of daily average dry weather flow are compared under the following conditions :

- Runoff coefficient = 0.75
- Domestic wastewater generation with groundwater infiltration : Q = 512,000 m^3/day
- BOD_5 concentration of storm runoff : 50 mg/l
- BOD_5 concentration of domestic wastewater : 180 mg/l
- Sewerage area : 3,065 ha
- Capacity of WWTP : 512,000 m^3/day (Q.ave.)
- Wastewater collected by interceptor, excess quantity of treatment plant capacity, is discharged after primary sedimentation and disinfection as primary effluent.
- BOD_5 removal efficiency of primary effluent : 30 % of mixed wastewater and storm water
- WWTP BOD_5 effluent : 20 mg/l in wet season
  15 mg/l in dry season
- Total rainy minutes per year : 24,630 (17 days)

Total effluent BOD_5 load in combined system and separate system are computed as below.

- Domestic wastewater generation : 512,000 m^3/day = 186,880,000 m^3/year
- Storm water runoff : 42,467,108 m^3/year
- BOD_5 load from domestic wastewater : 33,638,400 kg/year
- BOD_5 load from storm runoff : 2,123,355 kg/year
- Total BOD_5 load generation : 35,761,755 kg/year

- Interceptor Capacity = 1.4 times of Dry Weather Flow
  - BOD_5 discharged from Diversion Chamber : 2,811,342 kg/year
  - Effluent BOD_5 load from WWTP : 3,022,467 kg/year
  - Total discharged BOD_5 load per year : 5,833,808 kg/year
  - Total BOD_5 removal rate per year : 83.7 %

- Interceptor Capacity = 3.0 times of Dry Weather Flow
  - BOD_5 discharged from Diversion Chamber : 1,807,074 kg/year
  - Effluent BOD_5 load from WWTP : 3,725,454 kg/year
  - Total discharged BOD_5 load per year : 5,532,528 kg/year
  - Total BOD_5 removal rate per year : 84.5 %

From the calculations above, the following conclusions are led.

Annual BOD_5 reduction efficiencies of 1.4 times and 3 times of interceptor capacity to daily average domestic wastewater in combined sewerage system are 83.7 and 84.5 %, respectively. Therefore, the annual BOD_5 removal efficiency in 3 times of interceptor capacity to daily average domestic wastewater is only 0.8 % higher than that of 1.4 times.

With a comparison of construction cost in THBNDT sewerage zone, for example, in the case of 1.4 times and 3 times of interceptor capacity to daily average discharge is estimated 3,565,393 and 3,946,786 million VND, respectively. The case of 1.4 times of interceptor capacity to daily average discharge is 10.7 % cheaper than that of 3 times (refer to the table below).

Construction Cost of THBNDT Zone

(million VND)

Components	Description	Unit	Quantity		Amount	
			Interceptor : 1.4 * Qave.	Interceptor : 3.0 * Qave	Interceptor : 1.4 * Qave	Interceptor : 3.0 * Qave
Sewer Pipeline	Sewer Pipeline	Set	1	1	---	---
	House Connection	House No	60,110	60,110	70,329	70,329
	Interceptor Sewer	Set	1	1	585,366	742,407
	Diversion Chamber	Places	186	186	18,838	18,838
	Conveyance Sewer	Set	1	1	409,428	519,269
Pumping Station	Total Set	Places	1	1	233,762	348,273
Wastewater Treatment		Set	1	1	224,7670	224,7670
Total					3,565,393	3,946,786

In comparison of annual BOD_5 reduction and cost, the priority should be in project cost, therefore, the study team decided that intereceptor capacity should be 1.4 times to daily average discharge.

6.4 Treatment Plant

6.4.1 Selection of Optimum Treatment System

The required treated water quality for the urgent stage and the master plan stage are 50 mg/l and 20 mg/l in terms of BOD_5 respectively.

The following treatment systems can meet the requirement of each stage.

- Stabilization Pond
- Aerated Lagoon
- Oxidation Ditch
- Conventional Activated Sludge
- Rotating Biological Contractor

These five (5) treatment systems are compared from the following viewpoints for selection of the optimum system.

- Adaptability to overload
- Required technology level of operation and maintenance
- Required costs of construction and operation and maintenance
- Required sludge disposal
- Required land acquisition

In this study, the capacity of the treatment plant will be designed to meet a daily average discharge of wastewater to minimize the required land area for treatment plant. Then, the proposed system should be able to treat a daily peak wastewater discharge to acceptable level.

The comparison of the systems are shown in Table F.6.3.

As evident from the above tables, stabilization pond or aerated lagoon system is the most appropriate as long as sufficient land space is available. For the areas where available land space is not enough, conventional activated sludge system will be applied.

Based on the location of proposed treatment plant sites, conventional activated sludge process is proposed due to the difficulties of land acquisition for huge area. The process of the proposed conventional activated treatments are shown in Fig. F.6.3.

6.4.2 Design Criteria

(1) Design flow

Daily average discharge including groundwater infiltration is used as the design flow of treatment plant.

Daily average discharge including groundwater infiltration is used for the design of treatment plant excluding inlet pumps, grit chamber, disinfection basin and effluent facility. Inlet pumps, grit chamber, disinfection basin and effluent facility will be designed based on the wet weather flow. Wet weather flow is determined as 1.4 times as daily average discharge in dry weather flow.

(2) Design Influent and Effluent Water Quality

Wastewater	BOD_5 (mg/l)	SS (mg/l)
Influent	180 – 250	180 – 360
Effluent	50 (Urgent Stage)	100 (Urgent Stage)
	20 (Master Plan stage)	50 (Master Plan stage)

The sewerage zones covered by combined sewage collection system, the influent water quality is diluted by storm water in the wet weather flow. However, the water quality in dry weather flow will be adopted as the design influent water quality for the treatment plant. In this system, the wet weather flow exceeded the design capacity of treatment plant would be discharged after treated by the primary sedimentation and disinfection into the public water bodies.

In case the wastewater treatment plant accepts to treat the industrial wastewater from the small home factories with toxic substrates, the industrial wastewater should be pre-treated up to the acceptable level and an appropriate treatment charge system will be adopted.

(3) Wastewater Temperature

According to the atmosphere temperature of HCMC ranging from 25.9 to 29.3℃, the minimum temperature of 25℃ is used as the wastewater temperature for designing the treatment plant.

6.4.3 Activated Sludge Process

(1) Design Parameters for Main Facilities

(i) Water Treatment System

From the above design criteria, BOD_5 reduction efficiency of more than 90% is required in the Master Plant Stage.

Based on the design standards in USA, Japan and other tropical countries such as Malaysia, Thailand and Indonesia, the following design parameters are proposed to meet the requirement of the reduction of BOD_5 of more than 90%.

