APPENDIX-14

ENVIRONMENTAL IMPACT ASSESSMENT SURVEY

Contents

A14.1 INTRODUCTION

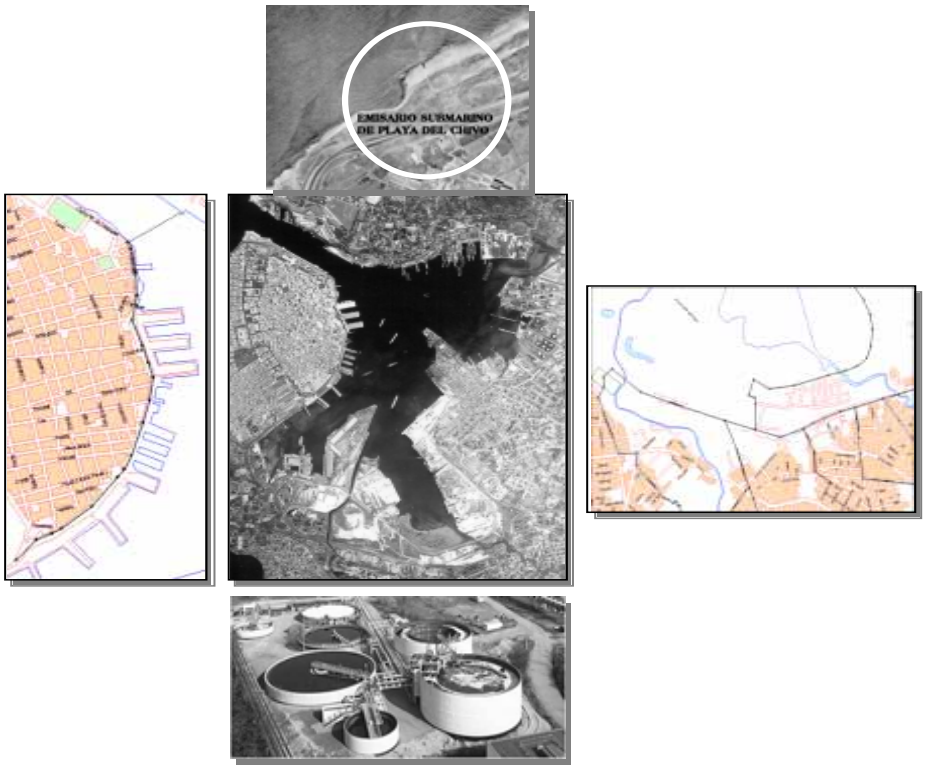
Environmental Impact Assessment Survey was carried our by the CIMAB under the direction of JICA Study Team. The Draft Report is attached herewith.

Cimab
CENTRO DE INGENIERIA Y MANEJO AMBIENTAL
DE BAHIAS Y COSTAS

The Development Study on the Improvement of the Sewerage and Drainage System
for the Havana Bay in the Republic of Cuba

Environmental Impact Assessment Study

Priority Projects on Rehabilitation of Existing Sewerage
and Development of a New Sewerage System



FINAL REPORT

Havana City, November 2003

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CENTRO DE INGENIERIA Y MANEJO AMBIENTAL DE BAHIAS Y COSTAS

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

Environmental Impact Assessment Study

Priority Projects on Rehabilitation of Existing Sewerage
and Development of a New Sewerage System

FINAL REPORT

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Havana City, November 2003

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I. INTRODUCTION

The Resolution 77/99 of the Ministry of Science, Technology and Environment (CITMA), establishes the Regulation to undertake the Environmental Base Line Studies, the execution and approval of Environmental Impact Assessment and the Environmental License. Cimab is a research institution authorized by the CITMA to execute the environmental impact studies in industrial projects.

The work, called under this Tender (hereinafter to as the EIA Study) will be conducted as part of the Development Study on the Improvement of the Sewerage and Drainage System for the Havana Bay in the Republic of Cuba. The output of the EIA Study will serve as a basis to obtain the Environment License in the future.

The environmental impact assessment (EIA) is a process of analysis that predicts in advance the future negative and positive environmental impacts of human actions allowing to select the alternatives which, fulfilling the proposed objectives, maximizes the benefits and mitigates the undesirable impacts. A process of environmental impact assessment for investment projects should be designed to coordinate the environmental protection and the execution of human activities with the preservation of the environment and the life quality, allowing a sustainable use of the natural resources.

This is the case of the EIA that has been requested by JICA Study Team to CIMAB where the study will be executed on parallel with the feasibility studies of the projects proposed in the Master Plan of the development of the sewer system and the pluvial drainage in the Havana Bay.

2. METHODOLOGY

The matrix of impacts shall be used in the execution of study. Before gives any valuation, a previous analysis will be done on the main influenced environmental factors. This method identifies the project actions in the construction and operation phases as well as the environmental factors influenced by the Priority Projects.

It identifies the positive and negative impacts and the importance of each impact in the territory according to the character, intensity, extension, moment, persistence, reversibility, recuperative, synergism, accumulation, effect, rhythm and importance approaches (annex 1). Consequently, proposals of measures to prevent or mitigate negative environmental impacts will be also identified.

The preventive and correction measures consider the mitigation actions for the different influenced environmental factors; in particular, wastewater and solid waste generated in the new activity, materials storage, noise, the environment visible changes and potential risks for human safety and the environment. Preventive measures belong to the design and early stages of the project. Correction measures are able to mitigate the negative effects resulting from the project.

The project area is within the Havana Bay basin and most of the aspects to consider are common to each location; therefore, the Report would be very repetitive if they are considered independently. The study will be carried out based on the information made available by the JICA Study Team and therefore, EIA need to be refined or strengthened in the subsequent stages of the project. In spite of the changes, the results of this study will serve as a base study for the application of the Environmental License of the priority projects approved in the Master Plan.

3. MASTER PLAN

3.1 Brief description

One of the main outputs of the GEF/UNDP Project "Planning and Management of Heavily Contaminated Bays in the Wider Caribbean" was the development of an Investment Action Plan for Havana Bay rehabilitation. The first action of this plan was lead to the urgent need of diminish the uncontrolled and unsustainable discharge of sewage into the bay. This included the construction sewage treatment plants, the rehabilitation and construction of new sewage networks and to design and constructs a new outfall.

Having this conditions, and in order to overcome the Havana bay pollution problem, the Cuban Government made a request to Japan for technical assistance in the formulation of a sewage and drainage systems Master Plan. As a result of the Cuba-Japan collaboration agreement the project "Development Study on the Improvement of the Sewerage and Drainage System for the Havana Bay in the Republic of Cuba" was signed being the reason of this EIA Study.

The main project objectives are:

- To prepare a Master Plan for the sewerage and drainage systems of Havana with the year 2020 as target year.
- Carry out feasibility studies to selected projects of the Master Plan

At this stage, major Master Plan projects and activities are already outlined. Altogether, feasibility studies are being carried out to some selected projects within the Master Plan. On the other hand, few priorities projects have been identified and an environmental impact assessment will be performed under this report.

The Master Plan, as a whole, has been considered as the combination of the (1) Improvement of Existing Central Sewerage System and (2) New Sewerage System, Development in the Luyanó-Martin Pérez Abajo Sewer District. The Master Plan should be implemented in three consecutive stages with specific activities or projects within each stage, as depicted in Table 1 together with some other relevant information (data obtained in the last meeting of the Technical Advisor Committee, Held on October, 2003).

According to preliminaries results of the feasibilities studies, the total cost (foreign + local currency) of the Master Plan implementation is around 212 millions. From them, 97 millions, 60 millions and 55 millions for the first, second and third stages respectively. At this moment the ratio of foreign and local currency is 60 % and 40% respectively, although this is still under discussion.

It is estimated that from the total cost of the project, 50 millions belong to the Improvement of Existing Central Sewerage System and 170 millions to the New Sewerage System, Development in the Luyanó-Martin Pérez Abajo Sewer District.

Table 1. Summary of the proposed Master Plan

Item	Proposed Sewerage Master Plan (Up the year 2020)	Breakdown 1: Improvement of Existing Central Sewerage System	Breakdown 2: New Sewerage System, Development in the Luyano-Martin Pérez Abajo Sewer District
Sewer Service population	Total: 750 600 inhabitants Study area: 591 500 ha	Service Population: 587 000 inhabitants Study area: 427 900 ha	Service Population: 163 600 inhabitants Study area: 138 300 ha
Sewerage Service Area	Total area: 4 289 ha Study area: 3 522 ha	Total Sewered area: 2 989 ha Study area: 2 222 ha	Total Sewered area: 1 300 ha Proposed sewered area: 1 054 ha
Wastewater generation as of year 2020	Total: 263 700 $m^3.day^{-1}$ Study area: 204 600 $m^3.day^{-1}$	Total: 207 300 $m^3.day^{-1}$ Study area: 148 200 $m^3.day^{-1}$	Total: 56 400 $m^3.day^{-1}$ By the implementation plan: 47 940 $m^3.day^{-1}$
BOD_5 Pollution Loads as of year 2020 ▪ Generated Load ▪ Discharged Load ▪ Reduced Load	 55.5 ton.day^{-1} 15.3 ton.day^{-1} 54.3 ton.day^{-1}	 43.8 ton.day^{-1} 0 ton.day^{-1} 43.8 ton.day^{-1}	 11.7 ton.day^{-1} 15.3 ton.day^{-1} 10.5 ton.day^{-1}
Proposed Phased Implementation Program (Sewerage Master Plan)			
First Stage Project			
		Detailed Survey and Design Work to solve the Cross Connection Problems in area related to the Dren Matadero	Installation of the proposed Luyanó-Martin Pérez Right Colector
		Survey on Physical conditions of Siphon	Installation of the proposed Luyanó Left Colector
		Rehabilitation of Screen Facilities at Caballeria	Construction of Biological Secondary Wastewater Treatment Facilities at the Luyanó WWTP, having the treatment capacity of 207 L.s^{-1}, the total treatment capacity becomes 407 L.s^{-1} or 35 200 $m^3.day^{-1}$ including the capacity of 200 L.s^{-1} developed by the GEF/UNDP Project.
		Rehabilitation of Casablanca Pumping Station	Construction of Sewer Networks and House Connections in Luyanó-Martin Pérez Abajo Sewer District
		Construction of the proposed Matadero Pumping Station	
		Installation of the Bypass pipe between the Colector Cerro and the Matadero Pumping Station	
		Installation of the Pumped Main and the Colector Sur Nuevo between the Matadero Pumping Station and the Screen Facilities at Caballeria	

Second Stage Project			
		Detailed Survey and Design Work to solve the Cross Connection Problems in area related to the Drain Agua Dulce	Extended Installation of the Luyanó-Martin Pérez Right Colector
		Rehabilitation of the Colector Sur	Extended Installation of the Luyanó Left Colector
		Construction of the proposed Re-pumping Station for the Central Sewerage System with a minor repair of the Transmission Tunnel	Expansion of the Biological Secondary Wastewater Treatment Facilities at the Luyanó WWTP. The expansion of the treatment capacity is 207 $L.s^{-1}$, thus the total treatment capacity becomes 614 $L.s^{-1}$ or 53 100 $m^3.day^{-1}$
		Replacement of the Sewer Outfall	Construction of Sewer Networks and House Connections in Luyanó-Martín Pérez Abajo Sewer District
Third Stage Project			
		To take measures to solve the cross connection problems in the area related to the Dren Agua Dulce	Extended Installation of the Luyanó-Martín Pérez Right Colector
			Extended Installation of the Luyanó Left Colector
			Expansion of the Biological Secondary Wastewater Treatment Facilities at the Luyanó WWTP. The expansion of the treatment capacity is 207 $L.s^{-1}$, thus the total treatment capacity becomes 821 $L.s^{-1}$ or 71 000 $m^3.day^{-1}$
			Construction of Sewer Networks and House Connections in Luyanó-Martín Pérez Abajo Sewer District

3.2 Background

The bay drainage area is formed by three river basins Luyanó (28.1 km.^{2}), Martin Pérez (12.2 km.^{2}) and Arroyo Tadeo (2.6 km.^{2}). More waters come from the superficial runoff of the upper parts of Morro and Cabaña Castle as well as from other the areas served by the pluvial drainage discharging their waters directly into the bay. The fresh water flow entering the bay is around 330 000 $m^3.day^{-1}$.

The water quality of Havana bay and adjacent coastal waters are currently showing critical conditions due to the high level of pollutants discharged into that coastal ecosystem. The main pollutants contributions come from the fluvial currents (Luyanó, Martin Pérez and Arroyo Tadeo rivers), the pluvial drainage (Matadero, Agua Dulce and San Nicolás) and from nearby industries, mainly the petroleum refinery Ñico López.

According to base studies carried out during the Plan Master preparation, the current conditions of wastewater discharges into the Havana Bay as well as its values are showed in Table 2.

Table 2. Existing conditions (2002)

Sewer District	Source	Flow rate $m^3.day^{-1}$	DBO_5 kg. day^{-1}	N-T kg. day^{-1}	P-T kg. day^{-1}	SS kg. day^{-1}
River						
Luyanó - Abajo	Luyanó	114 826	9 874	1 627	732	3 875
Luyanó - Arriba						
Martin Pérez - Abajo	Martin Pérez	62 122	1 518	245	55	1 066
Martin Pérez - Arriba						
Arroyo Tadeo	Arroyo Tadeo	8 517	1 812	104	46	98
Drainage						
Matadero	Matadero	8 554	1 320	145	79	352
San Nicolás	San Nicolás	77 760	8 942	610	1 053	3 650
Agua Dulce	Agua Dulce	43 200	6 770	529	1 171	3 242
Industry						
Oil Refinery	Oil Refinery	6 404	21 723	54	1	
Total		**321 385**	**51 869**	**3 314**	**3 137**	**12 284**

Table 2 depicts that, currently, the bay receives an organic load near to 52 $ton.day^{-1}$ causing the occurrence of anoxic areas in few points, mainly in Atares and Guasabacoa coves. According to estimations carried out by the JICA Study Team for the 2020 year, in the Master Plan study area, an organic load (DBO_5) of 55.5 $ton.day^{-1}$ will be generated.

According to several analyses, it is considered that once the Master Plan is implemented (year 2020), 80% of the generated organic load won't have the bay waters as final destination. Similarly, a noticeable reduction of nutrients and solids discharge can be expected.

Just mentioning the expected reduction figures gives an idea of the overall magnitude of the positive impact for the bay water quality and in general for the environmental quality of the Havana Bay ecosystem. However, the implementation of this Plan in the bay basin will bring several negative impacts that need to be deeply analysed within environmental impact assessment of the selected Priority Projects.

4. ENVIRONMENTAL CHARACTERIZATION

4.1 Historical environmental changes background of the territory

The San Cristobal de La Habana Village was founded in 1519, in the western coast of Havana bay, being this natural element that determined the establishment of the village. In 1600 year had a population of around 2000 inhabitants and occupied an area of 37 hectares. This village was designated officially as the capital of the Colony in 1607.

During more than 2 centuries, the Havana port was the most relevant in the western hemisphere. The city became a strategic place for the Spain domain, because was established as the center of the maritime traffic between the old and new world.

In the second half of the XVII century was initiated the territorial, architectural and urban development, and reached its maximum splendour in the XIX century. An important infrastructure works and urban development were carried out as the railroad, the public gas lighting, the mail and telegraph systems, the phone communications, the first aqueducts, and at the end of the century, the electrical lighting. In 1899, the city had already 250 000 inhabitants and an extension of 800 ha. The warehouses and industrial activity were located inside the urban area, associate basically to the port area and prevailing the small factories (tobacco, livestock slaughter, and leather).

The location of the city and the port in the Havana bay coastline, the deforestation with the consequent land erosion and the use of the bay's water as a receptor of domestics, shipping and industrial (mainly slaughterhouse and tannery) wastes, resulted in depths decrease, water pollution and ecosystem biodiversity loss.

The city development substituted the natural landscape for a cultural landscape, disappearing the natural forest, due to the urban growth, the agriculture activity and the livestock rising.

In the 1900-1924 period (Neocolonial stage) the city grows in all directions basically a greatest expansion process toward the West and South of the original center and lesser toward the East. It was developed the Intermediate Area of the current city which is characterized by a medium and low land occupation, prevailing 1 and 2 floors individual housing, largely seated on soils of good agricultural capacity.

In the early stages of the XX century was consolidated the current traditional center, urbanized in the sector that previously occupied the walls. It was built the sewer system and new aqueducts. The industry continued being inserted in the urban sector, mainly near to the port areas. The population in 1925 ascended to 600 000 inhabitants and the city reached an area of 3000 hectares.

During the 1925-1958 period continued the territorial expansion and demographic growth, the existing sewer system was overloaded (projected for 600 000 inhabitants), in the new urbanizations partial solutions were executed or the wastes were infiltrated in the water table. Polluting industries were developed as electricity plants, oil refinery, fertilizers, soft drinks and liquors among others, mainly without treatment solutions for their aggressive wastes.

The city had more than a million of inhabitants in 1958, being duplicated the population and with an extension of 2000 hectares in a 25 year-old period. The capital concentrated the 52% of the industrial facilities of the country, the 90% of imports, the 35% of the domestic trade, the 60% of hotel capacities and the 70% of health services.

The great industrial investments were located around the port, beginning with thermal pollution in the bay waters, and afterwards increasing the chemical and organic pollution of them. Also, the fluvial currents were polluted by this fashion. The contribution of domestic and industrial solid wastes was increased too, due to the land discharge of garbage in Cayo Cruz dump, located at the south of the bay.

The design capacity of the city sewer system was insufficient at the end of the period; also, the Playa del Chivo outfall discharged the sewage wastewaters without treatment at the east of the bay entrance channel, polluting the coast.

Although in this period, the urban development plans were elaborated, the city doesn't escape to the great social contradictions that will be reflected in its growth.

During the 1959 to 1981 period (Revolutionary stage) the population's increment is significantly smaller compared with the previous stage. Action plans were carried out for the development of others provinces of the country, the increase of the women cultural level and their incorporation to the work. All these aspects implied the decrease of the migratory patterns toward the capital and for that reason, a substantial decrease of the birth rate. In 1981, the city had 1,9 million inhabitants being reported an inferior growth in almost 300 000 inhabitants to the one registered in the two decades previously to the year 1959.

In the 1963 - 1970 period, Urban Masters Plans were elaborated, relating the growth of the urbanized area with the development of infrastructure works, new industrial areas and great transport facilities mainly associated to the port development. Also, the railway was reconstructed, an important road network was build and the enlargement of the airport was carried out.

The pressures upon the environment were decreased from demographic growth point of view, but the land expansion was increased. The limitations of the city hydraulic works continue, for example, the water supply system doesn't provide the extracted real volume, because the water losses due to the deficient conditions of the pipes and networks. The sewer system continues overloaded and the pluvial drainage development is insufficient, as well as, the sanitary cleaning and the final disposal of solid wastes.

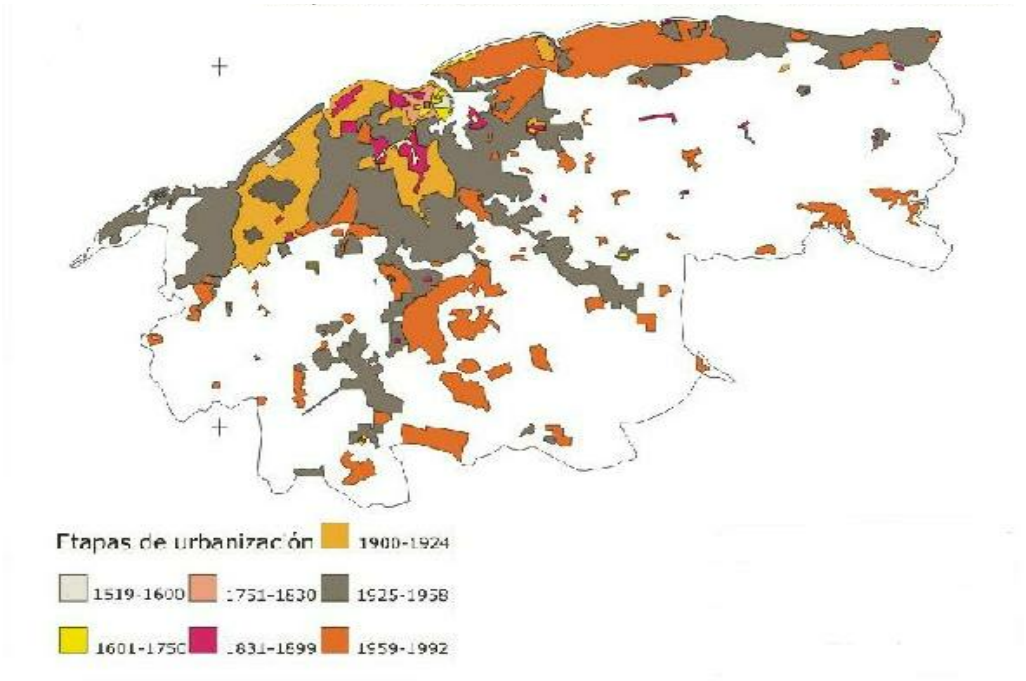
In this stage, the Cayo Cruz dump was closed and the operation of Guanabacoa and Calle 100 landfills began, this last one located on the Almendares Vento Basin.

In 1984, the Cuban Ministers Council accepted the actions of the City Master Plan. Also were defined the Development Conditions toward the year 2000, and the Technical-Economic Basis to the year 2030. In this Plan was highlighted the criteria of population growth control, so that the City doesn't exceed 2.2 million inhabitants in the year 2000. Also, was considered that urbanization should maintain inside the existing limits to achieve a better land use, as well as, the conservation and rehabilitation of the building facilities. In figure 1 is shown the progressive urbanization of Havana City.

With the beginning of the *Special Period,* the initiate programs were interrupted and others were overdue. It is guaranteed the Health, the Education, the Social Security and food basic supplies. The employment level decreases significantly in the industry, transport and construction, discontinuing the investment process. As consequence of this crisis period, the migratory flow toward the city increased of 12 000 people (annual average) to 28 000 in these years. Due to this migratory flow special regulations were established.

A slight economical recuperation began in 1994, the tourism sector impacts strongly in the improvement of other economic sectors in the city, supplemented with the search of new development alternatives.

The production activity decrease and the look for new alternatives and solutions, e.g. the increment of the efficiency and energy saving due to the petroleum deficit, the increment of organic agriculture due to the drastic reduction of the fertilizers manufacture and import, the employ of useless soil and the improvement of the feeding possibilities with the urban agriculture, the construction of 2 submarine outfalls when was not able to be carried out the foreseen sewer systems, etc, produce a reduction of the environment pressures.



