THE DEVELOPMENT STUDY ON THE IMPROVEMENT OF SEWERAGE AND DRAINAGE SYSTEM FOR THE HAVANA BAY IN THE REPUBLIC OF CUBA

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ABBREVIATION

B/C	=	Benefit Cost Ratio
CAP	=	Provincial Administrative Council
CAR	=	Cartagena convention
CECM	=	Executive Committee of the Council of Ministers
CENHICA	=	National Center for Hydrology and Water Quality
CIMAB	=	Cuba’s Center for Engineering and Environmental Management of Bays and Coastal Zones
CITMA	=	Delegation of the Ministry for Science, Technology and the Environment in Havana City
DISM	=	Directorate of Marine Security and Protection
DPRH/Havana-City	=	Provincial Delegation of Resources of Havana City of the National Institute for Hydraulic Resources
EAH	=	Enterprise of Hydraulic Usage
EIA	=	Environmental Impact Assessment
EIRR	=	Economic Internal Rate of Return
FIRR	=	Financial Internal Rate of Return
GDP	=	Gross Domestic Product
GEF	=	Global Environmental Facility
GNP	=	Growth National Product
GOC	=	Government of the Republic of Cuba
GOJ	=	Government of Japan
GTE	=	State Working Group for Cleaning Up, Conservation and Development for the Havana Bay
IDB	=	Inter-American Development Bank
IMF	=	International Monetary Fund
INRH	=	National Institute of Water Resources
ISO	=	International Standards Organization
JBIC	=	Japan Bank of International Cooperation
JICA	=	Japan International Cooperation Agency
LBS	=	Land Based Sources
MINAG	=	Ministry of Agriculture
MINBAS	=	Ministry of Basic Industry
MININT	=	Ministry of the Interior
MINSAP	=	Ministry of Health
MINTRANS	=	Ministry of Transport

MINVEC	=	Ministry of Foreign Investment and Economic Collaboration
MIP	=	Ministry of Fisheries
MIZC	=	Integrated Management of Coastal Zones
NC	=	Norma Cubanas (National Standard)
NGO	=	Non-Governmental Organization
NPV	=	Net Present Value
O/M, O&M	=	Operation and Maintenance
ONAT	=	National Office of Tax Administration
Ps	=	Cuban Peso
ROA	=	Return on Assets
SAMARP	=	National Company for Port Sanitation
SCF	=	Standard Conversion Factor
SERF	=	Shadow Exchange Rate Factor
SWRF	=	Standard Wage Rate Factor
UNDP	=	United Nations Development Programme
UNEP	=	United Nations Environment Programme
UNESCO	=	United Nations Education and Scientific Organization
UNICEF	=	United Nations Children’s Fund
USA	=	United States of America
WRC	=	Wider Caribbean Region
WS & S	=	Water Supply & Sewerage
WTA	=	Willingness to Accept
WTP	=	Willingness to Pay
WWTP	=	Wastewater Treatment Plant

PART I: BASIC STUDY

1.1 INTRODUCTION

1.1.1 BACKGROUNDS

Ciudad de La Habana Province, the largest city in the Caribbean, is Cuba's political, cultural and economic center. The total estimated population is about 2,188,000 in year 2000, which represents about 20 % of the total population of 12,000,000 in Cuba.

Havana Bay with an area of 5.0 km^2, an average water depth of 9 meters, and a capacity of 47 million m^3, plays very important role as commercial and industrial seaport and tourist attractions. The bay basin has an area of 68 km^2 and a population of about 800,000 in 2000, which represents 37% of population of Ciudad de La Habana Province. Due to the Bay characteristics of closed water environment, the water of the Bay is not exchanged easily with seawater in the ocean. The pollutants originated from domestic and industrial wastewaters are being discharged into the Bay without proper or enough treatment, which resulted in contaminating the water and accumulating the pollutants at the bottom of the Bay.

Without improved water pollution control measures, the water quality becomes worse and the eutrophication phenomena will be revealed to cause damage to the aquatic ecosystem of the Bay and to the tourism of Havana and the economy of Cuba.

To solve the water pollution and improve water environment of the Bay, GOC established the State Working Group for Cleaning up, conservation and development for the Havana Bay (GTE) to coordinate the government agencies concerned the Havana Bay. GTE is the state authority for planning, organizing, coordinating and controlling the program for the cleaning up and environmental management at local level. During 1995 to 1997, under the cooperation of Global Environmental Facility/UNDP (GEF), who proposed the establishment of GTE, GTE has conducted a study on Water Pollution Control Measures of the Havana Area.

Under the circumstances, to decrease the pollutants loads discharging into the Havana Bay from various pollution sources and to improve the water environment in the Havana Bay, GOC has requested Government of Japan (GOJ) for technical assistance for formulating the Sewerage and Drainage System Master Plan (M/P) and the Feasibility Study (F/S) for selected sewerage projects in the M/P.

In response to the request of the GOC, the JICA has dispatched the Preparatory Study Team headed by Ms. Keiko Yamamoto, to the Republic of Cuba from February 17 to March 8, 2002 to discuss the Scope of Work for the Development Study on the Improvement of Sewerage and Drainage System for the Havana Bay in the Republic of Cuba. The Scope of Work (S/W) was finally concluded between GTE and JICA.

1.1.2 OUTLINE OF STUDY

The objectives of the Study are set as follows:

- To formulate a master plan for improving sewerage and drainage system for the Havana Bay to the target year of 2020;
- To conduct a feasibility study for the priority project(s) selected in the master plan; and
- To pursue technology transfer to the Cuban counterpart personnel in the course of the Study.

The Study has been conducted in three phases;

- Phase I, Basic Study
- Phase II, Formulation of Master Plan
- Phase III, Feasibility Study on Priority Project

1.1.3 COMPOSITION OF REPORTS

This Report is comprised with the followings:

Volume I: Executive Summary

Volume II: Main Report, Part I Master Plan Part II Feasibility Study

Volume III: Supporting Report

Volume IV: Spanish version of the Executive Summary

Volume V: Spanish version of the Main Report

1.2 THE STUDY AREA

1.2.1 PHYSICAL CONDITIONS

(1) Meteorology

The climate and weather conditions in the Study Area are summarized.

1) Temperatures

The annual highest average temperature in Havana City is 28.8°C and the annual lowest average is 21.4°C. The highest and lowest temperature recorded was 35.8°C and 8.5°C, respectively. The mean average temperature in the warmest month, August, is 27.3°C, while in the coolest month, February, it is 21.6°C.

2) Precipitation and Humidity

The mean annual rainfall is 1,411mm; in the rainy season, May to October, the Havana receives 70% of the total annual rainfall. The rainiest months are September and October. Relative humidity in general is high with an annual average of 79.5%.

(2) Hydrology

Three rivers namely Rio Luyanó, Rio Martin Pérez and Arroyo Tadeo drain to the bay from southern part of basin with combined river basin area of 45.7 km^2. Rio Luyanó is the largest in terms of basin area, river length and river flow.

There are no permanent river gauging stations in these rivers. Table 1.1 shows the characteristics of rivers.

Table 1.1 Characteristics of Tributary Rivers to Havana Bay

Item	Rio Luyanó	Rio Martin Pérez	Arroyo Tadeo	Total
Basin area, km^2	30.0	13.1	2.6	45.7
Length of River, km	10.1	6.4	2.3	
Flow in year 2002*, m^3/d	114,860	62,105	8,004	184,969
Average Yield, L/km^2 /s	0.1214	0.1503	0.0976	0.1283

Source : CIMAB, August 2002

Rio Luyanó originates from an altitude of approximately 90 m whereas Rio Martin Pérez originates from an altitude of 55 m above MSL (mean sea level). Arroyo Tadeo is an urban stream receiving domestic wastewater.

1.2.2 SOCIO-ECONOMY

(1) Population

The present population of Cuba is approximately 12 million. The area of Cuba is 110,860 km^2 giving an overall population density of 101 persons/ km^2, which is roughly the same as France. Statistics for year 2000 give a total population of 11, 217,100 of which, 8,445,036 (75%), live in urban areas. Cuba is highly urbanized; hence the rural areas are sparsely populated with quite higher densities in urban areas.

The Ciudad de La Habana Province where Study Area is situated had a total estimated population of about 2,188,000 in year 2000, which represents about 20% of the total population of Cuba, and about 26% of the total urban population. The average population density of the Ciudad de La Habana Province is a little over 3000 persons/ km^2. Population census data for 1981 and the estimates for 1995-2000 for the Ciudad de La Habana Province is as shown below and that population is decreasing after 1996.

Table 1.2 Population census data and estimates

Year	1981 census	1995	1996	1997	1998	1999	2000
Population	1,929,432	2,184,990	2,204,333	2,197,706	2,192,321	2,189,716	2,186,332
% change			0.885	-0.301	-0.245	-0.119	-0.155

DPPFA has estimated the population within the basin of Havana Bay at 795,144 as of 1996. Table 1.3 shows the estimated population within the Havana Bay basin for the year 2000. The study area contains about 35% of population of Ciudad de la Habana Province and 51.6% of the ten municipalities which falls within the basin area. Average population density within the basin is approximately 11,250 / km^2.

Table 1.3 Population within the Havana Bay Basin, Year 2000

Municipality	Total Municipal Population	Population within Basin
Plaza de la Revolucion	173,416	18,359
Centro Havana	153,878	73,684
Havana Vieja	99,499	97,026
Regla	42,870	40,764
Havana del Este	184,634	17,675
Guanabacoa	106,618	24,848
San Miguel del Padron	154,675	145,803
Diez de Octubre	230,865	217,038
Cerro	135,729	97,889
Arroyo Naranjo	199,317	31,676
Total	1,481,501	764,762

(2) Economic Scale and Growth Rate of the City of Havana

The fall of the Berlin Wall in 1989 and the collapse of the Soviet Union in 1991 dealt a severe blow to the economy of Cuba. 1990 saw the inauguration of the “ Special period in Time of Peace”, heralding hard times for all Cubans.

In the first half of the 1990’s, Cuba adopted more liberal policies with some degree of free market activities and found economic partners other than the old soviet block, to form joint ventures with foreign capital. Capital flowed mainly from Canada, Mexico and Europe and joint ventures were initially formed in the oil industry, tourism and the telecommunications and mining sectors.

In the early 1990's Cuba's GNP shrunk by 37%, however, by the middle of the 1990's the economy showed signs of recovery, albeit slow, with increases in the GNP of around 1% between 1994 and 1998. The opening up of all sectors of the economy to foreign investment in 1995 (except defense, health and education), led to the current upward trend. However, external forces, particularly the USA's Helms-Burton Act has restrained willing investors with the threat of the loss of their markets in the USA. Should this threat be removed the Cuban economy is in a position to rapidly expand. The GDP data are summarized as follows:

Table 1.4 Gross Domestic Product

	Year 1996	Year 1997	Year 1998	Year 1999	Year 2000
Total GDP (Million pesos)					
At current prices	22,815	22,952	23,901	25,504	27,635
At constant (1981) prices	14,218	14,572	14,754	15,674	16,556
% change, year on year	7.8%	2.5%	1.2%	6.2%	5.6%
By expenditure (Million pesos at constant 1981 prices)					
Private consumption	6,085	6,120	6,315	6,599	6,904
Government consumption	4,749	4,809	4,957	5,000	5,133
Gross fixed investment	1,166	1,180	1,254	1,615	2,185
External balance	2,403	2,375	2,302	2,586	2,467
Statistical discrepancy	-185	87	-74	-125	-132
Total	14,218	14,572	14,754	15,674	16,556
By sector (Million pesos at constant 1981 prices)					
Agriculture	1,075	1,074	1,018	1,123	1,253
Industry	4,949	5,314	5,490	5,843	6,168
Mining	177	182	184	186	213
Construction	539	556	588	632	694
Electricity, gas & water sup	398	422	427	430	468
Manufacturing	3,835	4,155	4,291	4,595	4,794
Services	8,193	8,185	8,247	8,708	9,135
Total	14,218	14,572	14,754	15,674	16,556

Sources: Banco Central de Cuba

With almost one in five Cubans being residents of Havana, the poor national economic situation was reflected even more so in Havana. The city, which has 55 industrial complexes, was hard hit by the economic downturn in the early 1990's, but it is now recovering. The city has also been boosted by the rapid growth in the tourism industry.

(3) Tourism Industry Trends

The Tourism industry was one of the first sectors of the economy to be involved with foreign capital. Since the creation of the Ministry of Tourism in 1994, and the passing of the Foreign Investment Law in 1995, 13 major organization, including mixed enterprises and international operators have been formed.

Tourism has become a priority area in the economy with its ability to generate a healthy amount of US dollars as well as expanding employment opportunities.

The following tables show the statistics for tourist arrivals and income:

Table 1.5 Number of Tourists and Tourism Income (In Millions)

Cuba	1994	1995	1996	1997	1998	1999	2000
International Arrivals	0.619	0.745	1.004	1.170	1.416	1.603	1.774
Total Tourists	0.617	0.742	0.999	1.153	1.390	1.561	1.741
Tourism Income (US$)	0.850	1.100	1.333	1.515	1.759	1.901	1.948

The total number of tourist arrivals is likely to continue to increase, with a corresponding increase in revenue which will, by now, have exceeded US$ 2 billion per year.

Havana has about 28% of the rooms/beds in Cuba, compared to Varadero, which has about 30%. Tourism revenue has increased by 230% from 1994 to 2000, with a corresponding 150% increase in the number of beds. The current occupancy rate of about 75% leaves some room for a further increase in tourist revenue as the accommodation expands.

1.2.3 URBAN STRUCTURE

(1) Urban Planning and Land Use

Present land use in the Study is summarized in the table below.

Table 1.6 Present Land Use

Land use	Area (km^2)	Ratio (%)
1. Residential and commercial areas	40.55	61
2. Industrial area	13.20	20
3. Agriculture	6.25	10
4. Parks and green areas	4.00	6
5. Reserved area	2.00	3
Total	66.00	100

Source: Estudio de caso: Bahía de La Habana, Cuba, under "Proyecto GEF/RLA/93/G41Proyecto Regional Planificación y Manejo de Bahías y Areas Costeras Fuertemente Contaminadas del Gran Caribe"

The ratio of residential, commercial and industrial areas reached more than 80%, indicating high urbanization.

(2) Water Supply Conditions and Future Plan

Present public water supply system provides the service to about 2.2 million people of 15 municipalities in the city of Havana.

The daily water volume produced is 1,317,000m^3/day, in which the treated surface water of 48,400 m^3/day and the groundwater of 1,268,600m^3/day. The groundwater source is more than 96.6%, thus the almost all of water supplied to the city is groundwater origin.

From the total intake volume of 4,806 million m^3/year (1.32 million m^3/day), the unit water volume supplied by capita can be calculated as 604 liter per capita per day (lpcd) with the service population of 2,180,000. The figure of unit supply volume is not small compared the same scale of cities. However, in the actual situation, the intake water is lost through the production process, transmission mains, pumps and water distribution networks. A hearing survey estimates about 50% of intake water is lost through transmission mains due to the lack of capacity and age.

In the city of Havana, 24 hours continuous water supply is limited, an intermittent water supply, averagely about 10 hours supply, is commonly practiced.

A future plan for improving the water supply conditions and water supply system is prepared for the city of Havana by INRH under the finance of Europa-Union. The Cuban water supply standards (Norm) set a per capita water supply volume: 220 lpcd of domestic water for the city having 500,000 population and 470 lpcd including water for institutional and public purposes parks, and roads.

1.3 HAVANA BAY

1.3.1 HYDRAULIC CHARACTERISTICS

Important hydraulic characteristics of Havana bay can be summarized as follows:

- Tidal currents inside the bay is relatively little, due to the narrow entrance (270m in width) and low tidal amplitude (0.29m in average) in the bay.
- Retention time of the fresh water in the bay is approximately 4 months and water exchange between the bay and the open sea is relatively small.
- The average and maximum water depth of the bay is 9 and 17 meters respectively. Therefore, water temperature stratification would be broken up easily by wind blown or strong currents. On the other hand, density flow both in horizontal and vertical directions could be strong in some estuaries such as Atares and Guasabacoa, due to a large quantity of fresh water inflow from rivers and drainage.
- Heat exchange between seawater and atmosphere would be one of the most important factors to the water temperature inside the bay.
- Precipitation, especially in the rain season, could promote the generation of the density currents in the bay.

1.3.2 CHARACTERISTICS OF WATER QUALITY

A comparison of water quality data of DO and nutrients obtained during 1986-90 and those of 2002 indicates that the water quality has been improved, the improvement could be explained that the pollution loads have been reduced by the economic slow down and a contribution of modified wastewater treatment in distillery industry.

According to the results of water quality data obtained in 2002 by CIMAB and of field surveys in the Study and other reported data, characteristic of water pollution in Havana bay can be concluded as follows.

- DO concentrations is different significantly for the sampling locations. Generally, water areas adjacent to the estuaries within the bay and source inflows show lower DO concentration. Particularly for the locations of Atares and Marimelena, in which drainage of sewage and industrial wastewater are discharged, DO depletion is remarkable. In the rainy season, DO drops very much and DO level for the two locations are as low as 2.0 mg/L. Low DO condition particularly in the seabed would results in excess release of nutrients from the sediments, as well as suffocation of living resources. These nutrients would promote the growth of phytoplankton and cause eutrophication of the waterbody.
- Phosphorous concentration in the bay varied seasonally and spatially. Both for the phosphate and total phosphorous, the dry season shows a high concentration than the rain season. In the areas of Atares, Marimelena and Guasabacoa, a high concentrations of phosphorous are observed. From the concentration gradient, it can be deduced that the main external source of phosphorous is the discharge from the rivers and drainage channels.
- High concentration of ammonia was observed in the bay's inner parts such as Atares, Marimelena and Guasabacoa. Particularly in the area of Atares, NH_4-N concentration both in the surface and second layer is as high as 0.5 mg/L. Concentration of NO_2-N and NO_3-N and their variation among the locations are comparatively small. Therefore, it can be considered that ammonia distribution is more dependent on the pollutant load of the source inflow and the release from sediment, while the nitrite and nitrate are more relied

on the nitrification process occurring within the bay.

- High SS concentration is observed at Atares and Guasabacoa compared to other areas. This is similar to other parameters and can be attributed to the inflow of the suspended water via the rivers and drainage channels.
- Although phytoplankton and chlorophyll-a, as two very important parameters to evaluate the eutrophication level, were measured, inconsistency in the results of the two parameters makes it difficult to grasp the characteristics of the primary production in the bay. As a general tendency, Canal de Entrada and Centro de la Bahia show a higher concentration of chlorophyll-a. Phytoplankton concentrations at Canal de Entrada and Atares are relatively high. Comparing with the nutrient (inorganic nitrogen and phosphate) level in the bay, it can be said that the chlorophyll-a concentration is relatively low.

1.3.3 CHARACTERISTICS OF SEDIMENT

According to the existing surface sediment data (1991-2001), high concentrations of Zinc (Zn) and Copper (Cu) were observed at Atarés and Centro de la Bahía, which were exceeding the Dutch standard values that requires intervention.

The field survey conducted under this Study resulted that major heavy metals were in low concentration level except Zinc (Zn) at Atares, slightly above the Dutch intervention value, and that petroleum hydrocarbons were uniformly distributed ranging from 1,759 mg/kg-dry weight at Atares to 1,230 mg/kg at Guasabacoa, which are the same level of existing data (1,043 to 1,623 mg/kg).

1.4 PRESENT POLLUTION LOAD

Deterioration of water quality of Havana Bay is due to pollution load received by rivers, wastewater Colectors and urban drains discharging to the bay or through direct discharges from sources located along the shore of the bay.

Pollution load is estimated at the point of generation and at the point of discharge to the bay. Estimates of pollution load generation are made based on unit pollutant load. Pollutant load discharge to the bay is estimated based on the monitoring data at the most downstream end of drains and rivers draining to bay. Industries along the periphery of the bay and discharging directly are also estimated based on monitoring data. The estimation of loads is made for each of the nine basins for the year 1996 and year 2000.

Table 1.7 shows the preliminary results of the relationship between BOD_5 generation and discharge. Pollution load generated in Habana Vieja basin, Dren Arroyo Matadero basin and and Dren Agua Dulce basin is intended to be collected by Colector Principal and discharged outside the bay near Playa del Chivo. However, due to cross connections to stormwater drains and crossconnection/overflow between Principal Colector and stormwater drains, pollution load generated in those areas are discharged to the bay through stormwater drains. In addition, the Colector Paralelo Orengo serves areas outside the Havana Bay Basin and connected to Principal Colector, from which part of wastewater is discharged to the bay through stromwater drains. Further investigation will be necessary to quantify wastewater discharge from collectors to stormwater drains in these areas. Further, estimated pollutant load generation is smaller than the discharged load for Arroyo Tadeo which also needs further investigation.

Table 1.7 Relationship between Generation and Discharge (Preliminary)

Basin	Estimated BOD_5 Generation, kg/d		Intended Discharge to Bay	Actual Discharged BOD_5, kg/d		Remarks
	1996	2000		1996/97	2002	
Habana Vieja	4,455	4,070	0	830	1,320	Wastewater is intended to be collected by Colector Principal.
Dren Arroyo Matadero	5,126	4,808	0	20,015	8,942	
Dren Agua Dulce	5,943	5,567	0	5,630	6,770	
Rio Luyano	36,594	12,688		29,803	9,784	
Rio Martin Perez	3,185	3,737		629	1,518	
Rio Tadeo	2,281	899		3,256	1,807	Requires investigation
Refinery Area	23,701	22,634		22,823	21,723	
Casa Blanca	542	592		23	23	
Cabaña	26	27		0	0	
Total	81,853	55,021		83,009	51,888	

1.5 CROSS CONNECTIONS

1.5.1 GENERAL

Large amount of wastewater is discharged through main drainage channels such as Agua Dulce and Arroyo Matadero. It is reported that the main reason is that cross connections are practiced in the sewer service area. The cross connections are called as “illegal connections” in the Study Area. A survey on the cross connection has been conducted to identify the current situations.

A dye-colored water test method is selected, considering the wastewater flow condition in each drainage pipe surveyed, house connection design, and other local conditions.

1.5.2 PRELIMINARY SURVEY

Ten locations are selected for the cross connection survey to cover the main drainage areas of Agua Dulce, Arroyo Matadero, and San Nicolás.

The results of preliminary survey are presented in the table below:

Table 1.8 Results of Cross Connections Survey

Drainage area	Location ID No.	House number surveyed	Cross connection number identified
I) San Nicolas	1	31	0
II) Arroyo Matadero	2	31	0
	3	24	0
	4	8	0
	5	33	2
	6	13	0
III) Agua Duluce	7	5	0
	8	17	1
	9	20	0
	10	35	0
Total		**217**	**3**

The results show that cross connections are not identified; almost all of house connections are connected to the sanitary sewer correctly.