(a) Grid Chamber

Collection System	Overflow Rate ($m^3/m^2/day$)	Average Velocity (m/sec)	Retention Time (sec)	Limit Width (m)
Combined System	3,600	0.3	50	3.0
Separate System	1,800	0.3	50	3.0

(Remark) Material of the tank : R.C
Shape : Rectangular

(b) Primary Sedimentation

Collection System	Overflow Rate ($m^3/m^2/day$)	Average Velocity (m/hr)	Retention Time (hour)	Effective Depth (m)	Length : Width
Combined System	30	Less than 18	3.0	3.3 - 3.8	3:1 – 5:1
Separate System	40	Less than 18	1.5	2.4 -.2.7	3:1 – 5:1

(Remark) Material of the tank : R.C
Shape : Rectangular

(c) Aeration Tank

Design water temperature	:	25 °C
Sludge Retention Time	:	5 days
Hydraulic retention time	:	5.0 hours
Effective Depth of the Tank	:	4.5 m
Width of each tank	:	9.0 m
MLVSS	:	2,800 mg/l
Concentration of return sludge	:	8,000 mg/l
Shape	:	Rectangular

Material of the tank : R.C

(d) Secondary Sedimentation

Over flow rate	:	20 $m^3/m^2/day$
Length : width	:	3:1 – 5:1
Effective depth	:	3.8 – 4.5 m
Detention time	:	5.0 hours
Average velocity	:	less than 18 m/h
Shape	:	Rectangular
Material of the tank	:	R.C

(e) Disinfection Tank

Retention time : 15 minutes for wet weather flow as for combined system
: 15 minutes for daily average flow as for separate system

Shape	:	Rectangular
Material of the tank	:	R.C

(2) Sludge Treatment System

Excess sludge from Water Treatment Process (kg/day)
= $Q_{daily.\ ave}$ (m^3/day) * removed SS (kg /m^3) * 1.0

SS in	:	200 mg/l
SS out	:	50 mg/l
Excess sludge concentration	:	0.8 %

(a) Sludge Reservoir

Retention Time	:	3 days
Effective depth of the tank	:	4.0 m
Shape	:	Circular
Material of the tank	:	R.C

(b) Sludge Thickening Tank

Solid Load	:	90 kg – SS /m^2/day
Effective Depth of the tank	:	4 m
Retention time	:	8 - 16 hour
Shape	:	Circular
Material of the tank	:	R.C

(c) Two Stage Anaerobic Digestion Tank
Inflow Sludge Concentration from Sludge Thickening Tank : 4 %

Retention time :

First Stage	:	20 days for Anaerobic digestion
Second Stage	:	10 days for solid -- liquid separation
Digestion temperature	:	30 to 38
Min. Side Height of tank	:	6 m
Diameter of tank	:	6 – 35 m
Diameter	:	2 * Height
Decrease of Solid	:	40 %
Shape	:	Circular
Material of the tank	:	R.C

(d) Dewatering Machine

Mechanical Dewatering	:	Belt Filter
Inflow Sludge Concentration	:	6 %
Belt Filter		
Filtration velocity	:	100 kg - SS/m/hour
Width of Belt Filter cloth	:	3 m/machine
Operation time per day	:	8 hours

6.5 Sewerage Development of Each sewerage Zone

Sewerage development plans are established for the Nine (9) proposed sewerage zones, and zone-wise description is presented below.

6.5.1 Tau Hu – Ben Nghe – Doi – Te Sewerage Zone (THBNDT)

(1) General

This zone is located at the central part of the inner city area of Ho Chi Minh City and consists of 9 districts of Districts 1, 3, 4, 5, 6, 8, 10, 11 and Tan Binh with total 88 wards.

The canals of Tau Hu, Ben Nghe, Doi and Te flow from west to east and vice versa in this zone. The zone is enclosed by the Saigon river to the east, Te canal and boundary of District 8 to the south, boundary of Tan Hoa – Lo Gom zone to the west and boundary of Nhieu Loc -- Thi Nghe zone to the north.

The zone covers an area of 3,065 ha with an existing population of 1,468,703. The average population density of all wards in this zone is 479 person/ha, which ranges from 114 person/ha of Ward Ben Nghe in District 1 to 1,417 person/ha of Ward 5 in District 8. The existing land use pattern in this zone is summarized as follows.

- The area near by Saigon river in District 1 is mainly occupied by commercial and institutional facilities.

- Many illegal houses are located along four (4) canals of Tau Hu, Ben Nghe, Doi and Te.
- The area of District 4 enclosed by Saigon river, Ben Nhge and Te canals is a residential area with high population density.
- The western part of this zone in District 6 is occupied by residential and commercial area which were developed in old time.

Based on the future land use plan for the year 2020 prepared by Urban Planing Institute (UPI) in PCHCM, no drastic changes of land use are proposed. The legal and illegal houses along and on the canals are planed to be relocated in new developed districts.

The existing and future land use of this zone are compared as shown below.

Land use	Existing	Future (2020)
Residential area including Commercial and Institutional areas	1,969 ha	2,204 ha
Industrial area	195 ha	32 ha
Green Space	72 ha	122 ha
Agricultural area	163 ha	-
Others (roads and water ways)	666 ha	707 ha
Total	3,065 ha	3,065 ha

The projected future population of THBNDT zone is reduced to 1,390,282, and the net population density which is population per inhabitable area (residential, commercial and institutional and industrial areas) is estimated at 622 person/ha. Sewerage system covers the residential, commercial, institutional and small industrial area of 2,236 ha.

(2) Collection System

The existing combined sewer system covers an area of 2,403 ha of the THBNDT sewerage development zone as shown in Fig. F.6.4.

Interceptor sewer along both sides of canals of Tau Hu, Ben Nghe, Doi and Te are proposed. Diameter of interceptor sewer ranges from 500 mm to 2,500 mm.

Conveyance sewer with a diameter of 2,500 mm is proposed from Ward 3 in District 8 to the proposed treatment plant site. Total length of the conveyance sewer is about 6,400 m.

Pumping station with an ultimate capacity of 356 m^3/min. for dry weather flow and 499 m^3/min. for wet weather flow are proposed at the location of Ward 3 in District 8.

Proposed collection sewer length is presented in Table F.6.4.

The collection system of THBNDT sewerage zone is summarized as follows:

Collection system	Combined
Service Area (ha)	2,236
Service population in 2020	1,390,282
Population Density (per./ha)	622
Sewer	
Intereceptor sewer (m)	34,750
Conveyance sewer (m)	6,400
Total	41,150

(3) Treatment Plant

Swamp area enclosed Cay Kho canal to the east and Go Noi canal to the west and south is proposed as the location of wastewater treatment plant for THBNDT sewerage zone. The area is located in Ward Phuoc Loc in Nha Be District.

Conventional activated sludge system with a capacity of 512,000 m^3/day for this zone requires the area of about 37 ha, which includes the sludge treatment system and other auxiliary as well.

The capacity, dimension and other relevant details of each treatment facility is shown below.

(i) Wastewater Treatment

Grit chamber : size 15 m (L) x 2.7 m (W) x 2.1 m (H) @ 5 units
: constructed with R.C.
Primary sedimentation tank : size 51 m (L) x 14 m (W) x 3.8 m (H) @ 24 units
: constructed with R.C.
Aeration tank : size 72 m (L) x 9 m (W) x 4.5 m (H) @ 36 units
: constructed with R.C.
Secondary sedimentation tank : size 70 m (L) x 14 m (w) x 3.8 m (H) @ 24 units
: constructed with R.C.
Disinfection tank : size 54 m (L) x 17 m (W) x 2 m (H) @ 4 units
: constructed with R.C.

(ii) Sludge Treatment

Sludge tank : size 48 m (ϕ) x 4 m (H) @ 4 units
: constructed with R.C.
Sludge thickener : size 24 m (ϕ) x 4 m (H) @ 2 units
: constructed with R.C.

