C. Final Disposal:

C1 Basic Concept for Landfill Plan

C1. BASIC CONCEPT FOR LANDFILL PLAN

C1.1 LINER FACILITY

A liner facility is very important to prevent the pollution of public water areas and/or underground water by leachate and to mitigate adverse impact of such pollution to surrounding areas.

(1) Classification of liner facility and its selection

The liner facility can be classified according to structure and type of material used for the vertical liner facility and the surface liner facility. Their features are shown in Table 1.

Table 1 Comparison between Vertical and Surface Liner Facilities

Item	Vertical liner facility	Surface liner facility
Suitable application	Presence of horizontal layer in the ground. If the soil foundation has alternating layers of clay and sand, then a combination of vertical liner facility using steel sheet piling and subterranean clay liner is normally adopted.	Presence of suitable foundation of the landfill site which can be covered by impermeable material
Groundwater drainage facility	Not required	Generally required
Ease of inspection	Difficult to inspect because of being buried	Although the liner can be inspected visually during construction it is difficult to inspect once landfill has begun.
Cost effectiveness	Construction cost per unit area of liner facility is high, but it is not significant compared to the overall cost.	Construction cost per unit area is cheap, but its total cost is high because of the need to cover the whole surface of the landfill site.
Maintenance	Difficult but is possible to strengthen the function of the liner facility	Possible before land-fill processing, after which it is difficult.

Although there are no detailed topographical, geological and hydrological or soil data for the New Guanabacoa landfill site, it is predicted from the existing data that there must be a high water level in some areas of the site. Therefore, a surface liner system was considered for the New Guanabacoa landfill site. As for New Site 1, the location is not fixed. Therefore, it is difficult to decide which system should be adopted. However, a surface liner facility is considered for cost estimation as a reference.

(2) Liner sheet

A liner sheet was already proposed by the Cuban side for the New Guanabacoa landfill site. The Cuban side advised that clay for the liner with the required water permeability of less than 10^{-5}cm/sec cannot be found in Havana City. In this regard, a sheet liner system was proposed in the M/P. Furthermore, using a membrane sheet as a liner is now common in many Latin countries. In case it is possible to get a good quality of clay liner, two liner systems, namely membrane and clay liner systems, should be considered in future planning.

1) Membrane liner system

There are many membrane liner systems with materials such as rubber, PVC and HDPE. Here, HDPE, which is widely used in other parts of the world, is considered as shown in Figure 1.

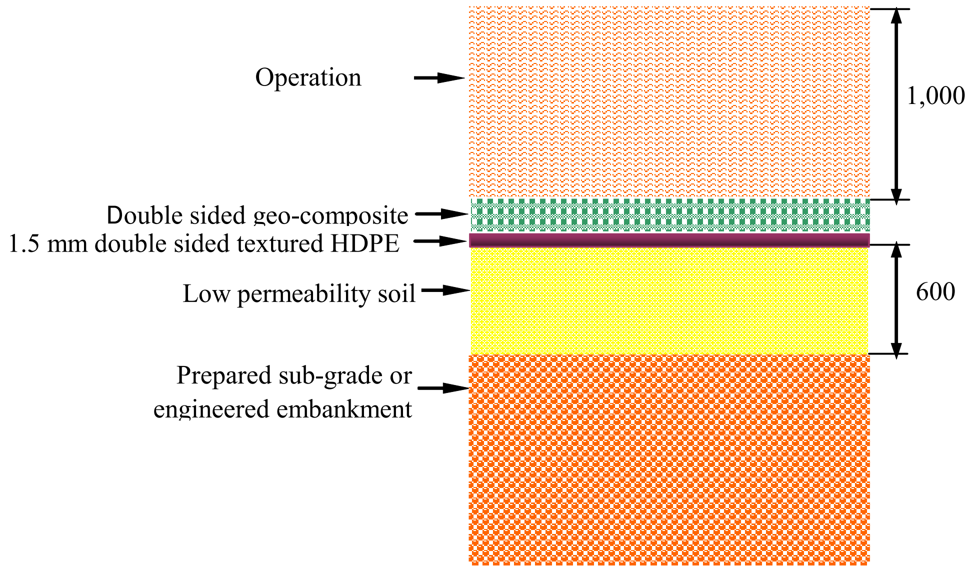


Figure 1 Composition of HDPE Sheet Liner System (Bottom)

The membrane sheet liner system is composed of an underlying 60 cm layer of compacted low permeability soil with a 1.5 mm high-density polyethylene (HDPE) geo-membrane. The composite of soil and geo-membrane results in a liner system that has a much lower leakage potential than either material alone. In areas that have the potential for high groundwater, an under-drain trench filled with gravel around a pipe will be installed. This will prevent rising groundwater, so that pore pressures do not build up under the liner.

The liner system will be built in stages by jointing together as the landfill area expands. In the design of geo-synthetic liners, international standards shall be duly taken into account to assure the qualities of material properties, manufacturing and construction method, and testing procedures.

2) Clay liner

If clay is used, it is desirable to have a clay layer of a minimum thickness of 0.75 m and to use clay material having permeability of 1.0×10^{-6}cm/sec or less.

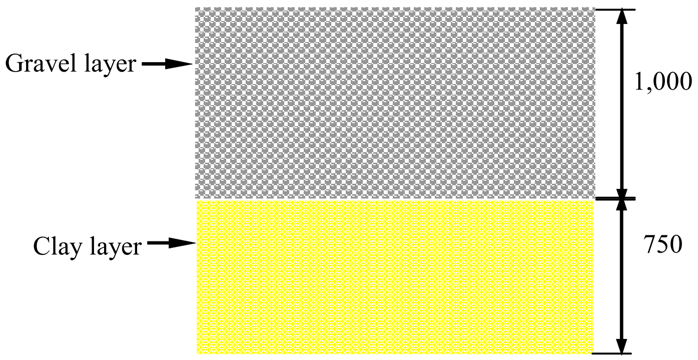


Figure 2 Composition of Clay Liner System (Bottom)

The concepts of liner designs stated above were considered not only for the landfill area but also for the area of ponds for leachate treatment.

Because there is no available clay liner in Havana City, it was estimated that the greatest part of the cost of the clay liner is the delivery cost from other areas.

In this Study, the HDPE sheet liner system was tentatively proposed in consideration of the difficulty of finding clay materials meeting the required specification.

C1.2 OPERATION OF LANDFILL

The final disposal sites proposed in the M/P are sanitary and environmentally friendly landfill types. Therefore, “land-filling work” means the whole series of works that include the delivery of solid wastes into the landfill site, spreading, mixing, final cover soil, and all related temporary measures. Table 1 shows landfill works and their purposes.

Table 1 Landfill Works and Their Purposes

Land-filling work items \ Purpose		Efficiney of sanitary landfill	Stablisation of landfilled waste layers	Leachate Quality	Leachate volume	Gaseous products	To prevent settelement of land-filled ground	To prevent littreing of wastes by wind	Physical characteristucs of landfilled ground	Ultimate landuse plan	Workablity	Cost effectiveness	Maintenance and control	Fire prevention
Land filing	Landfill method	◎	◎				○		◎	◎	◎	◎		
	Order of land filling		○	○	◎					○	○		○	○
	Spreading/compaction	◎	◎	○	○	○	◎	◎	◎	◎	◎	◎	◎	○
	Separate landfill		◎	○	○	○	○		◎	◎	○	◎	◎	
Covering	Selection of cover soil		◎	◎	◎	◎	○	○	○	○	◎	◎		○
	Daily cover	◎	○	○	◎	○	○	◎	○	○	○	○		◎
	Intermediate cover	◎	○	○	◎	○	○		◎	○	◎	○		○
	Final cover	◎	○	○	◎	◎	○		◎	◎		◎		○
Construction of access road	Trunk route	◎									◎	○	◎	
	Branch route	◎									◎	○	◎	
Mounting-up		◎								◎	◎	○		◎

Source: Technical Section of Local Government Division, Ministry of Housing and Local Government, Malaysia, Technical Guideline on Sanitary Landfill, Design and Operation (Draft), October, 1990.

(1) Order of land-fill process

In mountains or valleys, like at the New Guanabacoa landfill, there are two methods of carrying out the landfill operation, namely, landfill from upstream down or landfill from downstream up. Table 2 shows the features.

Table 2 Features of Order of Land-filling

Order of Landfill	Advantage	Disadvantage
Landfill from upstream down	• Easy access to the landfill area via the already filled area. • The rain water absorbed into the inner land-filled layers during the early stages of landfill would have time to seep out.	• Difficult to remove rain water from the unfilled areas. • Slipping of the land-filled layer due to rain water onto the liners at the bottom of the land-filled site. This sometimes causes damage of liners.
Landfill from downstream up	• The rain water in the unfilled area is collected effectively into leachate collection pipes.	• First, an access road to the landfill area needs to be constructed.

Order of Landfill	Advantage	Disadvantage
	• The risk of slipping of the land-filled layer due to rain water and damage of liners is small.	

For the New Guanabacoa landfill, filling from downstream up was proposed, taking account of the advantages described in the above table. The same arrangement shall be planned for the other landfill sites, Calle 100 Extension and New Site 1.