1.5.3 ADDITIONAL SURVEY

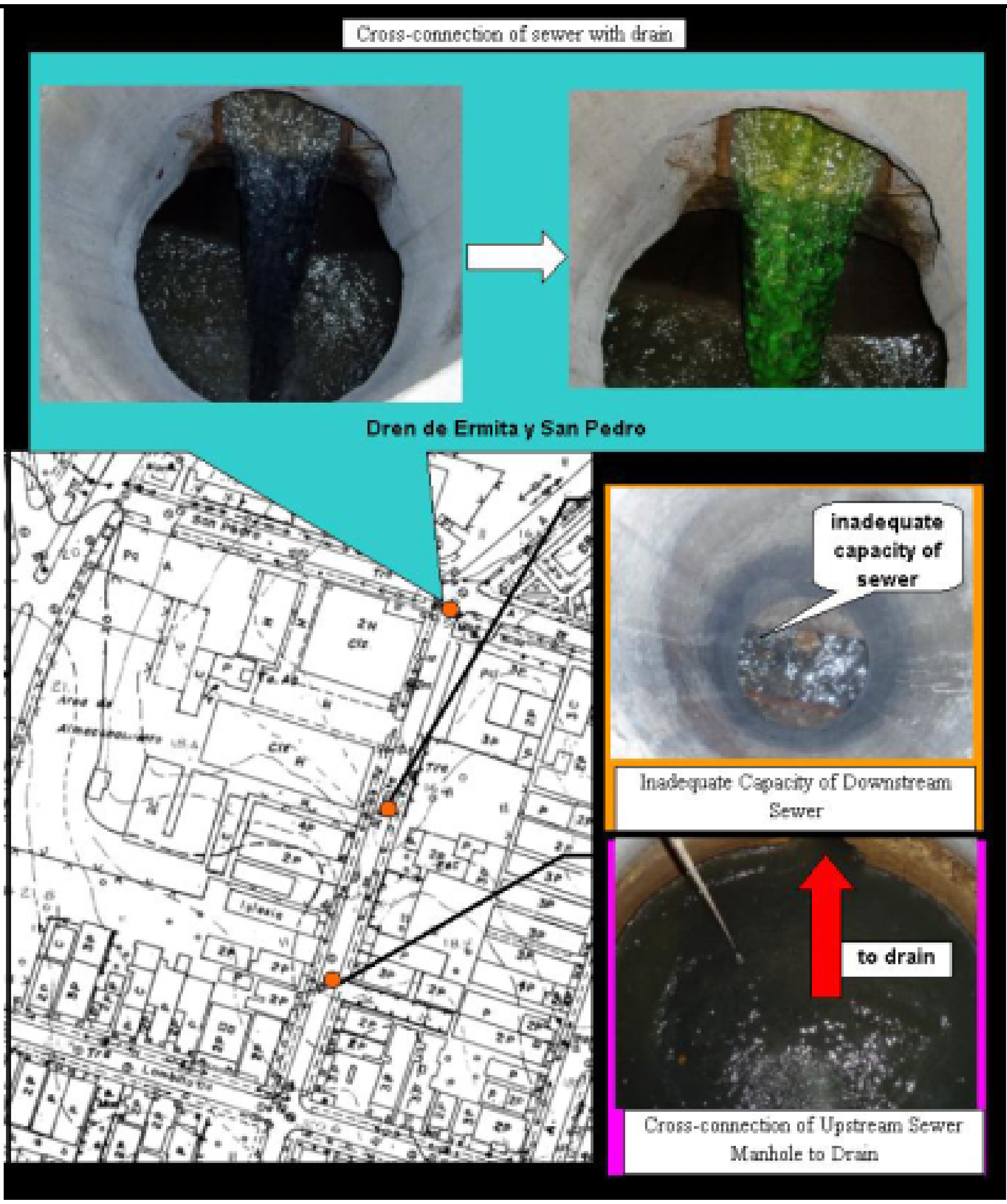
A further survey has been conducted on four of the locations previously identified by the INRH to understand the detail situations of the cross connections in the area related to the Dren Matadero.

Out of the four locations it was possible to identify the origin or source of cross connection at three locations. To eliminate the cross connections in these three locations following measures will be required.

- A cross connection is from a housing apartment block at Avenida Colon y Bellavista and only some part of the grey water is discharged. This cross connection can be eliminated easily by connecting to the nearest sewer main.
- A cross connection between a sewer manhole to a nearby drain manhole at Tulipan y Estancia. Reason for the cross connection could be either inadequate capacity of the nearest sewer or due to simple mistake. Elimination of this will require an investigation of existing capacity and elevation of sewer main.
- Figure 1.1 exhibits a cross connection due to inadequate capacity of sewer at Ermita y San Pedro. In this case, it will be necessary to construct new sewers to increase the capacity of sewer.

In addition, it was found that a siphon structured Colectors crossing over the nearby storm-water channel had overflow structures to divert the wastewater to the drainage channel when it reached over the capacity of Colector.

The survey results recommend that a long-term detailed survey be required to identify the exact locations and reasons of the cross connections and to prepare appropriate and cost-effective solution measures for different individual cases.



THE DEVELOPMENT STUDY ON THE IMPROVEMENT OF SEWERAGE AND DRAINAGE SYSTEM FOR THE HAVANA BAY	Figure 1.1 Cross connection of Sewer Manhole to Drain due to Inadequate Sewer Capacity
JAPAN INTERNATIONAL COOPERATION AGENCY	

PART II: MASTER PLAN

2.1 INTRODUCTION

This part describes a series of studies to determine the required sewerage system components to improve the water environment of Havana Bay as a part of Master Plan, evaluation of the financial and economic viabilities, and selection of Priority Projects for Feasibility Study. Figure 2.1 shows a procedure to formulate the Sewerage System Master Plan for the Havana Bay.

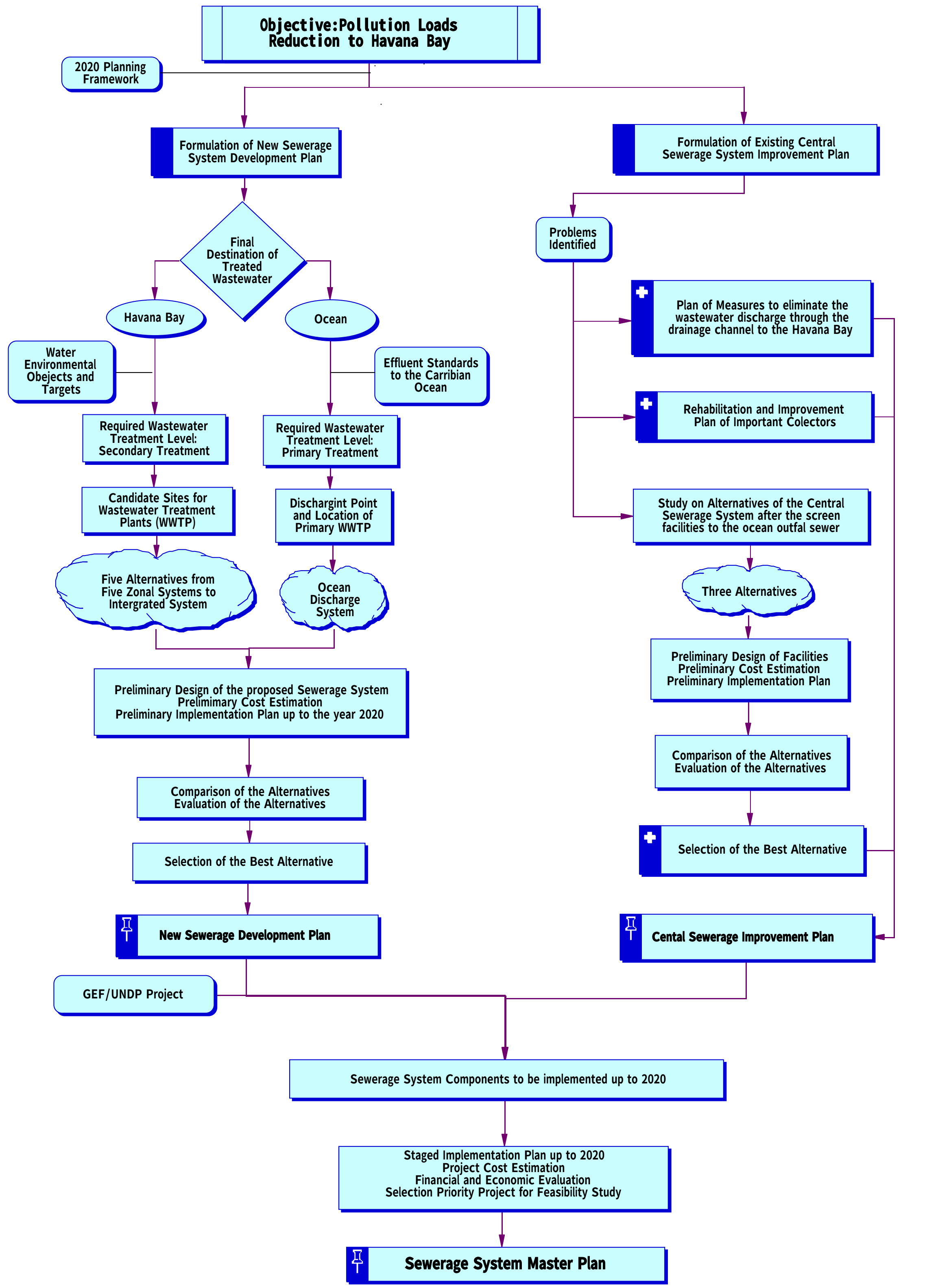
Initially a strategy of water pollution control will be explained, in which how and how much the bay water environment will be improved by rehabilitation and improvement of the existing sewerage system and by development of new sewerage systems. Water quality goals considering present and future water use in the Havana Bay will be proposed based on the draft of Cuban environmental quality standards for the water bodies and a series of water quality simulation study. Through the study, the required level of wastewater treatment will be identified for the case of treated water discharge to the Havana Bay.

The planning framework such as service area, service population, wastewater generation, pollution loads and inflow/infiltration are briefly summarized. These are bases to formulate the sewerage system plans.

It should be noted that the Master Plan proposed in the Study is defined as a sewerage improvement and development plan to be implemented by the target year of 2020, which will be selected among sewerage plans prepared for the Havana Bay basin. Because, the construction and operation of sewerage systems requires huge capital investment, high running costs, qualified engineers and experienced operators. The development of sewerage system is generally executed in phased construction for long time horizon.

Appropriate rehabilitation and improvement measures for the existing sewerage system will be proposed based on current problems identified and series of studies to solve the problems and to increase the system reliability to play their roles forward. New sewerage system development plan will be also proposed to reduce the pollution loads effectively and efficiently through series of studies on alternatives related to the treated water discharge destination of the Havana Bay or the Caribbean Sea.

The Master Plan includes an implementation schedule, a proposal of institutional strengthening, cost estimation, projects effects on water quality improvement, and evaluations of financial and economical viabilities as well as the sewerage system components to be constructed up to the year 2020. Finally, priority projects will be selected for the next study phase of Feasibility Study.



THE DEVELOPMENT STUDY ON THE IMPROVEMENT OF SEWERAGE AND DRAINAGE SYSTEM FOR THE HAVANA BAY	Figure 2.1 Flowchart of formulating Sewerage System Master Plan
JAPAN INTERNATIONAL COOPERATION AGENCY	

2.2 STRATEGY FOR WATER POLLUTION CONTROL IN HAVANA BAY

2.2.1 WATER ENVIRONMENTAL GOALS

(1) Water use

When considering the future uses, existing uses described below still remain. The uses are:

Tourist attractions: With its world heritage sites and important historical monuments located at the entrance of Havana Bay, it is an essential part of many important tourist attractions in the City of Havana.

Recreation: The promenade along the entrance channel to Havana Bay and its continuation along Malecon is of indispensable value to citizens of Havana City (*Habaneros*) for its use as recreational area and also as an area for recreational fishing.

Industrial and commercial port: It is one of the major industrial and commercial port in Cuba. It also serves as a source of cooling water and finally as a receptor for their effluents. There are also many workshops along the coast of the bay for repair to ships etc.

Transportation: It also serves as a transportation link between eastern and western parts of the Havana City.

(2) Water Quality Goals

A standard for water quality for bays and coastal areas is in the preparatory stage, namely "*Vertimiento De Aguas Residuales a Las Costas y Aguas Marinas - Especificaciones*", which classifies uses into six categories. Categories are as follows:

- Class A - Coral reef areas, areas for ecological conservation or protected areas
- Class B - Marine areas reserved for bathing and recreational activity where persons contact with water
- Class C - Marine areas for fishery development
- Class D - Marine areas where sea water is used as cooling water for power generation
- Class E - Bay areas developed for port activity
- Class F - Marine areas without specific use

Table 2.1 shows the environmental quality standards for the water bodies suitable for their functions in terms of dissolved oxygen and total coliform concentration. Port use of Havana Bay fits into the Class E water body.

Table 2.1 Draft Coastal and Bay Water Quality Standards

Parameter	Unit	Type Water Body				
		Class A	Class C	Class D	Class E	Class F
Dissolved oxygen (DO)	mg/L	5.0	5.0	4.0	3.0	2.0
Total coliforms	MPN/100 mL	100	250	250	1000	5000

Note: Standards for Class B are not available.

Figure 2.2 shows the existing DO levels in comparison with the classification of water bodies in the proposed standards. Existing conditions as measured in this Study in year 2002 at coves of the bay, namely Atares, Guasabacoa and Marimelena, do not satisfy Class E water body. DO levels at Atares was below Class F and at Guasabacoa was Class F. At Marimelena, it varied between that of Class D and F. At Centro, it was between Class C and F and that at the Entrance Channel was between Class C and E.

Water quality goals necessary for maintaining existing uses:

Goal 1 : To achieve the draft standards for Class E water body in terms of dissolved oxygen levels (3 mg/L)

Goal 2 : To achieve the draft effluent standards for discharge to Class E water body in terms of oil/grease (below 5 mg/L)

Table 2.2 shows the goals and key sectors in which action is required. An increase of dissolved oxygen levels will require that the organic pollution load to the bay be reduced and action is required to control sewerage, drainage and industrial wastewater. Industries and workshops along the coast of the bay and in the basin are required to take action to reduce oil/grease discharge to the bay.

Table 2.2 Goals and Responsibilities of Sector

Goal	Key Sector in which action required		
	Sewerage	Drainage	Industry
Increase dissolved oxygen level	O	O	O
Reduce floating oil, grease etc.			O

Wastewater treatment managed by sewerage schemes mainly remove organic matter and nutrients to some extent. Removal of oil/grease and other toxic materials such as heavy metals will not be possible and will hinder the functioning of wastewater treatment.

2.2.2 REQUIRED LEVEL OF WASTEWATER TREATMENT

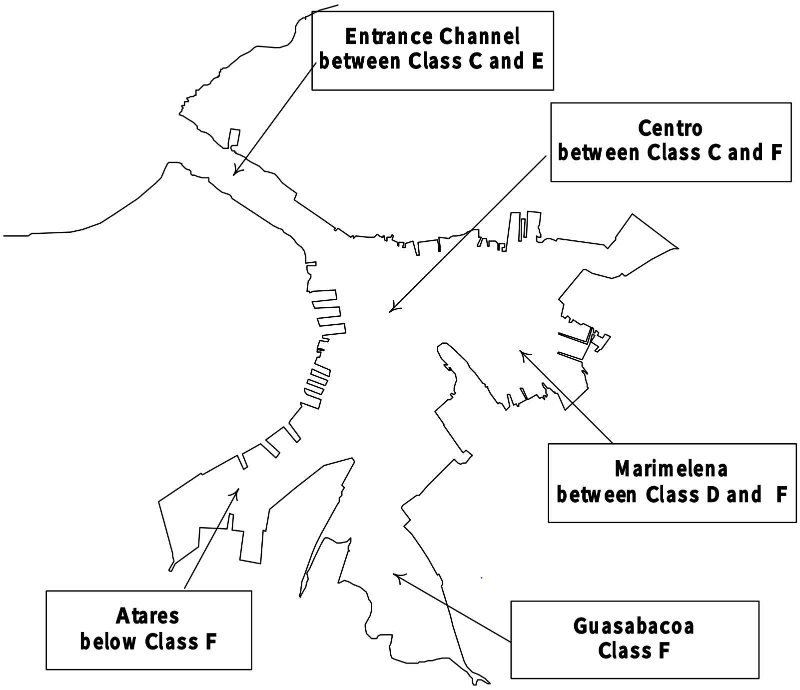
(1) General

Water quality objectives of the water bodies depends on the intended use of water bodies for example navigation, source of cooling water for industries, fishing etc. To achieve and maintain the water quality objectives, either water quality standards for the water bodies or discharge standards to the water bodies are set. In some cases, both standards are also set.

In case of new sewerage system in the Havana Bay Basin, wastewater effluent can be discharged either within the bay basin to Havana Bay through rivers or directly to sea through a sea-outfall.

For discharge within the bay basin, receiving water bodies are the rivers and the bay. For rivers, discharge standards are set by NC-27 (1999) “Discharge Standards to Inland Surface Waters”. Rio Luyanó and Rio Martin Pérez are in the category of Type B rivers for agriculture use. One of the water quality goals is set to a minimum of 3 mg/L of DO corresponding to Class E water body. By carrying-out water quality simulation for different scenarios of sewerage system development, required level of treatment is determined to achieve the water quality goal. Level of treatment to be adopted shall satisfy discharge standards to rivers as well as the water quality goal of the bay.

For discharge to sea, effluent standards set under the Land Based Sources Protocol (LBS Protocol) which followed the Cartagena Convention will become necessary to protect the environment of Greater Caribbean.



Note: Comparison is to the DO levels measured in this Study.

Draft Coastal and Bay Water Quality Standards

Parameter	Unit	Type Water Body				
		Class A	Class C	Class D	Class E	Class F
Dissolved oxygen (DO)	mg/L	5.0	5.0	4.0	3.0	2.0
Total coliforms	MPN/100 mL	100	250	250	1000	5000

Note: Standards for Class B are not available.

Class A - Coral reef areas, areas for ecological conservation or protected areas
Class B - Marine areas reserved for bathing and recreational activity where persons in direct contact with water
Class C - Marine areas for fishery development
Class D - Marine areas where sea water is used as cooling water for power generation
Class E - Bay areas developed for port activity
Class F - Marine areas without specific use

THE DEVELOPMENT STUDY ON THE IMPROVEMENT OF SEWERAGE AND DRAINAGE SYSTEM FOR THE HAVANA BAY

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Figure 2.2 Comparison of DO Levels in Havana Bay (Year 2002) to Draft Standards

(2) Scenario of Pollution Control

To determine the level of wastewater treatment, water quality simulation for several scenarios of pollution reduction was carried out. Scenarios include primary treatment, secondary treatment and advanced treatment of pollution load generated within area covered by the sewerage system and other measures such as pollution reduction of refinery wastewater effluent, reduction of internal sediment load etc.

Out of the several scenarios studied, following scenarios are pertinent for discharge within the bay. They are:

Case 2 - Future (2020) with implementation of only GEF/UNDP Projects (Zone 4 and Zone 6)

Case 4 - Secondary treatment in new sewerage system and elimination of cross-connections in existing sewerage system

Case 5 - Primary treatment in new sewerage system and elimination of cross-connections in existing sewerage system

Case 6 - Advanced treatment in new sewerage system and elimination of cross-connections in existing sewerage system

Case 2 represents future condition in year 2020 with on-going GEF/UNDP projects for Zone 4 and Zone 6 are completed and without implementation of any other projects. In this case, pollutant load reduction will be for Dren Agua Dulce which will be diverted and treated together with industrial wastewater near the mouth of Rio Luyanó and for part of the areas in Luyanó-Abajo (Zone 6).

In Case 4, provision of secondary wastewater treatment in all of the sewer districts in Rio Luyanó, Rio Martin Pérez and in Arroyo Tadeo and elimination of pollution load discharged through stormwater drains generated in the existing sewerage system through improvement of cross-connections is considered. Case 4 signifies what could be achieved by new wastewater treatment system proposed in terms of organic pollution load reduction.

In Case 5, wastewater treatment level in the new sewerage system if primary treatment is provided in the new sewerage system instead of secondary treatment as in Case 4. Therefore, organic pollution load reduction will be less than that can be achieved in Case 4.

Case 6 in which effect of enhanced removal of nutrients through advanced treatment to the wastewater generated in the new sewerage system is considered.

(3) Results of Water Quality Projection

1) DO

Significant improvement in DO can be observed between Case 2 and Case 4 as shown in Figure 2.3. DO levels reach 3 mg/L in Atares which is the most polluted part of the bay in terms of organic pollution. With Case 3 i. e. primary treatment DO levels in Atares fall below 3 mg/L and therefore not sufficient to achieve water quality goals. Improvement of DO levels in Atares in Case 4 is due to improvement of DO levels resulting in Guasabacoa with secondary treatment as there will be no change in the pollution input to Atares which receives wastewater through drains.

2) BODd

Difference in BODd concentration (dissolved bio-degradable organic matter) in Guasabacoa between Case 4 (secondary treatment) and Case 5 (primary treatment) is due to level of treatment whereas no significant improvement between Case 4 (secondary treatment) and Case6 (advanced treatment) can be observed.

3) NH_4-N and PO_4-P

In case of nutrients, significant improvement in Gusabacoa can be observed in Case 6 (advanced treatment) due to removal of nutrients.

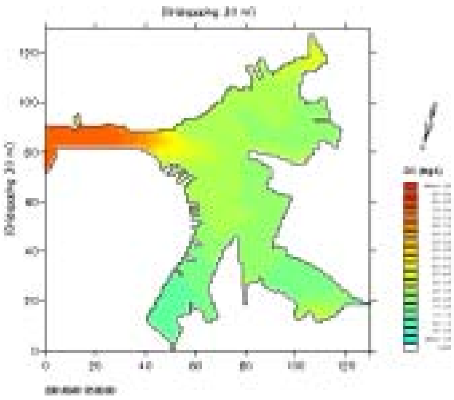
4) Chl-a

Simulated Chl-a concentration in Case 4 (secondary treatment) is approximately 6 µg/L which similar to the levels observed outside the bay. With Case 6 (advanced treatment) overall reduction of Chl-a concentration in all parts of the bay was observed.

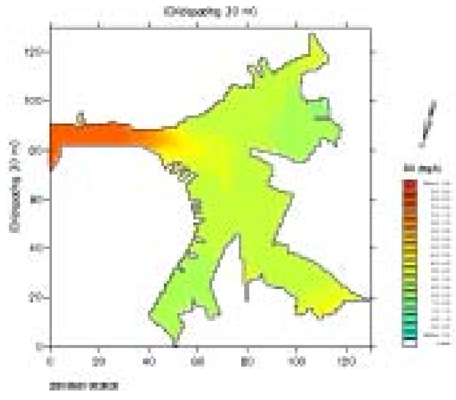
(4) Level of Wastewater Treatment

Based on the comparison of simulation results and the required water quality goal of minimum DO level of 3 mg/L in the bay the followings can be said.

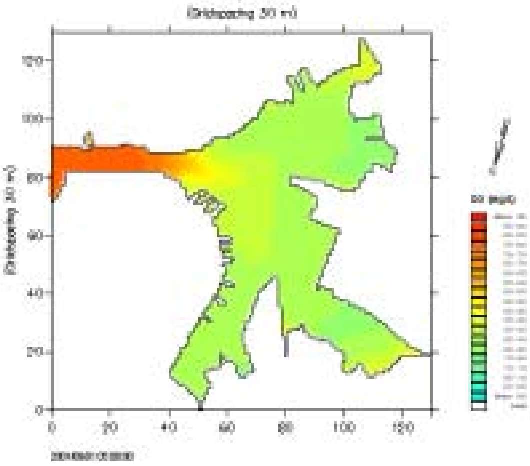
- To achieve minimum DO level of 3 mg/L in Atares where DO level is the lowest, it is necessary to provide secondary treatment to all the wastewater generated in the new sewerage system.
- With secondary wastewater treatment for wastewater generated in the new sewerage system, simulation results do not show tendency of eutrophication. With the limitation in the number of data sets available and its extreme scatter especially in the data of total nitrogen and total phosphorous load to the bay and Chl-a which is the index of eutrophication, need for the provision of advanced wastewater treatment could not be justified at this stage.
- It is therefore concluded that development of new sewerage system shall be with secondary wastewater treatment to reduce the organic pollution load which severely affects coves of Atares and Guasabacoa.