Anaerobic digestion tank	:	size 30 m (ϕ) x 14.5 m (H) @ 6 units
	:	constructed with R.C.
Dewatering room	:	44 m (L) x 45 m (W) x 15 m (H)
	:	constructed with R.C.

(iii) Other Facility

Operation Building	:	100 m (L) x 60 m (W) x 14 m (H)
	:	constructed with R.C.
Chemical Storage House	:	60 m (L) x 50 m (W) x 5 m (H)
	:	constructed with R.C.

The treated effluent is discharged to the Cay Kho canal.

Layout of treatment plant is shown in Fig. F.6.5.

6.5.2 Nhieu Loc – Thi Nghe (NLTN) Sewerage Development Zone

(1) General

This zone is the largest zone among nine (9) sewerage development zones. This zone covers whole or part of 70 wards in seven (7) districts of District 1, 3, 10, Binh Thanh, Go Vap, Phu Nhuan and Tan Binh.

This zone is bounded by Saigon river to the east, boundary of TLBC zone and Tan Son Nhat airport to the north, boundary of THLG zone to the west and boundary of THBNDT zone to the south.

This NLTN zone covers an area of 3,935 ha with an existing population of 1,217,258. Average population density of all wards is 309 person/ha which ranges from 18 person/ha of Ward 15 in District Tan Binh to 873 person/ha of Ward 17 in District Phu Nhuan.

Existing land use patter of this zone is summarized as follows.

- Residential area mainly occupies this zone.
- Military base is located at the northern fringe near the airport.
- Agricultural area is still remained in District Binh Thanh.

Based on the future land use plan, existing industrial area will be relocated to the newly developed industrial zones. Agricultural area is also replaced by the green space.

The existing and future land use of this zone are compared as shown below.

Land use	Existing	Future (2020)
Residential area including Commercial and Institutional areas	3,045 ha	3,084 ha
Industrial area	146 ha	0 ha
Green Space	84 ha	200 ha
Agricultural area	124 ha	4 ha
Others (roads and water ways)	536 ha	647 ha
Total	3,935 ha	3,935 ha

The projected population in the year 2020 is 1,359,569 with a net population density of 441 person/ha. Proposed sewerage system covers the residential, commercial and institutional areas of 3,084 ha.

(2) Collection System

The existing combined sewer system covers an area of 2,132 ha or 69 % of the NLTN sewerage development zone covering the residential, commercial and institutional area as shown in Fig. F.6.6.

The combined sewage collection system is proposed in the remaining area of 952 ha.

Interceptor sewer installed in the operation and maintenance road along both sides of canals of Nhieu Loc and Thi Nghe are proposed.

Conveyance sewer with a diameter of 2,500 mm is proposed from the estuary of Thi Nghe canal to the proposed treatment plant at Ward Phuoc Loc in District Nha Be along roads of Ton Duc Thang and Ben Chuong Duong.

Five (5) pumping stations are proposed as shown below.

Location	Capacity (m^3/min.)	
	Dry Weather Flow	Wet Weather Flow
Do Bridge of Lang canal	95	133
Cong Ly Bridge of Nhieu Loc canal	95	133
Tran Khac Chan Rd.	158	221
Huynh Man Dat Rd.	316	442
Y Bridge	316	442

Proposed collection system of NLTN zone is summarized in Table F.6.4.

The collection system of NLTN sewerage zone is summarized as follows:

Collection system	Combined
Service Area (ha)	3,084
Service population in 2020	1,359,569
Population Density (per./ha)	441
Sewer	
Interceptor sewer (m)	32,033
Conveyance sewer (m)	9,358
Total	41,391

(3) Treatment Plant

Same location of the treatment plant site of THBNDT is proposed as the location of treatment plant for NLTN sewerage zone.

Wastewater and sludge treatment processes are also proposed the same system as those of THBNDT treatment plant. The proposed capacity of NLTN treatment plant is 501,000 m^3/day and its required land space is about 33 ha.

The capacity, dimension and other relevant details of each treatment facility is shown below.

(i) Wastewater Treatment

Grit chamber : size 15 m (L) x 2.6 m (W) x 2.1 m (H) @ 5 units
: constructed with R.C.

Primary sedimentation tank : size 51 m (L) x 14 m (W) x 3.8 m (H) @ 24 units
: constructed with R.C.

Aeration tank : size 72 m (L) x 9 m (W) x 4.5 m (H) @ 36 units
: constructed with R.C.

Secondary sedimentation tank : size 70 m (L) x 14 m (W) x 4.5 m (H) @ 24 units
: constructed with R.C.

Disinfection tank : size 50 m (L) x 18 m (w) x 2 m (H) @ 4 units
: constructed R.C.

(ii) Sludge Treatment

Sludge tank : size 48 m (ϕ) x 4 m (H) @ 4 units
: constructed with R.C.

Sludge thickener : size 24 m (ϕ) x 4 m (H) @ 2 units
: constructed with R.C.

Anaerobic digestion tank : size 30 m (ϕ) x 14.5 m (H) @ 6 units
: constructed with R.C.

Dewatering House : 44 m (L) x 45 m (W) x 15 m (H)
: constructed with R.C.

(iii) Other Facility

Operation Building	:	size 100 m (L) x 60 m (W) x 14 m (H)
	:	constructed with R.C.
Chemical Storage House	:	size 60 m (L) x 50 m (W) x 5 m (H)
	:	constructed with R.C.

The treated effluent is discharged to Cay Kho canal. Layout of treatment plant is shown in Fig. F.6.5.

However, PCHCMC recently started that Cat Lai area in District 2 is also high potential site as the location of treatment plant of Nhieu Loc – Thi Nghe sewerage development zone. The further discussion will be done in the detailed design stage.

6.5.3 Tan Hoa – Lo Gom (THLG) Sewerage Development Zone

(1) General

This Tan Hoa - Lo Gom sewerage zone covers the drainage area of Tan Hoa and Lo Gom canals consisting of 32 wards in five (5) districts of District 6, 8, 11, Tan Binh and Binh Chanh.

This zone is bordered by boundaries of THBNDT and NLTN sewerage zones to the east, Tan Ky Tan Quy Rd. to the north, Binh Long and An Duong Vuong Rds. to the west and Tau Hu canal to the south.

This zone covers an area of 2,447 ha with an existing population of 542,108. The average population density of all wards in this zone is 222 person/ha which ranges from 20 person/ha of Ward X. Binh Tri Dong in District Binh Chanh to 1,299 person/ha of Ward 6 in District 6.

The existing land use pattern in this zone is summarized as follows.

- The residential area mainly occupies in this zone.
- Many small industrial areas are distributed.
- Dam Sen park of about 26 ha is located in this sewerage zone.

Based on the future land use plan for the year 2020, commercial center will be developed along An Duong Vuong Rd.

The existing and future land use of this zone are compared as shown below.

Land use	Existing	Future (2020)
Residential area including commercial and institutional areas	1,385 ha	1,887 ha
Industrial area	162 ha	59 ha
Green area	20 ha	192 ha
Agricultural area	686 ha	3 ha
Others	194 ha	306 ha
Total	2,447 ha	2,447 ha

The projected future population of this zone is 655,540 in the year 2020 with an average net population density of 337 person/ha. Sewerage system covers the residential, commercial, institutional and small industrial areas of 1,946 ha.