(2) Spreading/compacting method

The spreading and compaction of the solid waste hauled to the landfill will affect the capacity of the landfill, stabilization of the landfill layer, usability of the closed landfill site, environmental conservation, etc. There are two methods of spreading/compacting solid waste, namely "push up" and "push down" on the waste slope with a bulldozer or a loader.

In the M/P, the push up method was proposed because it is easy to make a uniform landfill layer. Compaction is also easy and preferable when the compaction layer has to be established as soon as possible.

(3) Cell construction

Cell construction is classified into the sandwich method, cell method and dumping method as described in Table 3.

Table 3 Method of Cell Construction

Landfill Method	Features
Sandwich method	Levels waste horizontally and stacks waste layers and cover soil alternately. Used in a narrow mountainous site. When the area of landfill is large, the dumping area for one day must be restricted to assure the thickness of waste required to apply cover soil. This inevitably causes the waste layer to slope.
Cell method	Applies cover soil on the filled waste and slopes to finish it cell-like. Its use is popular in Japan. The cell size is automatically determined by the daily quantity of landfill. Each cell forms an independent waste landfill layer. This is effective in prevention of fire outbreak and propagation, scattered waste, offensive odor and harmful insect generation.
Dumping method	Only dumps waste into place without leveling or compacting. This method is not expected to form ground with good dynamic properties or prevent scattered waste, offensive odor generation, harmful insect generation and the like. This method is not suitable for handling landfill waste in a sanitary and systematic manner.

In the M/P, the cell method is recommended because it is suitable for preventing current problems such as fire outbreak and propagation, scattering of waste, offensive odor and harmful insect generation. This method was implemented along with the push up method in a pilot project (PLP) under the Study.

C1.3 LEACHATE TREATMENT

1. Establishment of Guidelines for Leachate Discharge into Public Water Bodies

1.1 Leachate Treatment Parameters and Treatment Facilities

For waste that is mainly composed of bio-gradable organic substances, like kitchen waste, the organic substances or byproducts of bacterial decomposition of organic substances like BOD_5, COD, T-N, NH_4-N, etc. are the main measures of pollution at which treatment is targeted. Other parameters are pH, SS, E.coli, color and odor. Metallic substances buried in the landfill will form insoluble compounds that, in general, do not flow out of the landfill. Table 1 shows leachate quality parameters for planning a leachate treatment facility.

Table 1 Leachate Components for Leachate Treatment Facility Planning

Category	Evaluation Based on Facility Planning	Leachate quality parameters
A	Evaluation for Facility Planning Necessary in setting the design raw leachate quality level, for design of discharge quality and for determination of the treatment method and size of the facility	BOD_5, SS, COD, NH_4-N, T-N, T-N,T-P, additionally (in case of landfill of incinerated ash) Ca^{2+}
B	Design of facility is necessary once the need for treatment is identified.	pH, E.Coli.
C	In general, no need to consider the treatment facility in case of adopting chemical treatment process for removing the pollutants mentioned above.	Fe^{2+}, Mn^{2+}, Other heavy metal; Color and order
D	There is no existing economically feasible way to treat these pollutants. The only option available is to decide on a suitable location to dispose of the pollutants.	TDS, Cl^-, etc.

1.2 Basic Concept of a Leachate Treatment System

A leachate treatment system consists of biological and physical-chemical treatment processes as shown in Figure 1

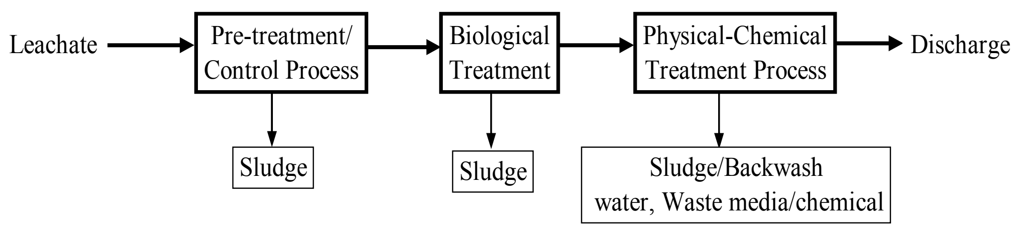


Figure 1 General Flow of Leachate Treatment

The treatment system inevitably produces sludge/waste including backwash water, media or/and chemical. In discussing a leachate treatment system, the treatment and disposal process, cost and ease of maintenance of the sludge/waste should be discussed. A leachate treatment system depends on the pollutants and the level of treatment. Leachate quality fluctuates daily, seasonally and yearly. It is very important to plan the control, regulation and pre-treatment facilities such as screens, grid chamber, oil removal and sedimentation to achieve a stable treatment. Generally, in a biological process, there should be a preventative measures against the entry of oil and grease.

The reasons are shown below:

Grease and oil:

- Hinders the performance of the secondary sedimentation tank (Clarifier)
- Hinders the ability to dissolve oxygen efficiently
- Gives a drastically high BOD_5 when turned to acid by bacteria activity. This means the load on the plant increases beyond the design and the effluent quality deteriorates, even with appropriate O/M of the plant. Therefore, the entry of oil/grease into the system should be limited. In adopting a biological system, 60 mg/L of grease and 5 mg/L of mineral oil are considered upper limits.

1.3 General Treatment Process for Removal of Specific Pollutants

In general treatment should be targeted towards reducing the following eight parameters, if required: BOD_5, COD, Heavy Metals, Nitrogen Compounds, Phosphorous Compounds, SS, Salt and E.Coli. Table 2 to 9 shows the principle and effectiveness of the treatment process for each parameter.

Table 2 General Process to Treat BOD_5

	(a) Biological Treatment	(b) Activated Carbon	(c) Flocculation
Principle	Bio-degradation of organic matter by microbes	Adsorption of soluble organic matter by activated carbon particles	Suspended BOD_5 is removed using coagulants
Effectiveness	Can be used regardless of high or low (20 mg/L) concentration levels,	For low concentrations only.(less than 20 mg/L)	If suspended BOD_5 is very high or as pre-treatment for activated carbon

Table 3 General Process to Treat COD

	(a) Flocculation	(b) Activated Carbon	(c) Biological Treatment	(d) Chemical Oxidation
Principle	Suspended COD is removed by using coagulants	Adsorption of soluble organic matter by activated carbon particles	Bio-degradation of organic matter by microbes	Decompose COD components by using ozone or H_2O_2, UV
Effectiveness	Effective where molecular components of COD are relatively big and colored, and used as pretreatment for activated carbon	For low concentrations only.(less than 60 mg/L)	Effective only where COD components are easily bio-degradable. By using an anaerobic process, they can be bio-degradable.	Effective where COD components are not easily bio-degradable

Table 4 General Process to Treat Heavy Metals

	(a) Flocculation with alkali	(b) Chelating agents	(c) Ion-exchange	(d) NF or RO
Principle	Causes formation of hydroxides of metal	Reaction of soluble metal with chelating agents	Adsorption of metal on the ion-exchange resin	Sieving of metal ions
Effectiveness	Appropriate for highly concentrated leachate in case of non existence of chelate formation	Effective where the metal exits as a soluble chelate in relatively low concentrations.	Effective where the metal is soluble in very low concentrations, regardless of chelate formation	Effective where the metal exists as a soluble in very low concentrations, regardless of chelate formation

Table 5 General Process to Treat Nitrogen Compounds

	(a) Biological Treatment	(b) Absorption	(c) Wetland
Principle	NH_4-N changes to NO_3-N in aerobic conditions and NO_3-N changes to N_2 gas and is released by microbes in anaerobic conditions	NH_4-N is adsorbed by zeolite	Some species absorb nitrogen compounds for growing
Effectiveness	Applicable from high to relatively low concentrations in leachate	Effectiveness where NH_4-N concentration is relatively low	Applicable from high to low concentrations in leachate

Table 6 General Process to Treat Phosphorous Compounds

	(a) Flocculation	(b) Crystal formation	(c) Biological Treatment	(d) NF or RO	(e) Wetland
Principle	Causes formation of PO_4-Fe/Al complex	When mixed liquid composed of PO_4 and Ca passes through a tower packed with P-mineral or bone carbon as a nucleus of crystal formation, insoluble P compounds are formulated.	Activated sludge absorbs in anaerobic condition more than usual	Sieving of P ions	Some plant species absorbs PO_4 for growth
Effective-ness	Applicable from high to relatively low concentrations in leachate	Effective where Ortho-PO_4 concentrations are relatively low. No sludge produced	Applicable from high to relatively low concentrations in leachate. In aerobic condition, activated sludge releases absorbed PO_4, again.	Effectiveness where P compounds exists in very low concentrations, regardless of P compounds	Applicable from high to low concentrations in leachate

Table 7 General Process to Treat SS

	(a) Sedimentation	(b) Filtration
Principle	Settling particles naturally or after flocculation	Filter off SS components through a sand layer or MF
Effectiveness	Applicable from high to relatively low concentrations in leachate	Applicable for relatively low concentrations in leachate after sedimentation or as pre-treatment for advanced processes such as activated carbon, chemical oxidation, ion-exchange, crystal formulation, NF or RO