SOURCE: Institute of Ecology and Systematic, Cuba

Figure 1. Urbanization Map of Havana City

Nevertheless, other factors implicate the increment of the pressures on specific natural resources and the environment in general. The limited actions in the rehabilitation of the man-made structures and of the technical work nets, have accentuated their deterioration; it has been needed to keep the thermoelectric in the city, increasing the pollution because it should operate with Cuban petroleum that has high sulphur content.

To guarantee the gathering of solid wastes with the minimum fuel and equipments consumption, was needed to locate in each municipality temporal landfill, without an appropriate management of these wastes, increasing in consequence, the risks of soil and water pollution. The solutions adopted for the massive passengers transport contribute to the deterioration of the road networks, the increase of the noise level and air pollution. The impossibility to implement the needed housings, has implicated the setting of transitory communities in some areas of the periphery, with low cost housings that constitute a potential focus of man-made construction deterioration in the future.

In the last decade, due to the land demands inherent to the establishment of new economic relationships, the tourism development and the introduction of the real state topic, several documents of Strategy, Policy and Guidelines were elaborated. In this document was highlighted as prioritised aspects the following: the reduction of environmental and hygienic deterioration of the city, the protection of the natural and built inheritance, and generally, to achieve the sustainable use of the natural resources and the environment.

As main aspects, it can be mentioned the population growth planning and the limitations on land expansion of the city; the establishment of the Protected Areas system; the rehabilitation of Havana Bay and the restrictions to industry increase in the central area or at industrial areas established on prioritised basins, making technological changes that contribute to the atmosphere and soil protection, and to the water and energy saving.

4.2 Base line description

4.2.1 Characterization of the Natural or Physical Environment

Geology and Topography

Mainly, the prevailing topography is smooth in the study area, with an altimetry that goes from 0.7 m in the lowest areas of the basin (in the Tiscornia cove), to approximately 100 m of height, upon the mean sea level, in the south part (surroundings of Rio Hondo).

Surrounding most of the bay, appears a low flat plain, which occasionally is inundated, but in the Tiscornia area stays permanently flooded with mangrove vegetation. Contiguous to this low plain at the Northwest and the West appears a terrace like coastal plain with a soft slope, constituted mainly by calcareous reef, Neocene coralline and also friable deposits of the Quaternary age.

A hilly plain furrowed by a great number of creeks that represent the rivers fluvial heads forms the central and south part of the basin territory. From the geological point of view, this plain is formed by argillites, arenite, aleurolites, tufas and loams dislocated intensely. To the east there is an undulating plain on clay sands, lime, and loam clays, forming a terrigenous flysch of the Superior Cretaceous, with a presence of hills, lithological represented by ultra basic serpentine.

A denudation scarp worked on calcareous rock, loams and limestone, with a strong slope toward the south, reaching an approximate 60 m height, represents the perimeter that limits the study area through the northwest part.

Geology of the site of GEF/UNDP Plant Project

In the specific case of the GEF/UNDP Plant, that will be located less than 1 km. from the ongoing Luyano River Treatment Plant. This investigated area is nearby to the Luyano river mouth and tectonically, belongs to the group structural-tectonic heights, horst-anticline type, being distinguished two main tectonic structures, sub latitudinal and sub meridian.

It can be distinguished two lithologic types of soils and rocks from the land surface:

- Quaternary Deposits: Filled soils, lagoon lime, marine-lagoon clays, marine and clays delluvial clays.
- Cretaceous Deposits: elluvial clays, loams clastic, aleurolites and argillites elluvial, arenite.

From lithological point of view, clays, aleurolites, arenite, gravesites, conglomerates and olistostromes represent this formation. The first ones appear associated in sequences of flysch type, inside which can be presented layers of thicker lithology.

Geologic description of the layers

In general, in that area can be founded the following lithologic layers:

- *Filler material*: Clays and sandy material of cream-yellow colour with rocky fragments, plastic, not very hard consistency. Average thickness: 1.0 m
- *Silt layer:* silt material of fetid black colour, with garbage residues, scrap, roots, abundant organic matter in decomposition at the superior intervals, that goes in transition to lime oozy silt, plastic, of black colour, very fetid. The cut tool penetrates without any resistance.
- *Clay with sandy fraction*: Sandy clay of green colour with tonalities gray-blue, not very plastic, in the inferior part of this layer the sandy fraction is thicker and with abundant remains of snails and conchs. It presents a medium to hard consistency.
- *Plastic clay:* Brown colour, hard, very plastic, well consolidated. It changes from green-brown tones with sticks of greenish colour to a clear homogeneous brown colour. In some occasions, there are small glasses of calcites, and in the layer base usually appear inserted fragments of calcareous, arenite and very weathering argillites inside of the clay matrix.

- *Arenite:* Arenite of clear cream colour with blue tonalities very well defined. It is very hard, massive, presents some fractural planes, in occasions can appear more fractured and inserted inside of the plastic clay layer. Average thickness: 8 m.
- *Argillite:* Argillite of clear green colour to brown very altered, with thin sticks of calcium carbonate and plaster, stains of iron oxide. Average thickness: 10 m.
- Geologic layers determine and its physical and mechanical properties:

  - ✓ *Geologic Layer A*: Concrete + filler.
  - ✓ *Geologic Layer* B: By the results obtained, is a silt lime-clay, dark gray colour to gray blue with fetidity, of plastic flowed consistency, saturated with a content of organic matter of 83.15% and a high porosity. Inside of the layer there are solids wastes such as: wood, textile, glasses, rubbish residues, but in a largest proportion because of river contributions and the existence of the old uncontrolled dump of Cayo Cruz. in the West coast.
  - ✓ *Geologic Layer C*: Sandy clay of clear green colour, middle to hard consistency, without characteristic odour, not very plastic and corresponds to fluvial - marine deposits, with variables conditions of sedimentation, due to this fact its physical properties are non homogeneous and can reach a thickness average of 2.0 - 3.0 m (although is very variable).
  - ✓ *Geologic Layer D*: Very plastic clay of rigid consistency, very thick, of brown and brownish colours. In these stratums can be observed detritus lenses, clastic material, sand, Chalk and carbonates. These soils are subjected to swelling processes.
  - ✓ *Geologic Layer E*: Underneath the clay deposits the cretaceous rocks lie, their superior part usually appears destroyed as a result of the weathering and disintegration processes. This layer is formed locally by argillites of green to brown clear colour with thin plaster sticks, arenite lenses that can reach considerable sizes and are always located above the argillite, as the arenite lenses present in the study area. It consistency is hard to semi-hard in some parts, due to the presence of fissures. Appears to the depth that was perforated (25 m) beginning from the 12.0 to14.0 m.

Characteristics of the Guasabacoa Cove

The lithologic composition from the surface to the bottom of the bay water is as follows:

- From 0.0 to ± (- 11.0) is seawater (Layer A).
- From ± (-11.0) to ± (- 13.0) is plastic fluid silt (Layer B).
- From ± (- 13.0) to ± (-14.0) is silty Clay (Layer C).

At the Luyanó River mouth, a silt thickness (Layer B) of 10 m is appreciated. In the layers D and E serpentine appears in the variants of clay serpentine and gravels due to the ultrabasite intrusion of the geologic area.

The results of the laboratory studies carried out to determine the physical properties of the polluted sediments are shown in the Table 3.

Table 3. Physical properties of the Guasabacoa Cove

Geologic Layer	Lithological description	Wf %	ϒf g/cm³	ϒd g/cm³	LL %	LP %	IP	IC adm	ϒs g/cm³	Q %	e adm	s %	η %
B	Grey silt	107.02	1.38	0.70	94	47	47	0.17	2.52	83.15	2.60	103.7	72.2
C	Clay	53.60	1.60	0.97	93	40	53	0.98	2.66	86.77	1.74	81.83	63.5

Geologic Layer B

It is silt lime-clayed of dark grey to blue grey colour with fetidity, of plastic fluid consistency, saturated with organic matter with a content of 83.15% and a high porosity. In Guasabacoa Cove occur the same phenomena as in the Atares Cove, the silt layer contains wood, textile, glasses, rubbish residues, but in a largest proportion due to the pollutant inputs from the Luyanó and Martin Pérez rivers and the existence of the old Cayo Cruz landfill, in the West coast. At the Luyanó river mouth a silt thickness of 10 meters is appreciated (Layer B).

Engineer Geologic Layer C

It is classified as a silty clay of dark grey to blue grey colour, of duriplastic to semi-hard consistency, and is semi-saturated. In the Guasabacoa Cove differ to the Atares Cove; the silty clay has a porosity of 63.53% and 86.77% of organic matter due to the presence of lumber wastes and others. The thickness varies from 1.0 meter to 0.

Meteorology

The subtropical climate of Cuba receives a strong influence of the moderate northeast winds that change lightly toward the east, in the summer. Due to the island form, few places are distant of these moderate breezes, and in the seasons great variations of temperatures are not observed. In Cuba, differing to other countries, two very defined seasons exist: the summer with predominance of rains and the winter or dry period. Those periods are manifested between May-October and November-April respectively.

The highest mean annual temperature in Havana City is 28.8 ^{o}C and the lowest is 21.4 ^{o}C. The humidity ranges varied between 81% in the summer and 79% at the winter, and specifically in Havana City is register 79.5%. The mean annual rainfall is 1411 mm.

Hydrology

The basin extension is 68 km^2 and the bay area 5.0 km.^{2}. In the Table 4 shows the extension of the main sub-basins where the main projects of the EIA are involved.

Table 4. Main basins area

Basin	Area (km.^{2})
Habana Vieja	2.6
Arroyo Matadero	6.8
Agua Dulce	6.5
Luyanó River	30.0
Martin Pérez River	13.1

The Luyanó, Martin Pérez and Arroyo Tadeo rivers discharged to the bay from the south, with a combined basin area of 45.7 km^2. In the Table 5 are shown some of the characteristics of these rivers.

Table 5. Characteristics of Havana Bay tributary rivers

Indicators	Luyanó River	Martin Pérez River	Arroyo Tadeo	Total
Basin area, km.^{2}	30.0	13.1	2.6	45.7
River longitude, km.	10.1	6.4	2.3	-
Flow in the year 2002, m^3.day^{-1}	114 860	62 105	8.004	184 969
Average volume, L/km.^{2}.s	0.1214	0.1503	0.0976	0.1283

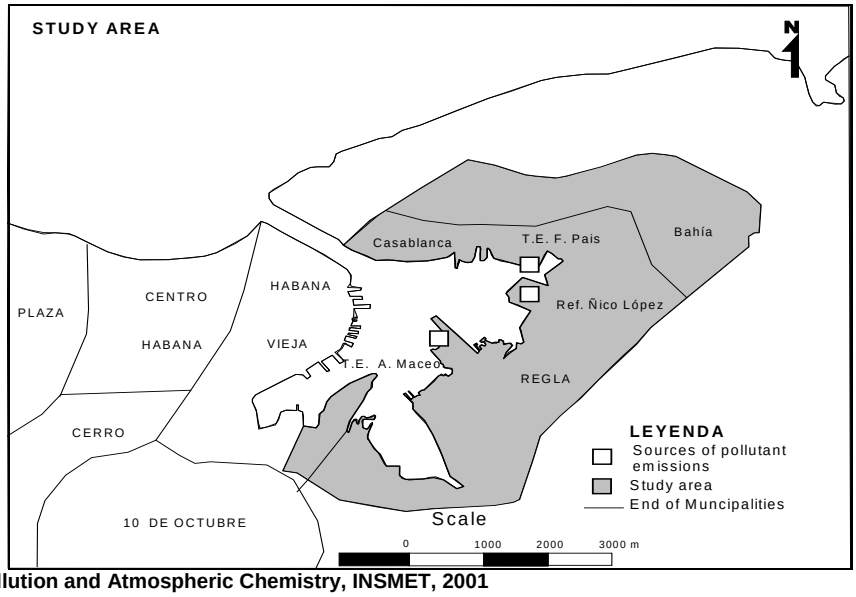
Soil

The soil is the most external solid part of the earth crust and has experienced the actions caused by atmospheric agents and human activities. Also, support the vegetation. There are some actions that cause the loss of soil quality, and as consequence can influence in the decreasing of the soil value, the decrement of the agricultural production and the landscape deterioration. In the study area, can be appreciated changes in the land use, because the agricultural soils have became in urbanized zones. The predominant soils are Red Ferralitic Type, Hume calcimorphic y Hume carbonate, which are productive soils, being affected the cultivations yield because restrictive factors as concretion, hydromorphia, rockiness and soil depth. The landscape is flat with slight slopes.

Air

The air pollution in Havana City doesn't only have industrial origin but also, of mobile sources. Currently, there are very few resources to assume an appropriate monitoring, which can allow to quantify and to thoroughly know the emissions. Neither can determine, with accuracy, the pressure to which the environment is subjected and the effects on the atmosphere. In 1999, the city had 1961 installations of the industrial sector belonging to 21 branches. The 75% of the installations corresponds to electric energy, chemistry, food stock, fishing industry, soft drinks and tobaccos, construction of non-electric machinery and other industrial activities. These installations are located disperse inside the urban area as well as grouped and industrial areas, such as Duty Free areas. According to the Air Pollutant Sources Inventory, 568 sources are identified in the city; from which are unknown the emission levels in general, being needed to implement through the managerial administration these emissions characterization.

Within the framework of the Programa Ramal Científico-Técnico “Protección del Medio Ambiente y el Desarrollo Sostenible Cubano”, Centre of Pollution and Atmospheric Chemistry, the Centre of Climate and the Centre of Physics Atmosphere of the Meteorology Institute, in cooperation with the Health Municipal Directions of Regla and Habana del Este, carried out the characterization of the atmospheric environment in the area of the east coast of Havana Bay (Figure 2) and elaborated methods to foreseen bronchial asthma and High Breathing Infections. This constituted a contribution to the epidemic surveillance system in this area. The pollutants detected, can be associated to the incidence of these illnesses in the population. The emitting sources were identified and are proposed the needed actions to mitigate this impact in the study area.



Source: Centre of Pollution and Atmospheric Chemistry, INSMET, 2001

Figure 2. Study area location

Landscape

The landscape is classified as heavily modified due to the land changes of the urban-industrial development. It is recommended reforestation for the landscape improvement.

4.2.2 Biota characterization

Flora

In the West bank of Luyanó river, the vegetation is scarce and only in some points near to the bank exist trees and isolated bushes, associated to the secondary herbaceous vegetation forming tropical forests. On the opposed way, in the east bank there are mangroves with thorny brushes. The area is characterized by the poor presence of endemic vegetation.

Land Fauna

In the study area, the land fauna communities and the hydrophilic fauna can be found and are the following:

- False *sparverius sparveriodes* (sparrow-hawk)
- *Colinus virginianus cubanensis* (quail)
- *Sturnella magna hippocrepis* (starling)

In the area are not reported migrations of important species, neither exotic species or in danger of extinction.

Aquatic Fauna

The study of the natural fishes communities was carried out from the entrance channel of Havana bay to the center and the Sierra Maestra docks. Currently, the results showed that a portion of the bay, is a nursery area for several fish species. Were counted 402 individuals belonging to 19 species. The total diversity was low, although not as much as it could be expected. The most abundant specie (*Gerres cinereus,* dagger) is typical of estuarine environments or with strong influence of the land run off. It were observed, although in smaller abundance, typical coral reefs species, as the case of the genus Chaetodon indicating that the bay presents a mixed ichthyfauna from diverse origins.

The 84% of the count individuals can be classified unequivocally as juvenile due to its small size. These individuals were observed mainly in the area of the entrance channel near the coastline grouped generally around submerged objects.

Currently, this bay area, is very important because its economic value; the potential area for nursery is much bigger and an increase should be expected with an effective control of the pollution sources. The reproductive capacity of the natural fishes communities is very large in these areas, because the local ichthyfauna is renewed by a great deposit of pelagic larvae, which are develop at the open sea.

4.2.3 Socio - economic and cultural characterization

Socio-demographic factors

This aspect is very important in the planning of the development policies, social programs and ecosystems management due to the population movement or distribution.

At the end of the year 2001, the resident population grew up to 2 millions 181 000 inhabitants, that means 16 000 inhabitants less than at the end of 1997, with an annual growth rate of *-2.3* per thousand inhabitants, in the last year. The birth rate, the mortality and the child mortality show a decreasing behaviour in the last 5 years.

As consequence of the economic crisis, in the year 96, the amount of immigrants increased to 28 000 inhabitants; this immigration was offset with the external migration. The application of migratory control rules and signals of economic recovery in the country, (although it keeps a positive migratory balance), the rate of total migration shows a decreasing behaviour from the year 1998. Also can be pointed out, that the year 2001 reflected a slight increase that didn't mean the resident population was incrementing (Table 6).

Table 6. Resident Population in Havana City, Rate and Net Migration

Year	Net Migration	Total Migration Rate	Population
1997	14571	6.6	2 197 706
1998	14139	6.5	2 192 321
1999	11006	5.1	2 189 716
2000	9444	4.3	2 186 632
2001	10601	4,8	2 181 535

Source: Territorial Office of Statistics, 2002

The Public Health and socio-economic environment

Havana City has 41 hospitals, 13 research institutes, 82 clinics, 19 Maternal Homes, 32 dental clinics and 2729 Family Doctors that are distributed in the community, industries, schools and day cares, being a total of 4025 doctors. Between 1996 and 2001, the number of doctors, dentists and nurses increased. For the social security, the city has 55 Homes, 14 Disable Homes and 13 Grandparents Clubs, with a total of 4622 beds.

The mortality and the child mortality have decreased, as well as, the morbidity caused by acute diarrhoea illness (ADI), breathing acute illness (BAI), syphilis, tuberculosis and viral hepatitis among others. Cases of illnesses as diphtheria, paratyphoid fever, poliomyelitis, measles and tetanus have not been reported. (Table 7).

Table 7. Behaviour of the most important illnesses in the years 1996 and 2001

Item	1996	2001
Child Mortality	7.9	6.7
Mortality	9.2	8.8
Inhabitants/ doctor	109	106
Inhabitants/dentist	877	574
Beds	28 746	23 256
Thousands of cases of ADI	309,8	249,3
Thousands of cases BAI	1271,4	1175,2
Viral Hepatitis (cases)	5 598	2 210
Tuberculosis	404	207
Malaria	6	2
Infectious Encephalitis	11	0

Source: Territorial Office of Statistics, 2002

Human Health and Environment

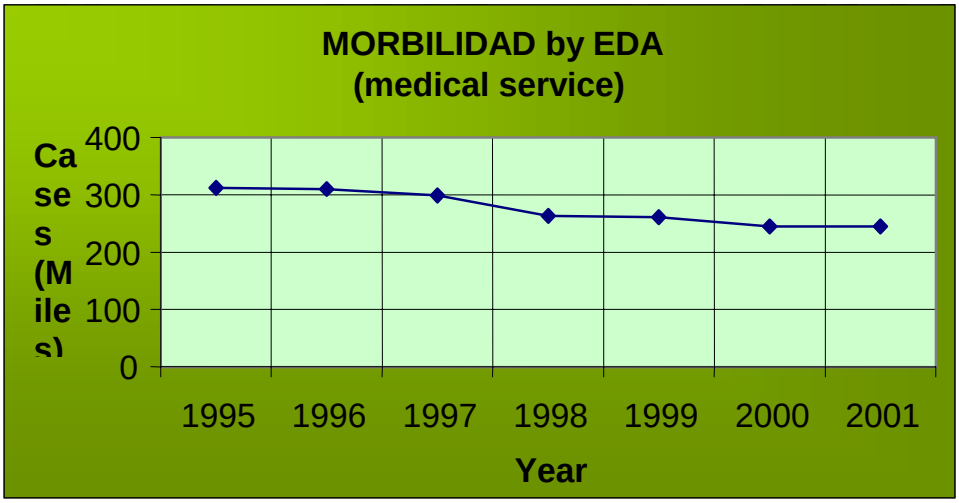
The knowledge improvement of the atmosphere sciences in the last decades has been able to confirm the hypotheses of the narrow relationship between the environmental factors and the human health.

The main identified factors of risk are:

- Quality of the fresh water
- Pollution of coastal and surface waters
- Inadequate management of the solid wastes associated to the vectors proliferation
- Inadequate management of hazardous wastes and lack of controlled landfill
- Inadequate final disposal of wastewaters
- Chemical, physical and biological factors involved in the air quality
- Climatologic parameters
- Deterioration of man made structures
- Lack of green urban areas
- Transport operation and road networks condition
- Sonic pollution
- Physic-chemical and biological pollution of the foods
- Exposition to electromagnetic radiations
- Quality of the workplace environment

Among the main illnesses apparently originated by environmental problems, can be found the acute diarrhoea illness, the bronchial asthma, the lung cancer and other breathing acute illness, the arterial hypertension, intoxications by pesticides, hepatitis, skin cancer and others.

In the last 5 years a decrease of the Acute Diarrhea Illness is reported (Figure 3) (ADI).



Source: Provincial Center of Hygiene and Epidemiology, 2002

Figure 3. Morbility by ADI

The mortality rate for ***Melanoma maligno*** is increased from 0.7 to 1.6 per 100 inhabitants, while the incidence of others skin tumors decreased sensibly in the period.

Studies that relate this behavior with the incidence of the solar radiation do not exist (Figure 4).

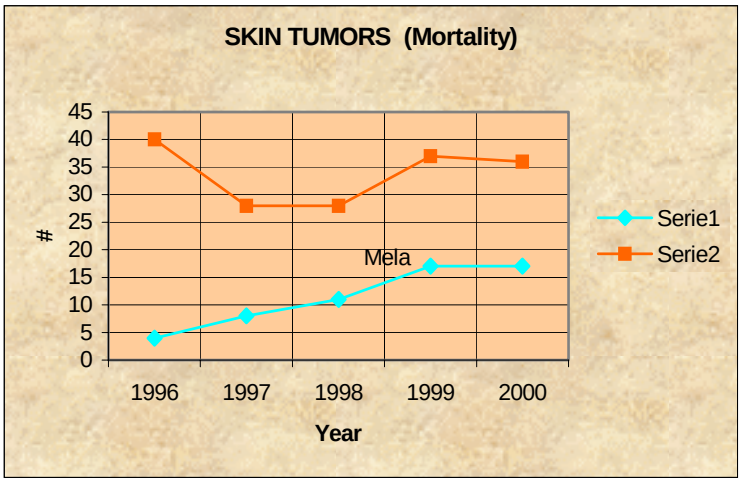
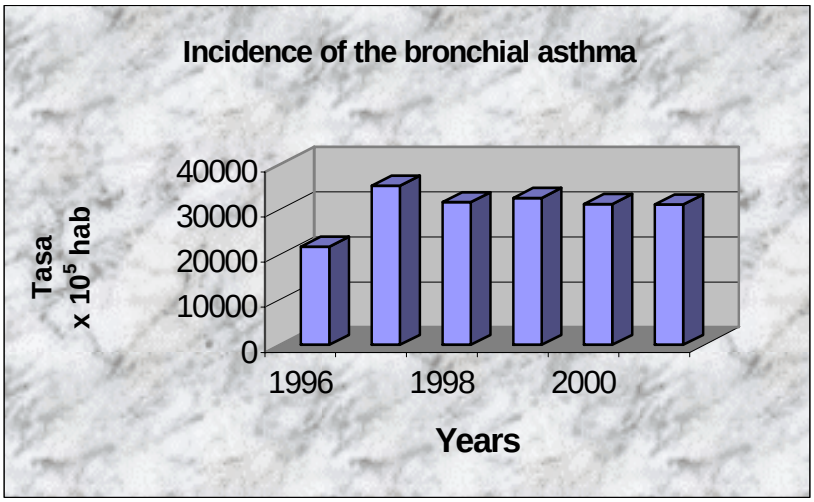


Figure 4. Skin tumours

In the case of the Bronchial Asthma (Figure 5), in spite of having several causes and that in the case of Cuba is present, as a genetic factor in the population, is well known that among the factors that affect the air quality, there are some elements that can cause bronchial asthma.