(2) Collection System

The existing combined sewer covers an area of 1,191 ha or 61 % of the THLG sewerage zone as shown in Fig. F.6.7.

The combined sewer system will be proposed to collect wastewater from the remaining area of 755 ha. Interceptor sewer is proposed along both sides of Tan Hoa and Lo Gom canals with a total length of 16 km. Conveyance sewer with a diameter of 2,500 mm is installed along Ben Luc river to the treatment plant site.

Pumping stations are proposed at three (3) locations of Ward 20 in District Tan Binh, Ward 14 and Ward 10 in District 6 along Tan Hoa Lo Gom canals. The ultimate capacity of each pumping station is as follows.

Location	Capacity (m^3/min.)	
	Dry Weather Flow	Wet Weather Flow
Hoa Binh Rd. near Tre Bridge	46	65
Hung Vuong Rd. near Ong Buong Bridge	76	107
Nyuyen Van Luong Rd.	122	171

Proposed collection sewer length is presented in Table F.6.4.

The collection system of THLG zone is summarized as follows:

Collection system	Combined
Service Area (ha)	1,946
Service population in 2020	655,540
Population Density (per./ha)	337
Sewer	
Interceptor sewer (m)	16,305
Conveyance sewer (m)	6,564
Total	22,869

(3) Treatment Plant

Agricultural area near-by Ba Goc canal in Ward Tan Kien in District Binh Chanh is proposed as the location of treatment plant for THLG sewerage zone.

Conventional activated sludge system with a capacity of 242,000 m^3/day is proposed with an area of 20 ha, which includes sludge treatment system and other auxiliary as well.

The capacity, dimension and other relevant detailes of each treatment facility is shown below.

(i) Wastewater Treatment

Grit chamber	:	size 15 m (L) x 2.1 m (W) x 2.1 m (H) @ 3 units
	:	constructed with R.C.
Primary sedimentation tank	:	size 42 m (L) x 14 m (W) x 3.3 m (H) @ 16 units
	:	constructed with R.C.
Aeration tank	:	size 51 m (L) x 9 m (W) x 4.5 m (H) @ 24 units
	:	constructed with R.C.
Secondary sedimentation tank	:	size 54 m (L) x 14 m (W) x 4.2 m (H) @ 16 units
	:	constructed with R.C.
Disinfection tank	:	size 45 m (L) x 20 m (W) x 2 m (H) @ 2 units
	:	constructed with R.C.

(ii) Sludge Treatment

Sludge tank	:	size 47 m (ϕ) x 4 m (H) @ 2 units
	:	constructed with R.C.
Sludge thickener	:	size 17 m (ϕ) x 4 m (H) @ 2 units
	:	constructed with R.C.
Anaerobic digestion tank	:	29 m (ϕ) x 14.2 m (H) @ 3 units
	:	constructed with R.C.
Dewatering House	:	size 30 m (L) x 36 m (W) x 15 m (H)
	:	constructed with R.C.

(iii) Other Facility

Operation Building	:	size 70 m (L) x 30 m (W) x 14 m (H)
	:	constructed with R.C.
Chemical Storage House	:	size 40 m (L) x 35 m (W) x 5 m (H)
	:	constructed R.C.

The treated effluent is discharged to Ba Goc river.

Layout of treatment plant is shown in Fig. F.6.8.

6.5.4 Tham Luong – Ben Cat (TLBC) Sewerage Development Zone

(1) General

This zone covers mainly District Go Vap and partially District Binh Thanh consisting of 11 wards.

This zone is enclosed by Saigon river to the east, boundary of District 12 to the north, boundary of Ward 12 in District Go Vap to the west and Tan Son Nhat airport and railway to the south.

This zone covers an area of 1,495 ha with an existing population of 185,696. Existing population density of all wards covered by this zone is 124 person/ha, which ranges from 61 person/ha in Wards 13 of District Binh Thanh to 367 person/ha in Wards 4 of District Go Vap.

Based on the future land use plan, existing military space will be transferred to the residential area. Existing small industrial area is relocated to the new developed districts.

Agriculture area will be also transferred to residential and green space in future.

The existing and future land use of this zone are compared as shown below.

Land use	Existing	Future (2020)
Residential area including commercial and institutional areas	790 ha	1,116 ha
Industrial area	27 ha	0 ha
Green area	21 ha	114 ha
Agricultural area	522 ha	4 ha
Others	135 ha	261 ha
Total	1,495 ha	1,495 ha

Green area of 114 ha, agricultural area of 4 ha and other areas of 260 ha will not be covered by the sewerage system. Hence, sewerage system will cover an area of 1,116 ha consisting of residential, commercial and institutional areas.

The projected future population in the year 2020 is 354,857 with an average net population density of 318 person/ha.

(2) Collection System

The existing combined system covers an area of 421 ha or 38 % of the TLBC sewerage development zone as shown in Fig. F.6.9. The combined sewer system is adopted for this sewerage zone. Intercceptor sewer is proposed along right bank of Ben Cat river. The diameter of proposed interceptor sewer ranges from 700 mm to 1,600 mm. Conveyance sewer of 1,600 mm diameter with a total length of 635 m is installed to the proposed treatment plant site.

Pumping station with a capacity of 42 m^3/min. for dry weather flow and 59 m^3/min. for wet weather flow is proposed on the right bank of Ben Cat river in Ward 17 of District Go Vap.

Proposed collection sewer length is presented in Table F.6.4.

The collection system of TLBC sewerage zone is summarized as follows.

Collection system	Combined
Service Area (ha)	1,116
Service population in 2020	354,857
Population Density (per./ha)	318
Sewer	
Interceptor sewer (m)	9,356
Conveyance sewer (m)	635
Total	9,991

(3) Treatment Plant

The green space enclosed Saigon river to the west, Vam Thuat river to the west and south is proposed as the location of treatment plant for TLBC sewerage zone. The area is located in Ward 17 of District 12.

Conventional activated sludge system with a capacity of 131,000 m^3/day requires an area of about 11 ha, which includes the space of sludge treatment and other auxiliary as well.

The capacity, dimension and other relevant details of each treatment facility is shown

below.

(i) Wastewater Treatment

Grit chamber	: size 15 m (L) x 1.7 m (W) x 2.1 m (H) @ 2 units
	: constructed with R.C.
Primary sedimentation tank	: size 31 m (L) x 9 m (W) x 3.7 m (H) @ 16 units
	: constructed with R.C.
Aeration tank	: size 41 m (L) x 9 m (W) x 4.5 m (H) @ 16 units
	: constructed with R.C.
Secondary sedimentation tank	: 45 m (L) x 9 m (W) x 4.3 m (H) @ 16 units
	: constructed with R.C.
Disinfection tank	: size 45 m (L) x 11 m (W) x 2 m (H) @ 2 units
	: constructed with R.C.

(ii) Sludge Treatment

Sludge tank	: size 35 m (ϕ) x 4 m (H) @ 2 units
	: constructed with R.C.
Sludge thickener	: size 12 m (ϕ) x 4 m (H) @ 2 units
	: constructed with R.C.
Anaerobic digestion tank	: size 24 m (ϕ) x 11.6 m (H) @ 3 units
	: constructed with R.C.
Dewatering House	: size 30 m (L) x 36 m (W) x 15 m (H)
	: constructed with R.C.