Table 8 General Process to Treat Salt

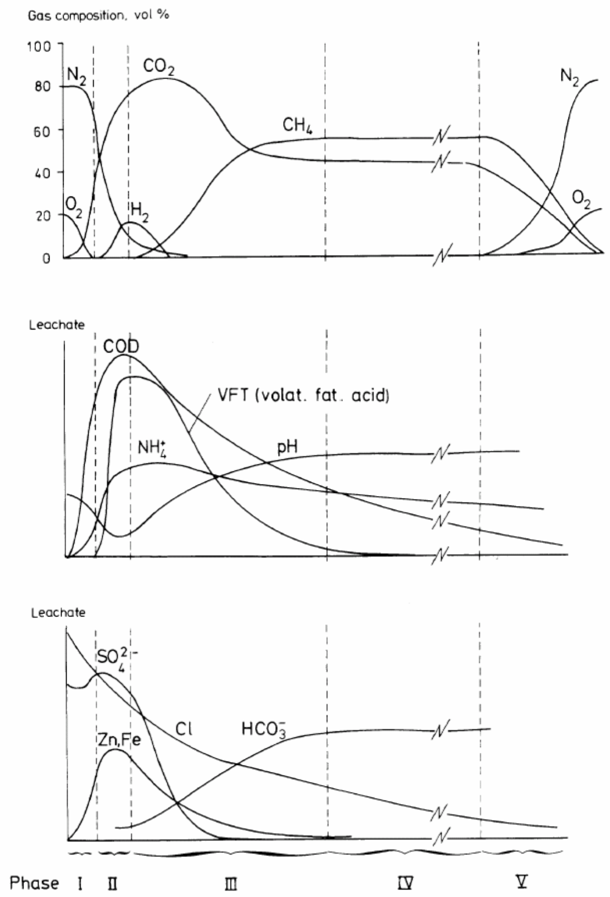
	(a) Evaporation	(b) NF or RO
Principle	Separation of salt and liquid by using heat	Sieving of P ions
Effectiveness	Applicable for relatively high concentrations in leachate	Applicable for relatively low concentrations in leachate

Table 9 General Process to Treat E.Coli

	(a) Disinfection	(b) MF or UF Membrane	(c) Natural pond
Principle	Disinfection by using disinfection agents such as chlorine, ozone, Ozone +UV	Sieving of MF or UF	By increasing the number of facultative ponds
Effectiveness	Applicable for relatively low concentrations in leachate	Applicable for relatively low concentrations in leachate	Applicable for relatively high concentrations in leachate

1.4 Characteristics of Leachate Quality

In general, the pollution level of the leachate is high. For example, the concentrations of organic matter in the leachate during the early stages of landfill are high. As time goes by the concentrations drop and after several years only the non-biodegradable substances are left. Figure 2 shows the changes in leachate quality and gas generation in a landfill cell. The leachate quality is generally determined by the quality of the wastes and landfill type, method, size, time, etc.



Phase I: Aerobic phase
Phase II: Acid phase
Phase III: Intermediate methanogenic phase
Phase IV: Stabilized methanogenic phase
Phase V: Final aerobic phase

Illustration of developments in leachate and gas in a landfill cell
(CHRISTENSEN & KJELDSEN, 1989)

Figure 2 Illustration of the Changes of Leachate Quality and Gas

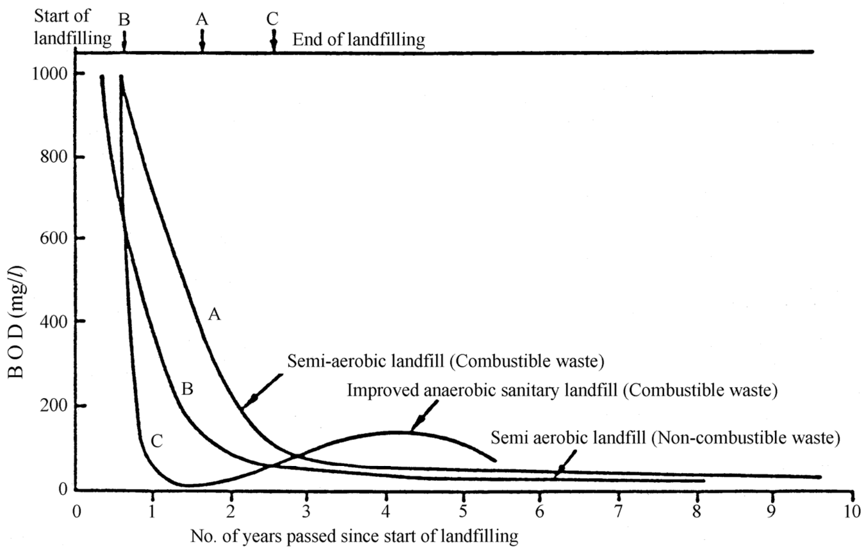


Figure 3 Leachate quality changes by landfill type.

Source: Guidline for Construction of Land Disposal Site p.142, Japan Waste Management Association, March 1989

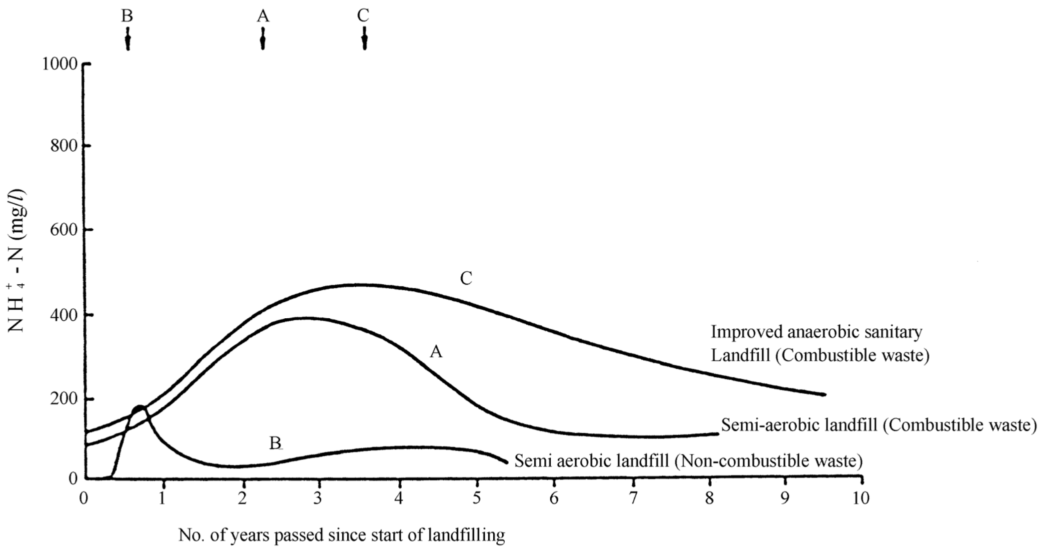


Figure 4 Changes of BOD_5 and NH_4-N by Landfill Type

Source: Guidline for Construction of Land Disposal Site p.142, Japan Waste Management Association, March 1989

1.5 Estimation of Leachate Quality

As for the estimation of leachate quality, many studies have been conducted and many are proposed. However, as the conditions for the quality estimates are not the same, no set procedure for estimation has been established. Table 10 shows an example of leachate quality.

The concentrations shown in Reference B seem too high because the results include non-sanitary landfills without a daily cover of soil. It is said that heavy metals are absorbed in waste and soil layers. Therefore, reference A will be used as a guideline for leachate quality.

The Reference A is similar to the average quality surveyed in the existing Calle 100 landfill.

Table 10 Example of Leachate Quality

(Units : mg/L, except pH)

Item	Reference A	Reference B	Criteria**
BOD_5	1,200	2,000 - 30,000 (10,000)	60
SS	300	200 - 1,000 (500)	5
CODcr	1,500	3,000 - 45,000 (18,000)	120
T-N or NH_4-N	480	Org-N : 10 - 600 (200) NH_4-N : 10 - 800 (200) Nitrate : 5 - 40 (25)	20 as K-N
PH	Acid side where the ratio of biodegradable organic matter is high	5.3 - 8.5 (6)	6-9
T-P	-	1 - 70 (30)	10
TDS	1,000 to 10,000	-	-
Total Coliforms (cfu/mL)	More than 3,000	-	-
Conductivity	-	-	3,500 μS/cm
Heavy metals	Fe^{2+} : : approximately 10 Mn^{2+} : trace Other heavy metals : ND	T-Fe 50 - 600 (60) As ND - 40 Ba ND -9.0 Cd ND - 116 Pb ND - 6.6 T-Hg ND - 0.16 Selenium ND - 0.45 Ag ND - 0.24	
Color	Black brown to thin yellow	-	-

Reference A : Technical Guideline on Sanitary Landfill, Yasushi Matsufuji, JICA and Kitakyushu City Government
Reference B : Integrated solid waste management, George Tchobanoglous, McGRAW-HILL, Inc., Average
** : Industrial wastewater discharge criteria in Cuba for discharge to public water body

Table 11 shows a part of the survey result of the existing Calle 100 and Guanabacoa landfills.