Source: Territorial Office of Statistics, 2002

Figure 5. Incidence of the bronchial asthma

Socio-cultural Factors and Education

Although it is difficult to classify the socio-cultural factors, because the great spectrum that culture definition implicates, that includes all the relationships of environment transformation, as well as, the own transformation of the subject with the environment, it is important to highlight some cultural values that should be considered in order to define the impacts that the projects can cause.

- Affectation to the culture and local traditions.
- Affectations to the archaeological, historical and artistic resources.
- Affectations linked with the social differentiation caused by the operation of the projects and the increment of the criminal index.

The cultural projection of Havana City is sustained in a great diversity of artistic performances, many of them represented by top figures of the art and the culture.

Cultural Patrimonies to protect due to the Projects execution

Most of the studied area is located inside of the Protected Zones declared by the Patrimonial Architecture Office of Havana City. It is possible to undertake this work, keeping in mind that, in general, there are not major affectations to the monuments or constructions having a cultural or historical value.

From the archaeological point of view, it doesn't exist any specific plan at this time, for the Avenida del Puerto and their prolongation toward the south. The section between the Caballeria Dock and the railroad heights is mostly on reclaimed land, taken from the sea, but there is a possibility to find some locations highly importance in the colonial time, and that can explain the origins and the facts which motivated that Havana was the city it used to be in the past.

The works that should be carried out in the other sections don't cause negative impacts on buildings with cultural or historical values. Specifically, there are five areas where highest attention should be pay:

- The section that goes from Plaza San Francisco to the Caballeria Dock, where remains of old docks, piers and others could appear.
- The surroundings of Alameda de Paula, where can be evidences of the city sea wall.
- The section of the Avenida del Puerto, between the Central Station patio trains and the sea, because was located the Havana Arsenal, which was one of the two more important ship yard of the whole Spanish America, and where objects could appear and certain structures where the ships were rise for its construction.
- The surroundings of the railroad heights, because the city landfill was located for many years in this area, and can be found pieces or objects of historical and even artistic value.
- The areas belonging to the Castillo de Atares or Castillo del Principe, proposed area for the construction of Matadero Pumping Station.

Educational development

Havana City has 414 kindergarten, 496 Primary Schools, 162 Junior High Schools, 75 special schools, 34 Polytechnic Institutes, 6 High Schools and other related locations, with 360 000 students and around 33 000 workers. Besides, there are 15 universities and others Higher Education Institutions.

The highest level in the scientific activities of the country concentrates in the city, having a high-qualified personnel for Biotechnology development, the pharmaceutical industry and the informatics.

In the last years, educational system has being improved and its advances are widely recognized. Particularly in Havana City, it is carry out a extensive reparation, enlargement and construction program of schools that will facilitate to introduce new changes to the primary teaching, decreasing the quantity of students up to 20 students by classroom and being generalized the use of the informatics and the visual equipment in the teaching programs (Table 8).

Table 8. Behaviour of the educational system in the 97-98 and 2001-2002 courses

Items	Course 97-98	Course 2001-2002
Kindergarten capacities	49 898	51 585
Teaching Personnel	21 596	33 002
Graduated by levels		
▪ Primary	27 501	30 130
▪ Jr. High school	23 641	25 406
▪ High school *	1 399	1 792
▪ Technical- professional	8 448	12 950
▪ Technical	8 214	9 939
▪ Adults	533	1270

***In the table do not appear high school students that were in agriculture works in 1999. 148 283 graduated.**

5. PROJECTS DESCRIPTION, IMPACT ASSESSMENT AND MITIGATION MEASURES

Within the Master Plan few priority projects have been identified to mitigate problems related to the insufficient networks, treatment and final disposal of the sewage wastewaters generated into the Havana Bay Watershed. JICA Study Team has identified these projects as Rehabilitation of Existing Sewerage (Central System) and New Sewerage System.

5.1 Rehabilitation of Existing Sewerage (Central System)

5.1.1 Rehabilitation of the existing sewer network by repair works, replacement or installation of new sewer network between Caballeria and at the crossing of Colector Sur and Dren Arroyo Matadero (Colector Sur Nuevo)

5.1.1.1 Project description

The Colector from the Pumping Station until Caballeria Dock is divided in two sections: a pumped main Colector and Colector Sur Nuevo (by gravity). In this study, the environmental impacts of the Colector construction will be analysed as a whole, only specifying when technical specifications require it.

Pumped main

The Colector layout is from the Pumping Station until Egido y Desamparados street to transport by pressure the sewage wastewaters pumped from the Pumping Station to be built in areas of the Castillo de Atares. The Colector will be made of ductile iron with diameter of 1350 mm and an approximate length off 1 km. The work will be done with *zanjeadora* and digger, the trench width the will be of 2.5 m and the maximum excavation depth is *-2* m. The figure 6 shows the pumped main Colector layout.

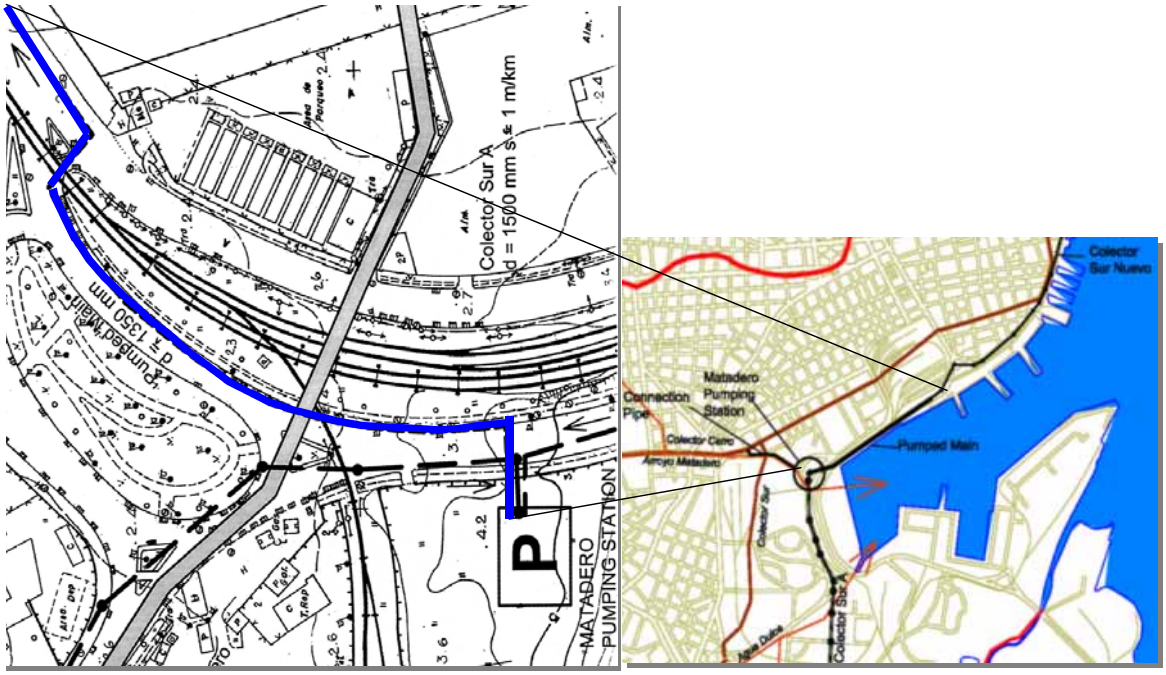


Figure 6. Pumped Main Colector

Colector Sur Nuevo

The Colector layout is from Desamparados and Egido street until Caballeria dock and it will transport by gravity the sewage coming from the Matadero Pumping Station to be built in areas of the Castillo de Atares. The Colector will be made of concrete with diameter of 1500 mm and a length of 1830 m (1.83 Km.). The work will be done in sections of 100 m between manholes and it will have 17 manholes. The construction stage will be 21 days per sections of 100 m. The work will be carry out using *zanjeadora* and digger. The trench width will be *-2.5* m and *-6.5* m the maximum excavation depth. The estimated construction period is 3 years taking into consideration the interruptions of the activity in the affected area.

Figure 7 shows the layout of the Colector Sur Nuevo with places of interest to consider in the impacts evaluation. The study area will be divided in 4 sections due to its socio-economic characteristics. The section 1 goes from Desamparados street and Egido street to Paula's Church (manhole 1- manhole 10), the section 2 will be from Paula's Church until Luz's dock (manhole 10- manhole 11), the section 3 will be from Luz's dock until Cruises Terminal (manhole 11- manhole 14) and the section 4 is the distance between Cruises Terminal and Caballeria dock (manhole 14- manhole 17).

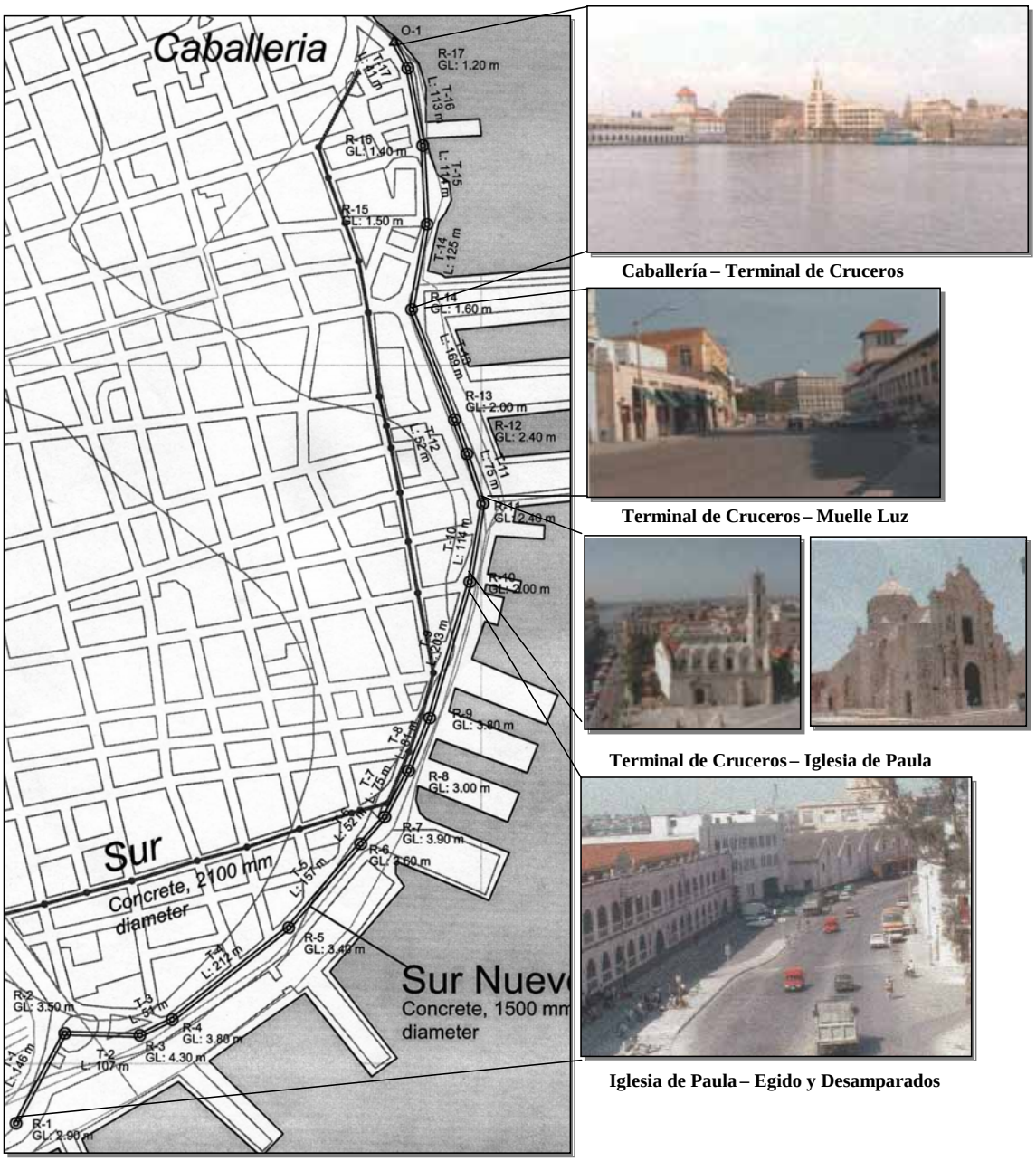


Figure 7. Colector Sur and Colector Sur Nuevo

For the environmental impact assessment both sections will be consider as a whole due to their similar socio economic characteristics.

5.1.1.2 Impact Assessment

Project actions

Construction stage	Operation Stage
A. Excavations and earthworks	G. Conduction of sewage wastewaters
B. Transport of heavy machinery and materials	
C. Construction of channels, pipes installation and interconnection of the Colector	
D. Pave and auxiliary works	
E. Hedge and deviation of the traffic	
F. Management of construction wastes	

Environmental factors influenced by the project

Natural or Physical environment

- Soil
- Air
- Water
- Landscape

Socio-economic environment

- Health and Safety
- Institutional and commercial activities
- Employment
- Infrastructure and network
- Tourist and patrimonial places
- Roadway and traffic

Identification of the impacts

Construction stage	Operation Stage
Change of land use	Changes of land use and the use of unproductive lands
Increase of the erosive processes	Soil compaction
Changes in the dynamic local geomorphology	Changes in the erosion and sedimentation processes
Soil compaction	Introduction of inadequate elements to the landscape
Changes of the drainage patterns	Generation of employments
Deposition of sediments in soils and waters	Stimulation to the industrial development
Soil pollution	Growth of the human establishments
Waters pollution	Decrease of the problems of public and environmental health
Air pollution by dust and emissions of gases	Changes in the population's space distribution
Increase of the continuous and intermittent sound levels	
Modification of the landscape	
Damages to the health for emission of pollutants and noises	
Overloads of the existing infrastructure in the area	
Affectations to the tourist and institutional activity in the area	
Changes in the traffic flow	
Generation of employments and economic opportunities	
Movement of personal of other areas	
Increase of the risk of work accidents	
Discharge of materials and polluting substances to the waters and soils	
Generation of material due to the excavation	

Analysis of the impacts caused by the project actions in the influenced environmental factors

Natural or physical environment

Soils

From the physical-geographical point of view the area is in the shore line plain, located in a small section, with brown carbonated soil formed by flood planes and fluvial terraces that is developed in the north part of the anticline Havana-Matanzas, and the hilly plain with thin brown-yellowish soils. In the study area changes are appreciated in the land use that opened the way to the urbanization. There is an increment of the erosive process and the pollution levels but they are not significant.

Water

The construction of the Colector Sur Nuevo and Pumped main is near to the bay shore line and therefore, there is a potential risk of spilling materials and polluting to the water body. The water quality can be affected in the construction stage, some parameters could change such as suspended and dissolved solids and the nutrients (extraction and temporary accumulation of earth and excavation material) grease and oils and hydrocarbons (accidental spilling by the machinery and by the temporary facilities). The reconstruction and road pavement, after the pipe placement, is closely linked to the pollution of the water bodies as consequence of occasional spills of fluid asphalt during the stage of priming and poring of asphalt concrete.

Air

The produced environmental impact is the air pollution by dust and gases emissions. The changes in the quality parameters associated to this resource occur mainly during the construction stage and as consequence of the transport of building materials and the earthworks. These actions take place at a local scale with an increase of the emission and inhalation levels of suspended and settable particles. On the other hand, the surfacing construction produces gases emissions during the phase of asphalt heating for the priming. Also, during the construction phase a remarkable increment of the noise takes place mainly during the earthwork, the manipulation of the heavy machinery, the haulage of the building materials, the surfacing and pavement process during the pipes installation. The Cuban Standard NC 26: 1999 states the maximum and allowed noises (annex 2) in urban and commercial areas.

Landscape

The landscape is classified as strongly modified due to the changes in the territory caused by the industrial and urban development. The impacts related to the landscape modification can be considered temporary during the construction period. During the construction phase, continuous changes on landscape might be expected, as there will be accumulation of construction wastes, presence of heavy machinery and location of the temporary facilities. During the operation phase significant impacts should not arise because it is an underground pipe that won't affect the visual of the landscape.

Socio-economic environment

Health and safety

Undoubtedly, the construction stage activities generate noises (continuous and intermittent), dust, combustion gases and the risks of accidents are increased which generates a negative health impact, not only to the employees but to the surrounding population. It is worth to highlight that this impact can be totally minimized if organizational and protection measures are taken. In the operation stage the Colector Sur Nuevo impact on the health is considered positive because it improves the hygienic-sanitary quality of the territory due to the conduction of the wastewaters and its disposal in the sea through a submarine outfall. At the moment, an important volume of these waters ended in the Havana Bay with the consequent detriment of its environmental quality and the potential increment of the risks to the health of the users and the surrounding bay population.

Infrastructure and networks

The construction of the Colector Sur Nuevo and the Pumped main will bring conflicts with the existing network in the layout area. It should be verified that phone and hydraulic networks do not interfere with the new Colector. The Colector will provide an overload in the infrastructure of the area in terms of networks.

Cultural and patrimonial

The Colector Sur Nuevo and the Pumped main will be built in an area where several places with cultural and patrimonial importance are located and which in smaller or bigger degree could be affected by the project, among them, Paula's Church, the Port Terminal Aracelio Iglesias, the Convent and Church of San Francisco de Asis and the Building of the Customs. The efforts of the Historian's Office for the preservation and care of these constructions are well known. The dust generation, the haulage of heavy machinery, the pipe installation and accidental discharges of polluting substances, in particular the grease and oils and hydrocarbons, are project actions with potential negative impacts on these patrimonial places.

Tourist and Institutional activity

During the construction stage different and important affectations to the tourist and institutional activity in the study area will take place and therefore, preventive and mitigation measures are required to minimize the effect of these impacts. The main tourist attractiveness of the Caballeria dock- Cruises terminal section is the landscape to the Morro-Cabana Park. This visual will be seriously affected due to the dust, noise, machineries and the haulage of building materials. The impacts with temporary character will also influence on Los Marinos restaurant located 300 m far from Caballeria dock. The normal operation of La Lonja del Comercio business centre, and especially the access to their parking lot, as well as the building of the Managerial Group of the Army (FAR) will be affected when congestions and deviations of the traffic during the constructive phase take place. However, measures to minimize these affectations need to be taken.

The section Cruise Terminal-Luz dock has a great tourist and institutional importance. From the tourist point of view there will be affectations on the Cruises Terminal, the Square San Francisco de Asis, Rum Museum, Armadores de Santander Hotel and the Garden Mother Teresa from Calcutta among others. Institutionally, the Colector Sur Nuevo will impact the Cuban Pilots Offices, Customs, Sierra Maestra 2 and Sierra Maestra 3 docks including the port scale and other small establishments.

The section Luz dock-Church of Paula will be the less affected, although it should be considered the patrimonial and tourist value of the Church and Paula's Boulevard. Nevertheless, facilities as the Offices of the Argus Managerial Group and Firemen's Unit are potential places to be impacted.

In the last section, between the Church of Paula-Egido and Desamparados streets, places with tourist and institutional interest are located such as the Port Terminals Aracelio Iglesias, Juan Manuel Diaz, La Coubre and the called wood dock. Disturbances are expected to occur in all of them during the construction phase. Similarly, the La Coubre Bus and Railroad Terminal will face changes on the established arrival and departure schedule and consequently, the possible deviation of its routes should be evaluated.

Roadway and traffic

The layout of the Colector Sur Nuevo and Pumped main go through Puerto Avenue which constitutes a road of national interest that links in an expedite way the National Freeway with the Historical Center of the City, Havana ocean drive and the North of the city. It is a road of high tourist value as it is part of the marine boulevard of the Havana seashore. In the section of Caballeria dock-Egido and Pumping stations different cross sections of the road are presented requiring detail analysis of the impacts:

- *Caballeria dock-Cruises terminal*; the road has four lanes, two in each direction; in the first part of the section it has a median used as parking. There are six routes of public transport in the zone, including a bus stop. The proposals are: close the lanes in the Caballeria dock-Cruises terminal direction and to allow the circulation in both directions in the North carriageway, the suspension of the parking of vehicles in front of the building of the Managerial Group of the Army and in the section with median. The following photos (1 and 2) show characteristics of the cross section.

Photo 1. Characteristics of the cross section

Photo 2. South carriageway

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- *Cruises terminal-Luz dock;* for this section, a project to enlarge the lanes open to the traffic was approved by the Infrastructure Division of the Ministry of Transport. At present, the roadbed is divided by a median that defines: two lanes open to the traffic, one in each direction and in the other side a parking area. The construction of the Colector implies to disable the carriageway in use and it is convenient to implement the solution proposed in the project above mentioned. Attention should be paid to the solution of continuity of the pedestrian crossing between the Cruises Terminal and the Square San Francisco de Asis, likewise the parking of the horse cars should be relocated during the constructive stage. A bus stop is located in the area. One of the main causes of conflicts to the traffic in the area is the scale located close to Luz's dock, the relocation of the scale is proposed. It is important to consider the access solution to the Armadores de Santander Hotel that will be affected by the Colector layout. The photo 3 shows characteristic of the section.

