CHAPTER 4 IMPROVEMENT PLAN FOR SEWERAGE DEVELOPMENT

4.1 Sewerage Development

4.1.1 Current Sanitation Situation

(1) Overview

At present, there is no proper sewerage system in Haiphong. Most of the households in the urban area have septic tanks, though septic tank maintenance is inappropriate and inadequate. These septic tanks only receive black water while all gray water is discharged either into surface drains or to the ambient environment. Some households in urban area and most households in semi-urban area have bucket latrine, which is not hygienic at all. The rest use some sort of pit latrines.

The urban areas have a combined sewer network. In the three urban districts, this network is extensive, around 200 km in total. This collects overflows from septic tanks, all gray water and also storm water. These combined sewers then discharge into surface water bodies causing extreme surface water pollution.

(2) Incidences of Waterborne Diseases Due to Unsanitary Conditions

No statistics are available for waterborne diseases in Haiphong, but based on national data it is estimated that the number of cases leading to consultations with doctors or hospitalisation varies between 10,000 and 15,000 each year. This estimate is based on registered cases. However, it is estimated that there are a much greater number of unregistered cases.

(3) Current Water Quality

Poor surface water quality exists in parts of the Study Area. The worst surface water pollution exists in the 3 urban districts (Hong Bang District, Ngo Quyen District, and Le Chan District). Surface water pollution also exists in other areas, including Kien An district and Do Son town, but the extent of the pollution is localized.

There also are natural lakes in the 3 urban districts. However, there are several ponds and lakes, which are artificially fed from the network of rivers and channels and constitute parts of the city's drainage system. The system of lakes and channels in the 3 urban districts has 2 main functions:

- to store storm water during high tides
- to store and treat wastewater

Some of the lakes are also used for aquaculture. They are also important from landscape and recreational points of view. Wastewater is directly discharged from the sewer system to these lakes.

The conditions of the lakes and channels are generally poor. Typical features in most of the lakes and channels are:

- bad smell
- dark green to greyish black colour
- mortality of fish
- solid waste on the lake surface and shores
- gas discharges (bubbling) from the bottom

The biological oxygen demand (BOD) is high in all lakes and channels. The levels of BOD are as high as 150 mg/l (Tien Nga Lake), several times higher than the VN Standard of 25 mg/l. High ammonia values are reported in the lakes and most probably caused by organic pollution from sewage. The levels of nutrients are in the order of 50 mg/l for T-N (Tien Nga and Ho An Bien Lakes) and 5 mg/l for T-P (Tien Nga Lake). Some lakes and channels like Tien Nga Lake and An Kim Hai Channel are already exhibiting the characteristics of eutrophication and are densely covered by water hyacinth.

No data is available concerning degradation of groundwater quality. However, the groundwater table is very high in Haiphong because of the close proximity of the sea. Contamination from the polluted surface waters certainly exists, as well as from septic tanks not connected to the sewerage network in areas with high population densities. Groundwater pollution will increase in the future, if measures to reduce surface water pollution are not implemented, and if wastewater is not collected from septic tanks.

(4) Nightsoil Collection and Disposal

The present practice for nightsoil collection is not at all hygienic. The collection is carried out between 11 PM and 4 AM. The URENCO staff collect nightsoil manually and provides it to farmers of sub-urban areas, as there is a long tradition and great demand for nightsoil as fertilizer. There is no treatment available for nightsoil in Haiphong. There are 5 tank trucks used for nightsoil collection. The capacity of each truck is 3 m^3 or 5 tons. The present collection frequency is once every 2 days from each bucket latrines covered by URENCO.

The exact number of remaining bucket latrines is not known. Estimates vary from 2,000 to 3,000, with a median figure at 2,500. URENCO now collects nightsoil from 1,600 bucket-latrines. Approximate nightsoil generation is about 10 tons/day. It is a point of worry from public health aspect that not all bucket latrines in the 3 old urban districts are serviced by URENCO; some of the owners remove the nightsoil by themselves and sell it to farmers.

There is no separate charge for nightsoil collection, this is included in the solid waste collection fee. The solid waste collection fee varies between 500 and 1,000 VND per person.

There are eight public toilets within the 3 old urban districts. These are managed by URENCO's Environment Service Dept. There is a user fee for the use of public toilets. The fees are VND500 for urination and VND1,000 for defecation.

Bucket latrine conversion program

HPWSSP started replacement of bucket latrines with pour-flush toilets and septic tanks in 1995, and the programme is continuing. Original program target was to eliminate night soil collection service and bucket latrines by the end of 2000. However, the target year has now been revised to 2003. At the beginning of the program, there were about 14,000 bucket-latrines in the 3 old urban districts. In the first year, 2,486 latrines were upgraded. In 1999, 784 bucket-latrines were converted into septic tanks. The target for 2000 is to convert 660 bucket-latrines.

It is estimated that the conversion of one bucket-latrine costs about VND4 million. The contribution towards this cost by HPWSSP is about US$100 per septic tank. There was also some subsidy from Haiphong PC and the total subsidy was up to 75 % of the conversion cost. Unfortunately, this subsidy program will be stopped by 2000, after which, it is assumed that another 2,000 bucket-latrines will remain in operation.

Revolving fund

In the on-going 1B project financed by the World Bank (WB), there is a portion to upgrade existing bucket latrines into pour-flush toilets with septic tank. However, it is proposed that there will be no subsidy. Instead the money will be loaned from a revolving fund and borrowers will have to repay that along with interest. It was also agreed that the City Women's Union would be responsible for management of the revolving fund.

In the 1B project cost estimate, the sanitation improvement portion allocation is US$1.0 million. Out of US$1 million fund, US$300,000 will be used for a sanitation survey, and the rest will be used for bucket latrine conversion.

The loan will be given to each member of a group, the group as a whole will be responsible for each individual's loan. The system is based upon the Grameen Bank model. Each family will receive around VND2 million, the repayment time is 2 years and the interest rate is 0.6 % per month. Because of the more generous subsidy system that previously applied, the successfulness of this program is questionable. It must be noted that the remaining 2,000 families are the poorest of the poor, since they failed to avail themselves of the favorable conditions that had existed for the last 6 years.

Kien An

The total number of households in Kien An is 11,000 and out of that 6,000 households are in the central area. In the central area, 40 % of households have septic tanks and 48 % have semi-septic tanks. The remaining 22 % use bucket latrines. In the sub-urban areas, overhang latrines and pit latrines are common. Usually local farmers collect the nightsoil to use as fertilizer. There are 25 community latrines managed by KA PWC. A total of 150 of these are bucket latrines. There is no user fee collected for the use of these latrines. There is no plan to start a bucket latrine conversion program. In rural areas, people use husk in their pit latrines which creates a kind of compost latrine.

Do Son

There are about 3,000 households, 100 state run hotels and 300 private hotels in Do Son area. All hotels are served with septic tanks. About 95 % of households are also using septic tanks. The prevalence of the bucket latrine is only 5 % of the households. Households clean their bucket latrines and sell the nightsoil to farmers. There are 4 public toilets managed by DS PWC and the users do not have to pay any charge. There is a plan to install 5 new mobile toilets for tourist use. In 1985, a bucket latrine conversion program was funded by the EC. Under that program, most of the then existing bucket latrines were upgraded. There is no new plan for a bucket latrine conversion program.

(5) Septic Tank Sludge Collection and Disposal

1) Introduction

The septic tank is an on-site, water-borne sanitation system. A septic tank does not dispose of wastes, it only helps to separate and digest the solid matters. The liquid effluent flowing out of the tank remains to be disposed of, either by a soakage pit or by a sewer pipe; and the sludge accumulated in the tank must be periodically removed.

Septic tanks are widely used in Haiphong. Most of them have a sewer connection. Septic tanks in Haiphong are underground structures with one, two or three chambers. Private septic tanks are generally sited directly underneath toilets and shared septic tanks just below ground in the back of block of flats. The tank is made of relatively watertight materials built with brick and cement or concrete. The tanks usually receive only wastewater from toilets, i.e. foul sewage or black water. In the tank, the influent organic material, both liquid and solids, is digested anaerobically leaving a reduced soluble organic concentration. Inorganic solids, such as sand or grit, settle to the bottom of the tank as sludge, as well as any inert organic solids in the wastewater discharge.

Tanks should be inspected regularly to establish desludging needs. A well-operated septic tank provides about 30 - 50 % BOD and 50 - 70 % solids reduction (Appropriate Technology for the Treatment of Wastewater for Small Rural Communities, EURO Reports No. 90, World Health Organization, Regional Office for Europe, Copenhagen).

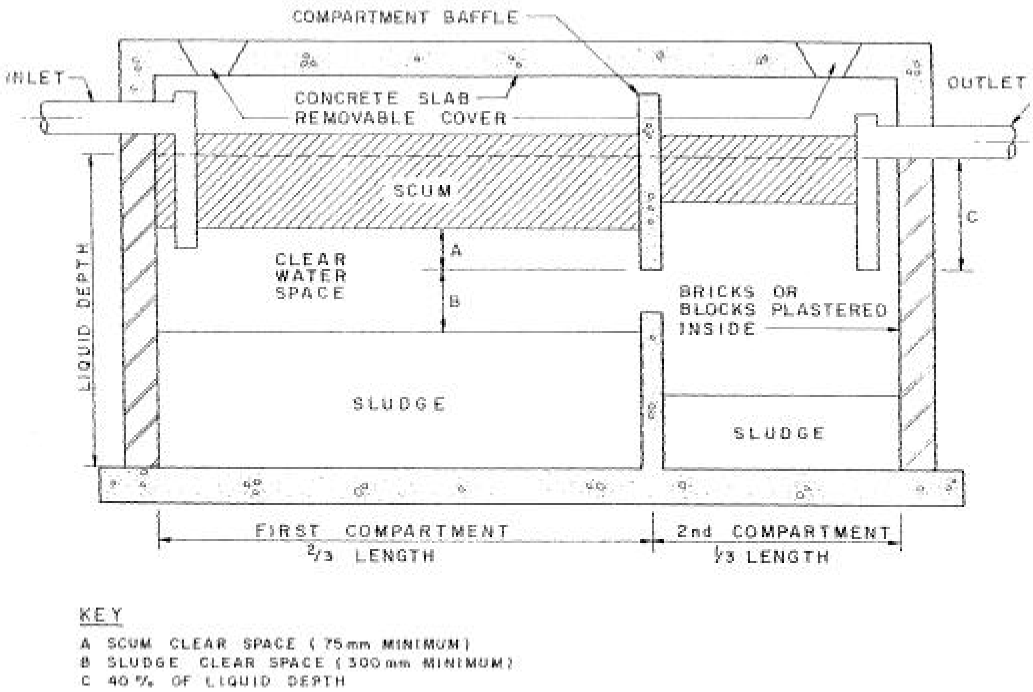
2) System Description

The septic tank is a watertight underground structure for wastewater (see Figure below). The septic tank receives the sewage, separates solids from liquids, stores scum and solids, provides for limited digestion of organic matter and allows clarified liquid to be discharged for further treatment by the disposal system. Solids and partially decomposed matter settle to the floor of the tank and accumulate as sludge, while lightweight materials such as fats and grease rise to the surface and accumulate as scum. In this way three distinct layers develop in the tank:

- a layer of sludge at the bottom
- a floating layer of scum
- a layer of reasonably clear liquid in between

Colloidal substances initially remain in suspension, but later coagulate to form larger particles that rise or fall depending on their density.

The effluent wastewater can be disposed through sewer connection or to an on-site treatment, which can be a subsurface absorption system.



Schemetic Diagram of Septic tank

The sludge at the bottom of the tank accumulates and has to be cleaned out at regular intervals. The tank is designed to allow for a certain amount of build-up of solids to give intervals of cleaning of 1 to 5 years, however it is important that tanks are regularly inspected to determine the amount of sludge and scum built-up. There must be reasonable vehicular access to permit vacuum tanker emptying of septic tanks. The contents of the tank must be transported and disposed. The average solids content of septage can be expected to range between 5 % and 12 % total solids.

The effluent from septic tanks is in most respects the same as settled raw domestic sewage. The improvement in quality of the effluent is a result of stabilization. The short retention time in the tank does little to reduce the concentrations of bacteria, protozoa or viruses present in the sewage. From a public health point of view the effluent from septic tank is as dangerous as raw sewage.

3) Regulations and Standards

<u>Governmental regulations:</u> Regulations concerning septic tanks are documented in the Building Code of Vietnam Volume 1 (promulgated by Minister of Construction Decision No: 682/BXD-CSXD). This Decision is effective throughout the country from 1 January 1997. Ministries, ministerial level bodies under Government, People's Committee of provinces and cities under direct Central Authority are responsible to organize the implementation of this Decision. Building Code of Vietnam is a legal document, which specifies the minimum requirements for all construction activities. According to that regulation, "Sanitary sewage from toilets and hospital sewage must be treated through septic tanks".

<u>City legislation:</u> Based on the decision of Haiphong PC No 648 QD/UB dated April 27 1998 septage management is responsibility of Haiphong SADCO from July 1 1998. Draft Regulation - Haiphong Sewerage and Drainage System Management stipulates that "Waste water from bathroom and toilet must be settled in septic tank before discharging into public system". According to Haiphong Construction Service, one of the preconditions for issuing a construction permit is that a septic tank must be included in the design.

<u>Proposed improvement:</u> None of these legislation/regulations stipulate any special requirement for emptying of septic tanks. Since successful performance of septic tanks requires regular emptying, it is necessary to propose an obligatory septic tank emptying program that will cover all the septic tanks in the urban area of Haiphong.

4) Design and Construction Issues

<u>Design criteria</u>

Generally, septic tanks should be designed to meet the following five criteria:

- a theoretical liquid retention time of at least 24 hours at maximum sludge and scum accumulation
- sufficient storage capacity to ensure a reasonable desluging interval and to prevent sludge and scum discharge
- tank geometry, inlet and outlet structures that minimizes disturbance of sludge and scum
- ventilation to allow methane and hydrogen sulfide gases to escape
- access for the purpose of inspecting and emptying

From these criteria, the first two are the most important for the performance of a septic tank.

<u>Vietnamese standards</u>

20 TCN-51-84 Sector Standards, Design Criteria for Sewerage and Drainage Network and Structures specify requirements for new and rehabilitation designs for sewerage and drainage network and structures, including septic tanks. For septic tanks, these standards stipulate design characteristics in small areas where urban sewerage is not available, including network and treatment structures for separate buildings, hospitals, schools, groups of buildings or blocks of flats.

The specification includes:

- septic tank volume
- desludging interval
- compartments
- design dimension
- cover slab

Architectural Structure (by Housing and Public Works Design Institute, Ministry of Construction), a reference document for designers and constructors, also gives typical drawings and dimensioning formulas for semi-septic tanks, which has only 2 chambers instead of 3.

5) Septic tanks in Haiphong

<u>New households:</u> During the last ten years sanitary conditions in Haiphong have improved considerably. Part of this improvement has been due to old houses being renovated and new houses built in the city. The typical toilet in

the newly constructed/renovated buildings is the pour-flush or flush toilet with a septic tank.

Number of Septic Tanks: At the moment, information concerning septic tanks is limited: locations, sizes, number of septic tanks etc. are not known. Moderate estimates suggest the number of septic tanks is from 35,000 to 70,000. A most likely number is around 50,000. There is a septic tank survey proposed in the revolving fund for sanitation improvement to be implemented by the Women's Union. Under the FINNIDA program, there is to be a pilot survey in Cat Bi Phoung.

Types of Septic Tanks: There are two types of septic tanks in use in Haiphong. One kind is 3 chamber conventional septic tank usually found in city center residential area, high rise buildings and industries. The other type has 2 chambers. This is locally called a semi-septic tank and the prevalence rate is around 35 % out of all septic tanks in Haiphong.

6) Desludging of Septic Tanks in Haiphong

Current practice

At the moment, SADCO's septage management and desludging program is demand based. SADCO provides a maintenance service (tank emptying) only when called out by householders, often after problems arise with blockages in the foul drainage system, and then charge for doing it. Normal procedure is to break into the tank by partially destroying the floor, expecting the householder to carry out reconstruction afterwards. SADCO's phuong representatives (37 people) receive requests for septic tank emptying and pass them onto the district teams (known as Sewerage Team). Sewerage Team asks Transportation and Construction Dept., which is responsible for septage collection and disposal.

Private septic tanks are generally located directly underneath toilets at the back of houses. In such locations they are often a long way from the nearest access point for road vehicles, even if road tankers can reach the frontage. In case operational failure happens, the septic tanks are manually emptied by URENCO staff, on request.

At present, SADCO has a fleet of three vacuum trucks (2 x 1.8 m^3 and 1 x 0.5 m^3) for septic tank desludging. In addition, trucks designated for sewer cleaning (2 x 7.8 m^3) are sometimes used for septage collection. The number of staff for this activity is 2 people per small truck and 3 people per big truck. Under WB 1B Project, there is a provision for equipment totaling US$2.5 m. These include 4 high-pressure jets and 9 vacuum trucks (3 x 4 m^3 and 6 x 2 m^3). It is expected that this equipment will be procured by 2001.

Considering the access problem, FINNIDA provided 3 hand-trailer mounted vacuum trucks. However, the width of these trucks is 1.5 meter, which is too wide for most of the narrow alleys. As a result, SADCO is not able to use these trucks.

SADCO's septage collection activity is summarized below.

Septage Collection by SADCO

unit: m^3

Area	1998	1999	2000 (up to June)
3 urban	794	2,417	183.5
Kien An	--	8	2.5
Do Son	--	--	1
Other Sub-urban	--	26	7

Fees for emptying septic tank are

VND50 000/0.5m^3;

VND100 000/1.8m^3; and

VND850 000/7.8m^3.

At present, the collected septage is disposed at the Tran Cat landfill site. Thus, sludge treatment is now a responsibility of URENCO. It is planned that from 2001, sludge treatment will come under SADCO's responsibility. For this purpose, 17 ha of land is placed under SADCO's jurisdiction.

<u>Sludge Treatment</u>

Under WB 1B project, a septage treatment plant is proposed in Trang Cat landfill site. SADCO recently received 17 ha of land for this purpose. The salient features of that treatment plant (Draft Engineering Design Report, 1B project, March 2000) are given below.

Sludge from sewerage system and septic tanks will be treated in this plant. Septage will be dewatered and composted. The liquid portion will be treated biologically and the solid portion will be spread over drying bed. The mature septage compost will be used as fertilizer. The total plant capacity is 26,000 m^3/year. The design septage to be treated is 21,000 m^3/year. Rest is sewerage sludge. Out of 6 ponds for dewatering, 2 ponds will be used for septage. In the compost process, structure material (municipal solid waste, rice straw, husk, etc.) will be mixed 1:1 in volume. The composting will be carried out in open air windrows. During the rainy season, the windrows shall be covered by tarpaulins. The composting will have two main periods:

- Active composting period of 8 weeks
- Post-composting and maturation period of 12 weeks

The liquid portion of the dewatering unit will be treated in an anaerobic pond with a retention time of 20 days. There will be 2 ponds with each 6,000 m^3 volume.

Special characteristics in Haiphong

As mentioned before, most of the septic tanks are inaccessible and they do not have access points to the compartments. This is a major constraint of septic tank emptying in Haiphong and needs to be solved at household level.

A typical feature of Haiphong is that roads are long and form very narrow zigzag alleys. Houses along these alleys cannot be accessed by a vacuum tanker. It is estimated that more than 70 % of houses are further than 40 meters from four-wheel vehicular access that is approximately the “reach” of the present vacuum tanker. This means that the septage management in the long run cannot be operated by traditional vacuum tanker solution and alternative desludging methods and equipment have to be used.

Some times people throw garbage inside the septic tanks. This is one of the major reasons of septic tank blockage. During the desludging, these objects block the suction pipe since there is no screen in front of the nozzle.

7) Kien An

As mentioned earlier, 88% of the central area population use septic tanks. Most of the septic tanks are connected with sewer lines. Since KA Public Works Company has no facilities, SADCO is requested to collect septage.

8) Do Son

All septic tanks in Do Son are followed by a leaching pit or soakaways. This is mandatory since there is no sewer pipes in DS area. Apart from 5 % of the households, all residential houses and hotels are served with septic tanks. Since DS Public Works Company has no facilities, SADCO is requested to collect septage. Usually hotels have big multi-chamber septic tanks. It is reported that for a hotel with 150 rooms, the size of septic tank is about 40 to 50 m^3.

9) Quan Tuan

Quan Tuan has been included under SADCO’s management since 1995. Apart from 9 multi-storied buildings, the whole population lives in rural areas. There are 28 septic tanks managed by SADCO serving those 9 buildings. These septic tanks are connected to a sewer pipe, the length of which is 1.2 km. This sewer pipe discharges into an irrigation channel.

SADCO has not collected any septage from these 28 septic tanks since 1995 until the present.

(6) Existing Sewerage System and Sewerage Development Plans for the Future

The Haiphong Sewerage and Drainage Master Plan provides comprehensive development plans for the sewerage systems in the Study Area. The Haiphong Sewerage and Drainage Master Plan has been approved by the Haiphong People's Committee, and its development plans are summarized in the following sections.

1) Urban Districts

The sewerage development plans for the 3 urban districts are summarized as follows:

- Sewerage planning for the city area north of the existing railways is based on existing combined sewer system
- Sewerage planning for the city area south of railways is based on separately collecting the wastewater and transporting the collected wastewater to a treatment plant
- There are 2 options for future development of the sewerage systems

Option 1: central wastewater treatment plant option. This option is based on construction of a main trunk sewer with big diameter and deep installation in the center route of the city, which enables the collection of wastewater with average distances of 1-1.5 km/zone. Local pumping stations will be constructed for zones far from the main trunk sewer.

Option 2: decentralized wastewater treatment plant options. This option is based on 2 separate sewerage zones, with 2 main trunk sewers of smaller sizes, transporting collected wastewater to 2 wastewater treatment plants.

2) Kien An District

The sewerage development plans for Kien An are summarized as follows:

- In future, when the sanitary demand is higher, it is essential to build a separate sewer system. The whole town area would then be divided into 2 areas
- Area A: mainly consists of the old town and the airport. All wastewater from this area is gathered to a treatment plant prior to discharge to Lach Tray River
- Area B: consists of the east and south of the town. There will be two treatment plants each for the South Catchment basin and the East Catchment basin

3) Do Son Town

The sewerage development plans for Do Son Town are summarized as follows:

- Due to complicated topography and scattered construction, sewerage is recommended for each sub-area
- In one side of the peninsula, the main sewer line shall be along the West Coast. Treated wastewater shall be discharged to the sea because there is no beach on this side
- In other side of the peninsula, the main sewer line shall be along the coast
- For villas and houses scattered on mountain sides individual treatment plant shall be constructed for each house. Treated wastewater shall be used for gardening

4) Vat Cach Area

The sewerage development plans for Vat Cach are summarized as follows:

- Development of a main trunk sewer from north to south, starting point is the residential are in Quan Toan and the last point is a wastewater treatment plant located close to the lowland, which will be converted to a regulating lake
- Industrial wastewater, after satisfactory on-site treatment, shall also discharge into this main trunk sewer
- Regulating lake also serves as an emergency lake for industrial wastewater discharges

5) New Development Area

The sewerage development plans for New Development Area are summarized as follows:

- The area is divided into 7 sewerage zones, each consists of a network, pumping station(s) and a local treatment plant

6) Minh Duc

The sewerage development plans for Minh Duc are summarized as follows:

- Industrial wastewater shall be treated by factories to meet urban wastewater requirements prior to discharge to the common sewerage
- The area is divided into 2 sewerage zones basing on the topographical and planning characteristics
- After treatment, all wastewater shall drain into the Bach Dang River

4.1.2 Problems Associated with Sewage Management

(1) Class A Areas

Class A area include Old City Center (OCC) within Hong Bang District, Le Chan District, south of Le Chan District (2 communes), Ngo Quyen District, and west of Ngo Quyen District (4 communes). These areas are characterized as urbanized with high population densities. The present and future population densities of the western half of Hong Bang district are quite low compared to the Old City Center of the district. The six non-urban communes are included in the Class A area because of their high present population density and strong possibility of being included in the urban district in the near future.

Sewage disposal in Class A area is based on septic tanks followed by wastewater discharge into the combined sewer network. Figure 4.1.1 shows the locations of existing septic tanks and combined sewer pipelines. Wastewater from the combined sewer network is then discharged into the local receiving waters, including the local rivers, lakes and channels.

For Class A area the main problems with sewage management are as follows:

- Lakes and channels are extremely polluted with very poor sanitation conditions. The lakes and channels provide drainage in the areas with combined sewers discharging both storm water and wastewater to these water bodies. Septic tanks are used, but the degree of treatment is not effective. Wastewater from septic tanks is discharged directly to lakes and channels without adequate treatment
- The combined sewer system is characterized by tidal water ingress into the network. A similar problem exists for sewers draining into lakes and channels, with water standing in the sewers. Detention time of wastewater in the network is high, with very low flow velocities. Solids in wastewater settle out in sewers, causing high maintenance needs and costs. The high detention time also contributes to physical deterioration of sewers caused by chemical reactions in the wastewater with the sewer walls

(2) Class B Areas

Class B area include Kien An District, Do Son Town, and Quan Toan Area. These areas are undergoing urbanization with middle population density and tourism areas:

- Septic tanks are used in Class B area. However, emptying of septic tanks is not properly managed. For many septic tanks, there is no access to empty the tanks, both at the tank itself and from a vehicle that could locate near the septic tank. The degree of sewage treatment is, then, ineffective

- Some septic tanks in the Class B area are connected to the existing combined sewer network. However, because emptying of septic tanks is not properly managed, sludge overflows into the sewer network, which reduces the capacity of the sewers and requires high and costly maintenance needs

In Kien An and Quan Toan, septic tanks are connected to the existing combined sewer network. Functional and operational problems of the combined sewer network occurs because of poor septic tank management with septage sludge overflowing into the network. Otherwise, population densities and pollution loads are not great in these areas. Pollution of surface water bodies is mainly localized and is not considered to be a problem.

Wastewater disposal in Do Son is based on septic tanks with wastewater discharge to the permeable soil near the tank. There are no connections to the existing sewer network. Groundwater pollution is not considered a problem, because of favorable geological conditions and low population density. Tourism in the town is seasonal for a five-month summer period and mainly occurs on weekends.

(3) Class C Areas

Class C area include Minh Duc, New Development Area, and Dinh Vu. These areas are characterized as rural or undeveloped areas with low population densities and where agriculture is the predominant land use is dominating.

Wastewater disposal in Minh Duc and the New Development Area is based mainly on direct discharge to nearby ditches, channels, and rivers. Septic tanks are present in some houses. Wastewater from these septic tanks is discharged to the permeable soil near the tank. The population density and pollution loads are very low in these areas. Pollution of surface water bodies and groundwater is mainly localized and is not considered to be a problem.

In Dinh Vu the sewerage system is the responsibility of the Economic Zone and the industries that locate in the area. However, public authority should monitor the effluent quality discharged from the industrial zone.

4.1.3 Outline of Proposed World Bank Sanitation Project and FINNIDA Projects

The proposed World Bank Sanitation Project consists of the following system and facility measures for sewerage improvements:

- Construction of interceptor sewers for 2 lakes in Class A area: Le Chan District (Sen Lake) and Ngo Quyen District (Tien Nga Lake)
- Construction of septage treatment facilities at Trang Cat Landfill
- Procurement of sewer cleaning and septage collection vehicles and vacuum trucks
- Revolving fund for households to purchase and install septic tanks

The proposed FINNIDA projects consist of the following system and facility measures for sewerage improvements:

- Rehabilitation and construction of wastewater collection and treatment system in Dong Quoc Bin area in Ngo Quyen District

4.2 System and Facility Measures for Sewerage Development

4.2.1 Planning Objectives

Planning objectives for sewage management are as follows:

- Main objective is to provide healthy living environment and to promote favorable urban development
- Development objective is to provide sewerage in areas with high population densities generating high pollution loads
- Environmental objective is to reduce wastewater discharges to highly polluted surface water bodies
- Selected measures for sewerage should be sustainable and compatible with local standards and practices

4.2.2 Planning Strategy

Population density is the key parameter in determining the appropriate level of sewage disposal system for a given area. The following population density-based selection criterion was adopted to select he appropriate sewage disposal system in the Study Area.

Population density	Range	Target
High	more than 40 person/ha	Sewer System
Medium	11-39 person/ha	Septic Tank Based System
Low	less than 10 person/ha	Improved Latrine (Twin Pit Latrine, VIP Latrine, Compost Latrine etc.)

Besides population density criteria, the following aspects were also considered:

- The current and expected situation of water supply in the area
- The current and expected septic tank development
- Quality of the receiving water with respect to he likely effect of treated or raw sewage on it
- Areas with special interest like, ports, tourist spots, industrial areas, etc.

<u>Sewer System Area</u>

In areas with high population density, more than 40 person/ha, the sewer system has to be developed so that sewage from each household can be collected and treated.

Of the two types of sewerage collection system, namely combined and separate, the separate system is selected as the preferred option for Haiphong in accordance with the "Decision by the Prime Minister On the Approval of the Development Orientation to 2020 for Vietnam Municipal Drainage and Sewerage System (Hanoi March 05, 1999.)". However, if development of a separate system is not realistic technically and/or financially, as is the case for the densely populated area in the three Urban Districts, a combined system may have to be adopted.

Septic Tank Based System Area

Medium population density (11-39 persons/ha) areas shall be served by septic tank systems, and each household is to install a septic tank. Within the medium population density area, the phuong–level population density varies considerably. Hence, the following two septic tank based systems are proposed.

Population density	Septic tank system	Human excreta	Gray water
25-39 person/ha	Simplified system	Off-site Treatment	Off-site Treatment
11-24 person/ha	Septic tank	On-site Anaerobic treatment	No treatment

Note: Simplified system - Please refer to the section 4.2.4 2)

In the area where the population density is 25-39 person/ha, effluent from septic tank and gray water would be collected by a simplified system and treated. Because the liquid to be collected is the supernatant of the septic tanks, a small diameter low gradient pipelines can serve the purpose. Since the influent of the treatment plant will have a low BOD, a simplified low cost treatment system is proposed. Among these, Rotating Biological Contactor (RBC) and Up-flow Anaerobic Sludge Bed (UASB) are promising biological treatment processes that would satisfy the required conditions.

Improved Latrine Area

The low population density area (10 person/ha) shall be served with an improved latrine system, so that each household can manage human waste in a sanitary manner. This is to ensure minimum pollution to the surrounding environment. Bucket Latrine and over hang latrines are among the most unsafe sanitation practices. It is highly recommended to discontinue the present use of bucket latrines and over hang latrines.

Item	human excreta	gray water
Improved Latrine	storage	discharge to drainage

4.2.3 Planning Outline

(1) General Outline

Population density of each district is given below.

Population density for each area

Unit: Persons/ha

Administrative division		Population Density Forecast			
	1999	2005	2010	2015	2020
3 Urban Districts	54	59	64	69	73
Kien An Districts	27	31	34	37	40
Do Son Town	8	9	9	10	11
Quan Toan	8	10	12	13	14
Minh Duc	12	15	17	19	22
Dinh Vu	0	-	-	-	-
New Development Area	6	8	10	11	13
Total	33	36	40	43	46

In the 3 urban districts, the population density is expected to increase rapidly and urbanization is expected to intensify. In Kien An District, the population density will approach that of the 3 Central Urban Districts. The population density of other areas is expected to increase but at a slower pace.

Based on projected population density, the appropriate target sewerage systems in 2020 are selected as follows.

Area	2020
Urban area	Sewer
Kien An Districts	Sewer
Do Son Town	Septic
Quan Toan	Septic
Minh Duc	Septic
Dinh Vu	No action
New Development Area	Septic

Urban Area and Kien An District are to be served with a sewer system, and other areas in the Study Area are to be served by a septic tank based system. All of Dinh Vu will be developed as an industrial area. So no action is required for the public sector. Wastewater treatment is the responsibility of each industry located there and the Economic Zone Authority. However, proper monitoring is required for the effluent discharged by the Economic Zone to the public water bodies. The effluent quality from the Economic Zone should comply with the Vietnam Standard.

(2) Concept of Sewage Disposal by each Area

1) Class A; Urbanized Area

District wise population densities for the urban area are given below. The entire area is to be served with a sewer system. The details are given in Section 4.3.

	Population		Area (ha)	Population Density (person/ha)	
	1999	2020	1999	1999	2020
Hong Bang District	97,565	118,861	15.20	64	78
South of Hong Bang	20,896	35,457	10.76	19	33
Le Chan District	146,204	163,904	4.42	331	371
South of Le Chan	33,903	72,339	8.32	41	87
Ngo Quyen District	171,623	191,642	12.24	140	157
Southeast of the City	83,234	164,940	51.02	16	32
Total (Urban area)	553,425	747,142	101.96	54	73

The forecast population densities in Le Chan District and Ngo Quyen District in 2020 are very high. Hence, the development of a sewer system in these districts is an urgent priority. On the other hand, the 2020 population densities in South Hong Ban District and Southeast of the City will be relatively low. Hence, the priority to develop a sewer system in these areas may be lower.

2) Class B; Developing area

Kien An

The population of Kien An District, which became an Urban District in 1997, is expected to exceed 100,000 in 2020. Currently there are 9 phuongs in the district, and the total area is 26.7 km^2. As explained above, the appropriate level of sewage disposal in Kien An District is a sewer system. However, the population is not distributed evenly, as is evident from the following table.

Administrative division	Present	Population Density Forecast (person/ha)			
	1999	2005	2010	2015	2020
Kien An Dist.	**27**	**31**	**34**	**37**	**40**
Quan Tru Ward	34	40	46	51	56
Dong Hoa Ward	14	15	15	16	16
Bac Son Ward	33	37	40	43	46
Nam Son Ward	20	22	24	26	28
Ngoc Son Ward	23	28	33	38	43
Tran Thanh Ngo Ward	54	64	71	79	86
Van Dau Ward	34	37	40	42	45
Phu Lien Ward	25	28	30	33	35
Trang Minh Ward	23	24	25	26	26

Based on the population density-wise selection criterion, the appropriate phuong-level sewage disposal systems in 2020 are selected as shown in the following table. The details are given in Section 4.4.

Administrative division	2020
Quan Tru Ward	Sewer
Dong Hoa Ward	Septic
Bac Son Ward	Sewer
Nam Son Ward	Simplified
Ngoc Son Ward	Sewer
Tran Thanh Ngo Ward	Sewer
Van Dau Ward	Sewer
Phu Lien Ward	Simplified
Trang Minh Ward	Simplified

Do Son

Do Son Town, having a population 30,560 (1990) and area of 39.5 km^2 is known for tourism. There are 5 phuongs in the Town.

As discussed in the previous section, the appropriate sewage disposal system for Do Son Town is a septic tank based system, according to the town-level population density. Here again, however, the phuong-level population is distributed unevenly.

Administrative division	Present	Population Density Forecast (person/ha)			
	1999	2005	2010	2015	2020
Do Son Town	**8**	**9**	**9**	**10**	**11**
Ngoc Xuyen Ward	6	6	6	7	7
Ngoc Hai Ward	13	13	14	14	15
Van Huong Ward	5	7	7	8	9
Van Son Ward	10	11	12	13	13
Bang La Commune	8	9	9	10	11

Hence, the following phuong-level systems are recommended.

	2020
Ngoc Xuyen Ward	Latrine
Ngoc Hai Ward	Septic
Van Huong Ward	Latrine
Van Son Ward	Septic
Bang La Commune	Septic

The need to develop a sewer system by 2020 is not high because the population density is low. However, Do Son is a tourism area, and there is room for further consideration. In the city center, there are a number of hotels and restaurants serving tourists. Because of this concentration, and because of the high number of tourists visiting the area, a simplified septic tank based sewer system is proposed for the city center and tourism area. The details are given in Section 4.4.

Quan Toan

Quan Toan is an area where industrial development is planned. The present and future population densities are as follows.

Administrative division	Present	Population Density Forecast (person/ha)			
	1999	2005	2010	2015	2020
Quan Toan	8	10	12	13	14

The appropriate sewage disposal system for Quan Toan is a septic tank based system. No detailed facility planning is proposed. However, the cost of septic tank development will be considered in the total Project cost.

	2020
Quan Toan	Septic

3) Class C; Sub-urban Area

Minh Duc is an area where industrial development is anticipated. The projected population density in 2020 is about 22 persons/ha. The appropriate sewage disposal system for Minh Duc is septic tanks.

Dinh Vu is being developed as an industrial area. There are essentially no permanent residents there at present. In future, only the workers for the industrial park will live in the area. As explained before, the sewerage system in Dinh Vu is the responsibility of the Economic Zone Authority. The public sector should only monitor the effluent quality for compliance with the Vietnam standard.

The New Development Area is being urbanized along Highway 14, and the estimated future population density is about 13 persons/ha. The appropriate sewage disposal system for the New Development Area is also septic tanks.

No detailed facility planning is proposed. However, the cost of septic tank development will be included in the total Project cost.

4.2.4 Alternatives for Collection and Disposal

(1) Wastewater Collection System

1) Combined Sewer System

In this alternative, sewage and storm water would be collected in the same sewer. Septic tanks can be used, but are not needed. Dry weather sewage flows are intercepted at selected points in the system and transported to a wastewater treatment plant. Storm water is bypassed as overflow and discharged to surface water bodies.

2) Simplified Separate Sewer System

In this alternative, sewage and storm water are collected in different sewers. Septic tanks are used. Wastewater is collected from septic tanks by a small-bore pipe system and transported to a wastewater treatment plant. Primary treatment of the collected wastewater is generally not needed. Treatment is also simplified. This septic tank based small-bore sewer system with simplified treatment is hereinafter referred to as a simplified sewer system.

3) Separate Sewer System

In this alternative, sewage and storm water are collected in different sewers. Septic tanks are not used. Wastewater is collected directly from the source and transported to a wastewater treatment plant. Primary treatment of the collected wastewater is needed.

4) Pumping Stations

Pumping stations are needed for wastewater collection systems, if the topography in the sewerage area is flat: Sewer longitudinal gradients are steep; or if the distance to the treatment facilities is great.

(2) Wastewater Disposal System

1) On-Site Disposal System

This includes two alternative methods; simple on-site treatment to treat toilet wastewater only, or high-level on-site treatment to treat both toilet wastewater and gray water. A wastewater collection system is not needed for on-side disposal systems.

2) Community Disposal System

In this alternative, wastewater is collected and treated at each community zone, such as housing, industrial estates, and business centers. Wastewater collection system is based on separate sewers.

3) Centralized Disposal System

In this alternative, wastewater is collected and treated using the public sewerage system. Wastewater collection can employ combined sewers, simplified separate sewers, or complete separate sewers.

4.2.5 Planning Criteria and Targets for Sewerage Development

(1) Planning Criteria

Sewerage development is defined according to the following technical factors, with testicular emphasis on the quantities of sewage, pollution loads, and geographic conditions:

- drainage basins
- land use (present and future)
- population density (present and future)
- wastewater and pollution load generation
- configuration of wastewater disposal systems
- existing wastewater collection systems
- city development plans

Potential sites for wastewater treatment plants are generally identified from the following criteria:

- Treatment plants are to be located at sites where wastewater can be collected and transported mostly by gravity flow with a minimum amount of pumping stations
- Sites will have enough space for construction of the treatment plant facilities with minimal effects on existing buildings and structures
- Treatment plants will be located at sites where operation of the plants will have minimal environmental impacts
- Sites are to be adjacent to the receiving waters of the treatment plant
- Sites are to be selected from less extensive land use areas both at present and in future
- Treatment plants are to be located where reuse of the treated wastewater is possible

(2) Phased Implementation

The following schedule is adopted to allow phased implementation of sewerage development:

- Year 2010: Short term
- Year 2020: Long term

The specific components of the system and facility measures that are to be developed are considering the desirable and achievable levels of sewage disposal in the respective years.

(3) Target Sewerage Levels

The following 2 levels of sewerage targets are adopted and measures to achieve them are considered:

- Level A: Wastewater is collected and treated without any use of septic tanks
- Level B: Wastewater is collected and treated with septic tanks being used

(4) Target Areas

1) Class A Areas

The main target sewerage areas are Le Chan District and Ngo Quyen District. The population density and pollution loads are high in these districts. Drainage and sewerage in these areas are based on existing combined sewer network, storage lakes, and channels. The lakes and channels in these districts are extremely polluted with very poor sanitation conditions. Septic tanks are used, but the degree of treatment is inadequate to prevent pollution of the lakes and channels.

Commercial and public activities in these districts are high. The lakes also have recreational value. Improvement of environmental conditions in these districts will have positive socio-economic impacts of meaningful magnitude.