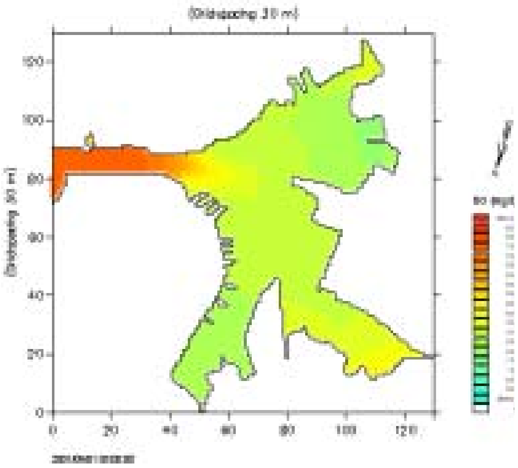
Case 2 DO



Case 4 DO



Case 5 DO



Case 6 DO

THE DEVELOPMENT STUDY ON THE IMPROVEMENT OF SEWERAGE AND DRAINAGE SYSTEM FOR THE HAVANA BAY	Figure 2.3 Results of DO Levels for Different Levels of Wastewater Treatment
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2.3 PLANNING FRAMEWORK OF SEWERAGE SYSTEM

2.3.1 PLANNING AREA

Table 2.3 summarizes the sewerage planning area covers a total of about 6,500 ha comprising 5,700 ha within Havana Bay basin and 800 ha out the basin. The area of 100 ha covered by other sewerage scheme and the area covered by on-site sanitation or factories are excluded in the Study. The sewer planning area was selected to encompass all feasible wastewater collection areas consistent with topography, probable future population concentrations and distributions, and future housing development districts.

Table 2.3 Sewerage Planning Area (Year: 2020)

Item	**Area**	Remarks
1. Sewerage Planning Area in this Study	**6,432.2** ha	
within Havana Bay Basin	5,665.3 ha	
out of Havana Bay Basin	766.9 ha	
Total	6,432.2 ha	
2. Sewerage Planning Area by other scheme	**97.1** ha	
5. On-site Treatment	**1,086.6** ha	
Sanitation	851.0 ha	
Factory	235.6 ha	
Total	1,086.6 ha	

Source: JICA Study Team

2.3.2 POPULATION

The total population within the basin is set at 800,000 in 2020 as the same level of 1996. The population of each municipality within the Havana Bay basin was estimated based on the census data and other detailed data and information in 1996. The ratio of the population within the basin against the total population is used to estimate the future population of each municipality within the basin in 2020. Table 2.4 summarizes the population distribution within the basin. These population figures will be used for sewerage planning bases.

Table 2.4 Population Projection within Havana Bay basin

Municipality related Havana Basin	*** 1996**	**2001**	**2005**	**2010**	**2015**	**2020**
Plaza de la revolucion	9,395	9,400	9,400	9,400	9,500	**9,500**
Centro habana	86,106	78,700	77,800	76,800	75,700	**74,600**
Habana vieja	105,178	95,000	94,400	93,600	92,800	**92,000**
Regla	41,798	42,200	43,100	44,300	45,500	**46,700**
La habana del este	15,025	15,500	16,500	17,700	19,000	**20,200**
Guanabacoa	24,354	24,400	25,400	26,700	27,900	**29,200**
San miguel del padron	145,880	144,800	149,700	155,900	162,000	**168,200**
Diez de octubre	239,768	228,700	228,000	227,100	226,200	**225,300**
Cerro	97,507	95,200	96,000	96,900	97,900	**98,800**
Arroyo naranjo	31,087	31,700	32,500	33,500	34,500	**35,500**
Total	796,098	765,600	772,800	781,900	791,000	**800,000**

*:**Estudio de Diagnostico sobre Asentamiento Humano en la Cuenca Bahia dela Habana**

Source: JICA Study Team

Table 2.5 summarize sewer service population; a target population to be served by public sewerage system.

Table 2.5 Sewer Service Population (Year: 2020)

Item	**Population**	Remarks
1. Population in Ciudad Habana	2,110,256	
2. Population within Study Area (Havana Bay Basin)	800,000	
3. Sewer Service Population in this Study	**884,700**	
within Havana Bay Basin	**725,600**	
out of Havana Bay Basin	**159,100**	
Total	884,700	
4. Population in other sewerage scheme	19,900	
5. Population served by on-site Treatment	54,500	
Sanitation	54,500	
Factory	0	
Total	54,500	

Source: JICA Study Team

2.3.3 WASTEWATER GENERATION

(1) Basics

Wastewater is classified into following four categories based on water supply conditions and each categorized wastewater generation is estimated as shown in the table below.

Table 2.6 Wastewater Generation

Wastewater	**Equation**
1. Domestic Wastewater	Per Capita Water Consumption Rate x Wastewater Generation Rate x Population
2. Commercial, Institutional and Industrial Wastewater, from small pollution source	Per Capita Water Consumption Rate x Wastewater Generation Rate x Population
3. Commercial and Institutional Wastewater, from large pollution source	Water consumption data x Wastewater Generation Rate
4. Industrial Wastewater, from large pollution source	Water consumption data x Wastewater Generation Rate

The future wastewater generation in 2020 is estimated based on the Cuban Norm of water supply and actual water supply data for large water consumer together with a future economic growth up to 2020.

(2) Future per capita wastewater generation

Table 2.7 summarizes the future per capita wastewater generation rates are set by category for planning purposes, base on the Cuban Norm of Water Demand with assuming wastewater generation rate of 0.9.

Table 2.7 Future Per Capita Wastewater Generation

<table>
<tr><th>Item</th><th>Unit</th><th>Domestic</th><th>Commercial</th><th>Public</th><th>Small Industry</th></tr>
<tr><td>Per capita water consumption (Norma Cubana)</td><td>lpcd</td><td>220</td><td>132</td><td>66</td><td>23</td></tr>
<tr><td>Water use not discharged to sewer</td><td>lpcd</td><td>-</td><td>-</td><td>20</td><td>-</td></tr>
<tr><td>Loss accounted in the norm</td><td>%</td><td colspan="4">15</td></tr>
<tr><td rowspan="2">Net per capita water consumption</td><td rowspan="2">lpcd</td><td rowspan="2">187</td><td>112</td><td>39</td><td>20</td></tr>
<tr><td colspan="3">171</td></tr>
<tr><td>Wastewater generation rate</td><td>%</td><td colspan="4">90</td></tr>
<tr><td>Net wastewater generation rate</td><td>lpcd</td><td>168.3
=> 168</td><td colspan="3">153.9
=>154</td></tr>
</table>

Source: JICA Study Team

(3) Wastewater Generation

Table 2.8 summarizes the wastewater generation.

Table 2.8 Summary of Wastewater Generation

Item	**Population**		**Wastewater Generation (m^3/d)**	
	2001	**2020**	**2001**	**2020**
1. Within Study Area (Havana Bay Basin)	**765,800**	**800,000**	**240,300**	**256,900**
2. Total in the Study	**862,600**	**884,700**	**268,600**	**315,900**
2.1 Domestic wastewater generation	-	-	145,000	148,600
2.2 Non-domestic wastewater generation by small user	-	-	94,900	136,300
2.3 Non-domestic wastewater generation by large user	-	-	28,800	31,000
3. Sewerage total within Havana Bay basin	**703,500**	**725,600**	**216,500**	**256,800**
3.1 Domestic wastewater generation	-	-	118,200	121,900
3.2 Non-domestic wastewater generation by small user	-	-	77,400	111,700
3.3 Non-domestic wastewater generation by large user	-	-	20,900	23,200
4. Sewerage total out of Havana Bay basin	**159,100**	**159,100**	**52,100**	**59,100**
4.1 Domestic wastewater generation	-	-	26,700	26,700
4.2 Non-domestic wastewater generation by small user	-	-	17,500	24,500
4.3 Non-domestic wastewater generation by large user	-	-	7,900	7,900
5. Other sewerage scheme	**14,900**	**19,900**	**4,200**	**6,400**
6. On-site Treatment	**47,400**	**54,500**	**13,200**	**24,000**
Sanitation	47,400	54,500	13,200	17,600
Factory	0	0	6,400	6,400

Source: JICA Study Team

2.3.4 POLLUTION LOAD

(1) Domestic Wastewater

For sewerage planning purpose, the following per capita pollutants loads are used to estimate domestic origin pollutants. The unit load of BOD are set based on the data of Cuba as discussed in Chapter 4 and those of SS, T-N and T-P are set based on typical domestic wastewater concentrations in literature.

Table 2.9 Per Capita Pollutant Load

Per capita pollutant load	- 40 g BOD_5 /capita/d
	- 40 g SS* /capita/d
	- 7.4 g T-N/capita/d
	- 1.9 g T-P/capita/d

Source: JICA Study Team

(2) Non-domestic Wastewater by small water users

Per capita pollutant load of non-domestic wastewater discharged by small water users are set assuming followings:

- Water quality is similar to grey water component of domestic wastewater
- Ratio of pollutant load generated by toilet use (excreta) and grey water (sullage) is assumed based on literature as follows:

Table 2.10 Per Capita Pollutant Load in toilet wastewater and grey water

Load (g/capita/d)	**BOD_5**	**SS**	**T-N**	**T-P**
- toilet	18	18	5.2	1.3
- grey water	22	22	2.2	0.6

Note: For T-N and T-P, their ratio in toilet and grey water is 70% : 30% respectively.

(3) Non-domestic Wastewater by large water users

Non-domestic wastewater discharged from large water consumers (commercial, institutional and industrial) are estimated under the following conditions:

- For food processing industries, future effluent quality for discharge into public sewer is set to the maximum concentration acceptable for discharge to public sewers (300 mg/L BOD5, 300 mg/L SS, 50 mg/L T-N and 10 mg/L T-P).
- Average effluent quality of electrical/machinery industries is set at 100 mg/L BOD5, 100 mg/L SS, 15 mg/L T-N and 5 mg/L T-P.
- Approximate volume ratio of food processing to electrical/machinery industry is 70 % versus 30%.

2.3.5 INFLOW/INFILTRATION

A fixed I/I rate of 20 to 40 lpcd will be added to all wastewater flowing conditions. This fixed rate is considered to be of a reasonable assumption, taken into consideration of geographic conditions, sewer installation practice, and the planning and design report on existing sewer system “Analisis Hidraulico del Sistema de Alcantarillado Principal de Ciudad de La Habana, 1996”, estimated that the I/I rate is $5m^3$/ha/dia for Colector Norte and Sur, and $3m^3$/ha/dia for other collectors, and the I/I rate is also estimated as per capita: 19.4 lpcd..

2.4 STUDIES ON IMPROVEMENT AND DEVELOPMENT OF SEWERAGE SYSTEM

2.4.1 GENERAL

Different approaches have been used to formulate the improvement plan of the existing sewerage system and the development plan of a new sewerage system.

For the improvement plan of the existing sewerage system, the present problems are analyzed at first to identify the reasons and to prepare appropriate solutions. Engineering studies have been conducted to prepare the Central Sewerage Improvement Plan, comprising following plans:

- Plan of measures to eliminate the wastewater discharge through the drainage channel to the Havana Bay.
- Rehabilitation and improvement plan of important Colectors.
- Alternative Study on the Central sewerage system after the screen facilities to the ocean outfall sewer to select the best alternative.

For the development plan of new sewerage system, an alternative study has been conducted to select the best alternative for the most effective and efficient new sewerage system in terms of pollution loads reduction and costs. Based on the final destination of the treated wastewater discharge, five alternatives are prepared for the discharge to the Havana Bay, which are comprising from the five zonal sewerage systems to the integrated (one) sewerage system and one alternative are prepared for the ocean discharge.

2.4.2 IMPROVEMENT OF THE EXISTING SEWERAGE SYSTEM

The proposed improvement plan of the existing sewerage facilities is summarized in the table below.

Table 2.11 Proposed Improvement Plan of the Existing Central Sewerage System

Item	Proposed Plan	Remarks
1. Design Flows		
Average Daily Flow	230,600 m^3/day	
Maximum Daily Flow	272,000 m^3/day	
Maximum Hourly Flow	329,500 m^3/day	
3. Projected Influent Quality	BOD: 190 mg/L, SS: 190 mg/L	Unless any inflow of water and storm water.
4. Effluent Quality Standards	BOD: 150 mg/L, TSS: 150 mg/L	The Greater Caribbean
5. Improvement Plan		
5.1 Detailed Surveys on cross connections to prepare appropriate solution measures.	To conduct Detailed Surveys for identifying the cross connections and preparing solution measures to eliminate the direct wastewater discharge through the Dren Matadero and the Dren Agua Dulce to Atares.	
5.2 Rehabilitation of the inadequate capacity of Colectors	The inadequate capacity of the existing Colectors in the Centro Habana, Cerro, Sur 1, Sur 2 and Sur 3 will be added or replaced with new Colectors.	
5.3 Rehabilitation of Colector Sur and Construction of the proposed Colector system	Rehabiltation of Colector Sur (Dia.: 1500 to 2100mm, CP, Length: 2.78km) and Construction of the proposed Colector system: pumped main (Dia.: 1,350mm, CP, Length 1,020m), Colector Sur Nuevo (Dia. 1500mm, CP, Length: 1,830m), and interconnection pipe (Dia.:1,030(/1200)mm, HDPE, to 1500mm, CP, Length: 500m) Construction of the proposed Colector Sur A (Open Cut, Dia.1500mm, CP, Length: 580m, and Tunnelling, Dia.1500mm, CP, Length:1070m) Construction of the proposed Matadero pumping station, Q=20 m^3/min, H=12 m, 3 units including one standby. During the rehabilitation of Colector Sur, additional Q=40 m^3/min, H=12 m, 2 units will be installed.	Dia.: Inner diameter of sewer. CP: Centrifugal reinforced concrete pipe. HDPE: High density polyethylene pipe. Figure of diameter in the parenthesis shows an outer diameter of sewer.
5.4 Rehabilitation of Screen Facilities and Detailed Survey of Siphon Structure	To rehabilitate the screen facilities (2 units) at Caballeria, and to conduct detailed surveys on physical conditions of siphon structures to prepare rehabilitation plans.	
5.5 Rehabilitation of Casablanca Pumping Station	To replace the pump equipment (Q=1.75 m^3/s, H=8 m), 4 units including one unit standby.	
5.6 Rehabilitation of transmission tunnel and construction of pumping station to discharge the wastewater to the ocean by installation of new ocean outfall sewer	To discharge the wastewater by new ocean outfall sewer with minor repairs of the transmission tunnel, a pumping station, Q=1.75 m^3/s, H=5 m, 4 units including one standby, shall be constructed after the tunnel to mitigate the water head loss. The wastewater can be transmitted gravity flow in the tunnel, thus a simple repair work such as inner lining can be applicable.	
5.7 Wastewater Primary Treatment and Sludge Treatment Facilities	To meet the greater Caribbean wastewater effluent standards, a construction of wastewater primary treatment and sludge treatment facilities may be necessary in the future. A general layout plan of the treatment facilities is prepared.	The necessity of construction shall be decided based on the influent quality prior to the execution of the plan.
5.8 Installation of Ocean Outfall Sewers	To install an ocean outfall sewers 300m in length including two diffuser pipes of 140m long.	

Source: JICA Study Team

2.4.3 DEVELOPMENT PLAN OF NEW SEWERAGE SYSTEM UP TO THE YEAR 2020

(1) Results of Alternative Study

The study on six (6) alternatives selected the Alternative, comprising four zonal sewerage systems as the new sewerage plan for the Havana Bay basin. Comparison of an implementation plan up to the year 2020 prepared for each alternative demonstrated that the Luyanó-Martín Pérez Abajo sewer district would reduce the pollution loads to the Havana Bay most effectively and efficiently, because the coverage areas possible by 2020 are densely populated and exit many factories.

(2) Issues

To adopt the selected new sewerage plan for the Luyanó-Martín Pérez Abajo sewer district as the new sewerage development plan up to the year 2020, the following issues were identified and needed to study further:

- A study on possibility of Cuban proposal to divert the wastewater from part of the Luyanó sewer district to the Central sewerage system for final disposal to ocean through the Casablanca pumping station.
- The candidate site for WWTP of the Lunanó-Martín Pérez Abajo sewer district in the alternative study is very difficult to obtain because it is already planned to use as a container stock yard. GTE and INRH proposed that the site of WWTP for GEF/UNDP project could be expanded to construct the proposed WWTP for the Lunanó-Martín Pérez Abajo sewer district. Coordination is required for the design of wastewater treatment and sludge treatment between JICA Study Team and the Cuban design institutes for GEF/UNDP Project.

On the first issue, the possibility of the Cuban proposal was studied and a partly revised plan was accepted as an alternative plan of the second stage components of the proposed new development plan of the Master Plan.

To solve the second issue, coordination and adjustment have been done to demarcate the sewer service area, to prepare the treatment plant layout, and to provide design conditions to construct the common facilities such as influent pumping station, preliminary treatment facilities, and administration/operators buildings.

The wastewater treatment process be constructed under the GEF/UNDP Project is required to meet high nutrient removal rates, thus an advanced treatment process will be needed. However, as mentioned in the previous section 2.2, the first priority is given to the removal of the organic matters in our Study, in other words, a secondary process will be applied for the expanded treatment facilities. Therefore, we proposed that major wastewater treatment facilities will be constructed separately due to the different wastewater treatment levels, except common facilities such inlet pumps, screen equipment and grit chambers, and administration/operator buildings.

(3) Development Plan of New Sewerage System up to the Year 2020

Table 2.12 presents the new sewerage development plan up to year 2020 for the part of Sewerage Master Plan. It is proposed that all the wastewater generated in the Luyanó-Martín Pérez Abajo sewer district will be treated at the Luyanó WWTP in principle.

Table 2.12 Outline of New Sewerage Development Plan up to the year 2020

Item	Luyanó-Martín Pérez Abajo Sewer District	Proposed Total with GEF/UNDP
1. Sewer Service Population	138,300	163,600
2. Sewerage Service Area	1,054 ha	1,300 ha
3. Wastewater Generation as of year 2020	47,940 m^3/d	56,400 m^3/d
Domestic	23,240 m^3/d	27,485 m^3/d
Non-domestic (small consumers)	21,300 m^3/d	25,194 m^3/d
Non-domestic (large consumer)	3,400 m^3/d	3,704 m^3/d
4. Wastewater Collection System		
4.1 Sewer Networks	*Dia.: 216/250 mm, HDPE, Length: 212 km (Luyanó-Martín Pérez Right Colector: 105 km long, Luyanó Left Colector: 107 km long)	
4.2 Sewer Main (Colector)	Luyanó-Martín Pérez Right Colector: Open Cut Method: Dia.: 216/250mm to 1030/1200mm, HDPE, Length: 13.0 km, Tunneling Method: Tunnel Dia. 1500mm, Length: 5.4 km. Inserted Inner Pipe Dia. 216/250 mm to 1030/1200mm, HDPE.	
	Luyanó Left Colector: Open Cut Method: Dia. 216/250mm to 1030/1200mm, HDPE, Length:13.0 km, Tunneling Method: Tunnel Dia. 1500mm, Length: 1.3 km, Inserted Inner Pipe Dia. 535/630 mm to 1030/1200mm.	
5. Wastewater Treatment Plant	Luyanó WWTP	
5.1 Design Capacity	53,700 m^3/d (621 L/s)	71,000 m^3/d (821 L/s)
5.2 Wastewater Treatment Level and Process	Secondary Treatment Level, Conventional Activated Sludge Process; Preliminary Treatment + Primary Sedimentation + Aeration + Final Sedimentation + Sludge Return	
5.2 Sludge Treatment and Disposal	Sludge thickener + Anaerobic Digestion + Mechanical Dewatering +Disposal (Sanitary Landfill)	

Note: *The diameter of the HDPE (High density polyethylene pipe) are shown both inner diameter/outer diameter.
Source: JICA Study Team

(4) Alternative of Wastewater Ocean Disposal for the Area of Luyanó Left Colector

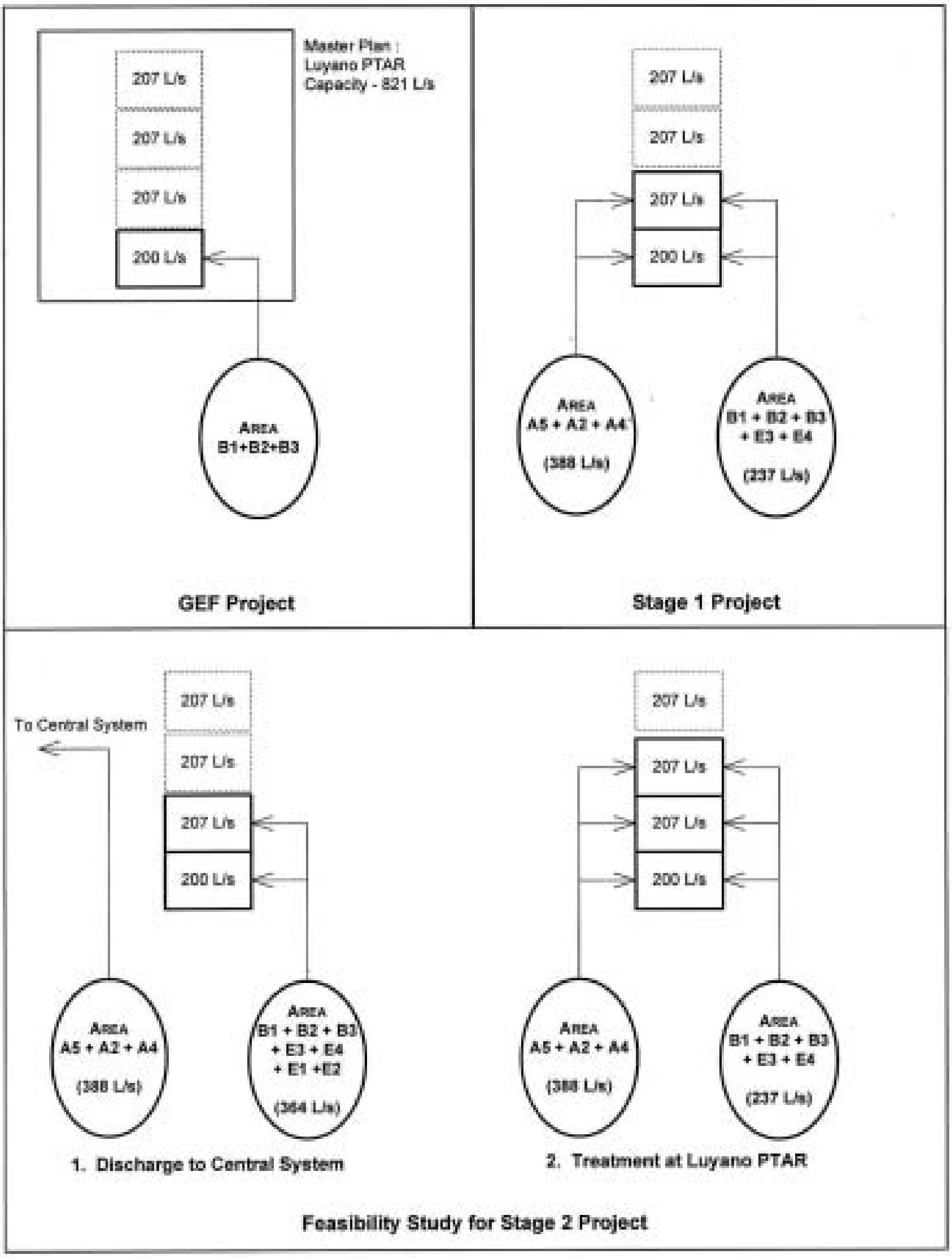
The ocean disposal plan for the wastewater collected by the Luyanó Left Colector may be possible to implement as an alternative plan for the expansion plan of treatment facilities at the WWTP under the proposed second stage project.