(iii) Other Facility

Operation Building	: size 60 m (L) x 30 m (W) x 14 m (H)
	: constructed with R.C.
Chemical Storage House	: size 35 m (L) x 35 m (W) x 5 m (H)
	: constructed with R.C.

The treated effluent is discharged to Saigon river.

Layout of treatment plant is shown in Fig. F.6.10.

6.5.5 Saigon West Sewerage Development Zone

(1) General

This Saigon West sewerage development zone covers an area of 1,315 ha in District 12 consisting of 7 wards.

This zone is enclosed by Tham Luong canal to the east, boundary of District 12 to the south and west and provincial Rd. No. 16 to the north.

The existing population in this sewerage zone is 97,782 with an average population density of all wards of 42, which ranges from 19 person/ha in Ward Tan Chanh Hiep to 76 person/ha in Ward Dong Hung Thuan.

The existing land use patter in this zone is summarized as follows.

- Agricultural area and other areas still occupy about 60 % of this zone.
- Residential area is now under developing.

Base on the future land use plan, all agricultural area will be conveyed to the residential, commercial and institutional areas.

The existing and future land use of this zone are compared as shown below.

Land use	Existing	Future (2020)
Residential area including commercial and institutional areas	531 ha	1,186 ha
Industrial area	23 ha	0 ha
Green area	0 ha	0 ha
Agricultural area	626 ha	0 ha
Others	135 ha	129 ha
Total	1,315 ha	1,315 ha

Future residential area including commercial and institutional areas of 1,186 ha will be covered by sewerage system.

The projected future population in the year 2020 is 398,000 with an average net population density of 336 person/ha.

(2) Collection System

The separate sewer system is proposed to collect wastewater of SW sewerage development zone. Main sewer is proposed along National Rd. No. 1 and Provincial Rd. 22. Two (2) pumping stations are proposed to convey wastewater to the treatment plant.

The capacity of two (2) pumping stations are 32 m^3/min. and 54 m^3/min. respectively. The location of main sewer and two (2) pumping stations are shown in Fig. F.6.11.

Proposed collection sewer length is presented in Table F.6.4.

The collection system of SW sewerage zone is summarized as follows:

Collection system	Separate System
Service Area (ha)	1,186
Service population in 2020	398,000
Population Density (per./ha)	336
Sewer (m)	
Secondary & tertiary	63,120
Main	143,066
Conveyance	2,899
Total	209,085

(3) Treatment Plant

Green space enclosed May 19 canal and provincial Rd. 13 and Tan Ky Tan Quy Rd. is proposed as the location of the treatment plant for SW sewerage zone.
Conventional activated sludge system with a capacity of 111,000 m^3/day is proposed. The required area for the treatment plant including wastewater treatment, sludge treatment and other auxiliary facility is about 11 ha.

The dimension and other relevant details of each treatment facility is shown below.

(i) Wastewater Treatment

Grit chamber	:	size 15 m (L) x 2.9 m (W) x 1 m (H) @ 2 units
	:	constructed with R.C.
Primary sedimentation tank	:	size 27 m (L) x 8.6 m (W) x 2.5 m (H) @ 12 units
	:	constructed with R.C.
Aeration tank	:	size 47 m (L) x 9 m (W) x 4.5 m (H) @ 12 units
	:	constructed with R.C.
Secondary sedimentation tank	:	50 m (L) x 14 m (W) x 4.2 m (H) @ 8 units
	:	constructed with R.C.
Disinfection tank	:	size 33 m (L) x 9 m (W) x 2 m (H) @ 2 units
	:	constructed with R.C.

(ii) Sludge Treatment

Sludge tank	: size 32 m (ϕ) x 4 m (H) @ 2 units
	: constructed with R.C.
Sludge thickener	: size 11 m (ϕ) x 4 m (H) @ 2 units
	: constructed with R.C.
Anaerobic digestion tank	: size 22 m (ϕ) x 11 m (H) @ 2 units
	: constructed with R.C.
Dewatering House	: size 30 m (L) x 26 m (W) x 15 m (H)
	: constructed with R.C.

(iii) Other Facility

Operation Building	: size 40 m (L) x 35 m (W) x 14 m (H)
	: constructed with R.C.
Chemical Storage House	: size 32 m (L) x 20 m (W) x 5 m (H)
	: constructed with R.C.

The treated effluent is discharged to May 19 canal.

Layout of treatment plant is shown in Fig. F.6.12.

6.5.6 Saigon South (SS) Sewerage Development Zone

(1) General

This sewerage development zone covers the future developed residential area of District 7 consisting of 11 wards.

This zone is bordered by Te canal to the north, Ong Lon river to the west, Phu Xuan river to the south and provincial Rd. 15 and boundary of residential area development to the east.

This zone covers an area of 1,555 ha with an existing population of 80,960. The average population density of all wards covered by this zone is 43 person/ha with ranging from 5 person/ha in Ward Tan Phong to 137 person/ha in Ward Tan Qui.

The existing land use patter in this zone is summarized as follows.

- Agricultural area and other areas still occupy more than 83% of this zone.
- Residential area is developed along Te canal and provincial Rd. 15.

Base on the future land use plan, all agricultural area will be conveyed to the residential,

commercial and institutional areas. And green space will also be developed. The existing and future land use of this zone are compared as shown below.

Land use	Existing	Future (2020)
Residential area including commercial and institutional areas	254 ha	1,162 ha
Industrial area	7 ha	0 ha
Green area	0 ha	131 ha
Agricultural area	1,201 ha	0 ha
Others	93 ha	262 ha
Total	1,555 ha	1,555 ha

Future residential area including commercial and institutional areas of 1,162 ha will be covered by sewerage system.

The projected future population in the year 2020 is 320,000 with an average net population density of 275 person/ha.

(2) Collection System

No combined sewer was developed in SS sewerage zone. The separate system is proposed to collect wastewater of this zone. Main sewer is proposed along Te canal, provincial Rds. 15 and 34 and communal Rd. 1. Diameter of main sewer ranges from 600 mm to 1,100 mm with a total length of 165 km. Pumping station at the crossing communal Rd. 1 and Thay Tieu canal, and along Provincial Rd. 15 in Ward Phu Thuan with a capacity of 26 m^3/min. and 43 m^3/min. are proposed. The location of main sewer and pumping station are shown in Fig. F.6.13.

Proposed collection sewer length is presented in Table F.6.4.

The collection system of SS zone is summarized as follows.

Collection system	Separate System
Service Area (ha)	1,162
Service population in 2020	320,000
Population Density (per./ha)	275
Sewer (m)	
Secondary & tertiary	71,424
Main	165,168
Conveyance	0
Total	236,592

(3) Treatment Plant

Green space enclosed by Dia and Roi rivers in Ward Phuoc Kien of District Nha Be is

proposed as the location of the treatment plant for SS sewerage zone.

Conventional activated sludge system with a capacity of 89,000 m^3/day is proposed. The required area for the treatment plant including wastewater treatment, sludge treatment and other auxiliary facility is about 8 ha.

The dimension and other relevant details of each treatment facility is shown below.