A secondary target sewerage area is the eastern side of Hong Bang District (Old City Center). The population density and pollution loads are high in this district. The combined sewers discharge directly to the rivers. The fluctuating tide provides some flushing of the pollution loads in the rivers. The pollution loads are then transported to the sea, including to tourism areas associated with Do Son.

Considering the population density, administrative importance, and economic activity, the urgency to implement sewerage facilities for Class A area is much higher than for the other two areas. A holistic master plan will be prepared for Class A area.

2) Class B Areas

Class B area are considered as secondary targets for sewerage development. There are few sewer lines in these areas, so the ultimate objective is to achieve a separate sewer system. At the moment, the low population densities in these areas do not justify immediate investments in sewerage. However, improvements in septage management are needed. A detailed master plan will be prepared for Class B area.

3) Class C Areas

Urbanization of Minh Duc and New Development Area is not expected in the near future, and there is no immediate need for investments in sewer systems. However, septic tanks should be used wherever sewage is generated. In Dinh Vu, the sewerage system is the responsibility of the Economic Zone and the industries that locate in the area. An outline master plan will be prepared for Class C area.

4.3 Preliminary Design and Cost Estimates for the Optimum Measures for Class A Area

4.3.1 Alternatives, Timeframes, and Preliminary Costs Estimates

(1) Formulation of Modules

The sewerage improvement master plan in this Study consists of a number of modules or components. These modules are based on sub-areas within the target area and target sewerage system. These do not consider implementation phasing or implementation cost.

1) Factors to be Considered

(a) Target/objective Area

The target area and alternative plans should be identified. The most appropriate area and plan should be selected after comparitive analysis and this should be hollowed by a feasibility study.

(b) Division of the Selected Target Area into sub-areas Considering

- Current land use and future land use plan, future growth potential and plan
- Current and future planned population density
- Whether combined sewers are existing or not
- Whether septic tanks are existing or not

(c) Target Level or Type of Sewerage Development

This includes separate sewerage, simplified sewerage, and combined sewer system.

(d) Relevance to other Sanitation Improvement/sewerage Development

For combined sewer options, drainage improvement is a pre-requisite.

For simplified sewer options, septic tank management is a pre-requisite.

(e) Consideration and Compatibility/being Complimentary with other Committed Plans

- Septic tank management plan by WB
- Combined sewer plan by FINNIDA and 1B projects

2) Formulation of the Sewerage Modules (or components)

(a) Selection of the Target Area for Detailed Sewerage Planning

The target area proposed is the same as that of storm water drainage and consists of Le Chan urban district, Ngo Quyen urban district, Old City Center within the Hong Bang urban district, 2 communes located in the south of Le Chan district and 4 communes located in the east of Ngo Quyen district. The total area is 5,240 ha.

The principal basis for selection of the target area are i) the current and future population density, ii) ambient water quality and iii) development trend. The present and future population densities of the western half of Hong Bang district are quite low compared to the Old City Center district. The four non-urban communes are included in the target area because of their high present population density and strong possibility bing including in the urban district in near future.

(b) Division of the Target Area into Sub-areas

Based on drainage zoning, the total planning area is sub-divided into the following areas:

- Old City Center (OCC) area: Combined sewerage pipes and septic tanks exist
- Central area: Combined sewerage pipes and septic tanks pipes exist
- New Urban Area (NUA): No sewerage pipes are exist, septic tanks exist but coverage is low

(c) Appropriate Level or Type of Sewerage Development

a) Types in Advanced Countries/Japan

In Japan, the most common type of sewerage is the separate system. However, many other types of system also exist. Combined systems are also popular around the world. However, there are only a few examples of simplified sewer systems and there are none in Southeast Asia.

b) Levels Adopted in the other Study/plans for Haiphong

A combined system is proposed by WB/FINNIDA plan.

c) Appropriate types

- Where combined sewers already exist, either combined or separate sewer should be proposed
- Where septic tanks are existing, either combined, simplified, or separate sewer should be proposed
- Where there are neither combined sewers nor septic tanks either combined or separate sewers should be proposed

Thus,

OCC	combined, simplified, separate
Central Area	combined, simplified, separate
NUA	combined, simplified

N.B. Simplified system should be via septic tanks.

It may be noted here that according to the Vietnamese M/P, sewerage priority is set as lowest for the old city center area (OCC). It is proposed that no new facilities are required for that area and that sewage will flow to Cam River untreated. Since this river is tidal and has huge water flow, it is considered that self purification of the river is sufficient to address the incoming pollution load.

(d) Relevance with Sewerage Development

Drainage projects/options for OCC and Central Area, where combined sewers already exist, would contribute to the sewerage development if combined-sewer-based sewerage development is to be proposed in the Study for OCC and Central Area.

(e) Consideration and Compatibility/being Complimentary with other Committed Plans

Options should be compatible with the sewerage development plan by WB/FINNIDA. For the Central Area and OCC, WB/FINNIDA is proposing a combined sewer system with septic tank management improvement.

(f) Formulated Options

Sub-area	Combined	Simplified	Separate
OCC	■	■	■
Central Area	■	■	■
NUA	■		■

In total, there are 8 options (modules).

The target area, target population and target level for each module is given in the following table.

Catchment Area	Area	Beneficiary (2020)	Population Density per ha.	Target Level
Old City Center	857 ha	121,452	141.7	No action
Old City Center	857 ha	121,452	141.7	Combined
Old City Center	857 ha	121,452	141.7	Simplified
Old City Center	857 ha	121,452	141.7	Separate
Central area	1275 ha	285,663	224.1	Combined
Central area	1275 ha	285,663	224.1	Simplified
Central area	1275 ha	285,663	224.1	Separate
New Urban Area	3108 ha	167,561	53.9	Combined
New Urban Area	3108 ha	167,561	53.9	Separate
Total	5240 ha	574,676	109.7	--

(2) Formulation of Appropriate Sewerage Improvement Planning Alternatives

Several alternatives for the sewerage improvement master plan are proposed in this Study. Sewerage Development Master Plan alternatives are formulated by selecting one module each for the three catchment areas as explained above. Within each alternative, different modules can have a different target system.

1) Formulation Criteria

(a) Central Area

The major formulation criteria for the Central area is that it is most densely populated both present and in he future.

Therefore this area has the highest priority for sewerage improvement and should be included in the first phase of development.

(b) NUA

The major formulation criteria for the NUA area are that it:

- has relatively low population density at present
- is planned to develop fast

Therefore this area has the second highest priority for sewerage improvement and should be developed in the second phase.

(c) OCC

Major formulation criteria for the OCC are that:

- It is densely populated but further development is planned to be restricted
- Most of the Government offices are located there
- Out of the 2 objectives of sanitation improvement and surface water quality improvement, the second would not be significant because of the large flow and clean water quality of the Cua Cam River

Therefore this area has the third highest priority area for sewerage improvement and sewerage development can be delayed until 2^{nd} phase.

2) Alternatives formulation

Four alternatives for sewerage improvement have been proposed as shown below.

Alternatives for Sewerage Improvement Master Plan

	Target Area	Target System
Alternative S1	Central Area New Urban Area Old City Center	Combined Combined No action
Alternative S2	Central Area New Urban Area Old City Center	Simplified Separate Simplified
Alternative S3	Central Area New Urban Area Old City Center	Combined Separate Combined
Alternative S4	Central Area New Urban Area Old City Center,	Separate Separate Separate

Four alternatives for sewerage system improvements have been proposed. All cost estimates are preliminary in nature. However, similar benchmarks (like unit cost, treatment cost per person, pipeline per ha, pumping station per ha, etc.) were used to estimate costs, hence it is possible to compare the costs of the various alternatives.

In the formulation of alternatives the old city center is also considered as a relatively low priority. In one option, this area is excluded from the cover area. In the other three options, however, this area is included considering its high population density and economic importance.

Considering the sewerage catchment and ease of flow, the new urban area is divided into two catchments, namely east and west.

All options are divided into two phases. The central area is considered to be covered in Phase I. As the old city center is considered to have a relatively low priority with respect to pollution it is included in Phase II when this area is included in planning area. The New Urban Area is yet to be developed, so this area is also included in Phase II.

(3) Sewerage Alternative S1

1) Planning Basis

The schematic diagram of sewerage option S1 is given in Figure 4.3.1. This option does not consider facilities or systems development in the old city center in either phase. It emphasizes Class A area at the main target for sewerage development. Phase I will emphasize the Central area whilst Phase II will emphasize the New Urban Area.

Sewerage Option S1 is based on a combined sewer network with interception of dry weather sewage flows, both for existing areas and new urban areas. Existing sewers will be utilized as much as possible to collect wastewater from each source of sewage generation.

Sewage from houses and shops is intercepted before being discharged to channels or rivers and is transported to a wastewater treatment plant. The storm water is bypassed as overflow and discharged to surface water bodies.

The objective is to achieve Target Sewerage Level B for the Central area and New Urban Area.

2) Advantages

The advantages of S1 include the following:

- The existing combined sewer system can be utilized
- Only one sewer is used for both sewage and storm water discharges

3) Disadvantages

The disadvantages of S1 include the following:

- Option requires rehabilitation and upgrading of the drainage system
- Existing sewer system is old, and leakage of wastewater as well as infiltration of groundwater into sewers can be a problem
- Many existing sewers do not have enough gradient to allow sufficient self-cleaning velocity
- Substantial release of pollution load to channels and rivers will occur during storms

4) System and Facility Measures

The system and facility measures for S1 include the following:

(a) Phase I

- Construction of Wastewater treatment plant to be located near Vinh Niem tidal gate
- Construction of Interceptor trunk sewer system
- Construction of Interceptor branch sewer system
- Construction of Wastewater pumping stations

(b) Phase II - New Urban Areas

- Expansion of wastewater treatment plant at Vinh Niem tidal gate
- Construction of Wastewater treatment plant to be located near Cam River by Dinh Vu
- Construction of Interceptor trunk and branch sewer system
- Construction of Wastewater pumping stations

5) Timeframe

The timeframe for Phase I of Sewerage Option S1 is estimated as 5 years. The total timeframe including Phase II is 15 years.

6) Preliminary Costs Estimates

The preliminary costs estimates for Sewerage Option S1 include the following:

(a) Phase I

- Wastewater treatment plant: US$30 million
- Interceptor trunk sewer system: US$18 million
- Interceptor branch sewer system: US$12 million
- Wastewater pumping stations: US$10 million

(b) Phase II – New Urban Area

- Expansion of wastewater treatment plant: US$15 million
- Wastewater treatment plant: US$20 million
- Interceptor trunk and branch sewer system: US$30 million
- Wastewater pumping stations: US$15 million

(c) Total Costs

The preliminary costs estimate for Phase I of S1 is US$70 million. The total preliminary cost estimate when including Phase II is US$150 million.

(4) Sewerage Alternative S2

1) Planning Basis

The schematic diagram of sewerage option S2 is given in Figure 4.3.2. The option emphasizes Class A area as the main target for sewerage development. Phase I will emphasize the Central Area. Phase II will emphasize the Old City Center and New Urban Area.

Sewerage Option S2 is based on a simplified separate sewer system with the use of septic tanks for Le Chan, Ngo Quyen and Hong Bang Districts. New Urban Area is based on a complete separate system with no septic tanks.

Septic tanks are used as a preliminary interceptor to reduce suspended solids and BOD. The overflows of the septic tanks are collected by small diameter sewers with shallow slope because there is less suspended solids and no need to provide self-cleaning velocity.

Small-scale treatment plants will be built along An Kim Hai Channel. The treatment method and scale will be simple because influent BOD is low, about 100 mg/l, and discharge will be to a drainage channel, so BOD discharge can be about 50 mg/l. Water in the channel will be regularly pumped out and flushed to maintain water quality.

In Phase II wastewater collected in Hong Bang District will be transported to small-scale wastewater treatment facilities and discharged to local rivers.

The objective is to achieve Target Sewerage Level B for Le Chan, Ngo Quyen and Hong Bang Districts, and Target Sewerage Level A for New Urban Area

2) Advantages

The advantages of S2 include the following:

- Option does not depend on drainage conditions
- Shallow installation of sewers is possible, which reduces the number of pumping stations required

3) Disadvantages

The disadvantages of S2 include the following:

- The system is not common, and requires detailed investigations to determine its applicability. There is no example of this system in Asian countries
- Septic tanks have to be maintained, and a septage collection service is needed. It is not possible to implement phase-out plan of septic tanks. Septic tank improvement and proper management is a part of the system

4) System and Facility Measures

The system and facility measures for S2 include the following: Septic tank improvement and management costs are also included.

(a) Phase I

- 4 small-scale wastewater treatment facilities at An Kim Hai Channel
- Trunk separate sewers
- Small bore sewers at branch and tertiary level
- Wastewater pumping stations
- Septic tank improvements

(b) Phase II – Old City Center

- Small-scale wastewater treatment facilities
- Trunk separate sewers
- Small bore sewers at branch and tertiary level
- Wastewater pumping station
- Septic tank improvements

(c) Phase II – New Urban Area

- Wastewater treatment plant at Vinh Niem tidal gate
- Wastewater treatment plant at Cam River near Dinh Vu
- Trunk separate sewer system
- Branch and tertiary separate sewer system
- Wastewater pumping stations

5) Timeframe

The timeframe for Phase I of Sewerage Option S2 is estimated as 5 years. The total timeframe including Phase II is 15 years.

6) Preliminary Costs Estimates

The preliminary costs estimates for Sewerage Option S2 include the following:

(a) Phase I

- Small-scale wastewater treatment plants: US$20 million
- Trunk separate sewers: US$12 million
- Small bore sewers: US$18 million
- Wastewater pumping stations: US$10 million
- Septic tank improvements: US$5 million

(b) Phase II – Old City Center

- Small-scale wastewater treatment plants: US$10 million
- Trunk separate sewers: US$5 million
- Small bore sewers: US$8 million
- Wastewater pumping station: US$5 million
- Septic tank improvements: US$2 million

(c) Phase II – New Urban Area

- Wastewater treatment plants: US$30 million
- Trunk separate sewer system: US$20 million
- Branch and tertiary separate sewer system: US$30 million
- Wastewater pumping stations: US$20 million

(d) Total Costs

The preliminary costs estimate for Phase I of S2 is US$65 million. The total preliminary costs when including Phase II is US$195 million.

(5) Sewerage Alternative S3

1) Planning Basis

The schematic diagram of sewerage option S3 is given in Figure 4.3.3. This option also emphasizes sewerage development in Class A area. Phase I will emphasize Le Chan District and Ngo Quyen District. Phase II will emphasize Hong Bang District and New Urban Area.

Sewerage Option S3 is based on a combined sewer network with interception of dry weather sewage flows for Le Chan, Ngo Quyen and Hong Bang Districts. New Urban Area is based on a completely separate system with no septic tanks.

The objective is to achieve Target Sewerage Level B for central area, and Target Sewerage Level A for New Urban Area.

2) Advantages

The advantages of S3 include the following:

- The existing combined sewer system can be used in the system
- Only one sewer is used for both sewage and storm water discharges

3) Disadvantages

The disadvantages of S3 include the following:

- Requires rehabilitation and upgrading of the drainage system
- Existing sewer system is old, and leakage of wastewater as well as infiltration of groundwater into sewers can be a problem
- Many existing sewers do not have enough gradient to allow sufficient self-cleaning velocity
- Substantial release of pollution load to channels and rivers will occur during storms

4) System and Facility Measures

The system and facility measures for S3 include the following:

(a) Phase I

- Wastewater treatment plant to be located near Vinh Niem tidal gate
- Construction of Interceptor trunk sewer system
- Construction of Branch sewers to collect intercepted wastewater
- Construction of Wastewater pumping stations

(b) Phase II – Old City Center

- Expansion of wastewater treatment plant at Vinh Niem tidal gate
- Construction of Interceptor trunk sewer system
- Construction of Interceptor branch sewer system
- Construction of Wastewater pumping stations

(c) Phase II – New Urban Area

- Expansion of wastewater treatment plant at Vinh Niem tidal gate
- Construction of Wastewater treatment plant at Cam River near Dinh Vu
- Construction of Trunk separate sewer system
- Construction of Branch and tertiary separate sewer system
- Construction of Wastewater pumping stations

5) Timeframe

The timeframe for Phase I of Sewerage Option S3 is estimated as 5 years. The total timeframe including Phase II is 15 years.

6) Preliminary Costs Estimates

The preliminary costs estimates for Sewerage Option S3 include the following:

(a) Phase I

- Wastewater treatment plant: US$30 million
- Interceptor trunk sewer system: US$18 million
- Interceptor branch sewer system: US$12 million
- Wastewater pumping stations: US$10 million

(b) Phase II – Old City Center

- Expansion of wastewater treatment plant: US$10 million
- Interceptor trunk sewer system: US$12 million
- Interceptor branch sewer system: US$8 million
- Wastewater pumping stations: US$5 million

(c) Phase II – New Urban Area

- Expansion of wastewater treatment plant: 10 million
- Wastewater treatment plant: US$20 million
- Trunk separate sewer system: US$20 million
- Branch and tertiary separate sewer system: US$30 million
- Wastewater pumping stations: US$20 million

(d) Total Costs

The preliminary costs estimate for Phase I of S3 is US$70 million. The total preliminary costs estimate when including Phase II is US$205 million.

(6) Sewerage Alternative S4

1) Planning Basis

The schematic diagram of sewerage option S4 is given in Figure 4.3.4. This option also emphasizes Class A area. Phase I will emphasize the Central area. Phase II will emphasize the Old City Center and New Urban Area.

Sewerage Option S4 is based on a complete separate sewer system.

Sewage and storm water will be collected in different sewers. Wastewater is collected directly from source and transported to wastewater treatment plant.

The objective is to achieve Target Sewerage Level A for Le Chan, Ngo Quyen and Hong Bang Districts, and New Urban Area.

2) Advantages

The advantages of S4 include the following:

- Option does not depend on drainage conditions

- Septic tanks are not needed

3) Disadvantages

The disadvantages of S4 include the following:

- Sewers must have an adequate gradient to ensure sufficient self-cleaning velocity. In flat terrain like Haiphong, sewers have to be installed deep underground, resulting in substantial construction and pumping costs
- The system has to be developed from the wastewater treatment plant to individual tertiary sewers. Hence, implementation time is long

4) System and Facility Measures

The system and facility measures for S4 include the following:

(a) Phase I

- Wastewater treatment plant to be located near Vinh Niem tidal gate
- Trunk separate sewers
- Branch and tertiary separate sewers
- Wastewater pumping stations

(b) Phase II – Old City Center

- Expansion of wastewater treatment plant at Vinh Niem tidal gate
- Trunk separate sewers
- Branch and tertiary separate sewers
- Wastewater pumping stations

(c) Phase II – New Urban Area

- Wastewater treatment plant at Cam River near Dinh Vu
- Trunk separate sewer system
- Branch and tertiary separate sewer system
- Wastewater pumping stations

5) Timeframe

The timeframe for Phase I of Sewerage Option S4 is estimated as 10 years. The total timeframe when including Phase II is 20 years.

6) Preliminary Costs Estimates

The preliminary costs estimates for Sewerage Option S4 include the following:

(a) Phase I

- Wastewater treatment plant: US$30 million
- Trunk separate sewer system: US$18 million
- Branch and tertiary separate sewer system: US$27 million
- Wastewater pumping stations: US$15 million

(b) Phase II – Old City Center

- Expansion of wastewater treatment plant: US$10 million
- Trunk separate sewer system: US$12 million
- Branch and tertiary separate sewer system: US$18 million
- Wastewater pumping stations: US$10 million

(c) Phase II – New Urban Area

- Expansion of wastewater treatment plant: US$10 million
- Wastewater treatment plant: US$20 million
- Trunk separate sewer system: US$20 million
- Branch and tertiary separate sewer system: US$30 million
- Wastewater pumping stations: US$20 million

(d) Total Costs

The preliminary costs estimate for Phase I of S4 is US$90 million. The total preliminary costs estimate when including Phase II is US$240 million.

4.3.2 Comparison of Alternatives and Selection of the Optimum Measures

Outlines of the sewerage master plan alternatives are shown in Table 4.3.1. The target areas and systems are compared in the following table.

Target Area and Sewerage Target Levels of Each Option

	Phase I		Phase II	
	Target Area	Sewerage Target Systems	Target Area	Sewerage Target Systems
S1	Central Area	Combined	New Urban Area	Combined
S2	Central Area	Simplified	Old City Center, New Urban Area	Simplified Separate
S3	Central Area	Combined	Old City Center, New Urban Area	Combined, Separate
S4	Central Area	Separate	Old City Center, New Urban Area	Separate Separate

The preliminary cost estimates of each option are compared in the following table.

Preliminary Costs Estimates of Each Option

	Phase I	Phase II	Total
S1	US$70 million	US$80 million	US$150 million
S2	US$65 million	US$130 million	US$195 million
S3	US$70 million	US$135 million	US$205 million
S4	US$90 million	US$150 million	US$240 million

Various aspects of the formulated alternatives are compared below.

(1) Cost Comparison

A cost comparison of the formulated alternatives, including the total investment cost and cost per beneficiary, is given below. It should be noted that implementation timings of the alternatives are not same and costs are in constant price.

Alternatives	Investment Cost	Cost per beneficiary
S1	US$150 million	US$352.11
S2	US$195 million	US$356.49
S3	US$205 million	US$374.77
S4	US$240 million	US$438.76

As shown in the table, investment cost and cost per beneficiary is the lowest for S1 being followed by S2.

(2) Overall Comparison and Selection of the Optimum Drainage Improvement Plan

Assessment of the sewerage master plan alternatives is given in Table 4.3.2. The formulated alternatives are compared from the following major points:

1) Inclusion/exclusion of the Old City Center
2) Selection of the most appropriate target system for each sub-area
3) Appropriate phasing of the implementation of sewerage improvement for each sub-area

After discussion with HPPC, in particular TUPWS, SADCO, PMU and Steering Committee, following assessment was made:

1) S1 does not cover the old city center, whereas all other options do cover the old city center. As a result, S1 has a low cover area and less beneficiaries compared to the other options. According to Vietnamese sewerage M/P, no sewerage system is required for the old city center because the self purification capacity of Cam River is sufficient to handle the incoming pollution load.
   Of the two major objectives of sewerage development, namely, sanitation improvement and water quality improvement, sewerage development in OCC is less important from water quality.
   However, it is, still considered important to improve the sewerage system in the OCC for sanitation improvement aspect.
2) S2 proposes a simplified septic tank based sewer system. Thus, strict septic tank management is a pre-requisite. The effluent quality from a simplified treatment plant would be lower. To offset this, simplified treatment plants could be constructed along An Kim Hai Channel, though the channel water quality would be degraded. However, this is not fully proven technology and

requires a pilot study before implementation. This technology has not yet been implemented in Asian countries.

S4 is the ideal case but requires a huge investment and long implementation time. It would take more than 10 years to complete which is considered to be too long for the Central Area and OCC. Though Vietnamese M/P proposed a complete separate sewer system, it is perhaps too ambitious. This would require a bigger capital outlay and cost per beneficiary, even though it is certainly better from the viewpoint of achieving sanitary environment.

Using the existing combined sewer system will reduce the investment cost and shorten the implementation time. However, a certain pollution load will discharge to surface water bodies during storms for the case of combined sewer system. Also, the on-going FINNIDA/1B project is considering a combined sewer system.

3) Considering the high total investment cost required for sewerage improvement of the whole target area, the sewerage improvement should be implemented in phases. Considering the high population density and future development potential among the sub-areas, the Central Area should firstly be improved among the sub-area of the target area. The other sub-areas should follow in the second phase.

Considering the above explanation, and through detailed discussion with HPPC, the most optimum alternative is selected following the steps given below:

- Construction of a new sewer system takes a long time and requires a large capital outlay. So where combined sewers are existing, utilization of the combined system is more recommendable
- For developing area where no combined sewers are existing, separate system is more recommendable to assure better improvement of surface water quality
- A sizable part of the target area is already served by septic tanks, so a simplified system may be one option. But considering that Asian countries have no experience of this method, and that strict management of septic tanks is essential, it may be more recommendable to firstly implement a pilot-scale project before implementing a large-scale project
- Though both investment cost and investment cost per beneficiary are relatively high, it is better for OCC to be covered because of its importance

Consequently, alternative S3 has been selected as the optimum plan for sewerage improvement of the target area.

(3) Characteristics and Merits of the Selected Alternative S3

Sewerage Option S3 is selected as the optimum measure for Class A area. The basis for this selection includes the following:

- Both investment cost and investment cost per beneficiary are third lowest

- OCC is included, however, the sewerage improvement may be delayed for this area
- Time requirement for Central Area and OCC is satisfactory
- For NUA, a higher improvement effect can be assured. The time requirement for this area is also satisfactory

The selected alternative of S3 covers the whole of the target area of 5,240 ha including the Old City Center with 574,000 inhabitants. The cost would be US$356.72 per beneficiary.

4.3.3 Preliminary Design and Cost Estimates for the Selected Alternative

(1) Estimated Generation of Sewage

The coverage area for the Phase I area was examined critically from hydrological, hydraulic, hydrogeological, and topographic point. Also, the existing, on-going and planned facilities related to drainage, sewerage and other relevant sectors were duly considered. From these practical considerations, slight modification of the coverage area was made. A portion in the northeast was excluded while another portion in the southeast was included. The dividing lines are the Northeast Channel and proposed Phoung Luu Lake. Also, slight modification was made for some of the phoungs.

The phoung-wise area included in the project, population and population projection for the sewerage service area was calculated and is presented in Table 4.3.3.

Sewage generation primarily depends on water supply. A rough estimation is presented here based on water supply. Some portion of this sewage enters the sewer pipes; however, some portion is discharged into drainage channels or lakes.

Generation of Sewage is estimated as follows.

Water consumption

$Cdom = Po \times (Wc/100) \times (Uc/1000)$

Where,

Po : Population

Wc : Water Supply Service coverage (house connection) (%)

Uc : Unit water consumption (l/capita/day)

(present; 61 - 123 l/capita/day, design figure in 2020;130lpcd)

Cdom :Domestic water consumption (m^3/d)

$Ct = Cdom + Ccom + Cins + Cind$

Where,

Ccom : Commercial water consumption (m^3/d) , according to water supply plan

Cins : Institutional water consumption (m^3/d) , according to water supply plan

Cind : Industrial water consumption (m^3/d) , according to water supply plan
Ct : Total water consumption (m^3/d)

Sewage flow

Sdom/com/ins = Cdom/com/ins × Rss × Rgdom/com/ins

Where,

Rss : Sewerage service ratio (%)
Rgdom/com/ins: Generation rate of domestic/commercial/institutional sewage (%)
Sdom/com/ins : Domestic/commercial/institutional sewage flow (m^3/d)

Sind = Cind × Rss × Rgind

Where,

Rss : Sewerage service ratio (%)
Rgind : Generation rate of industrial wastewater (%)
Sind : Industrial wastewater flow (m^3/d)

Qs = (Sdom + Scom + Sins + Sind) x (1 + Ri)

Where,

Ri : Groundwater Infiltration ratio (10%)
Qs : Daily Average Sewage Flow (m^3/d)

All water consumption data used are based on the water supply master plan presented in Chapter 2. Important information required for sewage generation estimation is compiled in Table 4.3.4. This gives total water consumption for domestic, industrial, institutional and commercial purposes.

At present, in most cases, only black water enters in the existing septic tanks. Gray water is discharged from drainage pipes. As a result, it is not possible that all black and gray water can be collected from the beginning. It is assumed that initially around 80 % of the water consumption can be collected as sewage for domestic, commercial and institutional use. This value will increase gradually and will reach 100 % by the target year of 2020. Because of various water losses in the industrial processes, it is considered that sewage generation for industrial purpose is 80 % of the water consumption and it is considered constant. The generation rate of sewage is given in Table 4.3.5.

The service ratio is considered as 50 % in the beginning and will reach 100 % by the year 2010.

The detail sewage generation for each Phoung (ward) is given in Table 4.3.6 and the summary is given in Table 4.3.7. The total sewage generation in 2020 is 87,485 m^3/day. Of this, the west treatment plant catchment generates 71,773 m^3/day. The Phase I sewage generation in 2010 is estimated to be 35,325 m^3/day.

(2) Design Principle

The design concept is proposed to meet the following standards and guidelines:

- Design Standard for Works of Sewerage & Drainage System in Vietnam (1989)
- Environmental Protection Law in Vietnam (1994)
- Temporary Guidance for Environmental Impact Assessment (1993)
- Vietnam System of Environmental Standards (1993)
- Sewerage Law in Japan (1976)
- Water Pollution Control Law in Japan (1983)
- Building Standard Law in Japan (1983)
- Japan Sewage Works Association Standards (1984)

Facilities planning and cost estimates are based on the following design principles.

Target Year

The target year of the master plan is 2020 and intermediate target year is 2010.

Groundwater Infiltration

Groundwater infiltration and unexpected surface water intrusion is considered when designing the capacity of the sewerage collection system. Groundwater infiltration including unexpected surface water intrusion is usually assumed to be 10 % to 20 % of Average Dry Weather Flow (ADWF). In this study, the rate is proposed to be 10 % of ADWF in consideration of the following factors:

- Sub-surface geological conditions: clay & silt with low permeability
- Static groundwater level: deeper than 3 m
- Construction method & material: Reinforced concrete pipes with collar joints

Peak Wastewater Flow

It is considered that the peak flow is 1.5 times of ADWF in case of separate system and 3 times in case of combined system.

Planned Sewage Quality

The sewage discharged from polluters, such as houses and industries, always fluctuates in quantity and quality. Because of this, even if daily BOD loading data is available, it cannot represent the acceptable BOD loading for planning. Although unit pollution load survey was conducted under the Study, sewage quality for the Study was determined in consideration of design data used for other similar locations and engineering judgement. It may be noted that domestic unit design pollution load in Hanoi in 1992 was 40 g/c/d.

The planned wastewater quality for 2020 in terms of BOD was determined as follows:

Domestic wastewater: 50 g/c/d of BOD
Commercial wastewater: 350 mg/l of BOD
Industrial wastewater: 400 mg/l of BOD

Considering the unit water consumption of 130 l/c/d (Chapter 2), the pollution load for domestic wastewater is 380 mg/l before considering groundwater infiltration. With 10 % groundwater infiltration, the load is 350 mg/l. Suspended solid (SS) is considered as 90 % of the BOD load. Thus, influent SS is 315 mg/l. The effluent SS is considered as 60 mg/l.

Treated wastewater quality shall be decided in conformity to the effluent standards in Vietnam, as shown in Supporting Report C. Considering the rivers surrounding Haiphong, the effluent quality should meet Class B river requirements, which is 50 mg/l of BOD.

Target treated water quality: BOD level of 50mg/l.

Design Flow

Sewerage facilities, including sewers and wastewater treatment plants, shall be principally designed using design flows as follows. It may be noted that these values should be modified depending on the selected treatment process.

Collection System	Facilities	Design Flow
Separate	Sewer	Peak Dry Weather Flow (PDWF=1.5ADWF)
	Primary Treatment	Average Dry Weather Flow (ADWF)
	Secondary Treatment	Average Dry Weather Flow (ADWF)
Combined	Sewer	Peak Wet Weather Flow (PWWF=3ADWF)
	Primary Treatment	2 × Average Dry Weather Flow (2ADWF)
	Secondary Treatment	Average Dry Weather Flow (ADWF)

Alternatives on the Wastewater Disposal System

The sewerage development plan in each zone was evaluated for the following alternative disposal systems:

- Combination of on-site and community disposal systems
- Simplified sewer system
- Small scale sewer system
- Central sewer system

Target Wastewater Flow (Q) for each Sewer System

- Combination of on-site and community disposal systems Case specific
- Simplified sewer system : $Q < 2{,}000 m^3/day$
- Small-scale sewer system : $2{,}000 < Q < 20{,}000 m^3/day$
- Central sewer system : $Q > 20{,}000 m^3/day$

Sewer Pipe

Sewage collection system for the newly developed area is assumed to be a separate system. The length of the sewer is estimated as 100 m per hectare of sewered area. The length of conveyance sewer with a diameter of more than 1,000 mm is assumed as follows:

- Combination of on-site and community disposal systems No sewer
- Simplified sewer system 0 % of total sewer length
- Small scale sewer system 3 % of total sewer length
- Central sewer system 10 % of total sewer length for Separate sewer system

For the combined sewer system, the length of interceptor is the actual length.

Sewer Construction Cost

Unit construction cast is mostly based on the unit cost used for HCMC Drainage project (JICA, 1999). Rational engineering judgment is used to interpret as required.

Construction cost at the 1994 price level is estimated as following:

- Unit cost of sewer : US$120/m to US$ 210 for depending on diameter
- Unit cost of trunk : US$1,220/m
- Unit cost of conveyance : US$310/m for average diameter of 1000 mm
- Unit cost of conveyance (jacking method)
  : US$1,350/m for average diameter of 1000 mm

The cost of conveyance pipeline (jacking method) is estimated by the following formula in Japan Sewage Works Association Standards (1996)

$C=(3.0 \times 10\text{-}6 \times D2+1.3 \times 10\text{-}2 \times D + 3.68) \times (113.2/90.1) \times 10000/110 \times kc$
= US$1,350/m

D=1,000 mm, kc=0.6

Treatment Plant Cost

The cost of a wastewater treatment plant is estimated from the HCMC Drainage Project (JICA, 1999). The treatment process was activated sludge and the capacity was 141,000 m^3/day. The estimated cost is US$71.5 million and this gives a unit cost of US$507/$m^3$/day. Since unit cost will vary depending on the treatment capacity, it will be adjusted by a scale factor. The scale factor of one plant will be calculated by using the cost of a treatment plant of similar capacity in Japan and the cost of a treatment plant in Japan with similar capacity to that of HCMC.

In case of simplified sewage treatment facilities, the plant cost is assumed as 50% of the conventional one.

Other costs

Unit cost of septic tank : US$ 50/person

This includes construction of septic tanks and its maintenance.

Pumping Station Cost

Manhole type relay pumping station

The cost of a manhole type relay pumping station is rationally modified based on the price of the following formula from Hanoi Report (The study on urban drainage and wastewater disposal system in Hanoi city Final Report Main Report, February 1995):

$C=8.5Q^{0.598}/110 \times 1000$
where,
C : Construction cost (1000 US$)
Q : Planned wastewater flow (m^3/min)

Main relay pumping station

The cost of a main rely pumping station is estimated by the following formula in Japan Sewage Works Association Standards (1996). It is rationally adjusted after subsequent studies carried out in feasibility study stage.

Cc=85.51Q0.598(113.2/90.1) × 106/110/1000xRc × kc
Cm=85.51Q0.598(113.2/90.1) × 106/110/1000 × Rm × km
where,
Cm : Construction cost for machinery & equipment (US$1000)
Cc : Construction cost for civil works (US$1000)
Q : Planned wastewater flow (m^3/min)
Rc=0.414, Rm=0.586, kc=0.6, km=0.6

Ratio of construction cost

All construction costs are divided into two parts, civil/architecture and electrical/mechanical. For the treatment plants and main pumping stations, the ratio of civil/architecture is 0.6 and that of electrical/mechanical is 0.4.

O&M cost

The estimated cost of operation and maintenance (O & M) for a wastewater treatment plant and pumping station is divided into two parts. It is 3 % of the electrical and mechanical portion and 0.3 % of the civil construction cost portion. In percentage of investment cost, the O&M cost is 3% for the sewer pipes.

<u>Land acquisition and compensation cost</u>

Unit land acquisition and compensation cost is based on the values proposed in 1B project (Resettlement Action Plan, 1B project, Feb. 1999). Land acquisition and compensation cost is considered to be comprised of two components, land loss and house loss. There could be two types of land loss, residential land loss and agricultural land loss. Based on the 1B project, agricultural land loss compensation is considered as US$3/$m^2$ while residential land loss compensation is considered as US$28/$m^2$. House loss compensation is set as US$100/$m^2$ of floor space. For the master plan study, it is considered that the average floor area of each house is 50 m^2. That gives a house loss compensation of US$5,000/house. Since actual land use situation is not known in detail, it is considered to increase the total land acquisition and compensation cost by an additional 50 %.

(3) Facilities and Cost Estimates

According to the selected alternative S3, the central area will be served with a combined sewer system in Phase I. All other facilities will be implemented in Phase II. This includes a combined sewer system in the old city area and a separate sewer system in the new urban area. Two wastewater treatment plants are proposed, namely west and east treatment plant. A portion of the new urban area is included in the west treatment plant command area and the rest is included in east treatment plant command area. Area, population and sewage generation is summarized below based on treatment plant command area.

Area, population and sewage generation by treatment plant command area

			Population (2020)	Sewage (m^3/d, 2020)	Area (ha)
West Wastewater Treatment Area			**439,079**	**71,773**	**2,654**
	Phase I	Combined sewer system	239,938 (2010)	35,325 (2010)	1,103
	Phase II	Combined sewer system	121,452	20,462	856
		Combine sewer extension	259,286	39,847	1,103
		Separate sewer system	58,341	11,464	695
		sub-total(Phase II)	439,079	71,773	1,551
East Wastewater Treatment Area			**135,598**	**15,712**	**2,587**
	Phase II	Separate sewer system	135,598	15,712	2,587
Grand Total			**574,677**	**87,485**	**5,241**

Based on the design principles explained before, the required sewerage facilities are estimated and given in Table 4.3.8 and shown in Figure 4.3.5. The proposed facilities include 2 wastewater treatment plants, 6 main pumping stations, 28 sub pumping stations, 55 km of conveyance sewers and 391 km of sewer pipes.

The treatment process was fixed as aerated lagoon for the west plant and stabilization pond for the east plant. The selection process is explained in Section 4.3.3. (6) and in the feasibility study.

The weighted unit costs of the treatment plants are calculated based on JICA study for HCMC and detail study in the feasibility study stage. A scale factor is used to take care of variation of capacity.

Based on the proposed facilities and unit costs, costs estimates of the Project are given in Table 4.3.9. The total cost is estimated at US$152 million as direct construction cost. Phase I total cost is US$50 million.

(4) Land Acquisition and Compensation

For the west WWTP, aerated lagoon and for east WWTP, stabilization pond are selected for the land acquisition purpose. Calculated cost is adjusted based on detailed study carried out in the feasibility study.

Table 4.3.10 shows land acquisition required for WWTP, pumping station, total requirement, and compensation. The total compensation is US$3.2 million, out of which Phase I requirement is US$2.2 million.

(5) Comparison of Treatment Process

There are two proposed treatment plants, namely, west and east treatment plants. For the east treatment plant, use of a stabilization pond is recommended because land is likely to be available for this relatively small scale treatment plant, though the land has not yet been acquired.

For the west WWTP, there are various options. These methods shall be compared from the following points of view, to select the most suitable process for the Study area:

- Flexibility to shock/over load
- Workability with the operation and maintenance (O&M)
- Required costs of construction and O & M
- Required sludge disposal and volume of excess sludge
- Required land acquisition

Five treatment processes were considered as alternatives:

- Wastewater Stabilization Pond — WSP
- Modified Wastewater Stabilization Pond — MWSP
- Aerated Lagoon — AL
- Oxidation Ditch — OD
- Conventional Activated Sludge Process — CAS

To facilitate selection of the most suitable treatment process, detailed calculations were made for each alternative with respect to land requirements, effluent load, sludge treatment, construction cost estimations, O&M cost estimations and net present value. The basic conditions for the calculations were as estimated in section 4.3.3, i.e.

- Wastewater flow 72,000 m^3/day
- Influent BOD 350 mg/l
- Influent SS 315 mg/l
- Effluent BOD 50 mg/l
- Effluent SS 60 mg/l

Sludge treatment was considered for AL, OD and CAS. For WSP and MWSP sludge was considered to be desludged directly from the ponds. Extra land was manned to be for the buttes green belt and for supporting facilities. The extra land was assumed as 20 % for large facilities and 100 % for small facilities. Chlorination was considered to be used in all alternatives except WSP because the maturation ponds in a WSP act as a microorganism removal basin. A retention time of 15 min. is adopted for the chlorination tank.

As the sewerage system would consist of both separate and combined systems, the design flow was based on the following,

Flow volume for Combined System

Unit: times of ADWF

Treatment Stage	WSP	MWSP	AL	OD	CAS
Preliminary	3	3	3	3	3
Primary	1	1	--	2	2
Secondary	1	1	1	1	1

Flow volume for Separate System

Unit: times of ADWF

Treatment Stage	WSP	MWSP	AL	OD	CAS
Preliminary	1.5	1.5	1.5	1.5	1.5
Primary	1	1	1	1	1
Secondary	1	1	1	1	1

Result of the detailed calculations for design parameters are given in Table 4.3.11 (1/5) to 4.3.11 (5/5). The effluent BOD load is less than 50 mg/l for all cases except MWSP, in which case it is around 100 mg/l. The required land area is lowest for CAS at 12 ha while it is highest for WSP at 130 ha.