Photo 3. Pedestrian crossing at Cruises Terminal

- *Luz dock-Church of Paula;* the section has an asymmetric cross section, three lanes in the Luz dock - Church of Paula direction and two in Paula's Church-Luz dock direction, being Paula's Boulevard like a median. There are two alternatives to minimize the impacts due to the layout of the Colector Sur Nuevo: maintain a lane open in the direction Luz dock-church of Paula and not affect the north carriageway or to disable the three lanes in the direction Luz dock-Church of Paula and declare both directions in the North carriageway.

- *Church of Paula-Egido and Desamparados street;* this section is very complicated to adopt a solution due to the load and unload operations from the Port Terminal Juan Manuel Diaz (Photo 4). The cross section is four lanes, two in each direction. The lanes in Church of Paula-Egido and Desamparados street direction will be close during the construction of Colector Sur Nuevo and the traffic will use the two remaining lanes, one in each direction. The railroad located in the section and very close to the outer lane of the north carriageway (Egido and Abandoned-Church of Paula direction) is a great danger because the loaders working and using part of the outer lane. It is possible to analyse the feasibility to change the load operations to the night. Also, the access to the parking of the business centre will be taking into account. Photo 5 shows characteristics of the section.

Photo 4. Fork lift working on the carriage way

Photo 5. Cross-section characteristics

- *Egido and Desamparados street - Ave del Puerto and Arroyo street*: the cross section of the road is uniform, four lanes, two in each direction with a median determined by the horizontal signalling. In the area is located. La Coubre port terminal (Photo 6), La Coubre Bus and Railroad Station with intercity departures and arrivals (Photo 7). In this section route of public transport has stops.

Photo 6. La Coubre Port Terminal

Photo 7. La Coubre Bus and Railroad Terminal

The proposals are: close the lanes in the direction *Egido and Desamparados street - Ave del Puerto and Arroyo street*, allowing the circulation in both directions in the others lanes. It is necessary to carry out a program of reorganize the bus and Railroad Terminal schedule during the construction period.

The pipe layout crosses the railroad access to the Central Station and La Coubre Bus and Railroad Terminal (Photo 8). The work schedule will be very accurate to carry out the crossing.

Photo 8. At grade railway crossing

Residuals (Waste management)

The excavation activities and earthwork generate high quantities of solid wastes. It is estimated that the total production of excavated material will be approximately 30 000 m^3, with fractions of 800 m^3 for sections of 50 m long.

Impacts Identification Matrix

	Environmental factors	Actions						
		Construction stage						Operation Stage
		A	B	C	D	E	F	G
Natural Factors	1. Soil	X	X	X	X		X	
	2- Air	X	X	X				
	3. Water	X	X				X	
	4. Landscape	X	X	X				
Socio-economic Factors	5. Health and Safety	X	X	X	X	X		X
	6. Institutional and commercial activities	X	X	X		X		X
	7. Employment	X	X	X				
	8. Infrastructure and networks	X		X				
	9. Tourist and patrimonial places	X	X	X				
	10. Roadway and traffic					X		

Evaluation of the impacts

Impact	CI	I	EX	MO	PE	RV	SI	AC	EF	PR	MC	IM	CI. I
A_1	-	2	2	4	2	4	1	1	4	4	8	38	M
B_1	-	1	1	2	1	1	1	1	4	1	4	20	I
C_1	-	2	1	4	1	4	1	1	4	4	8	35	M
D_1	-	1	1	4	1	1	1	1	4	4	1	22	I
F_1	-	1	1	4	1	1	1	1	4	4	4	25	M
A_2	-	4	2	4	1	1	1	1	4	1	1	30	M
B_2	-	2	1	4	1	1	1	1	4	1		21	I
C_2	-	2	1	4	1	1	1	1	4	1		21	I
A_3	-	2	1	2	2	1	1	1	4	1	4	24	I
B_3	-	1	1	1	1	1	1	1	4	1	1	16	I
F_3	-	2	1	2	2	1	1	1	4	1	4	24	I
A_4	-	4	2	4	1		1	1	4		4	31	M
B_4	-	2	1	4	1		1	1	4		1	20	I
C_4	-	1	1	4	1		1	1	4		1	17	I
A_5	-	2	1	4	1				4	1	4	22	I
B_5	-	1	1	2	1				4	1	4	17	I
C_5	-	1	1	2	1				4	1	4	17	I
D_5	-	1	1	2	1				4	1	4	17	I
E_5	-	1	1	4	1				4	1	4	19	I
G_5	+	12	8	4	4				1	4	4	69	S
A_6	-	2	2	4	2				1	1	4	22	I
B_6	-	1	1	4	1				1	1	1	13	I
C_6	-	1	1	2	1				1	1	1	11	I
E_6	-	1	1	4	1				1	1	1	13	I
G_6	+	2	2	4	4				4	4		26	M
A_7	+	2	2	4	1				4	1		20	I
B_7	+	1	1	4	1				4	1		15	I
C_7	+	2	2	4	1				4	1		20	I
A_8	-	4	2	4	2				4		4	30	M
C_8	-	2	2	4	4				4	4	4	30	M
A_9	-	8	2	4	1				4		4	41	M
B_9	-	4	1	4	1				4		4	27	M
C_9	-	2	1	4	1				4		4	21	I
E_{10}	-	8	2	4	1				4	1	4	42	M

Character of the Impact (CI)
Intensity of the Impact (I)
Extension of the Impact (EX)
Moment of the Impact (MO)
Persistency (PE)
Reversibility (RV)
Synergism (SI)
Accumulation (AC)
Effect (EF)
Periodicity (PR)
Recoverability (MC)
Importance of the Impact (IM)

Classification of the Impact (CI.I):

Irrelevant (I)	IM< 25
Moderate (M)	25 < IM < 50
Severe (S)	50 <IM < 75
Critic (C)	IM> 75

$$IM = \pm (3I + 2\,EX + MO + PE + RV + SI + AC + EF + PR + MC)$$

IMPORTANCE MATRIX

	Environmental factors	Actions							Total per factor	Total per environment
		Construction stage						Operation Stage		
		A	B	C	D	E	F	G		
Natural Factors	1. Soil	-38	-20	-35	-22		-25		**-140**	**-344**
	2- Air	-30	-21	-21					**-72**	
	3. Water	-24	-16				-24		**-64**	
	4. Landscape	-31	-20	-17					**-68**	
Socio-economic Factors	5. Health and Safety	-22	-17	-17	-17	-19		+69	**-23**	**-192**
	6. Institutional activities	-22	-13	-11		-13		+26	**-33**	
	7. Employment	+20	+15	+20					**55**	
	8. Infrastructure and network	-30		-30					**-60**	
	9. Tourist and patrimonial places	-41	-27	-21					**-89**	
	10. Roadway and traffic					-42			**-42**	
	Total per action	**-218**	**-119**	**-132**	**-39**	**-74**	**-49**	**95**		
	Total per period	**-631**						**95**		

Summarize of impacts

Character of the Impact (CI)	Classification of the Impact (CI.I)	Total
+	Irrelevant	3
	Moderate	1
	Severe	1
	Critics	
	Sub-Total	5
-	Irrelevant	19
	Moderate	10
	Severe	
	Critics	
	Sub-Total	29
	Total	**34**

Analysis of the importance matrix

Analysing the impact evaluation matrix the following can be established:

Project Actions

Construction Stage

During the construction stage, the most aggressive actions are the earthworks and excavations, the transport of heavy machinery and the construction of channels, pipes installation and interconnection of the Colector because they gather high negative importance values. It is also very important to mention the hedge and deviation of the traffic, which has high negatives impacts mainly on socio-economic factors. The less aggressive action is the pave and auxiliary works.

Operation Stage

In the operation stage, the most important action is the transport of urban-industrial wastewaters (as expected, according to the Master Plan objectives), accumulating a positive importance value of 95.

The construction stage resulted the most impacted with an overall negative importance value of 631, having most of the negative impacts of the project: 19 of them are considered irrelevant and 10 as moderates. Within a short to medium term all these negative impacts can be mitigate if corrective and preventive measures are taken at early stages of the project.

Analysis of the environmental factors

The most impacted (negatively) natural factors are the soil, air and landscape in that order. The tourist and patrimonial places, the infrastructure and network as well as the roadway and traffic are evaluated as the most impacted socio-economic factors. This result was expected because the project in located in a very sensitive area of Old Havana.

5.1.1.3 Preventive and mitigation measures

The following measures are necessary to be undertaken in the subsequent stages of the project to prevent or mitigate impacts, mainly during construction stage.

1. Coordination with the Historians Office Master Plan and relevant authorities
   - The design projects of the Colector Sur Nuevo layout.
   - To execute actions during the construction stage leaded to the protection of places with patrimonial and/or archaeological value.

2. Coordination with Utilities
   - The telephone company (ETECSA).
   - The Power Company
   - The National Institute of Hydraulic Resources (INRH)
   - The Railway Company
   - ¨Redes Tecnicas¨, to gather information on any other underground utilities related to the Port.

3. To investigate the feasibility of carrying out the work at night with relevant authorities and to the possibility of covering the trench with steel sheets to provide more room for traffic

4. To investigate the traffic flow pattern and origin-destination of the traffic during the detailed design stage to take necessary steps for traffic control and detour

5. Coordination with Traffic Division of Police (PNR) and other relevant institutions
   - To inform the public and other relevant institutions in advance
   - To provide personnel to direct control traffic flow
   - To relocate bus stops where necessary

6. Set up a committee comprising of all relevant institutions to share information on the progress of construction and to facilitate coordination among institutions.

7. Public information
   - To use the mass media network to inform the public about the project benefits as well as the possible affectations during the project time period.

8. Instruction to the Contractor to conform to good Construction Practices

   - To provide tight containers for transport of materials and to provide covered containers to avoid loss of material during transportation
   - To use safety devices in the concrete-mixer trucks to avoid the spill of material during the transport
   - To avoid spilling of construction materials i.e. cement, concrete etc. to prevent blocking of drains and their ultimate discharge to bay
   - To avoid cleaning of containers, machineries etc. on the street pavement to prevent spilling of fuel, lubricants etc. to the bay
   - To manage construction waste and excavated material to avoid piling-up along the street which can obstruct traffic, cause floods by blocking drains etc. and to dispose them at approved locations
   - To place barriers along the banks of the bay to prevent accidental spill of construction material to the bay
   - To control the speed of construction traffic and maintain awareness of safety
   - To take organizational measures to reduce construction noise

5.1.2 Pumping Station near the crossing of Colector Sur and Arroyo Matadero Drain as well as a new installation of the by-pass pipe between Cerro Colector and the Matadero Pumping Station

5.1.2.1 Project description

Matadero Pumping Station will have two main functions:

- During the rehabilitation of Colector Sur it will pump the wastewaters coming from Cerro and Sur 1 Colector through the Colector Sur Nuevo.
- Once Colector Sur is rehabilitated, the pumping station will pump waters coming from Sur A Colector (left bank of Luyano River) to Caballeria Screens.

Location for the Matadero Pumping Station (JICA Study Team information) is selected to a vacant land belonging to FAR (*Fuerzas Armadas Revolucionarias*). Figure 8 shows the macro localization of the pumping station.

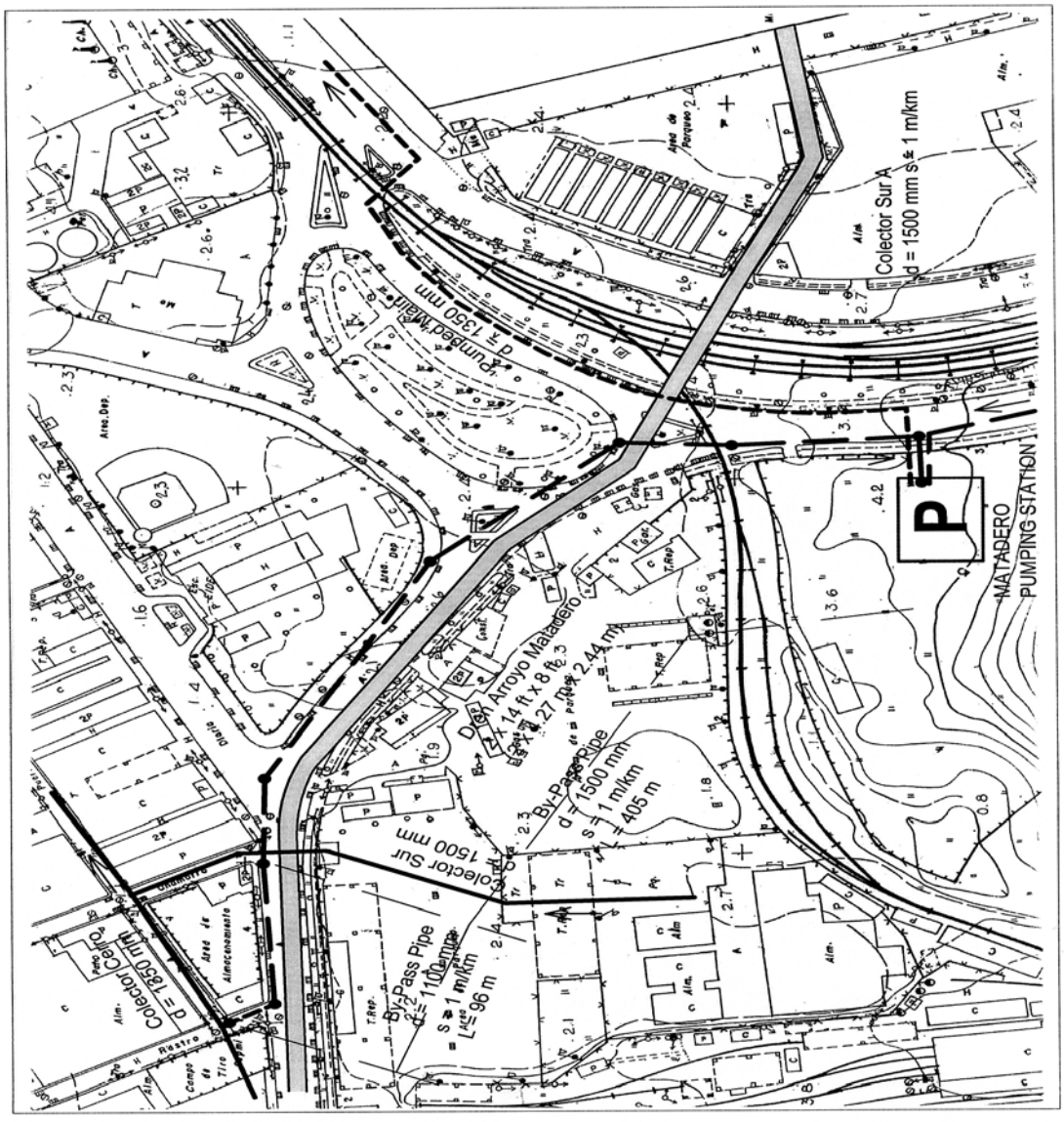
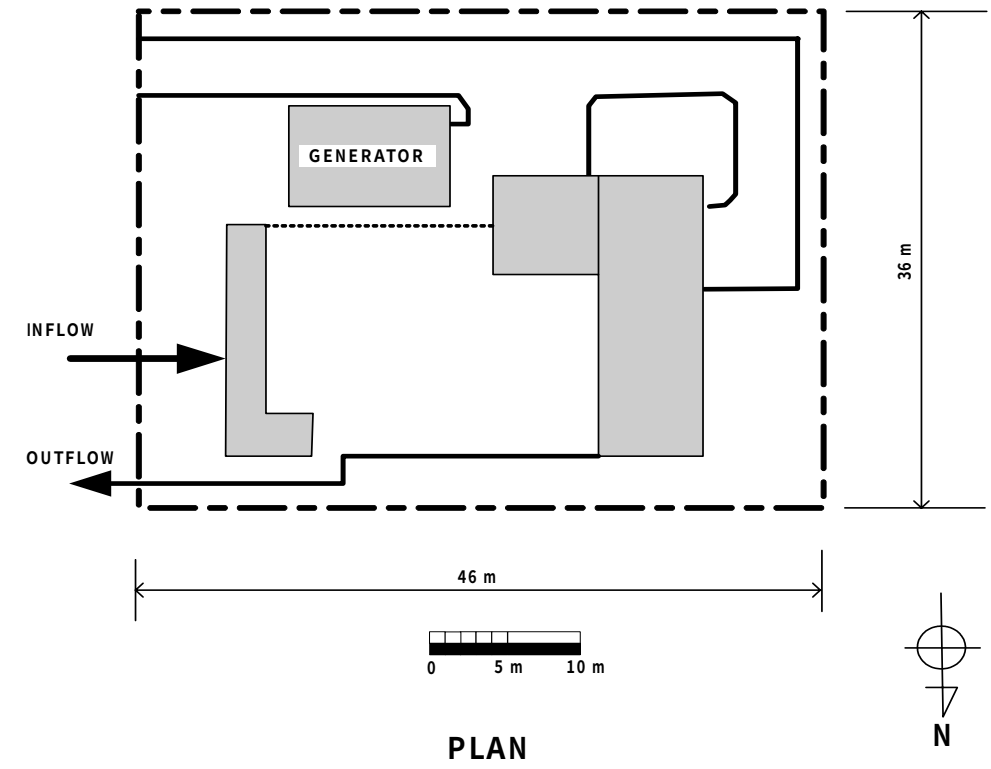


Figure 8. Macro localization of the Matadero Pumping Station

The figure 9 shows the micro localization of the pumping station.



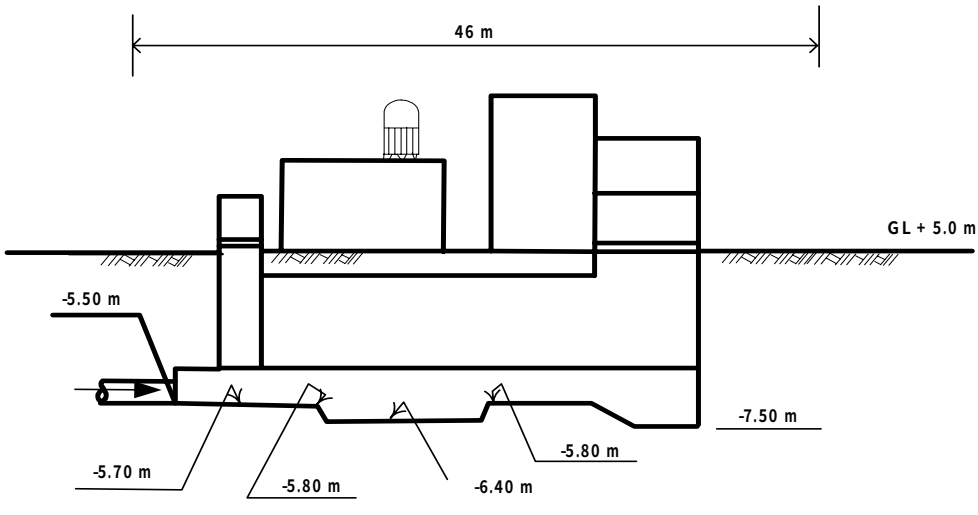


Figure 9. Micro localization of the Matadero Pumping Station

The Matadero Pumping Station will have a preliminary treatment system to retain solids. It will has a Coarse Screen to retain solids such as nylon, cloths, leaves, among others; a Gravity type Grit Removal Tank, to remove other particles as gravel, sand, ash, or any other heavy material; and a Fine Screen where the smaller diameter particles will be retained. The objective of this system is to facilitate the pumping operation and to guarantee a higher useful life of the installed pumps. When the wastewaters pass through the Inflow Gate, the Submersible Sewage Pump will send it first to the pumped main Colector and then through Colector Sur Nuevo by gravity (Figure 10). As expected, the preliminary treatment system will generate certain amount of solid wastes classified in coarse and fine. It is estimated that 4.46 $m^3.day^{-1}$ will need to be disposed.

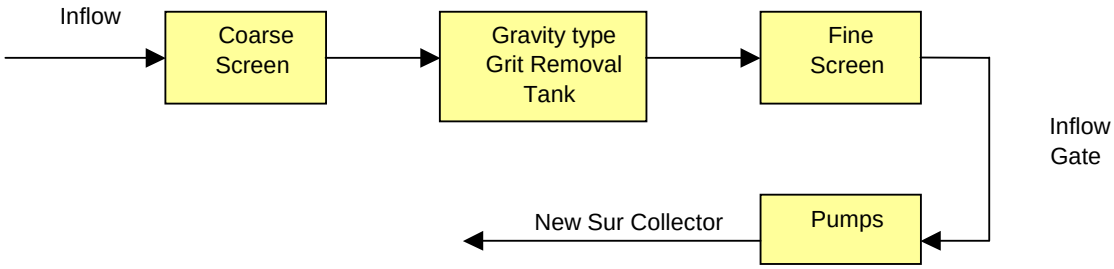


Figure 10. Productive flow of the Matadero Pumping Station

5.1.2.2 Impact Assessment

Project actions

Construction Stage	Operation Stage
A. Excavations and earthworks	I. Transport of sewage wastewaters
B. Transport of heavy machinery and materials	J. Waste management
C. Demolition of existing construction	
D. Deposit of materials	
E. Construction of pumping stations, channels and pipes installation	
F. Spreading of concrete	
G. Temporary deviation of the flows	
H. Wastes management	

Environmental factors influenced by the project

Natural or Physical environment

- Soil
- Air
- Landscape

Socio-economic environment

- Health and Safety
- Soil use
- Employment
- Infrastructure
- Institutional and commercial activities

Identification of the environmental impacts

Construction Stage	Operation Stage
Soil compaction	Unpleasant odours
Air pollution by dust and emissions of gases	Increment of noise levels
Increment of noise levels	Accumulation of wastes in Matadero Pumping Station area
Landscape modification	Improvements in the life quality of workers and surrounding bay population
Health damages caused by pollutants emissions	Generation of employments
Change of land use	Increase of the bay waters quality
Visibility related problems caused by the construction	Changes of land use and the use of unproductive lands
Overloads of the existing infrastructure	Introduction of inadequate elements to the landscape
Discharge of materials and polluting substances to the waters and soils	Barrier effect (historic-cultural patrimony)
Generation of excavation material	Stimulation to the industrial development
Increment of erosion processes	
Changes of the drainage patterns	
Affectations to the tourist and institutional activity in the area	
Generation of employments and economic opportunities	
Movement of personal of other areas	
Traffic interruptions	
Changes in the traffic flow	
Increase of the risk of work and traffic accidents	
Loss of the vegetable cover	
Soil pollution	

Qualitative evaluation of the most important impacts

- The construction of the Matadero Pumping Station and the by-pass will avoid, before and after the rehabilitation of the Colector Sur, the discharge of sewage waters into the Havana Bay with a positive improvement in the water quality.
- The installation of the Pumping Station and the by-pass during the construction stage involves impacting actions such as the earthworks, materials transport and movement of heavy machinery; discharge and deposit of materials, among others. The impacts can be mitigated and therefore become irrelevant when comparing them with the socio-economic advantages of the project.
- The civil structure of the Pumping Station will reach a maximum 6 m high, which should not modify significantly the landscape. However, temporarily, the landscape will be affected as a result of construction activities.
- During the construction stage the atmospheric and sonic affection will tend to increase, related to the equipment performance, the excavation and earthworks. The adverse effects can be attenuated if the meteorological conditions in the area are favourable. During the operation stage the pumps operation can increase the noise levels.
- The movement of the big trucks, the asphalt spreading and the concrete application, have a direct impact on soil destruction.
- Somehow the traffic flow will be affected, with more incidences during the derivation pipe (by-pass) construction with 480 m long crossing few roads.
- During the operation stage, the principal action is the urban-industrial wastewaters transfer. To facilitate the operations, they should be impelled until a certain point where they will continue by gravity force. These wastewaters will be disposed through the Playa del Chivo outfall.
- During the wastewaters pumping of unpleasant odours might occur causing air pollution, although this impact can be considered as moderate.