(i) Wastewater Treatment

Grit chamber	: size 15 m (L) x 2.3 m (W) x 1 m (H) @ 2 units
	: constructed with R.C.
Primary sedimentation tank	: size 31 m (L) x 90 m (W) x 2.5 m (H) @ 8 units
	: constructed with R.C.
Aeration tank	: size 56 m (L) x 9 m (W) x 4.5 m (H) @ 8 units
	: constructed with R.C.
Secondary sedimentation tank	: size 60 m (L) x 18 m (W) x 4.3 m (H) @ 4 units
	: constructed with R.C.
Disinfection tank	: size 32 m (L) x 14 m (W) x 2 m (H) @ 2 units
	: constructed with R.C.

(ii) Sludge Treatment

Sludge tank	: size 29 m (ϕ) x 4 m (H) @ 2 units
	: constructed with R.C.
Sludge thickener	: size 10 m (ϕ) x 4 m (H) @ 2 units
	: constructed with R.C.
Anaerobic digestion tank	: 21 m (ϕ) x 10.2 m (H) @ 3 units
	: constructed with R.C.
Dewatering House	: size 30 m (L) x 26 m (W) x 15 m (H)
	: constructed with R.C.

(iii) Other Facility

Operation Building	: size 40 m (L) x 25 m (W) x 14 m (H)
	: constructed with R.C.
Chemical Storage House	: size 25 m (L) x 20 m (W) x 5 m (H)
	: constructed with R.C.

The treated effluent is discharged to Dia River.

Layout of treatment plant is shown in Fig. F.6.14.

6.5.7 Saigon North I (SN-I) Sewerage Development Zone

(1) General

This Saigon North I (SN-I) sewerage zone covers an area of 2,324 ha in District Thu Duc consisting of 12 wards.

This zone is enclosed by National Rd. Hanoi to the east, boundary of the industrial area to the north and green belt along Saigon river to the west and south.

The existing population in this sewerage zone is 171,165 with an average population density of 74 person/ha.

The existing land use patter in this zone is summarized as follows.

- Agricultural area occupies about 70 % of this zone.
- Residential area is developed in the hilly area and also areas along the main roads.

Base on the future land use plan, all agricultural area will be conveyed to the residential, commercial and institutional areas.

The existing and future land use of this zone are compared as shown below.

Land use	Existing	Future (2020)
Residential area including commercial and institutional areas	642 ha	1,968 ha
Industrial area	56 ha	0 ha
Green area	0 ha	10 ha
Agricultural area	1,624 ha	3 ha
Others	2 ha	343 ha
Total	2,324 ha	2,324 ha

Future residential area including commercial and institutional areas of 1,968 ha will be covered by sewerage system.

The projected future population in the year 2020 is 500,000 with an average net population density of 254 person/ha.

(2) Collection System

The separate sewer system is proposed to collect wastewater of SN-I sewerage development zone. Main sewer is proposed along main roads of Quoc Lo 13, Kha Van Can, To Ngoc Van and Vo Van Ngan. Three (3) pumping stations along Quoc Lo 13, Kha Van Can and the junction of Kha Van Can and To Ngoc Van are required to lift up

wastewater to the treatment plant. The capacity of three (3) pumping station are 14 m^3/min., 41 m^3/min. and 68 m^3/min. The location of three (3) pumping stations and the location of the main sewer are shown in Fig. F.6.15.

Proposed collection sewer length is presented in Table F.6.4.

The collection system of SN-1 zone is summarized as follows.

Collection system	Separate System
Service Area (ha)	1,968
Service population in 2020	500,000
Population Density (per./ha)	254
Sewer (m)	
Secondary & tertiary	101,472
Main	234,654
Total	336,126

(3) Treatment Plant

Green space enclosed by Dao canal and National Rd. Hanoi is proposed as the location of the treatment plant for SN-1 sewerage zone.

Conventional activated sludge system with a capacity of 139,000 m^3/day is proposed. The required area for the treatment plant including wastewater treatment, sludge treatment and other auxiliary facility is about 10 ha.
The dimension and other relevant details of each treatment facility is shown below.

(i) Wastewater Treatment

Grit chamber : size 15 m (L) x 2.4 m (W) x 1 m (H) @ 3 units
: constructed with R.C.
Primary sedimentation tank : size 27 m (L) x 9 m (W) x 2.4 m (H) @ 15 units
: constructed with R.C.
Aeration tank : size 47 m (L) x 9 m (W) x 4.5 m (H) @ 15 units
: constructed with R.C.
Secondary sedimentation tank : size 51 m (L) x 14 m (W) x 4.1 m (H) @ 10 units
: constructed with R.C.
Disinfection tank : size 40 m (L) x 9 m (W) x 2 m (H) @ 2 units
: constructed with R.C.

(ii) Sludge Treatment

Sludge tank : size 36 m (ϕ) x 4 m (H) @ 2 units

	: constructed with R.C.
Sludge thickener	: size 13 m (ϕ) x 4 m (H) @ 2 units
	: constructed with R.C.
Anaerobic digestion tank	: size 24 m (ϕ) x 11.8 m (H) @ 3 units
	: constructed with R.C.
Dewatering House	: size 30 m (L) x 20 m (W) x 15 m (H)
	: constructed with R.C.

(iii) Other Facility

Operation Building	: size 35 m (L) x 30 m (W) x 14 m (H)
	: Constructed with R.C.
Chemical Storage House	: size 40 m (L) x 20 m (W) x 5 m (H)
	: constructed with R.C.

The treated effluent is discharged to Dao canal.

Layout of treatment plant is shown in Fig. F.6.16.

6.5.8 Saigon North II (SN-II) Sewerage Development Zone

(1) General

This Saigon North II (SN-II) sewerage development zone covers an area of 1,152 ha in District 9 with 8 wards.

This zone is enclosed by the national road Hanoi to the west, Chiec and Dong Nhien canals to the south, Kinh Ong Hong and Dinh canals to the east and Cau canal to the north.

The existing population of this SN-II sewerage zone is 63,410 with an average population density of 55 person/ha.

The existing land use pattern in this zone is summarized as follow.

- Agricultural area occupies more than 60 % of this zone.
- Residential area is developed only along the main roads.

Based on the future land use plan, all agricultural area will be conveyed to the residential, commercial and institutional areas.

The existing and future land use of this zone are compared as shown below.

Land use	Existing	Future (2020)
Residential area including commercial and institutional areas	372 ha	1,027 ha
Industrial area	37 ha	0 ha
Green area	0 ha	0 ha
Agricultural area	741 ha	0 ha
Others	2 ha	125 ha
Total	1,152 ha	1,152 ha

Future residential area including commercial and institutional areas of 1,027 ha will be covered by sewerage system.

The projected future population in the year 2020 is 196,500 with an average net population density of 191 person/ha.

(2) Collection System

The separate sewer system is proposed to collect wastewater of SN-II sewerage development zone. Main sewer is proposed along main roads. Two (2) pumping stations are proposed to transfer wastewater to the treatment plant. The capacity of two (2) pumping stations are 16 m^3/min. and 27 m^3/min. respectively. The location of two (2) pumping stations and main sewer are shown in Fig. F.6.17

Proposed collection sewer length is represented in Table F.6.4.

The collection system of SN-II zone is summarized as follows.

Collection system	Separate System
Service Area (ha)	1,027
Service population in 2020	196500
Population Density (per./ha)	191
Sewer (m)	
Secondary & tertiary	55,296
Main	127,872
Total	183,168

(3) Treatment Plant

Green space near-by Con canal is proposed as the location of treatment plant for SN-II sewerage zone.