Unit construction and O&M costs for different treatment process were adopted from HCMC project (JICA, 1999). This report provides costs for CAS, AL and WSP. The unit costs for MWSP and OD were interpreted by linear interpolation. Since the treatment capacities of HCMC and proposed plant are different, all unit costs were multiplied with a scaling factor. The unit costs used and cost estimates are given in Table 4.3.12. The calculated construction cost is lowest for MWSP at US$24 million. The O&M cost is also lowest for MWSP at US$0.6 million/year.

A summary cost comparison is given in Table 4.3.13 including compensation cost. All costs were converted into net present value for easy comparison. Two discount rates were used, namely 5 % and 8 %. The calculation for 5 % discount rate is given in Table 4.3.14 and summarized in Table 4.3.15. With a 5 % discount rate, MWSP option is cheapest at US$24 million.

(6) Selection of Treatment Process

It is obvious that high treatment technology methods require less land but are more expensive. Out of the five alternatives, WSP is rather cheap but requires a huge amount of land (130 ha). It would be rather difficult to acquire such land space. On the other hand, CAS requires the least amount of land but is very expensive. The other three alternatives can be considered as feasible options. A step-wise improvement is most suitable.

Two possible alternative scenarios are proposed. In one option, a MWSP would be implemented in Phase 1 and then upgraded into an AL in Phase II. In the other option, an AL would be implemented in Phase 1 and continued in Phase II.

In Phase I, the treatment capacity is about half and so the land requirement is also half. With 27 ha of land required for AL, MWSP could be implemented in Phase I with half the ultimate capacity.

However, it is to be noted that the effluent quality of MWSP can not meet Vietnam effluent standard. Since the discharge is going to Lac Tray River, wich has a flow rate of around 80 m^3/sec, the water quality degradation would be insignificant (less than 1 ppm increase of BOD load). In case effluent quality plays significant role, AL can be employed from the Phase I.

The recommended option is AL. However, considering the high cost, MWSP leading to AL is also recommended, provided that minor water quality degradation is acceptable. The final selection of AL as the treatment process is made in the feasibility study stage after confirming land availability and discussion with HPPC.

(7) Dependence on Drainage System Development

The selected alternative consists of both separate and combined sewer systems. It is to be noted that proper functioning of a combined sewer system partly depends on a proper drainage system.

At present, many combined sewers drain into lakes, canals, and other surface water bodies. Combined Sewer Overflow (CSO) will be placed in such pipes to intercept dry weather flow. At present, water can back flow into the sewers from the surface water bodies. A proper drainage system must be implemented to eliminate this situation. Otherwise, surface water can enter the interceptor pipe and the WWTP may receive a huge amount of water with low BOD load. On the other hand, if gates are placed at CSO of tidal influence, dependency can be eliminated. Nevertheless, proper drainage will certainly facilitate the sewerage system.

4.4 Preliminary Design and Cost Estimates for the Optimum Measures for Class B Area

4.4.1 Kien An

(1) Selection of Alternative

As explained in Section 4.2.3, out of nine phoungs of Kien An, only one is served by septic tanks. Three phoungs will have a simplified sewer system and the remaining five phoungs will be served by a centralized sewer system. Because existing sewer lines are limited, a separate sewer system is proposed in the centralized sewer area. Among the phuongs to be sewered, Tran Thanh Ngo Ward (population density 86 person/ha in 2020), Bac Son Ward (population density 46 person/ha in 2020) and Quan Tru Ward (population density 56 person/ha in 2020) have the most urgent need for a sewer system. The development of sewer systems in these areas shall be carried out in Phase I. The sewer systems for the remaining area, i.e., Ngoc Son Ward and Van Dau Ward to be developed in Phase II. A simplified system will also be implemented in three phoungs in Phase II. Only one treatment plant is proposed as shown in Figure 4.4.1. The estimated service population and service area in 2020 are 72,213 persons and 1,362 ha, respectively. For Phase I, the estimated service population and service area are 38,624persons and 784 ha, respectively. The service population and service area for the simplified sewer system are about 28,026 persons and 947 ha, respectively.

(2) Estimated Generation of Sewage

Exactly the same conditions that were used for the Class A area were used to calculate sewage generation in Kien An.

Water supply data formed the basis for estimating sewage generation and is compiled in Table 4.4.1 based on information provided in Chapter 2. The proposed sewerage service ratio and sewage generation rate are given in Table 4.4.2. The detailed estimates are presented in Table 4.4.3 and the summary is given in Table 4.4.4.

The total sewerage generation in 2020 is 12,380 m^3/day, out of which 7,955 m^3/day will be treated in the central treatment plant while 4,425 m^3/day will be treated in the simplified treatment plant. The required treatment plant capacity in Phase I is 4,579 m^3/day.

(3) Facilities and Cost Estimates

For facilities planning and cost estimates, design principles used were the same as these used for Class A area. Three phoungs will be served by a central sewer system in Phase I and two more phoungs will be added in Phase II. Also in Phase II, three phoungs will be covered by simplified sewer system. The area involved population and sewage generation are summarized below.

Area, population and sewage generation of Kien An

			Area (ha)	Population	Sewage (m^3/d)
Kien An Central Sewage Treatment Area					
	Phase I	Separate sewer system	784	38624	4579
	Phase II	Separate sewer system	578	33589	3376
	sub-total		1,362	72213	7955
Nam Son Simplified sewage treatment area					
	Phase II	Simplified sewer system	337	9423	1575
Phu Lien Simplified sewage treatment area					
	Phase II	Simplified sewer system	289	10146	1350
Trang Minh Simplified sewage treatment area					
	Phase II	Simplified sewer system	321	8457	1500
Simplified sewage treatment area total					
	Phase II	Simplified sewer system	947	28026	4425

The sewerage facilities required are given in Table 4.4.5. The facilities include 1 central WWTP and 3 simplified WWTP. The weighted unit cost of the treatment plants were calculated using the same principal as used for Class A area and given in the following table.

Unit contruction cost for Wastewater Treatment Plants

	Flow m^3/day (1)	Cost. cost in Japan Million Yen (2)	Unit cost Million Yen/(m3/day) (3)=(2)/(1)	Ratio (5)=(3)/(4)	Unit cost US$/($m^3$/day) (6)*(5)
Ho Chi Minh city WWTP	141,000	18,300	0.130 (4)	1.00	507
Kien An WWTP	7955	2244	0.282	2.17	**1102**
Simplified WWTP	1500	664 × 0.5=332*	0.221	1.7	**864**

Note :
Base WWTP construction unit price = 507 US$/($m^3$/day) (6)
Construction cost in Japan is from Japan Sewage Works Association Standards (1996)
Construction cost (Million Yen) =393*(Q/1000)^0.73*(113.2/90.1)
where, Q = wastewater flow (m^3/day)
* = For Simplified, construction cost is half of conventional one.

Based on the proposed facilities and unit costs, cost estimates of the Project are given in Table 4.4.6. The total direct cost is estimated at US$34 million, of which Phase I accounts for US$15 million.

(4) Land Acquisition and Compensation

At the stage of master plan, there still remain several options for WWTP types. In this master plan, stabilization pond which requires the biggest land, wasassumed so that the plan can be revised more easily if other options are to be selected. Namely, land requirement and the compensation would be less if other treatment processes are selected. For the simplified WWTP, Anaerobic Aerobic Bio-filter is proposed.

Table 4.4.7 shows land acquisition required for WWTP, pumping station, total requirement, and compensation. The total compensation is US$0.825 million, out of which Phase I requirement is US$0.641 million.

4.4.2 Do Son

(1) Selection of alternative

As explained in Section 4.2.3, the need to develop a sewer system in Do Son by 2020 is not high because the population density is low. According to the basic planning strategy, three of the five phoungs should have septic tanks whilst the other that two could be served with sanitary latrines in 2020. However, considering Do Son is a tourist area, a simplified septic tank based sewer system is proposed for the three phoungs. The other two phoungs will be served with sanitary latrines as originally proposed. Among the phuongs to be served with a simplified sewer system, Ngoc Hai Ward (population density 15 person/ha in 2020) and Van Son Ward (population density 14 person/ha in 2020) have the most urgent need for sewer systems as these are the town center. The development of sewer system in these areas shall be carried out in Phase I. The simplified sewer systems for the remaining area, i.e., Van Huong Ward (population density 9 person/ha in 2020) is to be developed in Phase II. Two treatment plants are proposed as shown in Figure 4.4.2. The estimated service population and service area in 2020 are 23,298 persons and 1,949 ha, respectively. For Phase I, the estimated service population and service area are 14,384 persons and 1,139 ha, respectively

(2) Estimated Generation of Sewage

Exactly the same conditions that were used for the Class A area were used to calculate sewage generation in Do Son.

Water supply data formed the basis for estimating sewage generation and it compiled in Table 4.4.8 based on information provided in Chapter 2. The proposed sewerage service ratio and sewage generation rate are given in Table 4.4.9. The detailed estimates are given in Table 4.4.10 and the summary is presented in Table 4.4.11.

The total sewerage generation in 2020 is 2,973 m^3/day, out of which 1,821 m^3/day will be treated in the Do Son Center treatment plant while 1,151 m^3/day will be treated in the Van Huong treatment plant. The required treatment plant capacity of in Phase I is 1,134 m^3/day.

(3) Facilities and Cost Estimates

For facilities planning and cost estimates, design principles used were same as these used for Class A area. Two phoungs will be served by a simplified sewer system in Phase I and one more phoung will be added in Phase II. The area, population and sewage generation for Do Son are summarized below.

Area, population and sewage generation of Do Son

			Area (ha)	Population	Sewage (m^3/d)
Do Son Center Simplified Treatment Area					
	Phase I	Simplified sewer system	1139	14384	1134
	Phase II	Simplified sewer system	Same as Phase I Area	1738 (increment)	687 (increment)
	sub-total		1139	16122	1821
Van Huong Simplified sewage treatment area					
	Phase II	Simplified sewer system	810	7176	1151

The sewerage facilities required are given in Table 4.4.12. The facilities include 2 simplified WWTP. The weighted unit cost of the treatment plants were calculated using the same principle as used for Class A areas.

Based on the proposed facilities and unit costs, cost estimates of the Project are given in Table 4.4.13. The total direct cost is estimated at US$7.3 million of Phase I accounts for US$4.3 million.

(4) Land Acquisition and Compensation

It is proposed that the simplified WWTP employ an Anaerobic Aerobic Bio-filter. Table 4.4.14 shows that land acquisition required for WWTP pumping stations, total land requirement, and compensation. The total compensation is US$0.118 million, of which the Phase I requirement is US$67 thousand.

4.5 Phased Development and Disbursement Schedule

Within the Study Area, sewerage projects are proposed for Class A area, Kien An and Do Son. All projects are divided into two phases. Phase I has a target year of 2010 while the target year of Phase II is 2020. For the areas where no sewerage system is proposed, septic tanks and sanitary latrines are recommended. For the new septic tank system development, US$50/person is the estimated investment cost. Total Project investment cost is shown in Table 4.5.1. The table also shows the civil costs and electrical & mechanical cost portions for WWTP, pumping stations, and pipelines. The total investment costs for Class A area, Kien An and Do Son are US$160 million, 35 million and 8 million respectively. The total costs of phase I and II are US$69 and 137 million respectively. The total investment cost is US$207 million. Summary of total cost including land acquisition and compensation is given in Table 4.5.2. The total cost for sewerage development for the entire Study Area is US$211 million. Phase I cost is US$72 million.

Construction of the sewerage project and land acquisition are expected to start from 2004. Detailed design and pre-construction activities should start from mid-2003 in order to facilitate smooth implementation of the Project. The implementation schedule is given in Table 4.5.3. The annual disbursement of the costs is given in Table 4.5.4. The total cost including operation and maintenance is US$224 million, of which the Phase I cost is US$76 million.

4.6 Nightsoil Collection and Disposal

4.6.1 Problems Associated with Nightsoil Management

Bucket latrines are one of the worst methods of sanitation. They are not hygienic and it is always recommended to upgrade these kinds of latrines to a safer system.

At present, URENCO is responsible for nightsoil collection in 3 old urban districts within the Class A area. The workers use their hands and simple tools to transfer the nightsoil from the buckets to the truck. This is very unsafe and a great risk to public health.

A good number of users sell their nightsoil directly to farmers. This exposes a large number of residents to potential health risks.

The collected nightsoil is taken to the suburban agricultural areas and given to the farmers to be used as fertilizer. There is no control or monitoring system. According to WHO standard, raw nightsoil should not be used as a fertilizer for edible agricultural products.

It is estimated that the present number of bucket latrines in the 3 old urban districts is between 2,000 and 2,500. Though it was planned to eliminate bucket latrines by 2000, the target year is now set at 2002. In 2000, it is planned to convert 660 toilets. In addition, it is expected that all future conversion will be supported by revolving fund proposed in 1B project.

Until now all the conversions took place with direct or in-direct subsidy. Sometimes, this subsidy was as high as 80 %. With the revolving fund proposed in the 1B project, not only do the users have to pay 100 % of the conversion cost, they also have to pay interest of 0.6 % per year. The more favorable precedence will reduce the motivation of conversion with the revolving fund.

4.6.2 Estimated Nightsoil Generation

It is recognized that the quantities of human excreta produced may be influenced by local conditions, not only physiological, but also cultural and religious, especially the food habits. Guidelines show that in Asia, the amount of feces produced is about 200 – 400 gm per person per day (wet weight) ("Excreta Disposal for Rural Areas and Small Communities", WHO monograph No. 39, World Health Organization, 1958). It is also reported that the amount of urine produced is from 600 to 1130 gm per person per day. The total amount produced may also vary depending on some other factors. An example may be the use of ablution water or other personal cleansing materials. However, it has been suggested that for design purposes, a total excreta of 1 kg (wet weight) per person per day should be used.

The average household size in the 3 old urban districts is 3.86. However, it is found that at least two households are using one bucket-latrine in most of the cases. Considering that there are 2,500 existing bucket latrines and 8 persons use one bucket-latrine, the total present generation is around 20 tons/day. URENCO is now collecting about 10 tons/day. This indicates that about half of the nightsoil generated in the 3 urban districts is disposed of by the owners themselves, generally by selling it directly to farmers.

4.6.3 System and Facility Measures

(1) Targets and Principles for Improvement

1) Targets

The main target is to eliminate the nightsoil management system by converting all existing bucket latrines into septic tanks or other safer systems. However, until the elimination of all existing bucket latrines, a safe and hygienic nightsoil management system has to be secured. At the same time, public awareness is vital to prevent installation of new bucket latrines.

2) Early and Confident Conversion Procedure

The need for upgrading the existing bucket latrines has been felt for a long time, and different governmental agencies of Haiphong were working on the problem for a considerable period. It was reported that in 1995, the total number of bucket latrines was 14,000, which has reduced to between 2,000 and 2,500 at present. To motivate the upgrade, the program enjoyed considerable subsidy until now. It is reported that it costs around 4 million VND to convert a bucket latrine to a septic tank. The subsidy varied between 25 and 75 % during different stages. At one stage, the total subsidy was around 75 % (50 % provided by FINNIDA and 25 % provided by Haiphong PC). However, this system came to an end in 2000. As part of the

WB 1B project, provision is made for a revolving fund. The amount earmarked is US$1 million, which includes funds for a household-level existing sanitation system survey. In this revolving funds system, Women's Union will work as an executing agency. People have to repay all the money borrowed with 0.6 % annual interest.

Though the bucket latrines users and women's union is highly motivated to reach the goal of upgrading all existing unhygienic bucket latrines, people may feel frustrated because of the precedence of a 75 % subsidy. Although subsidy for this purpose is not a recommended procedure, for the present case it may be unavoidable because of the recent precedent. In case it appears that the revolving fund is not going to work, funds should be arranged from either external sources or Haiphong PC.

3) Public Awareness and Legal Framework to Prevent New Installation

Bucket latrines are a very unsafe method of excreta disposal. There are other safer options with identical cost. Installation of new bucket latrines should be prevented in newly developed areas. To ensure this, a law or building code is important. Also, proper implementation of such a law can only be secured by proper monitoring and public awareness building. The subject can be brought into the public's attention by radio, TV or print media, and also by being introduced into school sanitation texts.

4) Safe Collection Practice

Until all bucket latrines are eliminated, a safe and hygienic collection and disposal system is indispensable. For the collection, two options can be recommended. Workers can be provided with special protective clothing to stop direct contact with the raw excreta. Otherwise, small suction pumps can be utilized to transfer the excreta into the trucks. URENCO now uses 5 trucks each with 5 ton (volume 3 m^3) capacity for the excreta collection. Present generation is 20 ton per day. The trucks are enough for the purpose.

5) Full Collection Coverage

At present, URENCO is collecting about 10 tons/day of nightsoil out of around 20 tons per day generated. URENCO now collects nightsoil from 1,600 bucket-latrines out of an estimated 2,500 bucket-latrines. A legal framework should be established so that all existing bucket latrines come under the URENCO collection system until they are replaced by more hygienic systems.

6) Safe Disposal Practice

Since all bucket latrines are expected to be eliminated by 2002, no special treatment system is proposed. For the interim period, it is proposed to use co-disposal with solid waste in Tran Cat landfill site. An other option is for nightsoil to be given to farmers after ensuring that they will not use raw excreta for edible agricultural products. A simple drying bed prepared and maintained by the farmers can provide better situation. Excreta should be mixed with soil and spread over a large land area.

(2) Alternatives, Time Frame and Rough Cost Estimation

1) Conversion to Septic Tanks

As proposed in the 1B project, conversion will be carried out by using a revolving fund. In this option, all conversion is planned to be completed by 2002. As this is included in the 1B project, no new fund is required.

Since there is a high possibility that revolving fund program may fail, other suitable alternatives should be considered. In such option, 75 % of the conversion cost should be subsidized inline with the recent practice. Considering the cost of one conversion is VND4 million, the funding required is around US$700,000. Because of the subsidy, implementation can be expected to occur more quickly.

2) Collection System

The option of giving special protective clothing to collectors would only cost a few thousand dollars and can be implemented immediately.

The option of five small suction pumps will cost around US$300,000. Despite its higher cost this option is considerably more hygienic and is recommended by the Study.

3) Disposal System

There will be no capital investment for the disposal system as it is a short-term option. Some legal and institutional measurements are required both for co-disposal with solid waste and compost drying by the farmers.

(3) Comparison among Alternatives

Because of the recent practice of providing subsidies for septic tank conversion, there is a possibility that the revolving fund system may not work. Though it is not a good option to provide subsidy for such conversion, probably there would be no way other than providing subsidy because of system practiced until now.

Suction pumps are more hygienic compared to simple tools used for collection. After the elimination of bucket latrines, these pumps can be hand-over to SADCO to be used for septage collection.

Since there is a strong demand for nightsoil by farmers, it would be better to give away the nightsoil to the farmers. However, a proper system has to be implemented to safeguard the public health conditions for both farmers and consumers of the products.

4.7 Septic Tank Sludge Collection and Disposal

4.7.1 Problems Associated with Septage Management

The major problem associated with septage management is collection. Most of the septic tanks are inaccessible and they do not have access points required for desludging. In most cases, septic tanks are constructed just below the toilet and there are no manholes. This is a constraint to septic tank emptying and needs to be solved at the household level.

Apart from the major roads, most roads in the three urban districts are very narrow zigzag alleys. Houses along these alleys cannot be accessed by vacuum tanker. It is estimated that more than 70 % of houses are further than 40 meters from four-wheel vehicular access (Vietnam Sanitation Project – Haiphong Component, Preliminary Design Report, The World Bank, Feb. 1999). This means that septage management cannot be handled by traditional vacuum tanker solution alone.

As the cost of highly advanced septage collection equipment might be too high to operate in Haiphong because of low the fee received for septage collection, methods should be selected that require low investment, operation and maintenance costs.

At present, SADCO's septage management is demand based. SADCO provides a tank emptying service only when called out by householders, often after problems arise with blockages in the foul drainage system. This leads to a major problem of irregular desludging. First, there is no set fixed desludging interval. In addition, there is no system to monitor the desludging practice. A proper desludging system should be placed into operation.

All septic tanks are designed to handle only black water. Gray water is discharged into the drainage pipes.

4.7.2 Estimated Septage Generation

The amounts of septage that require collection and disposal in the future will depend on:

- how sewerage development proceeds over the planning period
- how frequently septic tanks are cleaned.

There are three options regarding the septic tanks within the overall sewerage development. In the first case, septic tanks can be proposed to be eliminated. However, this cannot be achieved within a short period. In this case, septage management should be considered for at least 15 years and the amount of septage to be collected will be reduced gradually. In the second option, the present septic tanks can be kept as is whilst requiring all new construction to be connected to the sewer pipelines. In this case, the number of septic tanks and amount of septage to be collected will remain constant. In the third option, it can be considered that all future sewerage development will be based on septic tanks. In this case, comprehensive septage management will be required, as the number of septic tanks and the amount of septage will increase gradually.

Under any of he options for sewerage under consideration, there will still be a large percentage of the population using septic tanks well beyond the year 2010. Improvements in sewerage will therefore need to be accompanied by corresponding improvements in septage collection and treatment facilities to prevent environmental degradation, sewer maintenance problems and potential health hazards from the indiscriminant disposal of septage.

As proposed in the sewerage development plan, a wastewater treatment plant will start operating by 2008. After that, the number of septic tanks will start to reduce in the central area. Still, until the implementation of Phase II, septic tanks will remain in use for areas other than the central area.

The quantity of septage collected from septic tanks must be estimated in order to plan for collection and treatment infrastructure. The quantities of septage will depend mainly on the number of tanks in service, the cleaning frequency, and the size of the tank. The collection of the parameters required to accurately estimate septage quantities was beyond the scope of this study. However for planning purposes it is necessary to establish future trends

The calculation method used to estimate septage quantities in urban areas requiring collection and treatment is described in Fig. 4.7.1. The estimates are based on the following simplified assumptions:

- One septic tank system serves on average about 8 persons. The average is higher than the number of people per household to allow for larger installations serving apartment buildings, community septic tank that is very common to Haiphong three urban districts, hospitals, commercial and institutional buildings
- Solids are removed when tanks are 1/3 full
- Septic tanks are removed gradually when households are connected to sewers. If tanks are not taken out of service, the amount of septage that must be collected will increase significantly despite the implementation of public sewerage systems

The exact number of septic tanks in the 3 old urban districts is not known. Estimates indicate that the number is between 35,000 and 75,000 probably about 50,000. Assuming an average desludging period of 4 years, and an average volume of each tank as 4 m^3, the present generation rate is around 50,000 m^3 per year (137 m^3/day).

The range of sludge accumulation is usually 0.03 to 0.06 m^3/person/year. It is assumed the sludge accumulation rate is 0.04 m^3/person/year for Haiphong. Considering the present population as 400,000, the total sludge generation is about 16,000 m^3/year. Since the total volume of the septic tank has to be removed during desludging, and desludging should be done when the tank is 1/3 full, the septage (not the sludge) to be removed is 48,000 m^3/day (132 m^3/day).

The range of unit septage BOD loading is usually 0.00454 to 0.0136 kg/capita/day. It is assumed the unit septage BOD loading is 0.005 kg/capita/day for Haiphong. The range of BOD concentration of septage is usually 2,000 to 30,000 mg/l. It is assumed that the BOD concentration in Haiphong is 15,000 mg/l. Considering a population of 400,000, the total septage is 48,667 m^3/day (133 m^3/day).

The values from three methods are rather close. This value is used for all further calculations.

SADCO collected about 2,417 m^3 of septage in 1999 from the 3 urban areas (6.62 m^3/day), which is relatively small compared to the estimated amounts if tanks are cleaned when 1/3 full. The low collection amount may be explained by a number of factors:

- very few septic tanks are maintained properly
- a large number of septic tanks are not accessible for mechanical septage collection
- URENCO is actively involved in collection and disposal where vehicular access is not possible
- desludging frequency is not maintained

4.7.3 System and Facility Measures

(1) Targets and Principles for Improvement

1) Targets

The major target is to formulate the most appropriate collection and disposal system. In this section, possible alternatives for the improvement of septage collection and subsequent disposal are discussed. Considering all the local and specific factors, the most appropriate solution is proposed. Based on the total sewerage development strategy, septic tanks are proposed to be eliminated gradually.

2) Base line Data Preparation

At present, the information concerning septic tanks is limited: locations, sizes, number of septic tanks etc. are not known precisely. Estimates for the number of septic tanks vary from 35,000 to 70,000, and 50,000 is the most probable number. In order to carry out the task of septage management and to present a meaningful plan for septic tank improvements, a detailed study of septic tank related issues should be carried out. This study should cover every household in the Study Area. The result of this study should provide such information as:

- number of persons using the septic tank
- size of septic tank
- number of chambers
- existence of access points
- desludging frequency
- access of vacuum truck
- as a final result, the total number of septic tanks and number of households having other types of sanitation system with owners name and address

As a pilot study, HPWSSP is now executing a septic tank survey in Cat Bi Phoung. In World Bank 1B project, there is also one component for septic tank survey. An estimated US$300,000 is budgeted to carry out the survey in 21 phuongs. Women association will be entrusted to carry out the survey. A similar survey should be carried out for the entire Study Area.

3) Public Awareness

A public awareness campaign prior or parallel to this Study is essential to promote an understanding of septic tank improvement. Also users should be taught the proper use of septic tanks. An example might be that the users should not put cigarette butts, plastic, metal and facial tissues into the tank as they either do not degrade or degrade very slowly and may clog the system.

4) Consideration for New Septic Tanks

It is essential to follow the requirements specified in the Vietnam Standards to ensure proper function of the septic tanks. Although the standard itself is sufficient for the basic objective, it does not give detail technical instruction for septic tank construction. On the other hand, the Vietnam Architectural Structure Book includes all necessary details for the construction.

However, the standard is not followed properly in the Study Area. The inspection holes are missing and in some cases, minimum requirements on the dimension of septic tank have not been strictly followed. To overcome these problems, better supervision in the design and construction phases are needed. In the construction phase, special attention to the invert levels should be paid in order to avoid septic tanks being installed too low is commonly encountered in Haiphong.

5) Communal Septic Tank

Installation of communal septic tanks shared by groups of flats would be beneficial to SADCO's septage management. There would be fewer septic tanks to empty and it would reduce construction costs. The main problem of this idea is to find suitable locations for the tanks.

6) Improvement of Existing Septic Tanks

The most important task in the improvement of existing septic tanks is to provide each septic tank with an access hole with a sealed cover. The present practice of breaking the toilet floor to empty a septic tank cannot function well for routine septage collection. The hole size and shape should be standardized in order to enable the use of standard emptying equipment and tools.

Where they are not already installed, it would be very helpful to construct baffles, scumboard, and tee to the effluent pipe. This will improve the septic tank performance and prevent solids entering sewer pipes although it would be very difficult to implement.

7) Septage Collection

The conventional septage collection method is to use vacuum trucks. At present SADCO is using this system. However, it is not physically possible to collect septage from septic tanks located in the narrow alleys. At present, septage from such locations is collected manually, which can be a serious risk to public health and esthetic nuisance.

Finding suitable equipment for septic tank emptying in Haiphong is a challenging proposition. Conventional vacuum tankers or mini vacuum tankers can empty the septic tanks that have good vehicular access. However, even mini vacuum tankers presently owned by SADCO can not access most places. There are two options. One is the use of special sophisticated equipment as proposed in the 1B project and the other is a low-cost appropriate technology. A combination of these two options can also be considered.

In the first option, special high-pressure vacuum pumps with long nozzle can be introduced. This is a proven technology but requires a huge capital investment and high operation and maintenance cost.

The other possibility is the selection of a hand cart mounted small vacuum tank. This will not only lower the investment and O&M cost, but also help in getting access to narrow alleys facilitating easy collection. In this proposed system, a small tank and a small vacuum pump will be mounted on two handcarts. These can be brought close to septic tanks in narrow alleys and collected septage can later be transferred to conventional vacuum truck.

8) Desludging Interval

To assure proper functioning of a septic tank, the liquid retention time should be at least 1 day. One-third of the tank volume is normally reserved for the storage of accumulated sludge and another one-third is kept reserved for scum. As a result, a septic tank should be designed with 3 days retention time. Since the septic tank should be emptied when it is approximately one-third full of sludge, the desludging interval (DSI) in years can be approximately found from the following equation.

$$DSI = \frac{0.33\,Vt}{Vs\,P}$$

where,
V_t is the septic tank volume (m^3)
V_s is sludge accumulation rate (normally, 0.03 – 0.04 m^3/capita/year), and
P is population.

This equation gives a rough tool to estimate desludging interval. When the sludge and scum have accumulated to a level where they might start discharging with the effluent, the tank should be emptied and the sludge and scum removed. It should be noted that sludge and scum measurements should be done in the first compartment of multi-chamber septic tanks.

There are two options by which desludging operations can be carried out in Haiphong. One is periodic inspection method and the other is GIS based computer database monitoring.

In the first method, inspectors (or the household owners after receiving training) will check the septic tanks at least twice a year. A useful tool for measuring the thickness of the scum is a rod graduated in centimeters to which a disc or square flap is attached. If this rod is pushed through the scum mat, moved sideways to a place where the scum is undisturbed, and then pulled up gently, the depth of the scum can be known. Whenever, the distance between the scum layer and the outlet pipe is 8 cm or less, the tank should be emptied.

In the second method, information about all septic tanks will be kept in a GIS based computer database. There should be information about tank size and number of users along with the address. Specially tailored software can determine the desludging interval for each septic tank. For a certain month, it is possible to generate the addresses for which desludging are required.

SADCO can carry out the septage collection for the designated septic tanks after pre informing the owners. The advantage of this method is that it is a fully automated information retrieval system assuring proper septage collection. It will also eliminate the need of inspectors, which in the long run will be cost effective.

This system will not be costly because of the certain prevailing situation in Haiphong. A detail septic tank survey is already planned in 1B project. This can be used for the preparation of the database. A GIS information base is already available with Haiphong Water Supply Company that can be obtained immediately. As a result, a computer based desludging system can be started with little effort.

9) Treatment and Disposal of Septage

The principal methods most commonly used for the treatment and disposal of septage are as follows:

- Land application (drying bed)
- Co-disposal with solid wastes
  - land filling with solid waste
  - composting with solid waste
- Co-treatment with wastewater
  - biological treatment
- Processing at separate facilities including
  - Aqua culture
  - biological treatment
  - lime stabilization
  - composting

Land Application

Septage can be applied in liquid form directly to the surface of the land with spray guns, trucks equipped with liquid spreaders, and liquid manure spreaders used on farms. Spreading should be followed by a short drying period and then disking to incorporate the dried sludge into the soil.

Septage can also be dewatered in lagoons or on drying beds and applied directly to land in a solid or semi-solid form. High annual rainfall in Haiphong makes the use of year round sludge drying beds impractical.

Most of the problems associated with surface application can be overcome by subsurface application. The methods most commonly used for subsurface application of septage are: i) the furrow cover method in which septage is applied in narrow furrows and covered with soil by a following plow, and ii) the injection method in which septage is injected in a wide band or several narrow bands 150 mm below the surface of the soil. Subject to loading limitations, land application can provide effective treatment and disposal of soil.

In the study area, the use of nightsoil as fertilizer is widespread in low population density areas. Land application of septage is considered sustainable for all sub-urban settlements in areas with densities of less than 30 persons per hectare.

For Haiphong City, the daily quantities generated are large. The principal concerns associated with direct application of septage on land are the potential health risks, the possible contamination of groundwater, and the production of nuisance conditions and odors.

Co-disposal with Solid Waste

At present, most of the septage collected by SADCO is disposed of at the Tran Cat landfill site. The landfill site must be sealed properly to eliminate contamination of the underlying groundwater. The landfill site at Tran Cat presently is not designed for gas production and recovery, therefore the application of septage would lead to anaerobic decomposition and the undesirable production of gas (methane). Therefore co-disposal of septage with solid wastes at the landfill site is not sanitary. However, sanitary landfill is proposed in this Study including gas release. So in future, it is possible to co-dispose septage together with solid waste.

Septage solids can also be co-composted with solid wastes to produce a humus-like end product (as proposed in 1B project). Composting is the biological decomposition of the organic matter in the septage and solid waste (paper) in the presence of oxygen under thermophilic (49 to 57°C) dewatered conditions. Composting of municipal solid waste is often used to process the waste into a soil conditioner for agricultural purposes. Ranges of nutrients commonly found in solid waste compost are:

Nitrogen	0.5% to 3%
Phosphorous	1% to 2%
Potassium	1% to 2%

As such, solid waste compost does not lend itself to being marketed as a fertilizer substitute. Adding nutrients by septage sludge is a method that could improve the fertilizer value and marketability of the compost.

While composting solid waste with septage can provide a much more valuable final product, a proper mix of solid waste and septage must be maintained. The ratio of solid waste to septage that will compost properly is usually 1:1 by weight when septage is applied in liquid form with about 5 %

solids. Co-composting can only be used effectively if solids contents of the septage are high. Thus it is usually only used for further treatment of the solids separated from the septage by drying or dewatering process.

The success of processing septage at the composting facility will affected by many variables which are impossible to predict:

- the quality of the solid waste
- the quality of the septage
- the proper operations of the composting process

At present there is no compost plant in Haiphong and there is no proposal to construct such facilities. In order to properly assess the composting process and its capacity for treating septage, a pilot study is recommended. Due to the cost of even the smallest mechanized operation, it is recommended that a manually operated, small-scale composting plant be developed before implementing a full scale composting facility.

The proposed septage treatment plant under 1B is basically co-treatment with solid waste preceded by dewatering. This is a good system but there are some disadvantages. First, the dewatering cannot work properly in Haiphong as the total rainfall is huge and concentrated within a few months. Secondly, mixing with solid waste may not produce good compost while it requires mechanical mixers. Most importantly, the proposed capacity is not sufficient to meet the existing demand.

Co-treatment with Wastewater

Co-treatment with wastewater at a local wastewater treatment plant is usually one of the most cost-effective methods for the treatment and disposal of septage. Since new wastewater treatment plants are proposed in the wastewater master plan, the option of co-treatment of septage with wastewater appears to be the most practical and logical way for septage disposal. However, because septage has higher BOD and SS loads than wastewater, the treatment plants will need sufficient excess capacity and solids handling capability to process septage.

If septic tanks are to remain in operation in Haiphong for a long time, it is recommended to use this option.

Separate Septage Treatment Facilities

If wastewater treatment plants are not available, consideration must be given to the construction of facilities specifically designed for the purpose of septage treatment and disposal. Septage processing at specially designed facilities can be accomplished by : a) biological treatment, or combined physical and biological treatment, b) lime stabilization and c) chemical oxidation. One of the major problems associated with the processing of septage at separate facilities is that some method must be found for the disposal of the liquid and solid portions of the septage after treatment. Discharge of the liquid portion to a receiving water body must meet the Vietnamese Standards for Industrial Effluent.

(a) Biological Treatment:

The biological treatment of septage is usually accomplished in: i) either aerobic or facultative (anaerobic/aerobic) waste stabilization ponds, ii) conventional biological treatment facilities, and iii) combined physical and biological treatment facilities.

Where climatic conditions are favorable and land is readily available, waste stabilization ponds can be a cost-effective way to treat wastewater and can also be designed to receive solely septage. A typical flow diagram is shown in Figure 4.7.2

Aerobic lagoons are shallow (0.3 to 0.9 m) impoundments into which septage is discharged. Oxygen is supplied by the photosynthesis of algae. Facultative ponds provide aerobic stabilization of waste in the surface layers and anaerobic digestion in the lower layers. Facultative ponds are usually 1.2 to 2 m deep. Typically at least two lagoons are used so that one can be dewatered and dried for solids removal. The dried solids can be disposed of at the landfill site or spread on land. Pond effluent can be disposed of i) in infiltration beds, ii) by evaporation, iii) by further treatment in maturation ponds and constructed wetlands before using in irrigation to remove the risk of pathogens. Facultative ponds can, in some cases, lead to nuisance problems such as odors and should be sited away from population centers.

Where discharge requirements for nitrogen and phosphorus are quite low, the treatment of septage is accomplished using more process intensive facilities such as shown in Figure 4.7.3.

(b) Lime Stabilization:

In the lime stabilization process, lime is added to destroy pathogenic organisms. For the process to be effective the pH must be raised to a value of 12 or greater for at least 30 minutes. After lime treatment the solids must be removed. The liquids and the solids must be disposed of separately. Because of the number of treatment steps involved in the process and the cost of chemicals, this process is not often used on a long-term basis. However, lime stabilization can be used to deal with short-term septage disposal problems.

(c) Chemical Oxidation

The most common chemical oxidation process involves the use of chlorine gas for stabilization of the septage. Because of the cost and complexity of this and other similar processes, chemical oxidation is not used extensively for the treatment of septage and is not recommended.

Comparison of Treatment Options and Recommendations

A qualitative comparison of options is presented in the following table in order to find out which methods are likely to be the most practical or feasible for the situation in Haiphong. Based on the evaluation of advantages and disadvantages there are three possible options:

- Co-treatment of septage with wastewater at sewage treatment plants
- Co-disposal of septage with solid waste at sanitary landfill site
- Treatment of septage at waste stabilization ponds designed to receive septage only

Comparison of Septage Treatment and Disposal Options

DISPOSAL METHOD	ADVANTAGES	DISADVANTAGES	FEASIBILITY
Surface application	• no treatment required • inexpensive	• potential health risks • groundwater and surface water contamination • nuisance odors	Large-scale application is rejected because of potential environmental and health risks. Feasible only for small-scale use in rural areas.
Co-disposal with solid waste	• convenient • no need for separate disposal site or treatment	• potential groundwater contamination • formation of methane in the landfill	Feasible for a landfill site with leachate collection and gas release facilities. Recommended as an interim solution.
Compost	• potential for beneficial re-use of end product	• septage must be de-watered to increase solids content • de-watering is expensive • disposal cost for composted septage outweigh the economic benefits	Requires pilot study to determine feasibility.
Co-treat with wastewater	• cost effective where treatment plants have excess capacity	• excess treatment capacity is required for high BOD and SS of septage to prevent treatment plant upsets • creates more sludge that must be disposed	Recommended as the cost-effective solution if treatment plants are constructed for wastewater.
Separate conventional biological treatment	• high level of treatment	• expensive • same treatment can be provided at wastewater treatment facilities	Rejected because it is too expensive.
Waste stabilization ponds	• inexpensive operation and maintenance • simple technology and easy to operate • Efficient treatment levels and reduction of pathogens and helminth eggs.	• higher land requirements • potential odor problems	Recommended as most cost effective solution
Lime stabilization	• effective destruction of pathogenic organisms • simple treatment process	• septage must be de-watered • water and solids must then be treated separately • intensive chemical use, therefore high cost	Rejected because it is expensive and increases the amount of solids that must be disposed.
Chemical oxidation	• effective treatment	• expensive • complex	Rejected because it is very expensive and complex

(2) Alternatives, Timeframe and Rough Cost Estimation

1) Base Line Data Preparation

In FINNIDA program, a pilot scale septic tank survey is now on-going in Cat Bi Phoung. The survey is carried out by Women's Union under SADCO supervision. A full-scale survey will be undertaken in the other 21 Phoungs under 1B project. An estimated US$300,000 is budgeted for that in 1B project. It is recommended to implement a similar survey in other phoungs in the Class A area in Phase I. The total cost is estimated at US$1 million.

2) Septic Tank Monitoring Unit

A monitoring unit within SADCO is proposed to oversee the issues related to septic tanks. All new construction should be checked and approved by this unit. Also the unit will be in charge of creating public awareness and motivating people to improve their existing septic tanks. The unit should be started in Phase I stage and the inception cost is estimated at US$1 million.

3) Septage Collection

Considering there is about 50 % vehicular access, the amount to be collected by conventional vacuum truck is 67 m^3/day. The present capacity of SADCO is about 24 m^3/day. Under the 1B project, new vacuum trucks will be procured soon. The additional capacity will be 18 m^3/day. So additional trucks will be required for collecting the remaining 25 m^3/day. The estimated cost is US$3 million and this should be procured in Phase I. It is to be noted that the 1B project has a budget of US$2.5 million.

A hand cart based small scale vacuum truck system is proposed in order to facilitate access to the septic tanks in narrow alleys. A rectangular deep but narrow tank of a capacity between 0.5 and 1 m^3 can be placed on a hand cart along with a small vacuum engine. The estimated cost is US$1 million and this should be procured in Phase I.