Table 11 Result of Leachate Quality Survey in *Calle100* and *Guanabacoa* Landfills

Parameter	Unit	Calle 100						Guanabacoa
		No.1	No.2	No.3	No.4	No.5	Average	
pH	-	7.9	8.7	7.9	8.4	7.4	8.1	8.2
EC	μS/cm	16,700	9,420	5,380	9,250	1,580	8,470	10,500
TDS	mg.L	10,700	7,800	4,700	5,300	920	5,900	7,800
COD	mg.L	5,400	3,200	270	950	400	2,000	1,600
BOD_5	mg.L	2,500	1,100	230	560	470	970	580
SS	mg.L	1,700	37	59	230	1,100	630	670
Coliform bacteria	MNP/100mL	3	3	3	3	3,000,000	600,000	91,000
NH_4-N	mg.L	260	35	13	290	24	120	5.1
T-N	mg.L	360	59	37	320	41	160	60
T-P	mg.L	120	19	13	37	160	70	57
Grease and oil	mg.L	0.80	0.13	0.06	0.18	22	5.0	0.03

Here in Table 12, the preliminary criteria for leachate quality are proposed for a leachate treatment system based on the average of the survey of existing Calle 100 and Guanabacoa landfills and Reference A.

Table 12 Proposed leachate quality

	Unit	Calle100 (Average)	Guanabacoa	Reference A	Average (Proposed leachate quality)
T-BOD_5	mg/L	970	580	1,200	920
SS	mg/L	630	670	300	540
T-COD	mg/L	2,000	1,600	1,500	1,700
T-N	mg/L	160	60	480	240
T-P	mg/L	70	57	-	64
EC	μ S/cm	8,470	10,500	-	9,500

Reference A : Leachate guideline for sanitary landfill reclaimed mainly of combustible waste in Japan

1.6 Target Treatment Level

There are no discharge criteria for treated leachate into public water bodies. Therefore, a temporary leachate discharge guideline should be proposed.

There are discharge criteria for industrial wastewater into public water bodies, which can be used as a reference. The present discharge criteria for treated industrial wastewater into public water bodies are the following; pH: 6-9, EC: 3,500μS/cm, Maximum temperature : 50℃, Oil and grease : 30mg/L, SS : 5mg/L, T-BOD_5 : 60mg/L, COD : 120mg/L, Kjeldahl -N : 20mg/L, T-P : 10mg/L. If these criteria are applied to the leachate discharge into public water bodies, the required removal rate of each parameter is as in Table 13.

Table 13 Required removal rate if industrial waste water discharge criterion is applied to the leachate discharge into public water bodies.

Parameter	Unit	Proposed Leachate	Discharge criteria*	Required removal rate (%)
T-BOD_5	mg/L	920	60	94
COD	mg/L	1,700	120	93
SS	mg/L	540	5	100
T-N	mg/L	540	20	97
T-P	mg/L	64	10	85
EC	µS/cm	9,500	3,500	64

* Discharge criteria for industrial wastewater into general water bodi

It is clear that removal of all of the contaminants up to the industrial wastewater discharge criterion using only conventional treatment processes is impossible. According to the survey conducted at the existing Calle 100 and Guanabacoa landfills mentioned above, the average EC is 9,500µS/cm. It is impossible to reduce EC to the criterion without using an RO or NF (nano-filtration) system that is used in Japan and some European countries. This system is costly to construct and the O/M requires highly skilled technicians. Therefore, at the moment, EC is eliminated from the proposed discharge guidelines for treated leachate.

To reduce COD, T-N and T-P to the industrial wastewater discharge criterion seems to be also considerably difficult by unit processes. Even T-BOD_5 removal of more than 94% cannot be achieved by only one treatment process and to achieve it requires a combination of unit processes. It is also very difficult to achieve the removal rate of SS by only conventional process such as coagulation, sedimentation and filtration. To achieve the level, another physical-chemical process is necessary such as MF (micro-filtration), which is costly and requires high-level technicians.

Whether industrial wastewater dischargers obey the criterion of 5 mg/L of SS is uncertain. However 5 mg/L of SS with 60 mg/L of T-BOD5 is unrealistic, considering water quality in general. Therefore the criterion of 5 mg/L for SS was judged as unrealistic and 70 mg/L of SS is proposed as a fairly realistic guideline in this study. In this case the required SS removal rate is 87%. By using an appropriate volume of cover soil, the T-P level is expected to decrease. In this case, the required removal rate of T-P will be smaller.

2. Selection of the Leachate Treatment Process

2.1 Biological Treatment Process

The treatment process is determined by the raw water characteristics and the target guidelines for each parameter. In general, compared to other parameters such as COD, T-N and T-P, the removal of T-BOD_5 and SS is not difficult by a combination of biological treatment and solid-liquid separation. The priority is for a treatment process using only biological processes, considering the construction and O/M costs and ease of O/M. It is too early to propose target guidelines for COD, T-N and T-P in this Study.

The reasons are:

- The treatment removal rate of T-P by biological process is not very high at around 60 to 70%.
- To consider advanced technology such as flocculation with sedimentation, activated carbon, crystal formation, ion-exchange, chemical oxidation, RO or NF or evaporation would not be appropriate given that few industrial wastewater treatment plants meet the above criterion.

The priority target parameters are T-BOD_5 and SS and the recommended maximum acceptable concentrations are 60 and 70 mg/L respectively, as mentioned above. In spite of these facts, biological treatment processes to approach the industrial wastewater discharge criterion should be discussed and employed as much as possible.

2.2 Classification and Features of Biological Treatment

Biological treatment processes are the most common practice for leachate treatment. Biological systems could be divided into anaerobic and aerobic treatment processes like in Table 14. Wastewater with high concentrations of T-BOD_5 like leachate is, in general, treated by a combination of anaerobic and aerobic biological processes. Advantages and disadvantages of anaerobic systems are shown in Table 15.

Table 14 Aerobic and Anaerobic Biological Treatment Systems

Biological Treatment System	
Anaerobic	Aerobic
- Anaerobic ponds - Anaerobic filters - Anaerobic sludge bed reactors (UASB)	- Conventional activated sludge - Rotating biological contactors (RBC) - Trickling filters - Oxidation ditches - Contact oxidation - Facultative ponds - Bio-filters - Wetlands

Table 15 The Advantages and Disadvantages of Anaerobic Systems

Advantages of anaerobic system	Disadvantages of anaerobic system
- Energy saving type due to no necessity of aeration - Sludge generation is smaller than aerobic system - Organic matters that are hardly bio-degradable are slowly decomposed to change to bio-degradable compounds such as low class acids or alcohols, which results in a decrease of COD.	- Need larger space - Applicable for relatively high concentrations - Finally need aerobic system to polish quality - Applicable for soluble organic matters - Applicable in hot climate

Biological treatment systems are, in principle, also divided into three categories, suspended bio-sludge, bio-film and natural pond systems, as shown in Table 16 and Table 17.

Table 16 Classification of biological treatment systems

Biological Treatment System		
Suspended bio-sludge systems	Bio-film systems	Natural pond systems
- Aerated lagoons - Anaerobic sludge bed reactors (UASB) - Conventional activated sludge - Oxidation ditches	- Anaerobic filters - Rotating biological contactors (RBC) - Trickling filters - Bio-filters - Contact oxidation	- Anaerobic ponds - Facultative ponds - Wetlands

Table 17 Principle, Advantages and Disadvantages of the Three Biological Systems

	Suspended bio-sludge systems	Bio-film systems	Natural pond systems
Principle	Flocs of microbes called activated sludge are suspended in a reactor. Suspended sludge has functions of adsorption, oxidation/reduction and decomposition of organic matter in terms of BOD_5.or/and parts of COD.	Microbes attached and thriving on the surface of media such as plastic, stone, sand, honeycombed type cell, fiber and so on adsorb, oxidize/reduce and decompose organic matter in terms of BOD_5 and parts of COD.	Microbes naturally thriving in the natural pond oxidize/reduce and decompose organic matter in terms of BOD_5 and parts of COD.
Advantages	- When solid-liquid separation is properly achieved, clear treated water can be obtained.	- No control of sludge return necessary - Relatively easy maintenance - Relatively tolerant of fluctuation of leachate quality. - No need for final sedimentation tank in bio-filter method - Smaller space than suspended bio-sludge system.	- No power needed - Easy maintenance - Maintenance cost is minimum. - Possible to remove N and P - Tolerant of fluctuation of leachate quality - Hygienic bacterial removal by increasing numbers of ponds.

	Suspended bio-sludge systems	Bio-film systems	Natural pond systems
Disadvantages	- Solid (activated sludge) – liquid separation and keeping sludge concentration in the reactor by returning concentrated sludge from sedimentation tank are the key factors. - Need trained and skilled technicians. - USAB and conventional activated sludge methods are intolerant of fluctuation of leachate quality.	- Impossible to control microbes due to no sludge return. - Generally, the final effluent is not clear due to out flow of small microbes.	- Need larger space - SS removal rate is inferior

2.3 Selection of Biological Process

The most advantageous of the biological systems from the viewpoint of ease of O/M and maintenance cost is the natural pond system, although it needs a large space, which results additional cost if a liner system is necessary. In this study, the treatment of leachate with a natural pond system or, an aerated lagoon with sedimentation tanks or, maturation ponds for liquid-solid separation and a combination of wetland systems were considered for the removal of T-BOD$_5$, SS, COD, T-N and T-P.