Conventional activated sludge system with a capacity of 55,000 m^3/day is proposed. The required area for the treatment plant including wastewater treatment, sludge treatment and other auxiliary facility is about 7 ha.

The dimension and other relevant details of each treatment facility is shown below.

(i) Wastewater Treatment

Grit chamber	: size 15 m (L) x 1.4 m (W) x 1 m (H) @ 2 units
	: constructed with R.C.
Primary sedimentation tank	: size 27 m (L) x 9 m (W) x 2.5 m (H) @ 6 units
	: constructed with R.C.
Aeration tank	: size 46 m (L) x 9 m (W) x 4.5 m (H) @ 6 units
	: constructed with R.C.
Secondary sedimentation tank	: size 56 m (L) x 14 m (W) x 3.8 m (H) @ 4 units
	: constructed with R.C.
Disinfection tank	: size 25 m (L) x 6 m (W) x 2 m (H) @ 2 units
	: constructed with R.C.

(ii) Sludge Treatment

Sludge tank	: size 23 m (ϕ) x 4 m (H) @ 2 units
	: constructed with R.C.
Sludge thickener	: size 8 m (ϕ) x 4 m (H) @ 2 units
	: constructed with R.C.
Anaerobic digestion tank	: size 18 m (ϕ) x 8.7 m (H) @ 3 units
	: constructed with R.C.
Dewatering House	: size 23 m (L) x 20 m (W) x 15 m (H)
	: constructed with R.C.

(iii) Other Facility

Operation Building	: size 20 m (L) x 20 m (W) x 14 m (H)
	: constructed with R.C.
Chemical Storage House	: size 20 m (L) x 15 m (W) x 5 m (H)
	: constructed with R.C.

The treated effluent is discharged to Con canal.

Layout of treatment plant is shown in Fig. F.6.18.

6.5.9 Saigon East (SE) Sewerage Development Zone

(1) General

This Saigon East (SE) sewerage development zone covers an area of 1,690 ha in District 2 with 12 wards. This area includes the new city center which will be developed at Thu

Thiem.

This zone is enclosed by Saigon river to the west and south, proposed inner ring road to the east and Rd. Duong So 33 to the north.

The existing population in this zone is 68,100 with an average population density of 40 person/ha.
The existing and future land use of this zone are compared as shown below.

Land use	Existing	Future (2020)
Residential area including commercial and institutional areas	455 ha	1,515 ha
Industrial area	5 ha	0 ha
Green area	0 ha	0 ha
Agricultural area	1,138 ha	0 ha
Others	92 ha	175 ha
Total	1,690 ha	1,690 ha

Future residential area including commercial and institutional areas of 1,515 ha will be covered by sewerage system.

The projected future population in the year 2020 is 600,000 with an average net population density of 396 person/ha.

(2) Collection System

The separate sewer system is proposed to collect wastewater of SE sewerage development zone. Main sewer is proposed along main roads of Luong Dinh Cua and Tinh Lo 25. Three (3) pumping stations are proposed to transfer wastewater to the treatment plant. The capacity of three (3) pumping stations are 16 m^3/min., 49 m^3/min. and 81 m^3/min. The location of three (3) pumping stations and main sewer are shown in Fig. F.6.19.

Proposed collection sewer length is presented in Table F.6.4.

The collection system of SE zone is summarized as follows.

Collection system	Separate System
Service Area (ha)	1,515
Service population in 2020	600,000
Population Density (per./ha)	396
Sewer (m)	
Secondary & tertiary	81,120
Main	187,590
Total	268,710

(3) Treatment Plant

Green space enclosed by Saigon river, Giong Ong To river and Ca Tre Nho canal is proposed as the location of treatment plant for SE sewerage zone.

Conventional activated sludge system with a capacity of 167,000 m^3/day is proposed. The required area for the treatment plant including wastewater treatment, sludge treatment and other auxiliary facility is about 12 ha.

The dimension and other relevant details of each treatment facility is shown below.

(i) Wastewater Treatment

Grit chamber	:	size 15 m (L) x 2.9 m (W) x 1 m (H) @ 2 units
	:	constructed with R.C.
Primary sedimentation tank	:	size 29 m (L) x 9 m (W) x 2.5 m (H) @ 16 units
	:	constructed with R.C.
Aeration tank	:	size 53 m (L) x 9 m (W) x 4.5 m (H) @ 16 units
	:	constructed with R.C.
Secondary sedimentation tank	:	size 57 m (L) x 18 m (W) x 4.2 m (H) @ 8 units
	:	constructed with R.C.
Disinfection tank	:	size 32 m (L) x 14 m (W) x 2 m (H) @ 2 units
	:	constructed with R.C.

(ii) Sludge Treatment

Sludge tank	:	size 39 m (ϕ) x 4 m (H) @ 2 units
	:	constructed with R.C.
Sludge thickener	:	size 14 m (ϕ) x 4 m (H) @ 2 units
	:	constructed with R.C.
Anaerobic digestion tank	:	size 26 m (ϕ) x 12.6 m (H) @ 3 units
	:	constructed with R.C.
Dewatering House	:	size 30 m (L) x 20 m (W) x 15 m (H)
	:	constructed with R.C.

(iii) Other Facility

Operation Building	:	size 60 m (L) x 30 m (W) x 14 m (H)
	:	constructed with R.C.
Chemical Storage House	:	size 40 m (L) x 24 m (W) x 5 m (H)
	:	constructed with R.C.

The treated effluent is discharged to Saigon river.

Layout of treatment plant is shown in Fig. F.6.20.

7. On-site Sanitation Improvement System

(1) General

On-site sanitation improvement system is proposed in the wards mainly in rural areas with a population of less than 200 person/ha and without sewerage system.

Contact aeration type of Jouka-sou with the capacity of 20 mg/l of effluent BOD_5 is proposed for on-site sanitation improvement system. (refer to Fig. F.3.2)

It is set under the ground of each house by the owner of the house or the developer of the developing area.

Purchasing, installing, connecting discharge pipe to the public water bodies and O&M cost are basically attributed to the owner of the house.

Treated water by Jouka-sou is discharged into the public water bodies near the house.

Accumulated sludge in Jouka-sou is withdrawn periodically and treated, on the other hand.

Therefore, on site sanitation improvement system needs sludge treatment.

(2) Cost estimation of sludge treatment in on-site sanitation improvement system

The covered population in the year 2020 by on-site sanitation improvement system, is 1,656,237 person (22 % of total population in the study area in the year 2020).

Unit sludge generation from Jouka-sou is assumed 0.05 m^3/person/year.
Therefore, sludge generation from on-site sanitation improvement system is estimated at 91,812 m^3/year (= 7,651m^3/month = 252 m^3/day).

Two cases are considered to treat generated sludge from on-site sanitation improvement system as below.

Case 1 : Construction of sludge treatment plant only for on-site sanitation improvement system
Case 2 : Sludge transportation to wastewater treatment plants for sewerage system areas

Case 1 : Construction of sludge treatment plant only for on-site sanitation improvement System

252 m^3/day of sludge generation from on-site sanitation improvement system areas is considered equal to that from an activated sludge process plant with capacity of 13,400 m^3/day.

Construction cost, O&M cost and land acquisition cost are estimated.