There are some alleys where even hand carts can not enter. For those places, high pressure vacuum pumps with 100 m nozzle can be the solution. Since the number of those locations is few, only one such truck can serve the purpose. The estimated cost is US$1 million and this should be procured in Phase I.

4) Desludging Interval Monitoring

As an intermediate measure, periodic inspection is the better option. The job can be included in the duties of the Septic Tank Monitoring Unit.

However, if the septic tanks are to be kept for a long period, a GIS based system will be more cost effective. Since the base line information will come from septic tank surveys, and a GIS database for Haiphong can be obtained from WSCo, the system can be implemented with low capital expenses, and the service can be entrusted with the septic tank monitoring unit. The estimated cost is US$1 million.

5) Improvement of Existing Septic Tanks

Opening of the manhole for desludging access is a must for sustainable septage management program. Public awareness, legal enforcement, and subsidy may be required for quick achievement of the target. Cost is estimated at US$1 million for this purpose. Public awareness program should be conducted in conjunction with this activity.

6) Treatment and Disposal of Septage

Three options are considered. These are co-treatment with wastewater, co-disposal with solid waste and separate stabilization pond. If co-treatment with wastewater is adopted, the capacity of the WWTP will need to be increased to take into account that the BOD of septage is 10 to 30 times higher than normal wastewater. The estimated cost is around US$5 million.

The proposed co-disposal with solid waste option in 1 B project can handle about 21,000 m^3/year of septage and the cost is estimated at US$2.2 million. For the greater service area and higher sepatge generation value, the design should be changed from that proposed in 1B project. The estimated cost is around US$5 million.

A separate pond system only to treat septage can also be constructed. The simplicity of the treatment method is the key advantage, the cost is estimated at US$5 million. This can be constructed at the proposed septage treatment plant at Trang Cat landfill site.

(3) Comparison among Alternatives

Base line data preparation, establishment of a Septic Tank Monitoring Unit, and trucks for septage collection are essential and have to be implemented in Phase I.

Among the two options proposed for the monitoring of desludging interval, periodic inspection is recommended as an intermediate solution. As the septic tanks are to remain for a foreseeable period, GIS based system is recommended.

4.7.4 Preliminary Design and Cost Estimates for the Selected Alternatives

(1) Septage Treatment

The on-going 1B project proposed a septage treatment plant with a capacity of only 21,000 m^3/year on SADCO land within Trang Cat landfill site. The method consists of dewatering followed by composting with solid waste. The cost is estimated at US$2.2 million.

Considering the low capacity and possible operation limitation, this Study proposes separate septage treatment employing waste stabilization pond method at the same location. The detail design procedure is shown in Table 4.7.1. The effluent water quality is 50 mg/l. Total land requirement is 13 ha. The process consists of preliminary screening, anaerobic primary pond, secondary lagoon and sludge drying bed. Construction cost estimation is based on HCMC treatment plant (stabilization pond with sludge drying bed) proposed in the JICA Study (1999). The calculation is shown in Table 4.7.2. The estimated cost is around US$5 million. There is no land acquisition cost since the plant is proposed to be constructed within SADCO's 17 ha land available at the Trang Cat landfill site.

(2) Total Cost Estimates

Small vacuum trucks for nightsoil collection: Until the elimination of bucket latrines, small vacuum trucks should be used to collect nightsoil. Estimated cost is US$300,000.

Bucket Latrine Conversion: Until now, bucket latrine conversion is subsidized. This practice will end by the end of 2000. 1B project will carry out the conversion by revolving fund. However, the success of this program can not be ascertained. In line with the current practice, subsidy may not be avoided. Estimated cost of conversion under subsidy is US$700,000.

Base line data preparation: On-going 1B project proposes to carry out a base line survey on septic tanks for 21 Phoungs. An amount of US$700,000 is budgeted for that. To cover all class A area, it is estimated to required US$1 million.

Improvement of existing septic tanks: Inspection and enforcement is required to improve the existing septic tanks. Subsidy may be required for smooth implementation. The Major component is to provide an access point for desludging in each septic tanks and tank modification, if necessary. The cost is estimated at US$1 million. This should also include a public awareness program.

Septic Tank Monitoring Unit: A monitoring unit within SADCO is proposed to oversee the issues related to septic tank management. The inception cost is estimated at US$1 million.

Desludging interval monitoring and data base: A GIS based system is proposed to monitor desludging interval. As an intermediate option, periodic inspection is proposed. Cost is estimated at US$1 million.

Collection Vehicle: New collection vehicle will be procured under 1B project at a cost of US$2.5 million. However, this will not fulfil the total requirement. It is proposed to procure additional vacuum trucks, a high pressure vacuum truck and hand cart based vacuum trucks. Total cost is estimated at US$5 million. The breakdown shows that the costs of conventional, high-pressure and hand-cart based vacuum trucks are US$3, 1 and 1 million respectively.

Septage Treatment Plant: The 1B project proposes to construct a septage treatment plant of capacity 21,000 m^3/year at a cost of US$2.2 million. It is recommended to increase the capacity to satisfy present demand and to change the treatment process into a sustainable system. The estimated cost is US$5 million.

Land requirement: Since the new septage treatment plant will be constructed at the same place that is selected by 1B project, no new land is required.

Total cost: The total cost for septage management including nightsoil management is US$15 million.

(3) Septage Management Investment in Consideration with Sewerage Development

As proposed in the sewerage development plan, the treatment plant will start operating by 2008. Septage management is required as an intermediate solution. Investment in septage management is planned in a way that facilities supplied can be utilized effectively for the sewerage development projects.

The small vacuum trucks for nightsoil collection and septage collection vehicles can be used for sewer sludge collection.

Information collected and complied for the desludging interval monitoring can be used for the sewerage tariff collection system.

The septage treatment plant can be used for the treatment of WWTP sludge and sewer sludge.

(4) Phased Development and Disbursement Schedule

Septic tank management is an intermediate solution, thus the septage management projects should be implemented immediately. Implementation is proposed to start in 2002 and be completed by 2004.

The disbursement schedule is shown in Table 4.7.3.

4.8 Strengthening of the Management and Manpower Training for Sewerage/Septage/Nightsoil and Drainage System

4.8.1 Strengthening the Institutional Framework for Urban Sewerage and Drainage

(1) Protection of the Drainage System and the Environment

The proposed new regulation on "The Management, Utilization, and Usage of the Urban Sewerage and Drainage System in Haiphong City" provides general provisions and assigns the overall responsibility to TUPWS. The proposed regulations set down various provisions to protect the drainage facilities and water quality of the drainage and sewerage system including:

- specific prohibitions on construction within specified buffer zones around all sewerage and drainage facilities
- specific provisions with respect to restrictions on discharges of sewage, dumping of solid waste, or industrial effluent to the sewerage and drainage system
- specific provisions requiring that organization and individuals who discharge to the sewerage and drainage system and use the system for other purposes to seek permission from the "agency who manages and protects the drainage system"

The proposed regulations authorize the People's Committee at different levels to supervise and monitor the implementation of the regulations. The regulations do not set out any specific provisions on administrative penalties for violation of the regulations, nor do they specify any responsibilities for enforcement.

Beside TUPWS, other Haiphong government departments and industrial enterprises also have responsibilities. The proposed regulations do little to clarify these responsibilities for land use associated with drainage facilities and environmental protection of lakes, rivers, and channels. One area of overlapping and/or unclear responsibility is the environmental management and protection of lakes and channels that make up part of the drainage system. There are overlapping functions and authorities between the DOSTE and SADCO. The DOSTE is responsible for the environment in general, including the water in the lakes and channels. The actual operational responsibility for the lakes and channels belongs to SADCO. And the channels have more than one function (e.g. irrigation and drainage). The Department of Agriculture and Rural Development (DARD) has responsibility for irrigation.

An Kim Hai Channel is an irrigation channel and is currently under the control of DARD. The proposed priority project for drainage improvement includes the upgrading of An Kim Hai Channel. TUPWS and then SADCO will have to be assigned sufficient responsibility and authority for An Kim Hai channel to allow for the project to be implemented and the drainage system to be efficiently operated.

(2) Tariff System, Cost recovery and Revenue Collection

1) Full Cost Recovery for Septage Management Services

It is generally accepted that septic tanks users will pay a fee for the service of desludging. In general there are three major cost elements: 1) administration cost of septage monitoring unit; 2) the cost of collection and transport; and 3) the cost of operation of the septage facility. All three costs must be recovered in setting the fees for septage services. Fees will be collected directly from the customers.

2) Recovery of Operating Costs for Sewerage.

The costs of the sewerage and drainage system are the most difficult to recover. Here again there are three major cost elements; 1) SADCO's administration cost; 2) operation and maintenance costs; and 3) capital costs associated with equipment and sewerage and drainage improvements. The principle of charging a fee for this service is being established. There is currently a sewerage fee (VND200/m^3) that is added as a surcharge to the water bill. In the short term, this charge should be increased until the operating and maintenance costs associated with the sewerage system are covered.

3) Recovery of Capital Costs for Sewerage

In principle, the user should pay for the capital costs associated with sewerage. However, it will be difficult to fully recover the costs associated with capital improvements. It may be many years before the residents of Haiphong will be able to pay a user fee for sewerage that includes all costs.

(3) Improvements in Administrative Efficiency

In general, there are a number of improvements in administrative efficiency that need to be introduced into SADCO. The following description focuses on the institutional changes, technical assistance, and training needs.

1) Action Planning and Financial Planning

The annual corporate planning process needs to be strengthened. The next important improvement is the introduction of a performance based reporting model that is based on indicators. Each sector is to prepare and plan and regular quarterly meetings will be held to evaluate progress.

2) Accounting

The accounting systems need to be upgraded and developed. In general, there are a number of areas that are being worked on: 1) collection, and analysis, and production of statistics: 2) completion of the billing, collection, and accounts receivable 3) cost controls based on new developed cost indicators and cost codes; and 4) auditing procedures for the accounts.

In general, these activities involve the introduction of new computerized systems, both hardware and software. And of course, training in the use of these systems.

3) Management Information Systems

Management information systems may incorporate a number of existing and future systems, including: 1) an internal local area network, 2) the proposed material management system, 3) accounting systems, 4) the billing collection, and accounts receivable system, 5) proposed reporting systems

The first step is to create a basic design of the system using the basic approaches for design and development of management information systems.

4) Material Management Systems

Better systems are required to manage the procurement process and track the use and disposal of materials. Computerization under development needs to be completed and training in standard operating procedures undertaken.

(4) Business Planning to help SADCO to become a Commercial and Financially Autonomous Enterprise.

At a workshop on Public Utility Socialization held in Hai Phong on November 18-19, 1999, the director of SADCO suggested that the following types of sewerage and drainage services were suitable for socialization:

- septic management services
- construction of waste treatment system for offices, companies, and households

SADCO has created a new division for private construction activities as a potential new line of business. In addition, one viable option for the new septage management unit would be to operate the unit for profit. However, before SADCO ventures into private business activities, it needs to begin a rigorous strategic business planning process that helps it identify clearly:

- its current and future business opportunities
- its comparative advantage
- its assets
- its ability to attract financing
- the expected revenues and costs

- the strength of its senior management team
- the strength of its "Board of Management"
- the regulatory environment for Public Utility Enterprises

This will help SADCO organize itself to achieve its social and business goals.

4.8.2 Proposed Organizational Changes

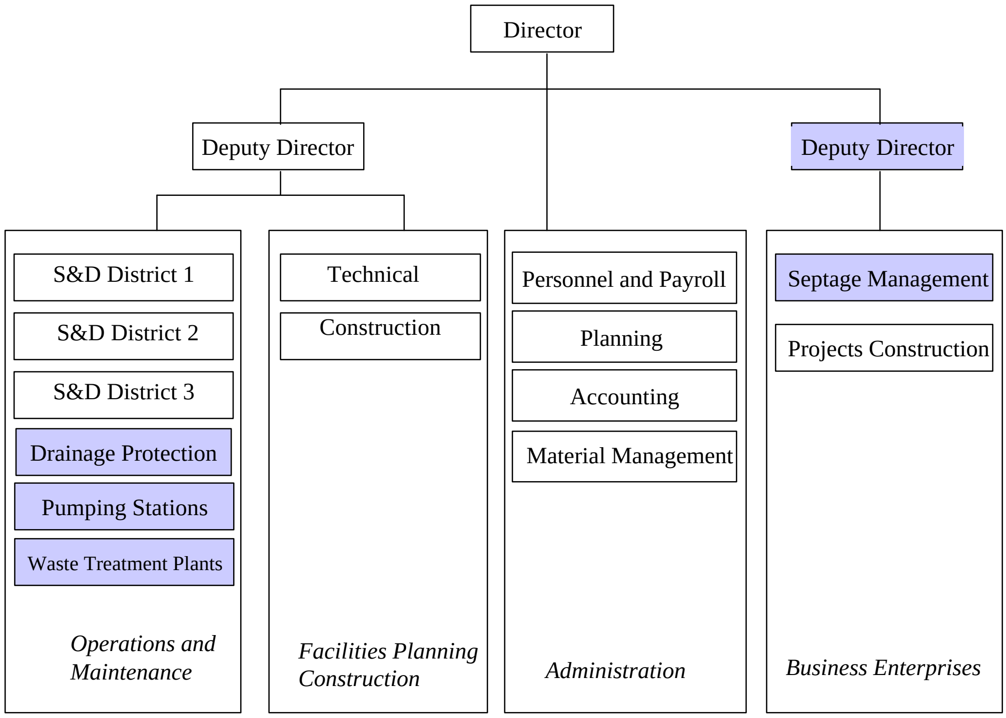
The organizational and personnel consequences associated with the implementation of the World Bank 1B project and the proposed priority projects for sewerage and drainage are:

- creation of a new septage management unit
- creation of a new unit or units to operate wastewater treatment plants and pumping stations (see organizational chart below)
- recruitment of sewerage and drainage engineers to lead the new units
- upgrading of operation and maintenance of drainage and sewerage system
- increased staff for operation and maintenance
- increased vehicle and maintenance responsibilities

It is proposed that SADCO be reorganized to be better able to manage its new responsibilities and facilities. The proposed organizational structure (Figure below) divides the organization into four functional groups:

- operations and maintenance
- facilities planning and construction
- administration
- business enterprises

A new deputy director will need to be recruited for the business enterprises group. The new organizational units for pumping stations, wastewater treatment plants, and drainage protection will become part of the operations and maintenance group. The septage management unit will be part of the business enterprises group and will be operated for-profit following the criteria for socialization of public services.



Proposed Organizational Chart

Most of the reorganization should be completed by 2002 (see table below) during the implementation of the World Bank 1B project. Formation of a unit with responsibility for the waste treatment plants can wait until the beginning of the priority project on sewerage.

Implementation Time Schedule

Time	Organizational Development Event
2002	Creation of Unit for Pumping Stations
2002	Creation of Drainage Protection Unit
2002	Creation of Septage Management Unit
2005	Creation of Unit for Operation of Waste Treatment Plants

(1) Pumping Station and Wastewater Treatment Plants

SADCO will have to recruit new technical and engineering expertise to run the pumping stations and wastewater treatment plants. SADCO will have to continue to upgrade its capacity for operation and maintenance to ensure that new investment is sewerage and drainage is not lost.

(2) Creation of Sewerage and Drainage System Protection Unit

The proposed regulations on urban sewerage and drainage will give TUPWS and by delegation, SADCO responsibilities for protection of all components of the sewerage and drainage system including: sewer lines, ditches, channels, rainwater ditches, regulation lakes, test wells, outlets, tidal gates, pumping stations, and wastewater treatment facilities. Responsibilities will include security, maintenance of buffer zones around fixed facilities, and environmental protection of water quality in sewers and drainage channels. In particular, the proposed regulations on urban sewerage and drainage will also give SADCO the responsibility for:

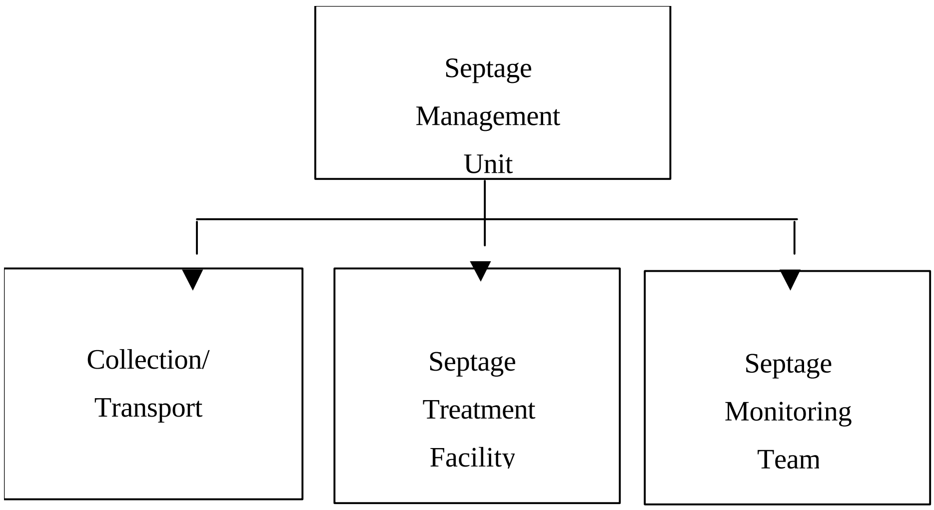
- Inspection of point source wastewater discharges (flows) to the drainage and sewerage system
- Monitoring wastewater quality of point source discharges

The existing professional inspection capabilities of the existing inspection unit should be strengthened to allow it to take over these additional responsibilities. The Inspection Unit would be renamed the Drainage System Protection Unit.

(3) Creation of a Septage Management Unit

After completion of the World Bank 1B project, SADCO will be responsible for operation of a septage treatment facility at the Trang Cat site. In addition, it is proposed that SADCO should set up a septage management unit that will have three primary functions:

- Monitoring - maintenance of customer records, billings, and scheduling of desludging
- collection and transport of septage to treatment facility
- operation of the septage treatment facility



The new septage management unit can be operated as a separate profit center within the SADCO PUE mandate (as shown in the Figure of the organization chart). In this case, it would have a separate accounting system and a degree of financial autonomy. It can also be operated within the State Management framework of SADCO, in which case it would not be part of the business enterprise group.

(4) Management of Septage Treatment Process

There are three possible models. The goal is to ensure that all houses with septic tanks have their tank desludged at least once every three years.

1) SADCO Manages All Aspects of Septage

In the first model, SADCO maintains a central register of houses that have a septic tank, the capacity of the tank, and the date at which servicing has been carried. SADCO would advise each household (with a three-ticket voucher) when it, septic tank was due for desludging. To comply, the householder would arrange for SADCO to empty the septic tank with payment of the specified fee. The first ticket would be handed to the householder as proof that the tank had been emptied. After cleanout, the vacuum truck operator would take the septage to the treatment facility for disposal. Upon arrival at the facility, the second and third ticket would be endorsed by the septage treatment operator and the third ticket would be sent to the SADCO data section for recording the date of the pumpout. The vacuum truck operator would keep the second ticket for his records. The three ticket voucher system would ensure that all septage collected was actually deposited at the septage treatment facility.

2) Phuong Level Management of Collection

In the second model, SADCO turns over management of the septage process to the Phuongs. In this model, the Phuong would provide the service in return for a fee paid by SADCO. The Phoungs would maintain a register of septic tanks and would use the registry to advise householders when their tanks were due for emptying. The Phuongs would keep accurate records of the emptying of tanks and advise SADCO on a regular basis. SADCO would also be advised by the septage treatment facility.

3) Households Responsible

In the third model, households would be encouraged to be responsible for initiating the cleanout, as necessary, but at least every three years. In this case the septage management facility would maintain the records of cleanouts. The vacuum truck operator would issue the voucher and the household would retain the first portion and pay for the service. The operator would retain the second portion and the septage treatment facility, the third portion, would be forwarded to SADCO. SADCO would be able to monitor the rate at which tanks are to be emptied and take appropriate action depending on the success of this model.

4) Establishment of Central Registry of Septic Tanks

The implementation of the first model will require the development of a central registry of septic tanks. A pilot scale survey of septic tanks is being currently being undertaken by the Women's Union, under SADCO supervision, in Cat Bi Phoung. It is expected that a full-scale survey of all 21 Phuongs will be needed to ensure effective operation of the septage management system

5) Septic Tank Monitoring Unit

Under all models, SADCO will have to set up a septic tank monitoring unit. The functions of the monitoring unit will include:

- approval of new construction
- septic tank registration
- septic inspection

4.8.3 Manpower Estimates

The following sections provide an estimate of the incremental staffing needs for septage management and sewerage and drainage improvements in Class A area. This is based on present staff, their efficiency, incremental workload, available facilities and work approach.

(1) New Staff for Septage Management

The table below shows the estimated staff requirements for septage management.

Estimated staffing requirements for septage management.

	Engineer/ University	Technical School	Total O&M	Admin.	Total
Septage Treatment Plant	2	8	10	5	15
Septage Collection	20	30	50	25	75
Septage Monitoring Unit:					
Database Management	4		4		
Septic tank improvement	2	8	10	5	15
Fee Collection	4		4		4
Total	30	46	76	35	111

(2) New Staff for Priority Projects on Sewerage and Drainage

The table below shows the estimated additional staff needed for implementation of the priority projects on sewerage and drainage.

Incremental Staffing Requirements for Sewerage Improvement Project

	Incremental Staff (Number)				
	Engineer/ University	Technical/ School	Total O&M	Admin.	Total
Phase I (begin 2006)					
West WWTP	2	18	20	10	30
Relay P/S	0	4	4	2	6
CSO control structure, Manholepump	0	6	6	3	9
Sewer pipe	0	4	4	2	6
Total	2	32	34	17	51
Phase II (begin 2013, incremental to Phase I)					
West WWTP	2	18	20	10	30
East WWTP	2	12	14	7	21
Relay P/S	0	12	12	6	18
CSO control structure, Manholepump	0	6	6	3	9
Sewer pipe	0	12	12	6	18
Total	4	60	64	32	96

Incremental Staffing Requirements for Drainage Improvement Project

	Incremental Staff (Number)				
	Engineer/ University	Technical/ School	Total O&M	Admin.	Total
Phase I (in 2006)					
1Bproject etc.	0	8	8	4	12
An Kim Hai Channel and Phong Luu Lake	0	4	4	2	6
Total	0	12	12	6	18
Phase II (in 2013, incremental to Phase I)					
Drainage P/S	0	20	20	10	30
Channel and lakes	0	4	4	2	6
Drainage pipelines	0	6	6	3	9
Total	0	30	30	15	45

(3) Staffing Projection

The projection for the total staffing needs for all of SADCO is based on the assumptions outlined in the table below.

Assumptions used to estimate future staffing levels

Unit	2000 (estimated)	Assumptions Used to Estimate Future Staffing
Directors, 2 vice directors	3	Organizational size and mission
Administration	37	10% of Organization size
Sewage and Drainage Units	182	Expansion of S&D network, improvements in O&M
Drainage Protection Unit (currently Inspection)	15	Expansion of S&D network New Responsibilities under S&D regulations
Projects Construction Unit	8	5% growth due to increased business opportunities
Project Management Unit	25	- no additional staff needed
New Septage Management Unit (Currently Transportation and Construction Unit)	26	
Pumping Stations		
Waste Treatment Plants		
Total	295	

The table below shows the staffing projections derived primarily from additional staff needed because of new facilities and the necessary organizational changes.

Projected Staffing for SADCO

	2000	2005	2010	2015	2020
Directors Office	3	3	3	3	3
Administration	36	42	43	50	45
Sewage and Drainage Units	182	215	215	269	269
Projects Management Unit	25	25	25	25	25
Drainage Protection (Inspection) Unit	15	20	25	30	30
Pumping Stations		6	6	24	24
Waste Treatment Plants		30	30	81	81
Septage Management Unit***	26	111	111	50	0
Projects Construction Unit	8	10	13	17	21
Total	295	462	471	548	499

*** Currently the Transportation and Construction Unit

The main increase in staff in the existing organization units will be due to the increased O&M responsibilities that will be placed on sewerage and drainage units. The finance and administrative part of the organization will increase in response to the increased size of the organization. By the year 2020, the sewerage drainage units will have about 269 people.

The new unit, which will be responsible for operations and maintenance of the pumping stations, will grow to 24 people by 2020. The wastewater treatment plants will require about 81 people by 2020.

The septage treatment management unit will be created during the 1B project implementation and will have about 111 staff by 2005. After 2010 staff numbers will gradually decline as both the number of septic tanks and the need for sludge removal declines.

The drainage protection unit will be created through reorganization of the existing inspection unit and will be given new responsibilities mandated under the new sewerage and drainage regulations. To fulfill its functions, it will need to increase in size from 15 to 30 people.

By contrast, the project management unit is not expected to increase in size.

(4) Human Resource Development

1) Recent Training

Training in the past few years has concentrated on upgrading English language skills and administrative skills necessary for project management. The training plan for 2000 (Table below) concentrated more on the development of technical skills.

SADCO Training Plan for 2000

TRAINING COURSE	Place	Trainees
1. Waging And Labour Force	Hai Phong	10
2. Work Safety And Hygiene	Hai Phong	45
3. Basic And Advanced English	Hai Phong	25
4. Computer Application	Hai Phong	20
5. Solid Waste Management	AIT, Hanoi	2
6. HRD Management	AIT, Hanoi	2
7. Project Supervision And Appraisal	AIT, Hanoi	3
8. Computerised Accounting	AIT, Hanoi	2
9. Hook-Lift Truck Operation	Hai Phong	2
10. Mechanics	Hai Phong	5
11. Sewer Jetter Operation	Hai Phong	2
12. Workshop on Waste Water Collection & Treatment	Hai Phong	
13. Workshop on Pipeline Flushing	Hai Phong	
14. Financial Management	Hai Phong	
15. Community Participation and Public Awareness	Hai Phong	
16. Workshop on Septage Management	Hai Phong	
17. Course for skill-grade promotion	Hai Phong	50

2) Basic Strategy for HRD

The basic human resource development strategy for SADCO is to:

- Strengthen the capacity of the project management unit (PMU) to ensure that it can effectively implement the capital investment projects
- Improve administrative efficiency throughout the organization
- Increase the technical competence of operations and maintenance staff to ensure sustainability of new system improvements
- Upgrading managerial skills to introduce modern management methods
- Introduce business planning methods to foster the development of SADCO into an autonomous and commercially viable business entity

The set of specific courses given in the following table that must be developed and delivered to achieve these objectives are:

Specific Courses Needed

Strategic Objectives	Specific Courses
Strengthening Project Management Units	• Project management skills • Financial management skills (planning and budgeting • Bidding and Contract Management • Engineering skills • Foreign Languages
Improving Administrative Efficiency	• Accounting • Billing and Collection Systems • Finance and Budgeting • Management Information Systems • Personnel Management and Training • Performance monitoring • Human Resources Development
Improving Operations and Maintenance Competence	• Construction, Transportation, Septage, Inspection, and Sewerage and Drainage Units
Upgrading of Management Skills	• Post secondary training – Master of Business Administration of Master of Public Administration or other executive programs
Business Planning	• Formal business plans designed at defining the core business • Characterizing of business opportunities – including revenue projections and cost estimates • Planning for financing and the recruitment of staff to take advantage of the business opportunities

Training for Operations and Maintenance

Department	Specific Courses
Project Construction	• Standards and Testing for Pipe Laying • Construction Management
Sewerage and Drainage	• Sewer Cleaning, Rehabilitation and Maintenance • Engineering and Maintenance of Sewerage Systems • CSO O&M • Equipment O&M
Drainage Protection Unit (currently Inspection)	• Regulations for urban sewerage and drainage and solid waste management • Administering fines and penalties for violation of urban sewerage and drainage regulations • Source sampling for point source discharges • Environmental monitoring
Septage Management	• Customer relations • Septage Collection, Treatment and Disposal • Management information systems
Pumping Stations	• O&M of Sewerage Pumping Stations
Waste Treatment Plants	• O&M of Wastewater Treatment Plants

3) Training and Technical Assistance Costs

The human resource development plan has two primary components:

- An extensive program of training to be delivered to all departments and staff in SADCO. It is anticipated that the FINNIDA fund Water Supply, Drainage, Sewerage, and Sanitation Management Program (WSDSSMP) will conduct most of the training required. This training will occur over the four year period 2001-2004

- A program of technical assistance to be provided to support the priority projects. This program includes advisors to provide technical assistance in: 1) sewerage and drainage project management, 2) pumping stations; and 3) wastewater treatment plants. The technical assistance will be conducted during the implementation of the priority project (2005 – 2007).

Some of the training is directly linked to the priority project implementation for sewerage and drainage. This training is to be supported by technical advisors. Other training is designed to improve the administrative efficiency and business orientation of SADCO. The total cost for training is $97,000. The total cost for technical assistance is $750,000 (Table below).

Human Resource Development Costs

I. Training	1	2	3	4	5	6
	Trainee	Course Units	Days/ Unit	Trainer Days	Cost/ Day	Total Cost
1. Directors Office						
Foreign University MBA Degree	1	1	n/a	n/a	n/a	$ 40,000
Business Planning	3	3	10	30	100	$ 3,000
2. Finance and Administration						
Improving Administrative Efficiency	20	7	10	70	100	$ 7,000
3. Sewerage and Drainage Units						
Cleaning, Rehabilitation, and Maintenance	100	10	5	50	100	$ 5,000
Engineering and Maintenance	10	2	5	10	100	$ 1,000
CSO O&M	6	2	5	10	100	$ 1,000
Equipment Operation and Maintenance	100	2	20	40	100	$ 4,000
4. Project Management Unit						
Project Management Systems	10	2	5	10	100	$ 1,000
Financial Management	5	2	5	10	100	$ 1,000
Bidding and Contract Management	5	2	10	20	100	$ 2,000
Foreign Language Training	10	1	40	40	100	$ 4,000
5. Drainage Protection Unit						
Point Source Sampling	15	2	10	20	100	$ 2,000
Environmental Monitoring	15	2	10	20	100	$ 2,000
New Regulation and Inspection Procedures	15	2	10	20	100	$ 2,000
6. Pumping Stations						
O&M of Pumping Stations	4	3	20	60	100	$ 6,000
7. Waste Treatment Plants						
O&M of Waste Treatment Plants	12	6	5	30	100	$ 3,000
8.Septage Management Team						
Customer Service	20	2	5	10	100	$ 1,000
Septage Management Information Systems	4	4	5	20	100	$ 2,000
Vacuum Truck Operations	20	2	10	20	100	$ 2,000
O&M at Septage Disposal Site	20	2	10	20	100	$ 2,000
9. Projects Construction Unit						
Construction Management	6	4	10	40	100	$ 4,000
Standards and Testing for Pipe Laying	6	1	20	20	100	$ 2,000
TOTAL COSTS TRAINING						$ 97,000

II. Technical Assistance - Priority Projects	Person Months	Cost/ Month	Total Cost
1. Sewerage Advisor- Project Management	12	25000	$ 300,000
2. Drainage Advisor - Project Management	12	25000	$ 300,000
3. Waste Treatment Plant Advisor	3	25000	$ 75,000
4. Pumping Stations Advisor	3	25000	$ 75,000
TOTAL COST TECHNICAL ASSISTANCE			$ 750,000

Table 4.3.1 Outline of the Sewerage Master Plan Alternatives

	S1	S2	S3	S4
1. Target Area	Central Area, New Urban Area	Central Area, Old City Center, New Urban Area	Central Area, Old City Center, New Urban Area	Central Area, Old City Center, New Urban Area
2. Sewerage System Type	Combined sewer for all area	Simplified sewer system except New Urban Area where system is separate sewer	Combined sewer system except New Urban Area where system is separate sewer	Separate sewer for all area
3. Beneficiary (2020)	453,224	574,676	574,676	574,676
4. Cover Area	4,383 ha	5,240 ha	5,240 ha	5,240 ha
5. Population density	103 persons/ha	110 persons/ha	110 persons/ha	110 persons/ha
6. Project Components	a. Wastewater treatment plants 2 nos. b. Interceptor trunk sewer c. Interceptor branch sewer d. Wastewater pumping stations	a. Small-scale wastewater treatment plants 6 nos b. Trunk separate sewer c. Small bore branch sewer d. Wastewater pumping stations e. Wastewater treatment plants 2 nos. f. Trunk sewer g. Branch sewer	a. Wastewater treatment plants 2 nos. b. Interceptor trunk sewer c. Interceptor branch sewer d. Wastewater pumping stations e. Trunk separate sewer f. Branch separate sewer	a. Wastewater treatment plants 2 nos. b. Separate trunk sewer c. Separate branch sewer d. Wastewater pumping stations
7. Investment Cost	US$ 150 million	US$ 195 million	US$ 205 million	US$ 240 million

Table 4.3.2 Assessment of the Sewerage Master Plan Alternatives

	S1	S2	S3	S4
1. Target Area	Central Area, New Urban Area	Central Area, Old City Center, New Urban Area	Central Area, Old City Center, New Urban Area	Central Area, Old City Center, New Urban Area
2. Sewerage System Type	Combined sewer for all area	Simplified sewer system except New Urban Area where system is separate sewer	Combined sewer system except New Urban Area where system is separate sewer	Seperate sewer for all area
3. Beneficiary (2020)	453,224	574,676	574,676	574,676
4. Cover Area	4,383 ha	5,240 ha	5,240 ha	5,240 ha
5. Urgency	a. Surface water bodies receiving high organic pollution b. Serious risk for public health	a. Surface water bodies receiving high organic pollution b. Serious risk for public health	a. Surface water bodies receiving high organic pollution b. Serious risk for public health	a. Surface water bodies receiving high organic pollution b. Serious risk for public health
6. Advantages	a. existing combined sewer can be used	a. Option does not depends on drainage condition b. Less costly than separate system	a. existing combined sewer can be used b. New urban area is covered with separate system	a. Option does not depends on drainage condition c. Septic tanks are not required
7. Disadvantages	a. Option requires improved drainage system b. Requires skilled O/M	a. Not fully proven technology b. Strict management of Septic tank is required	a. Option requires improved drainage system b. Requires skilled O/M	a. Requires long implementation time b. Very expensive
6. Compatibility with other plans	Not Compatible with SADCO MP	Not compatible	Partly not compatible with SADCO MP	Not Compatible with FINNIDA / 1B
7. Investment Cost	US$ 150 million	US$ 195 million	US$ 205 million	US$ 240 million
8. Investment cost per beneficiary	US$ 330.96	US$ 339.32	US$ 356.72	US$ 417.63
9. Preliminary Assessment	B	C	A	D

Table 4.3.3 Area and Population of Class A Area Based on Phasing (1/3)

Administrative division	Average population (person)				Population Forecast (person)				Area (ha)
	1989	**1993**	**1994**	**1999**	**2005**	**2010**	**2015**	**2020**	**1999**
Hong Bang Dist.	**91,339**	**94,450**	**89,849**	**97,565**	**103,715**	**108,796**	**113,844**	**118,861**	**15.20**
Quan Toan Ward	4,563	6,763	7,400	8,035	11,255	13,650	16,168	18,798	2.60
Hung Vuong Ward	7,726	8,252	8,041	8,732	9,936	10,917	11,917	12,935	4.56
So Dau Ward	7,306	7,341	9,839	10,684	13,754	16,374	19,120	21,982	3.48
Thuong Ly Ward	15,862	15,939	16,045	17,423	19,394	21,144	22,917	24,713	1.58
Trai Chuoi Ward	8,665	8,707	9,166	9,953	9,704	9,455	9,207	8,958	0.43
Ha Ly Ward	12,129	12,188	11,912	12,935	12,612	12,288	11,965	11,642	1.06
Minh Khai Ward	6,471	6,502	5,624	6,107	6,097	6,128	6,126	6,092	0.67
Quang Trung Ward	8,209	8,249	6,343	6,887	6,176	5,628	5,000	4,299	0.22
Hoang Van Thu Ward	5,783	5,811	4,655	5,055	4,719	4,472	4,177	3,839	0.29
Phan Boi Chau Ward	9,259	9,304	6,926	7,521	6,518	5,731	4,844	3,865	0.16
Pham Hong Thai Ward	5,366	5,394	3,898	4,233	3,549	3,008	2,402	1,738	0.15
Ngo Quyen Dist.	**150,474**	**164,066**	**166,224**	**171,623**	**177,017**	**181,890**	**186,765**	**191,642**	**12.24**
May To Ward	13,304	12,695	12,862	13,280	12,640	12,542	12,456	12,379	1.48
May Chai Ward	12,424	15,364	15,566	16,072	18,149	19,651	21,141	22,621	2.32
Van My Ward	13,032	14,830	15,026	15,514	16,713	17,705	18,692	19,677	1.08
Lac Vien Ward	10,802	11,856	12,012	12,402	12,092	11,782	11,472	11,162	0.38
Cau Tre Ward	14,116	15,159	15,358	15,857	15,461	15,064	14,668	14,271	0.45
Luong Khanh Thien Ward	9,133	8,220	8,329	8,600	7,784	7,493	7,212	6,942	0.13
Gia Vien Ward	10,302	10,585	10,724	11,072	10,795	10,518	10,242	9,965	0.25
Cau Dat Ward	9,913	8,000	8,105	8,366	6,775	6,039	5,320	4,616	0.15
Le Loi Ward	9,762	8,556	8,669	8,951	7,903	7,487	7,084	6,692	0.23
Lach Tray Ward	7,886	9,667	9,794	10,113	10,720	10,854	10,988	11,122	0.67
Dang Giang Ward	9,884	12,564	12,729	13,142	15,054	16,403	17,741	19,069	1.82
Dong Khe Ward	6,960	10,058	10,190	10,521	12,791	14,291	15,775	17,245	1.76
Dong Quoc Binh Ward	8,856	8,472	8,583	8,862	8,452	8,396	8,348	8,306	0.23
Cat Bi Ward	14,100	18,040	18,277	18,871	21,688	23,666	25,627	27,574	1.29
Le ChanDist.	**126,546**	**137,975**	**140,631**	**146,204**	**151,036**	**155,327**	**159,616**	**163,904**	**4.42**
Cat Dai Ward	9,423	9,435	9,617	9,998	10,000	10,214	10,432	10,654	0.34
An Bien Ward	9,319	7,445	7,588	7,889	6,422	5,752	5,096	4,452	0.18
Me Linh Ward	7,279	5,293	5,395	5,609	4,056	3,289	2,536	1,794	0.12
Lam Son Ward	10,687	11,526	11,748	12,214	11,909	11,603	11,298	10,993	0.49
An Duong Ward	8,162	9,367	9,547	9,925	9,677	9,429	9,181	8,933	0.21
Tran Nguyen Han Ward	9,820	11,221	11,437	11,890	11,593	11,296	10,998	10,701	0.27
Ho Nam Ward	14,230	14,349	14,625	15,205	14,825	14,445	14,065	13,685	0.36
Trai Cau Ward	11,065	10,355	10,554	10,972	10,410	10,322	10,243	10,172	0.30
Du Hang Ward	10,452	11,214	11,430	11,883	12,469	13,056	13,643	14,232	0.27
Hang Kenh Ward	12,965	14,715	14,999	15,593	16,947	18,051	19,152	20,251	0.37
Dong Hai Ward	9,772	11,843	12,071	12,549	14,155	15,338	16,515	17,687	0.39
Niem Nghia Ward	13,372	21,212	21,620	22,477	28,575	32,533	36,457	40,352	1.12
Du Hang Kenh Com.	13,265	14,169	20,829	22,801	28,739	34,046	38,776	43,473	2.69
Vinh Niem Com.	8,026	8,573	10,149	11,102	15,543	19,984	24,424	28,865	5.63
Dong Hai Com.	10,539	11,257	14,790	16,180	19,604	22,749	25,508	28,251	9.52
Dang Lam Com.	7,396	7,900	9,246	10,115	13,150	16,184	19,219	23,265	4.62
Dang Hai Com.	6,291	6,720	6,876	7,522	9,403	11,283	13,164	15,044	2.98
Nam Hai Com.	6,338	6,770	6,895	7,543	9,429	11,315	13,200	15,086	5.74
TOTAL								628,391.46	63.04

Table 4.3.3 Area and Population of Class A Area Based on Phasing (2/3)