The wastewater generated from the left bank of Rio Luyanó could be conveyed by the proposed new Colector system, comprising Colector Sur A, Matadero Pumping Station, pumped main and Colector Sur Nuevo for the Colector Sur through the Casablanca pumping station to the ocean.

To realize this alternative, the cross connection problems in drainage area of Dren Arroyo Matadero should be solved during the first stage project, and during the second and third stages, the cross connection problems in the drainage area of Dren Agua Dulce should be also solved.

When this alternative is applied for the second stage project for the new sewerage development, the expansion plan of treatment facilities at the Luyanó WWTP as proposed as a part of Master Plan is needed to revise after the second stage:

- Expansion plan of the treatment facilities under the second stage project would be cancelled as illustrated in Figure 2.4.
- The treatment capacity of 407 L/s or 35,200 m^3/d at the end of the first stage project could receive and treat the wastewater generated in the expanded area without any expansion in the treatment capacity. Figure 2.4 illustrates this situation as shown in the left-bottom figure in case of Feasibility Study for 2^{nd} stage project.
- When the ocean disposal alternative would be implemented after the second stage project, it is recommended that the proposed plan of four zonal sewerage systems should be reviewed and revised including an evaluation of the improvement effects on bay water quality by the implemented projects. The revision of the sewerage plan should include a study that the Luyanó Arriba Sewer District could be unified with the Luyanó-Martín Pérez Abajo Sewer District to treat all wastewater at the Luyanó WWTP.



Note: All flows shown in L/s are daily maximum flows.

Figure Staged Implementation (Draft) of Luyano PTAR

THE DEVELOPMENT STUDY ON THE IMPROVEMENT OF SEWERAGE AND DRAINAGE SYSTEM FOR THE HAVANA BAY	Figure 2.4 Schematic Staged Capacity Development Plan of the Luyanó WWTP
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2.5 SEWERAGE SYSTEM MASTER PLAN

2.5.1 PROPOSED SEWERAGE SYSTEM

Table 2.13 shows the outline of the proposed sewerage master plan, in which the proposed sewerage system will be improved and constructed up to the year 2020.

2.5.2 PROPOSED IMPLEMENTATION SCHEDULE

A staged construction of the proposed sewerage system components will spread capital expenditures over an extended period of years. An entire 15-year sewerage implementation program is proposed for realization of the proposed sewerage plan up to the year 2020 as shown in Figure 2.5. The implementation program will be divided into three consecutive construction stages, starting at the earliest in 2006 and ending in 2020.

Table 2.13 Summary of the Proposed Sewerage Master Plan

Item	(A) Proposed Sewerage Master Plan (up to the year 2020)	(B) Breakdown 1 : Improvement of Existing Central Sewerage System	(C) Breakdown 2: New Sewerage System Development in the Luyanó-Martín Pérez Abajo Sewer District	(D) Within Study Area (Havana Bay Basin)	Coverage Ratio (A)/(D)
1. Sewer Service Population	Total Service Population: **750,600** Within the Study Area: **591,500** Out of the Study Area: **159,100**	Service Population: **587,000** Within the Study Area:**427,900** Out of the Study Area: 159,100	Sewer Service Population: **163,600** Proposed implementation plan: **138,300** By GEF/UNDP Project: 25,300	Total Population: 800,000	74 %
2. Sewerage Service Area	Total Area: 4,289 ha **Within the Study Area: 3,522** ha From out of the study area: 767 ha	Total Sewered Area: 2,989 ha **Sewered Area within Study Area: 2,222** ha, From out of the study area: 767 ha	Total Sewered Area: **1,300 ha (1,628 ha)**, Proposed Sewered Area **1,054 ha**, By GEF/UNDP Project: 246 ha	Total Area: 5,665 ha,	62 %
3. Wastewater Generation as of year 2020	**Within: 204,600** m^3/d Total: 263,700 m^3/d	**Within**: **148,200** m^3/d Total 207,300 m^3/d	**56,400** m^3/d By the implementation plan (47,940 m^3/d)	256,900 m^3/d	80 %
Domestic	**Within: 99,373** m^3/d Total: 126,102 m^3/d	**Within: 71,888** m^3/d Total 98,617 m^3/d	**27,485** m^3/d By the implementation plan (23,240 m^3/d)	121,900 m^3/d	82 %
Non-domestic (small consumers)	**Within: 91,091** m^3/d Total: 115,592 m^3/d	**Within: 65,897 m^3/d** Total: 90,398 m^3/d	**25,194** m^3/d By the implementation plan (21,300 m^3/d)	111,800 m^3/d	82 %
Non-domestic (large consumer)	**Within: 14,081** m^3/d Total: 21,918 m^3/d	**Within: 10,377 m^3/d** Total: 18,214 m^3/d	**3,704** m^3/d By the implementation plan (3,400 m^3/d)	23,100 m^3/d	61 %
4. BOD Pollution Loads as of year 2020					
Generated Load	43.4 ton/d	31.7 ton/d	11.7 ton/d	78.4 ton/d including other three sewer districts exclude in M/P of 11.1 ton/d, sanitation of 2.2 ton/d and refinery of 21.7 ton/d.	55 %
Discharged Load to Havana Bay	1.2 ton/d	0.0 ton/d	1.2 ton/d	36.2 ton/d	
Reduced Load to Havana Bay	42.2 ton/d	31.7 ton/d	10.5 ton/d	52.2 ton/d Potential by sewerage	81 % of the expected

Table 2.13 Summary of the Proposed Sewerage Master Plan (Continued)

Item	(A) Proposed Sewerage Master Plan (up to the year 2020)	(B) Breakdown 1 : Improvement of Existing Central Sewerage System	(C) Breakdown 2: New Sewerage System Development in the Luyanó-Martín Pérez Abajo Sewer District	(D) Within Study Area (Havana Bay Basin)	Coverage Ratio (A)/(D)
5. Proposed Phased Implementation Program (Sewerage Master Plan)					
5.1 First Stage Project	Project components are the combination of the components shown in the right two columns.	To conduct the detailed cross connection surveys to identify and prepare design works for installation of connection pipe to solve the problem in the area related to the Dran Matadero. To conduct detailed surveys on physical conditions of the siphon structure and prepare a rehabilitation plan including installation of additional siphon structure. To take measures to solve the cross connections in the area related to the Dren Matadero. To rehabilitate the two units of screen facilities at Caballeria. To rehabilitate the Casablanca Pumping station including replacement of the existing pump equipment with new 4 units, Q=1.75 m^3/s, H=8 m, including one standby. To construct the proposed Matadero Pumping Station. To installation of the proposed interconnection pipe between the Colector Cerro and the Matadero Pumping Station. To install the proposed Pumpted Main and Colector Sur Nuevo between the Matadero Pumping Station and the Screen Facilities at Caballeria.	To install the proposed Luyanó-Martín Pérez Right Colector. To install the proposed Luyanó Left Colector. To construct the biological secondary wastewater treatment facilities at the Luyanó WWTP, having the treatment capacity of 207 L/s, which makes the total treatment capacity of 407 L/s or 35,200 m3/d including the capacity of 200 L/s developed by the GEF/UNDP Project. To install sewer networks and house connections in the Luyanó-Martín Pérez Abajo sewer district.		
5.2 Second Stage Project	Project components are the combination of the components shown in the right two columns.	To conduct the detailed cross connection surveys to identify and prepare design works for installation of connection pipe to solve the problem in the area related to the Dran Agua Dulce. To take measures to solve the cross connections in the area related to the Dren Agua Dulce. To rehabilitate the Colector Sur. To construct the Colector Sur A To construct a pumping station (Re-pumping station) after the transmission tunnel, 4 units of =1.75 m^3/s, H=5 m including one standby. To conduct a minor repair work for the existing transmission tunnel. To replace the ocean outfall sewer.	To extend the Luyanó-Martín Pérez Right Colector. To extend the Luyanó Left Colector. To expand the treatment capacity of the Luyanó WWTP by 207 L/s, which makes the total treatment capacity of 614 L/s or 53,100 m^3/d. To install sewer networks and house connections in the Luyanó-Martín Pérez Abajo sewer district.		
5.3 Third Stage Project	Project components are the combination of the components shown in the right two columns.	To take measures to solve the cross connections in the area related to the Dren Agua Dulce.	To extend the Luyanó-Martín Pérez Right Colector. To extend the Luyanó Left Colector. To expand the treatment capacity of the Luyanó WWTP by 207 L/s, which makes the total treatment capacity of 821 L/s or 71,000 m^3/d. To install sewer networks and house connections in the Luyanó-Martín Pérez Abajo sewer district.		

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Figure 2.5 General Implementation Schedule

			Preparatory			First Stage					Second Stage					Third Stage				
No.	**Stage**	**Item**	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
0.		JICA Study																		
1.	**1st**	**Financing Arrangements (Loans, etc.,)**																		
2.1		**Selection of International and Local Consultants**																		
2.2		**Detailed Design and Tendering**																		
3.		**Pre Qualification and Contract**																		
4.		**Execusion of the 1st Stage Project Components**																		
5.		**Construction Supervision**																		
6.	**2nd**	**Financing Arrangements (Loans, etc.,)**																		
7.1		**Selection of International and Local Consultants**																		
7.2		**Detailed Design and Tendering**																		
8.		**Pre Qualification and Contract**																		
9.		**Execusion of the 2nd Stage Project Components**																		
10.		**Construction Supervision**																		
11.	**3rd**	**Financing Arrangements (Loans, etc.,)**																		
12.1		**Selection of International and Local Consultants**																		
12.2		**Detailed Design and Tendering**																		
13.		**Pre Qualification and Contract**																		
14.		**Execusion of the 3rd Stage Project Components**																		
15.		**Construction Supervision**																		

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2.5.3 INSTITUTIONAL STRENGTHENING

(1) Government Agencies

Institutional strengthening for Cuban major government institutions related to the sewerage and environment of Havana Bay is proposed and summarized in the table below.

Table 2.14 Recommendations of Strengthening for Government Institutions

Institutions	Recommendations
GTE	It plays a great role in the control of the pollution, as well as the water quality monitoring. It coordinates the environmental functions of MINAG, MINSAP and MIP within the Bay to strengthen its position as the leading group responsible for the environment of the Bay. It also receives sufficient funding to take responsible for an integrated water quality data base.
CITMA	More laws and regulations in the environmental sector are required to strengthen the Environmental Law (No.81) and ensure enforcement. There may be a need for strengthening the administrative and executive capacity.
INRH/DPRH	It is a viable institution and does not require any strengthening.
Others	MINBAS should be in charge of hydrocarbon pollution, yet MINBAS does not appear to be within the institutional framework regarding pollution of the bay.

(2) Water and Sewerage Corporations

It is likely that the mixed enterprise Aguas de la Habana will expand and take over the service area of Acueducto del Este in the near future and certainly well before the proposed commencement of the sewerage MP. Under the institutional arrangement of the concession, INRH will become the owner of the assets on behalf of the state, and Aguas de la Habana will operate and maintain them.

The mixed enterprise Aguas de la Habana is about three years into its twenty five year concession agreement with Aguas de Barcelona, and has already achieved major improvements in the management of operations and the rehabilitation of the assets.

Additional staff required for operation and maintenance of the proposed sewerage facilities are recommended, the staff will be hired newly or transferred from other sections in the corporation. Table below represents the proposed staff number necessary to operate the facilities at the ultimate stage.

Table 2.15 Number of Staff proposed for the operation of WWTP and PS

Staff	Luyanó WWTP	Matadero PS	Casablanca PS	Chivo Re-ps
Manager	1	0	1	0
Section Chief-Management	0	1	0	0
Section Chief-Treatment	1	0	0	0
Seciton Chief-Operations	1	1	1	1
Section Chief-Water quality	1	0	0	0
Engineer-Treatment	2	0	0	0
Engineer-Water quality	3	0	0	0
Administrator-Management	1	1	1	1
Operators-WWTP/PS	2	8	12	6
Operators-General	12	0	0	0
Drivers	2	1	1	1
Worker	4	2	6	3
Total	30	14	22	12

Whilst the new Luyanó treatment plant using the activated sludge system will require training of the staff there would be little need for any institutional strengthening. The Management & Training Section of the Human Resources Department should be able to cope with staff training for the additional works. On the job training will form part of the construction contract, and Aguas de Barcelona, through its management contract within the concession agreement can provide any further specialized training requirements. Aguas de la Habana already operates such plants in Varadero, where it was shown that the Cuban staff has the education level to readily absorb new technology.

To establish departments in the Aguas de la Habana is also proposed for the new sewerage system development.

Table 2.16 Departments and Staff in the Headquarter proposed for the Sewerage MP

Department	Staff requirements	Remarks
Management and Services Department	Director general (1), General management (5), Accounting (4), Billing management (9), Personnel (3), Property affairs (3), Information management (3), and Vehicle management (4)	26 initially, rising to 32 at the 3rd stage.
Construction Department	Head (1), General Management (6), Planning division (4), Design division (6), Construction division (7), House connection engineering (7)	Under the control of the Construction Division of the existing Technical Department
Operation and Maintenance Department	Head (1), General Management (6), Sewer maintenance (4), WWTP (4), Water quality monitoring (3), House connection services (7)	20 initially, rising to 25 at 3rd stage. Under the control of the Sewerage and Drainage Division o f the existing Technical Department
Two Sewer Maintenance Branch Offices	Managers (2), Engineers (8), Administrators (2), Drivers (12), and Workers (24)	24 initially, rising to 48 at the 3rd stage.

2.5.4 PROJECT COSTS

(1) Basis of Cost Estimate

The price level of the cost estimation is as of 2003. The cost includes a Foreign Currency (F.C.) portion and Local Currency (L.C.) portion. F.C. and L.C. is estimated in terms of US Dollar and Cuban Peso. Principally, goods and services available in local market are estimated in terms of L.C. and goods and services imported from other countries are estimated in terms of F.C. However, when the allocation of F.C. portion and L.C. portion is difficult due to lack of data available, experiences and practices of Cuban and Japanese experts were used to allocate the costs.

(2) Capital Investment

The capital investment is estimated with the following components.

Table 2.17 Cost Components of Capital Investment

Item	Remarks
(1) Direct Construction Cost	Sewers (pipe material, civil woks), Pumping Station and Wastewater Treatment Plant(civil work, architectural work, mechanical and electrical work)
(2) Indirect Construction Cost	
(a) Land acquisition and compensation	
(b) Administration expenses	3% x Local portion of (1)
(c) Engineering service	10% x Direct construction cost of new construction work 12% x Direct construction cost of rehabilitation work
(d) Physical contingency	10% of Total Direct construction cost

Table 2.18 Total Capital Investment required for the Sewerage Master Plan

Unit: FC (x 1,000 US$) and LC (x 1,000 Pesos)

No.	Item	Existing Sewer District		New Sewer District		Required Projet Cost	
		Central System		Luyanó-Martín Pérez Abajo		Total	
		FC	LC	FC	LC	FC	LC
1.	**Sewers**	19,525	12,367	60,010	40,006	79,535	52,373
2.	**Pumping System**	7,881	4,117	0	0	7,881	4,117
3.	**WWTP**	0	0	20,816	9,711	20,816	9,711
	Total Direct Cost	27,406	16,484	80,826	49,717	108,232	66,201
1.	**Land Acquisition and Compensation**	0	0	0	0	0	0
2.	**Administrative Expenses**	0	495	0	1,491	0	1,986
3.	**Engineering Services**	3,018	1,830	8,083	4,972	11,101	6,802
4.	**Physical Contingency**	2,741	1,648	8,083	4,972	10,824	6,620
	Total Indirect Cost	5,759	3,973	16,166	11,435	21,925	15,408
	Total Capital Cost at 2003 Price	33,165	20,457	96,992	61,152	130,157	81,609

Source : JICA Study Team

Table 2.19 Capital Investment for the Central System Improvement

Unit: FC (x 1,000 US$) and LC (x 1,000 Pe

No.	Component	Project Cost		First Stage		Second Stage		Third Stage	
		FC	LC	FC	LC	FC	LC	FC	LC
1.1	**New Installation of Pumped Main, Colector Sur Nuevo, and Interconnection Pipe**	3,139	2,091	3,139	2,091	0	0	0	0
1.2	**Solution Measures of the Cross connections**	7,237	4,824	3,480	2,320	1,357	904	2,400	1,600
1.3	**Rehabilitation of the Colector Sur**	1,956	1,304	0	0	1,956	1,304	0	0
1.4	**New Construction of Colector Sur A**	3,271	2,181	0	0	3,271	2,181	0	0
1.5	**Replacement of Inadequate Colectors**	1,848	1,232	0	0	822	548	1,026	684
1.6	**Repair of the Transmission Tunnel**	174	260	0	0	174	260	0	0
1.7	**Replacement of the Ocean Outfall Sewer**	1,900	475	0	0	1,900	475	0	0
1.	**Sub-total of the Sewers**	19,525	12,367	6,619	4,411	9,480	5,672	3,426	2,284
2.1	**Rehabilitation of the Screen Facilities**	190	87	190	87	0	0	0	0
2.2	**New Construction of Matadero Pumping Station**	2,971	1,490	2,971	1,490	0	0	0	0
2.3	**Rehabilitation of the Casablanca Pumping Station**	2,508	1,358	2,508	1,358	0	0	0	0
2.4	**New construction of the Re-pumping Station**	2,212	1,182	0	0	2,212	1,182	0	0
2.	**Sub-total of the Pumping Station**	7,881	4,117	5,669	2,935	2,212	1,182	0	0
	Total Direct Cost	27,406	16,484	12,288	7,346	11,692	6,854	3,426	2,284
1.	**Land Acquisition and Compensation**	0	0	0	0	0	0	0	0
2.	**Administrative Expenses**	0	495	0	220	0	206	0	69
3.	**Engineering Services**	3,018	1,830	1,352	810	1,255	746	411	274
4.	**Physical Contingency**	2,741	1,648	1,229	735	1,169	685	343	228
	Total Indirect Cost	5,759	3,973	2,581	1,765	2,424	1,637	754	571
	Total Capital Cost at 2003 Price	33,165	20,457	14,869	9,111	14,116	8,491	4,180	2,855

Source: JICA Study Team

Table 2.20 Capital Investment for the New Sewerage System Development

Unit: FC (x 1,000 US$) and LC (x 1,000 Pesos

No.	Component	Project Cost		First Stage		Second Stage		Third Stage	
		FC	LC	FC	LC	FC	LC	FC	LC
1.1	**Luyanó-Martín Pérez Right Colector and sewer networks**	35,303	23,535	19,234	12,822	7,554	5,036	8,515	5,677
1.2	**Luyanó Left Colectors and sewer networks**	24,707	16,471	4,730	3,154	7,211	4,807	12,766	8,510
1.	**Sub-total of the Sewers**	60,010	40,006	23,964	15,976	14,765	9,843	21,281	14,187
2.	**WWTP**	20,816	9,711	6,891	3,273	7,709	3,614	6,216	2,824
	Total Direct Cost	80,826	49,717	30,855	19,249	22,474	13,457	27,497	17,011
1.	**Land Acquisition and Compensation**	0	0	0	0	0	0	0	0
2.	**Administrative Expenses**	0	1,491	0	577	0	404	0	510
3.	**Engineering Services**	8,083	4,972	3,086	1,925	2,247	1,346	2,750	1,701
4.	**Physical Contingency**	8,083	4,972	3,086	1,925	2,247	1,346	2,750	1,701
	Total Indirect Cost	16,166	11,435	6,172	4,427	4,494	3,096	5,500	3,912
	Total Capital Cost at 2003 Price	96,992	61,152	37,027	23,676	26,968	16,553	32,997	20,923

Source: JICA Study Team

(2) O/M Cost

O/M cost for the proposed sewerage facilities comprises following compositions: 1) Personnel Cost, 2) Power Cost, and 3) Chemical Cost. The estimated O/M cost is summarized in Table 2.21

1) Personnel Cost

Personnel cost is estimated in terms of local currency of Cuban Pesos. The unit cost is based on the actual cost required for each classified personnel. The personnel cost is estimated for the proposed personnel necessary to construct and operate and maintain the proposed sewerage facilities.

2) Power Cost

Power cost is estimated in terms of local currency of Cuban Pesos. Power cost is estimated for the existing Casablanca pumping station, the Matadero pumping station, and the Luyanó WWTPs. The required power cost depends on the wastewater volume pumped and treated which is estimated based on the assumption of sewerage coverage.

3) Chemical Cost

Chemical cost is estimated based on volume of chemicals required for de-watering of sludge produced in the Luyanó WWTP by mechanical dewatering facilities. Since the chemicals will be imported the chemical cost is estimated in terms of foreign currency of US Dollars.

Table 2.21 Annual Operation and Maintenance Cost for the proposed sewerage system components of the Sewerage MP

Year	Annual Personnel Cost (x 1,000 Pesos)							Annual Power Cost (x 1,000 Pesos)						Chemical Cost (x 1,000 USD)	O/M Cost Total	
	Head Quarter	Improvements of the Central system				Luyanó WWTP	Total	Improvements of the Central system				Luyanó WWTP	Total	Luyanó WWTP	Posos	USD
		Matadero PS	Casablanca PS	Chivo Re-PS	Sub-total			Madero PS	Casablanca PS	Chivo Re-PS	Sub-total				x 1,000	x 1,000
2011	540	73	107	0	180	145	865	53	180	0	233	44	277	17	1,142	17
2012	540	73	107	0	180	145	865	53	180	0	233	51	284	33	1,149	33
2013	540	73	107	0	180	145	865	138	180	0	318	56	374	46	1,239	46
2014	540	73	107	0	180	145	865	138	180	0	318	59	377	54	1,242	54
2015	540	73	107	0	180	145	865	138	180	0	318	63	381	62	1,246	62
2016	657	73	107	57	237	162	1,056	53	184	118	355	101	456	83	1,512	83
2017	657	73	107	57	237	162	1,056	53	184	118	355	111	466	104	1,522	104
2018	657	73	107	57	237	162	1,056	53	184	118	355	119	474	121	1,530	121
2019	657	73	107	57	237	162	1,056	53	184	118	355	124	479	133	1,535	133
2020	657	73	107	57	237	162	1,056	53	184	118	355	130	485	146	1,541	146
2021	692	73	107	57	237	162	1,091	53	187	119	359	164	523	166	1,614	166
2022	692	73	107	57	237	162	1,091	53	187	119	359	175	534	187	1,625	187
2023	692	73	107	57	237	162	1,091	53	187	119	359	184	543	204	1,634	204
2024	692	73	107	57	237	162	1,091	53	187	119	359	190	549	216	1,640	216
2025	692	73	107	57	237	162	1,091	53	187	119	359	197	556	229	1,647	229
2026	692	73	107	57	237	162	1,091	53	187	119	359	199	558	233	1,649	233
2027	692	73	107	57	237	162	1,091	53	187	119	359	201	560	237	1,651	237
2028	692	73	107	57	237	162	1,091	53	187	119	359	204	563	241	1,654	241
2029	692	73	107	57	237	162	1,091	53	187	119	359	206	565	245	1,656	245
2030	692	73	107	57	237	162	1,091	53	187	119	359	208	567	249	1,658	249
2031	692	73	107	57	237	162	1,091	53	187	119	359	208	567	249	1,658	249
2032	692	73	107	57	237	162	1,091	53	187	119	359	208	567	249	1,658	249
2033	692	73	107	57	237	162	1,091	53	187	119	359	208	567	249	1,658	249
2034	692	73	107	57	237	162	1,091	53	187	119	359	208	567	249	1,658	249
2035	692	73	107	57	237	162	1,091	53	187	119	359	208	567	249	1,658	249

2.5.5 PROJECT EFFECTS ON WATER QUALITY IMPROVEMENT

(1) Pollution Load Reduction

Implementation of the Projects proposed in the M/P will cover Central System and part of the New Sewerage System i.e. Luyanó-Martin Perez Abajo Sewer District with secondary treatment. Table 2.22 shows the estimated pollution load reduction with the implementation of M/P in the New Sewerage System and its comparison to the potential pollution load reduction if secondary sewage treatment is implemented in all sewer districts in the New Sewerage System.