2.4 Study of Alternatives for Leachate Treatment Systems

Alternatives for treatment systems were considered as shown in Figure 5. They are basically a combination of pond systems or natural systems, including wetland systems. Leachate recirculation to the landfill is considered as a common factor in all systems to promote decomposition of organic matter in the leachate.

Alternative 1	Aerated Lagoon	==>	Maturation Pond				
Alternative 2	Aerated Lagoon	==>	Sedimentation Pond	==>	Wet Land		
Alternative 3	Anaerobic Pond	==>	Facultative Pond	==>	Maturation Pond		
Alternative 4	Anaerobic Pond	==>	Facultative Pond	==>	Wetland		
Alternative 5	Anaerobic Pond	==>	Aerated Lagoon	==>	Sedimentation Pond	==>	Wetland
Alternative 6	Anaerobic Pond	==>	Aerated Lagoon	==>	Maturation Pond		

Figure 5 Treatment Alternatives

2.5 Calculation results of alternatives

Table 18 shows the results of calculations.

Table 18 Results – Cost of Alternatives (million USD during M/P, Peso: USD = 1:1)

Cost (million US$ during M/P, Peso: = 1:1)

Alternatives	Procurement Cost of Heavy Equipment	O/M Cost	Total cost	Easiness of O/M	Water Quality	Remarks
1	1.85	0.97	2.82	○	△	
2	1.89	1.02	2.91	△	○	Need test
3	0.22	0.22	0.44	◎	◎	
4	0.22	0.22	0.43	○	△	Need test
5	1.38	0.65	2.02	△	○	Need test
6	1.38	0.61	1.99	○	○	
3-(2)	0.09	0.00	0.09	◎	◎	Without recirculation pump

Table 19 shows the expected performance of the treatment system.

Table 19 Treatment system and expected performance

	Parameters				
Alternatives	T-BOD_5	COD	SS	N	P
1	○	△	○	×	×
2	◎	△	◎	△	△
3	○	○	○	○	◎
4	△	○	△	△	△
5	◎	○	◎	◎	△
6	○	○	○	△	△
3-(2)	○	○	○	○	◎

◎ : Very good, ○ : Fairly good, △ : Good, × : Poor

Expected treatment performance of T-BOD_5, T-N and T-P in Table 19 is based on Table 20.

Table 20 Treatment System and Expected Removal Rate

Treatment System	Parameter	Removal rate (%)
Aerated lagoon with sedimentation	T-BOD_5	95
	T-N	Not expected
	T-P	Not expected
Maturation pond with faculatative pond	T-BOD_5	95
	T-N	80
	T-P	70
Wetland (SFS[1])* after facultative pond	T-BOD_5	73
	TSS	70
	T-N	90
	T-P	60
Wetland (Floating, duckweed[2])* after facultative pond	T-BOD_5	75
	TSS	80
	T-N	85
	T-P	50 to 60

* :Estimation

A maturation pond after an aerated lagoon mainly acts as a sedimentation pond. In general, wetland systems seem to be a little bit superior, in the removal rate of T-N, to natural pond systems in combination with facultative ponds but inferior in the removal rate of T-P. Removal rates of T-N and T-P by wetlands depend on species, system and density of plantation. The design needs to be determined by pilot scale site experience. Adopting wetlands is not recommended at this moment (Alternative 2.4 and 5).

Among the rest, Alternative 6 (Anaerobic pond + aerated lagoon + Maturation Pond) was concluded as the best option from viewpoints of cost and removal of T-BOD_5 and SS, which was agreed between the Study Team and Cuban Side as the main parameters to be improved.

However, it is reminded that Alternative 6 has a risk of becoming non-functional in the case of power failure, which often occurs in Cuba at present. In this regard, Alternative 3 (Anaerobic Pond + Facultative Pond + Maturation Pond) was concluded as the second option from viewpoints of water quality and ease of maintenance.

The disadvantage of this system is that it is more costly because it needs huge liner sheets. If the ground consists of impermeable clay, the cost will be reduced (Refer to Supporting Report including Alternative 3 without leachate recirculation pump). The performance of a pond system can be confirmed by observing small living animals in the pond with a portable microscope. (Data Book)

C1.4 Natural System (Pond System and Wetland System)

1. Principal Features of Pond System

Figure 1 shows the principals of a natural pond system.

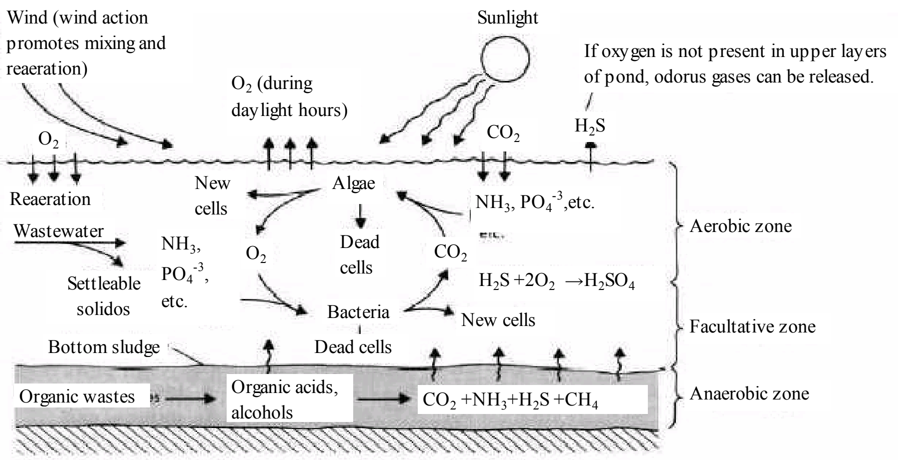


Figure 1 Operation of the facultative pond (*Tchobanoglous* and *Schroeder* 1987)

Algae are generally generated in a shallow pond (facultative pond). With sunlight, algae produce oxygen that decomposes organic matter in the leachate. In a deep pond anaerobic bacteria also decomposes organic matter. This system generally consists of a combination of anaerobic, facultative and maturation ponds used as the final treatment. Generally an anaerobic pond is used to reduce the required retention time in the subsequent pond, as well as reducing COD and sludge generation. Typical performance of a pond system is shown in Table 1.

Table 1 Performance of Pond System

Pond system	Parameter	Removal rate (%)	Remarks
Aerated lagoon	T-BOD_5	95	with sedimentation
	T-N	Not expected	
	T-P	Not expected	
Facultative pond	T-BOD_5	80	100-400 kg BOD/ha/d at 20-25℃, 70 to 90%of effluent BOD_5 from facultative pond will be "algal BOD_5". 500-,2000mg-chlorophyll/L.
		95	with maturation pond
	T-N	80	with maturation pond, ammonia removal can be as high as 95 percent.
	T-P	70	with maturation pond

2. Additional Technologies to Improve Effluent from a Pond System

Effluent quality from a facultative or stablization pond sometimes fails to meet target levels.

For such cases, some additional systems are used after the faculatative pond to improve the effluent quality.

Some examples of additional technologies are shown in Table 2.

Table 2 Options after Pond System (after facultative pond)

Options	Parameter to be expected to remove	Removal rate (%)	Remarks
Rock filter	TSS (algae from facultative pond)	60	after facultative pond, 0.33-0.044 $kgTSS/m^3$
	T-BOD_5	60	
	T-P	46	
Maturation pond	T-BOD_5	95	with facultative pond
	T-N	80	
	T-P	70	
Overland flow	T-BOD_5	90	5.5 to 22.5 kg/ha/d, raw domestic waste water after screening
	TSS	up to 15mg/L	algae removal rate is inferior
	NH_4-N	90	at 0.10 m^3/m/h
	T-P	40 to 50	
	Heavy metal	50 to 80	
Wetland (SFS)*	T-BOD_5	73	after facultative pond, possible to remove algae, 7 days retention time
	TSS	70	
	T-N	90	
	T-P	60	
Wetland (Floating,	T-BOD_5	75	after facultative pond with 20 days' retention time,
	TSS	80	
	T-N	85	
	T-P	50 to 60	

* : estimation

2.1 Wetlands

Constructed wetland systems are designed to stimulate and optimize filtering and biodegradation processes that occur in natural wetlands. They are a possible solution to improve the performance of pond systems as they can further purify wastewater effluent before it is discharged to a waterway.