Administrative division	Central	Service Area(ha)	Population	Population Forecast (person)				Old City	Service Area(ha)	Population	Population Forecast (person)			
	PhaseI Area (Combined Sewer)		1999	2005	2010	2015	2020	PhaseII Area (Combined Sewer)		1999	2005	2010	2015	2020
Hong Bang Dist.		**0.00**							**4.56**					
Quan Toan Ward	0%	0.00	0	0	0	0	0	0%	0.00	0	0	0	0	0
Hung Vuong Ward	0%	0.00	0	0	0	0	0	0%	0.00	0	0	0	0	0
So Dau Ward	0%	0.00	0	0	0	0	0	0%	0.00	0	0	0	0	0
Thuong Ly Ward	0%	0.00	0	0	0	0	0	100%	1.58	17,423	19,394	21,144	22,917	24,713
Trai Chuoi Ward	0%	0.00	0	0	0	0	0	100%	0.43	9,953	9,704	9,455	9,207	8,958
Ha Ly Ward	0%	0.00	0	0	0	0	0	100%	1.06	12,935	12,612	12,288	11,965	11,642
Minh Khai Ward	0%	0.00	0	0	0	0	0	100%	0.67	6,107	6,097	6,128	6,126	6,092
Quang Trung Ward	0%	0.00	0	0	0	0	0	100%	0.22	6,887	6,176	5,628	5,000	4,299
Hoang Van Thu Ward	0%	0.00	0	0	0	0	0	100%	0.29	5,055	4,719	4,472	4,177	3,839
Phan Boi Chau Ward	0%	0.00	0	0	0	0	0	100%	0.16	7,521	6,518	5,731	4,844	3,865
Pham Hong Thai Ward	0%	0.00	0	0	0	0	0	100%	0.15	4,233	3,549	3,008	2,402	1,738
Ngo Quyen Dist.		**4.66**							**3.36**					
May To Ward	17%	0.26	2,294	2,184	2,167	2,152	2,139	83%	1.22	10,986	10,456	10,375	10,304	10,241
May Chai Ward	6%	0.14	942	1,064	1,152	1,240	1,327	81%	1.87	12,982	14,660	15,873	17,077	18,273
Van My Ward	0%	0.00	0	0	0	0	0	0%	0.00	0	0	0	0	0
Lac Vien Ward	100%	0.38	12,402	12,092	11,782	11,472	11,162	0%	0.00	0	0	0	0	0
Cau Tre Ward	100%	0.45	15,857	15,461	15,064	14,668	14,271	0%	0.00	0	0	0	0	0
Luong Khanh Thien Ward	0%	0.00	0	0	0	0	0	100%	0.13	8,600	7,784	7,493	7,212	6,942
Gia Vien Ward	100%	0.25	11,072	10,795	10,518	10,242	9,965	0%	0.00	0	0	0	0	0
Cau Dat Ward	14%	0.02	1,204	975	869	766	664	86%	0.13	7,162	5,800	5,170	4,554	3,952
Le Loi Ward	100%	0.23	8,951	7,903	7,487	7,084	6,692	0%	0.00	0	0	0	0	0
Lach Tray Ward	100%	0.67	10,113	10,720	10,854	10,988	11,122	0%	0.00	0	0	0	0	0
Dang Giang Ward	50%	0.91	6,579	7,537	8,212	8,882	9,546	0%	0.00	0	0	0	0	0
Dong Khe Ward	77%	1.36	8,101	9,849	11,004	12,146	13,279	0%	0.00	0	0	0	0	0
Dong Quoc Binh Ward	0%	0.00	0	0	0	0	0	0%	0.00	0	0	0	0	0
Cat Bi Ward	0%	0.00	0	0	0	0	0	0%	0.00	0	0	0	0	0
Le ChanDist.		**3.78**							**0.64**					
Cat Dai Ward	0%	0.00	0	0	0	0	0	100%	0.34	9,998	10,000	10,214	10,432	10,654
An Bien Ward	0%	0.00	0	0	0	0	0	100%	0.18	7,889	6,422	5,752	5,096	4,452
Me Linh Ward	0%	0.00	0	0	0	0	0	100%	0.12	5,609	4,056	3,289	2,536	1,794
Lam Son Ward	100%	0.49	12,214	11,909	11,603	11,298	10,993	0%	0.00	0	0	0	0	0
An Duong Ward	100%	0.21	9,925	9,677	9,429	9,181	8,933	0%	0.00	0	0	0	0	0
Tran Nguyen Han Ward	100%	0.27	11,890	11,593	11,296	10,998	10,701	0%	0.00	0	0	0	0	0
Ho Nam Ward	100%	0.36	15,205	14,825	14,445	14,065	13,685	0%	0.00	0	0	0	0	0
Trai Cau Ward	100%	0.30	10,972	10,410	10,322	10,243	10,172	0%	0.00	0	0	0	0	0
Du Hang Ward	100%	0.27	11,883	12,469	13,056	13,643	14,232	0%	0.00	0	0	0	0	0
Hang Kenh Ward	100%	0.37	15,593	16,947	18,051	19,152	20,251	0%	0.00	0	0	0	0	0
Dong Hai Ward	100%	0.39	12,549	14,155	15,338	16,515	17,687	0%	0.00	0	0	0	0	0
Niem Nghia Ward	100%	1.12	22,477	28,575	32,533	36,457	40,352	0%	0.00	0	0	0	0	0
Du Hang Kenh Com.	64%	1.71	14,518	18,299	21,678	24,689	27,681		0.00	0	0	0	0	0
Vinh Niem Com.	14%	0.79	1,559	2,182	2,806	3,430	4,053		0.00	0	0	0	0	0
Dong Hai Com.	0%	0.03	47	57	66	74	82		0.00	0	0	0	0	0
Dang Lam Com.	1%	0.06	130	169	208	247	299		0.00	0	0	0	0	0
Dang Hai Com.		0.00	0	0	0	0	0		0.00	0	0	0	0	0
Nam Hai Com.		0.00	0	0	0	0	0		0.00	0	0	0	0	0
TOTAL		11.03	216,478	229,844	239,938	249,630	259,286		8.56	133,340	127,948	126,021	123,850	121,452

Table 4.3.3 Area and Population of Class A Area Based on Phasing (3/3)

Administrative division	NUA West PhaseII Area (Separated Sewer)	Service Area(ha)	Population 1999	Population Forecast (person) 2005	2010	2015	2020	NUA East PhaseII Area (Separated Sewer)	Service Area(ha)	Population 1999	Population Forecast 2005	2010	2015	2020
Hong Bang Dist.		**0.00**							**0.00**					
Quan Toan Ward		0.00	0	0	0	0	0		0.00	0	0	0	0	0
Hung Vuong Ward		0.00	0	0	0	0	0		0.00	0	0	0	0	0
So Dau Ward		0.00	0	0	0	0	0		0.00	0	0	0	0	0
Thuong Ly Ward		0.00	0	0	0	0	0		0.00	0	0	0	0	0
Trai Chuoi Ward		0.00	0	0	0	0	0		0.00	0	0	0	0	0
Ha Ly Ward		0.00	0	0	0	0	0		0.00	0	0	0	0	0
Minh Khai Ward		0.00	0	0	0	0	0		0.00	0	0	0	0	0
Quang Trung Ward		0.00	0	0	0	0	0		0.00	0	0	0	0	0
Hoang Van Thu Ward		0.00	0	0	0	0	0		0.00	0	0	0	0	0
Phan Boi Chau Ward		0.00	0	0	0	0	0		0.00	0	0	0	0	0
Pham Hong Thai Ward		0.00	0	0	0	0	0		0.00	0	0	0	0	0
Ngo Quyen Dist.		**1.13**							**3.09**					
May To Ward		0.00	0	0	0	0	0		0.00	0	0	0	0	0
May Chai Ward		0.00	0	0	0	0	0	13%	0.31	2,147	2,425	2,625	2,824	3,022
Van My Ward		0.00	0	0	0	0	0	100%	1.08	15,514	16,713	17,705	18,692	19,677
Lac Vien Ward		0.00	0	0	0	0	0		0.00	0	0	0	0	0
Cau Tre Ward		0.00	0	0	0	0	0		0.00	0	0	0	0	0
Luong Khanh Thien Ward		0.00	0	0	0	0	0		0.00	0	0	0	0	0
Gia Vien Ward		0.00	0	0	0	0	0		0.00	0	0	0	0	0
Cau Dat Ward		0.00	0	0	0	0	0		0.00	0	0	0	0	0
Le Loi Ward		0.00	0	0	0	0	0		0.00	0	0	0	0	0
Lach Tray Ward		0.00	0	0	0	0	0		0.00	0	0	0	0	0
Dang Giang Ward	49%	0.90	6,499	7,445	8,112	8,773	9,430	0%	0.01	64	74	80	87	93
Dong Khe Ward		0.00	0	0	0	0	0	23%	0.40	2,420	2,942	3,287	3,628	3,966
Dong Quoc Binh Ward	100%	0.23	8,862	8,452	8,396	8,348	8,306		0.00	0	0	0	0	0
Cat Bi Ward		0.00	0	0	0	0	0	100%	1.29	18,871	21,688	23,666	25,627	27,574
Le ChanDist.		**0.00**							**0.00**					
Cat Dai Ward		0.00	0	0	0	0	0		0.00	0	0	0	0	0
An Bien Ward		0.00	0	0	0	0	0		0.00	0	0	0	0	0
Me Linh Ward		0.00	0	0	0	0	0		0.00	0	0	0	0	0
Lam Son Ward		0.00	0	0	0	0	0		0.00	0	0	0	0	0
An Duong Ward		0.00	0	0	0	0	0		0.00	0	0	0	0	0
Tran Nguyen Han Ward		0.00	0	0	0	0	0		0.00	0	0	0	0	0
Ho Nam Ward		0.00	0	0	0	0	0		0.00	0	0	0	0	0
Trai Cau Ward		0.00	0	0	0	0	0		0.00	0	0	0	0	0
Du Hang Ward		0.00	0	0	0	0	0		0.00	0	0	0	0	0
Hang Kenh Ward		0.00	0	0	0	0	0		0.00	0	0	0	0	0
Dong Hai Ward		0.00	0	0	0	0	0		0.00	0	0	0	0	0
Niem Nghia Ward		0.00	0	0	0	0	0		0.00	0	0	0	0	0
Du Hang Kenh Com.	36%	0.98	8,283	10,440	12,368	14,086	15,793		0.00	0	0	0	0	0
Vinh Niem Com.	86%	4.84	9,543	13,360	17,178	20,995	24,812		0.00	0	0	0	0	0
Dong Hai Com.		0.00	0	0	0	0	0	100%	9.49	16,133	19,547	22,683	25,434	28,169
Dang Lam Com.		0.00	0	0	0	0	0	99%	4.56	9,985	12,981	15,976	18,972	22,966
Dang Hai Com.		0.00	0	0	0	0	0	100%	2.98	7,522	9,403	11,283	13,164	15,044
Nam Hai Com.		0.00	0	0	0	0	0	100%	5.74	7,543	9,429	11,315	13,200	15,086
TOTAL		6.95	33,187	39,697	46,053	52,202	58,341		25.87	80,199	95,201	108,620	121,629	135,598

Table 4.3.4 Water Consumption Data (Compiled from Chapter 2)

			1999	2005	2010	2015	2020
Hong Bang	- Population	nos.	97,565	103,715	108,796	113,844	118,861
	- Population served with h.c.	nos.	23,066	97,492	107,708	113,844	118,861
	- Service coverage (house conn.)	%	24	94	99	100	100
	- Unit consumption	lpcd	108	120	130	130	130
	- Total Domestic consumption	m3/d	2,904	11,699	14,002	14,800	15,452
	- Industrial consumption	m3/d	2,265	3,300	5,300	7,300	8,300
	- Commercial consumption	m3/d	861	1,265	1,508	1,703	1,828
	- Institutional consumption	m3/d	1,759	2,029	2,502	2,705	2,858
Ngo Quyen	- Population	nos.	171,623	177,017	181,890	186,765	191,642
	- Population served with h.c.	nos.	131,688	141,614	169,158	183,030	189,726
	- Service coverage (house conn.)	%	77	80	93	98	99
	- Unit consumption	lpcd	91	120	130	130	130
	- Total Domestic consumption	m3/d	12,910	16,994	21,991	23,794	24,664
	- Industrial consumption	m3/d	2,964	2,800	2,800	2,800	2,800
	- Commercial consumption	m3/d	1,184	1,529	1,979	2,141	2,220
	- Institutional consumption	m3/d	1,668	1,699	2,199	2,379	2,466
Le Chan	- Population	nos.	146,204	151,036	155,327	159,616	163,904
	- Population served with h.c.	nos.	141,818	148,015	153,774	159,616	163,904
	- Service coverage (house conn.)	%	97	98	99	100	100
	- Unit consumption	lpcd	106	120	130	130	130
	- Total Domestic consumption	m3/d	17,974	17,762	19,991	20,750	21,308
	- Industrial consumption	m3/d	823	900	900	900	900
	- Commercial consumption	m3/d	384	710	800	830	852
	- Institutional consumption	m3/d	1,331	1,332	1,499	1,556	1,598
Effective Study Area	- Population	nos.	20,896	24,857	28,622	32,045	35,457
South of Hong Bang	- Population served with h.c.	nos.	2,191	8,720	17,343	22,069	26,122
	- Service coverage (house conn.)NAM SON	%	0	0	15	20	25
	- Service coverage (house conn.)AN DONG	%	15	50	80	90	95
	- Unit consumption	lpcd	91	120	130	130	130
	- Total Domestic consumption	m3/d	199	1,046	2,255	2,869	3,396
	- Industrial consumption	m3/d	-	-	-	-	-
	- Commercial consumption	m3/d	10	52	113	143	170
	- Institutional consumption	m3/d	10	52	113	143	170
Effective Study Area	- Population	nos.	33,903	44,282	54,030	63,200	72,338
South of Le Chan	- Population served with h.c.	nos.	-	14,956	36,415	53,002	70,895
	- Service coverage (house conn.)DU HANG KEHN	%	0	25	60	80	100
	- Service coverage (house conn.)VINH NIEM	%	0	50	80	90	95
	- Unit consumption	lpcd	91	120	130	130	130
	- Total Domestic consumption	m3/d	0	1,795	4,734	6,890	9,216
	- Industrial consumption	m3/d	0	100	200	400	800
	- Commercial consumption	m3/d	0	90	237	345	461
	- Institutional consumption	m3/d	0	90	237	345	461
Effective Study Area	- Population	nos.	20,997	25,029	28,865	32,318	35,757
Southeast of the City	- Population served with h.c.	nos.	0	10,072	27,879	46,327	73,044
	- Service coverage (house conn.)DONG HAI&DANG LAM	%	0	25	60	80	95
	- Service coverage (house conn.)DANG HAI&NAM HAI	%	0	10	20	40	80
	- Service coverage (house conn.)TRANG CAT	%	0	0	0	0	0
	- Unit consumption	lpcd	91	120	130	130	130
	- Total Domestic consumption	m3/d	0	1,209	3,624	6,023	9,496
	- Industrial consumption	m3/d	0	-	-	-	-
	- Commercial consumption	m3/d	0	60	181	301	475
	- Institutional consumption	m3/d	0	60	181	301	475

Table 4.3.5 Generation Rate of Sewage (%), Rg

Area		Domestic				Commercial				Institutional				Industrial			
		2005	2010	2015	2020	2005	2010	2015	2020	2005	2010	2015	2020	2005	2010	2015	2020
Hong Bang	%			80	100			80	100			80	100			80	80
Ngo Quyen	%	80	100	100	100	80	100	100	100	80	100	100	100	80	80	80	80
Le Chan	%	80	100	100	100	80	100	100	100	80	100	100	100	80	80	80	80
South of Hong Bang	%																
South of Le Chan	%	80	100	100	100	80	100	100	100	80	100	100	100	80	80	80	80
Southeast of the City	%			80	100			80	100			80	100			80	80

Table 4.3.6 Estimated Generation of Sewage (1/4) (West Treatment Area, Phase I, Combined system)

Administrative division			Domestic				Commercial				Institutional				Industrial				Total		Rg(%)=	10
			2005	2010	2015	2020	2005	2010	2015	2020	2005	2010	2015	2020	2005	2010	2015	2020	2005	2010	2015	2020
Ngo Quyen	C	m3/d	16,994	21,991	23,794	24,664	1,529	1,979	2,141	2,220	1,699	2,199	2,379	2,466	2,800	2,800	2,800	2,800	23,022	28,969	31,115	32,151
May To Ward	C	m3/d	2,055	2,659	2,877	2,982	185	239	259	268	205	266	288	298	339	339	339	339	2,784	3,503	3,762	3,887
	Rss	%	8.5	17	17	17	8.5	17	17	17	8.5	17	17	17	8.5	17	17	17				
	Rg	%	80	100	100	100	80	100	100	100	80	100	100	100	80	80	80	80				
	S	m3/d	140	452	489	507	13	41	44	46	14	45	49	51	23	46	46	46	208	642	691	714
May Chai Ward	C	m3/d	3,221	4,168	4,510	4,675	290	375	406	421	322	417	451	467	531	531	531	531	4,364	5,491	5,898	6,094
	Rss	%	3	6	6	6	3	6	6	6	3	6	6	6	3	6	6	6				
	Rg	%	80	100	100	100	80	100	100	100	80	100	100	100	80	80	80	80				
	S	m3/d	77	250	271	280	7	23	24	25	8	25	27	28	13	25	25	25	115	355	382	395
Van My Ward	C	m3/d	1,499	1,940	2,099	2,176	135	175	189	196	150	194	210	218	247	247	247	247	2,031	2,556	2,745	2,837
	Rss	%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0				
	Rg	%	80	100	100	100	80	100	100	100	80	100	100	100	80	80	80	80				
	S	m3/d	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lac Vien Ward	C	m3/d	528	683	739	766	47	61	66	69	53	68	74	77	87	87	87	87	715	899	966	998
	Rss	%	50	100	100	100	50	100	100	100	50	100	100	100	50	100	100	100				
	Rg	%	80	100	100	100	80	100	100	100	80	100	100	100	80	80	80	80				
	S	m3/d	211	683	739	766	19	61	66	69	21	68	74	77	35	70	70	70	314	970	1,043	1,079
Cau Tre Ward	C	m3/d	625	808	875	907	56	73	79	82	62	81	87	91	103	103	103	103	846	1,065	1,144	1,182
	Rss	%	50	100	100	100	50	100	100	100	50	100	100	100	50	100	100	100				
	Rg	%	80	100	100	100	80	100	100	100	80	100	100	100	80	80	80	80				
	S	m3/d	250	808	875	907	22	73	79	82	25	81	87	91	41	82	82	82	372	1,149	1,236	1,278
Gia Vien Ward	C	m3/d	347	449	486	504	31	40	44	45	35	45	49	50	57	57	57	57	470	592	636	657
	Rss	%	50	100	100	100	50	100	100	100	50	100	100	100	50	100	100	100				
	Rg	%	80	100	100	100	80	100	100	100	80	100	100	100	80	80	80	80				
	S	m3/d	139	449	486	504	12	40	44	45	14	45	49	50	23	46	46	46	207	638	686	710
Cau Dat Ward	C	m3/d	208	269	292	302	19	24	26	27	21	27	29	30	34	34	34	34	282	355	381	394
	Rss	%	7	14	14	14	7	14	14	14	7	14	14	14	7	14	14	14				
	Rg	%	80	100	100	100	80	100	100	100	80	100	100	100	80	80	80	80				
	S	m3/d	12	38	41	42	1	3	4	4	1	4	4	4	2	4	4	4	17	54	58	60
Le Loi Ward	C	m3/d	319	413	447	463	29	37	40	42	32	41	45	46	53	53	53	53	433	544	585	604
	Rss	%	50	100	100	100	50	100	100	100	50	100	100	100	50	100	100	100				
	Rg	%	80	100	100	100	80	100	100	100	80	100	100	100	80	80	80	80				
	S	m3/d	128	413	447	463	11	37	40	42	13	41	45	46	21	42	42	42	190	587	632	653
Lach Tray Ward	C	m3/d	930	1,204	1,302	1,350	84	108	117	122	93	120	130	135	153	153	153	153	1,260	1,586	1,703	1,760
	Rss	%	50	100	100	100	50	100	100	100	50	100	100	100	50	100	100	100				
	Rg	%	80	100	100	100	80	100	100	100	80	100	100	100	80	80	80	80				
	S	m3/d	372	1,204	1,302	1,350	33	108	117	122	37	120	130	135	61	123	123	123	554	1,711	1,840	1,902
Dang Giang Ward	C	m3/d	2,527	3,270	3,538	3,667	227	294	318	330	253	327	354	367	416	416	416	416	3,423	4,307	4,627	4,781
	Rss	%	25	50	50	50	25	50	50	50	25	50	50	50	25	50	50	50				
	Rg	%	80	100	100	100	80	100	100	100	80	100	100	100	80	80	80	80				
	S	m3/d	505	1,635	1,769	1,834	45	147	159	165	51	163	177	183	83	167	167	167	753	2,323	2,499	2,584
Dong Khe Ward	C	m3/d	2,444	3,162	3,421	3,547	220	285	308	319	244	316	342	355	403	403	403	403	3,310	4,165	4,474	4,623
	Rss	%	38.5	77	77	77	38.5	77	77	77	38.5	77	77	77	38.5	77	77	77				
	Rg	%	80	100	100	100	80	100	100	100	80	100	100	100	80	80	80	80				
	S	m3/d	753	2,435	2,634	2,731	68	219	237	246	75	243	263	273	124	248	248	248	1,122	3,460	3,721	3,847
Le Chan	C	m3/d	17,762	19,991	20,750	21,308	710	800	830	852	1,332	1,499	1,556	1,598	900	900	900	900	20,704	23,190	24,036	24,658
Lam Son Ward	C	m3/d	1,969	2,216	2,300	2,362	79	89	92	94	148	166	173	177	100	100	100	100	2,295	2,571	2,665	2,734
	Rss	%	50	100	100	100	50	100	100	100	50	100	100	100	50	100	100	100				
	Rg	%	80	100	100	100	80	100	100	100	80	100	100	100	80	80	80	80				
	S	m3/d	788	2,216	2,300	2,362	32	89	92	94	59	166	173	177	40	80	80	80	1,010	2,806	2,909	2,985
An Duong Ward	C	m3/d	844	950	986	1,012	34	38	39	40	63	71	74	76	43	43	43	43	984	1,102	1,142	1,172
	Rss	%	50	100	100	100	50	100	100	100	50	100	100	100	50	100	100	100				
	Rg	%	80	100	100	100	80	100	100	100	80	100	100	100	80	80	80	80				
	S	m3/d	338	950	986	1,012	14	38	39	40	25	71	74	76	17	34	34	34	433	1,203	1,247	1,279
Tran Nguyen Han Ward	C	m3/d	1,085	1,221	1,268	1,302	43	49	51	52	81	92	95	98	55	55	55	55	1,265	1,417	1,468	1,506
	Rss	%	50	100	100	100	50	100	100	100	50	100	100	100	50	100	100	100				
	Rg	%	80	100	100	100	80	100	100	100	80	100	100	100	80	80	80	80				
	S	m3/d	434	1,221	1,268	1,302	17	49	51	52	33	92	95	98	22	44	44	44	556	1,546	1,603	1,645
Ho Nam Ward	C	m3/d	1,447	1,628	1,690	1,735	58	65	68	69	108	122	127	130	73	73	73	73	1,686	1,889	1,958	2,008
	Rss	%	50	100	100	100	50	100	100	100	50	100	100	100	50	100	100	100				
	Rg	%	80	100	100	100	80	100	100	100	80	100	100	100	80	80	80	80				
	S	m3/d	579	1,628	1,690	1,735	23	65	68	69	43	122	127	130	29	59	59	59	742	2,061	2,137	2,193
Ward Trai Cau	C	m3/d	1,206	1,357	1,408	1,446	48	54	56	58	90	102	106	108	61	61	61	61	1,405	1,574	1,631	1,674
	Rss	%	50	100	100	100	50	100	100	100	50	100	100	100	50	100	100	100				
	Rg	%	80	100	100	100	80	100	100	100	80	100	100	100	80	80	80	80				
	S	m3/d	482	1,357	1,408	1,446	19	54	56	58	36	102	106	108	24	49	49	49	618	1,718	1,781	1,828
Du Hang Ward	C	m3/d	1,085	1,221	1,268	1,302	43	49	51	52	81	92	95	98	55	55	55	55	1,265	1,417	1,468	1,506
	Rss	%	50	100	100	100	50	100	100	100	50	100	100	100	50	100	100	100				
	Rg	%	80	100	100	100	80	100	100	100	80	100	100	100	80	80	80	80				
	S	m3/d	434	1,221	1,268	1,302	17	49	51	52	33	92	95	98	22	44	44	44	556	1,546	1,603	1,645
Hang Kenh Ward	C	m3/d	1,487	1,673	1,737	1,784	59	67	69	71	112	126	130	134	75	75	75	75	1,733	1,941	2,012	2,064
	Rss	%	50	100	100	100	50	100	100	100	50	100	100	100	50	100	100	100				
	Rg	%	80	100	100	100	80	100	100	100	80	100	100	100	80	80	80	80				
	S	m3/d	595	1,673	1,737	1,784	24	67	69	71	45	126	130	134	30	60	60	60	763	2,119	2,197	2,254
Dong Hai Ward	C	m3/d	1,567	1,764	1,831	1,880	63	71	73	75	118	132	137	141	79	79	79	79	1,827	2,046	2,121	2,176
	Rss	%	50	100	100	100	50	100	100	100	50	100	100	100	50	100	100	100				
	Rg	%	80	100	100	100	80	100	100	100	80	100	100	100	80	80	80	80				
	S	m3/d	627	1,764	1,831	1,880	25	71	73	75	47	132	137	141	32	64	64	64	804	2,233	2,315	2,376
Niem Nghia Ward	C	m3/d	4,501	5,065	5,258	5,399	180	203	210	216	338	380	394	405	228	228	228	228	5,246	5,876	6,091	6,248
	Rss	%	50	100	100	100	50	100	100	100	50	100	100	100	50	100	100	100				
	Rg	%	80	100	100	100	80	100	100	100	80	100	100	100	80	80	80	80				
	S	m3/d	1,800	5,065	5,258	5,399	72	203	210	216	135	380	394	405	91	182	182	182	2,308	6,414	6,650	6,823
South of Le Chan	C	m3/d	1,795	4,734	6,890	9,216	90	237	345	461	90	237	345	461	100	200	400	800				
Du Hang Kenh Com.	C	m3/d	580	1,531	2,228	2,980	29	77	111	149	29	77	111	149	32	65	129	259	671	1,748	2,580	3,536
	Rss	%	32	64	64	64	32	64	64	64	32	64	64	64	32	64	64	64				
	Rg	%	80	100	100	100	80	100	100	100	80	100	100	100	80	80	80	80				
	S	m3/d	149	980	1,426	1,907	7	49	71	95	7	49	71	95	8	33	66	132	189	1,222	1,798	2,453
Vinh Niem Com.	C	m3/d	1,214	3,203	4,663	6,237	61	160	233	312	61	160	233	312	68	135	271	541	1,404	3,659	5,399	7,402
	Rss	%	7	14	14	14	7	14	14	14	7	14	14	14	7	14	14	14				
	Rg	%	80	100	100	100	80	100	100	100	80	100	100	100	80	80	80	80				
	S	m3/d	68	448	653	873	3	22	33	44	3	22	33	44	4	15	30	61	86	559	823	1,123
Southeast of the City	C	m3/d	1,209	3,624	6,023	9,496	60	181	301	475	60	181	301	475	0	0	0	0				
Dong Hai Com.	C	m3/d	304	913	1,517	2,392	15	46	76	120	15	46	76	120	0	0	0	0	335	1,004	1,668	2,631
	Rss	%	0.2	0.3	0.3	0.3	0.2	0.3	0.3	0.3	0.2	0.3	0.3	0.3	0.2	0.3	0.3	0.3				
	Rg	%	80	100	100	100	80	100	100	100	80	100	100	100	80	80	80	80				
	S	m3/d	0	3	5	7	0	0	0	0	0	0	0	0	0	0	0	0	0	3	6	9
Dang Lam Com.	C	m3/d	148	443	736	1,161	7	22	37	58	7	22	37	58	0	0	0	0	162	487	810	1,277
	Rss	%	0.5	1	1	1	0.5	1	1	1	0.5	1	1	1	0.5	1	1	1				
	Rg	%	80	100	100	100	80	100	100	100	80	100	100	100	80	80	80	80				
	S	m3/d	1	4	7	12	0	0	0	1	0	0	0	1	0	0	0	0	1	5	9	14
Sub-total(Ngo Quyen)		m3/d	2,586	8,367	9,053	9,384	233	753	815	845	259	837	905	938	426	852	852	852	3,854	11,890	12,788	13,221
Sub-total(Le Chan)		m3/d	6,076	17,096	17,746	18,222	243	684	710	729	456	1,282	1,331	1,367	308	616	616	616	7,791	21,646	22,442	23,027
Sub-total(South of Le Chan)		m3/d	217	1,428	2,079	2,780	11	71	104	139	11	71	104	139	12	48	97	193	275	1,781	2,621	3,576
Sub-total(Southeast of the City)		m3/d	1	7	12	19	0	0	1	1	0	0	1	1	0	0	0	0	1	9	14	23
Total		m3/d	8,880	26,898	28,889	30,405	487	1,509	1,629	1,713	725	2,191	2,341	2,445	746	1,516	1,565	1,661	11,921	35,325	37,866	39,847

Table 4.3.6 Estimated Generation of Sewage (2/4) (West Treatment Area, Phase II, Combined System)

Administrative division			Domestic				Commercial				Institutional				Industrial				Total		Rg(%)=	10
			2005	2010	2015	2020	2005	2010	2015	2020	2005	2010	2015	2020	2005	2010	2015	2020	2005	2010	2015	2020
Hong Bang	C	m3/d	11,699	14,002	14,800	15,452	1,265	1,508	1,703	1,828	2,029	2,502	2,705	2,858	2,265	3,300	5,300	7,300	17,258	21,312	24,508	27,438
Thuong Ly Ward	C	m3/d	1,216	1,455	1,538	1,606	131	157	177	190	211	260	281	297	235	343	551	759	1,794	2,215	2,548	2,852
	Rss	%	0	0	50	100	0	0	50	100	0	0	50	100	0	0	50	100				
	Rg	%	0	0	80	100	0	0	80	100	0	0	80	100	0	0	80	80				
	S	m3/d	0	0	615	1,606	0	0	71	190	0	0	112	297	0	0	220	607	0	0	1,121	2,970
Trai Chuoi Ward	C	m3/d	331	396	419	437	36	43	48	52	57	71	77	81	64	93	150	207	488	603	693	776
	Rss	%	0	0	50	100	0	0	50	100	0	0	50	100	0	0	50	100				
	Rg	%	0	0	80	100	0	0	80	100	0	0	80	100	0	0	80	80				
	S	m3/d	0	0	167	437	0	0	19	52	0	0	31	81	0	0	60	165	0	0	305	808
Ha Ly Ward	C	m3/d	816	976	1,032	1,078	88	105	119	127	141	174	189	199	158	230	370	509	1,204	1,486	1,709	1,913
	Rss	%	0	0	50	100	0	0	50	100	0	0	50	100	0	0	50	100				
	Rg	%	0	0	80	100	0	0	80	100	0	0	80	100	0	0	80	80				
	S	m3/d	0	0	413	1,078	0	0	48	127	0	0	75	199	0	0	148	407	0	0	752	1,993
Minh Khai Ward	C	m3/d	516	617	652	681	56	66	75	81	89	110	119	126	100	145	234	322	761	939	1,080	1,209
	Rss	%	0	0	50	100	0	0	50	100	0	0	50	100	0	0	50	100				
	Rg	%	0	0	80	100	0	0	80	100	0	0	80	100	0	0	80	80				
	S	m3/d	0	0	261	681	0	0	30	81	0	0	48	126	0	0	93	257	0	0	475	1,260
Quang Trung Ward	C	m3/d	169	203	214	224	18	22	25	26	29	36	39	41	33	48	77	106	250	308	355	397
	Rss	%	0	0	50	100	0	0	50	100	0	0	50	100	0	0	50	100				
	Rg	%	0	0	80	100	0	0	80	100	0	0	80	100	0	0	80	80				
	S	m3/d	0	0	86	224	0	0	10	26	0	0	16	41	0	0	31	85	0	0	156	414
Hoang Van Thu Ward	C	m3/d	223	267	282	295	24	29	32	35	39	48	52	55	43	63	101	139	329	407	468	523
	Rss	%	0	0	50	100	0	0	50	100	0	0	50	100	0	0	50	100				
	Rg	%	0	0	80	100	0	0	80	100	0	0	80	100	0	0	80	80				
	S	m3/d	0	0	113	295	0	0	13	35	0	0	21	55	0	0	40	111	0	0	206	545
Phan Boi Chau Ward	C	m3/d	123	147	156	163	13	16	18	19	21	26	28	30	24	35	56	77	182	224	258	289
	Rss	%	0	0	50	100	0	0	50	100	0	0	50	100	0	0	50	100				
	Rg	%	0	0	80	100	0	0	80	100	0	0	80	100	0	0	80	80				
	S	m3/d	0	0	62	163	0	0	7	19	0	0	11	30	0	0	22	61	0	0	114	301
Pham Hong Thai Ward	C	m3/d	115	138	146	152	12	15	17	18	20	25	27	28	22	33	52	72	170	210	242	271
	Rss	%	0	0	50	100	0	0	50	100	0	0	50	100	0	0	50	100				
	Rg	%	0	0	80	100	0	0	80	100	0	0	80	100	0	0	80	80				
	S	m3/d	0	0	58	152	0	0	7	18	0	0	11	28	0	0	21	58	0	0	106	282
Ngo Quyen	C	m3/d	16,994	21,991	23,794	24,664	1,529	1,979	2,141	2,220	1,699	2,199	2,379	2,466	2,800	2,800	2,800	2,800	23,022	28,969	31,115	32,151
May To Ward	C	m3/d	1,415	1,693	1,790	1,868	153	182	206	221	245	303	327	346	274	399	641	883	2,087	2,577	2,963	3,318
	Rss	%	0	0	41.5	83	0	0	41.5	83	0	0	41.5	83	0	0	41.5	83				
	Rg	%	80	100	100	100	80	100	100	100	80	100	100	100	80	80	80	80				
	S	m3/d	0	0	743	1,551	0	0	85	183	0	0	136	287	0	0	213	586	0	0	1,294	2,868
May Chai Ward	C	m3/d	2,217	2,654	2,805	2,929	240	286	323	346	385	474	513	542	429	625	1,005	1,384	3,271	4,040	4,645	5,201
	Rss	%	0	0	40.5	81	0	0	40.5	81	0	0	40.5	81	0	0	40.5	81				
	Rg	%	80	100	100	100	80	100	100	100	80	100	100	100	80	80	80	80				
	S	m3/d	0	0	1,136	2,372	0	0	131	281	0	0	208	439	0	0	325	897	0	0	1,980	4,387
Luong Khanh Thien Ward	C	m3/d	180	234	253	262	16	21	23	24	18	23	25	26	30	30	30	30	245	308	330	341
	Rss	%	0	0	50	100	0	0	50	100	0	0	50	100	0	0	50	100				
	Rg	%	80	100	100	100	80	100	100	100	80	100	100	100	80	80	80	80				
	S	m3/d	0	0	126	262	0	0	11	24	0	0	13	26	0	0	12	24	0	0	178	369
Cau Dat Ward	C	m3/d	208	269	292	302	19	24	26	27	21	27	29	30	34	34	34	34	282	355	381	394
	Rss	%	0	0	43	86	0	0	43	86	0	0	43	86	0	0	43	86				
	Rg	%	80	100	100	100	80	100	100	100	80	100	100	100	80	80	80	80				
	S	m3/d	0	0	125	260	0	0	11	23	0	0	13	26	0	0	12	24	0	0	177	366
Le Chan	C	m3/d	17,762	19,991	20,750	21,308	710	800	830	852	1,332	1,499	1,556	1,598	900	900	900	900	20,704	23,190	24,036	24,658
Cat Dai Ward	C	m3/d	1,366	1,538	1,596	1,639	55	62	64	66	102	115	120	123	69	69	69	69	1,593	1,784	1,849	1,897
	Rss	%	0	0	50	100	0	0	50	100	0	0	50	100	0	0	50	100				
	Rg	%	80	100	100	100	80	100	100	100	80	100	100	100	80	80	80	80				
	S	m3/d	0	0	798	1,639	0	0	32	66	0	0	60	123	0	0	28	55	0	0	1,009	2,071
An Bien Ward	C	m3/d	723	814	845	868	29	33	34	35	54	61	63	65	37	37	37	37	843	944	979	1,004
	Rss	%	0	0	50	100	0	0	50	100	0	0	50	100	0	0	50	100				
	Rg	%	80	100	100	100	80	100	100	100	80	100	100	100	80	80	80	80				
	S	m3/d	0	0	423	868	0	0	17	35	0	0	32	65	0	0	15	29	0	0	534	1,097
Me Linh Ward	C	m3/d	482	543	563	578	19	22	23	23	36	41	42	43	24	24	24	24	562	630	653	669
	Rss	%	0	0	50	100	0	0	50	100	0	0	50	100	0	0	50	100				
	Rg	%	80	100	100	100	80	100	100	100	80	100	100	100	80	80	80	80				
	S	m3/d	0	0	282	578	0	0	11	23	0	0	21	43	0	0	10	20	0	0	356	731
Sub-total(Hong Bang)		m3/d	0	0	1,776	4,636	0	0	204	548	0	0	325	857	0	0	636	1,752	0	0	3,235	8,573
Sub-total(Ngo Quyen)		m3/d	0	0	2,130	4,445	0	0	239	511	0	0	369	778	0	0	562	1,530	0	0	3,630	7,990
Sub-total(Le Chan)		m3/d	0	0	1,502	3,085	0	0	60	123	0	0	113	231	0	0	52	104	0	0	1,900	3,899
Total		m3/d	0	0	5,409	12,166	0	0	503	1,183	0	0	806	1,867	0	0	1,250	3,386	0	0	8,765	20,462

Table 4.3.6 Estimated Generation of Sewage (3/4) (West Treatment Area, Phase II, Separate system)

Administration division			Domestic				Commercial				Institutional				Industrial				Total		Rg(%)=	10
			2005	2010	2015	2020	2005	2010	2015	2020	2005	2010	2015	2020	2005	2010	2015	2020	2005	2010	2015	2020
Ngo Quyen	C	m3/d	16,994	21,991	23,794	24,664	1,529	1,979	2,141	2,220	1,699	2,199	2,379	2,466	2,800	2,800	2,800	2,800	23,022	28,969	31,115	32,151
11 Dang Giang Ward	C	m3/d	2,527	3,270	3,538	3,667	227	294	318	330	253	327	354	367	416	416	416	416	3,423	4,307	4,627	4,781
	Rss	%	0	0	24.5	49	0	0	24.5	49	0	0	24.5	49	0	0	24.5	49				
	Rg	%	80	100	100	100	80	100	100	100	80	100	100	100	80	80	80	80				
	S	m3/d	0	0	867	1,797	0	0	78	162	0	0	87	180	0	0	82	163	0	0	1,224	2,532
13 Dong Quoc Binh Ward	C	m3/d	319	413	447	463	29	37	40	42	32	41	45	46	53	53	53	53	433	544	585	604
	Rss	%	0	0	50	100	0	0	50	100	0	0	50	100	0	0	50	100				
	Rg	%	80	100	100	100	80	100	100	100	80	100	100	100	80	80	80	80				
	S	m3/d	0	0	224	463	0	0	20	42	0	0	22	46	0	0	21	42	0	0	316	653
South of Le Chan	C	m3/d	1,795	4,734	6,890	9,216	90	237	345	461	90	237	345	461	100	200	400	800				
Du Hang Kenh Com.	C	m3/d	580	1,531	2,228	2,980	29	77	111	149	29	77	111	149	32	65	129	259	671	1,748	2,580	3,536
	Rss	%	0	0	18	36	0	0	18	36	0	0	18	36	0	0	18	36				
	Rg	%	80	100	100	100	80	100	100	100	80	100	100	100	80	80	80	80				
	S	m3/d	0	0	401	1,073	0	0	20	54	0	0	20	54	0	0	19	74	0	0	506	1,380
Vinh Niem Com.	C	m3/d	1,214	3,203	4,663	6,237	61	160	233	312	61	160	233	312	68	135	271	541	1,404	3,659	5,399	7,402
	Rss	%	0	0	43	86	0	0	43	86	0	0	43	86	0	0	43	86				
	Rg	%	80	100	100	100	80	100	100	100	80	100	100	100	80	80	80	80				
	S	m3/d	0	0	2,005	5,363	0	0	100	268	0	0	100	268	0	0	93	372	0	0	2,528	6,899
Sub-total(Ngo Quyen)		m3/d	0	0	1,090	2,260	0	0	98	203	0	0	109	226	0	0	103	205	0	0	1,540	3,185
Sub-total(South of Le Chan)		m3/d	0	0	2,406	6,436	0	0	120	322	0	0	120	322	0	0	112	447	0	0	3,034	8,279
Total		m3/d	0	0	3,496	8,697	0	0	218	525	0	0	229	548	0	0	214	652	0	0	4,574	11,464