Impacts Identification Matrix

	Environmental factors	Actions									
		Construction stage								Operation Stage	
		A	B	C	D	E	F	G	H	I	J
Natural Factors	1. Soil	X	X	X	X	X	X	X	X		
	2- Air	X	X	X		X				X	X
	3. Landscape	X	X	X	X	X	X			X	
Socio-economic Factors	4. Health and Safety	X	X	X		X	X			X	
	5. Soil use	X		X		X				X	X
	6. Employment	X		X		X				X	
	7. Infrastructure	X	X	X		X	X			X	
	8. Institutional and commercial activities	X	X	X	X	X				X	

Evaluation of the impacts

Impacts	CI	I	EX	MO	PE	RV	SI	AC	EF	PR	MC	IM	CI. I
A_1	-	2	2	4	2	4	1	1	4	4	8	38	M
A_2	-	4	1	4	1	1	1	1	4	1	1	28	M
A_3	-	2	1	4	1		1	1	4		4	23	I
A_4	-	2	2	2	2				4	4	4	26	M
A_5	+	4	4	4	4	4	1	1	4	4		42	M
A_6	+	4	4	2	2	2			4	4		34	M
A_7	-	1	1	1	1		1	1	4	4	1	18	I
A_8	-	2	2	2	2	2		1	1	1	1	20	I
B_1	-	1	1	2	2	2	1	1	4	1	4	22	I
B_2	-	2	1	4	1	1	1	1	4	1		21	I
B_3	-	1	1	4	1		1	1	4		1	17	I
B_4	-	1	1	2	1				4	4	4	20	I
B_7	-	1	1	1	1		1	1	4	4	1	18	I
B_8	-	1	1	2	1	1		1	1	1	1	13	I
C_1	-	2	1	2	2	2	1	1	4	4	4	28	M
C_2	-	4	1	4	1	1	1	1	4	1	1	28	M
C_3	-	2	1	4	4		1	1	4		4	26	M
C_4	-	2	2	2	2				4	4	4	26	M
C_5	+	4	2	4	4	4	1	1	4	4		38	M
C_6	+	4	4	2	2	2			4	4		34	M
C_7	-	1	1	1	1		1	1	4	4	1	18	I
C_8	-	2	2	2	2	2		1	1	1	1	20	I
D_1	-	1	1	2	2	1	1	1	4	4	1	21	I
D_3	-	1	1	4	1		1	1	4		4	20	I
D_8	-	1	1	2	1	1		1	1	1	1	13	I
E_1	-	2	2	4	2	4	1	1	4	4	8	38	M
E_2	-	2	1	4	1	1	1	1	4	1		21	I
E_3	-	1	1	4	1		1	1	4		4	20	I
E_4	-	2	2	2	2				4	4	4	26	M
E_5	+	2	2	4	4	4	1	1	4	4		32	M
E_6	+	4	4	2	2	2			4	4		34	M
E_7	-	1	1	1	2		1	1	4	4	1	19	I
E_8	-	2	2	2	2	2		1	1	1	1	20	I
F_1	-	2	1	2	2	2	1	1	4	4	4	28	M
F_3	-	1	1	4	1		1	1	4		1	17	I
F_4	-	1	1	2	1				4	4	4	20	I
F_7	-	1	1	1	2		1		4	4	1	18	I
G_1	-	2	1	2	2	2	4	1	1	4	4	28	M
H_1	-	2	1	2	2	2	1	1	4	4	4	28	M
I_2	-	2	1	2	4	4	1	4	1	4	4	32	M
I_3	-	1	1	4	1		1	1	4		4	20	I
I_4	+	12	8	4	4				1	4	4	69	S
I_5	+	8	8	4	4	4			4	4		60	S
I_6	+	1	1	4	4				4	4		21	I
I_7	-	1	1	1	4		1	1	4	1	4	21	I
I_8	+	8	4	4	4	4		4	4	4		56	S
J_2	-	2	1	1	4	4	1	4	1	4	4	31	M
J_5	+	4	4	4	1	4			4	1		34	M

Character of the Impact (CI)
Intensity of the Impact (I)
Extension of the Impact (EX)
Moment of the Impact (MO)
Persistency (PE)
Reversibility (RV)
Synergism (SI)
Accumulation (AC)
Effect (EF)
Periodicity (PR)
Recoverability (MC)
Importance of the Impact (IM)

Classification of the Impact (Cl.I):

Irrelevant (I)	IM< 25
Moderate (M)	25 < IM < 50
Severe (S)	50 <IM < 75
Critic (C)	IM> 75

$$IM = \pm (3I + 2\,EX + MO + PE + RV + SI + AC + EF + PR + MC)$$

Importance Matrix

	Environmental factors	Actions										Total per factor	Total per environment
		Construction stage								Operation Stage			
		A	B	C	D	E	F	G	H	I	J		
Natural Factors	1. Soil	-38	-22	-28	-21	-38	-28	-28	-28			**-231**	**-535**
	2- Air	-28	-21	-28		-21				-32	-31	**-161**	
	3. Landscape	-23	-17	-26	-20	-20	-17			-20		**-143**	
Socio-economic Factors	4. Health and Safety	-26	-20	-26		-26	-20			+69		**-49**	**138**
	5. Soil use	+42		+38		+32				+60	+34	**206**	
	6. Employment	+34		+34		+34				+21		**123**	
	7. Infrastructure	-18	-18	-18		-19	-18			-21		**-112**	
	8. Industrial Development	-20	-13	-20	-13	-20				+56		**-30**	
	Total per action	**-77**	**-111**	**-74**	**-54**	**-78**	**-83**	**-28**	**-28**	**133**	**3**		
	Total per period	**-533**								**136**			

Summarize of impacts

Character of the Impact (CI)	Classification of the Impact (CI.I)	Total
+	Irrelevant	1
	Moderate	7
	Severe	3
	Critics	-
	Sub-Total	11
-	Irrelevant	23
	Moderate	14
	Severe	-
	Critics	-
	Sub-Total	37
	TOTAL	**48**

Analysis of the importance matrix

Analysing the impact evaluation matrix the following can be established:

Project Actions

Construction Stage

During the construction stage, the most aggressive actions are the transport of heavy machinery and materials and the spreading of concrete, because they gather high negative importance values (111 and 83 respectively). It is also important to mention the excavations and earthworks, the demolition of the current building and the construction of pumping station, that accumulate less negative values due to their positive impacts on socio-economic factors. The less aggressive actions are the temporary deviation of the flows and the wastes management.

Operation Stage

In the operation stage, the most important action is the transport of urban-industrial wastewaters (as expected, according to the Master Plan objectives), accumulating a positive importance value of 133. The wastes management gathers an overall positive value, because it has positive and negative impacts on the factors considered within the impacts evaluation.

The construction stage resulted the most impacted with an overall negative importance value of 533, having most of the negative impacts of the project: 23 of them are considered irrelevant and 14 as moderates.

Analysis of the environmental factors

The socio-economic factors are positively impacted by the project actions, although, undoubtedly, they receive negative impacts: 13 irrelevant and 3 moderates. These factors get the highest positive impacts: 7 moderate and 3 severe being consequent with the objectives of the Project. The natural factors receive only negative impacts, being the soil the most impacted one with 231. With 161 is the air, and the landscape with 143.

5.1.2.3 Preventive and mitigation measures

The following measures are necessary to be undertaken in the subsequent stages of the project to prevent or mitigate impacts, mainly during construction stage.

1. Land acquisition
   - Proposed land which currently belongs to FAR need to be acquired by INRH prior coordination and agreement with the Havana City Historians Office.

2. Building
   - Consideration to the architecture of the pump station building need to be given during the detailed design stage to blend with the surroundings

3. Measures during Power/Equipment Failure
   - Pumping station is planned with stand-by pumps in case of equipment failure and with stand-by generator in case of power failure. However, extreme eventualities such as the failure of all pumps or the failure of power supply and the generators shall be considered in the detailed design whether to provide a by-pass to pumping station against flooding of wastewater
   - Perform emergency plans, according to the risks analysis, for the cases of technological accidents.

4. Coordination with Traffic Division of Police (PNR) and other relevant institutions
   - To inform the public and other relevant institutions in advance
   - To provide personnel to direct control traffic flow

5. Prevention of odor and fly generation during operation stage
   - Adherence to proper operation and maintenance procedures for storage and disposal of screenings and grit will be necessary to prevent excessive odor generation

6. Public information
   - To use the mass media network to inform the public about the project benefits as well as the possible affectations during the project time period.

7. Instruction to the Contractor to conform to good Construction Practices
   - To control the established measures in each execution Project stage.
   - To guarantee the existence of the protection and hygiene equipment, required to the construction stage and the starting up of the project.
   - To provide tight containers for transport of materials and to provide covered containers to avoid loss of material during transportation
   - To use safety devices in the concrete-mixer trucks to avoid the spill of material during the transport
   - To avoid spilling of construction materials i.e. cement, concrete etc. to prevent blocking of drains and their ultimate discharge to bay
   - To avoid cleaning of containers, machineries etc. on the street pavement to prevent spilling of fuel, lubricants etc. to the bay
   - To manage construction waste and excavated material to avoid piling-up along the street which can obstruct traffic, cause floods by blocking drains etc. and to dispose them at approved locations
   - To control the speed of construction traffic and maintain awareness of safety
   - To take organizational measures to reduce construction noise

5.1.3 Repair of the two screen facilities at Caballeria

5.1.3.1 Project description

The Caballeria screens function is to retain and remove coarse solids from wastewater coming from different municipalities of Havana City. Two units of existing gates are not functioning and the grit removal is therefore inefficient. The facilities planned for rehabilitation are the replacement of these screens units and the installation of six (6) units of airlift pumps for grit removal. Figure 11 shows the facilities for rehabilitation and photo 9 is the screens appearance at this moment.

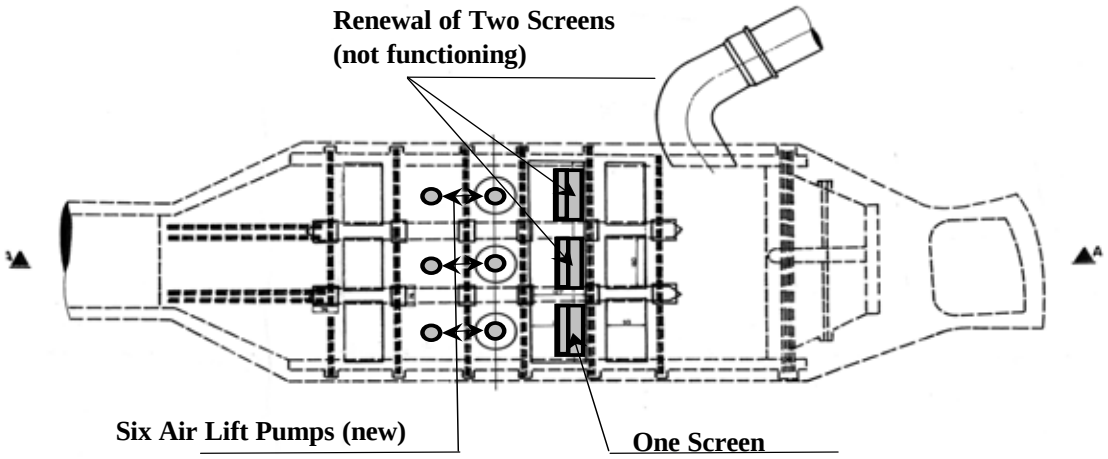


Figure 11. Facilities for rehabilitation of Caballeria screens

Photo 9. Caballeria Screens

5.1.3.2 Impact Assessment

Project actions

Construction Stage	Operation Stage
A - Collection, transport of equipments and materials	D - Screening of domestic wastewaters
B - Installation of the screens and pumps	E - Retention and removal of coarse solids and grits
C - Management of construction wastes	F - Collection and transport coarse and grits
	G - Maintenance of equipments

Environmental factors influenced by the project

The main environmental factors are:

Natural or Physical environment

- Water

Socio-economic environment

- Health and Safety
- Infrastructures
- Energy Consumption

Identification of the impacts

Construction Stage	Operation Stage
Overloads of the infrastructure	Contribution to the increase of water quality of Havana bay
Increase of the continuous and intermittent sound levels	Increase of sound levels
Visual obstruction	Stimulation to the industrial development
Health damages caused by the emission of pollutants and noises	Generation of unpleasant odours
Generation of employments and economic opportunities	Reduction of health impacts
Movement of personal of other areas	System operation failures
Increasing the risk of workplace accidents	Increasing efficiency of retention and removal process
Increase of waste production	Higher energy consumption

Analysis of the impacts caused by the project actions in the influenced environmental factors

Physical or natural environment

Water

The main function of the screens is to retain and remove coarse solids and grits from wastewater, therefore those removed material do not enter into the marine and coastal water contributing to a better water quality at the discharge area.

Socio-economic environment

Workplace health and safety

This factor is related to the risk of accidents that could occur in the workplace but in a short term during the replacement of the existing gates units and the pumps installation and also during the equipment maintenance at the operation stage. The use of a better technology undoubtedly will influence positively in the workplace health, safety and environment

There are bad odours during screens performance at operation stage. The increase of noise levels at construction and operation stages have influence in this factor but to a local scale due to the transport of equipments, materials and waste and the equipment maintenance. These impacts will have a temporary effect on employees, local citizens and visitors.

Infrastructure

This project will introduce some changes on the place infrastructure. New airlift pumps will be installed as part of the improvement measures to extract fine solid particles.

Energy consumption

With the operation of the new pumps an increase of the energy consumption takes place in the retention process and extraction of solids at Caballería.

Impacts Identification Matrix

	Environmental factors	**Actions**						
		Construction stage			**Operation Stage**			
		A	**B**	**C**	**D**	**E**	**F**	**G**
Natural Factors	1. Water				X	X		
Socio-economic Factors	2. Safety and health	X	X	X	X	X	X	X
	3. Infrastructures		X					
	4. Energy Consumption					X		

Evaluation of the impacts

Impacts	CI	I	EX	MO	PE	RV	SI	AC	EF	PR	MC	IM	Cl. I
A_2	-	1	2	4	1		1	1	4	1	4	23	I
B_2	-	1	1	4	1		1	1	4	1	4	21	I
B_3	-	2	1	4	4		1	1	4	4	8	34	M
C_2	-	1	1	4	1		1	1	4	1	4	21	I
D_1	+	4	2	4	4		2	1	4	4		35	M
D_2	+	2	2	4	4		1	1	1	4		25	M
E_1	+	4	2	4	4		2	1	4	4		35	M
E_2	-	2	2	4	4		1	1	4	2	4	30	M
E_4	-	2	1	4	4		1	1	4	4	8	34	M
F_2	-	2	2	4	4		1	1	4	2	4	30	M
G_2	-	1	1	4	1		1	1	4	2	4	22	I

Character of the Impact (CI)
Intensity of the Impact (I)
Extension of the Impact (EX)
Moment of the Impact (MO)
Persistency (PE)
Reversibility (RV)
Synergism (SI)
Accumulation (AC)
Effect (EF)
Periodicity (PR)
Recoverability (MC)
Importance of the Impact (IM)

Classification of the Impact (Cl.I):

Irrelevant (I)	IM< 25
Moderate (M)	25 < IM < 50
Severe (S)	50 <IM < 75
Critic (C)	IM> 75

$$IM = \pm (3I + 2\,EX + MO + PE + RV + SI + AC + EF + PR + MC)$$

Importance Matrix

	environmental factors	Actions							Total per factor	Total per environment
		Construction stage			Operation Stage					
		A	B	C	D	E	F	G		
Natural Factor	1. Water				+35	+35			**70**	**70**
Socio-economic Factors	2. Safety and health	-23	-21	-21	+25	-30	-30	-22	**-122**	**-190**
	3. Infrastructure		-34						**-34**	
	4. Energy Consumption					-34			**-34**	
	Total per action	**-23**	**-55**	**-21**	**60**	**-29**	**-30**	**-22**		
	Total per period	**-99**			**-21**					

Summarize of impacts

Character of the Impact (CI)	Classification of the Impact (CI.I)	Total
+	Irrelevant	
	Moderate	3
	Severe	
	Critics	
	Sub-Total	3
-	Irrelevant	4
	Moderate	4
	Severe	
	Critics	
	Sub-Total	8
	TOTAL	**11**

Analysis of the importance matrix

Analysing the impact evaluation matrix the following can be established:

Project Actions

Construction Stage

The actions related to this period have a negative nature. The main impact related to the risk of accidents is caused by the installation of the screens and pumps, accumulating 55 as importance value. The less aggressive actions are the collection, transport of equipments and materials and the management of construction wastes.

Operation Stage

There are different natures of impact at this period. Screening of domestic wastewaters causes the major impact accumulating a positive value of 60, while the less negative impacts are caused by the maintenance of equipment.

The construction stage resulted the most impacted.

Analysis of the environmental factors

The socio-economic factors will receive impacts, both negative and positive and the overall importance value is 190. The most impacted factor at this stage is safety and health.

On the natural factor, waters receive only positive impacts with an importance value of 70. The main function of the screens is to retain and remove coarse solids out of the wastewater.

5.1.3.2 Preventive and mitigation measures

The following measures are necessary to be undertaken in the subsequent stages of the project to prevent or mitigate impacts, mainly during construction stage.

1. Coordination
   - To coordinate with Historians Office Master Plan on the modifications.
   - To coordinate with Traffic Division of Police (PNR) to provide personnel to control traffic during installation

2. Individual Protection Equipment
   - To provide individual protection equipment to ensure health and safety of workers during rehabilitation and during operation.

3. Disposal of Screenings and Grit
   - To systematize the collection of screenings and grit and their disposal.

4. Public information
   - To use the mass media network to inform the public about the project benefits as well as the possible affectations during the project time period.

5.1.4 Replacement of the existing pumps at Casablanca Pumping Station

5.1.4.1 Project description

Current state of the Pumping Station

The sewage wastewaters coming from Caballeria are driven toward the Playa del Chivo through the Casablanca Pumping Station. This station has 4 floodgates that need to be renovated. Three pumps, including a stand by pump, form the pumps system. These pumps are obsolete and their substitution is required. There are 3 units for the electricity generation in the station, but none of them can be operated by the lack of spare parts and therefore sewage wastewaters are discharged directly into the bay during electricity blackouts and permissible wastewater level is exceeded in the wet well.

Method for rehabilitation

To minimize the discharge of wastewater to bay during rehabilitation, it is necessary to keep the minimum number of pumps in operation. Rehabilitation should to be executed as described in the following steps:

Step 1 : Stop inflow of siphon to pumping station. Wastewater will be discharged to bay
Step 2 : Empty wastewater left in the siphon with temporary pump ==> 7 days to empty
Step 3 : Remove 4 units of existing gate and install new gates ==> 8 days
Step 4 : During Step 3, remove bases of Pump No. 1 and No. 2 and piping and construct new dividing wall for the pump well
Step 5 : Install electrical equipment for B3 and B4
Step 6 : Start wastewater inflow to siphon ==> Wastewater will be discharged to Havana Bay during Step 1 to Step 6 which has an estimated duration of 21 days.
Following Step 6, commence pumping with Pump No. 3 at a capacity of 2.6 m^3/s. During Step 7 to Step 10 for an estimated duration of 18 days only No. 3 pump will be in operation.
Step 7 : Install Pump B3 and Pump B4
Step 8 : Install water level sensor
Step 9 : Commission Pump B3 and B4 ==> Increase of pumping capacity to 3.5 m^3/s during Step 9 and Step 13 for an estimated period of 24 days
Step 10 : Remove Pump No. 3, pump base and piping
Step 11 : Install electrical equipment B1 and B2
Step 12 : Install Pump B1 and B2 and their piping
Step 13 : Commission Pump B1 and B2 ==> Increase pumping capacity to 5.25 m^3/s

Total duration of construction is estimated to be 3 months (87 days) allowing for holiday during Saturday and Sunday. During this period of construction described above, remove of one unit of existing generator, install one unit of new generator and install cooling tower. Figure 12 shows the facilities planned for rehabilitation at Casablanca Pumping Station.