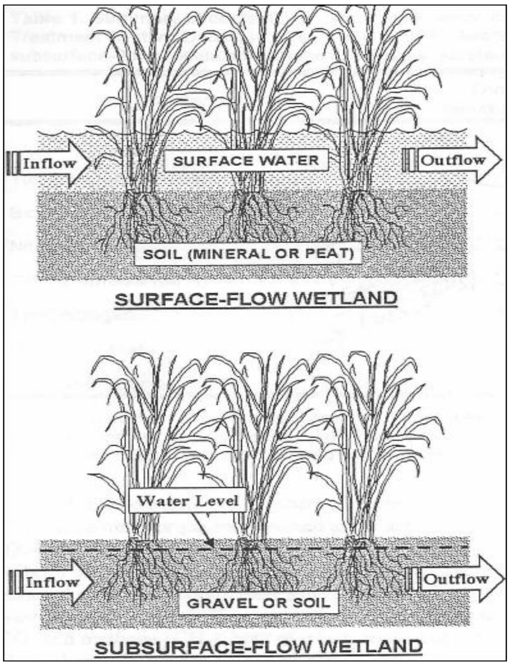


Figure 2 Conceptual diagram of surface-flow (SF) and subsurface-flow (SSF) wetlands

During the dry season such a system may even result in zero discharge to waterways, due to evaporation and evapotranspiration of the water component from the wetland. Constructed and natural wetlands are often used as low-tech treatment systems for domestic wastewater and a variety of industrial wastewater, including pulp and paper, food processing, slaughtering and rendering, chemical manufacturing, petroleum refining and landfill leachate.

Pretreatment, such as primary sedimentation or aeration stabilization, is often required for industrial effluents. Although a broad spectrum of designs have been used for wetland treatment systems, all can be classified as either surface-flow (SF) or subsurface-flow systems.

The features are:

- The SF design typically incorporates a shallow layer of surface water, flowing over mineral (sandy) or organic (peat) soils.
- Vegetation often consists of marsh plants, such as cattails and reeds, but may also include floating and submerged aquatic vegetation, as well as wetland shrubs and trees.
- In a subsurface-flow wetland, the basin is filled with gravel or some other coarse substrate, and the water level is maintained belowground.
- Water flows horizontally, or sometimes vertically, through the gravel and the root mat of the wetland vegetation.
- Each type of treatment wetland has characteristic advantages and limitations for treatment of various wastes.

Therefore, in adopting this system, pre-test by bench scale or pilot scale including species to confirm the efficiency and performance is necessary. Some pre-test examples are shown in the Data Book.

3. Integrated Facultative Ponds (Advanced Facultative Ponds)

Apart from additional technologies, some techniques have been trialed and implemented to improve the performance of the pond system.

3.1 Deep ponds

Deep ponds promote sedimentation of wastewater solids and anaerobic decomposition of methane. The pond is designed so that its surface remains aerobic, thus reducing the potential odor problem. Biogas may be collected using a submerged gas canopy and potentially used for energy production.

3.2 Mechanical Aeration

Mechanically aerated ponds generate turbulence to mix all the effluent in the pond and introduce oxygen through equipment that either:

- Introduces air into the effluent by injecting air under the pond surface (floating pumps).
- Exposes more effluent surface area to the air through spraying effluent into the air or agitating the effluent.

This technology can significantly reduce the nutrient, ammonia, odor, and BOD concentrations in the resulting effluent.

3.3 Chemical Treatment and Biological Additives

Several kinds of additives are available to control odors and break down crusting and organic matter. The main ones are the following:

- Bacterial Additives (bioremedation): using bacteria to degrade solids in ponds so that they are eventually liquefied. This may result in changes in BOD (may drop or may rise) and TSS (drop) concentrations and reduce temporary odor emission.
- Electrolytic Methods: It is claimed that copper electrodes immersed in the pond reduce odors, kill pathogenic micro-orgasms and prevent build-up of crust. The cost of this technology still high (copper probes need to be replaced every 12 to 18 months. This is in addition to maintenance, operation and energy cost.)

C. Final Disposal:

C2 Planning and Design of Landfill

C2. PLANNING AND DESIGN OF LANDFILL

1. Design Concept

1.1 M/P of landfill - Design and Cost Assumptions.

1) New Construction and Expansion of Existing Landfills

The new site 1, new Guanabacoa and expansion of Calle 100 are divided into two stages and are to be constructed depending on hauled waste per year. The operation and maintenance facilities as well as the access and maintenance roads are to be constructed in the first stage. Common facilities of the three landfills are:

- Enclosure embankment

In each case the enclosure bank is to be constructed by a piling up method due to a topographical limitation. Terraced enclosure embankments are to be constructed, with a height of 5 m and 3.5 m, for the storage of reclaimed waste. The embankment slope is 1:2 and each enclosure bank has a berm with a width of 2 m and rainwater drainage. Sodding work is to be done on the surface of the slope for protection from erosion due to surface water.

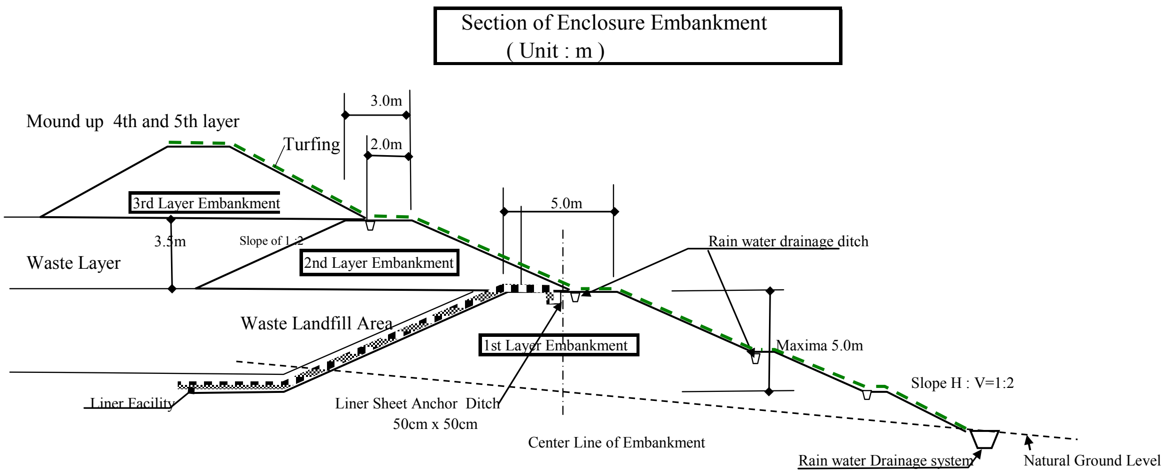


Figure 1 Typical Section of Enclosure Embankment

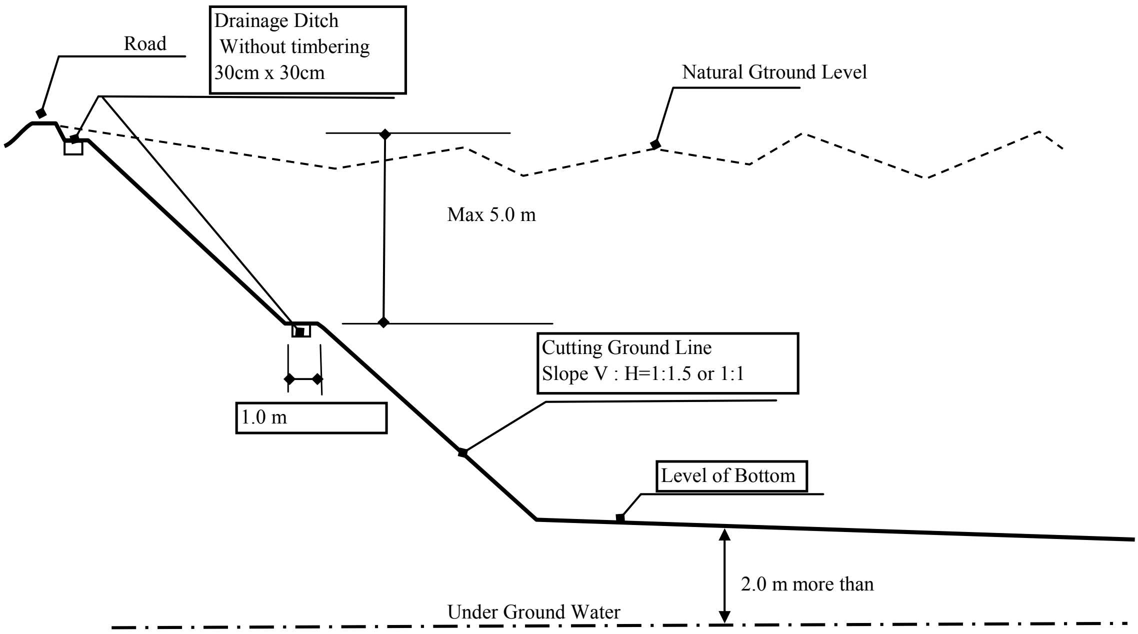


Figure 2 Dimension of Cutting Ground Line

- Road Facility

Approach and maintenance road are to be paved with asphalt and Macadam to accommodate the topographical conditions and waste collection vehicles. The width asphalt-paved road is to be 8m up to the site and 7m on site. And the width of Macadam maintenance road is 6 and 5m.