Table 4.3.6 Estimated Generation of Sewage (4/4) (East Treatment Area, Phase II, Separate system)

Administration division			Domestic				Commercial				Institutional				Industrial				Total		Rg(%)=	10
			2005	2010	2015	2020	2005	2010	2015	2020	2005	2010	2015	2020	2005	2010	2015	2020	2005	2010	2015	2020
Ngo Quyen	C	m3/d	16,994	21,991	23,794	24,664	1,529	1,979	2,141	2,220	1,699	2,199	2,379	2,466	2,800	2,800	2,800	2,800	23,022	28,969	31,115	32,151
May Chai Ward	C	m3/d	3,221	4,168	4,510	4,675	290	375	406	421	322	417	451	467	531	531	531	531	4,364	5,491	5,898	6,094
	Rss	%	0	0	6.5	13	0	0	6.5	13	0	0	6.5	13	0	0	6.5	13				
	Rg	%	80	100	100	100	80	100	100	100	80	100	100	100	80	80	80	80				
	S	m3/d	0	0	293	608	0	0	26	55	0	0	29	61	0	0	28	55	0	0	414	856
Van My Ward	C	m3/d	1,499	1,940	2,099	2,176	135	175	189	196	150	194	210	218	247	247	247	247	2,031	2,556	2,745	2,837
	Rss	%	0	0	50	100	0	0	50	100	0	0	50	100	0	0	50	100				
	Rg	%	80	100	100	100	80	100	100	100	80	100	100	100	80	80	80	80				
	S	m3/d	0	0	1,050	2,176	0	0	94	196	0	0	105	218	0	0	99	198	0	0	1,483	3,066
Dang Giang	C	m3/d	2,527	3,270	3,538	3,667	227	294	318	330	253	327	354	367	416	416	416	416	3,423	4,307	4,627	4,781
	Rss	%	0	0	0.5	1	0	0	0.5	1	0	0	0.5	1	0	0	0.5	1				
	Rg	%	80	100	100	100	80	100	100	100	80	100	100	100	80	80	80	80				
	S	m3/d	0	0	18	37	0	0	2	3	0	0	2	4	0	0	2	3	0	0	25	52
Dong Khe Ward	C	m3/d	2,444	3,162	3,421	3,547	220	285	308	319	244	316	342	355	403	403	403	403	3,310	4,165	4,474	4,623
	Rss	%	0	0	11.5	23	0	0	11.5	23	0	0	11.5	23	0	0	11.5	23				
	Rg	%	80	100	100	100	80	100	100	100	80	100	100	100	80	80	80	80				
	S	m3/d	0	0	393	816	0	0	35	73	0	0	39	82	0	0	37	74	0	0	556	1,149
Cat Bi Ward	C	m3/d	1,791	2,318	2,508	2,599	161	209	226	234	179	232	251	260	295	295	295	295	2,426	3,053	3,279	3,388
	Rss	%	0	0	50	100	0	0	50	100	0	0	50	100	0	0	50	100				
	Rg	%	80	100	100	100	80	100	100	100	80	100	100	100	80	80	80	80				
	S	m3/d	0	0	1,254	2,599	0	0	113	234	0	0	125	260	0	0	118	236	0	0	1,771	3,662
Southeast of the City	C	m3/d	1,209	3,624	6,023	9,496	60	181	301	475	60	181	301	475	0	0	0	0	1,329	3,987	6,625	10,446
Dong Hai Com.	C	m3/d	304	913	1,517	2,392	15	46	76	120	15	46	76	120	0	0	0	0	335	1,004	1,668	2,631
	Rss	%	0	0	49.85	99.7	0	0	49.85	99.7	0	0	49.85	99.7	0	0	49.85	99.7				
	Rg	%	0	0	80	100	0	0	80	100	0	0	80	100	0	0	80	80				
	S	m3/d	0	0	605	2,384	0	0	30	119	0	0	30	119	0	0	0	0	0	0	732	2,885
Dang Lam Com.	C	m3/d	148	443	736	1,161	7	22	37	58	7	22	37	58	0	0	0	0	162	487	810	1,277
	Rss	%	0	0	49.5	99	0	0	49.5	99	0	0	49.5	99	0	0	49.5	99				
	Rg	%	0	0	80	100	0	0	80	100	0	0	80	100	0	0	80	80				
	S	m3/d	0	0	291	1,149	0	0	15	57	0	0	15	57	0	0	0	0	0	0	353	1,390
Dang Hai Com.	C	m3/d	95	286	475	749	5	14	24	37	5	14	24	37	0	0	0	0	105	314	522	824
	Rss	%	0	0	50	100	0	0	50	100	0	0	50	100	0	0	50	100				
	Rg	%	0	0	80	100	0	0	80	100	0	0	80	100	0	0	80	80				
	S	m3/d	0	0	190	749	0	0	9	37	0	0	9	37	0	0	0	0	0	0	230	906
Nam Hai Com.	C	m3/d	184	550	915	1,442	9	28	46	72	9	28	46	72	0	0	0	0	202	605	1,006	1,586
	Rss	%	0	0	50	100	0	0	50	100	0	0	50	100	0	0	50	100				
	Rg	%	0	0	80	100	0	0	80	100	0	0	80	100	0	0	80	80				
	S	m3/d	0	0	366	1,442	0	0	18	72	0	0	18	72	0	0	0	0	0	0	443	1,745
Sub-total (Ngo Quyen)		m3/d	0	0	3,008	6,236	0	0	271	561	0	0	301	624	0	0	283	566	0	0	4,249	8,786
Sub-total (Southeast of the City)		m3/d	0	0	1,452	5,724	0	0	73	286	0	0	73	286	0	0	0	0	0	0	1,757	6,926
Total		m3/d	0	0	4,460	11,960	0	0	343	848	0	0	373	910	0	0	283	566	0	0	6,006	15,712

Table 4.3.7 Estimated Generation of Sewage (Class A Area, Total)

Area	Unit	West Treatment Area																East Treatment Area				Total			
		Phase I (Combined system)				Phase II (Combined system)				Phase II (Separate system)				Total				Phase II (Separate system)							
		2005	2010	2015	2020	2005	2010	2015	2020	2005	2010	2015	2020	2005	2010	2015	2020	2005	2010	2015	2020	2005	2010	2015	2020
Hong Bang	m3/d					0	0	3,235	8,573					0	0	3,235	8,573					0	0	3,235	8,573
Ngo Quyen	m3/d	3,854	11,890	12,788	13,221	0	0	3,630	7,990	0	0	1,540	3,185	3,854	11,890	17,958	24,396	0	0	4,249	8,786	3,854	11,890	22,207	33,182
Le Chan	m3/d	7,791	21,646	22,442	23,027	0	0	1,900	3,899					7,791	21,646	24,342	26,926					7,791	21,646	24,342	26,926
South of Hong Bang	m3/d													0	0	0	0					0	0	0	0
South of Le Chan	m3/d	275	1,781	2,621	3,576					0	0	3,034	8,279	275	1,781	5,655	11,856					275	1,781	5,655	11,856
Southeast of the City	m3/d	1	9	14	23									1	9	14	23	0	0	1,757	6,926	1	9	1,771	6,949
Total	m3/d	11,921	35,325	37,866	39,847	0	0	8,765	20,462	0	0	4,574	11,464	11,921	35,325	51,205	71,773	0	0	6,006	15,712	11,921	35,325	57,210	87,485
Sewage in urban center	m3/d	11,645	33,535	35,230	36,248	0	0	8,765	20,462	0	0	1,540	3,185	11,645	33,535	45,535	59,895	0	0	4,249	8,786	11,645	33,535	49,784	68,681
Sewage in effective area	m3/d	276	1,790	2,636	3,599	0	0	0	0	0	0	3,034	8,279	276	1,790	5,670	11,878	0	0	1,757	6,926	276	1,790	7,427	18,805
Total	m3/d	11,921	35,325	37,866	39,847	0	0	8,765	20,462	0	0	4,574	11,464	11,921	35,325	51,205	71,773	0	0	6,006	15,712	11,921	35,325	57,210	87,485

Table 4.3.8 Class A Area Sewerage Facilities List

West Wastewater Treatment Area						
	Phase I	Combined sewer system	CSO	nos.	60	
			sewer	m	20,000	
			sewer trunk and conveyance	m	20,000	actual sewer length, including open cut, jacking method
			sub pumping station	nos.	10	
			main pumping station	nos.	1	
			West WWTP	nos.	0.50	36,000m3/day(planning capacity 72,000m3/day)
	Phase II	Combined sewer system	CSO	nos.	60	
			sewer(average dia 500mm)	m	42,800	50 m/ha
			Conveyance (average dia 1000mm)	m	20,000	actual sewer length, including open cut, jacking method
			sub pumping station	nos.	4	4 nos/1000ha, about 3m3/min
			main pumping station	nos.	1	1 nos/1000ha, about 10m3/min
			West WWTP	nos.	0.25	20,462m3/day(planning capacity 72,000m3/day)
		Separate sewer system	sewer(average dia 500mm)	m	69,500	100 m/ha
			Conveyance (average dia 1000mm)	m	6,950	10% of total sewer length, including open cut, jacking method
			sub pumping station	nos.	3	4 nos/1000ha, about 3m3/min
			main pumping station	nos.	1	1 nos/1000ha, about 10m3/min
			West WWTP	nos.	0.25	11,464m3/day(planning capacity 72,000m3/day)
		sub-total(Phase II)	CSO	nos.	60	
			sewer(average dia 500mm)	m	112,300	
			Conveyance (average dia 1000mm)	m	26,950	
			sub pumping station	nos.	7	about 3m3/min
			main pumping station	nos.	2	about 10m3/min
			West WWTP	nos.	0.50	31,926m3/day(planning capacity 76,874m3/day)
	Total		CSO	nos.	120	
			sewer	m	132,300	
			conveyance	m	46,950	including Interceptor
			sub pumping station	nos.	17	about 3m3/min
			main pumping station	nos.	3	about 10m3/min
			West WWTP	nos.	1.00	planning capacity 72,000m3/day
East Wastewater Treatment Area						
	Phase II	Separate sewer system	sewer(average dia 500mm)	m	258,700	100 m/ha
			conveyance(average dia 1000mm)	m	7,761	3% of total sewer length, including open cut, jacking method
			sub pumping station	nos.	11	4 nos/1000ha, about 3m3/min
			main pumping station	nos.	3	1 nos/1000ha, about 10m3/min
			East WWTP	nos.	1.00	planning capacity 15,712m3/day

Table 4.3.9 Class A Area Sewerage Facilities Cost

Unit : 1000US$

				unit	quantity	civil works			mec/ele			Remarks
						unit cost		cost	unit cost		cost	
Urban Center												
West Wastewater Treatment Area												
	Phase I	Combined sewer area	CSO	nos.	60	37	1000USD/nos.	2,220				
			sewer	m	20,000	0.21	1000USD/m	4,200				
			sewer trunk and conveyance	m	20,000	1.22	1000USD/m	24,400				
			sub pumping station	nos.	10	89	1000USD	894				3 m3/min
			main pumping station	nos.	1	385	1000USD	385	546	1000USD	546	32 m3/min
			West WWTP	nos.	0.50	0.215	1000USD	7,733	0.143	1000USD	5,162	72,000 m3/day
			Miscellaneous	L.S.	1			3,983			571	10%
			sub total					**43,816**			**6,279**	50,095 (total)
	Phase II	Combined sewer system	CSO	nos.	60	37	1000USD/nos.	2,220				
			sewer(average dia 500mm)	m	42,800	0.12	1000USD/m	5,136				
			conveyance(average dia 1000mm)	m	13,333	0.31	1000USD/m	4,133				
			conveyance(jacking method)	m	6,667	1.35	1000USD/m	9,000				
			sub pumping station	nos.	4	89	1000USD	358				3 m3/min
			main pumping station	nos.	1	291	1000USD	291	412	1000USD	412	20 m3/min
			West WWTP	nos.	0.25	0.215	1000USD	3,866	0.143	1000USD	2,581	72,000 m3/day
			sub total(including Mis.)					**27,505**			**3,292**	30,797 (total)
		Separate sewer system	sewer(average dia 500mm)	m	69,500	0.12	1000USD/m	8,340				
			conveyance(average dia 1000mm)	m	4,633	0.31	1000USD/m	1,436				
			conveyance(jacking method)	m	2,317	1.35	1000USD/m	3,128				
			sub pumping station	nos.	3	89	1000USD	268				3 m3/min
			main pumping station	nos.	1	291	1000USD	291	412	1000USD	412	20 m3/min
			West WWTP	nos.	0.25	0.215	1000USD	3,866	0.143	1000USD	2,581	72,000 m3/day
			sub total(including Mis.)					**19,063**			**3,292**	22,355 (total)
		sub-total(Phase II)						**46,567**			**6,585**	53,152 (total)
	Total							**90,383**			**12,864**	103,247 (total)
East Wastewater Treatment Area												
	Phase II	Separate sewer system	sewer(average dia 500mm)	m	258,700	0.12	1000USD/m	31,044				
			conveyance(average dia 1000mm)	m	5,174	0.31	1000USD/m	1,604				
			conveyance(jacking method)	m	2,587	1.35	1000USD/m	3,492				
			sub pumping station	nos.	11	89	1000USD	984				3 m3/min
			main pumping station	nos.	3	291	1000USD	873	412	1000USD	1,236	20 m3/min
			West WWTP	nos.	1.00	0.357	1000USD	5,609	0.238	1000USD	3,733	15,712 m3/day
			sub total					**43,606**			**4,969**	48,575 (total)
Total								**133,990**			**17,833**	151,823 (total)
Grand Total											**151,823**	
	Phase I	Combined sewer system	pipeline and others					36,083			1,116	37,200 (total)
			WWTP					7,733			5,162	12,895 50,095
	Phase II	Combined sewer system	pipeline and others					23,639			711	24,350
			WWTP					3,866			2,581	6,448
		Separage sewer system	pipeline and others					53,193			1,947	55,140 (total)
			WWTP					9,476			6,314	15,790 101,728

Note: Constant Price of June 2000

Excludes engineering services, administrative costs and physical contingency

Table 4.3.10 Land Acquisition and Compensation

Land acquisition for WWTP

Name	wastewater flow		Treatment Method	Unit land	Land acquisition and conpensation			Phase I			Phase II		
	2010	2020			Land loss		House loss	Land loss		House loss	Land loss		House loss
					Agricaltual	Residential		Agricaltual	Residential		Agricaltual	Residential	
	m3/day	m3/day		m2/m3/day	ha	ha	nos.	ha	ha	nos.	ha	ha	nos.
West WWTP	35,325	71,773	Aerated Lagoon	5.5	39.5	0	10	39.5	0	10			
East WWTP	-	15,712	Stabilization Pond	15	23.6	0	0				23.6	0	0
sub-total					**63.1**	**0**	**10**	**39.5**	**0**	**10**	**23.6**	**0**	**0**

Land Acquisition for Pumping Station

Name	Pumping Station		Capacity	Unit land	Land acquisition and conpensation			Phase I			Phase II		
	unit	quantity			Land loss		House loss	Land loss		House loss	Land loss		House loss
					Agricaltual	Residential		Agricaltual	Residential		Agricaltual	Residential	
				m2/nos.	ha	ha	nos.	ha	ha	nos.	ha	ha	nos.
West Wastewater Treatment Area													
sub pumping station	nos.	17	approx. 3m3/s	100		0.17	13		0.06	6		0.07	7
main pumping station	nos.	3	approx. 10m3/s	500		0.15	20		0.10	10		0.10	10
East Wastewater Treatment Area													
sub pumping station	nos.	11	approx. 3m3/s	100		0.11	10					0.11	10
main pumping station	nos.	3	approx. 10m3/s	500		0.15	15					0.15	15
sub-total						**0.58**	**58**		**0.16**	**16**		**0.43**	**42**

Compensation	m US$	PhI	PhII
Agricultural	1.893	1.185	0.708
Residential	0.1624	0.0448	0.1204
House loss	0.34	0.13	0.21
Total	2.3954	1.3598	1.0384
Adjusted	3.24	2.2	1.04

Total Land Acquisation

	Land acquisition and conpensation			Phase I			Phase II		
	Land loss		House loss	Land loss		House loss	Land loss		House loss
	Agricaltual	Residential		Agricaltual	Residential		Agricaltual	Residential	
	ha	ha	nos.	ha	ha	nos.	ha	ha	nos.
for WWTP	63.1	0.0	10.0	39.5	0.0	10.0	23.6	0.0	0.0
for P/S	0.0	0.6	58.0	0.0	0.2	16.0	0.0	0.4	42.0
sub-total	**63.1**	**0.6**	**68.0**	**39.5**	**0.2**	**26.0**	**23.6**	**0.4**	**42.0**

Note: Constant Price of June 2000
Excludes engineering services, administrative costs and physical contingency

Table 4.3.11 Treatment Plant Alternatives Analysis (1/5)

Wastewater Stabilization Pond Treatment Process (WWSP)

Conditions

Wastewater Flow	72,000	m3/day	(ADWF)		
Influent BOD	350	mg/l			
Influent SS	315	mg/l			
Effluent BOD	50	mg/l	BOD removal ratio	86	%
Effluent SS	60	mg/l	SS removal ratio	81	%

Estimation

BOD load	25.2	ton/day	9,198	ton/year
SS load	22.7	ton/day	8,278	ton/year
Removal BOD load	21,600	kg/day	7,884	ton/year
Removal SS load	18,360	kg/day	6,701	ton/year

Collection System ♁❑❍♌♓■♏♎ ⬧♏⬧♏❐ ⬧⌧⬧⬥♏❍

Design flow

Pretreatment facility	216,000	Peak Wet Weather Flow = 3 x ADWF
Primary Treatment	144,000	2 Average Dry Weather Flow = 2 x ADWF
Secondary Treatment	72,000	Average Dry Weather Flow = 1 x ADWF

Treatment Flow

Wastewater inflow -->Pretreatment facilities -->Anaerobic Pond -->Facultative Pond -->Maturation Pond --> public water body

Sludge -->directly desludge from pond

Main Facilities

Pretreatment facilities	0.11	ha			
Anaerobic Pond	4.7	ha	AP+FP		
Facultative Pond	58.2	ha	63 x 1.20 =	76	ha
Maturation Pond			AP+FP+FMP		
First Maturatiion Pond	31.0	ha	94 x 1.20 =	113	ha
Second Maturation Pond	14.4	ha	AP+FP+FMP+SMP		
Third Maturation Pond	0.0	ha	108 x 1.20 =	130	ha

Design conditions

Secondary Lagoon Effluent BOD	Le	50	mg/l	

Design

Pretreatment facilities				
Design flow		216,000	m3/day	
Unit area		0.005	m2/(m3/day)	
Facilities area		0.11	ha	
Primary Lagoon (Anaerobic Pond)				
Mean air temperature of coldest month	T	14	°C	
Volumetric loading rate	λv	180	g/m3/day	λv = 20T-100
BOD removal		48	%	R=2T+20
Primary Lagoon Effluent BOD		182	mg/l	
AP volume	V	140,000	m3	V=BOD load / λ v
AP depth	d	3.0	m	
AP area	A	4.7	ha	
Retention time	t	1.9	days	
Secondary Lagoon (Facultative Pond)				
Influent BOD	Lo	182	mg/l	
Influent BOD load		13,104	kg/day	
Mean air temperature of coldest month	T	14	°C	
Surface loading rate	λs	152	kg/ha/day	λs = 350(1.107-0.002T)^(T-25)
Maximum surface loading	**l sm**	**225**	**kg/ha/day**	**l s = 60(1.099)^(T)**
FP surface — for λs		86.4	ha	
FP depth		1.5	m	
Retention time — for λs	t	18.0	days	
SL surface — for l sm		**58.2**	**ha**	
SL depth		**1.5**	**m**	
Retention time — for l sm	**t**	**12.1**	**day**	
Breakdown rate per day of sewage organic	K_T	0.224	d^{-1}	K_T=0.3(1.05)^(T-20)
Effluent BOD		36	mg/l	Le=(Lo)/(1+Kt x t)
Effluent BOD		**49**	**mg/l**	**Le=(Lo)/(1+Kt x t)**
Third Lagoon (Maturation Pond)				
First Maturation Pond (FMP)				
Influent BOD	Lo	49	mg/l	(Considering maximum surface loading)
Influent BOD load		3,526	kg/day	
Maximum permissible BOD loading rate	λs	114	kg/ha/day	λs = 75% of that of the preceeding FP
FMP surface area	A	31.0	ha	
FMP depthe	d	1.5	m	
Retention time	t	6.5	days	
Second Maturation Pond (SMP)				
Raw sewage fecal coliforms	Ni	1,000,000	number per 100mL	
Retention time in AP	t_A	1.9	days	
Retention time in FP	t_F	12.1	days	
Retention time in FMP	t_{FM}	6.5	days	
Retention time in SMP and TMP	t_{SMTM}	3	days	
Number of SMP and TMP	n	1	nos.	
First order rate constant for FC removal per day	K_T	0.916	d^{-1}	K_T=2.6 x (1.19)^(T-20)
Fecal coliforms of effluent number per 100mL	Ne	1,147	nos./100mL	$Ni/(1+K_Tt_A)(1+K_Tt_F)(1+K_Tt_{FM})(1+K_Tt_{SMTM})^n$
SMP depth	d	1.5	m	
SMP surface area	A	14.4	ha	
TMP surface area	A	0.0	ha	

Table 4.3.11 Treatment Plant Alternatives Analysis (2/5)

Modified Wastewater Stabilization Pond Treatment Process (MWSP)

Conditions					
Wastewater Flow	72,000	m3/day	(ADWF)		
Influent BOD	350	mg/l			
Influent SS	315	mg/l			
Effluent Quality					
Effluent BOD	106	mg/l	BOD removal ratio	70	%
Effluent SS	127	mg/l	SS removal ratio	60	%
Estimation					
BOD load	25.2	ton/day	9,198	ton/year	
SS load	22.7	ton/day	8,278	ton/year	
Removal BOD load	17,576	kg/day	6,415	ton/year	
Removal SS load	13,531	kg/day	4,939	ton/year	
Collection System	✍□❍♌♓■♏♎ ⬧♏⬥♏❒ ⬧⌧⬧⧫♏❍				
Design flow					
Pretreatment facility	216,000	Peak Wet Weather Flow = 3 x ADWF			
Primary Treatment	72,000	Average Dry Weather Flow = 1 x ADWF			
Secondary Treatment	72,000	Average Dry Weather Flow = 1 x ADWF			

Treatment Flow

Wastewater inflow -->Pretreatment facilities -->First Pond -->Secondary Pond -->Chlorination tank --> public water bod

Sludge -->directly desludge from pond

Main Facilities

Pretreatment facilities	0.11	ha	x 2.0=	0.2	
First Pond	24.0	ha	x 1.2=	28.8	
Secondary Pond	12.0	ha	x 1.2=	14.4	
Chlorination Pond	0.1	ha	x 2.0=	0.2	43.6 ha

Design

Pretreatment facilities						
Design flow		216,000	m3/day			
Unit area		0.005	m2/(m3/day)			
Facilities area		0.11	ha			
First Pond (FP)						
BOD load		25,200	kg/day			
Retention time	t	10.0	days			
FP volume	V	720,000	m3			
FP effective depth	d	3.0	m	effective depth	1.5	m
FP required surface area	A	24.0	ha	effective retention tim	5.0	days
Mean air temperature of coldest montl	T	14	°C			
Breakdown rate per day of sewage organi	K_T	0.224	d^{-1}	K_T=0.3(1.05)^(T-20)		
Effluent BOD		165	mg/l	Le=(Lo)/(1+Kt x t)		
Secondary Pond (SP)						
Retention time	t	5.0	days			
FP volume	V	360,000	m3			
FP effective depth	d	3.0	m	effective depth	1.5	m
FP required surface area	A	12.0	ha	effective retention tim	2.5	days
Effluent BOD		106	mg/l	Le=(Lo)/(1+Kt x t)		
Pond BOD loading rate		700	kg/ha/day	625	lbs/acre/day	
Chlorination Tank						
Design flow	Q	72,000	m3/day			
Detention time	t	15.0	min			
Tank Volume	V	750	m3			
Tank depth	d	1.0	m			
Required surface area	A	0.1	ha			

Table 4.3.11 Treatment Plant Alternatives Analysis (3/5)

Aerated Lagoon Treatment Process (AL)

Conditions

Wastewater Flow	72,000	m3/day	(ADWF)			
Influent BOD	350	mg/l				
Influent SS	315	mg/l				
Effluent BOD	50	mg/l	BOD removal ratio		86	%
Effluent SS	60	mg/l	SS removal ratio		81	%

Estimation

BOD load	25.2	ton/day	9,198	ton/year
SS load	22.7	ton/day	8,278	ton/year
Removal BOD load	21,600	kg/day	7,884	ton/year
Removal SS load	18,360	kg/day	6,701	ton/year

Collection System ✍□❍♌♓■♏♎ ⬧♏⬧♏❒ ⬧⌧⬧◆♏❍

Design flow

Pretreatment facility	216,000	Peak Wet Weather Flow = 3 x ADWF
Primary Treatment	-	-
Secondary Treatment	72,000	Average Dry Weather Flow = 1 x ADWF

Treatment Flow

Wastewater inflow -->Pretreatment facilities -->Aerated Lagoon -->Settling Pond --> Chlorination tank -->public water body

Sludge -->Sludge drying bed

Main Facilities

Pretreatment facilities	0.11	ha	x 2.0 =	0.2		
Aerated Lagoon	8.4	ha	x 1.20 =	10.1		
Settling Pond	4.8	ha	x 1.20 =	5.8		
Chlorination Tank	0.1	ha	x 1.20 =	0.1		
Sludge Drying Bed	9.2	ha	x 1.20 =	11.0	27.2	ha

Design

Pretreatment facilities				
Design flow		216,000	m3/day	
Unit area		0.005	m2/(m3/day)	
Facilities area		0.11	ha	
Aerated Lagoon (AL)				
Design flow	Q	72,000	m3/day	
Influent soluble BOD	Li	350	mg/l	
Influent SS		315	mg/l	
Target Effluent soluble BOD		50	mg/l	
Target Effluent soluble SS		60	mg/l	
Winter air temperature	T	14	°C	
soluble BOD removal-rate constant	k_T	1.76	d^{-1}	k_T=2.5(1.06)^(T-20)
mean cell-residence time	θc	3.5	days	
AL depth	d	3	m	
Required surface area	A	8.4	ha	
Effluent BOD	Le	48.8	mg/l	Le=Li/(1+k_T x θc)
Settling Pond				
Detention time	t	1.0	days	
depth	d	1.5	m	
Required surface area	A	4.8	ha	
Chlorination Tank				
Design flow	Q	72,000	m3/day	
Detention time	t	15.0	min	
Tank Volume	V	750	m3	
Tank depth	d	1.0	m	
Required surface area	A	0.1	ha	
Sludge Drying Bed				
Removal SS load		12,240	kg/day	
Sludge concentration		20,000	mg/l	
Sluge feeded	Q	612	m3/day	
Drying dutation	t	30	days	
Thickness of feeded sludge		20	cm	
Required surface area	A	9.2	ha	
Sludge loading		4.0	kg/m2	
Sludge loading rate		49	kg/m2/year	
Dryed sludge water contents		60	%	
Dryed sludge volume	V	31	m3/day	

Table 4.3.11 Treatment Plant Alternatives Analysis (4/5)

Oxidation Ditch Treatment Process (OD)

Conditions

Wastewater Flow	72,000	m3/day	(ADWF)		
Influent BOD	350	mg/l			
Influent SS	315	mg/l			
Effluent BOD	50	mg/l	BOD removal ratio	86	%
Effluent SS	60	mg/l	SS removal ratio	81	%

Estimation

BOD load	25.2	ton/day	9,198	ton/year
SS load	22.7	ton/day	8,278	ton/year
Removal BOD load	21,600	kg/day	7,884	ton/year
Removal SS load	18,360	kg/day	6,701	ton/year

Collection System ✍□❍♌♓■♏♎ ⬧♏⬧♏❐ ⬧⌧⬧◆♏❍

Design flow

Pretreatment facility	216,000	Peak Wet Weather Flow = 3 x ADWF
Primary Treatment	144,000	2 Average Dry Weather Flow = 2 x ADWF
Secondary Treatment	72,000	Average Dry Weather Flow = 1 x ADWF

Treatment Flow

Wastewater inflow -->Pretreatment facilities -->(Primary Sedimentation Tank for Wet Weater Flow)-->Oxidation ditch -->Secondary Sedimentation Tank -->Chlorination Tank --> public water body

Sludge -->Sludge Thickening Tank -->Sludge drying bed

Main Facilities

Pretreatment facilities	0.11 ha	x 2.0	0.2		
Primary Sedimentation Tank	0.4 ha	x 2.0	0.7		
Aeration Tank	1.6 ha	x 2.0	3.2		
Secondary Sedimentation Tank	0.7 ha	x 2.0	1.4	for water treatment	
Chlorination Tank	0.1 ha	x 2.0	0.2	5.7	ha
Sludge Thickening Tank	0.03 ha	x 2.0	0.1		
Sludge Drying Bed	9.2 ha	x 1.2	11.0	**16.8**	ha

Design

Pretreatment facilities			
Design flow	Q	216,000	m3/day
Unit area		0.005	m2/(m3/day)
Facilities area	A	0.11	ha
Primary Sedimentation Tank (for Wet Weather Flow)			
Design flow	Q	144,000	m3/day
Detention time	t	2.0	hr
Tank Volume	V	12,000	m3
Overflow rate		40	m3/m2/day
Tank depth	d	3.3	m
Required surface area	A	0.4	ha
Oxidation ditch			
Design flow	Q	72,000	m3/day
Aeration time	t	16	hr
Aeration tank volume	V	48,000	m3
Aeration tank depth	d	3	m
Required surface area	A	1.6	ha
Secondary Sedimentation Tank			
Design flow	Q	72,000	m3/day
Detention time	t	6.0	hr
Tank Volume	V	18,000	m3
Overflow rate		10	m3/m2/day
Tank depth	d	2.5	m
Required surface area	A	0.7	ha
Chlorination Tank			
Design flow	Q	72,000	m3/day
Detention time	t	15.0	min
Tank Volume	V	750	m3
Tank depth	d	1.0	m
Required surface area	A	0.1	ha
Sludge Thickening Tank			
Removal SS load		18,360	kg/day
Influent Sludge concentration		8,000	mg/l
Design sluge	Q	2,295	m3/day
Solids loading		60	kg/m2/day
Required surface area	A	0.03	ha
Tank depth	d	4.0	m
Detention time	t	12.8	hr
Tank Volume	V	1,224	m3
Sludge Drying Bed			
Removal SS load		12,240	kg/day
Sludge concentration		20,000	mg/l
Sluge feeded	Q	612	m3/day
Drying dutation	t	30	days
Thickness of feeded sludge		20	cm
Required surface area	A	9.2	ha
Sludge loading		4.0	kg/m2
Sludge loading rate		49	kg/m2/year
Dryed sludge water contents		60	%
Dryed sludge volume	V	31	m3/day

Table 4.3.11 Treatment Plant Alternatives Analysis (5/5)

Conventional Activated Sludge Treatment Process (CAS)

Conditions					
Wastewater Flow	72,000	m3/day	(ADWF)		
Influent BOD	350	mg/l			
Influent SS	315	mg/l			
Effluent BOD	50	mg/l	BOD removal ratio	86	%
Effluent SS	60	mg/l	SS removal ratio	81	%
Estimation					
BOD load	25.2	ton/day	9,198	ton/year	
SS load	22.7	ton/day	8,278	ton/year	
Removal BOD load	21,600	kg/day	7,884	ton/year	
Removal SS load	18,360	kg/day	6,701	ton/year	
Collection System	👍□❍♌♓■♏♎ ⬥♏⬥♏❒ ⬥⌧⬥♦♏❍				
Design flow					
Pretreatment facility	216,000	Peak Wet Weather Flow = 3 x ADWF			
Primary Treatment	144,000	2 Average Dry Weather Flow = 2 x ADWF			
Secondary Treatment	72,000	Average Dry Weather Flow = 1 x ADWF			

Treatment Flow

Wastewater inflow -->Pretreatment facilities -->Primary Sedimentation Tank -->Aeration Tank -->Secondary Sedimentation Tank -->Chlorination Tank --> public water body

Sludge -->Sludge Thickening Tank -->Sludge Digestion Tank -->Sludge drying bed

Main Facilities

Pretreatment facilities	0.11	ha	x 2.0	0.2		
Primary Sedimentation Tank	0.4	ha	x 2.0	0.7		
Aeration Tank	0.5	ha	x 2.0	0.9		
Secondary Sedimentation Tank	0.3	ha	x 2.0	0.6	for water treatment	
Chlorination Tank	0.1	ha	x 2.0	0.2	2.6	ha
Sludge Thickening Tank	0.03	ha	x 2.0	0.1	for ---digestion tanks	
Sludge Digestion Tank	0.8	ha	x 2.0	1.5	4.2	ha
Sludge Drying Bed	6.1	ha	x 1.2	7.3	**11.5**	ha

Design

Pretreatment facilities			
Design flow	Q	216,000	m3/day
Unit area		0.005	m2/(m3/day)
Facilities area	A	0.11	ha
Primary Sedimentation Tank			
Design flow	Q	144,000	m3/day
Detention time	t	2.0	hr
Tank Volume	V	12,000	m3
Overflow rate		40	m3/m2/day
Tank depth	d	3.3	m
Required surface area	A	0.4	ha
Aeration Tank			
Design flow	Q	72,000	m3/day
Aeration time	t	6	hr
Aeration tank volume	V	18,000	m3
Aeration tank depth	d	4	m
Required surface area	A	0.5	ha
Secondary Sedimentation Tank			
Design flow	Q	72,000	m3/day
Detention time	t	4.0	hr
Tank Volume	V	12,000	m3
Overflow rate		25	m3/m2/day
Tank depth	d	4.2	m
Required surface area	A	0.3	ha
Chlorination Tank			
Design flow	Q	72,000	m3/day
Detention time	t	15.0	min
Tank Volume	V	750	m3
Tank depth	d	1.0	m
Required surface area	A	0.1	ha
Sludge Thickening Tank			
Removal SS load		18,360	kg/day
Influent Sludge concentration		10,000	mg/l
Design sluge	Q	1,836	m3/day
Solids loading		60	kg/m2/day
Required surface area	A	0.03	ha
Tank depth	d	4.0	m
Detention time	t	16.0	hr
Tank Volume	V	1,224	m3
Sludge Digestion Tank			
Removal SS load		18,360	kg/day
Raw sludge concentration		30,000	mg/l
Raw sluge	Q	612	m3/day
Digested SS load		12,240	kg/day
Digested sluge concentration		30,000	mg/l
Digested sludge	Q	408	m3/day
Digestion time	t	90	days
Tank Volume	V	45,900	m3
Tank depth	d	6	m
Required surface area	A	0.8	ha
Sludge Drying Bed			
Digested sludge feeded	Q	408	m3/day
Digested sludge load		12,240	kg/day
Drying dutation	t	30	days
Thickness of feeded sludge		20	cm
Required surface area	A	6.1	ha
Sludge loading		6.0	kg/m2
Sludge loading rate		73	kg/m2/year
Dryed sludge water contents		60	%
Dryed sludge volume	V	31	m3/day

Table 4.3.12 Construction and Operation & Maintenance cost by Treatment Process

Condition

Wastewater Flow	72,000	m3/day	1.18 scale demerit
Construction unit cost			
Stabilization Pond		no Sludge Drying Bed	**373** US$/(m3/day)
Modified Stabilization Pond		no Sludge Drying Bed	336 US$/(m3/day)
Aerated Lagoon		Sludge Drying Bed	**359** US$/(m3/day)
Oxidation Ditch		Sludge Drying Bed	478 US$/(m3/day)
Activated Sludge Process		Sludge Drying Bed	**598** US$/(m3/day)
Operation & Maitenance unit cost			
Stabilization Pond		no Sludge Drying Bed	**0.024** US$/m3
Modified Stabilization Pond		no Sludge Drying Bed	0.022 US$/m3
Aerated Lagoon		Sludge Drying Bed	**0.052** US$/m3
Oxidation Ditch		Sludge Drying Bed	0.068 US$/m3
Activated Sludge Process		Sludge Drying Bed	**0.085** US$/m3

	Construction cost		Operation & Maintenance cost	
	Unit cost	Cost	Unit cost	Cost
	US$/(m3/day)	1000US$ (a)	US$/m3	1000US$/year
Stabilization Pond	373	26,847	0.024	620
Modified Stabilization Pond	336	24,163	0.022	589
Aerated Lagoon	359	25,828	0.052	1,364
Oxidation Ditch	478	34,451	0.068	1,799
Activated Sludge Process	598	43,075	0.085	2,233

Table 4.3.13 Comparison of Treatment Process

Design flow	72,000	m3/day
Land compensation cost	3	US$/m2 for agricultural land
House compensation cost	5,000	US$/house

		Main facilities	Required area	Required land	House loss	Cost			
						Construction	Compensation	sub-total	O & M
			ha	ha	nos.	million US$	million US$	million US$	million US$/year
Stabilization Pond	**WSP**	Anaerobic Pond, Facultative Pond, Maturation Pond, Average depth=1.5m	108	130	260	26.85	5.20	32.05	0.62
Modified Stabilization Pond	**MSP**	First Pond, Second Pond, Average depth=3.0m	36	44	88	24.16	1.76	25.92	0.59
Aerated Lagoon	**AL**	Aerated Lagoon, Settling Pond, average depth=3.0m	23	27	54	25.83	1.08	26.91	1.36
Oxidation Pond	**OD**	Oxidation Ditch, Settling Tank, Sludge Thickening Tank, Sludge Drying Bed, Average depth=3.0m	12	17	34	34.45	0.68	35.13	1.80
Activated Sludge Process	**ASP**	Pretreatment Facilities, Primary Sedimentation Tank, Aeration Tank, Secondary Sedimentation Tank, Sludge Thickening Tank, Sludge Drying Bed, Average depth=4.0m	8	12	24	43.07	0.48	43.55	2.23

Table 4.3.14 Present Value Estimation by Treatment Process (1/5)

Treatment Process	**Wastewater Stabilization Pond**			Land compensation cost	
Wastewater Flow	72,000 m3/day	Required land	130 ha	30	1000US$/ha
Construction cost	26,856 1000US$	House compensatio	260 houses	5	1000US$/house
O & M cost	631 1000US$/year	0.9 =k_{civil}	0.1 =$k_{mec/ele}$		
Discount Rate	5 %	Depreciation period (civil)	50years	(mec/ele)	20years