M/P for the New Sewerage System covers approximately 51% of all the load generated in the New Sewerage System and the reduction in the M/P is also approximately 51% of the potential reduction in all Sewer Districts when Sewerage System is implemented in all districts which includes the reduction by on-going GEF/UNDP Project. Excluding the reduction by GEF/UNDP Project, the reduction by projects under the M/P is 39% of the potential reduction.

Table 2.22 Pollution Load Reduction with the M/P of New Sewerage Development

Item	Load			
	BOD_5	T-N	T-P	SS
New Sewerage System-All Sewer Districts				
Estimated load generation, kg/d	22,794	3,481	892	22,794
Estimated load reduction (A), kg/d	20,515	522	134	20,515
New Sewerage System-M/P Area				
Estimated load generation, kg/d	11,723	1,779	460	11,723
Estimated load reduction by GEF/UNDP (B), kg/d	2,546	64	17	2,546
Estimated load reduction by M/P (C), kg/d	8,005	203	52	8,005
Total estimated load reduction by GEF and M/P, kg/d	10,551	267	69	10,551
C/A	39%	39%	39%	39%
(B+C)/A	51%	51%	51%	51%

In the Central System, implementation of the M/P will ensure that 100% of pollution load generated will be diverted to Playa del Chivo. Table 2.23 shows the pollution load generated in the Central System and that being discharged through the drains due to cross-connections based on measured load.

Table 2.23 Pollution Load Reduction with the M/P of Central Sewerage Improvement

Item	Load			
	BOD_5	T-N	T-P	SS
Central Sewerage System				
Estimated load generation, kg/d	17,116	3,167	813	17,116
Estimated load reduction based on generation	100%	100%	100%	100%
Load reduction based on measured load through drains due to cross-connections*	17,032	1,284	2,303	7,244

* - Total of that discharged through drains Matadero, Agua Dulce and San Nicholas and It should be noted that the existing Central System covers areas outside the bay basin. Wastewater generated in the areas outside bay basin will be discontinued.

(2) Water Quality Improvement

Tables 2.24 and 2.25 show the results of estimate for wastewater discharge to the Bay for existing conditions (measured) and that with the implementation of M/P based on the assumption described.

Table 2.24 Case 1- Existing Conditions (year 2002)

Sewer District	Source (River System)	Flow m^3/d	BOD_5 kg/d	T-N kg/d	T-P kg/d	SS kg/d
Luyanó-abajo	Luyanó	114,826	9,784	1,627	732	3,875
Luyanó-arriba						
Martin Pérez-abajo	Martin Pérez	62,122	1,518	245	55	1066
Martin Pérez-arriba						
Tadeo	Tadeo	8,517	1,812	104	46	98
Existing (Central)						
San Nicholas	San Nicholas	8,554	1,320	145	79	352
Matadero	Matadero	77,760	8,942	610	1,053	3,650
Agua Dulce	Agua Dulce	43,200	6,770	529	1,171	3,242
Refinery		*6,406*	*21,723*	*54*	*1*	
Total		321,385	51,869	3,314	3,137	12,283

Table 2. 25 Case M/P

Sewer District	Source (River System)	Flow m^3/d	BOD_5 kg/d	T-N kg/d	T-P kg/d	SS kg/d
Luyanó-abajo	Luyanó	167,122	5,840	2,191	562	6,873
Luyanó-arriba						
Martin Pérez-abajo	Martin Pérez	70,842	5,143	942	204	7,892
Martin Pérez-arriba						
Tadeo	Tadeo	10,635	1,934	307	76	1,945
Existing (Central)						
San Nicholas	San Nicholas					
Matadero	Matadero					
Agua Dulce	Agua Dulce					
Refinery		*6,406*	*21,723*	*54*	*1*	
Total		255,005	34,640	3,494	842	16,710

Water quality simulation results show that with the implementation of M/P, DO levels in Atares will improve to Class F (minimum 2 mg/L) from the existing level below Class F. This will be the first step in improving the water quality of the bay towards the water quality goal of 3 mg/L of DO when secondary treatment is provided (Case 4) to all the wastewater generated in the New Sewerage System area.

2.5.6 FINANCING CAPACITY

(1) Payers of the Project

Two principles can be used in determining who should pay the cost of a project. They are the polluter pays principle and the beneficiary pays principle.

In a sewerage project to remedy the contamination of the Havana Bay, there exist various polluters and beneficiaries. In many cases, polluters also have an aspect of beneficiary. Major parties concerned in a possible sewerage project are identified and their characteristics are summarized in Table 2.26.

Table 2.26 Analysis of Polluters and Beneficiaries

Stakeholder	Polluter aspect	Beneficiary aspect
Central government (including INRH)	Government offices discharge wastewater	If the Havana Bay becomes cleaner, various demands will be generated and the related industries will benefit from it. The government can expect more tax revenues and less subsidy expenditure. The reduction of morbidity of environment related diseases in the bay area will lead to less medical expenditure.
The City of Havana government	Ditto	Ditto
10 Municipalities in the study area	Ditto	Ditto
3 water companies in the study area	They themselves are not polluting the Havana bay although some discharges of wastewater from their facilities exist.	They may save some O/M costs that could be spent without the project. If the Havana Bay becomes cleaner, various demands will be generated and more water will be sold.
Households in the study area	They discharge wastewater	They can enjoy more leisure in the bay area.
Households outside the study area but inside the service areas of the 3 water companies	Their wastewater is not supposed to pollute the Havana Bay. However a part of the wastewater in fact infiltrates into the sewer in the study area and discharges into the bay.	Ditto
Industries in the study area	They discharge wastewater	If the Havana Bay becomes cleaner, various demands will be generated and the related industries will benefit from it.
Industries outside the study area but inside the service areas of the 3 water companies	Their wastewater is not supposed to pollute the Havana Bay. However a part of the wastewater in fact infiltrates into the sewer in the study area and discharges into the bay.	Ditto
Vessels	Ballast water, bilge water and waste oil are discharged by commercial vessels. But a sewerage project cannot resolve this type of pollution. Discharge of wastewater from small boats is negligible.	Cargo ships will have no or negligible benefit from the project. Tourist ships may benefit from the cleaned bay. Small boats can enjoy the cleaner environment of the bay.
Tourists who visit the City of Havana	Hotels and restaurants where tourists use can be considered as polluters.	They can enjoy tourism in the cleaner bay and the surrounding areas.

(2) Ability to Pay

Government: The ability of government to pay for a sewerage project could be estimated by the size of current expenditures. Based on the information of capital investment in environmental protection last two years, the Cuban Government has been annually spending about 100 million pesos for the water and sewerage related area.

Household: The ability to pay can be measured by the ratio of the possible service charge to the total income. If the ratio is smaller, the potential ability to pay is greater and maximum limit of the rates commonly employed for sewerage charge in developing countries is approximately 2 percent, if proposed charge is lower than 2 percent of total household income, the owners of such household are considered capable of paying the proposed charge.

The average size of a household is estimated to be 4 people composed of a husband, a wife, 1.5 children, and 0.5 elderly person. The monthly income and the spending of the average household are estimated to be 760 pesos.

The monthly water and sewerage charge combined is estimated to be 5 pesos per household. The 5 pesos comprise 3.85 pesos of water charge and 1.15 pesos of sewerage charge since the sewerage surcharge is 30 percent of a water charge.

It should be noted that the water and the sewerage prices are inexpensive compared with foods and nonessential grocery items, as shown in the table below. Even in comparison with the electricity bill, the water bill averagely costs merely one sixth.

The 1.15 pesos account for 0.15 percent of 760 pesos. A 2 percent of 760 pesos is 15.2 pesos, which is about 14 pesos higher than the current charge. In conclusion, the ability of households to pay more for sewerage charge would be considerable.

Table 2.27 Basic Prices in the City of Havana

(Havana City, Oct. 2002)

Item	Price		(price in US$ *)
Water bill	1.0	peso/ person/ month	0.04
Sewerage surcharge	0.3	peso/ person/ month	0.01
Public telephone	0.05	peso/ 3 minutes	0.00
Bus	0.4	peso/ ride	0.02
Taxi (share-ride type)	1.0	peso/ ride	0.04
News paper	0.2	peso/ copy	0.01
Rice (free market)	10.0	peso/ kg	0.38
Bean (free market)	10.0	peso/ kg	0.38
Bread	10.0	peso/ pound	0.38
Cola	9.0	peso/ can	0.35
Local tobacco (mild)	9.0	peso/ box	0.35

*US$1 is convertible to 26 pesos which is the legal but unofficial rate only used for personal transaction.

Source: Survey by the Study Team

(3) External Finance

Cuba's external debt has stabilized at around US$11 billion during 1997-2001. Cuba has no access to the World Bank, the International Monetary Fund or the Inter-American Development Bank. The main sources of multilateral assistance are the European community and UN agencies such as the World Food Programme, UNDP, and UNICEF. The debt service ratios of Cuba are estimated at around 20 percent during 1998-2001.

Taking the circumstances above analyzed into account, it would seem difficult for a single country or organization alone to finance a costly large-scale sewerage project at a stretch. If the sewerage project was split into several portions or the implementation was phased, the actual annual disbursement would be smaller, which would make donors or financial institutions easier to finance the project.

2.5.7 FINANCIAL EVALUATION

(1) Methodology

The financial viability of a capital investment project is analyzed on the basis of discounted cash flow method, using three indicators namely net present value (NPV), benefit cost ratio (B/C), and financial internal rate of return (FIRR).

(2) Conditions and Assumptions:

Following conditions and assumptions are applied.

Implementation Agency: DPRH (Provincial Delegation of the National Institute of Water Resources in the City of Havana) will be the constructor and Aguas de La Habana (Havana Water) will be the operator.

Project Cost: The project costs consist of capital investments and O/M costs. The O/M costs include only expenses required for rehabilitated and newly constructed facilities by the master plan project.

Project Benefits: The project benefits comprise revenues from sewerage users in served area and contributions from tourists who visit the City of Havana. The benefits are determined as the difference between the with-project and the without-project situations.

Exchange rate: The official exchange rate of Cuban pesos maintains at parity with the US dollar, while the unofficial rate which is used for domestic personal transactions only, has been changing on the no-regular basis. At the end of August 2003, the rate was Peso26:US$1. Under this dual currency system and uncertainty as to applying a single exchange rate to financial computations, four types of currency mix were employed for the analysis of the sewerage master plan project. The first was computation of Cuban peso portion only; the second was US$ portion only; the third was a combination of Cuban peso and US$ at the exchange rate of Ps1:US$1; and the forth was a combination at the Ps26:US$1.

Project Life: Considering the approximate component mix of the project, the project life was determined as 30 years after completion of the construction works of the second stage.

Discount rate (Opportunity cost of capital): Considering the referential rates, the discount rate used in US$ portion and peso portion were determined at a six percent and an eight percent respectively.

Number of users and sewerage rates: Main benefits of the project are revenues from sewerage users in served area and contributions from tourists who visit the Havana City. Number of users and foreign tourists, sewerage rates, and contribution from foreign tourists assumed for estimation of the revenue are summarized in the table below.

Table 2.28 Sewerage Rates and Contribution

	Item	2002	2004	2006	2011
1.	Domestic customers				
1.1	Sewerage rate (Peso/person/year)	5	6	12	36
1.2	Served population		860,000	=======➔	1,0000,000
2.	State entities and institutional customers				
2.1	Sewerage rate (Peso/customer/year)	150	180	360	900
2.2	Number of customer by the existing sewerage	10,581	11,000	11,000	11,000
2.3	Number of customer by the new sewerage	one customer/39 residents			one customer/13 residents
3.	Hard currency earners				
3.1	Sewerage rate (US$/customer/year)	* 220	270	365	495
3.2	Customer	* 4,066	4,500		Gradually increase
4.	Foreign tourists				
4.1	Contribution (US$/customer)	-	-	-	2
4.2	Number of tourists	959,000			1,300,000

Note: * the figures are average of customers in 2001 and 2002.

(3) Financial Evaluation

Based on the conditions and assumptions, a financial analysis has been conducted. Main point of the analysis results are summarized below.

Financial Viability: The project in fact, consists integrally not piecemeal, of the US$ and peso portions. If the exchange rate of Ps26:US$1 that is actually used in personal transactions is taken under the conservatism policy, the FIRR results in a 1.8 percent. The 1.8 percent implies that the project is intrinsically self-supporting. In other words, the revenue from customers and the contribution from tourists are sufficient enough to pay for the construction cost and the O/M cost. This can be true however, on the condition that the project is financed by a concessionary loan or a soft loan whose interest rate does not surpass the 1.8 percent.

Table 2.29 Resulted Financial Indicators of each case of Cash Flow Analysis

Case	FIRR	B/C	NPV	Remarks
I: US$ portion only	-0.1%	0.5	($) -40,511	
II: Peso portion only	45.1%	4.5	(P) 176,239	
III: US$ + Peso(1US$=1Ps)	21.0%	2.1	(P) 135,728	
IV: US$ + Peso(1US$=26Ps)	1.8%	0.6	(P) -877,044	

Note: Discount rate: US$ 6% Pesos 8%

Sensitivity Analysis: A sensitivity analysis was conducted, in which, the construction cost and the revenue are selected as key parameter. The results are shown in the table below.

The FIRR is slightly more sensitive to changes in construction cost than revenue. A decrease of 20 percent in construction cost improves the base FIRR by 1.7 points, while an increase of the same percentage reduces the base FIRR by 1.3 points and maintains the FIRR still positive. An increase of 20 percent in revenue improves the base FIRR by 1.5 points, while a decrease of the same percentage reduces the base FIRR by 1.6 points and maintains the FIRR still positive.

Table 2.30 Financial Sensitivity Analysis of Priority Project

	US$	Peso	US$+Peso (Ps1:US$1)	US$+Peso (Ps26:US$1)
Base case	-0.1%	45.1%	21.0%	1.8%
Construction cost increases by 20%	-1.2%	38.9%	17.4%	0.5%
Construction cost decreases by 20%	1.4%	53.5%	26.2%	3.5%
Revenue decreases by 20%	-1.6%	37.2%	16.4%	0.2%
Revenue increases by 20%	1.2%	52.2%	25.3%	3.3%

2.5.8 ECONOMIC EVALUATION

(1) Methodology

The discounted cash flow method is also applied to the economic evalations, using three indicators net present value (NPV), benefit cost ratio (B/C), and economic internal rate of return (EIRR).

(2) Economic Cost Valuation:

The conversion factors from the financial price to economic price applied are summarized in the table below.

Table 2.31 Conversion Factors for Economic Analysis

Item	Conversion Factor	Remarks
Material and equipment in foreign currency	0.9	Import duty is considered.
Transactional cost in foreign currency	0.96	Standard Conversion Factor (SCF)
Material and equipment in local currency	1.04	Shadow exchange rate factor (SERF) is applied.
Labor	0.8	A standard wage rate factor (SWRF) is used.
Transactional cost in local currency	1.0	No adjustment is necessary to remove the trade distortion effect.
Administrative expenses	1.02	The expenses are assumed as half traded and half non-traded.
Engineering services in foreign currency	1.0	No adjustment was necessary
Engineering services in local currency	1.0	SWRF of 1.0 is applied.
Physical contingency in foreign currency	0.98	Assumed as half traded and half non-traded (SCF 0.96).
Physical contingency in local currency	1.02	Assumed as half traded (SERF 1.04) and half non-traded.
Personnel cost in O/M	0.86	Assumed skilled (30% SWRF 1.0) and unskilled (70% SWRF 0.8)
Electricity cost in O/M	2.0	
Chemical cost in O/M	0.9	

Land: There is no land acquisition and compensation cost required for the proposed facilities. However from the viewpoint of economic valuation, any land diverted to the project is necessarily taken away from some other use. In Cuba the market for land is inexistent or imperfectly existent, the economic value of the land can be measured in its alternative use. Considering the present usage of the lands and their vicinities, urban agriculture is regarded an economically reasonable and feasible use. The values of lands required for the master plan project are computed and presented in Table 2.32.

Table 2.32 Economic Values of Land

	Area required for project (ha)	Cultivable area [b] (ha)	Tenure	Unit value (Ps/ha)	Value of land [c] (Ps)
Luyanó WWTP	3.0 [a]	2.1	38 years (2008-2045)	214,118	449,648
Matadero Pumping Station	0.2	0.1	38 years (2008-2045)	214,118	21,412
Chivo Repumping Station	0.2	0.0	35 years (2011-2045)	159,408	0
Total	4.4	2.4			471,060

Source: The study team

[a] Out of the WWTP site of 5.0ha, the GEF project will use 2.0ha, which is subtracted here.

[b] Estimated by the study team

[c] Price when the land tenure starts on the basis of the cultivable area

Electricity cost in O/M: As the electricity cost component information is not available, conversion of each financial cost into economic values cannot be done. Another conversion factor exists to remove price distortion due to subsidy. Aguas de La Habana has been approved a preferential treatment whereby the peso rate is charged during the concession period. This preferential treatment is considered as subsidy from the government and assumed to last until the end of the project period. The economic cost of electricity is higher than its financial cost. Hence, the conversion factor was assumed to be 2.0, which means that the economic cost is twice as high as its financial cost.

Discount rate: Opportunity cost of capital represents the permissible economic rate of return, or discount rate for development projects. In general, 10 percent is applied as the opportunity cost of capital for assessing the economic viability.

(3) Economic Benefit Valuation

Benefit of inhabitants: The aggregate benefit of inhabitants was computed by multiplying the number of households by a WTP. The WTP for an improved environment of the bay by materializing a sewerage project was estimated at Ps11 per household per month. The WTP of Ps11 is considered as a general WTP assuming that a wider improvement of the bay environment takes place as a result of the master plan project.

Benefit of industries: The WTP of industry was estimated based on the latest available revenue data of the four water companies that provide water and sewerage services in the Havana City. The sewerage revenue from industrial users was estimated about Ps2.698, 40% of the total sewerage revenue of Ps6.746 million. One third of industrial users pay in foreign currency.

Benefit of tourists: The WTP of tourists was estimated at US$2 or 0.2 percent of the tourist's average spending in Cuba. The number of tourist will be 1,300,000 in 2011 then the aggregate WTP of tourists in 2011 will be estimated at US$2.6 million.

(4) Economic Evaluation

Economic Viability: Based on the conditions previously explained, the economic analysis has been conducted. Main points of the analysis results are summarized in table below.

Table 2.33 Economic Indicators of Economic Analysis for Sewerage M/P

Case	EIRR	B/C	NPV	Remarks
I: US$ portion only	3.4%	0.5	($) -20.821	
II: Peso portion only	96.7%	10.3	(P) 330,635	
III: US$ + Peso(1US$=1Ps)	54.6%	4.9	(P) 309,814	
IV: US$ + Peso(1US$=26Ps)	7.6%	0.8	(P) -210,707	

Note: Discount rate: US$ 10% Pesos 10%

The EIRR result of 7.6 percent for US$/peso combined portion at the exchange rate of 1:26, is inferior to the discount rate of 10 percent. This means that the master plan project might not be viable form the economic viewpoints. However a sewerage project like the master plan project in general usually does not have a high EIRR. Furthermore the master plan project would rather be considered in the light of fulfilling basic human needs regarding environmental conditions. In this context the master plan project would be recommendable.

Sensitivity Analysis: Results of sensitivity analysis are shown in Table 2.34. The benchmark EIRRs would be those computed for a sum of the US$ and the peso portions at the exchange rate of Ps26:US$1. The EIRR is slightly more sensitive to changes in revenue than construction cost. A decrease of 20 percent in construction cost improves the base EIRR by 2.6 points, while an increase of the same percentage reduces the base EIRR by 1.9 points. An increase of 20 percent in revenue improves the base EIRR by 3.1 points, while a decrease of the same percentage reduces the base EIRR by 3.0 points.

Table 2.34 Economic Sensitivity Analysis of Sewerage M/P

	US$	Peso	US$+Peso (Ps1:US$1)	US$+Peso (Ps26:US$1)
Base case	3.4%	96.7%	54.6%	7.6%
Construction cost increases by 20%	2.0%	87.1%	47.6%	5.7%
Construction cost decreases by 20%	5.3%	109.1%	63.9%	10.2%
Revenue decreases by 20%	0.9%	84.8%	45.7%	4.6%
Revenue increases by 20%	5.9%	107.0%	62.5%	10.7%

Other Economic Benefits: The sewerage project can expectedly bring various types of benefits, some of which are perceived by inhabitants as a contributing factor to their WTP, but some are not perceived as such. Some benefits are unquantifiable in nature or due to lack of reasonable amount of information available.

The WTP of beneficiaries have been quantified in the above discussion. Additionally, health benefit from having less incidence of acute diarrhea is attempted to estimate.

Table below shows the estimated loss caused by contraction of diarrhea.

Table 2.35 Loss Caused by Contraction of Diarrhea

	Cuban local patient	Foreigner
①Medical examination	Nil	US$30
②Medicine	Ps10	US$10
③Average monthly wage	Ps 359 (a)	US$3,000
④Lost working day	2 days	2 days
⑤Labor market participation	42% (b)	40%
⑥Lost wage (③÷30×④×⑤)	Ps10	US$80
⑦Total cost (①+②+⑥)	Ps20	US$120

(a) “Economic report 2001”, Ministry of Economy and Planning.
(b) Computed from Data of “Statistics Yearbook of the City of Havana 2002”, The City of Havana Territorial Office of Statistics.
Other data are estimated by the study team.

In the City of Havana the incidence of acute diarrhea has been around 250,000 per year. It is assumed that if a 10 percent of the acute diarrhea is attributable to poor excreta disposal and if this can be eliminated by the project, then the reduction of the incidence would be 25,000 per year. By multiplying this by the cost incurred by a Cuban patient, the economic benefit results in Ps500,000 annually.

2.5.9 PRIORITY PROJECTS FOR FEASIBILITY STUDY

As for the Priority Project for Feasibility Study, the system components under the First Stage Program are selected. The followings are sewerage component facilities included in the Priority Project.

(1) Execution of necessary measures to solve the cross connections in the area related to the Dren Arroyo Matadero.
(2) Rehabilitation of the screen facilities at Caballeria.