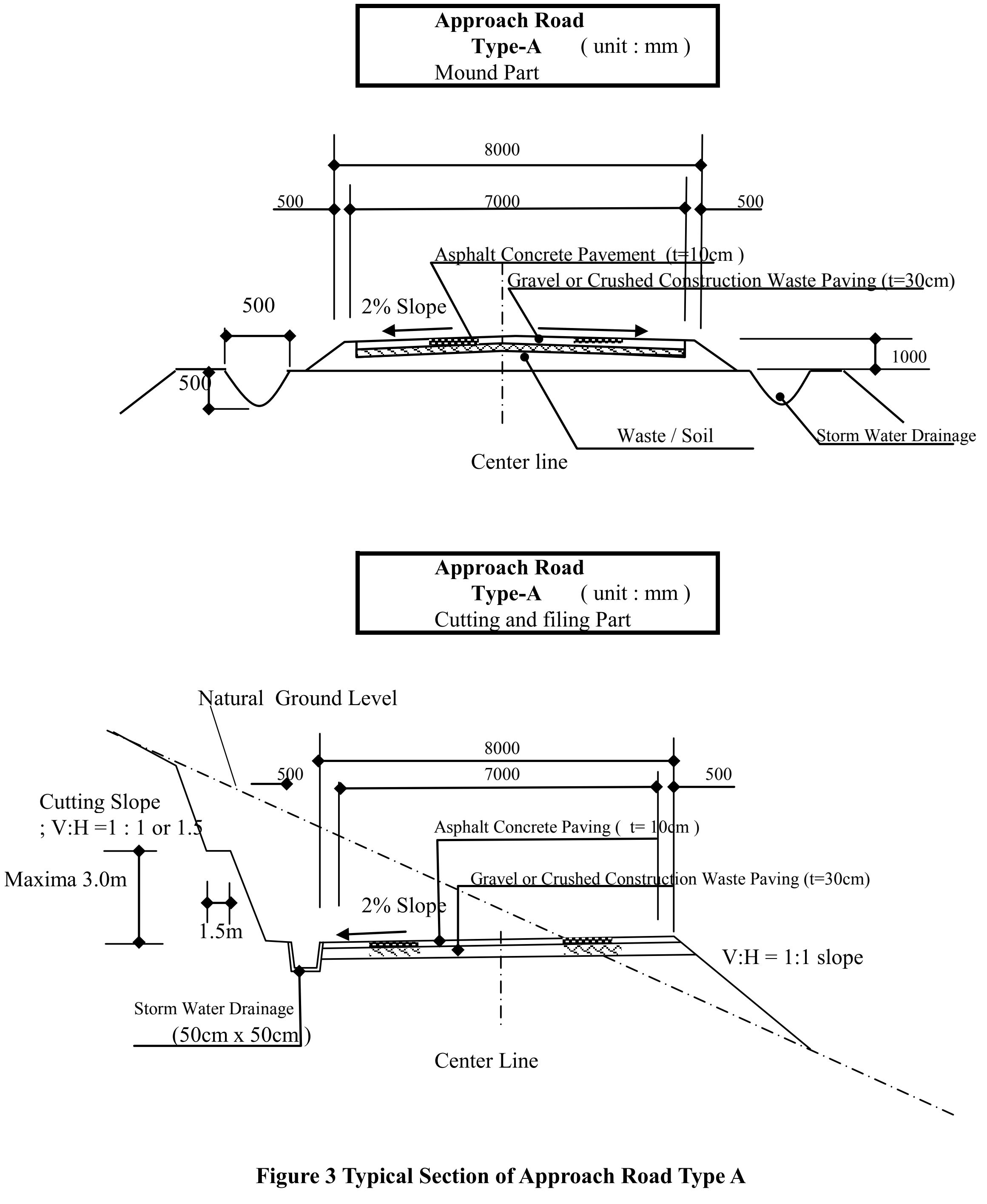


Figure 3 Typical Section of Approach Road Type A

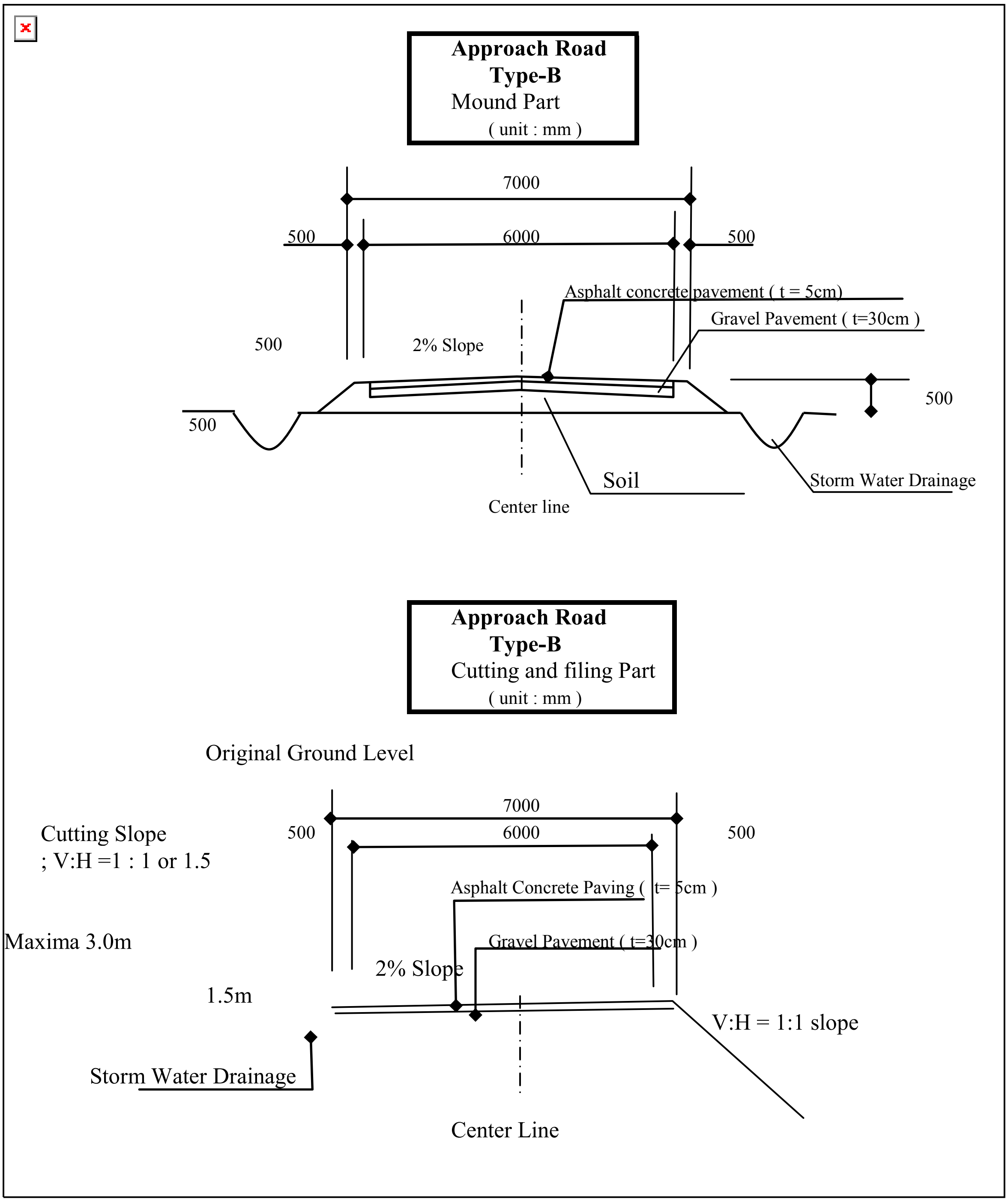


Figure 4 Typical Section of Approach Road Type B

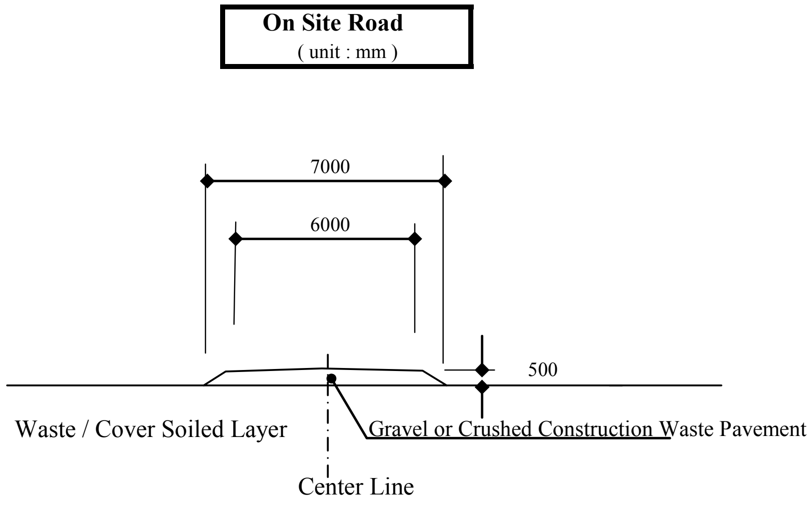


Figure 5 Typical Section of Onsite Road

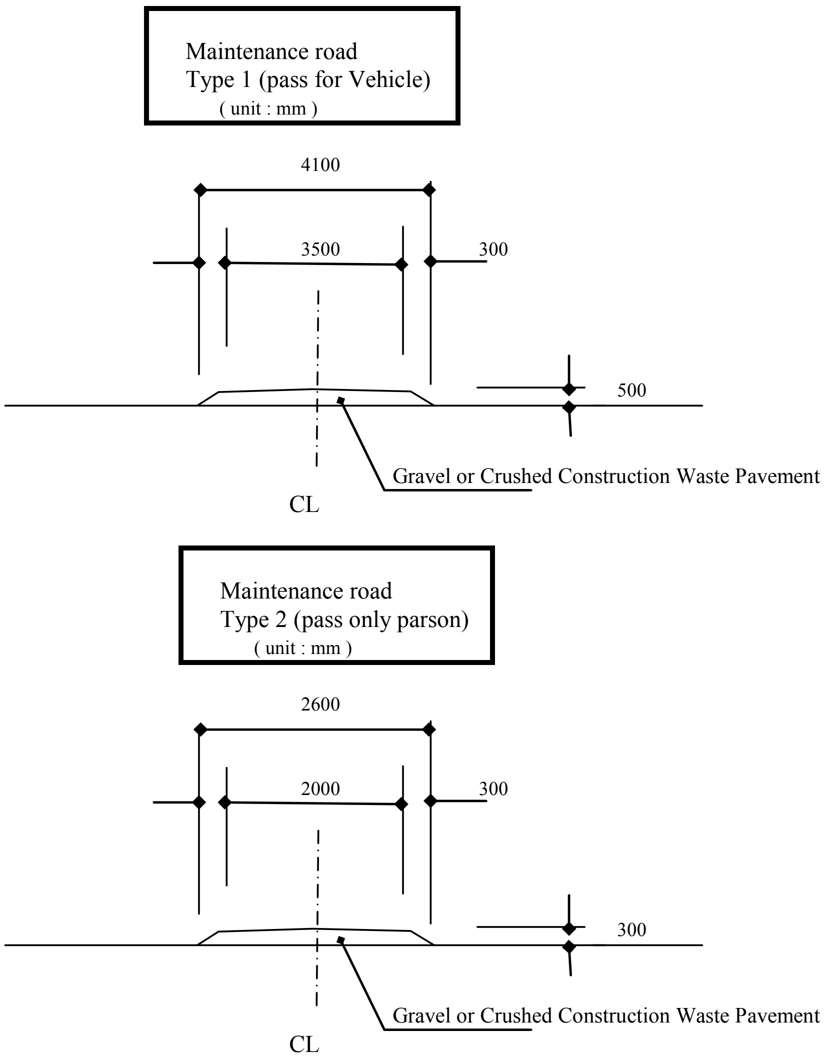


Figure 6 Typical Section of Maintenance Road

Liner Facility

HDPE liner is to be installed to prevent leachate from penetrating into the groundwater. A sand protection layer of 30 cm is to be laid on the liner. After excavation the bottom layer is to be compacted and leveled in order to reduce the water permeability of the existing clay layer.