No.	Year	Cost			(Unit : 1000US$)			Present Value			(Unit : 1000US$)		
		Costruction			O & M	Land Compensation	total	Costruction			O & M	Land Compensation	total
		Civil	Mec/Ele	sub-total				Civil	Mec/Ele	sub-total			
1	2001	0	0	0	0	0	0	0	0	0	0	0	0
2	2002	0	0	0	0	0	0	0	0	0	0	0	0
3	2003	0	0	0	0	0	0	0	0	0	0	0	0
4	2004	0	0	0	0	3,900	3,900	0	0	0	0	3,209	3,209
5	2005	4,028	448	4,476	0	0	4,476	3,156	351	3,507	0	0	3,507
6	2006	4,028	448	4,476	0	0	4,476	3,006	334	3,340	0	0	3,340
7	2007	4,028	448	4,476	0	0	4,476	2,863	318	3,181	0	0	3,181
8	2008	0	0	0	79	0	79	0	0	0	53	0	53
9	2009	0	0	0	158	0	158	0	0	0	102	0	102
10	2010	0	0	0	237	3,900	4,137	0	0	0	145	2,394	2,539
11	2011	4,028	448	4,476	315	0	4,791	2,355	262	2,617	184	0	2,801
12	2012	4,028	448	4,476	315	0	4,791	2,243	249	2,492	176	0	2,668
13	2013	4,028	448	4,476	315	0	4,791	2,136	237	2,374	167	0	2,541
14	2014	0	0	0	394	0	394	0	0	0	199	0	199
15	2015	0	0	0	473	0	473	0	0	0	228	0	228
16	2016	0	0	0	552	0	552	0	0	0	253	0	253
17	2017	0	0	0	631	0	631	0	0	0	275	0	275
18	2018	0	0	0	631	0	631	0	0	0	262	0	262
19	2019	0	0	0	631	0	631	0	0	0	250	0	250
20	2020	0	0	0	631	0	631	0	0	0	238	0	238
21	2021	0	0	0	631	0	631	0	0	0	226	0	226
22	2022	0	0	0	631	0	631	0	0	0	216	0	216
23	2023	0	0	0	631	0	631	0	0	0	205	0	205
24	2024	0	0	0	631	0	631	0	0	0	196	0	196
25	2025	0	448	448	631	0	1,078	0	132	132	186	0	318
26	2026	0	448	448	631	0	1,078	0	126	126	177	0	303
27	2027	0	448	448	631	0	1,078	0	120	120	169	0	289
28	2028	0	0	0	631	0	631	0	0	0	161	0	161
29	2029	0	0	0	631	0	631	0	0	0	153	0	153
30	2030	0	0	0	631	0	631	0	0	0	146	0	146
31	2031	0	448	448	631	0	1,078	0	99	99	139	0	238
32	2032	0	448	448	631	0	1,078	0	94	94	132	0	226
33	2033	0	448	448	631	0	1,078	0	89	89	126	0	216
34	2034	0	0	0	631	0	631	0	0	0	120	0	120
35	2035	0	0	0	631	0	631	0	0	0	114	0	114
36	2036	0	0	0	631	0	631	0	0	0	109	0	109
37	2037	0	0	0	631	0	631	0	0	0	104	0	104
38	2038	0	0	0	631	0	631	0	0	0	99	0	99
39	2039	0	0	0	631	0	631	0	0	0	94	0	94
40	2040	0	0	0	631	0	631	0	0	0	90	0	90
41	2041	0	0	0	631	0	631	0	0	0	85	0	85
42	2042	0	0	0	631	0	631	0	0	0	81	0	81
43	2043	0	0	0	631	0	631	0	0	0	77	0	77
44	2044	0	0	0	631	0	631	0	0	0	74	0	74
45	2045	0	448	448	631	0	1,078	0	50	50	70	0	120
46	2046	0	448	448	631	0	1,078	0	47	47	67	0	114
47	2047	0	448	448	631	0	1,078	0	45	45	64	0	109
48	2048	0	0	0	631	0	631	0	0	0	61	0	61
49	2049	0	0	0	631	0	631	0	0	0	58	0	58
50	2050	0	0	0	631	0	631	0	0	0	55	0	55
Total		24,170	6,714	30,884	24,283	7,800	62,967	15,760	2,554	18,314	6,186	5,603	30,102

Table4.3.14 Present Value Estimation by Treatment Process (2/5)

Treatment Process	**Modified Stabilization Pond**					Land compensation cost	
Wastewater Flow	72,000	m3/day	Required land	44	ha	30	1000US$/ha
Construction cost	24,192	1000US$	House compensatio	88	houses	5	1000US$/house
O & M cost	578	1000US$/year	0.9	$=k_{civil}$	0.1	$=k_{mec/ele}$	
Discount Rate	5	%	Depreciation period	(civil)	50years	(mec/ele)	20years

No.	Year	Cost			(Unit : 1000US$)			Present Value			(Unit : 1000US$)		
		Costruction			O & M	Land	total	Costruction			O & M	Land	total
		Civil	Mec/Ele	sub-total		Compensation		Civil	Mec/Ele	sub-total		Compensation	
1	2001	0	0	0	0	0	0	0	0	0	0	0	0
2	2002	0	0	0	0	0	0	0	0	0	0	0	0
3	2003	0	0	0	0	0	0	0	0	0	0	0	0
4	2004	0	0	0	0	1,320	1,320	0	0	0	0	1,086	1,086
5	2005	3,629	403	4,032	0	0	4,032	2,843	316	3,159	0	0	3,159
6	2006	3,629	403	4,032	0	0	4,032	2,708	301	3,009	0	0	3,009
7	2007	3,629	403	4,032	0	0	4,032	2,579	287	2,865	0	0	2,865
8	2008	0	0	0	72	0	72	0	0	0	49	0	49
9	2009	0	0	0	145	0	145	0	0	0	93	0	93
10	2010	0	0	0	217	1,320	1,537	0	0	0	133	810	943
11	2011	3,629	403	4,032	289	0	4,321	2,122	236	2,357	169	0	2,526
12	2012	3,629	403	4,032	289	0	4,321	2,021	225	2,245	161	0	2,406
13	2013	3,629	403	4,032	289	0	4,321	1,924	214	2,138	153	0	2,292
14	2014	0	0	0	361	0	361	0	0	0	183	0	183
15	2015	0	0	0	434	0	434	0	0	0	209	0	209
16	2016	0	0	0	506	0	506	0	0	0	232	0	232
17	2017	0	0	0	578	0	578	0	0	0	252	0	252
18	2018	0	0	0	578	0	578	0	0	0	240	0	240
19	2019	0	0	0	578	0	578	0	0	0	229	0	229
20	2020	0	0	0	578	0	578	0	0	0	218	0	218
21	2021	0	0	0	578	0	578	0	0	0	208	0	208
22	2022	0	0	0	578	0	578	0	0	0	198	0	198
23	2023	0	0	0	578	0	578	0	0	0	188	0	188
24	2024	0	0	0	578	0	578	0	0	0	179	0	179
25	2025	0	403	403	578	0	981	0	119	119	171	0	290
26	2026	0	403	403	578	0	981	0	113	113	163	0	276
27	2027	0	403	403	578	0	981	0	108	108	155	0	263
28	2028	0	0	0	578	0	578	0	0	0	147	0	147
29	2029	0	0	0	578	0	578	0	0	0	140	0	140
30	2030	0	0	0	578	0	578	0	0	0	134	0	134
31	2031	0	403	403	578	0	981	0	89	89	127	0	216
32	2032	0	403	403	578	0	981	0	85	85	121	0	206
33	2033	0	403	403	578	0	981	0	81	81	116	0	196
34	2034	0	0	0	578	0	578	0	0	0	110	0	110
35	2035	0	0	0	578	0	578	0	0	0	105	0	105
36	2036	0	0	0	578	0	578	0	0	0	100	0	100
37	2037	0	0	0	578	0	578	0	0	0	95	0	95
38	2038	0	0	0	578	0	578	0	0	0	91	0	91
39	2039	0	0	0	578	0	578	0	0	0	86	0	86
40	2040	0	0	0	578	0	578	0	0	0	82	0	82
41	2041	0	0	0	578	0	578	0	0	0	78	0	78
42	2042	0	0	0	578	0	578	0	0	0	74	0	74
43	2043	0	0	0	578	0	578	0	0	0	71	0	71
44	2044	0	0	0	578	0	578	0	0	0	68	0	68
45	2045	0	403	403	578	0	981	0	45	45	64	0	109
46	2046	0	403	403	578	0	981	0	43	43	61	0	104
47	2047	0	403	403	578	0	981	0	41	41	58	0	99
48	2048	0	0	0	578	0	578	0	0	0	56	0	56
49	2049	0	0	0	578	0	578	0	0	0	53	0	53
50	2050	0	0	0	578	0	578	0	0	0	50	0	50
Total		21,773	6,048	27,821	22,259	2,640	52,720	14,197	2,300	16,497	5,670	1,896	24,064

Table 4.3.14 Present Value Estimation by Treatment Process (3/5)

Treatment Process	**Aerated Lagoon**					Land compensation cost
Wastewater Flow	72,000	m3/day	Required land	27	ha	30 1000US$/ha
Construction cost	25,848	1000US$	House compensatio	54	houses	5 1000US$/house
O & M cost	1,367	1000US$/year	0.8 =k_{civil}	0.2	=$k_{mec/ele}$	
Discount Rate	5	%	Depreciation period	(civil)	50years	(mec/ele) 20years

No.	Year	Cost			(Unit : 1000US$)			Present Value			(Unit : 1000US$)		
		Costruction			O & M	Land	total	Costruction			O & M	Land	total
		Civil	Mec/Ele	sub-total		Compensation		Civil	Mec/Ele	sub-total		Compensation	
1	2001	0	0	0	0	0	0	0	0	0	0	0	0
2	2002	0	0	0	0	0	0	0	0	0	0	0	0
3	2003	0	0	0	0	0	0	0	0	0	0	0	0
4	2004	0	0	0	0	810	810	0	0	0	0	666	666
5	2005	3,446	862	4,308	0	0	4,308	2,700	675	3,375	0	0	3,375
6	2006	3,446	862	4,308	0	0	4,308	2,572	643	3,215	0	0	3,215
7	2007	3,446	862	4,308	0	0	4,308	2,449	612	3,062	0	0	3,062
8	2008	0	0	0	171	0	171	0	0	0	116	0	116
9	2009	0	0	0	342	0	342	0	0	0	220	0	220
10	2010	0	0	0	512	810	1,322	0	0	0	315	497	812
11	2011	3,446	862	4,308	683	0	4,991	2,015	504	2,519	399	0	2,918
12	2012	3,446	862	4,308	683	0	4,991	1,919	480	2,399	380	0	2,779
13	2013	3,446	862	4,308	683	0	4,991	1,828	457	2,285	362	0	2,647
14	2014	0	0	0	854	0	854	0	0	0	431	0	431
15	2015	0	0	0	1,025	0	1,025	0	0	0	493	0	493
16	2016	0	0	0	1,196	0	1,196	0	0	0	548	0	548
17	2017	0	0	0	1,367	0	1,367	0	0	0	596	0	596
18	2018	0	0	0	1,367	0	1,367	0	0	0	568	0	568
19	2019	0	0	0	1,367	0	1,367	0	0	0	541	0	541
20	2020	0	0	0	1,367	0	1,367	0	0	0	515	0	515
21	2021	0	0	0	1,367	0	1,367	0	0	0	491	0	491
22	2022	0	0	0	1,367	0	1,367	0	0	0	467	0	467
23	2023	0	0	0	1,367	0	1,367	0	0	0	445	0	445
24	2024	0	0	0	1,367	0	1,367	0	0	0	424	0	424
25	2025	0	862	862	1,367	0	2,228	0	254	254	404	0	658
26	2026	0	862	862	1,367	0	2,228	0	242	242	384	0	627
27	2027	0	862	862	1,367	0	2,228	0	231	231	366	0	597
28	2028	0	0	0	1,367	0	1,367	0	0	0	349	0	349
29	2029	0	0	0	1,367	0	1,367	0	0	0	332	0	332
30	2030	0	0	0	1,367	0	1,367	0	0	0	316	0	316
31	2031	0	862	862	1,367	0	2,228	0	190	190	301	0	491
32	2032	0	862	862	1,367	0	2,228	0	181	181	287	0	468
33	2033	0	862	862	1,367	0	2,228	0	172	172	273	0	445
34	2034	0	0	0	1,367	0	1,367	0	0	0	260	0	260
35	2035	0	0	0	1,367	0	1,367	0	0	0	248	0	248
36	2036	0	0	0	1,367	0	1,367	0	0	0	236	0	236
37	2037	0	0	0	1,367	0	1,367	0	0	0	225	0	225
38	2038	0	0	0	1,367	0	1,367	0	0	0	214	0	214
39	2039	0	0	0	1,367	0	1,367	0	0	0	204	0	204
40	2040	0	0	0	1,367	0	1,367	0	0	0	194	0	194
41	2041	0	0	0	1,367	0	1,367	0	0	0	185	0	185
42	2042	0	0	0	1,367	0	1,367	0	0	0	176	0	176
43	2043	0	0	0	1,367	0	1,367	0	0	0	168	0	168
44	2044	0	0	0	1,367	0	1,367	0	0	0	160	0	160
45	2045	0	862	862	1,367	0	2,228	0	96	96	152	0	248
46	2046	0	862	862	1,367	0	2,228	0	91	91	145	0	236
47	2047	0	862	862	1,367	0	2,228	0	87	87	138	0	225
48	2048	0	0	0	1,367	0	1,367	0	0	0	131	0	131
49	2049	0	0	0	1,367	0	1,367	0	0	0	125	0	125
50	2050	0	0	0	1,367	0	1,367	0	0	0	119	0	119
Total		20,678	12,924	33,602	52,613	1,620	87,835	13,483	4,915	18,399	13,402	1,164	32,965

Table4.3.14 Present Value Estimation by Treatment Process (4/5)

Treatment Process	**Oxidation Ditch**					Land compensation cost
Wastewater Flow	72,000	m3/day	Required land	17	ha	30 1000US$/ha
Construction cost	34,416	1000US$	House compensatio	34	houses	5 1000US$/house
O & M cost	1,787	1000US$/year	0.7 =k_{civil}	0.3	=$k_{mec/ele}$	
Discount Rate	5	%	Depreciation period	(civil)	50years	(mec/ele) 20years

No.	Year	Cost			(Unit : 1000US$)			Present Value			(Unit : 1000US$)		
		Costruction			O & M	Land Compensation	total	Costruction			O & M	Land Compensation	total
		Civil	Mec/Ele	sub-total				Civil	Mec/Ele	sub-total			
1	2001	0	0	0	0	0	0	0	0	0	0	0	0
2	2002	0	0	0	0	0	0	0	0	0	0	0	0
3	2003	0	0	0	0	0	0	0	0	0	0	0	0
4	2004	0	0	0	0	510	510	0	0	0	0	420	420
5	2005	4,015	1,721	5,736	0	0	5,736	3,146	1,348	4,494	0	0	4,494
6	2006	4,015	1,721	5,736	0	0	5,736	2,996	1,284	4,280	0	0	4,280
7	2007	4,015	1,721	5,736	0	0	5,736	2,854	1,223	4,076	0	0	4,076
8	2008	0	0	0	223	0	223	0	0	0	151	0	151
9	2009	0	0	0	447	0	447	0	0	0	288	0	288
10	2010	0	0	0	670	510	1,180	0	0	0	411	313	725
11	2011	4,015	1,721	5,736	894	0	6,630	2,348	1,006	3,354	522	0	3,876
12	2012	4,015	1,721	5,736	894	0	6,630	2,236	958	3,194	498	0	3,692
13	2013	4,015	1,721	5,736	894	0	6,630	2,129	913	3,042	474	0	3,516
14	2014	0	0	0	1,117	0	1,117	0	0	0	564	0	564
15	2015	0	0	0	1,340	0	1,340	0	0	0	645	0	645
16	2016	0	0	0	1,564	0	1,564	0	0	0	716	0	716
17	2017	0	0	0	1,787	0	1,787	0	0	0	780	0	780
18	2018	0	0	0	1,787	0	1,787	0	0	0	743	0	743
19	2019	0	0	0	1,787	0	1,787	0	0	0	707	0	707
20	2020	0	0	0	1,787	0	1,787	0	0	0	674	0	674
21	2021	0	0	0	1,787	0	1,787	0	0	0	641	0	641
22	2022	0	0	0	1,787	0	1,787	0	0	0	611	0	611
23	2023	0	0	0	1,787	0	1,787	0	0	0	582	0	582
24	2024	0	0	0	1,787	0	1,787	0	0	0	554	0	554
25	2025	0	1,721	1,721	1,787	0	3,508	0	508	508	528	0	1,036
26	2026	0	1,721	1,721	1,787	0	3,508	0	484	484	503	0	987
27	2027	0	1,721	1,721	1,787	0	3,508	0	461	461	479	0	940
28	2028	0	0	0	1,787	0	1,787	0	0	0	456	0	456
29	2029	0	0	0	1,787	0	1,787	0	0	0	434	0	434
30	2030	0	0	0	1,787	0	1,787	0	0	0	413	0	413
31	2031	0	1,721	1,721	1,787	0	3,508	0	379	379	394	0	773
32	2032	0	1,721	1,721	1,787	0	3,508	0	361	361	375	0	736
33	2033	0	1,721	1,721	1,787	0	3,508	0	344	344	357	0	701
34	2034	0	0	0	1,787	0	1,787	0	0	0	340	0	340
35	2035	0	0	0	1,787	0	1,787	0	0	0	324	0	324
36	2036	0	0	0	1,787	0	1,787	0	0	0	309	0	309
37	2037	0	0	0	1,787	0	1,787	0	0	0	294	0	294
38	2038	0	0	0	1,787	0	1,787	0	0	0	280	0	280
39	2039	0	0	0	1,787	0	1,787	0	0	0	267	0	267
40	2040	0	0	0	1,787	0	1,787	0	0	0	254	0	254
41	2041	0	0	0	1,787	0	1,787	0	0	0	242	0	242
42	2042	0	0	0	1,787	0	1,787	0	0	0	230	0	230
43	2043	0	0	0	1,787	0	1,787	0	0	0	219	0	219
44	2044	0	0	0	1,787	0	1,787	0	0	0	209	0	209
45	2045	0	1,721	1,721	1,787	0	3,508	0	192	192	199	0	390
46	2046	0	1,721	1,721	1,787	0	3,508	0	182	182	189	0	372
47	2047	0	1,721	1,721	1,787	0	3,508	0	174	174	180	0	354
48	2048	0	0	0	1,787	0	1,787	0	0	0	172	0	172
49	2049	0	0	0	1,787	0	1,787	0	0	0	164	0	164
50	2050	0	0	0	1,787	0	1,787	0	0	0	156	0	156
Total		24,091	25,812	49,903	68,801	1,020	119,724	15,709	9,817	25,526	17,526	733	43,784

Table 4.3.14 Present Value Estimation by Treatment Process (5/5)

Treatment Process	**Conventional Activated Sludge Process**				Land compensation cost
Wastewater Flow	72,000 m3/day	Required land	12 ha		30 1000US$/ha
Construction cost	43,056 1000US$	House compensatio	24 houses		5 1000US$/house
O & M cost	2,234 1000US$/year	0.6 =k_{civil}	0.4 =$k_{mec/ele}$		
Discount Rate	5 %	Depreciation period	(civil) 50years		(mec/ele) 20years

No.	Year	Cost Costruction Civil	Mec/Ele	sub-total	O & M (Unit : 1000US$)	Land Compensation	total	Present Value Costruction Civil	Mec/Ele	sub-total	O & M (Unit : 1000US$)	Land Compensation	total
1	2001	0	0	0	0	0	0	0	0	0	0	0	0
2	2002	0	0	0	0	0	0	0	0	0	0	0	0
3	2003	0	0	0	0	0	0	0	0	0	0	0	0
4	2004	0	0	0	0	360	360	0	0	0	0	296	296
5	2005	4,306	2,870	7,176	0	0	7,176	3,374	2,249	5,623	0	0	5,623
6	2006	4,306	2,870	7,176	0	0	7,176	3,213	2,142	5,355	0	0	5,355
7	2007	4,306	2,870	7,176	0	0	7,176	3,060	2,040	5,100	0	0	5,100
8	2008	0	0	0	279	0	279	0	0	0	189	0	189
9	2009	0	0	0	558	0	558	0	0	0	360	0	360
10	2010	0	0	0	838	360	1,198	0	0	0	514	221	735
11	2011	4,306	2,870	7,176	1,117	0	8,293	2,517	1,678	4,196	653	0	4,849
12	2012	4,306	2,870	7,176	1,117	0	8,293	2,398	1,598	3,996	622	0	4,618
13	2013	4,306	2,870	7,176	1,117	0	8,293	2,283	1,522	3,806	592	0	4,398
14	2014	0	0	0	1,396	0	1,396	0	0	0	705	0	705
15	2015	0	0	0	1,675	0	1,675	0	0	0	806	0	806
16	2016	0	0	0	1,955	0	1,955	0	0	0	895	0	895
17	2017	0	0	0	2,234	0	2,234	0	0	0	975	0	975
18	2018	0	0	0	2,234	0	2,234	0	0	0	928	0	928
19	2019	0	0	0	2,234	0	2,234	0	0	0	884	0	884
20	2020	0	0	0	2,234	0	2,234	0	0	0	842	0	842
21	2021	0	0	0	2,234	0	2,234	0	0	0	802	0	802
22	2022	0	0	0	2,234	0	2,234	0	0	0	764	0	764
23	2023	0	0	0	2,234	0	2,234	0	0	0	727	0	727
24	2024	0	0	0	2,234	0	2,234	0	0	0	693	0	693
25	2025	0	2,870	2,870	2,234	0	5,104	0	848	848	660	0	1,507
26	2026	0	2,870	2,870	2,234	0	5,104	0	807	807	628	0	1,436
27	2027	0	2,870	2,870	2,234	0	5,104	0	769	769	598	0	1,367
28	2028	0	0	0	2,234	0	2,234	0	0	0	570	0	570
29	2029	0	0	0	2,234	0	2,234	0	0	0	543	0	543
30	2030	0	0	0	2,234	0	2,234	0	0	0	517	0	517
31	2031	0	2,870	2,870	2,234	0	5,104	0	633	633	492	0	1,125
32	2032	0	2,870	2,870	2,234	0	5,104	0	602	602	469	0	1,071
33	2033	0	2,870	2,870	2,234	0	5,104	0	574	574	446	0	1,020
34	2034	0	0	0	2,234	0	2,234	0	0	0	425	0	425
35	2035	0	0	0	2,234	0	2,234	0	0	0	405	0	405
36	2036	0	0	0	2,234	0	2,234	0	0	0	386	0	386
37	2037	0	0	0	2,234	0	2,234	0	0	0	367	0	367
38	2038	0	0	0	2,234	0	2,234	0	0	0	350	0	350
39	2039	0	0	0	2,234	0	2,234	0	0	0	333	0	333
40	2040	0	0	0	2,234	0	2,234	0	0	0	317	0	317
41	2041	0	0	0	2,234	0	2,234	0	0	0	302	0	302
42	2042	0	0	0	2,234	0	2,234	0	0	0	288	0	288
43	2043	0	0	0	2,234	0	2,234	0	0	0	274	0	274
44	2044	0	0	0	2,234	0	2,234	0	0	0	261	0	261
45	2045	0	2,870	2,870	2,234	0	5,104	0	319	319	249	0	568
46	2046	0	2,870	2,870	2,234	0	5,104	0	304	304	237	0	541
47	2047	0	2,870	2,870	2,234	0	5,104	0	290	290	226	0	515
48	2048	0	0	0	2,234	0	2,234	0	0	0	215	0	215
49	2049	0	0	0	2,234	0	2,234	0	0	0	205	0	205
50	2050	0	0	0	2,234	0	2,234	0	0	0	195	0	195
Total		25,834	43,056	68,890	86,001	720	155,611	16,845	16,376	33,220	21,908	517	55,645

Table 4.3.15 Summary of Present Value Estimation by Treatment Process

Process	Net Present Value Unit 1,000 US$		Net Present Value Ratio AL=1	
	Discount Rate		Discount Rate	
	5%	8%	5%	8%
Wastewater Stabilization Pond	30,102	22,015	0.913	1.009
Modified Stabilization Pond	24,064	17,254	0.730	0.791
Aerated Lagoon	32,965	21,820	1.000	1.000
Oxidation Ditch	43,784	28,638	1.328	1.312
Conventional Activated Sludge	55,645	36,023	1.688	1.651

Table4.4.1 Water Supply Data for Kien An (according to Water Supply Plan)

			1999	2005	2010	2015	2020
Kien An	- Population	nos.	73,001	82,593	90,431	98,268	106,107
	- Population served with h.c.	nos.	25,748	40,900	63,600	76,400	89,000
	- Service coverage (house conn.)	%	35	50	70	78	84
	- Unit consumption	lpcd	94	110	120	130	130
	- Total Domestic consumption	m3/d	2,410	4,500	7,630	9,930	11,570
	- Industrial consumption	m3/d	140	270	458	596	694
	- Commercial consumption	m3/d	59	113	153	199	231
	- Institutional consumption	m3/d	1,071	1,190	1,370	1,580	1,820

Table 4.4.2 Sewerage Service Ratio of Kien An by Phuong and Phase

Administrative division	Area (km2)	Kien An Treatment Area						Others
		Phase I		Phase II		Phase II		
		Separate		Separate		Simplified		
	1999	2010	2020	2010	2020	2010	2020	
Kien An district	**26.70**							
Quan Tru Ward	4.25	100	100					
Dong Hoa Ward	3.61							100
Bac Son Ward	2.05	100	100					
Nam Son Ward	3.37						80	
Ngoc Son Ward	2.48				100			
Tran Thanh Ngo Ward	1.54	100	100					
Van Dau Ward	3.30				100			
Phu Lien Ward	2.89						80	
Trang Minh Ward	3.21						80	

Generation rate of Sewage

Area		Domestic				Commercial			
		2005	2010	2015	2020	2005	2010	2015	2020
Kien An	%	80	100	100	100	80	100	100	100

Area		Institutional				Industrial			
		2005	2010	2015	2020	2005	2010	2015	2020
Kien An	%	80	100	100	100	80	80	80	80

Table 4.4.3 Estimated Generation of Sewage in Kien An

Administration division				Domestic				Commercial				Institutional				Industrial				Total		Rg(%)=	10
				2005	2010	2015	2020	2005	2010	2015	2020	2005	2010	2015	2020	2005	2010	2015	2020	2005	2010	2015	2020
Kien An		C	m3/d	4,500	7,630	9,930	11,570	113	153	199	231	1,190	1,370	1,580	1,820	270	458	596	694	6,073	9,610	12,304	14,316
Se	Quan Tru Ward	C	m3/d	716	1,215	1,581	1,842	18	24	32	37	189	218	251	290	43	73	95	111	967	1,530	1,959	2,279
		Rss	%	50	100	100	100	50	100	100	100	50	100	100	100	50	100	100	100				
		Rg	%	80	100	100	100	80	100	100	100	80	100	100	100	80	80	80	80				
		S	m3/d	287	1,215	1,581	1,842	7	24	32	37	76	218	251	290	17	58	76	88	425	1,667	2,134	2,482
O	Dong Hoa Ward	C	m3/d	608	1,032	1,343	1,564	15	21	27	31	161	185	214	246	37	62	81	94	821	1,299	1,664	1,936
		Rss	%																				
		Rg	%																				
		S	m3/d	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	0	0
Se	Bac Son Ward	C	m3/d	346	586	762	888	9	12	15	18	91	105	121	140	21	35	46	53	466	738	945	1,099
		Rss	%	50	100	100	100	50	100	100	100	50	100	100	100	50	100	100	100				
		Rg	%	80	100	100	100	80	100	100	100	80	100	100	100	80	80	80	80				
		S	m3/d	138	586	762	888	3	12	15	18	37	105	121	140	8	28	37	43	205	804	1,029	1,197
Si	Nam Son Ward	C	m3/d	568	963	1,253	1,460	14	19	25	29	150	173	199	230	34	58	75	88	766	1,213	1,553	1,807
		Rss	%	0	0	40	80	0	0	40	80	0	0	40	80	0	0	40	80				
		Rg	%	80	100	100	100	80	100	100	100	80	100	100	100	80	80	80	80				
		S	m3/d	-	-	501	1,168	-	-	10	23	-	-	80	184	-	-	24	56	0	0	677	1,575
Se	Ngoc Son Ward	C	m3/d	418	709	922	1,075	10	14	18	21	111	127	147	169	25	43	55	64	564	893	1,143	1,330
		Rss	%	0	0	50	100	0	0	50	100	0	0	50	100	0	0	50	100				
		Rg	%	80	100	100	100	80	100	100	100	80	100	100	100	80	80	80	80				
		S	m3/d	-	-	461	1,075	-	-	9	21	-	-	73	169	-	-	22	52	0	0	622	1,448
Se	Tran Thanh Ngo Ward	C	m3/d	260	440	573	667	6	9	11	13	69	79	91	105	16	26	34	40	350	554	710	826
		Rss	%	50	100	100	100	50	100	100	100	50	100	100	100	50	100	100	100				
		Rg	%	80	100	100	100	80	100	100	100	80	100	100	100	80	80	80	80				
		S	m3/d	104	440	573	667	3	9	11	13	27	79	91	105	6	21	27	32	154	604	773	899
Se	Van Dau Ward	C	m3/d	556	943	1,227	1,430	14	19	25	29	147	169	195	225	33	57	74	86	751	1,188	1,521	1,769
		Rss	%	0	0	50	100	0	0	50	100	0	0	50	100	0	0	50	100				
		Rg	%	80	100	100	100	80	100	100	100	80	100	100	100	80	80	80	80				
		S	m3/d	-	-	614	1,430	-	-	12	29	-	-	98	225	-	-	29	69	0	0	828	1,927
Si	Phu Lien Ward	C	m3/d	487	826	1,075	1,252	12	17	21	25	129	148	171	197	29	50	64	75	657	1,040	1,332	1,550
		Rss	%	0	0	40	80	0	0	40	80	0	0	40	80	0	0	40	80				
		Rg	%	80	100	100	100	80	100	100	100	80	100	100	100	80	80	80	80				
		S	m3/d	-	-	430	1,002	-	-	9	20	-	-	68	158	-	-	21	48	0	0	580	1,350
Si	Trang Minh Ward	C	m3/d	541	917	1,194	1,391	14	18	24	28	143	165	190	219	32	55	72	83	730	1,155	1,479	1,721
		Rss	%	0	0	40	80	0	0	40	80	0	0	40	80	0	0	40	80				
		Rg	%	80	100	100	100	80	100	100	100	80	100	100	100	80	80	80	80				
		S	m3/d	-	-	478	1,113	-	-	10	22	-	-	76	175	-	-	23	53	0	0	645	1,500
Separate system			m3/d																	785	3,075	5,387	7,955
Simplified system			m3/d																	0	0	1,902	4,425
Total			m3/d																	785	3,075	7,288	12,380

Table 4.4.4 Summary of Sewage Generation (Kien An district)

Area	Unit	Kien An Treatment Area															
		Phase I (Separate system)				Phase II (Separate system)				Total				Phase II (Simplified system)			
		2005	2010	2015	2020	2005	2010	2015	2020	2005	2010	2015	2020	2005	2010	2015	2020
Quan Tru Ward	m3/d	425	1,667	2,134	2,482					425	1,667	2,134	2,482				
Dong Hoa Ward	m3/d									-	-	-	-				
Bac Son Ward	m3/d	205	804	1,029	1,197					205	804	1,029	1,197				
Nam Son Ward	m3/d									-	-	-	-	-	-	677	1,575
Ngoc Son Ward	m3/d					-	-	622	1,448	-	-	622	1,448				
Tran Thanh Ngo Ward	m3/d	154	604	773	899					154	604	773	899				
Van Dau Ward	m3/d					-	-	828	1,927	-	-	828	1,927				
Phu Lien Ward	m3/d									-	-	-	-	-	-	580	1,350
Trang Minh Ward	m3/d									-	-	-	-	-	-	645	1,500
Total (each system)	m3/d	785	3,075	3,936	4,579	0	0	1,451	3,376	785	3,075	5,387	7,955	0	0	1,902	4,425
Total	m3/d													785	3,075	7,288	12,380

Table 4.4.5 Kien An Sewerage Facilities List

Kien An Center Sewage Treatment Area				unit	quantity	remarks
	Phase I	Separate sewer system	sewer(average dia 500mm)	m	78,400	100 m/ha
			conveyance(average dia 1000mm)	m	2,352	3% of total sewer length, including open cut, jacking method
			sub pumping station	nos.	4	4 nos/1000ha, about 3m3/s
			main pumping station	nos.	1	1 nos/1000ha, about 10m3/s
			WWTP	nos.	0.50	3,075m3/day(planning capacity 7,955m3/day)
	Phase II	Separate sewer system	sewer(average dia 500mm)	m	57,800	100 m/ha
			conveyance(average dia 1000mm)	m	1,734	3% of total sewer length, including open cut, jacking method
			sub pumping station	nos.	3	4 nos/1000ha, about 3m3/s
			main pumping station	nos.	1	1 nos/1000ha, about 10m3/s
			WWTP	nos.	0.50	3,376m3/day(planning capacity 7,955m3/day)
	Total		sewer(average dia 500mm)	m	136,200	100 m/ha
			conveyance(average dia 1000mm)	m	4,086	
			sub pumping station	nos.	7	about 3m3/s
			main pumping station	nos.	2	about 10m3/s
			WWTP	nos.	1.00	planning capacity 7,955m3/day
Nam Son Simplified sewage treatment area						
	Phase II	Simplified sewer system	sewer(average dia 150mm)	m	8,425	25 m/ha
			pumping station	nos.	2	1 nos/200ha, about 1m3/s
			Sewage Treatment Facilities	nos.	1	planning capacity 1,575m3/day
Phu Lien Simplified sewage treatment area						
	Phase II	Simplified sewer system	sewer(average dia 150mm)	m	7,225	25 m/ha
			pumping station	nos.	2	1 nos/200ha, about 1m3/s
			Sewage Treatment Facilities	nos.	1	planning capacity 1,350m3/day
Trang Minh Simplified sewage treatment area						
	Phase II	Simplified sewer system	sewer(average dia 150mm)	m	8,025	25 m/ha
			pumping station	nos.	2	1 nos/200ha, about 1m3/s
			Sewage Treatment Facilities	nos.	1	planning capacity 1,500m3/day
Simplified sewage treatment area total						
			sewer(average dia 150mm)	m	23,675	
			pumping station	nos.	6	about 1m3/s
			Sewage Treatment Facilities	nos.	3	planning total capacity 4,425m3/day

Table 4.4.6 Kien An Sewerage Facilities Cost

			unit	quantity	civil works			mec/ele			Remarks	
					unit cost		cost	unit cost		cost		
Kien An sewer system area												
Phase I	Separate sewer system	sewer(average dia 500mm)	m	78,400	0.08	1000USD/m	6,272					
		conveyance(average dia 1000mm)	m	1,568	0.31	1000USD/m	486					
		conveyance(jacking method)	m	784	1.35	1000USD/m	1,058					
		sub pumping station	nos.	4	149	1000USD	596				3 m3/min	
		main pumping station	nos.	1	961	1000USD	961	1,361	1000USD	1,361	10 m3/min	
		Wastewater Treatment Plant	nos.	0.50	0.661	1000USD	2,629	0.441	1000USD	1,754	7,955 m3/day	
		sub total					**12,003**			**3,115**		
Phase II	Separate sewer system	sewer(average dia 500mm)	m	57,800	0.08	1000USD/m	4,624					
		conveyance(average dia 1000mm)	m	1,156	0.31	1000USD/m	358					
		conveyance(jacking method)	m	578	1.35	1000USD/m	780					
		sub pumping station	nos.	3	149	1000USD	447				3 m3/min	
		main pumping station	nos.	1	961	1000USD	961	1,361	1000USD	1,361	10 m3/min	
		Wastewater Treatment Plant	nos.	0.50	0.661	1000USD	2,629	0.441	1000USD	1,754	7,955 m3/day	
		sub total					**9,800**			**3,115**		
Total		sewer(average dia 500mm)	m	136,200			10,896			0		
		conveyance(average dia 1000mm)	m	2,724			844			0		
		conveyance(jacking method)	m	1,362			1,839			0		
		sub pumping station	nos.	7			1,043			0	3 m3/min	
		main pumping station	nos.	2			1,923			2,722	10 m3/min	
		Wastewater Treatment Plant	nos.	1.00			5,258			3,508	7,955 m3/day	
		total					**21,804**			**6,230**		
Nam Son Simplified sewer system area												
Phase II	Simplified sewer system	sewer(average dia 150mm)	m	8,425	0.08	1000USD/m	674					
		sub pumping station	nos.	2	77	1000USD	155				1 m3/min	
		Sewage Treatment Facilities	nos.	1.00	0.519	1000USD	817	0.346	1000USD	545	1,575 m3/day	
		sub total					**1,646**			**545**		
Phu Lien Simplified sewer sytem area												
Phase II	Simplified sewer system	sewer(average dia 150mm)	m	7,225	0.08	1000USD/m	578					
		sub pumping station	nos.	2	77	1000USD	155				1 m3/min	
		Sewage Treatment Facilities	nos.	1	0.519	1000USD	701	0.346	1000USD	467	1,350 m3/day	
		sub total					**1,433**			**467**		
Trang Minh Simplified sewer system area												
Phase II	Simplified sewer system	sewer(average dia 150mm)	m	8,025	0.08	1000USD/m	642					
		sub pumping station	nos.	2	77	1000USD	155				1 m3/min	
		Sewage Treatment Facilities	nos.	1	0.519	1000USD	779	0.346	1000USD	519	1,500 m3/day	
		sub total					**1,575**			**519**		
Simplified sewer system area total												
		sewer(average dia 150mm)	m	23,675			1,894			0		
		pumping station	nos.	6			464			0	1 m3/min	
		Sewage Treatment Facilities	nos.	3			2,297			1,531	4,425 m3/day	
		sub total					**4,654**			**1,531**		
Kien An Total		sewer(average dia 500mm)	m	159,875			12,790			0		
		conveyance(average dia 1000mm)	m	2,724			844			0		
		conveyance(jacking method)	m	1,362			1,839			0		
		sub pumping station	nos.	13			1,507			0		
		main pumping station	nos.	2			1,923			2,722		
		West WWTP	nos.	4			7,555			5,039		
		sub total					**26,458**			**7,761**		
Grand total										**34,219**		
Phase I	Separate sewer system	pipeline					9,374			1,361	10,735	
		WWTP					2,629			1,754	4,383	15,118
Phase II	Separate sewer system	pipeline					7,171			1,361	8,532	
		WWTP					2,629			1,754	4,383	12,915
	Simplified sewer system	pipeline					2,358				2,358	
		WWTP					2,297			1,531	3,828	6,185

Note: Constant Price of June 2000
Excludes engineering services, administrative costs and physical contingency

Table 4.4.7 Land Acquisition and Compensation for Kien An

Land acquisition for WWTP

Name	wastewater flow 2010	wastewater flow 2020	Treatment Method *tentative*	Unit land	Land acquisition and conpensation: Land loss Agricaltual	Land loss Residential	House loss	Phase I: Land loss Agricaltual	Land loss Residential	House loss	Phase II: Land loss Agricaltual	Land loss Residential	House loss
	m3/day	m3/day		m2/m3/day	ha	ha	nos.	ha	ha	nos.	ha	ha	nos.
Central WWTP	3,075	7,955	Stabilization Pond	15	11.9	0	0	11.9	0	0			
Nam Son STP	-	1,575	Anaerobic Aerobic Biofilter	2	0.3	0	0				0.3	0	0
Phu Lien STP	-	1,350	Anaerobic Aerobic Biofilter	2	0.3	0	0				0.3	0	0
Trang Minh STP	-	1,500	Anaerobic Aerobic Biofilter	2	0.3	0	0				0.3	0	0
sub-total					**12.8**	**0**	**0**	**11.9**	**0**	**0**	**0.9**	**0**	**0**

Land Acquisition for Pumping Station

Name	Pumping Station unit	Pumping Station quantity	Capacity	Unit land	Land acquisition and conpensation: Land loss Agricaltual	Land loss Residential	House loss	Phase I: Land loss Agricaltual	Land loss Residential	House loss	Phase II: Land loss Agricaltual	Land loss Residential	House loss
				m2/nos.	ha	ha	nos.	ha	ha	nos.	ha	ha	nos.
Central Wastewater Treatment Area													
sub pumping station	nos.	7	approx. 3m3/s	100		0.07	7		0.04	4		0.03	3
main pumping station	nos.	2	approx. 10m3/s	500		0.10	10		0.05	5		0.05	5
Simplified Wastewater Treatment Area													
pumping station	nos.	6	approx. 1m3/s	20		0.01	6					0.01	6
sub-total						**0.18**	**23**		**0.09**	**9**		**0.09**	**14**

Compensation	m US$	PhI	PhII
Agricultural	0.384	0.357	0.027
Residential	0.05096	0.0252	0.02576
House loss	0.115	0.045	0.07
Total	0.54996	0.4272	0.12276
Factored Total	0.82494	0.6408	0.18414

Total Land Acquisation

	Land acquisition and conpensation: Land loss Agricaltual	Land loss Residential	House loss	Phase I: Land loss Agricaltual	Land loss Residential	House loss	Phase II: Land loss Agricaltual	Land loss Residential	House loss
	ha	ha	nos.	ha	ha	nos.	ha	ha	nos.
for WWTP	12.8	0.0	0	11.9	0.0	0	0.9	0.0	0
for P/S	0.0	0.2	23	0.0	0.1	9	0.0	0.1	14
sub-total	**12.8**	**0.2**	**23**	**12**	**0**	**9**	**1**	**0**	**14**

Note: Constant Price of June 2000
Excludes engineering services, administrative costs and physical contingency

Table 4.4.8 Water Supply Data of Do Son (according to Water Supply Plan)

			1999	2005	2010	2015	2020
Do Son	- Population	nos.	30,560	33,580	36,262	38,944	41,626
	- Population served with h.c.	nos.	11,307	16,790	29,010	33,102	37,463
	- Service coverage (house conn.)	%	37	50	80	85	90
	- Unit consumption	lpcd	61	100	110	120	130
	- Total Domestic consumption	m3/d	691	1,679	3,191	3,972	4,870
	- Industrial consumption	m3/d	108	140	160	180	200
	- Commercial consumption	m3/d	525	700	750	800	850
	- Institutional consumption	m3/d	439	350	400	450	500