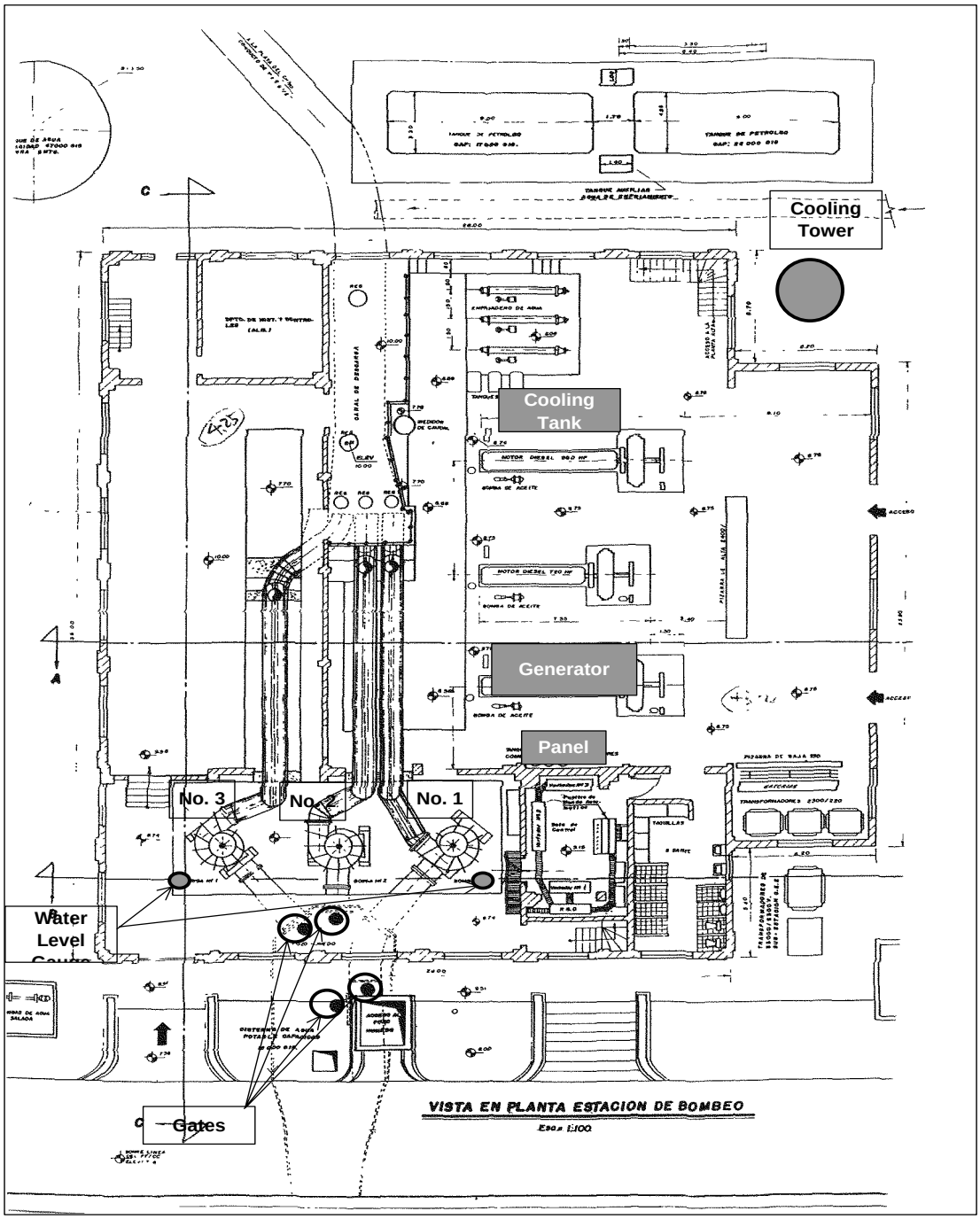


Figure 12. Facilities planned for Rehabilitation at Casablanca Pumping Station

5.1.4.2 Impact Assessment

Project actions

Construction stage	Operation Stage
A. Collection and transport of equipments and materials for the assembly	G. Conduction of sewage
B. Detention of the wastewater flow for the siphon toward the pumping station	
C. Installation of screens, the cooling tower and tank, the generator	
D. Demolition of the pumps base, installation of the new pumps	
E. Reestablishment of the wastewater flow	
F. Solid waste management coming from the construction work	

Environmental factors influenced by the project

The main environmental factors are:

Natural or Physical environment

- Waters
- Air

Socio-economic environment

- Health and Safety
- Infrastructures
- Employment

Identification of the environmental impacts

Construction Stage	Operation Stage
Overloads of the existing infrastructure in the area	Contribution to the increase of the environmental quality of Havana Bay
Increase of the continuous and intermittent sound levels	Bigger efficiency in the pumping
Affectation of the bay water quality	Stimulation to the industrial development
Increase of the particles levels in the air	Decrease of the noise levels
Generation of employments and economic opportunities	Decrease of the problems of environmental health
Movement of personal of other areas	Shortcomings for bad operation
Increase of the risk of work accidents	Improvement of the work conditions and security
Increase of the production of wastes	Wastewater management
	Increase of energy consumption

Analysis of the impacts caused by the project actions in the influenced environmental factors

Natural or physical factors

Water

During the construction stage the wastewater flow through the Siphon will stop. Therefore, temporally discharge to the bay will take place, according to the replacement schedule of rehabilitation at Casablanca Pumping Station. This will cause changes to the bay environmental quality. Normally, during the operation of the Pumping Station direct discharges of wastewater occur because of the electricity blackouts, which should be avoided by installing a new generator. It is important to mention that with the proposed rehabilitation, the probability of failure or discharge to the bay will be reduced.

Cimab's specialists have recently evaluated the impacts on the bay environmental quality of the direct discharge of wastewater for more than 30 days. Due to this event, a noticeable increment on nutrient concentrations was detected being the soluble silicate, the ammonia nitrogen and the total phosphorous the most affected pollution indicators. Consequently, the decrease in the dissolved oxygen concentrations was detected throughout the bay together with slightly decrease in the salinity values. Also, inevitably, the sanitary and hygienic conditions of the bay were deteriorated with a remarkable increment in the faecal coliforms leading to an extremely high risk to human health.

Only, future quality evaluation will give accurate information of the recoverability capacity of the Havana Bay ecosystem.

Air

The environmental impact takes place for the increment of the particles levels and gases generated during the construction stage by the demolition of the pumps base. This impact should have a high degree of incidence on the air, although its effect should not remain any longer. Also, there are high noise levels coming from the pumps operation. This situation should decrease with the installation of the new pumps. Noises can also take place during the construction and operation phase. The Cuban Standard NC 26: 1999 states the maximum and allowed noises (annex 2) in urban and commercial areas.

Socio-economic factors

Security and Health

Accidents can take place during the construction stage by the removal and installation of the equipments, as well as in their collection and transport. In the operation stage accidents can also take place the risk although in smaller scale during the pumps maintenance. This factor is also linked to the particles levels and noise generated during the constructive stage whose intensity can be high. The technological changes, such as the installation of new pumps, cooling tower and level sensor as well as the substitution of the existing generator for a new one improve the work environment.

Infrastructure

This project will introduce some changes on the place infrastructure. The installation of new pumps, screens, a cooling tower and a new generator will undoubtedly overload the infrastructure at the Casablanca pumping station site.

Impacts Identification Matrix

	Environmental factors	Actions						
		Construction stage						Operation Stage
		A	B	C	D	E	F	G
Natural Factors	1. Water		X			X		X
	2. Air				X			
Socio-economic Factors	3. Safety and health	X	X	X	X	X	X	X
	4. Infrastructures			X	X			
	5. Employment				X			

Evaluation of the impacts

Impacts	CI	I	EX	MO	PE	RV	SI	AC	EF	PR	MC	IM	Cl. I
A_3	-	1	2	4	1		1	1	1	1	4	20	I
B_1	-	8	4	4	2	1	4	1	4	4		52	S
B_3	-	8	4	4	2		1	1	1	4	4	49	M
C_3	-	1	1	4	1		1	1	4	1	4	21	I
C_4	-	2	1	4	4				4	4	8	32	M
D_2	-	4	1	4	1		1	1	4	4	4	33	M
D_3	-	4	1	4	1		1	1	1	1	4	27	M
D_4	-	2	1	4	1				4	1	1	19	I
D_5	+	4	1	4	1				4	4		27	M
E_1	+	8	4	4	2		1	1	4	4		48	M
E_3	+	8	4	4	2		1	1	1	4		45	M
F_3	-	2	2	4	1		1	1	4	1	4	26	M
G_1	+	8	4	4	4		1	1	4	4		50	S
G_3	+	8	4	4	4		1	1	1	4		47	M

Character of the Impact (CI)
Intensity of the Impact (I)
Extension of the Impact (EX)
Moment of the Impact (MO)
Persistency (PE)
Reversibility (RV)
Synergism (SI)
Accumulation (AC)
Effect (EF)
Periodicity (PR)
Recoverability (MC)
Importance of the Impact (IM)

Classification of the Impact (Cl.I):

Irrelevant (I)	IM< 25
Moderate (M)	25 < IM < 50
Severe (S)	50 <IM < 75
Critic (C)	IM> 75

$$IM = \pm (3I + 2\,EX + MO + PE + RV + SI + AC + EF + PR + MC)$$

Importance Matrix

	Environmental factors	Actions							Total per factor	Total
		Construction stage						Operation Stage		
		A	B	C	D	E	F	G		
Natural Factor	1. Water		-52			+48		+50	**46**	**13**
	2. Air				-33				**-33**	
Socio-economic Factor	3. Safety and health	-20	-49	-21	-27	+45	-26	+47	**-51**	**-75**
	4. Infrastructure			-32	-19				**-51**	
	5. Employment				+27				**27**	
	Total per action	**-20**	**-101**	**-53**	**-52**	**93**	**-26**	**97**		
	Total per period	**-159**						**97**		

Summarize of impacts

Character of the Impact (CI)	Classification of the Impact (CI.I)	Total
+	Irrelevant	
	Moderate	4
	Severe	1
	Critics	
	Sub-Total	5
-	Irrelevant	3
	Moderate	5
	Severe	1
	Critics	
	Sub-Total	9
	TOTAL	**14**

Analysis of the importance matrix

Analysing the impact evaluation matrix the following can be established:

Project Actions

Construction Stage

There are negative and positive actions within this project stage. The most aggressive action is the detention of the wastewater flow for the siphon toward the pumping station which lead to the direct discharge of raw wastewaters to the entrance channel of Havana Bay. Special attention should be paid to this point in the preventive and mitigation measure as well as in the monitoring program to be established.

Operation Stage

The most important action in this stage is by far beneficial. The efficient and optimal conduction of sewage wastewaters will lead to the improvement of the bay water quality as well as decrease the human health risks.

Analysis of the environmental factors

The socio-economic factors are influenced negatively and positively being the safety and health and the infrastructure the most influenced ones.

Water is most affected natural factor having high importance values considered as severe according to the applied environmental impact assessment methodology.

5.1.4.3 Preventive and mitigation measures

The following measures are necessary to be undertaken in the subsequent stages of the project to prevent or mitigate impacts, mainly during construction stage.

1. Public information
   - To use the mass media network to inform the public about the project benefits as well as the possible affectations during the project time period.

2. Planning of the Execution of the Tasks
   - To minimize the discharge of raw wastewater to at the entrance to the bay during rehabilitation, execution of tasks and necessary stand-by shall be planned and prepared prior to commencing the rehabilitation work.

3. Security and Safety
   - To Security and safety regulations shall be adhered to during transportation of equipment, materials, waste etc.
   - Safety and health precautions shall be taken while working in the existing pumping station, with skilled personnel and with protection equipment for workers
   - To provide adequate ventilation and lighting
   - Security permission for the demolition work shall be obtained and shall include measures for workers protection

4. Sludge Remaining in the Siphon and other Demolition Waste
   - Sludge remaining in the siphon shall be discharged to the landfill.
   - Disposal of any harmful waste generated during demolition shall be negotiated with Empresa Provincial de Servicios Comunales, EPSC.

5.2 New Sewerage System

5.2.1 Construction of a wastewater treatment plant (Luyano WWTP) at the site of the wastewater treatment plant financed by UNDP/GEF Project

5.2.1.1 Project description

The proposed treatment plant will process wastewater coming form the low and medium basin of Luyano and Martin Perez rivers and will increase the treatment capacity of the ongoing UNDP/GEF treatment plant from 200 $L.s^{-1}$ to 821 $L.s^{-1}$ in three consecutives phases of 207 $L.s^{-1}$ each.

Table 9 shows the design flow for the treatment plant. The proposed Conventional Activated Sludge Plant will treat a wastewater with an organic matter and suspended solids concentration of 200 mg $BOD_5.L^{-1}$ and 200 mg $SS.L^{-1}$ respectively.

Table 9. Design flow for the treatment plant

Item	$m^3.day^{-1}$
Daily Average Flow (Q_{ave})	59 600
Daily Maximum Flow (Q_{daymax})	71 000 (821 $L.s^{-1}$)
Hourly Maximum Flow ($Q_{hourmax}$)	106 500

The liquid and solid treatment lines are as follows (Figure 13):

Liquid line

Influent → Screen → Influent Pump → Grit Chamber → Primary Sedimentation Tank → Aeration Tank → Secondary Sedimentation Tank → Effluent to Luyano River

Sludge Line

Sludge from Primary Sedimentation Tank and Excess Sludge from Secondary Sedimentation Tank → Sludge Thickener → Sludge Digester → Mechanical Dewatering → Disposal (landfill or reuse)

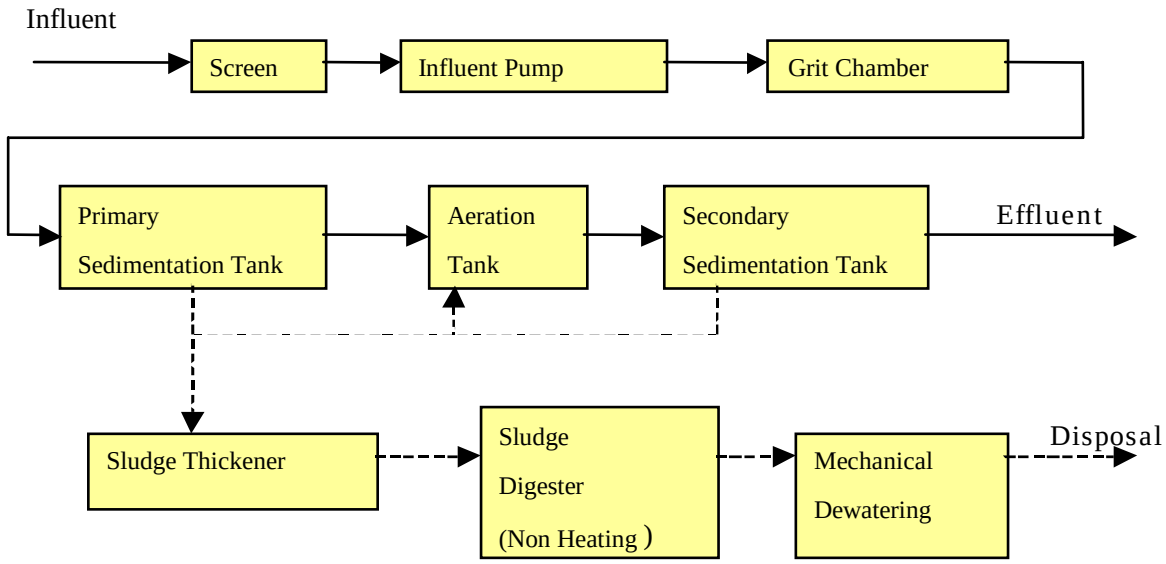


Figure 13. Productive flow of wastewater treatment plant (Luyano WWTP)

Table 10 shows the effluent design characteristics and the expected removal percentages of organic matter (BOD_5) and suspended solids (SS).

Table 10. Effluent characteristics and pollutant load reduction

Parameter	Removal Efficiency (%)			Concentration (mg/L)		
	Primary Treatment	Secondary Treatment	Overall Removal Rate (%)	Raw Wastewater	Primary Effluent	Secondary Effluent
BOD_5	30	86	90.2	200	140	19.6
SS	40	84	90.4	200	120	19.2

Table 11 shows an estimation of the solid waste to be generated in the plant for a treatment capacity of 821 $L.s^{-1}$ according Master Plan. Wastes are generated in the grit removal, the screens and in the sludge treatment line.

Table 11. Generation of Screenings, Grit and Sludge (Luyano WWTP)

Unit process	Unit	Master Plan (821 $L.s^{-1}$)	Observation
Grit	$m^3.day^{-1}$	1.19	
Screenings	$m^3.day^{-1}$	0.89	
Sludge			
▪ thickened sludge	t. day^{-1} $m^3.day^{-1}$	10.78 359	 Sludge concentration = 3%
▪ dewatered sludge	t. day^{-1} $m^3.day^{-1}$	7.08 35.40	 Sludge concentration = 20%
▪ sludge for transport	t. day^{-1}	35.40	Assumption 1t / m^3

Table 12 shows the chemical and power requirement of the Luyano Wastewater Treatment Plant for a treatment capacity of 821 $L.s^{-1}$ according Master Plan.

Table 12. Chemical and Power Requirement (Luyano WWTP)

Item	Unit	Master Plan (821 $L.s^{-1}$)	Observation
Chemical Requirement	Kg. day^{-1}	70	Polymer for sludge dewatering
Installed Power	kW	922	
Daily Power Consumption	KWh. day^{-1}	~14	

Figure 14 is a spatial representation of the treatment plant and its distribution on the site according to JICA proposal.

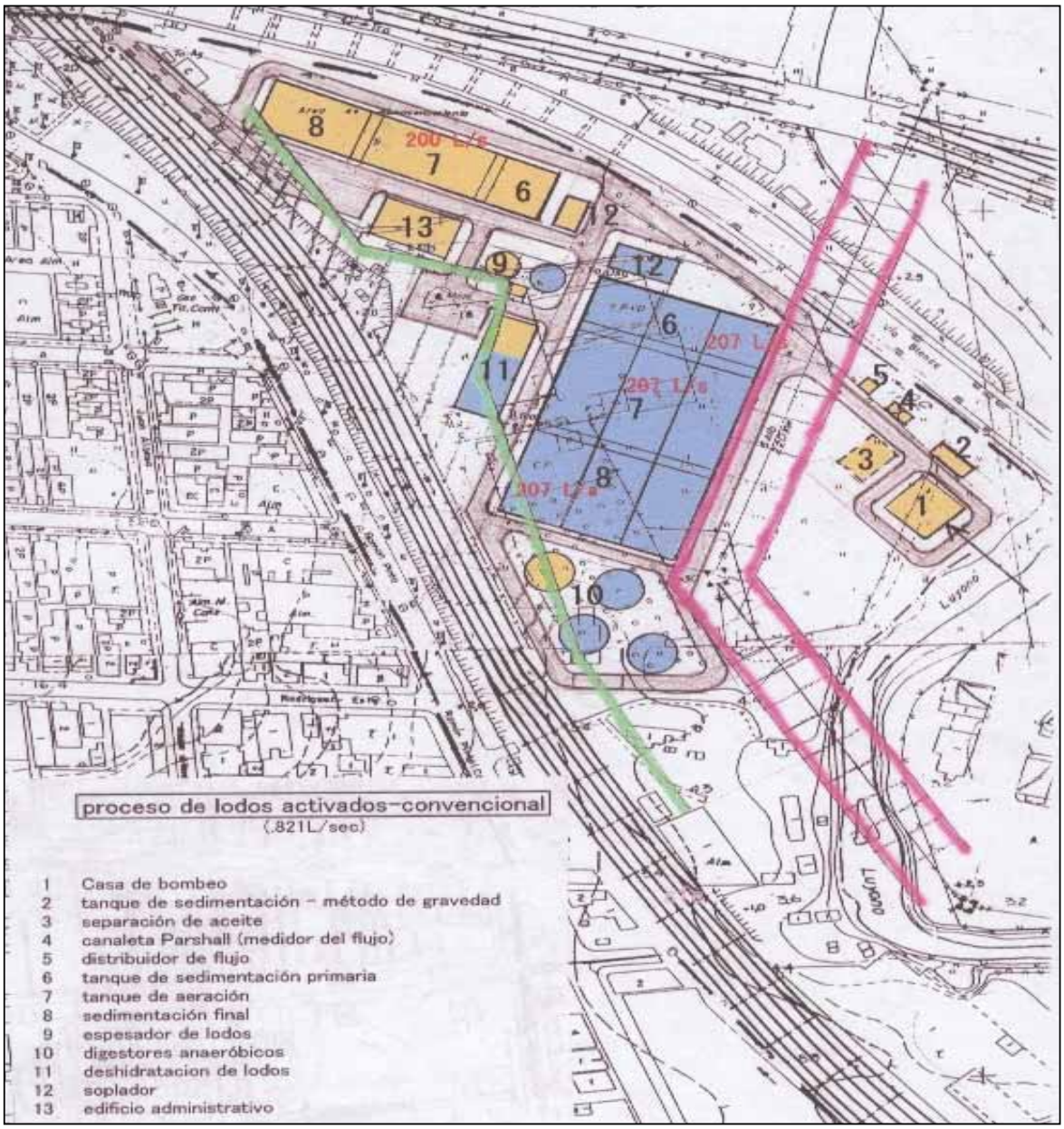


Figure 14. Unitary treatment processes at the site (JICA Proposal)

5.2.1.2 Impact Assessment

Project actions

Construction stage	Operation Stage
A. Excavations and earthworks	G. Sewage waters and sludge treatment
B. Transport of heavy machinery and materials	H. Accidental discharge of untreated sewage waters and sludge into the river
C. Spreading of concrete, pave and auxiliary works	I. Industrial solid wastes disposal
D. Installation and interconnection of networks and electromechanical equipments	
E. Demolition of houses	
F. Management of construction wastes	

Environmental factors influenced by the project

Natural or Physical environment

- Soil
- Air
- Landscape
- Fluvial currents and marine waters

Socio-economic environment

- Health and Safety
- Soil use
- Employment
- Housing
- Roadway and traffic
- Infrastructure
- Soil use

Identification of the environmental impacts

Construction stage	Operation Stage
Change of land use	Changes of land use and the use of unproductive lands
Loss of vegetal cover layer	Soil compaction
Changes of local geomorphology dynamic	Changes in the erosion and sedimentation processes
Soil compaction	Introduction of inadequate elements to the landscape
Changes of the drainage patterns	Generation of employments
Deposition of sediments in soils and waters	Stimulation to the industrial development
Waters pollution	Better economic opportunities
Air pollution by dust and emissions of gases.	Decrease of the problems of public and environmental health
Increase of the continuous and intermittent sound levels	Undesirable odours appearance
Modification of the landscape	Increase of risk of accidents
Damages to the health for emission of pollutants and noises	
Overloads of the existing infrastructure in the area	
Generation of employments and economic opportunities	
Movement of personal of other areas	
Increase of risk of accidents	
discharge of materials and polluting substances to the waters and soils	
Families relocation	

Analysis of the impacts caused by the project actions in the influenced environmental factors

Natural or physical environment

Soils

The impacts on soil are directly related to its compaction or destruction as a result of the earthworks and the civil construction. The magnitude depends on the destroyed surface as well as the quality of the occupied surfaces. The area of the project is an urban and relatively a small area. Photo 10 shows the project area.

Photo 10. Project area of GEF/UNDP treatment Plant

Air

The environmental impact comes from air pollution due to dust and gases emissions. The changes on quality parameters arise during the construction phase as a consequence of the transport and management of the construction materials and the earthworks. In these actions, on a short term and locally, an increase of the emission levels and inhalation of suspended and settable particles take place. Also, during the operation phase, emanations of gases will take place (CH_4, CO_2, H_2S) as final products of the sludge anaerobic digestion (closed anaerobic digester without heating). Some of these gases are considered greenhouse effect gases and therefore its estimation and control is very important to know the air quality in the study area and to prevent the potential health related problems to the surrounding population mainly due to the H_2S. It is worth to mention that 1 km. downstream Luyano river, on the treatment plant Administrative building (Italian technology) an air monitoring station will be settle and NOx, SOx and PM measurements will be performed.