(i) Construction cost of sludge treatment plant is 1/3 of that of wastewater treatment plant with the capacity of 13,400 m^3/day. : 52,072 million VND

Sludge treatment system consists of sludge reservoirs, thickeners, digestion tanks and dewatering machines.

(ii) Construction cost of wastewater treatment plant

Actually, in case of constructing a sludge treatment plant only for on-site sanitation improvement system, wastewater treatment plant to treat separated liquid from sludge treatment facilities is necessary.

The quantity of separated liquid is estimated approximately 90 % of initial sludge volume and the concentration of the substrates such as BOD_5, COD, SS, nitrogen and phosphate are sometimes higher than these in domestic wastewater.

If separated water is treated in the sludge treatment plant site to the accepted level, additional construction cost of wastewater treatment plant is estimated 3,013 million VND by using batch activated sludge process under the conditions as below.

- Capacity of wastewater treatment plant : 226 m^3/day (252 m^3/day * 0.9)
- Wastewater treatment process : Batch activated sludge process * 2 tanks+coagulation
- Construction cost : 1,000 US dollars/m^3

Another way of treating separated liquid from sludge treatment facilities is to

transport it by cars or pumps to the wastewater treatment plants for sewerage system areas. In this case, however, it would be better to transport the raw sludge generated from on-site treatment system directly to the wastewater treatment plants for sewerage system areas.

(iii) Car purchase cost : 19,200 million VND for 48 vacuum cars

Car purchase cost is base on the assumptions as below.

- Capacity of vacuum car : 2 m^3/car
- Net working rate of cars per day : 2 times/car/day
- Operation days per month : 20 days/car/month
- Unit purchasing cost : 30,000 US dollars/vacuum car
- 1 US dollar = 13,332 VND

(iv) Site Preparation : 7,689 million VND for 9,677 m^2 (@ 7,946 million VND/ha)

(v) Land acquisition cost :

- Required area for sludge treatment plant is 60 % of that for wastewater treatment plant with the capacity of 13,400 m^3/day due to necessities of auxiliary facilities such as parking lot, car-washing lot, separated liquid treatment plant and so on. : 9,677 m^2
- Unit land acquisition cost : 19,300 VND/m^2
- Land acquisition cost for sludge treatment plant : 187 million VND

(vi) Engineering cost : 5,738 million VND
(7 % of ((i)+(ii)+(iii)+(iv))

(vii) Administration cost : 1,232 million VND
(1.5 % of ((i)+(ii)+(iii)+(iv)+(v))

(viii) Physical contingency : 8,197 million VND
(10 % of ((i)+(ii)+(iii)+(iv))

Therefore, cost estimation of a sludge treatment plant for on-site sanitation improvement system is as follows.

(unit : million VND)

Construction Cost [a]				
Sludge Treatment Plant	WWTP	Car Purchase	Site Preparation	
52,052	3,013	19,200	7,689	
Land Acquisition Cost [b]	Engineering Cost (a)*0.07	Administration Cost {(a) + (b)} *0.015	Physical Contingency (a) *0.1	Total
187	5,738	1,232	8,197	97,328

(ix) Annual O&M cost for sludge treatment plant will be 0.7 times of that of wastewater treatment plant with the capacity of 13,400 m^3/day : 1,147 million VND/year

Case 2 : Sludge transportation to wastewater treatment plants for sewerage system areas

The quantity of sludge generated from on-site treatment system is estimated only 0.7 % of that from sewerage system areas.
From view point of the quality of separated liquid mentioned above, it would be better to transport the raw sludge generated from on-site sanitation improvement system directly to larger wastewater treatment plants for sewerage system areas such as NLTN, THLG, THBNDT, SE or SN- H wastewater treatment plant.

In this case, the sludge treatment cost for on-site sanitation system is estimated as below.

(i) Additional construction cost of sludge treatment plant : 24,743 million VND

Estimated conditions are as below.

- Construction cost of sludge treatment facilities is that of 1/3 of wastewater treatment plant.

- Additional cost of wastewater treatment facilities to treat separated liquid from sludge treatment facilities for on-site sanitation improvement system would be ignored because the amount of it is very small compared to total volume of domestic wastewater.

While total wastewater of wastewater treatment from sewerage system areas is estimated 1,947,000 m^3/day, separated liquid volume from sludge treatment facilities for on-site sanitation improvement system is estimated 226 m^3/day, on

the other hand.
Total additional cost would be estimated as below.

- Total construction cost of wastewater treatment plants for sewerage system area : 10,604,325 million VND (refer to Table J.2.1)

- Construction cost regarding sludge treatment facilities for sewerage system area : 3,534,775 million VND
  (1/3 * total construction cost of wastewater treatment plants)

-- Additional cost of sludge treatment for on-site sanitation improvement system
  : 0.7 % of construction cost regarding sludge treatment facilities.

(ii) Vacuum car purchase cost : 19,200 million VND

(iii) Site preparation : 7,946 million VND

Total area for wastewater treatment plant for sewerage system is 149 ha. (refer to Table I.2.1)

Additional area of sludge treatment facilities for on-site sanitation improvement system is estimated 1.0 ha (= 0.7 % * 149 ha = 10,000 m^2).

Therefore, site preparation of additional site for sludge treatment facilities for on-site sanitation improvement system is estimated 7,946 million VND (@ 7,946 million VND/ha)

(iv) Land acquisition cost : 193 million VND (@ 19,300 VND/m^2 *10,000 m^2)

(v) Engineering cost : 3,632 million VND (7 % of ((i)+(ii)+(iii))

(vi) Administration cost : 781 million VND (1.5 % of ((i)+(ii)+(iii)+(iv))

(vii) Physical contingency : 5,189 million VND (10 % of ((i)+(ii)+(iii))

Therefore, total additional cost for sludge treatment for on-site sanitation improvement system is 41,208 million VND.

(unit : million VND)

Construction Cost [a]				
Sludge Treatment Plant	WWTP	Car Purchase	Site Preparation	
24,743	Ignored	19,200	7,946	
Land Acquisition Cost [b]	Engineering Cost (a) *0.07	Administration Cost {(a) + (b)} *0.015	Physical Contingency (a) *0.1	Total
193	3,632	781	5,189	61,684

(viii) Additional O&M cost for sludge treatment plant for on-site sanitation improvement system areas

Additional O&M cost of wastewater treatment plant : 484 million VND/year

Estimated conditions are as below.

- O&M cost of sludge treatment facilities : 1/2 of wastewater treatment plant.
- Total annual O&M cost of wastewater treatment plants for sewerage system areas : 96,722 million VND/year (refer to Table. II.4.1)
- O&M cost regarding sludge treatment facilities for sewerage system areas : 48,361 million VND (1/2 * total O&M cost of wastewater treatment plants for sewerage treatment areas)
- Additional cost of sludge treatment for on-site sanitary improvement system : 484 million VND
  (1.0 % of O&M cost regarding sludge treatment facilities for sewerage system areas, including vacuum car maintenance).

From the comparisons of case 1 and 2, case 2, sludge transportation to wastewater treatment plants for sewerage system areas, is far more economical.

Therefore, sludge generated from on-site sanitation improvement system areas is recommended to be directly transported to larger wastewater treatment plants for sewerage system areas such as NLTN, TBLG, THBNDT, SE or SN- II wastewater treatment plant by vacuum cars.