Table 4.4.9 Sewerage Service Ratio in Do Son by Phuong and Phase

Administrative division	Area (km2)	Do Son Center Phase I Simplified		Van Huong Phase II Simplified		Others
	1999	2010	2020	2010	2020	
Do Son Town	**39.50**					
Ngoc Xuyen Ward	9.65					100
Ngoc Hai Ward	5.91	80	90			
Van Huong Ward	8.10				80	
Van Son Ward	5.48	80	90			
Bang La Commune	10.36					100

Generation rate of Sewage (Rg)

Area	Unit	Domestic				Commercial			
		2005	2010	2015	2020	2005	2010	2015	2020
Do Son	%	80	100	100	100	80	100	100	100

Area	Unit	Institutional				Industrial			
		2005	2010	2015	2020	2005	2010	2015	2020
Do Son	%	80	100	100	100	80	80	80	80

Table 4.4.10 Estimated Generation of Sewage in Do Son

Administration division			Domestic				Commercial				Institutional				Industrial				Total		Ri(%)=	10
			2005	2010	2015	2020	2005	2010	2015	2020	2005	2010	2015	2020	2005	2010	2015	2020	2005	2010	2015	2020
Do Son	C	m3/d	1,679	3,191	3,972	4,870	700	750	800	850	350	400	450	500	140	160	180	200	2,869	4,501	5,402	6,420
Ngoc Xuyen Ward	C	m3/d	410	780	970	1,190	171	183	195	208	86	98	110	122	34	39	44	49	701	1,100	1,320	1,568
	Rss	%																				
	Rg	%																				
	S	m3/d	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	0	0
Ngoc Hai Ward	C	m3/d	251	477	594	729	105	112	120	127	52	60	67	75	21	24	27	30	429	673	808	961
	Rss	%	40	80	85	90	40	80	85	90	40	80	85	90	40	80	85	90				
	Rg	%	80	100	100	100	80	100	100	100	80	100	100	100	80	80	80	80				
	S	m3/d	80	382	505	656	34	90	102	114	17	48	57	67	7	15	18	22	151	588	751	945
Van Huong Ward	C	m3/d	344	654	815	999	144	154	164	174	72	82	92	103	29	33	37	41	588	923	1,108	1,317
	Rss	%	0	0	40	80	0	0	40	80	0	0	40	80	0	0	40	80				
	Rg	%	80	100	100	100	80	100	100	100	80	100	100	100	80	80	80	80				
	S	m3/d	-	-	326	799	-	-	66	139	-	-	37	82	-	-	12	26	0	0	484	1,151
Van Son Ward	C	m3/d	233	443	551	676	97	104	111	118	49	55	62	69	19	22	25	28	398	624	749	891
	Rss	%	40	80	85	90	40	80	85	90	40	80	85	90	40	80	85	90				
	Rg	%	80	100	100	100	80	100	100	100	80	100	100	100	80	80	80	80				
	S	m3/d	75	354	468	608	31	83	94	106	16	44	53	62	6	14	17	20	140	546	696	876
Bang La Commune	C	m3/d	440	837	1,042	1,277	184	197	210	223	92	105	118	131	37	42	47	52	752	1,181	1,417	1,684
	Rss	%																				
	Rg	%																				
	S	m3/d	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	0	0
Total		m3/d																	291	1,134	1,931	2,973

Table 4.4.11 Summary of Sewage Generation (Do Son Town)

Area	Unit	Do Son Center Treatment Area				Van Huong Treatment Area							
		Phase I (Simplified system)				Phase II (Simplified system)				Total			
		2005	2010	2015	2020	2005	2010	2015	2020	2005	2010	2015	2020
Ngoc Xuyen Ward	m3/d									-	-	-	-
Ngoc Hai Ward	m3/d	151	588	751	945					151	588	751	945
Van Huong Ward	m3/d					-	-	484	1,151	-	-	484	1,151
Van Son Ward	m3/d	140	546	696	876					140	546	696	876
Bang La Commune	m3/d									-	-	-	-
Total	m3/d	291	1,134	1,447	1,821	0	0	484	1,151	291	1,134	1,931	2,973

Table 4.4.12 Do Son Sewerage Facilities List

Do Son Center Simplified sewage treatment area				unit	quantity	Remarks
	Phase I	Simplified sewer system	sewer(average dia 150mm)	m	28,500	25 m/ha
			pumping station	nos.	6	1 nos/200ha, about 1m3/s
			Sewage Treatment Facilities	nos.	1	planning capacity 1,825 m3/day
Van Huong Simplified sewage treatment area						
	Phase II	Simplified sewer system	sewer(average dia 150mm)	m	20,250	25 m/ha
			pumping station	nos.	5	1 nos/200ha, about 1m3/s
			Sewage Treatment Facilities	nos.	1	planning capacity 1,150 m3/day
Simplified sewage treatment area total						
			sewer(average dia 150mm)	m	48,750	25 m/ha
			pumping station	nos.	11	about 1m3/s
			Sewage Treatment Facilities	nos.	2	planning total capacity 2,975 m3/day

Table 4.4.13 Do Son Sewerage Facilities Cost

			unit	quantity	civil works			mec/ele			Remarks	
					unit cost		cost	unit cost		cost		
Do Son Town												
Do Son Center Simplified sewer system area												
Phase I	Simplified sewer system	sewer(average dia 150mm)	m	28,500	0.08	1000USD/m	2,280					
		pumping station	nos.	6	77	1000USD	464				1	m3/min
		Sewage Treatment Facilities	nos.	1	0.519	1000USD	945	0.346	1000USD	630	1,821	m3/day
		sub total					**3,689**			**630**		
Van Huong Simplified sewer system area												
Phase II	Simplified sewer system	sewer(average dia 150mm)	m	20,250	0.08	1000USD/m	1,620					
		pumping station	nos.	5	77	1000USD	386				1	m3/min
		Sewage Treatment Facilities	nos.	1	0.519	1000USD	597	0.346	1000USD	398	1,151	m3/day
		sub total					**2,604**			**398**		
Do Son Town Total		sewer(average dia 150mm)	m	48,750			3,900			0		
		pumping station	nos.	11			850			0		
		Sewage Treatment Facilities	nos.	2			1,542			1,028		
		sub total					**6,292**			**1,028**		
Grand total										**7,321**		
Phase I	Simplified sewer system	pipeline					2,744				2,744	
		WWTP					945			630	1,575	4,319
Phase II	Simplified sewer system	pipeline					2,006				2,006	
		WWTP					597			398	996	3,002

7,321

Note: Constant Price of June 2000

Excludes engineering services, administrative costs and physical contingency

Table 4.4.14 Land Acquisition and Compensation for Do Son

Land acquisition for WWTP

Name	wastewater flow		Treatment Method	Unit land	Land acquisition and conpensation			Phase I			Phase II		
	2010	2020	*tentative*		Land loss		House loss	Land loss		House loss	Land loss		House loss
					Agricaltual	Residential		Agricaltual	Residential		Agricaltual	Residential	
	m3/day	m3/day		m2/m3/day	ha	ha	nos.	ha	ha	nos.	ha	ha	nos.
Do Son Center SSTF	1,134	1,821	Anaerobic Aerobic Biofilter	2	0.4	0	0	0.4	0	0			
Van Huong SSTF	-	1,151	Anaerobic Aerobic Biofilter	2	0.2	0	0				0.2	0	0
sub-total					**0.6**	**0**	**0**	**0.4**	**0**	**0**	**0.2**	**0**	**0**

Land Acquisition for Pumping Station

Name	Pumping Station		Capacity	Unit land	Land acquisition and conpensation			Phase I			Phase II		
	unit	quantity			Land loss		House loss	Land loss		House loss	Land loss		House loss
					Agricaltual	Residential		Agricaltual	Residential		Agricaltual	Residential	
				m2/nos.	ha	ha	nos.	ha	ha	nos.	ha	ha	nos.
Simplified sewage treatment area													
pumping station	nos.	11	approx. 1m3/s	20		**0.02**	**11**		**0.01**	**6**		**0.01**	**5**
sub-total						**0.02**	**11**		**0.01**	**6**		**0.01**	**5**

Compensation	m US$	PhI	PhII
Agricultural	0.018	0.012	0.006
Residential	0.0056	0.0028	0.0028
House loss	0.055	0.03	0.025
Total	0.0786	0.0448	0.0338
Factored Total	0.1179	0.0672	0.0507

Total Land Acquisation

	Land acquisition and conpensation			Phase I			Phase II		
	Land loss		House loss	Land loss		House loss	Land loss		House loss
	Agricaltual	Residential		Agricaltual	Residential		Agricaltual	Residential	
	ha	ha	nos.	ha	ha	nos.	ha	ha	nos.
for WWTP	0.6	0.0	0	0.4	0.0	0	0.2	0.0	0
for P/S	0.0	0.0	11	0.0	0.0	6	0.0	0.0	5
sub-total	**0.6**	**0.0**	**11**	**0**	**0**	**6**	**0**	**0**	**5**

Note: Constant Price of June 2000
Excludes engineering services, administrative costs and physical contingency

Table 4.5.1 Project Cost by Sewer System and Area

Unit : 1000US$

Area	Phase I					Phase II					Total				
	Combined	Separate	Simplified	Septic tank	Sub-total	Combined	Separate	Simplified	Septic tank	Sub-total	Combined	Separate	Simplified	Septic tank	Total
1. Class A Area	50,095	0	0	0	50,095	30,797	70,930	0	8,623	110,351	80,892	70,930	0	8,623	160,446
2. Kien An district	0	15,118	0	0	15,118	0	12,915	6,185	293	19,394	0	28,033	6,185	293	34,512
3. Do Son Town	0	0	4,319	0	4,319	0	0	3,002	916	3,918	0	0	7,321	916	8,237
4. Quan Toan	0	0	0	0	0	0	0	0	350	350	0	0	0	350	350
5. Minh Duc	0	0	0	0	0	0	0	0	1,683	1,683	0	0	0	1,683	1,683
6. Dinh Vu	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7. New Development area	0	0	0	0	0	0	0	0	1,459	1,459	0	0	0	1,459	1,459
Total	50,095	15,118	4,319	0	69,532	30,797	83,846	9,187	13,325	137,155	80,892	98,964	13,506	13,325	206,686
Civil Works (pipeline, septic tank etc.)															
1. Class A Area	36,083				36,083	23,639	53,193		8,623	85,455	59,722	53,193	0	8,623	121,538
2. Kien An district		9,374			9,374		7,171	2,358	293	9,822	0	16,545	2,358	293	19,196
3. Do Son Town			2,744		2,744			2,006	916	2,923	0	0	4,750	916	5,666
4. Quan Toan					0				350	350	0	0	0	350	350
5. Minh Duc					0				1,683	1,683	0	0	0	1,683	1,683
6. Dinh Vu					0				0	0	0	0	0	0	0
7. New Development area					0				1,459	1,459	0	0	0	1,459	1,459
Sub-total	36,083	9,374	2,744	0	48,201	23,639	60,365	4,364	13,325	101,692	59,722	69,739	7,108	13,325	149,893
Mechanical & Electrical Works (pumping station)															
1. Class A Area	1,116				1,116	711	1,947			2,658					0
2. Kien An district		1,361			1,361		1,361			1,361					0
3. Do Son Town					0					0					0
4. Quan Toan					0					0					0
5. Minh Duc					0					0					0
6. Dinh Vu					0					0					0
7. New Development area					0					0					0
Sub-total	1,116	1,361	0	0	2,477	711	3,308	0	0	4,019	0	0	0	0	0
Civil Works (WWTP)															
1. Class A Area	7,733				7,733	3,866	9,476			13,342	11,599	9,476	0	0	21,075
2. Kien An district		2,629			2,629		2,629	2,297		4,926	0	5,258	2,297	0	7,555
3. Do Son Town			945		945			597		597	0	0	1,542	0	1,542
4. Quan Toan					0					0	0	0	0	0	0
5. Minh Duc					0					0	0	0	0	0	0
6. Dinh Vu					0					0	0	0	0	0	0
7. New Development area					0					0	0	0	0	0	0
Sub-total	7,733	2,629	945	0	11,307	3,866	12,105	2,894	0	18,865	11,599	14,734	3,839	0	30,172
Mecanical & Electrical Works (WWTP)															
1. Class A Area	5,162				5,162	2,581	6,314			8,896		6,314	0	0	6,314
2. Kien An district		1,754			1,754		1,754	1,531		3,285		3,508	1,531	0	5,039
3. Do Son Town			630		630			398		398		0	1,028	0	1,028
4. Quan Toan					0					0		0	0	0	0
5. Minh Duc					0					0		0	0	0	0
6. Dinh Vu					0					0		0	0	0	0
7. New Development area					0					0		0	0	0	0
Sub-total	5,162	1,754	630	0	7,547	2,581	8,068	1,929	0	12,579	0	9,823	2,559	0	12,382

Note: Constant Price of June 2000
Excludes engineering services, administrative costs and physical contingency

Table 4.5.2 Project Cost by Area

(Unit : 1000US$)

Item		Total (2000-2020)			Phase I (2000-2010)			Phase II (2010-2020)		
		Civil	Mecanical	sub-total	Civil	Mecanical	sub-total	Civil	Mecanical	sub-total
A. Construction Cost	sub-total 1	**180,065**	**26,622**	**206,686**	**59,508**	**10,024**	**69,532**	**120,557**	**16,598**	**137,155**
1. Class A Area		142,613	17,833	160,446	43,816	6,279	50,095	98,797	11,554	110,351
2. Kien An district		26,751	7,761	34,512	12,003	3,115	15,118	14,748	4,646	19,394
3. Do Son Town		7,209	1,028	8,237	3,689	630	4,319	3,520	398	3,918
4. Quan Toan		350	0	350	0	0	0	350	0	350
5. Minh Duc		1,683	0	1,683	0	0	0	1,683	0	1,683
6. Dinh Vu		0	0	0	0	0	0	0	0	0
7. New Development area		1,459	0	1,459	0	0	0	1,459	0	1,459
B. Land Acquisation and Compensation Cost	sub-total 2			**4,181**			**2,908**			**1,273**
1. Class A Area				3,238			2,200			1,038
2. Kien An district				825			641			184
3. Do Son Town				118			67			51
4. Quan Toan				0			0			0
5. Minh Duc				0			0			0
6. Dinh Vu				0			0			0
7. New Development area				0			0			0
	Grand total			210,868			72,440			138,428

Land acquisition and Compensation

for Agricaltual land	30	1000US$/ha
for Residential land	280	1000US$/ha
for House loss	5	1000US$/house

Note: Constant Price of June 2000
Excludes engineering services, administrative costs and physical contingency

Table4.5.3 Implementation Schedule for the Sewerage Improvement Projects

	Components	Area	Years																				
			2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
	Civil works	1. Urban center																					
	(pipeline, septic tank etc.	2. Kien An district																					
		3. Do Son Town																					
		4. Quan Toan																					
		5. Minh Duc																					
		6. Dinh Vu																					
		7. New Development area																					
	Mecanical/Electrical	1. Urban center																					
	(pumping station)	2. Kien An district																					
		3. Do Son Town																					
		4. Quan Toan																					
		5. Minh Duc																					
A. Construction		6. Dinh Vu																					
		7. New Development area																					
	Civil works	1. Urban center																					
	(WWTP)	2. Kien An district																					
		3. Do Son Town																					
		4. Quan Toan																					
		5. Minh Duc																					
		6. Dinh Vu																					
		7. New Development area																					
	Mecanical/Electrical	1. Urban center																					
	(WWTP)	2. Kien An district																					
		3. Do Son Town																					
		4. Quan Toan																					
		5. Minh Duc																					
		6. Dinh Vu																					
		7. New Development area																					
		1. Urban center																					
		2. Kien An district																					
		3. Do Son Town																					
B. Land Acquisation and Compensati		4. Quan Toan																					
		5. Minh Duc																					
		6. Dinh Vu																					
		7. New Development area																					

Table 4.5.4 Annual Disburcement of Construction and Operation & Maintenance Costs

Unit : 1000US$

Cost Component		Area	Phase I	Phase II	Years																					Total		
			2000-2010	2010-2020	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2000-2010	2010-2020	2000-2020
	Civil works	1. Class A Area	36,083	85,455	0	0	0	0	4,554	5,733	5,733	5,733	5,733	5,733	2,866	8,546	8,546	8,546	8,546	8,546	8,546	8,546	8,546	8,546	8,546	36,083	85,455	121,538
	(pipeline, septic tan	2. Kien An district	9,374	9,822	0	0	0	0	0	1,562	1,562	1,562	1,562	1,562	1,562	982	982	982	982	982	982	982	982	982	982	9,374	9,822	19,196
		3. Do Son Town	2,744	2,923	0	0	0	0	0	457	457	457	457	457	457	292	292	292	292	292	292	292	292	292	292	2,744	2,923	5,666
		4. Quan Toan	0	350	0	0	0	0	0	0	0	0	0	0	0	35	35	35	35	35	35	35	35	35	35	0	350	350
		5. Minh Duc	0	1,683	0	0	0	0	0	0	0	0	0	0	0	168	168	168	168	168	168	168	168	168	168	0	1,683	1,683
		6. Dinh Vu	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		7. New Development area	0	1,459	0	0	0	0	0	0	0	0	0	0	0	146	146	146	146	146	146	146	146	146	146	0	1,459	1,459
	Mecanical/Electrica	1. Class A Area	1,116	2,658	0							186	372	372	186	266	266	266	266	266	266	266	266	266	266	1,116	2,658	3,775
	(pumping station)	2. Kien An district	1,361	1,361	0					227	227	227	227	227	227	136	136	136	136	136	136	136	136	136	136	1,361	1,361	2,722
		3. Do Son Town	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		4. Quan Toan	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		5. Minh Duc	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		6. Dinh Vu	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		7. New Development area	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Civil works	1. Class A Area	7,733	13,342	0					3,093	3,093	1,547				4,447	4,447	4,447								7,733	13,342	21,075
	(WWTP)	2. Kien An district	2,629	4,926	0					876	876	876				1,642	1,642	1,642								2,629	4,926	7,555
		3. Do Son Town	945	597	0					315	315	315				199	199	199								945	597	1,542
A. Construction Cost		4. Quan Toan	0	0	0		0	0	0	0							0	0	0	0						0	0	0
		5. Minh Duc	0	0	0		0	0	0	0							0	0	0	0						0	0	0
		6. Dinh Vu	0	0	0		0	0	0	0							0	0	0	0						0	0	0
		7. New Development area	0	0	0		0	0	0	0							0	0	0	0						0	0	0
	Mecanical/Electrica	1. Class A Area	5,162	8,896	0					2,065	2,065	1,032					4,448	4,448								5,162	8,896	14,058
	(WWTP)	2. Kien An district	1,754	3,285	0						877	877					1,643	1,643								1,754	3,285	5,039
		3. Do Son Town	630	398	0						315	315					199	199								630	398	1,028
		4. Quan Toan	0	0	0			0	0	0								0	0	0						0	0	0
		5. Minh Duc	0	0	0			0	0	0								0	0	0						0	0	0
		6. Dinh Vu	0	0	0			0	0	0								0	0	0						0	0	0
		7. New Development area	0	0	0			0	0	0								0	0	0						0	0	0
	sub-total	1. Class A Area	50,095	110,351	0	0	0	0	4,554	10,891	10,891	8,498	6,105	6,105	3,052	13,259	17,706	17,706	8,811	8,811	8,811	8,811	8,811	8,811	8,811	50,095	110,351	160,446
		2. Kien An district	15,118	19,394	0	0	0	0	0	2,666	3,543	3,543	1,789	1,789	1,789	2,760	4,403	4,403	1,118	1,118	1,118	1,118	1,118	1,118	1,118	15,118	19,394	34,512
		3. Do Son Town	4,319	3,918	0	0	0	0	0	772	1,087	1,087	457	457	457	491	691	691	292	292	292	292	292	292	292	4,319	3,918	8,237
		4. Quan Toan	0	350	0	0	0	0	0	0	0	0	0	0	0	35	35	35	35	35	35	35	35	35	35	0	350	350
		5. Minh Duc	0	1,683	0	0	0	0	0	0	0	0	0	0	0	168	168	168	168	168	168	168	168	168	168	0	1,683	1,683
		6. Dinh Vu	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		7. New Development area	0	1,459	0	0	0	0	0	0	0	0	0	0	0	146	146	146	146	146	146	146	146	146	146	0	1,459	1,459
		All except Class A Area	19,437	26,804	0	0	0	0	0	3,438	4,630	4,630	2,246	2,246	2,246	3,601	5,442	5,442	1,760	1,760	1,760	1,760	1,760	1,760	1,760	19,437	26,804	46,241
		1. Class A Area	2,200	1,038				1100	1,100						1,038											3,238	0	3,238
		2. Kien An district	641	184					641						184											825	0	825
		3. Do Son Town	67	51					67						51											118	0	118
B. Land Acquisation and Com		4. Quan Toan	0	0					0						0											0	0	0
		5. Minh Duc	0	0					0						0											0	0	0
		6. Dinh Vu	0	0					0						0											0	0	0
		7. New Development area	0	0					0						0											0	0	0
		All except Class A Area	708	235	0	0	0	0	708	0	0	0	0	0	235	0	0	0	0	0	0	0	0	0	0	943	0	943
		1. Class A Area										309	309	426	426	426	473	653	834	867	901	935	968	1,002	1,035	1,470	8,094	9,564
		2. Kien An district											95	106	118	129	141	203	264	271	278	285	292	299	306	319	2,468	2,788
		3. Do Son Town											26	27	29	30	31	39	46	47	48	49	50	51	52	82	443	525
C. Recurring Cost (O & M and		4. Quan Toan											0	0	0	0	0	0	0	0	1	1	1	1	1	0	5	5
		5. Minh Duc											0	0	0	0	1	1	2	2	3	3	4	4	5	0	23	23
		6. Dinh Vu											0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		7. New Development area											0	0	0	0	0	1	1	2	2	3	3	4	4	0	20	20
		All except Class A Area	0	0	0	0	0	0	0	0	0	0	121	134	147	159	174	244	313	322	331	340	349	358	367	401	2958	3360
		A. Construction Cost			0	0	0	0	4,554	14,328	15,521	13,128	8,351	8,351	5,299	16,859	23,149	23,149	10,571	10,571	10,571	10,571	10,571	10,571	10,571	69,532	137,155	206,686
Sub-total		B. Land Acquisation and Compensation Cost			0	0	0	1,100	1,808	0	0	0	0	0	1,273	0	0	0	0	0	0	0	0	0	0	4,181	0	4,181
		C. Recurring Cost (O & M and related)			0	0	0	0	0	0	0	309	430	560	573	585	647	897	1,147	1,190	1,232	1,275	1,317	1,360	1,402	1,871	11,053	12,924
Total																										75,584	148,208	223,792

0.03 Operation and Maintenance Cost ratio of the mechanical/electrical facilities construction cost

0.003 Operation and Maintenance Cost ratio of the civil works construction cost

Note: Constant Price of June 2000

Excludes engineering services, administrative costs and physical contingency

Table 4.7.1 Design of Septage Treatment Plant

Conditions

Population	400,000	person	range
Septage BOD unit loading	0.005	kg/capita/day	0.00454-0.0136
Septage SS unit loading	0.013	kg/capita/day	0.00905-0.552
Septage BOD	15,000	mg/l	2,000-30,000
Septage SS	37,500	mg/l	2,000-100,000

Estimation

Septage BOD load	2.00	ton/day	730	ton/year
Septage Volume	133	m3/day	48,667	m3/year
Septage SS load	5.00	ton/day	1,825	ton/year
Septage Volume	133	m3/day	48,667	m3/year

Septage Treatment System

Double-lined, two-stage lagoon system

	Area(ha)	Total(ha)	Required land area (ha)
Main building and parking space	0.2		
Coarse screen	0.1		
Primary Lagoon (Anaerobic Pond)	0.4		
Secondary Lagoon (Facultative Pond	6.1		
Sludge Drying Bed	2.0	8.8	**13**

Design conditions

Secondary Lagoon Effluent BOD	Le	50	mg/l	

Design

Primary Lagoon (Anaerobic Pond)					
Mean air temperature of coldest month		T	14	°C	
Volumetric loading rate		λ v	180	g/m3/day	λ v = 20T-100
BOD removal			48	%	R=2T+20
Primary Lagoon Effluent BOD			7,800	mg/l	
PL volume			11,111	m3	
Retention time		t	83	day	
PL depth		d	3.0	m	
PL area		A	**0.4**	ha	
Secondary Lagoon (Facultative Pond)					
Influent BOD		Lo	7,800	mg/l	
Influent BOD load			1,040	kg/day	
Mean air temperature of coldest month		T	14	°C	
Maximum surface loading		λ sm	225	kg/ha/day	λ s = 60(1.099)^(T)
SL surface	for λ sm		4.6	ha	
SL depth			1.5	m	
Retention time	for λ sm	t	520	day	
Breakdown rate per day of sewage organic		K_T	0.224	d^{-1}	K_T=0.3(1.05)^(T-20)
Effluent BOD			66	mg/l	Le=(Lo)/(1+Kt x t)
Surface loading		λ sm	170	kg/ha/day	λ s = 60(1.099)^(T) x **75%**
SL surface	for λ sm		**6.1**	ha	
SL depth			1.5	m	
Retention time	for λ sm	t	688	day	
Breakdown rate per day of sewage organic		K_T	0.224	d^{-1}	K_T=0.3(1.05)^(T-20)
Effluent BOD			50	mg/l	Le=(Lo)/(1+Kt x t)
Sludge Drying Bed					
Removal SS load			5,000	kg/day	
Sludge concentration			37,500	mg/l	
Sluge feeded		Q	133	m3/day	
Drying dutation		t	30	days	
Thickness of feeded sludge			20	cm	
Required surface area		A	**2.0**	ha	
Sludge loading			7.5	kg/m2	
Sludge loading rate			91	kg/m2/year	
Dryed sludge water contents			60	%	
Dryed sludge volume		V	13	m3/day	

Table 4.7.2 Septage Treatment Plant Construction Cost

Conditions

Septage Volume	133	m3/day
Septage BOD	15,000	mg/l
Effluent BOD	50	mg/l

Esitimation as Sewage Volume

5,700 m3/day =133m3/day * ((15,000mg/l)/(350mg/l))

Unit cost in case of WWTP(Q=5,700m3/day)

Base WWTP construction unit price 316 US$/(m3/day) from Ho Chi Minh WWTP(Q=141,000m3/day) as Stabilization Pond +Sludge Drying Bed
(6)

	Flow	Cost.cost in Japan	Unit cost	Ratio	Unit cost	Civil unit cost		Mec/Ele cost		Total Cost
	m3/day	Million Yen	Million Yen/(m3/day)		US$/(m3/day)	ratio	cost	ratio	cost	
	(1)	(2)	(3)=(2)/(1)	(5)=(3)/(4)	(6)*(5)		US$/(m3/day)		US$/(m3/day)	million US$
WWTP(Q=5,700m3/day)	5,700	1,759	0.309	2.38	**751**	0.90	**676**	0.10	**75**	4.3
Ho Chi Minh city WWTP	141,000	18,300	0.130 (4)	1.00	316	0.60	190	0.40	126	44.6

Note : Costruction cost in Japan is from Japan Sewage Works Association Standards(1996)
Construction cost(Million Yen) =393*(Q/1000)^0.73*(113.2/90.1)
where, Q=wastewater flow(m3/day)

Septage Treatment Plant Construction Cost

4,283 1000US$

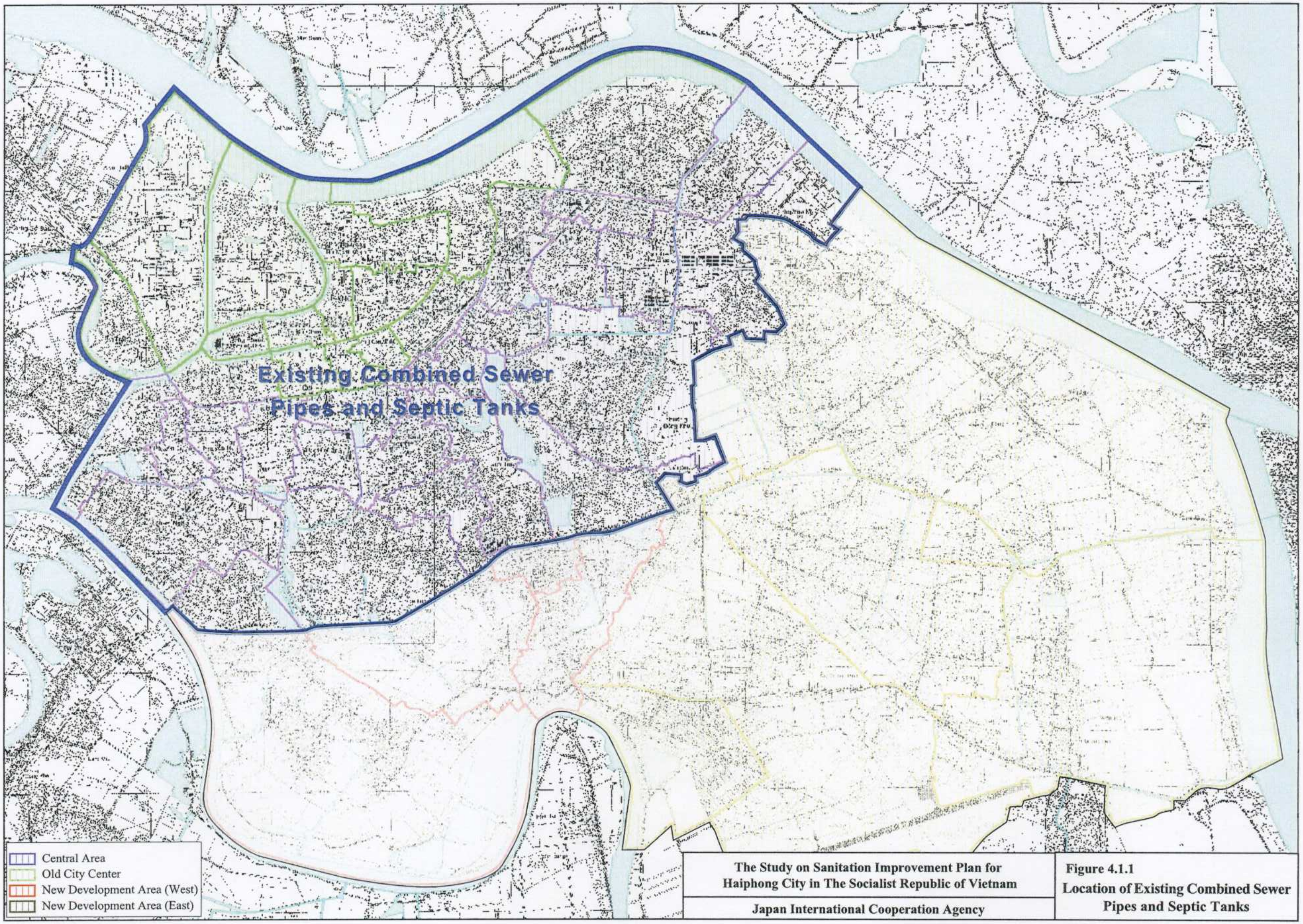
Note: Constant Price of June 2000
Excludes engineering services, administrative costs and physical contingency

Table 4.7.3 Annual Disburcement of Construction and Operation & Maintenance Costs for Septage Management

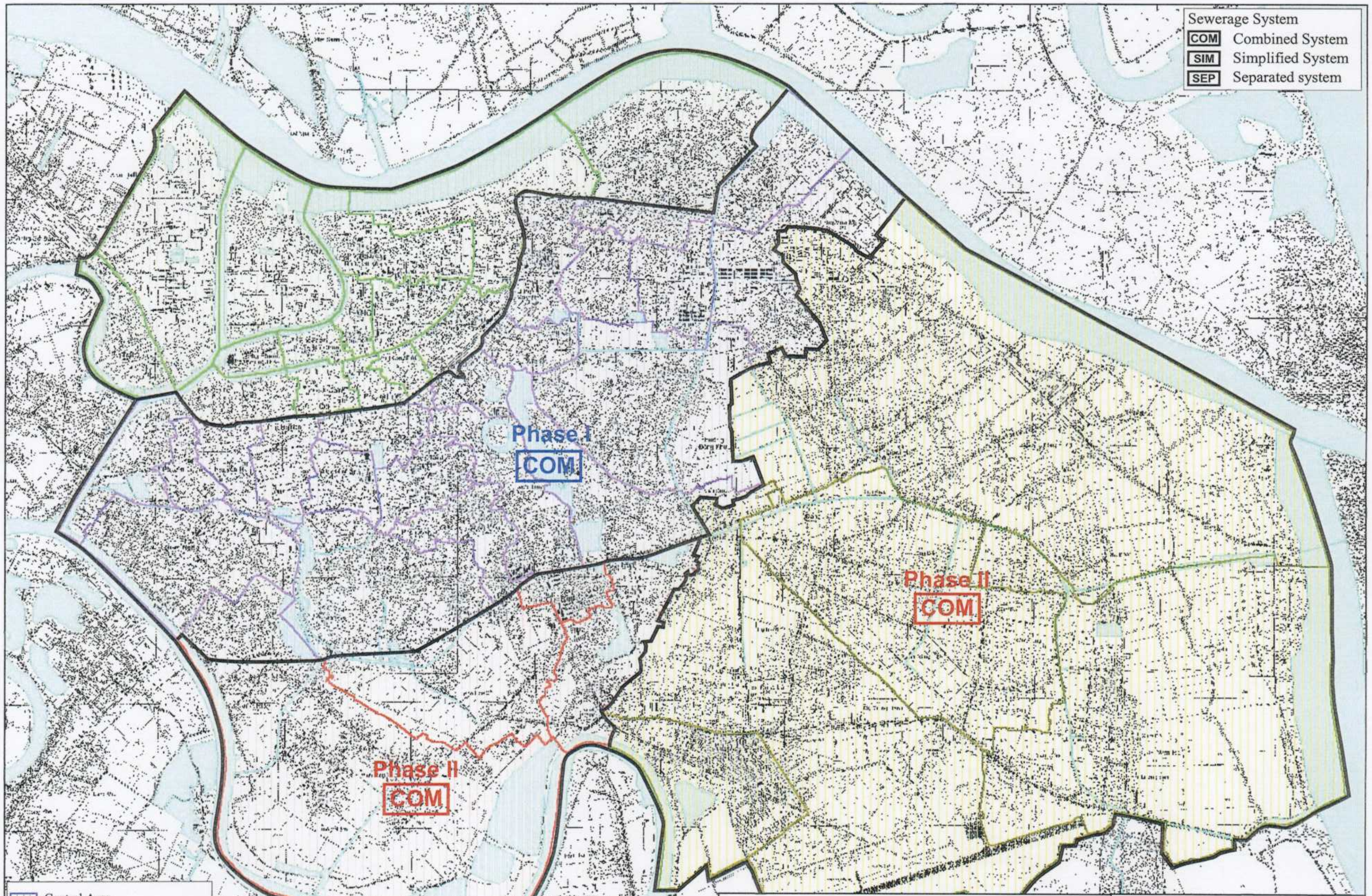
Unit : 1000US$

Cost Component		2002-2004	Years																				Total
		1000US$	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2000-2020
Construction Cost																								
	Septage Treatment Plant	4,283	0	0	1,428	1,428	1,428	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4,283
	Collection Vehicle Procurement	5,000	0	0	1,667	1,667	1,667	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5,000
	Inventory Improvement & Institutional Development	5,000	0	0	1,667	1,667	1,667	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5,000
	sub-total	14,283	0	0	4,761	4,761	4,761	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14,283
Recurring Cost (O & M and related)								413	413	413	413	413	413	413	413	413	413	413	413	413	413	413	413	6,606

0.003 Operation and Maintenance Cost ratio of the civil works construction cost
0.03 Operation and Maintenance Cost ratio of the mechanical/electrical facilities construction cost
0.05 Operation and Maintenance Cost ratio of Institute Development
Note: Constant Price of June 2000
Excludes engineering services, administrative costs and physical contingency



The Study on Sanitation Improvement Plan for Haiphong City in The Socialist Republic of Vietnam	Figure 4.1.1 Location of Existing Combined Sewer Pipes and Septic Tanks
Japan International Cooperation Agency	

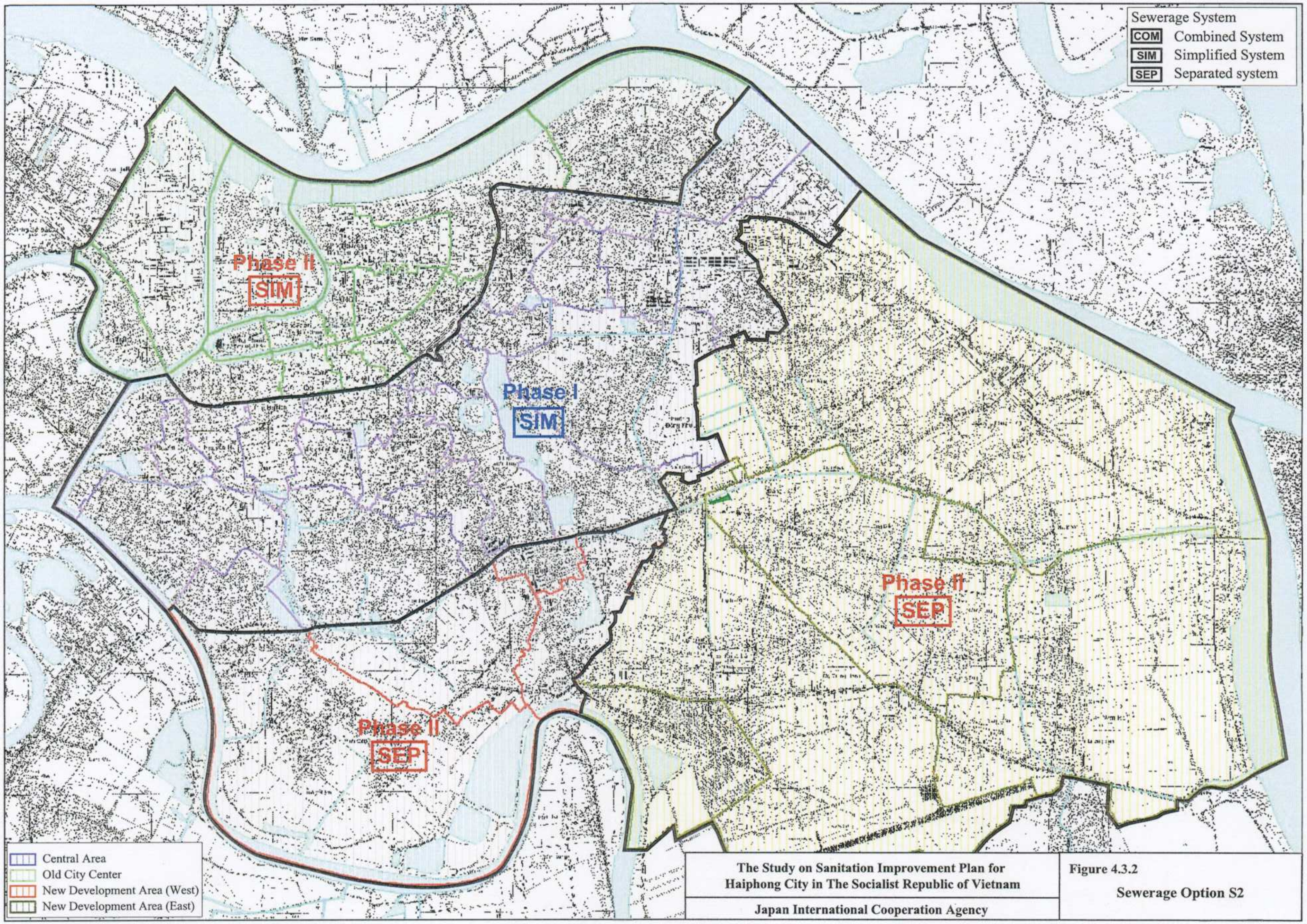


The Study on Sanitation Improvement Plan for Haiphong City in The Socialist Republic of Vietnam

Japan International Cooperation Agency

Figure 4.3.1

Sewerage Option S1



The Study on Sanitation Improvement Plan for Haiphong City in The Socialist Republic of Vietnam

Japan International Cooperation Agency

Figure 4.3.2

Sewerage Option S2