(3) Rehabilitation of Casablanca pumping station.
(4) New construction of the Matadero pumping station.
(5) New installation of the interconnection pipe between the Colector Cerro and the Matadero pumping station.
(6) New installation of the pumped main and the Colector Sur Nuevo between the Matadero pumping station to the screen facilities at Caballeria.
(7) New installation of the Luyanó-Martín Pérez Righ Colector in Luyanó-Martín Pérez Abajo sewer district.
(8) New installation of the Luyanó Left Colector in Luyanó-Martín Pérez Abajo sewer district.
(9) New construction of biological secondary wastewater treatment facilities at the same site of GEF-UNDP WWTP (treatment capacity of 207 L/s or 17,900 m^3/d), namely Luyanó WWTP. The total treatment capacity becomes 407 L/s or 35,200 m^3/d.
(10) New installation of sewer networks and house connections in Luyanó-Martín Pérez Abajo sewer district.

And the following surveys and design work are also included:

(11) Detailed survey and design work to solve the cross connection problems in the area related to the Dren Matadero.
(12) Survey on physical conditions of the siphon.

2.6 RECOMMENDATIONS

2.6.1 IMPROVEMENT OF THE EXISTING SEWERAGE SYSTEM

The improvement of the Central sewerage system will contribute continuously to protect the direct discharge of the wastewater to the Havana bay. However, success of the improvement plan depends on how much the cross connection problems could be solved, which cause the wastewater discharge to the bay through the drainage system of the Dren Matadero and the Dren Agua Dulce.

The construction of the primary wastewater treatment plant at Playa del Chivo is not proposed in the Sewerage Master Plan, taking into consideration of uncertainty of the necessity of wastewater treatment to meet the effluent standards up to 2020, the current limited land availability to apply the easy sludge treatment process. But the primary wastewater treatment facilities with appropriate sludge treatment process will be required inevitably to meet the effluent standards. Therefore, it is recommended that the Cuban authorities would obtain a large enough land area to construct the primary treatment facilities with appropriate sludge treatment methods with provision of revising the regulations or removing control by the regulation related to the land use for construction site.

2.6.2 DEVELOPMENT OF THE NEW SEWERAGE SYSTEM

For the new sewerage scheme, the six alternatives had been proposed and studied to select the four zonal sewerage system, considering the expected effects to improve the water quality in the Havana bay and the maximum increase in the sewer service population up to 2020. Among the four sewer districts, only Luyanó-Martín Pérez Abajo sewer district will be implemented up to 2020. Other three sewer districts of Luyanó Arriba sewer district, Martín Pérez Arriba sewer district and Tadeo sewer district are expected to implement as soon as possible after the execution of the proposed Master Plan.

As discussed in chapter 12, the land areas available for construction of the proposed WWTPs are key issues to select the most appropriate sewerage development plan and to choose the appropriate wastewater and sludge treatment processes such as trickling filter and OD processes and sludge drying beds which are easy to operate and cheaper in capital and O/M costs. The limited land area available for construction of the Luyanó WWTP should apply the conventional activated sludge process with mechanical dewatering facilities, which requires very high technology to operate and high costs in construction and operation and maintenance.

For realizing the remaining three sewer districts after the execution of the Master Plan, it is highly recommended to devote considerable efforts to obtain the land area enough to construct the appropriate wastewater and sludge treatment processes at the wastewater treatment plant sites.

As the alternative of the expansion plan of Luyanó WWTP under the second stage project in the Master Plan, the Luyanó Left Colector is proposed to connect to the Colector system comprising Matadero pumping station, pumped main and Colector Sur Nuevo with provision of Colector A to discharge the wastewater to the Caribbean ocean. But to realize this alternative, it is required that the cross connection problems in the area related to the Dren Matadero should be solved completely.

When the alternative of Ocean disposal for area of Luyanó Left Colector is realized, the capacity development of the Luyanó WWTP up to 2020 is required only 207L/s or 17,900m^3/d out of 621L/s or 53,700m^3/d. In such case, it is recommended that the sewerage system development plan should be revised, taken into consideration of a combined plan of Luyanó Arriba sewer district and the Luyanó-Martín Pérez Abajo sewer district.

2.6.3 BAY WATER ENVIRONMENT

(1) Water Quality Monitoring

Monitoring the water quality and pollutant loads related to the Havana bay basin is very important: 1) to understand the environmental conditions, 2) to provide data and information for improvement of the future water quality projection using simulation model, 3) to confirm the effects of projects related to reduce pollutant loads discharged to the bay, and 4) to assess when the primary treatment plant for the Central Sewerage System will be required to meet the effluent quality standards.

Main issues on monitoring are 1) to establish a unified and periodic water quality monitoring system, 2) to establish a database related to the overall water environment in the Havana Bay basin, 3) to establish the rules, limitations and procedures for sharing the data and information among the concerned authorities and opening to the public, and 4) to provide the budget for establishing and maintaining the recommended monitoring system.

(2) Improvement of the Water Quality Simulation Model

Reliability of bay water quality simulation model depends on: 1) the monitored pollutant load inflow data to the bay, and 2) on the bay water environment data since these data is used to describe the behavior of bay water environment in the simulation model. As the number of sets of existing data is very limited, it is very important to refine the model by acquiring further sets of data with improved monitoring.

Behavior of bay water system to external perturbations (i.e. pollution load reduction) is yet to be verified due to limitation of available sets of data. Monitoring data on the behavior of bay water environment with the implementation of Priority Projects will provide useful information to refine the model and to verify its predictions especially related to any trend of eutrophication in the future.

Improvement of the water quality simulation model will also play an important role during the revision of Master Plan when the feasibility of the discharge of wastewater from Luyanó Left Bank Area A to Central System is examined in the future.

(3) Water Environment Objectives

Water quality standards for the bay is in the draft preparation stage and need to be finalized to set a legal basis for improvement of the bay. It will create a common understanding among the various stakeholders related to bay environment protection. Water quality standards need to be set based on the future water uses of the bay. Water quality goals set in this study need to be reviewed through further discussion among various stakeholders. This discussion will be facilitated by this Sewerage Master Plan, in which the role and contribution of the sewerage and drainage sector to the improvement of bay water environment have been made clear together with required cost and time. Role of environmental education was also included in this Master Plan. Role and contribution of other sectors for example industrial sector, port and shipping sector etc. and measures such as dredging of sediments need to be explored in the review of water quality goals together with their cost and time implications.

2.6.4 OTHER RECOMMENDATIONS

In order to seek the early realization of the Master Plan, close cooperation and coordination are deemed indispensable not only between INRH and GTE, but also among INRH, GTE, CITMA, the Havana City and the relevant authorities concerned.

As urbanization is dynamic and has been exploring toward the outskirt of Havana City, a periodical review and update of the Master Plan is indispensable. INRH shall closely cooperative with physical planning of the Havana City to reflect the latest urban development of the staged sewerage improvement plan. To achieve such a plan properly, continuous data collection within INRH and from the authorities concerned shall be programmed and carried out.

Through the formulation work of sewerage plans in the Study, the land availability for the WWTP was very limited due to the existing land use plan or regulations on land use or environmental consideration. It was also explained and presented that the sophisticated wastewater and sludge treatment processes but require very high running costs should be applied when the land for WWTP is very limited, on the contrary, when the large area is obtained for the WWTP the simple treatment process but possible to operate easily and with very low running costs. In this respect, it is advised that INRH, GTE, and other related authorities would make continuous efforts to obtain the appropriate and larger land area for the WWTPs and to revise the existing land use plans and regulations if necessary.

PART III: FEASIBILITY STUDY

3.1 INTRODUCTION

Under the long-term improvement program up to the year 2020 (Master Plan), the improvement and development plans for the Central and new sewerage system have been envisaged, and the high priority improvement and development works selected for the immediate implementation under the First Stage Project.

The scope of the F/S Report is to prepare the preliminary engineering designs for the prioritized wastewater collection and treatment systems, and to undertake feasibility studies thereon to verify that the selected First Stage Project is reasonable and feasible for implementation.

3.2 PRIORITY PROJECT

3.2.1 DESIGN FUNDAMENTALS

Table 3.1 shows a target sewer service population in 2010 covered by the improvement and development of the sewerage system by the Priority Projects implemented during 2006 and 2010.

Table 3.1 Population covered by the Priority Project

Year	2001	**2010**	**MP(2020)**
1. Population within Basin	703,500	714,100	725,600
2. Population within the area covered by the Central Sewerage System	433,200	430,600	427,900
3. Population within the area to be covered by the New Sewerage System Development with MP	154,400	158,900	163,600
4. Population within the Sewerage Planned Area with MP	587,600	589,500	591,500
5. Target Service Population covered by the Improvement of the Central Sewerage System	**-**	**430,600**	427,900
6. Target Service Population covered by the Development of the New Sewerage System	**-**	**57,000 (82,300)**	96,200 (121,500)
7. Target Service Population of the Priority Project	**-**	**487,600 (512,900)**	138,300 (163,600)

Note: Figures in the parenthesis are the population covered by the on-going GEF/UNDP Project

Table 3.2 presents the wastewater quantities related to the area of the Priority Project.

Table 3.2 Wastewater Quantities related to the Priority Project Unit:m^3/d

Year	2001	**2010**	MP(2020)
1.Improvement of the Central Sewerage System			
1.1 Wastewater Generation	130,900	**138,700**	148,200
1) Domestic	72,800	72,350	71,900
2) Non-domestic by small user	47,650	55,980	65,900
3) Non-domestic by large user	10,380	10,380	10,400
1.2 Infiltration	17,200	17,100	17,000
1.3 Average Daily Flow	148,000	**155,800**	165,200
1.4 Maximum Daily Flow	174,200	**183,600**	194,800
2. Development of the New Luyanó-Martín Pérez Abajo Sewerage System			
1.1 Wastewater Generation	45,400	**50,400**	56,400
1) Domestic	26,000	26,700	27,500
2) Non-domestic by small user	17,000	20,700	25,200
3) Non-domestic by large user	2,400	3,000	3,700
1.2 Infiltration	3,100	3,200	3,300
1.3 Average Daily Flow	48,500	**53,500**	59,700
1.4 Maximum Daily Flow	57,500	**63,600**	71,000

Source: JICA Study Team

3.2.2 REHABILITATION AND IMPROVEMENT OF EXISTING SEWERAGE SYSTEM

The proposed improvement plan of the existing Central sewerage system under the priority project is summarized in Table 3.3. The general map is shown in Figure 3.1.

Table 3.3 Proposed Work for the improvement of the Central sewerage system under the priority project

Item	Proposed Plan	Remarks
1. Detailed Surveys on cross connections to prepare appropriate solution measures.	To conduct Detailed Surveys for identifying the cross connections and preparing solution measures to eliminate the direct wastewater discharge through the Dren Matadero to Atares in the Havana Bay.	
2. Construction of the proposed Colector system for rehabilitation of Colector Sur and the Matadero pumping station.	Construction of the proposed Colector system: pumped main (Dia.:1,350mm, CP, Length: 1,020m), Colector Sur Nuevo (Dia.:1500mm, CP, Length:1,830m), and the interconnection pipes between the Colector Cerro/Colector Sur and the Matadero pumping station (Dia.: 1,030/1200mm, HDPE to 1500mm, CP, Length: 500m). Construction of the proposed Matadero pumping station, Q=20 m^3/min, H=12 m, three (3) units including one standby. For the rehabilitation of Colector Sur, additional pumps, Q=40 m^3/min, H=12 m, two (2) units will be installed.	Colector Sur (Dia. 1500 to 2100mm, Length: 2.78km) will be rehabilitaed under the second stage project.

3. Rehabilitation of Screen Facilities and Detailed Survey of Siphon Structure	To rehabilitate the screen facilities (2 units) at Caballeria, and to conduct detailed surveys on physical conditions of siphon structures to prepare rehabilitation plans.	
4. Rehabilitation of Casablanca Pumping Station	To replace the pump equipment (Q=1.75 m^3/s, H=8 m), 4 units including one unit standby.	

Note: Dia.: Inner diameter of sewer. CP: Centrifugal reinforced concrete pipe. HDPE: High density polyethylene pipe. The inner and outer diameters are shown for the HDPE.
Source: JICA Study Team

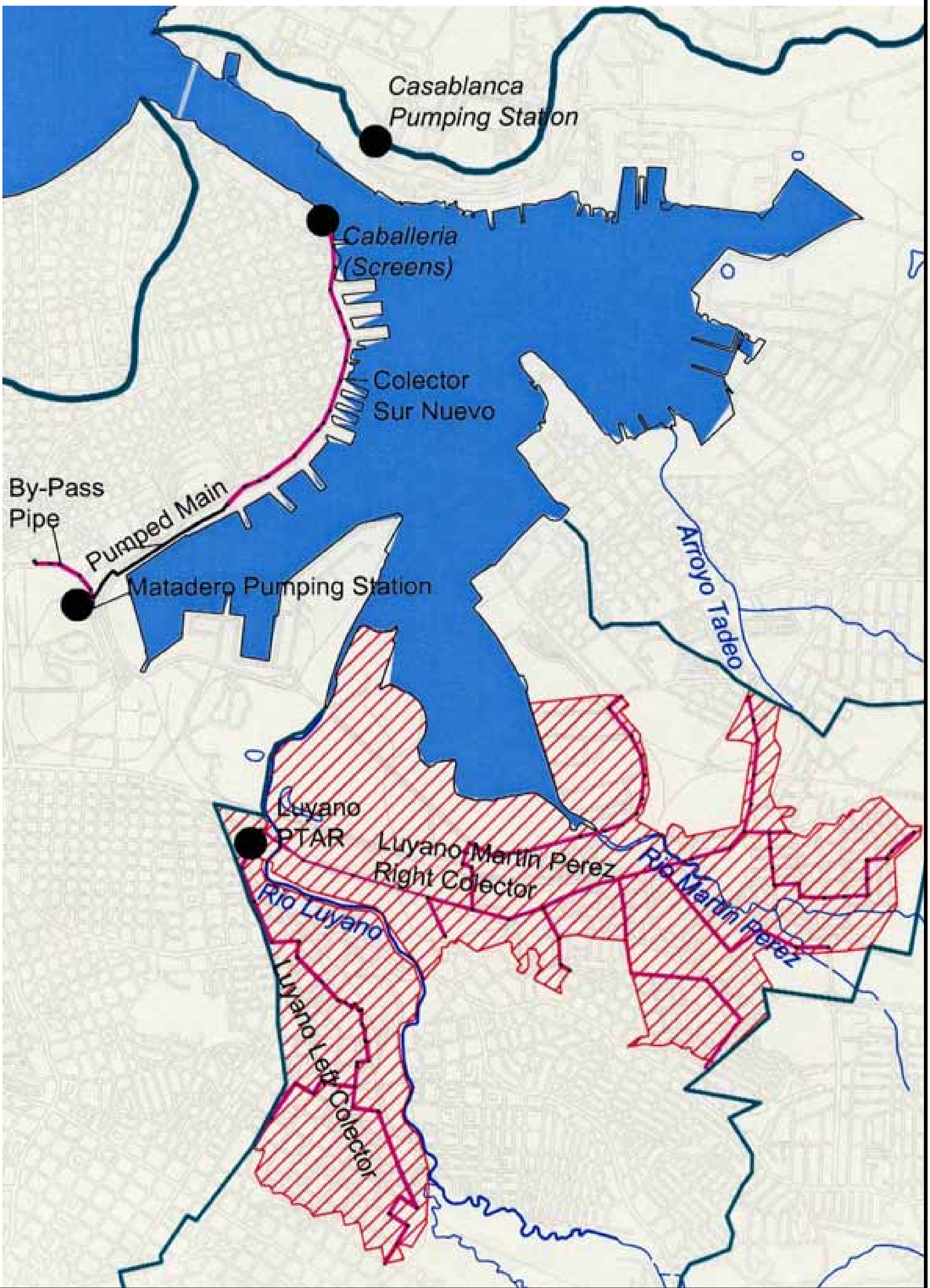
3.2.3 DEVELOPMENT OF NEW SEWERAGE SYSTEM

Figure 3.1 also shows the general map of the proposed new sewerage system under the priority project in the Luyanó-Martín Peréz Abajo sewer district.

Table 3.4 Proposed Work for the Development of the New Sewerage System under the Priority Project

Item	Proposed Plan	Remarks
1. Installation of new sewer networks	Installation of new lateral sewer having Dia.: 216/250mm, HDPE, will be installed about 68km long: for Luyanó-Martin Peréz Right Colector 54km long and for Luyanó Left Colector 14 km long	
2. Installation of new Colectors	Installation new Colectors about 14.4km long, including tunnel of 4.6km long. Diameters of the Colectors installed are ranging from 216/250mm to 1030/1200mm, HDPE. The inner diameter of the tunnels is planned at 1,500mm. The Luyanó-Martin Peréz Right Colector is 6.5km long including tunnel of 4.0km long. The Luyanó Left Colector is 3.9km long including tunnel of 0.6km long.	The inner and outer diameters are shown for the HDPE.
3. Construction of New Wastewater Treatment facilities Lunanó WWTP	Expansion of wastewater treatment capacity of 17,900 m^3/d or 207L/s, thus the total capacity of 35,200 m^3/d or 407 L/s. Proposed wastewater treatment level is a secondary treatment level, mainly removal for organic contents. BOD_5 conc.: Influent 200 mg/L, Treated 20 mg/L SS conc.: Influent 200 mg/L, Treated 20 mg/L The treatment processes of wastewater and generated sludge are proposed taken into consideration of the limited available land area and the surrounding environment. Wastewater treatment process: Conventional Activated Process comprising primary sedimentation tank, aeration tank, final sedimentation tank and necessary equipment. Sludge treatment process: Anaerobic Digestion Process with mechanical dewatering (belt filter press) and sanitary landfill.	Capacity o f 17,300 m^3/d or 200L/s developed by GEF/UNDP Following facilities and buildings are proposed to construct by the GEF project: Preliminary treatment facilities (screens and grit chambers), pump house, administration building and operator house.

Source: JICA Study Team



THE DEVELOPMENT STUDY ON THE IMPROVEMENT OF SEWERAGE AND DRAINAGE SYSTEM FOR THE HAVANA BAY	Figure 3.1 General Map of the Proposed Priority Project for Havana Bay basin
JAPAN INTERNATIONAL COOPERATION AGENCY	

3.3 PRIORITY PROJECT IMPLEMENTATION

3.3.1 IMPLEMENTATION SCHEDULE

The implementation schedule for the Priority Project is proposed as shown in Figure 3.2.

3.3.2 PROJECT COST ESTIMATES

(1) Capital Investment

The capital investment is estimated with the following components.

Table 3.5 Cost Components of Capital Investment

Item	Remarks
(1) Direct Construction Cost	
(2) Indirect Construction Cost	
(a) Land acquisition and compensation	
(b) Administration expenses	3% x Local portion of (1)
(c) Engineering service	10% x Direct construction cost of new construction work 12% x Direct construction cost of rehabilitation work
(d) Physical contingency	10% of Total Direct construction cost

The required capital investment at 2003 price for the priority project is shown in Table 3.6.

Table 3.6 Capital Investment for the Priority Project

Unit: FC(x1000US$), LC(x1000Pesos)

Item	Improvement of the Central Sewerage System		Development of the New Sewerage (Luyanó-Martín Pérez Abajo) System		Total	
	FC	LC	FC	LC	FC	LC
1. Sewers	6,619	4,411	23,964	15,976	30,583	20,387
2. Pumping System	5,669	2,935	0	0	5,669	2,935
3. WWTP	0	0	6,891	3,273	6,891	3,273
Total Direct Cost	12,288	7,346	30,855	19,249	43,143	26,595
1. Land Acquisition and Compensation	0	0	0	0	0	0
2. Administrative Expenses	0	220	0	577	0	797
3. Engineering Services	1,352	810	3,086	1,925	4,438	2,735
4. Physical Contingency	1,229	735	3,086	1,925	4,315	2,660
Total Indirect Cost	2,581	1,765	6,172	4,427	8,753	6,192
Total Capital Cost at 2003 Price	14,869	9,111	37,027	23,676	51,896	32,787

(2) O/M Cost

O/M cost for the proposed sewerage facilities comprises following compositions: 1) Personnel Cost, 2) Power Cost, and 3) Chemical Cost. The estimated O/M cost is summarized in Table 3.7.

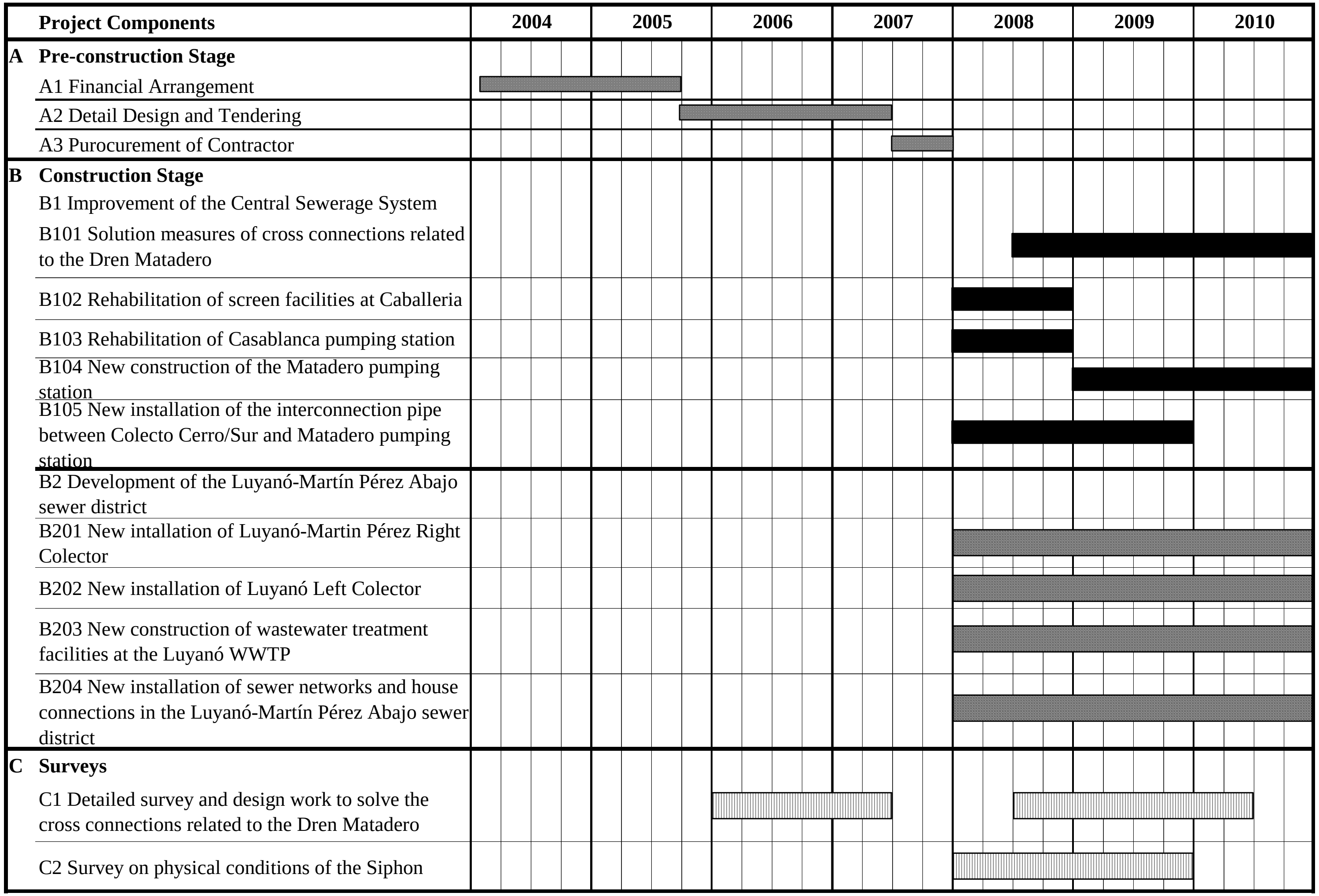


Figure 3.2 Implementation Schedule of the Priority Project

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1) Personnel Cost

Personnel cost is estimated in terms of local currency of Cuban Pesos. The unit cost is based on the actual cost required for each classified personnel. The personnel cost is estimated for the proposed personnel necessary to construct and operate and maintain the proposed sewerage facilities.