During the construction phase a remarkable increment of the continuous and intermittent sound levels will take place due to the earthworks, the heavy machinery activity, the management of construction materials and the plant civil construction. The noise during the operation stage is considered of continuous nature for the continuity of the treatment processes including pumping, aeration, mechanical drying, as well as a continuous movement of vehicles, mainly those in charge of the sludge handling. The Cuban Standard NC 26: 1999 states the maximum and allowed noises (annex 2) in urban and commercial areas

A potential and important impact is the odours appearance due to potential operational failures in processes such as the anaerobic digestion, the mechanical dewatering and the sludge accumulation. This aspect has to be taken into account from the very early stages of the project. Operational problems will also attract flies and vectors causing nuisances and risks for the public health.

Landscape

During the construction phase the impacts to the landscape are related to the earthworks, the construction waste accumulation, the presence of heavy machinery, the construction of temporary facilities, as well as plant civil construction. Although the impacts of these activities over the landscape can be considered important it is worth to emphasize their evident temporary character.

During the operation phase the impact on landscape will be permanent because the visual of the area will change completely. The plant construction and operation will transform the surrounding environment, which will be clearly seen by the users of Via Blanca Avenue.

Fluvial currents and marine waters

The discharge of construction material and polluting substances into the water ecosystem might modify quality parameters such as the suspended and dissolved solids (extraction and excavation wastes), oil and greases and hydrocarbons (accidents discharges). Nevertheless, the decrease of the fluvial currents and marine waters pollution is considered the most important impact in this project having a positive character. In the final phase of the project, around 59 600 $m^3.day^{-1}$ of waste waters with 200 $mg.L^{-1}$ for both, organic matter expressed as DBO_5 and suspended solids will be treated. 90% of removal efficiency is expected for both parameters and therefore the effluent should have concentrations of 20 $mg.L^{-1}$ of DBO_5 and SS respectively, fulfilling the Cuban Standard NC 27: 1999 for the discharge on fluvial currents.

A key topic to evaluate and to keep in mind through this project implementation is the concentrated discharge, in a spot, of around 60 000 $m^3.day^{-1}$ treated effluent. It should be guaranteed the optimal plant operation, which should be foreseen from the early stages of the design process. A continuous failure would generate a punctual discharge in the range of 6 to 10 $ton.day^{-1}$ of organic matter (DBO_5) into the Luyano River. Such discharge, undoubtedly, would cause anoxic, septic and eutrophic conditions downstream. It should be kept in mind that in the river outlet, in a short to medium term, a wastewater treatment plant with Italian technology would be treating the top layer of Luyano River and water from Dren Agua Dulce mixed with wastewater coming from some adjacent industries. A Primary Treatment Chemically Assisted will be the treatment process applied. Therefore, an unexpected increment of the polluting loads will increase the chemical consumption (coagulant and flocculants) and will increase the operation costs of the Italian plant.

Socio-economic environment

Employment

In the construction phase, temporary employments are generated. Although the accurate amount can't be yet determined, it is well known that this type of construction requires a lot of manpower. The recruiting of local manpower should be encouraged

Have been estimated that the employments to be generated during the opreration phase will be between 25-30, including all the administrative, technician and services personnel.

Health and safety

The construction related activities generate noises (continuous and intermittent), dust, combustion gases and they also increase the risks of accidents, generating a negative health impact, not only to the workers but also to the surrounding population. This impact can be thoroughly minimized if organizational measures and the established protection actions are taken. In the plant operation phase a lot of attention should be paid to the impacts related to the operational failures of the unitary treatment processes; also, it is necessary to avoid the direct contact of the workers and the surrounding population with the sewage waters and the sludge because of the pathogens and hazardous substances.

However, a positive impact takes place on human health as a result of the hygienic-sanitary quality improvement of the study area due to the treatment of sewage waters that at present ended at Havana Bay through Luyano River.

Houses

The impact on this factor is one of most important negative impacts arisen from the project and takes place since the early stages of the plant construction. 11 houses belonging to San Miguel municipality and located inside the study area will be affected. In order to guarantee that this impact doesn't turn into a social problem the houses owners will be indemnified with a new house with equal or better conditions than the previous one. For the socio-political connotation it should be strictly checked that each family demands are fulfilled, avoiding dissent problems. On the other hand, all the established legal procedures for the expropriation cases should be stated.

Soil use

The change of land use generates a significant impact due to the houses demolition, therefore this aspect will be considered with more detail on the socio-economic aspects

Roadway and traffic

In the constructive phase, the impact on this factor is considered irrelevant although some traffic deviation should originate minimum nuisances to the population. The main one road involved will be Via Blanca Avenue.

Solid waste (sludge)

The main point to consider is the solid and semisolid wastes production due to the plant unitary treatment processes. These wastes are divided in solids retained in coarse screen, the grit removal and the sludge coming from the dewatering process. With a capacity of 821 $L.s^{-1}$, 36 tonnes of sludge will be produced with a solids concentration of 20%. Also, around 2 $m^3.day^{-1}$ of grit and other solids will be produced. Appropriate disposal and/or reuses of these solids are alternatives to consider from the design stages of the project.

Impacts Identification Matrix

	Environmental factors	Actions								
		Construction stage						Operation Stage		
		A	B	C	D	E	F	G	H	I
Natural Factors	1. Soil	X	X	X	X		X	X		X
	2. Fluvial currents and marine waters	X	X				X	X	X	
	3- Air	X	X	X	X	X		X		X
	4. Landscape	X	X	X	X					
Socio-economic Factors	5. Health and Safety	X	X	X	X	X	X	X		X
	6. Industrial Development							X		X
	7. Employment	X				X		X		
	8. Housing					X				
	9. Roadway and traffic	X				X				
	10. Infrastructure				X					
	11. Soil use	X								

Evaluation of the impacts

Impacts	CI	I	EX	MO	PE	RV	SI	AC	EF	PR	MC	IM	CI. I
A_1	-	4	4	4	4		1	1	4	4	8	46	M
B_1	-	1	1	2	2	2	1	1	4	1	4	22	I
C_1	-	2	1	4	2		1	1	4	1	4	25	M
D_1	-	8	4	4	4		1	1	4	4	8	58	M
F_1	-	2	1	2	2	2	1	1	4	4	4	28	M
G_1	-	2	2	1	2	2	2	4	1	1	2	25	M
I_1	-	2	2	1	2	2	2	4	1	1	2	25	M
A_2	-	4	2	2	2	1	1	1	1	1	1	26	M
B_2	-	2	1	1	1	1	1	1	1	1		15	I
F_2	-	4	2	2	2	1	1	1	1	1	4	29	M
G_2	+	8	4	4	4		4		4	4		52	S
H_2	-	8	4	4	2	2	4	4	4	4	4	60	S
A_3	-	8	4	4	1	1	1	1	4	1	4	49	M
B_3	-	4	4	4	2	1	1	1	4	4	2	39	M
C_3	-	1	1	2	1	1	1	1	4	4	1	20	I
D_3	-	1	1	4	1	1	1	1	4	1		18	I
E_3	-	8	2	4	1	1	1	1	4	1	4	45	M
G_3	-	4	2	4	2	1	1	1	4	4	4	37	M
I_3	-	2	1	4	1	1	1	1	4	1		21	I
A_4	-	8	4	4	2		1	1	4	4	4	52	S
B_4	-	2	1	2	1		1	1	4	1	4	22	I
C_4	-	1	1	2	1		1	1	4	1	4	19	I
D_4	-	4	2	2	2		1	1	4	1	4	31	M
A_5	-	4	2	2	2		1	4	4	1	1	31	M
B_5	-	2	2	4	4		1	1	4	1	1	26	M
C_5	-	1	2	4	4		1	1	4	1	1	23	I
D_5	-	1	2	4	4		1	1	4	1	1	23	I
E_5	-	4	2	2	2		1	4	4	1	1	31	M
F_5	-	2	2	2	2		1	4	4	1	1	25	M
G_5	-	2	4	1	4		1	1	4	1	1	27	M
I_5	-	2	4	1	4		1	1	4	1	1	27	M
G_6	+	2	4	4	4		2	4	4	4	1	37	M
I_6	+	2	4	4	4		2	4	4	4	1	37	M
A_7	+	4	1	4	2	2			4	4		30	M
E_7	+	4	1	4	2	2			4	4		30	M
G_7	+	4	1	4	4	2			4	4		32	M
E_8	-	8	2	4	2		1	1	4		2	42	M
A_9	-	4	2	4	2				4	1	4	31	M
E_9	-	4	2	4	2				4	1	4	31	M
D_{10}	-	2	1	4	2				4		4	22	I
A_{11}	+	4	4	4	4	4	1	1	4	4		42	M

Character of the Impact (CI)
Intensity of the Impact (I)
Extension of the Impact (EX)
Moment of the Impact (MO)
Persistency (PE)
Reversibility (RV)

Synergism (SI)
Accumulation (AC)
Effect (EF)
Periodicity (PR)
Recoverability (MC)
Importance of the Impact (IM)

Classification of the Impact (Cl.I):

Irrelevant (I)	IM< 25
Moderate (M)	25 < IM < 50
Severe (S)	50 <IM < 75
Critic (C)	IM> 75

$$IM = \pm (3I + 2\,EX + MO + PE + RV + SI + AC + EF + PR + MC)$$

Importance Matrix

	Environmental factors	Actions									Total per factor	Total per environment
		Construction stage						Operation Stage				
		A	B	C	D	E	F	G	H	I		
Natural Factors	1. Soil	-46	-22	-25	-58		-28	-25		-25	**-229**	**-660**
	2. Fluvial currents and marine waters	-26	-15				-29	+52	-60		**-78**	
	3- Air	-49	-39	-20	-18	-45		-37		-21	**-229**	
	4. Landscape	-52	-22	-19	-31						**-124**	
Socio-economic Factors	5. Health and Safety	-31	-26	-23	-23	-31	-25	-27		-27	**-213**	**-215**
	6. Industrial Development							+37		+37	**74**	
	7. Employment	+30				+30		+32			**92**	
	8. Housing					-42					**-42**	
	9. Roadway and traffic	-31				-31					**-62**	
	10. Infrastructure				-22						**-22**	
	11. Soil use	-42									**-42**	
	Total per action	**-247**	**-124**	**-87**	**-152**	**-119**	**-82**	**32**	**-60**	**-36**		
	Total per period	**-811**						**-64**				

Summarize of impacts

Character of the Impact (CI)	Classification of the Impact (CI.I)	Total
+	Irrelevant	
	Moderate	5
	Severe	1
	Critics	
	Sub-Total	6
-	Irrelevant	10
	Moderate	22
	Severe	3
	Critics	
	Sub-Total	35
	TOTAL	**41**

Analysis of the importance matrix

Analysing the impact evaluation matrix the following can be established:

Project Actions

Construction Stage

During the construction stage, the most aggressive actions are the excavations and earthworks, the installation and interconnection of networks and electromechanical equipments, the transport of heavy machinery and materials and houses demolition because they gather high negative importance values. The less aggressive actions are the management of construction wastes and the pave and auxiliary works.

Operation Stage

In the operation stage, the most beneficial action is the treatment of sewage wastewater and sludge. This action is a core identified project within the development of the new sewage system.

On the other hand, the accidental discharge of untreated sewage waters and sludge into the river is the potential most aggressive action of this project, followed by the industrial solid waste disposal. Within a short to medium term all these negative impacts can be mitigate if corrective and preventive measures are taken at early stages of the project.

Analysis of the environmental factors

Two socio-economic factors are positively impacted by the project actions, although, undoubtedly, the rest of them receive negative impacts: Most negatively impacted are the heath and safety, the roadway and traffic as well as the housing.

The natural factors receive only negative impacts, being the soil and the air the most impacted ones, followed by the landscape and the fluvial currents and marine waters respectively.

5.2.1.3 Preventive and mitigation measures

The following measures are necessary to be undertaken in the subsequent stages of the project to prevent or mitigate impacts, mainly during construction stage.

1. On-going GEF/UNDP Project
   - Detailed Design of the GEF/UNDP Project shall take into account the details of the proposed Master Plan especially for the design of common facilities of the treatment plant.

2. Public information
   - To use the mass media network to inform the public about the project benefits as well as the possible affectations during the project time period.

3. Design Aspects
   - To provide stand-by power supply to sustain biomass in the activated sludge process during power-failure
   - To consider noise and vibration levels in the selection of equipment

4. Land Acquisition
   - Proposed land need to be acquired by GTE (/INRH) and the buildings need to be removed

5. Resettlement
   - An awareness program shall be started with the families whose residences are within the radius

6. Electric Power
   - Power requirement of the WWTP shall be informed to the Electric Power Company for its inclusion in the energy plan for Havana City.

7. Baseline Environmental Data
   - Existing wind direction, noise level and odor levels shall be observed around the proposed WWTP for comparison in the future with monitored data.

8. Disposal of Sludge
   - Sludge is planned to be disposed at land fill site with solid wastes. During the operation stage, it is necessary to investigate the composition of sludge and to evaluate its possible reuse such as soil conditioner, fertilizer, etc.
   - Containers which are water-tight and covered shall be used for transportation to avoid spill

9. Prevention of odor and fly generation
   - Adherence to proper operation and maintenance procedures for storage and disposal of screenings, grit and sludge will be necessary to prevent excessive odor and fly generation.

10. Coordination with Traffic Division of Police (PNR)
   - To inform the public and other relevant institutions in advance
   - To provide personnel to direct and control construction traffic leaving and entering the site

11. Instruction to the Contractor to conform to good Construction Practices
   - To provide tight containers for transport of materials and to provide covered containers to avoid loss of material during transportation
   - To use safety devices in the concrete-mixer trucks to avoid the spill of material during the transport
   - To avoid spilling of construction materials i.e. cement, concrete etc. to prevent blocking of drains and their ultimate discharge to Luyanó River and the bay
   - To avoid cleaning of containers, machineries etc. on the street pavements to prevent spilling of fuel, lubricants etc. to the bay
   - To control the speed of construction traffic and maintain awareness of safety

5.2.2 Installation of sewer networks and Colectors from the middle to downstream Luyano and Martin Perez rivers.

5.2.2.1 Project description

It have been mentioned that the Master Plan is considered as the combination of the (1) Improvement of Existing Central Sewerage System and (2) New Sewerage System, Development in the Luyano-Martin Pérez Abajo Sewer District. As part of the New Sewerage System the Installation of sewer networks and Colectors from the middle to downstream Luyano and Martin Perez rivers is one the core actions to undertake.

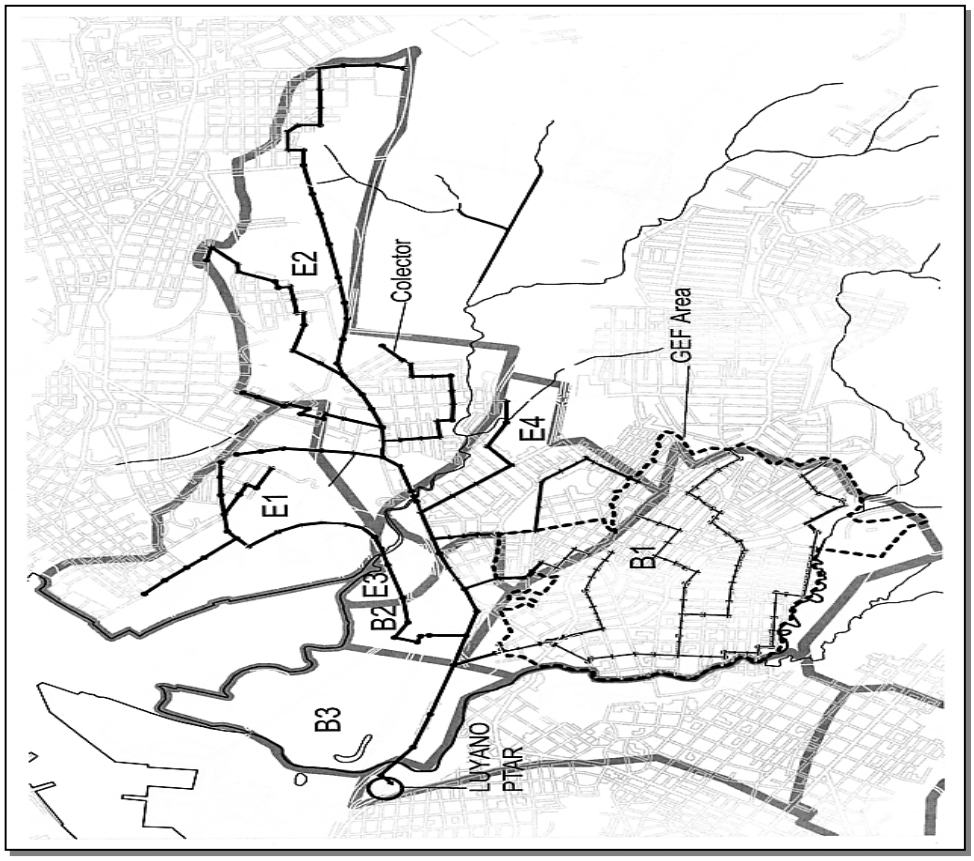


Figure 15. Route of Luyanó Martin Perez Right Bank Colector

Figure 15 shows service area of Luyano Martin Perez Colector to serve Area B (right bank of Luyano River) and Area E (Martin Perez River). Most part of Area B is demarcated to be served under the on-going GEF/UNDP Project and the Colectors are also being designed under that Project.

Figure 16 shows the route of Luyano left bank Colector and part of the GEF/UNDP area and technical information on the whole project, provide by the JICA Study Team, is shown in the following tables

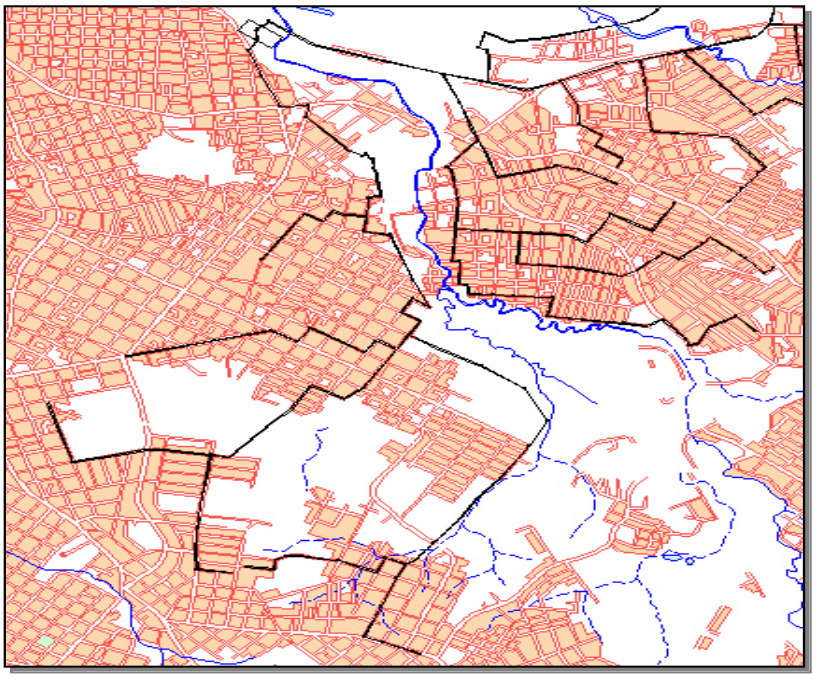


Figure 16. Route of Luyano left bank Colectors

It can be notice that with this project, a total area of 1054 ha should be sewered and 163600 will be the total sewered service population including, in both cases, the GEF/UNDP Project area.

At glance, it can be seen the huge magnitude of this project. Only within that phase 1,476.8 ha should be covered by sewer networks of different diameters and lengths. The implementation will be in three phases through different locations covering areas of Guanabacoa, San Miguel, 10 de Octubre municipalities. The total construction period is not yet estimated.

The EIA Study Team considers that a valuable and detailed environmental impact assessment to the installation of sewer networks and Colectors from the middle to downstream Luyano and Martin Perez will undoubtedly require more time, definitions and information. Only for this report, the EIA Study Team propose to apply the EIA methodology to the main part of this Colector (from Martin Perez to Luyano river through Via Blanca) and take it as a reference to the rest of the Colectors to be installed.

Table 13. Technical information of Luyano-Martin Perez Abajo Colectors

Summary of Luyano Martin Perez Abajo Colectors

Diameter	Length							Total
	Right Bank				Left Bank			
	GEF	Phase 1	Phase 2	Phase 3	Phase 1	Phase 2	Phase 3	
E-200 mm	1,750	1,230	-	1,050	-	-	2,130	**6,160**
E-250 mm	510	1,340	500	1,430	410	-	1,130	**5,320**
E-315 mm	1,400	1,040	940	-	270	-	490	**4,140**
E-400 mm	1,470	1,020	-	3,640	120	1,280	340	**7,870**
E-500 mm	2,140	640	-	-	-	230	450	**3,460**
E-630 mm	720	370	350	-	-	130	780	**2,350**
E-800 mm	290	3,510	-	-	-	1,480	1,100	**6,380**
E-1000 mm	-	250	-	-	120	-	-	**370**
E-1200 mm	-	1,070	-	-	2,970	-	-	**4,040**
Total	**8,280**	**10,470**	**1,790**	**6,120**	**3,890**	**3,120**	**6,420**	**40,090**
Total	**8,280**	**18,380**			**13,430**			**40,090**

Sewered Area

	Area, ha		
	Luyano Left	LuyanoMartin Perez Right	Total
GEF		225.8*	225.8*
Phase 1	134.5	342.3	476.8
Phase 2	113.74	101.2	214.94
Phase 3	260.5	101.4	361.92
Total sewered	**508.76**	**544.9**	1053.66
Total area	679	949	1628

Note: In addition to 225.8 ha, outside area of 20.3 ha is also included in GEF Area.