2) Power Cost

Power cost is estimated in terms of local currency of Cuban Pesos. Power cost is estimated for the existing Casablanca pumping station, the Matadero pumping station, and the Luyanó WWTPs. The required power cost depends on the wastewater volume pumped which is estimated based on the assumption of sewerage coverage.

3) Chemical Cost

Chemical cost is estimated based on volume of chemicals required for de-watering of sludge produced in the Luyanó WWTP by mechanical dewatering facilities. Since the chemicals will be imported the chemical cost is estimated in terms of foreign currency of US Dollars.

Table 3.7 Annual Operation and Maintenance Cost required under the Priority Project

Year	Annual Personnel Cost (x 1,000 Pesos)						Annual Power Cost (x 1,000 Pesos)					Chemical	O/M Cost Total	
	Head Quarter	Improvements of the Central system			Luyanó WWTP	Total	Improvements of the Central system			Luyanó WWTP	Total	Cost (x 1,000 USD)	Posos	USD
		Matadero PS	Casablanca PS	Sub-total			Madero PS	Casablanca PS	Sub-total			Luyanó WWTP	x 1,000	x 1,000
2011	540	73	107	180	145	865	53	180	233	44	277	17	1,142	17
2012	540	73	107	180	145	865	53	180	233	51	284	33	1,149	33
2013	540	73	107	180	145	865	53	180	233	56	289	46	1,154	46
2014	540	73	107	180	145	865	53	180	233	59	292	54	1,157	54
2015	540	73	107	180	145	865	53	180	233	63	296	62	1,161	62
2016	540	73	107	180	145	865	53	184	237	85	322	67	1,187	67
2017	540	73	107	180	145	865	53	184	237	87	324	71	1,189	71
2018	540	73	107	180	145	865	53	184	237	89	326	75	1,191	75
2019	540	73	107	180	145	865	53	184	237	91	328	79	1,193	79
2020	540	73	107	180	145	865	53	184	237	93	330	83	1,195	83
2021	540	73	107	180	145	865	53	187	240	104	344	83	1,209	83
2022	540	73	107	180	145	865	53	187	240	104	344	83	1,209	83
2023	540	73	107	180	145	865	53	187	240	104	344	83	1,209	83
2024	540	73	107	180	145	865	53	187	240	104	344	83	1,209	83
2025	540	73	107	180	145	865	53	187	240	104	344	83	1,209	83
2026	540	73	107	180	145	865	53	187	240	104	344	83	1,209	83
2027	540	73	107	180	145	865	53	187	240	104	344	83	1,209	83
2028	540	73	107	180	145	865	53	187	240	104	344	83	1,209	83
2029	540	73	107	180	145	865	53	187	240	104	344	83	1,209	83
2030	540	73	107	180	145	865	53	187	240	104	344	83	1,209	83
2031	540	73	107	180	145	865	53	187	240	104	344	83	1,209	83
2032	540	73	107	180	145	865	53	187	240	104	344	83	1,209	83
2033	540	73	107	180	145	865	53	187	240	104	344	83	1,209	83
2034	540	73	107	180	145	865	53	187	240	104	344	83	1,209	83
2035	540	73	107	180	145	865	53	187	240	104	344	83	1,209	83

Source:JICA Study Team

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3.3.3 ORGANIZATIONS AND INSTITUTIONS

This section makes recommendations for strengthening, where thought necessary, to assist in improving future operations in both the Water Supply & Sewerage, and Environmental Sectors for Havana Bay.

(1) Institutional Strengthening

Future studies would benefit from a clear demarcation of responsibilities, the timely provision of information, permission to visit all necessary places and the collection of vital information consistent with the general procedures for international projects.

In order to continue this strengthening, the implementation arrangements for the Priority Project must have an institutional arrangement that will ensure coordination of all the concerned parties, but without committees being too extensive which would lead to inefficiencies.

1) GTE

GTE is an inter-ministerial, inter-sectoral organization principally coordinating sectoral ministries (e.g. MINTRANS), the environmental sector (CITMA) and territorial interests through the Provincial Assembly of the City of Havana (CAP). GTE will be the environmental authority for the whole of the Havana Bay Basin. Because plans are underway to extend the mandate of GTE as a permanent organization by way of amendment to “Acuerdo” 3330.

The human resources and financial capacity must increase to suit the growing responsibilities of this organization. The specific areas concerning the Priority Works are the environmental monitoring and environmental education.

As regards environmental monitoring, GTE have taken note of the recommendations in the Master Plan section of this report and will implement the full proposals over time. Financial constraints have so far limited sampling and analysis. GTE would be well advised to solicit the necessary funding from GOC and/or external sources for a more modest scheme that will ensure that the recommended sampling and monitoring program can be put in place now.

The ability of GTE to expand its program of environmental education has been strengthened through this study by the production of a second video and two handbooks for community and schools programs, and the INRH program. Implementation of this environmental education program should commence immediately. However, should the human and/or financial resources be found inadequate when the implementation program is produced, then GTE may consider seeking the required resources from international donor agencies.

2) INRH

INRH has been able to operate successfully in the City of Havana through its Provincial Delegation, DPRH. INRH has the capacity to regulate and control the operation and maintenance activities of the City of Havana water supply & sewerage corporations. However, the Priority Works for the new sewerage area resulting from this study need to be augmented by the installation of primary sewers and household connections, and this will be the responsibility of GOC through INRH, and may also involve the operator, Aguas de la Habana., depending upon the terms and conditions of the concession agreement.

The human resources as well as the financial resources need to be carefully planned when this work is required. It is recommended that that the Concession Agreement with Aguas de la Habana be reviewed in the light of these requirements.

3) Aguas de la Habana

When the service area of Aguas de la Habana is extended it will be the sole operator of the works envisaged by this project. Hence, management, operation and maintenance will fall under this one authority. As a mixed enterprise company under a concession agreement with INRH to 2025, the full expertise of Aguas de Barcelona will be available during the Priority Project, for the rehabilitated and expanded sewerage system.

4) CITMA

There are two areas to be considered, these are the institutional capacity for coordination among the various agencies for efficient management, and compliance, modernization and completion of environmental legislation.

There are shortcomings which have to be addressed by institutional capacity building to strengthen CITMA for the monitoring of the environmental protection plans which the agencies are required to draw up and implement.

Regarding environmental legislation, lack of enforcement is mainly due to economic reasons and not a lack of institutional capacity. As the economy grows and/or external finance is made available the ability to enforce the laws will improve accordingly.

(2) Institutional Arrangement for Project Implementation

Due to the relatively high capital cost of rehabilitation and construction works resulting from this Master Plan and Feasibility Study for the Priority Works, it is assumed that international financing will be required and that international consultants and contractors will be involved in detailed design and construction.

For control of the projects in Cuba, it will therefore be necessary to involve those ministries related to foreign investment, the institutions involved in the environmental sector, and the water supply and sewerage sector in the City of Havana.

1) Project Institutional Framework

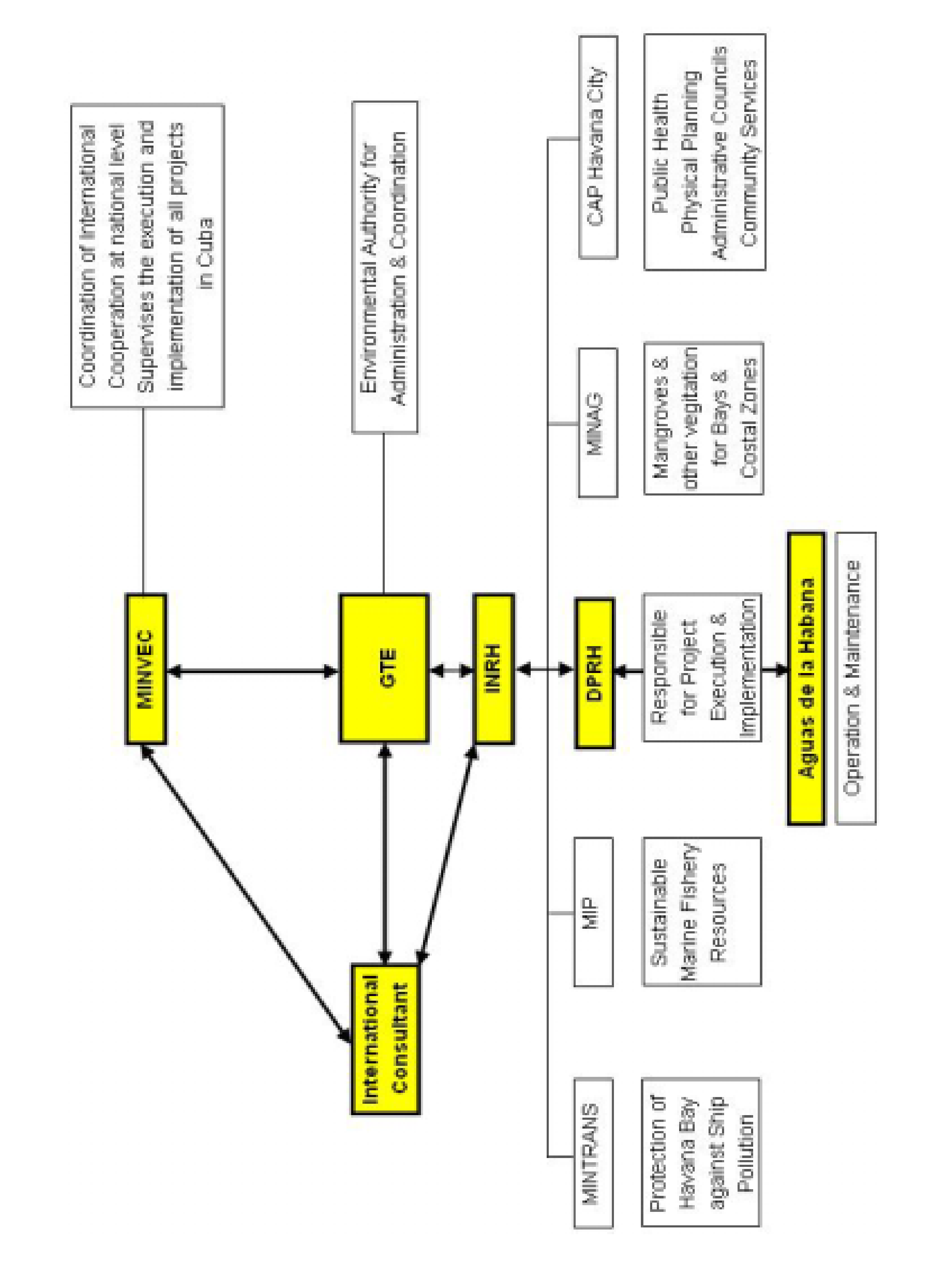
On commencement of the project it is recommended that a steering committee be formed representing all of the relevant agencies and bodies. The structure of the recommended Steering Committee, and the roles and responsibilities are shown in Figure 3.3. The Steering Committee will therefore comprise:

- MINVEC
- GTE
- INRH (DPRH)
- International Consultant
- Aguas de la Habana

For coordination of the project at national level, MINVEC is the central government ministry for the coordination of international cooperation and therefore supervises the execution and implementation of all foreign projects in Cuba.

For the administration of the project, GTE is being developed as the environmental authority for the Havana Bay basin and therefore should play a leading role for coordination at provincial and local level when the project is being developed.

The structure of GTE is such that it has strong links will all of the agencies and bodies concerned with the environmental matters of the City of Havana, Havana Bay, and the bay basin in particular. There will be a need to continually update information on water quality, and the growth and movement of the population in the bay basin and such information can be provided either directly by GTE or through its Technical Committee. The Technical Committee currently comprised of twelve organizations of the central state administration.



THE DEVELOPMENT STUDY ON THE IMPROVEMENT OF SEWERAGE AND DRAINAGE SYSTEM FOR THE HAVANA BAY	Figure 3.3 Project Institutional Framework Proposed Steering Committee
JAPAN INTERNATIONAL COOPERATION AGENCY	

The following list shows the organizations involved:

• MINTRANS	CIMAB; SAMARP; and DSIM
• MININT	Captain of Havana Port
• MIP	Directorate for Fishing Regulations
• INRH	DPRH
• CAP	Provincial Directorates of Community Services; Public Health; and Physical Planning. Administrative Councils of Habana Vieja, Regla, and del Este

Since this will be a design and construction project in the water supply & sewerage sector, a most important agency will be INRH who will represent the central government as the eventual owner of the new assets. For supervision of this project it is recommended that the provincial delegation DPRH for the City of Havana represents INRH.

The new and rehabilitated works will be operated and maintained by Aguas de la Habana, and this enterprise should be included in the planning stage of the project, particularly in view of the extensive rehabilitation of existing work.

2) Design and Construction Supervision

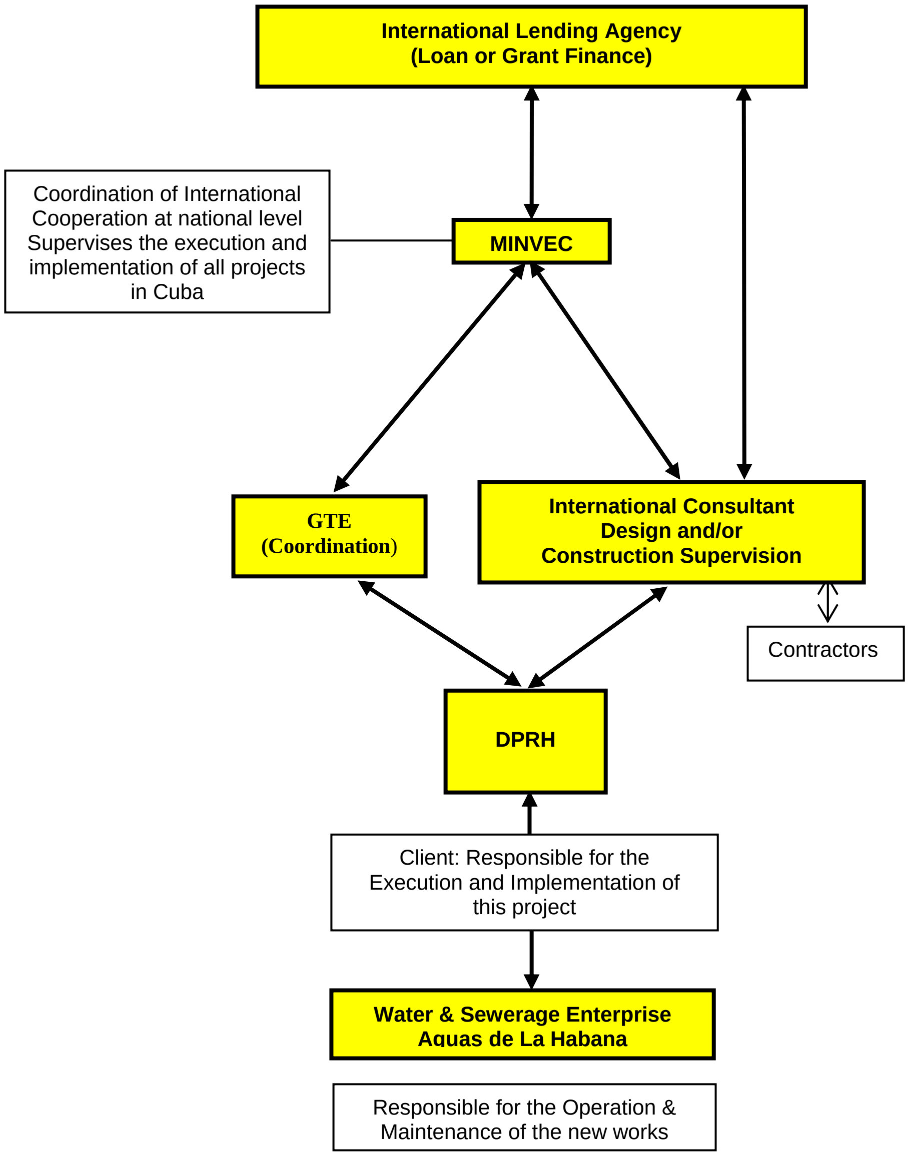
Loans and/or Grants from International Organizations will be channeled through MINVEC, and depending upon the donor country's project Loan/Grant system, the International Consultant will liaise directly or through MINVEC on financial and other related matters.

In view of the role of GTE as the environmental authority for the bay basin and its links with the many relevant agencies, GTE can again play an important coordinating role, however,since this is a construction project all technical matters which are the responsibility of the International Consultant should be dealt with by DPRH who will be responsible for the project as the client.

The role of Aguas de la Habana will vary depending upon the concession arrangement with INRH. As stated earlier in this report, the Concession Agreement should be reviewed before commencement of the Priority Works in view of the addition of assets to be operated and maintained, the financial consequences, and the disruption to services that may be caused by the construction works, particularly the extensive rehabilitation of the Central Sewerage System.

One system that may be adopted is to make the Operator responsible for some of the contracts, in place of INRH, if such an arrangement would be beneficial to all parties to the contracts and allowed under the donor's rules. For example, in this particular case in may be better to have Aguas de la Habana responsible as the "Client" for all of the rehabilitation contracts in view of the close liaison required to minimize disruption to the sewerage system.

The recommended organizational structure for technical design and supervision of construction is shown in Figure 3.4**.**



THE DEVELOPMENT STUDY ON THE IMPROVEMENT OF SEWERAGE AND DRAINAGE SYSTEM FOR THE HAVANA BAY

JAPAN INTERNATIONAL COOPERATION AGENCY

Figure 3.4
Proposed Institutional Arrangement for Design and Construction Supervision

3.4 PROJECT EVALUATION

3.4.1 TECHNICAL EVALUATION

The Priority Project will contribute to the improvement in the water environment of Havana Bay. The improvement of the existing Central sewerage system will make better the most deteriorated water environment at Atares in the bay. The development of new sewerage system will collect and treat the wastewater generated at the most densely populated area of the Luyanó and Martín Pérez rivers and contribute to the improvement in the water environment of Guasabacoa.

The Priority Project is based on the maximum use of the existing and new sewerage system to reduce the pollution loads discharged to the Havana Bay efficiently. The Project will provide the cost-effective wastewater collection and treatment facilities to service the most densely developed and severely degraded urban area in the Havana Bay basin and neighboring areas, which are compatible with a long-term strategy to serve the entire Area.

Each of the sewerage components is evaluated and confirmed its appropriateness and soundness for implementation:

(1) Wastewater collection system: the new sewer system is designed in principle to flow the wastewater by gravity, reducing to the maximum extent the energy need to pump up the wastewaters. Colector Sur, one of the most important existing sewer main for the Centaral Sewerage System, is suffering from the aging, used more than 90 years and inadequate capacity due to very low slope. The Colector is proposed to be rehabilitated and improved its reliability by the proposed new Colector system, comprising Matadero pumping station, pumped main and Colector Sur Nuevo. The proposed Colector system and rehabilitated Colector Sur are sure to contribute to the pollution loads reduction to the bay through discharging the wastewater to the Ocean together with complete solution of the cross connections in the catchment area of Dren Arrojo Matadero.

(2) Wastewater Treatment Plant (WWTP): Due to the limited availability for appropriate land area for the Luyanó WWTP, a conventional activated sludge process is applied. This process requires high technology and cost to operate but expected a high performance in pollution loads. The generated sludge, after being stabilized by the anaerobic digester, will be dewatered by a mechanical equipment of belt filter press, which is relatively easy to operate and lower in costs compared among mechanical dewatering equipment.

(3) Operation and Maintenance: There is a lack of operational and maintenance experience for the proposed wastewater treatment process. However, under the GEF/UNDP project, wastewater treatment facilities will be constructed prior to the proposed project. Therefore, experiences and practices accumulated during the operation of the facilities of GEF project will help to operate the proposed treatment facilities properly and an extensive staff training will further ensure the proper operation and maintenance.

(4) Land Acquisition and Rights: The new main sewers and pumping stations will be constructed within road reserves or on government-owned land. The site for construction of the wastewater treatment facilities under the Priority Project would be obtained together with the site for the GEF-UNDP Luyanó WWTP. The site has been selected at the vacant land so that no resettlement will be required, and any adverse environmental impacts could be minimized through implementation of prevention/mitigation measures.

3.4.2 FINANCIAL EVALUATION

(1) Financial Analysis

1) Methodology, Conditions and Assumptions

The methodology and major conditions and assumptions are the same as those set out for the sewerage master plan.

Main benefits of the project are revenues from sewerage users in served area and contributions from tourists who visit the Havana City. The benefits are determined as the difference between the with-project and the without-project situations. Number of users and sewerage rates assumed for estimation of the revenue are summarized in the table below. The table also includes the contribution from the foreign tourists who visit Havana City.

Table 3.8 Sewerage User Charges and Contribution of Foreign Tourists

	Item	2002	2004	2006	2011
1.	Domestic customers				
1.1	Sewerage rate (Peso/person/year)	5	6	12	36
1.2	Served population		860,000	=======➔	1,0000,000
2.	State entities and institutional customers				
2.1	Sewerage rate (Peso/customer/year)	150	180	360	900
2.2	Number of customer by the existing sewerage	10,581	11,000	11,000	11,000
2.3	Number of customer by the new sewerage	one customer/39 residents			one customer/13 residents
3.	Hard currency earners				
3.1	Sewerage rate (US$/customer/year)	* 220	270	365	495
3.2	Customer	* 4,066	4,500		
4.	Foreign tourists				
4.1	Contribution rate (US$/customer)	-	-	-	2
4.2	Number of tourists	959,000			1,300,000

Note: * the figures are average of customers in 2001 and 2002.

2) Results of Financial Analysis

Based on the conditions and assumptions, financial analysis has been conducted. Main point of the analysis results are summarized below.

Financial Viability: The FIRRs, the NPVs and the B/Cs show high and positive values at the all portions and exchange rates. All those results indicate that the revenues from customers and the contribution from tourists are large enough to pay for the construction cost and the O/M cost of the project. Thus the project is regarded financially viable under the assumed conditions.

Table 3.9 Resulted Financial Indicators of each case of Cash Flow Analysis

Case	FIRR	B/C	NPV	Remarks
I: US$ portion only	5.2%	0.9	($) -3.393	
II: Peso portion only	51.0%	7.6	(P) 175,413	
III: US$ + Peso(1US$=1Ps)	28.1%	3.6	(P) 172,020	
IV: US$ + Peso(1US$=26Ps)	7.3%	1.1	(P) 87,185	

Note: Discount rate: US$ 6% Pesos 8%

Sensitivity Analysis: A sensitivity analysis was conducted, in which, the construction cost and the revenue are selected as key parameter. The results are shown in the table below.

The benchmark FIRRs would be those computed for a sum of the US$ and the peso portions at the exchange rate of Ps1:US$1 and Ps26:US$1. The FIRRs are sensitive both to construction cost and revenue. A 20 percent increase in construction cost lowers the base FIRR by 1.5 percent. A 20 percent decrease in revenue lowers the base FIRR by 1.9 point. In these adverse cases, the FIRRs are still maintained over 5 percent, which is considered to be robust.