Sewered Service Population

	Population		
	Luyano	LuyanoMartin Perez	Total
GEF		25,300	25,300
Phase 1	28,513	28,430	56,943
Phase 2	27,820	11,440	39,260
Phase 3	35,368	6,730	42,098
Total Population	**91,700**	**71,900**	163,600

Note: Within the Study Area

Figure 17 shows the layout of the Colector from Luyano to Martin Perez river indicating places of interest to take into account on this EIA report

Figure 17. Layout of the Colector from Luyano to Martin Perez river

5.2.2.2 Impact Assessment

Identification and description of the environmental impacts

Construction stage	Operation Stage
A. Excavations and earthworks	G. Conduction of sewage wastewaters
B. Transport of heavy machinery and materials	
C. Construction of channels, pipes installation and interconnection of the Colector	
D. Pave and auxiliary works	
E. Hedge and deviation of the traffic	
F. Management of construction wastes	

Environmental factors influenced by the project

Natural or Physical environment

- Soil
- Air
- Landscape

Socio-economic environment

- Health and Safety
- Institutional and commercial activities
- Employment
- Roadway and traffic
- Infrastructure and network

Identification of the impacts

Construction stage	Operation Stage
Change of land use	Soil compaction
Increase of the erosive processes	Changes in the erosion and sedimentation processes
Changes in the dynamic local geomorphology	Stimulation to the industrial development
Soil compaction	Growth of the human establishments
Changes of the drainage patterns	Decrease of the problems of public and environmental health
Deposition of sediments in soils and waters	Changes in the population's space distribution
Soil pollution	Changes of land use and the use of unproductive lands
Waters pollution	
Air pollution by dust and emissions of gases	
Increase of the continuous and intermittent sound levels	
Modification of the landscape	
Damages to the health for emission of pollutants and noises	
Overloads of the existing infrastructure	
Affectations to the institutional activity in the area	
Changes in the traffic flow	
Generation of employments and economic opportunities	
Movement of personal of other areas	
Increase of the risk of work accidents	
Discharge of materials and polluting substances to the soils	
Generation of material due to the excavation	

Analysis of the impacts caused by the project actions in the influenced environmental factors

Natural or physical environment

Soils

In the study area changes are appreciated in the land use that opened the way to the urbanization. Geological studies carried out show the presence of a top layer with vegetal origin having fragments of rocky material. The following layers are composing by different types and fractions of clays. The ground water table varies from 1.5 to 3 m thus; any excavation under these levels will face the presence of underground water.

Air

The produced environmental impact is the air pollution by dust and gases emissions. The changes in the quality parameters associated to this resource occur mainly during the execution and as consequence of the transport of building materials and the earthworks. These actions should take place at a local scale with an increase of the emission and inhalation levels of suspended and settable particles. On the other hand, the surfacing construction produces gases emissions during the phase of asphalt heating for the priming. Also, during the construction phase a remarkable increment of the noise takes place mainly during the earthwork, the manipulation of the heavy machinery, the haulage of the building materials, the surfacing and also to the pavement process during the pipes installation.

Landscape

The impacts related to the landscape modification are considered temporary during the construction period. During the construction phase, continuous changes on landscape might be expected, as there will be accumulation of construction wastes, presence of heavy machinery and location of the temporary facilities. During the operation phase significant impacts should not arise because an underground pipe does not affect the landscape visual. In general, the landscape can be classified as strongly modified due to the changes in the territory caused by the industrial and urban development.

Socio-economic environment

Health and safety

Undoubtedly, the construction stage activities generate noises (continuous and intermittent), dust, combustion gases and the risks of accidents are increased which generates a negative health impact, not only to the employees but to the surrounding population. It is worth to highlight that this impact can be totally minimized if organizational and protection measures are taken. In the operation stage the Colectors impact on the health is considered positive because it improves the hygienic-sanitary quality of the territory due to the conduction of the wastewaters and its treatment in a sewage treatment plant. At the moment, an important volume of these waters ended in the Havana Bay leading to its environmental quality deterioration and the potential increment of the health risks of the users and the surrounding bay population.

Infrastructure and networks

The construction of the Colector through Via Blanca will bring conflicts with the existing network in the layout area. It should be verified that phone and hydraulic networks do not interfere with the new Colector. It is considered that the Colector will provide an overload in the infrastructure of the area in terms of networks.

Institutional activity

During the construction period affectations to the institutional activity in the study area will occur, that's why, preventive and mitigation measures are needed to reduce the effect of these impacts. In this area are placed important institutions such as:

- TAINO Engine Factory (Photo 11)
- Sugar Cane By-products Research Institute (Photo 12)
- Technical school

Photo 11. TAINO Engine Factory

Photo 12. Sugar Cane By-products Research Institute

The main economic impacts will be in freight transport, because this road links the Havana port with the national highway, measures to organise the traffic will be taking into to consideration.

Roadway and traffic

The layout of this Colector will be along the Via Blanca road, this road belongs to the main road network of Havana City and have characteristic of urban road, it has four lanes, two in each direction. Photo 13 shows the characteristics of this section and the traffic sign (arrow) indicates the access to the National Highway.

Photo 13. Section characteristics of the Via Blanca road

Moreover, this section is an alternative route to make possible the east-west connection when the tunnel under Havana Bay is closed. Also the traffic from the national highway to the port (Photo 14) and the city center, the local traffic coming from the municipalities of San Miguel, 10 de Octubre and Guanabacoa (Photo 15) use this road.

Photo 14. Heavy trucks from the Havana port

Photo 15. Traffic coming from San Miguel Municipality

This road has high traffic volumes, with high percent of heavy vehicles in the traffic flow, due to, any kind of works who affects the traffic will cause a serious problems. The following drawing (Figure 18) shows the cross-section of the road.

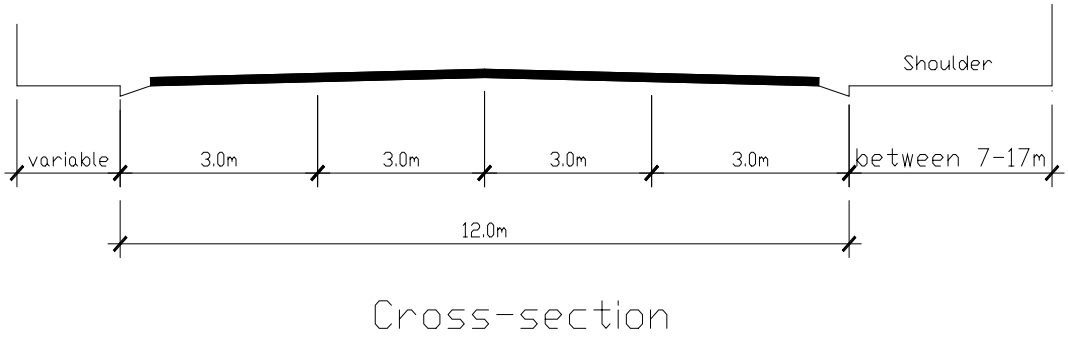


Figure 18. Cross-section of the road

The proposal is to use the area using by the north cycle path to place the pipe; the shoulder has a variable width between 7 and 17 m.

Residuals (Waste management)

The excavation activities and earthwork generate high quantities of solid wastes. It is estimated that the total production of excavated material, only for this part, will be approximately 20 000 m^3.

Impacts Identification Matrix

	Environmental factors	Actions						
		Construction stage						Operation stage
		A	B	C	D	E	F	G
Natural Factors	1. Soil	X	X	X	X		X	
	2- Air	X	X	X				
	3. Landscape	X	X	X				
Socio-economic Factors	4. Health and Safety	X	X	X	X	X		X
	5. Institutional and commercial activities	X	X	X		X		X
	6. Employment	X	X	X				
	7. Roadway and traffic					X		
	8. Infrastructure and networks	X		X				

Evaluation of the impacts

Impacts	CI	I	EX	MO	PE	RV	SI	AC	EF	PR	MC	IM	Cl. I
A_1	-	2	4	4	2	4	1	1	4	4	8	42	M
B_1	-	1	1	2	2	2	1	1	4	1	4	22	I
C_1	-	2	2	4	2	4	1	1	4	4	8	38	M
D_1	-	1	1	2	2	1	1	1	4	4	1	21	I
F_1	-	2	1	2	2	2	1	1	4	4	4	28	M
A_2	-	4	4	4	1	1	1	1	4	1	1	34	M
B_2	-	2	1	4	1	1	1	1	4	1		21	I
C_2	-	2	1	4	1	1	1	1	4	1		21	I
A_3	-	2	2	4	1		1	1	4		4	25	M
B_3	-	1	1	4	1		1	1	4		1	17	I
C_3	-	1	1	4	1		1	1	4		1	17	I
A_4	-	2	2	2	2				4	4	4	26	M
B_4	-	1	1	2	1				4	4	4	20	I
C_4	-	1	1	2	1				4	4	4	20	I
D_4	-	1	1	2	1				4	4	4	20	I
E_4	-	1	1	4	1				4	1	4	19	I
G_4	+	12	8	4	4				1	4	4	69	S
A_5	-	4	4	2	2				1	1	4	30	M
B_5	-	2	2	2	1				1	1	1	16	I
C_5	-	1	1	2	1				1	1	1	11	I
E_5	-	1	1	4	1				1	1	1	13	I
G_5	+	2	2	4	4				4	4		26	M
A_6	+	4	4	2	2	2			4	4		34	M
B_6	+	2	2	2	2	2			4	4		24	I
C_6	+	4	4	2	2	2			4	4		34	M
E_7	-	4	2	4	1				4	1	4	30	M
A_8	-	4	2	4	2				4		4	30	M
C_8	-	2	2	4	4				4	4	4	30	M

Character of the Impact (CI)
Intensity of the Impact (I)
Extension of the Impact (EX)
Moment of the Impact (MO)
Persistency (PE)
Reversibility (RV)
Synergism (SI)
Accumulation (AC)
Effect (EF)
Periodicity (PR)
Recoverability (MC)
Importance of the Impact (IM)

Classification of the Impact (Cl.I):

Irrelevant (I) IM< 25
Moderate (M) 25 < IM < 50
Severe (S) 50 <IM < 75
Critic (C) IM> 75

$$IM = \pm (3I + 2\,EX + MO + PE + RV + SI + AC + EF + PR + MC)$$

Importance Matrix

	Environmental factors	Actions							Total per factor	Total per environment
		Construction stage						Operation stage		
		A	B	C	D	E	F	G		
Natural Factors	1. Soil	-42	-21	-38	-21		-28		**-150**	**-285**
	2- Air	-34	-21	-21					**-76**	
	3. Landscape	-25	-17	-17					**-59**	
Socio-economic Factors	4. Health and Safety	-26	-20	-20	-20	-19		69	**-36**	**-78**
	5. Institutional and commercial activities	-30	-16	-11		-13		26	**-44**	
	6. Employment	34	24	34					**92**	
	7. Roadway and traffic					-30			**-30**	
	8. Infrastructure and networks	-30		-30					**-60**	
	Total per action	**-153**	**-71**	**-103**	**-41**	**-62**	**-28**	**95**		
	Total per period	**-458**						**95**		

Summarize of impacts

Character of the Impact (CI)	Classification of the Impact (CI.I)	Total
+	Irrelevant	1
	Moderate	1
	Severe	1
	Critics	
	Sub-Total	3
-	Irrelevant	13
	Moderate	12
	Severe	
	Critics	
	Sub-Total	25
	TOTAL	**28**

Analysis of the importance matrix

Analysing the impact evaluation matrix the following can be established:

Project Actions

Construction Stage

During the construction stage, the most aggressive actions, in decreasing order, are the earthworks and excavations, the construction of channels, pipes installation and interconnection of the Colector, the transport of heavy machinery because they gather high negative importance values. It is also very important to mention the hedge and deviation of the traffic, which has high negatives impacts mainly on socio-economic factors. The less aggressive action is the management of construction wastes.

Operation Stage

In the operation stage, the most important action is the conduction of urban-industrial wastewaters (as expected, according to the Master Plan objectives), accumulating a positive importance value of 95.

The construction stage resulted the most impacted with an overall negative importance value of 458, having most of the negative impacts of the project: 13 of them are considered irrelevant and 12 as moderates.

Analysis of the environmental factors

The most impacted (negatively) natural factors are the soil, air and landscape in that order. The infrastructure and network, the institutional and commercial activities, heath and safety as well as the roadway and traffic are evaluated as the most impacted socio-economic factors.

5.2.2.3 Preventive and mitigation measures

The following measures are necessary to be undertaken in the subsequent stages of the project to prevent or mitigate impacts, mainly during construction stage.

1. Public information
   - To use the mass media network to inform the public about the project benefits as well as the possible affectations during the project time period.

2. Coordination with Utilities
   - The telephone company (ETECSA).
   - The Power Company
   - The National Institute of Hydraulic Resources (INRH)
   - The Railway Company
   - ¨Redes Tecnicas¨ , to gather information on any other underground utilities related to the Port.

3. To investigate the feasibility of carrying out the work at night with relevant authorities and to the possibility of covering the trench with steel sheets to provide more room for traffic

4. To investigate the traffic flow pattern and origin-destination of the traffic during the detailed design stage to take necessary steps for traffic control and detour

5. Coordination with Traffic Division of Police (PNR) and other relevant institutions
   - To inform the public and other relevant institutions in advance
   - To provide personnel to direct control traffic flow
   - To relocate bus stops where necessary

6. Set up a committee comprising of all relevant institutions to share information on the progress of construction and to facilitate coordination among institutions.

7. Instruction to the Contractor to conform to good Construction Practices

   - To provide tight containers for transport of materials and to provide covered containers to avoid loss of material during transportation
   - To use safety devices in the concrete-mixer trucks to avoid the spill of material during the transport
   - To avoid spilling of construction materials i.e. cement, concrete etc. to prevent blocking of drains and their ultimate discharge to bay
   - To avoid cleaning of containers, machineries etc. on the street pavement to prevent spilling of fuel, lubricants etc. to the bay
   - To manage construction waste and excavated material to avoid piling-up along the street which can obstruct traffic, cause floods by blocking drains etc. and to dispose them at approved locations
   - To place barriers along the banks of the bay to prevent accidental spill of construction material to the bay
   - To control the speed of construction traffic and maintain awareness of safety
   - To take organizational measures to reduce construction noise

6. PUBLIC CONSULTATION

With the purpose of evaluate the Project acceptance, a public consultation was carried out by random and stratified samplings, covering the different categories of the occupational groups (leaders, professionals, technicians, workers and administrative) and companies.

The following questions are being applied to know the public perception of the project.

1. Do you consider necessary the execution of these projects for the integral development of the Havana City?.

Yes _____ No_____ I don´t know_____

2. Which benefits would bring the execution of these projects? Mark those you consider more relevant.

- They would improve the hygienic-sanitary conditions of my community.
- Improvement of the Havana Bay environmental quality.
- They will diminish the discharging levels of wastewaters to the bay
- The manpower would increase in the area
- Increase of tourism
- Improvement of health quality
- Contribution to the environmental rehabilitation of the Caribbean Sea.
- Others?

3. Which disadvantages would bring the execution of these projects? Mark those you consider more relevant.

- Affectations to patrimonial places
- Affectations to the tourism
- Health damages by dust and other pollutants
- Overloads in the infrastructure of the study area
- Economic losses
- Continuous traffic deviations
- Overlap with existing projects
- Others?

6.1 SURVEY RESULTS

To carry out the consultation with the local authorities a survey was used, it was applied to different Poder Popular officials of the municipalities of San Miguel, 10 de Octubre and Habana Vieja. Other entities involved in the project were also interviewed. Among the most significant are:

- Vice –president of the municipalities of San Miguel , 10 de Octubre and Habana Vieja.
- Specialists of CITMA offices in the municipalities of San Miguel , 10 de Octubre and Habana Vieja.
- Vice- director of Public Health in Habana Vieja municipality.

These surveys were focused on the local authorities opinions about the project emphasizing in the disadvantages and advantages that they considered more relevant.

In a general, the consent was positive. They agree about the importance of the works outlined in the Master Plan in the area of its jurisdiction, as well as the effect at city level.

The result of the applied surveys is the following :

Question No.1 Do you consider necessary the execution of these projects for the integral development of the Havana City?.

100% of the interviewees answers were affirmative, considering the great importance of the execution of these projects.

Question No. 2. Which benefits would bring the execution of these projects?

- Among those interviewed all they selected as benefits, an improvement of the hygienic-sanitary conditions of the community and an improvement in the environmental quality of the bay of Havana.

- 70% outlined the decrease from the discharging levels of waste waters to the bay and the contribution to the environmental rehabilitation of the Caribbean sea.

Question No. 3 . Which disadvantages would bring the execution of these projects?

- 70% of the interviewees said that the main disadvantages are health damages due to the dust and other pollutants and traffic deviations .

The analysis of the survey showed that all the interviewees are agree with the execution of the project, the outlined disadvantages will be kept in mind by the investors so that the impacts will be mitigated.

7. MONITORING

Construction stage

- Control on the sewage wastewater discharge to the bay during the repair works and construction of the pump systems.
- Control of the noise pollution and the gases and particles emissions during the construction stage.
- Carry out a sampling per month to verify the correct execution of the project from the environmental point of view keeping in mind the following aspects:

  - ✓ Solid waste disposal coming from the excavation and constructive activities to avoid the run off.
  - ✓ To control the appropriate use of the construction materials.
  - ✓ To control the execution of the mitigation and corrective measures.
  - ✓ To control the execution of the security measures and labour protection and hygiene.

Operation Stage

- To control the sewage wastewater discharge to the bay during the pump operations and breaks or maintenance.
- To control the Luyano River water quality, at least two times per year, before and after the discharge point of the GEF/UNDP wastewater treatment plant.

8. GENERAL COMMENTS ON THE MASTER PLAN

In spite of the environmental impact assessment to the selected priority projects, the whole Master Plan should be integrally analysed from the point of view of their environmental effects, both negative and positive.

As depicted in the summary of the Master Plan proposed (Table 1) as a whole, have been considered as the combination of the (1) Improvement of Existing Central Sewerage System and (2) New Sewerage System, Development in the Luyano-Martin Pérez Abajo Sewer District. Project components will be implemented in different stages but they depend on each other to the overall success of the Master Plan. Therefore, one aspect to highlight is the enforcement to the total fulfilment of the implementation schedule including all designed activities.

Special attention should be paid to the potential effects that can cause the decrease of the non-natural flow of the Martin Pérez River into the bay and on the river itself. Although, on the JICA Study Team opinion it should be irrelevant, it will be interesting to check the effects of this project over the Guasabacoa Cove hydrodynamics because the wastewaters generated in the Martin Pérez basin will be collected and transported to the Luyanó River treatment plant (GEF/UNDP) where they will be treated and discharged to the Luyanó River. The discharge of almost 60 000 $m^3.day^{-1}$ on the same spot constitutes one of the main potential negative impacts of this project, due to the high risk of operational failures leading to an estimated discharge of 6 to 10 $ton.day^{-1}$ of organic matter close to the river outlet.

Similarly, diversion of Dren Agua Dulce polluted waters and the elimination of cross connections in Dren Matadero is expected to cause effects on Atares Cove hydrodynamics, which should be considered in advance.

The positive effect of the polluting loads reduction entering the bay due to the insufficient sewer system has been already commented. There is no doubt on the expected improvement of Havana Bay water quality by the non-incorporation of almost 80% of the generated organic load. Implementation of the Projects proposed in the M/P will cover Central System and part of the New Sewerage System.

According to JICA Study Team information, table 14 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 and table 15 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 14. Pollution Load Reduction with the M/P

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%

Table 15. Pollution Load Reduction with the M/P

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.				

As part of the Master Plan Final Report, simulations with 3-D model of the hydrodynamic and hydro chemicals conditions in the 2020 year will be done and presented. This model should offer more accurate information on the improvement degree of the main quality indicators once the Master Plan is implemented. An overview of the expected effects over the ecosystem quality can be observed with the modelling analysis performed by JICA Study Team considering one of the first versions of the Master Plan. More recent water quality simulation results show that with the implementation of the Master Plan DO levels in Atares will improve to Class F (minimum 2 $mg.L^{-1}$) 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 to all the wastewater generated in the New Sewerage System area.

Undoubtedly, the success of the Master Plan implementation will depend on the total commitment of the national authorities. It is undeniable the high capital cost of this Master Plan. It is also undeniable the expected environmental impacts on natural and socio-economic factors, mostly during the construction stages. However, the environmental benefits and the long-term improvement of the life quality should be highly valued and therefore should counteract the expected negative impacts.

It is recommended that once the Master Plan is approved, output of the "Development Study on the Improvement of the Sewerage and Drainage System for the Havana Bay in the Republic of Cuba", the general public, as well as the involved and affected organisations, should be totally aware of the project components. Enough information must be provided on the benefits and negative impacts altogether with all the mitigation and corrective measures proposed to overcome them.

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10. ANNEXES

ANNEX 1

POINT SYSTEM

Table of importance

Character of the Impact (CI) - Beneficial impact + - Aggressive impact -	Intensity of the Impact (I) - Low 1 - Medium 2 - High 4 - Very high 8 - Total 12
Extension of the Impact (EX) - Punctual 1 - Partial 2 - Wide 4 - Total 8 - Critical (+4)	Moment of the Impact (MO) - Long term 1 - Medium term 2 - Immediate or short term 4 - Critical (+4)
Persistency (PE) - Quick 1 - Temporal 2 - Permanent 4	Reversibility (RV) - Short term 1 - Medium term 2 - Irreversible 4
Synergism (SI) - No synergism 1 - Synergic 2 - Very synergic 4	Accumulation (AC) - Simple 1 - Accumulative 4
Effect (EF) - Indirect 1 - Direct 4	Periodicity (PR) - Irregular or non periodic and discontinue 1 - Periodic 2 - Continue 4
Recoverability (MC) - Recoverable at short term 1 - Recoverable at medium term 2 - Mitigative 4 - Irrecoverable 8	Importance of the Impact (IM) IM = + (3I + 2 EX + MO + PE + RV + SI + AC + EF + PR + MC)

ANNEX 2

Table 1. Maximum sound levels and allowed levels (Leq y P90 de Lmax (dB(AF) at the most inappropriate hour from 07:00 am to 22:00 pm and from 22:00 hours to 07:00 hour within the urban areas near to building and houses.

	ALLOWED LEVELS				MAXIMUM LEVELS	
Leq (dB(AF))	Urbanized Areas		Reparations		New urbanizations	
	Day	Night	Day	Night	Day	Night
Suburban	73	73	70	64	59	59
Commercial	75	71	70	58	67	53
Traffic	68	58	65	55	47	47
Industrials areas	71	66	70	60	50	50
P90 de Lmax (dB (AF))	100		90		80	

Table 2. Maximum sound levels and allowed levels (Leq y P90 de Lmax (dB(AF) at the most inappropriate hour from 07:00 am to 22:00 pm and from 22:00 hours to 07;00 hour within the site in the house more affected by the noise.

	ALLOWED LEVELS				MAXIMUM LEVELS	
Leq dB(AF)	Urbanized Areas		Reparations		Urbanized Areas	
	Day	Night	Day	Night	Day	Night
Suburban	68	68	65	59	49	49
Commercial	70	66	65	53	57	43
Traffic	63	53	60	50	37	37
Industrials areas	66	61	65	55	40	40
P90 de Lmax (dB (AF))	85		75		65	