Table 3.10 Financial Sensitivity Analysis of Priority Project

	US$	Peso	US$+Peso (Ps1:US$1)	US$+Peso (Ps26:US$1)
Base case	5.2%	51.0%	28.1%	7.3%
Construction cost increases by 20%	3.8%	45.2%	24.4%	5.8%
Construction cost decreases by 20%	7.1%	58.9%	33.2%	9.4%
Revenue decreases by 20%	3.5%	43.6%	23.5%	5.4%
Revenue increases by 20%	6.7%	57.7%	32.4%	9.0%

Loan Repayment Projection: The priority project will entail great expense upon the implementation agency. The project cash flow shows that a heavy capital investment at the initial stage is required. After the rehabilitated or newly constructed facilities start the operation, cash flow turns to the black and keeps being positive throughout the project period.

In the year 2003 it is uncertain as to whether the central government can allocate the fund for the project. A possibility of Cuba's asking a loan to multilateral or bilateral financial institutions is also limited. Evidently it is not easy for Cuba to get a grant for that size of the project.

Under these circumstances, an exemplary case of getting loans at currently available lending rates and its repayment was examined. A trial computation is performed for repayment of a US dollar loan at a lending rate of 6 percent p.a., and a 30 year-loan period including a grace of 10 years. And a repayment schedule of a peso loan at a lending rate of 8 percent and a 25 year-loan period including a grace of 5 years is also simulated. In addition, the debt service coverage ratios are computed. The debt service coverage ratios of over 1.0 throughout the loan repayment period suggest that the implementation agency can safely repay the loans under the assumed conditions.

(2) Financial Evaluation

The result is that the priority project is considerably attractive in the light of financial soundness. The FIRRs were computed at 5.2 percent for the US$ portion, 51.0 percent for the peso portion, 28.1 percent for the combination of the US$ and peso at the exchange rate of US$1:Ps1, and 7.3 percent for the same combination at a different exchange rate of US$1:Ps26. The 28.1 percent is extremely high figure and the 7.3 percent is the lowest acceptable figure as a self sustainable project. In fact, it would be too conservative to evaluate the priority project if the exchange rate of US$1:Ps26 is strictly applied. Therefore the FIRR of 7.3 percent would be financially satisfactory.

When the soundness of a project is evaluated by financial indicators, the premises and assumptions applied in computation of the financial indicators naturally matter. Although we tried to be conservative in employing those assumptions, some assumptions may still seem optimistic. Thus, justifications of key assumptions are examined subsequently.

Exchange rate: It is extremely difficult to forecast future exchange rates. The official exchange rate of US$1:Ps1 simply exists for convenience of accounting system. The unofficial but legal exchange rate of US$1:Ps26 is currently used for personal transactions only. If this US$1:Ps26 exchange rate is actually applied to foreign exchange computation of the priority project, the exchange market will be affected by its enormous amount of inflow of hard currencies, and the exchange rate will go toward peso's appreciation against US dollar. As a result, the exchange rate will be no longer the same. Under the uncertainties of the foreign exchange market, if the exchange rate of US$1:Ps1 is applied, the situation is regarded the most favorable to the implementation agency. In other words the situation becomes the most unfavorable if the exchange rate of US$1:Ps26 is applied. We expect that a real outcome falls somewhere in-between the two situations.

Sewerage rate for domestic customers: Although a six fold multiplication in seven years may seem unrealistic, it is justifiable. The current sewerage bill of Ps6 per person per year can be approximately converted to a Ps2 per household per month. Considering the Ps760 is the average monthly household income, the Ps2 accounts for merely 0.26 percent. Even after the six fold increase, the sewerage bill of Ps12 will account for 1.58 percent of household income, which still stays around empirical ceilings[1]. Incidentally a real increase of household income, that is likely to happen during the project period, is not considered.

Sewerage rate for state entities and institutional customers: The assumed rates turn out to be a five hold multiplication in seven years. Compared with the tariff increase for domestic customers, which is six fold in seven years, this rise is still smaller.

Sewerage rate for hard currency earners: An 83 percent increase in seven years is small, compared with the tariff increase for domestic customers (500% increase) and that for state entities (400% increase).

Contribution from foreign tourists: The US$2 is a 0.2 percent of the average tourist spending in Cuba, which is regarded inexpensive compared with most of entertainment costs paid by tourists. The number of tourists visiting the City of Havana is assumed to increase from 0.959 million in 2002 to 1.3 million in 2011, which is a 36 percent increase in nine years. The City of Havana already experienced a 47 percent increase of tourist inflow in three years between the year 1997 (649,000 tourists) and 2000 (951,000 tourists).

Loan Repayment Projection: The simulation of borrowing and repaying loans and the changes in debt service coverage ratios indicate that the project can be funded through tariffs and tourist contributions except during the initial construction period. Under the year 2003 situations, the possibility of the government's asking a loan to multilateral or bilateral financial institutions is opaque. Getting a grant for this size of the project is not easy. It is essential that the central government should allocate the fund for the project during the initial construction period.

[1] The Pan American Health Organization reportedly employs benchmarks of a household's affordable amount for water supply and sewerage. According to this, total of water and sewerage bill should be below 5 percent of household income (3.5 percent for water and 1.5 percent for sewerage).

3.4.3 ECONOMIC EVALUATION

(1) Economic Analysis

The discounted cash flow method was applied. Three indicators were similarly computed, which were the net present value (NPV), benefit cost ratio (B/C), and economic internal rate of return (EIRR).

1) Economic Cost/Benefit Valuation

The conditions and assumptions applied to estimate economic costs and benefits of the Priority Project, which are the same as those for the M/P in principle.

Land: The same framework as that of master plan was used for the assumption. The priority project newly requires two plots of land which are for the Luyanó WWTP and the Matadero pumping station. The economic unit value of the lands is considered Ps210,528 as the land tenure lasts until 2040. Hence, the land values in 2008 are computed at Ps442,108 for Luyanó WWTP and Ps21,053 for Matadero pumping station.

Discount rate: 10 percent is applied for assessing the economic viability.

Benefit of inhabitants: The aggregate benefit of inhabitants was computed by multiplying the number of households by a WTP. The WTP for an improved environment of the bay by materializing a sewerage project was estimated at Ps11 per household per month. The WTP of Ps11 is considered as a general WTP assuming that a wider improvement of the bay environment takes place as a result of the master plan project. In estimating the WTP for the priority project, this general WTP has been adjusted in proportion to the level of improvement realizable as shown in the following manner.

According to the planning base, the maximum pollution load reduction is 52 ton BOD per day in the master plan project and 46 in the priority project. Hence the WTP for the priority project (WTP_p) can be expressed as follows:

$$WTP_p = Ps11 \times 46 \div 52 = Ps9.7$$

Aggregate benefits during the project period were therefore computed by applying the WTP_p of Ps9.7.

Benefit of industries: In the economic valuation of the master plan project, the WTP of industries who pay sewerage bills in US$ was estimated at 0.023 percent of the production. The WTP of industries who pay in peso was 0.046 percent. Since these percentages are considerably small in comparison with that of household WTP (1.4%) and make no difference in magnitude of the change of improvement, the proportional adjustment of the WTP like was not made.

Benefit of tourists: The WTP of tourists was estimated at US$2 or 0.2 percent of the tourist’s average spending in Cuba without any proportional adjustment of the WTP.

2) Results of Economic Analysis

Economic Viability: Based on the conditions previously explained, the economic analysis has been conducted. Main points of the analysis results are summarized in table below.

The EIRRs of combinations of US$ and peso all exceeds 10 percent. The B/Cs and the NPVs are also considerably high in all combinations. This means that the project is economically sound and its implementation is justifiable.

Table 3.11 Resulted Economic Indicators of Economic Analysis

Case	EIRR	B/C	NPV	Remarks
I: US$ portion only	8.9%	0.9	($) -2,648	
II: Peso portion only	93.5%	14.1	(P) 295,126	
III: US$ + Peso(1US$=1Ps)	55.3%	7.2	(P) 292,477	
IV: US$ + Peso(1US$=26Ps)	13.4%	1.3	(P) 226,272	

Note: Discount rate: US$ 10% Pesos 10%

Sensitivity Analysis: Results of sensitivity analysis are shown in Table 3.12. The benchmark EIRRs would be those computed for a sum of the US$ and the peso portions at the exchange rate of Ps26:US$1. The EIRRs are sensitive both to construction cost and revenue. A 20 percent increase in construction cost and a 20 percent decrease in revenue lowers the EIRR by 2.1 point and 3.4 point respectively. A 20 percent decrease in construction cost and a 20 percent increase in revenue lifts the EIRR by 2.9 point and 3.5 point respectively.

Table 3.12 Economic Sensitivity Analysis of Priority Project

	US$	Peso	US$+Peso (Ps1:US$1)	US$+Peso (Ps26:US$1)
Base case	8.9%	93.5%	55.3%	13.4%
Construction cost increases by 20%	7.2%	84.6%	49.1%	11.3%
Construction cost decreases by 20%	11.1%	105.2%	63.6%	16.3%
Revenue decreases by 20%	5.8%	82.5%	47.4%	10.0%
Revenue increases by 20%	11.9%	103.2%	62.5%	16.9%

(2) Economic Evaluation

The results of EIRRs of combinations of US$ and peso verified that the project is economically sound and its implementation is justifiable under the conditions and assumptions set for the Priority Project.

In the light of economic cost valuation, the appropriateness of conversion factors has to be ensured. In converting the financial cost of the priority project into its economic cost, various conversion factors were applied. On average, those conversion factors are around 0.8, which is an ordinary level in economic cost valuations.

The economic benefit of the priority project is composed of the benefits perceived by all the industries and inhabitants within the boundary of the city of Havana, and tourists who visit the city of Havana. Not all of them are direct beneficiaries or new sewerage users as the priority project covers only a part of the area of the city of Havana. However all of them are considered as beneficiaries in a sense that they can enjoy the improved environment of the bay area.

Reduction of morbidity of water-borne diseases related to the development of water supply and sewerage system is an understandable benefit. Assuming that a 10 percent of the acute diarrhea is attributable to poor excreta disposal and this can be eliminated by the priority project, the reduction of the incidence would be 25,000 per year. The economic benefit will be in Ps0.5 million per year at local price or US$3 million at foreign price.

Furthermore, the priority project, in combination with environmental education programs, will have a strong public appeal that the Cuban government commits itself to assume a responsible position for environmental improvement of the wider Caribbean region.

3.4.4 ENVIRONMENTAL EVALUATION

(1) Pollution Load Reduction

Figure 3.5 shows the comparison of pollutant load generation and reduction in the Master Plan and in the Priority Project in terms of BOD_5 load for the Central System and New Sewerage System.

1) New Sewerage System

Excluding the reduction by GEF/UNDP Project, the reduction by projects under the M/P in New Sewerage System (RN-M/P) is 35 % of total generation (G-N4) in all four sewer districts, 39% of the potential reduction in all four sewer districts and 20% of the total generation in Central System and New Sewerage System (G-CMN4) respectively.

Ratio of reduction in the Priority Projects (RN-F/S) to reduction in M/P (RN-M/P) is 32% and that to the generation in M/P area (GN-M/P) is 22% respectively. Corresponding ratio to the generation in all four sewer districts (G-N4) is 11%.

2) Central System

In the Central System, implementation of the Master Plan will result in the elimination of all load through drains (RC-M/P) and the implementation of Priority Project will result in 60% reduction (RC-F/S) of load through drains.

Overall, ratio of total load reduction in F/S (R-F/S) to the total load reduction (R-M/P) is 51%.

(2) Water Quality Improvement

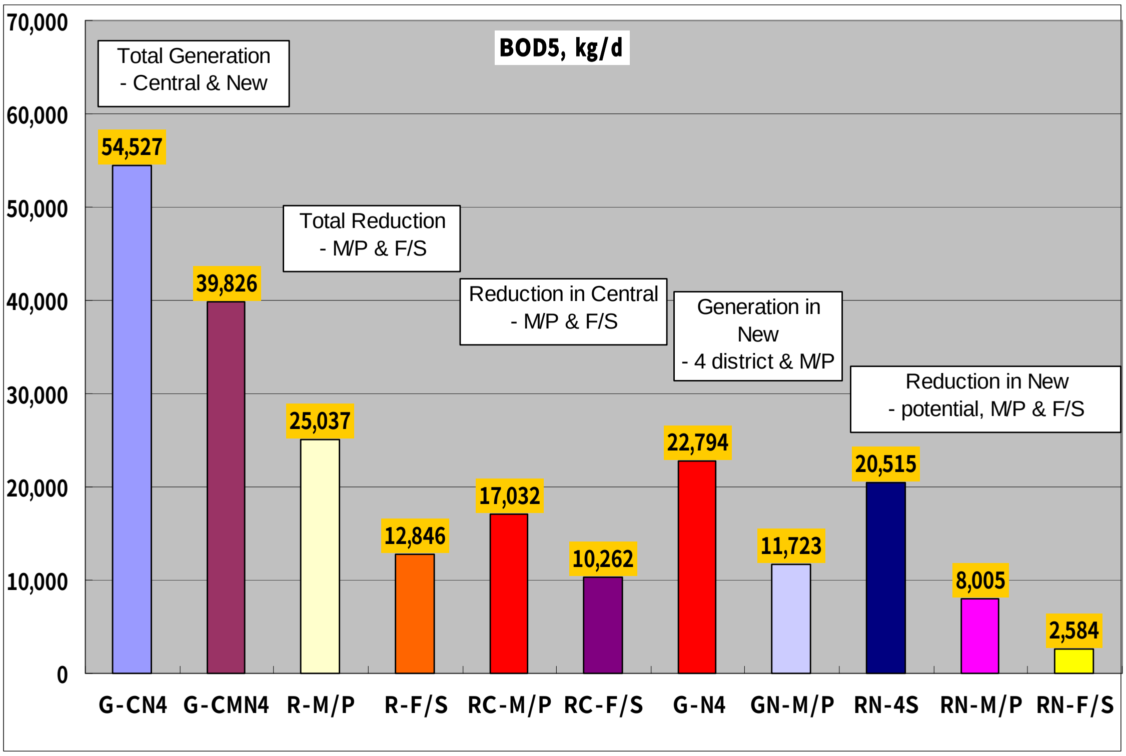
With the Priority Project, DO will be in the range of 1.5 to 2.0 mg/L in Atares and in Guasabacoa compared to 2.0 to 2.5 mg/L with the implementation of M/P as shown in Figure 3.6.

The difference between F/S and M/P in DO levels in Atares arise due to the location of Atares. Atares is the most inland cove of the bay and the oxygen supply through underwater ocean current will be limited compared to other areas resulting in lower DO levels in Atares. With the implementation of Priority Projects, pollution load input to Atares through drains will be eliminated through elimination of cross-connections related to Dren Arroyo Matadero and as a result of the on-going Belgium/Italian aided project in which Dren Agua Dulce will be diverted for treatment and discharge to Guasabacoa. Further improvement of DO levels in Atares in the subsequent stages will be possible due to overall improvement of water quality in the other parts of the bay.

Compared to the existing levels of DO in Atares which is below 1.0 mg/L, the improvement in the range of 1.5 to 2.0 mg/L due to implementation of Priority Projects will be significant considering the long-term water quality goal of 3.0 mg/L and by elimination of pollution load input to Atares. Priority Projects also improve water quality in Guasabacoa.

(3) EIA

EIA Study showed that the proposed Priority Projects are environmentally sound, however, localized impacts due to generation of odor and generation of sludge at the sewerage facilities are envisaged unless appropriate maintenance procedures are followed. Negative impacts are also expected during construction stage. It is recommended that several prevention/mitigation measures made through the results of EIA Study should be taken for necessary actions in the subsequent stages of the Priority Project.



Acronym	Description
G-CN4	Total Pollutant Load Generation (Central System and New Sewerage System)
G-CMN4	Total Pollutant Load Generation (Central System-measured and New Sewerage System-calculated)
R-M/P	Total Pollutant Load Reduction by M/P
R-F/S	Total Pollutant Load Reduction by F/S
RC-M/P	Pollutant Load Reduction in Central System by M/P
RC-F/S	Pollutant Load Reduction in Central System by F/S
G-N4	Pollutant Load Generation in All Areas of New Sewerage System (4 districts)
GN-M/P	Pollutant Load Generation in M/P Area of New Sewerage System
RN-4S	Potential Pollutant Load Reduction in All Areas of Sewerage System (4 districts)
RN-M/P	Pollutant Load Reduction in New Sewerage System by M/P
RN-F/S	Pollutant Load Reduction in New Sewerage System by F/S

Ratio	Value (%)
(RN-M/P)/(G-N4)	35
(RN-M/P)/(RN-4S)	39
(RN-M/P)/(G-CMN4)	20
(RN-F/S)/(RN-M/P)	32
(RN-F/S)/(GN-M/P)	22
(RN-F/S)/(G-N4)	11
(RC-M/P)/(RC-M/P)	100
(RC-F/S)/(RC-M/P)	60
(R-F/S)/(R-M/P)	51

THE DEVELOPMENT STUDY ON THE IMPROVEMENT OF SEWERAGE AND DRAINAGE SYSTEM FOR THE HAVANA BAY

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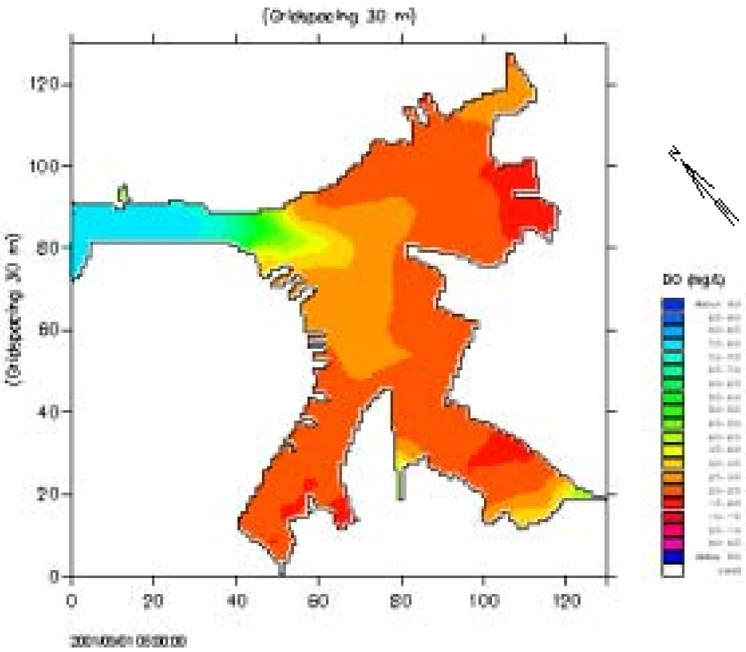
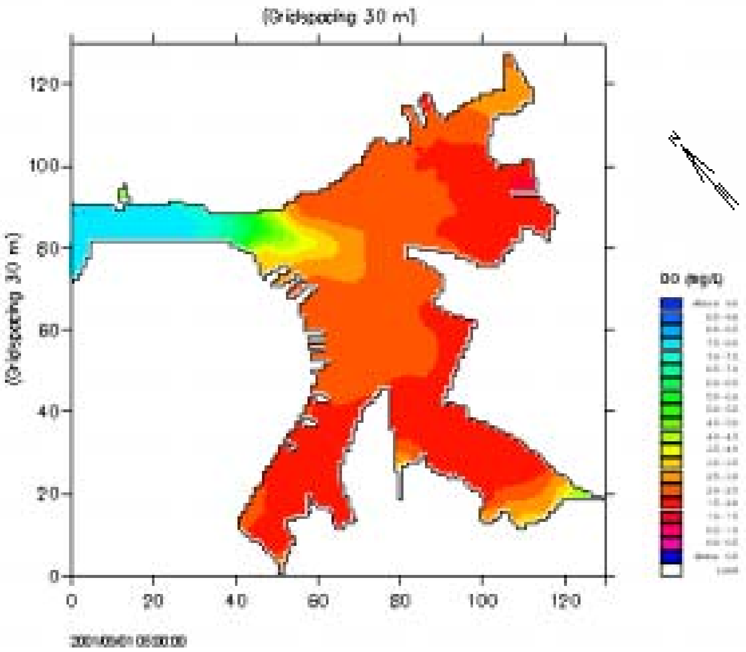
Figure 3.5
Comparison of Pollutant Load Generation and Reduction – BOD_5



Case M/P



Case F/S

THE DEVELOPMENT STUDY ON THE IMPROVEMENT OF SEWERAGE AND DRAINAGE SYSTEM FOR THE HAVANA BAY	Figure 3.6 Results of DO Levels for M/P and F/S
JAPAN INTERNATIONAL COOPERATION AGENCY	

3.5 CONCLUSIONS AND RECOMMENDATIONS

3.5.1 CONCLUSIONS

The Feasibility Study has verified the technical, economic, institutional and environmental feasibility of the proposed Priority Projects.

The proposed Priority Projects will contribute immensely to the improvement of the water quality environment of Havana Bay and will protect the bay from deterioration due to untreated wastewater discharge through sewerage and drainage which would occur if the Project is not implemented. The improvement of the Existing Sewerage System will contribute to the improvement the water environment of Atares which is the most polluted part in terms of DO level in Havana Bay. And the development of New Sewerage System will contribute to the improvement in Guasabacoa and to the overall improvement of bay water environment.

3.5.2 RECOMMENDATIONS

The study concluded that the implementation of the Priority Project is feasible. It is matter of fact that the Project could hardly be implemented without the external financial supports and the Cuban government subsidy or self-fund. Because at the beginning of the Project, the investment costs for the construction and rehabilitation works of such magnitude would be financially serious burden to the Cuban implementing agency such as INRH and GTE.

Under the year 2003 situations, the possibility of the government's asking a loan to multilateral or bilateral financial institutions is opaque. Getting a grant for this size of the project is not easy. It is recommended that the Cuban government should seek and establish a fund to allocate it for the following important and urgently required components of the proposed Priority Project but needed lower cost: 1) Detailed survey and design work to solve the cross connection problems in the area related to the Dren Matadero, 2) Survey on physical conditions of the siphon, and 3) Execution of necessary measures to solve the cross connections in the area related to the Dren Arroyo Matadero. These components are essential for the success of the improvement plan of existing sewerage system and to eliminate the wastewater discharge to Atares through the Dren Arroyo Matadero.

Some important institutional arrangements are proposed to strengthen and ensure the coordination of all the concerned parties. GTE will be continuously the environmental authority for the whole of the Havana Bay Basin, in particular it is advised to secure the necessary funding for conducting the proposed environmental monitoring and environmental education. INRH and DPRH will play important roles for execution and implementation of the projects. The management, operation and maintenance of the sewerage facilities rehabilitated and constructed under the project will fall under the Aguas de la Habana, thus it is recommended that the Concession Agreement with Aguas de la Habana would be reviewed and revised.

To facilitate smooth implementation of the project, the institutional arrangements for project implementation are proposed. It is recommended that a steering committee be formed representing all of the relevant agencies and bodies, such as MINVEC, GTE, INRH (DPRH), Aguas de la Habana, and International Consultants as a Project Institutional Framework. It is also proposed to establish an organization for technical design and construction supervision.

It should be reminded that the sewerage system can reduce pollution loads to the Havana Bay only when the system operates properly. To operate properly, the followings are indispensable: enough budget for the O/M, receive stable power supply and periodical trainings for operator and staff to lift their moral as well as the technology required. The central government's support in term of financial and institutional assistance is also essential for the operation of the sewerage system.