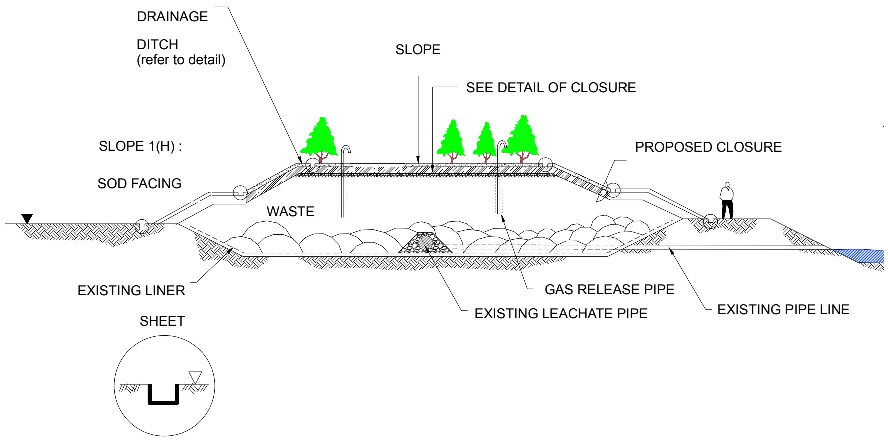


Figure 7 Conceptual Plan of Closure of Existing Landfills

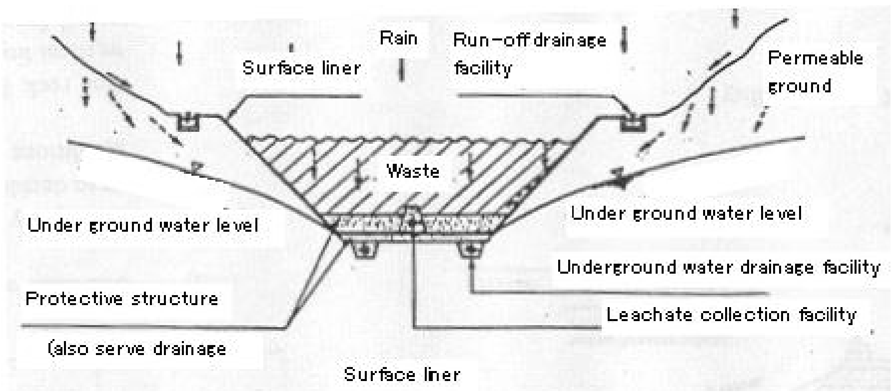


Figure 8 Surface Liner System

- Leachate collection facility

The leachate collection facility consists of a perforated main concrete pipe of 600 mm diameter and perforated PVC branch pipes of 200 mm diameter. These pipes are to be protected by cobble. The leachate collection pipes are connected with gas vents to provide air and promote drainage of the leachate. The branch leachate pipes are to be laid every 30 m.

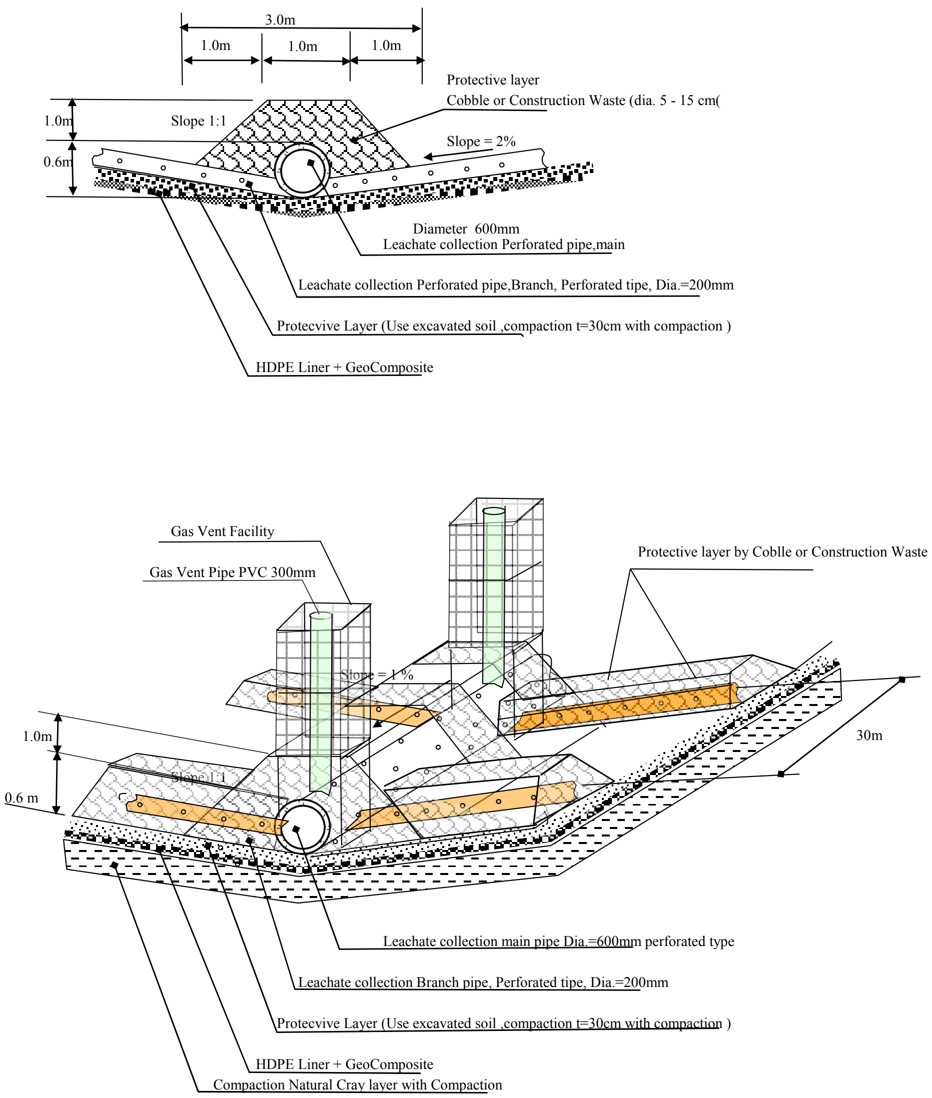
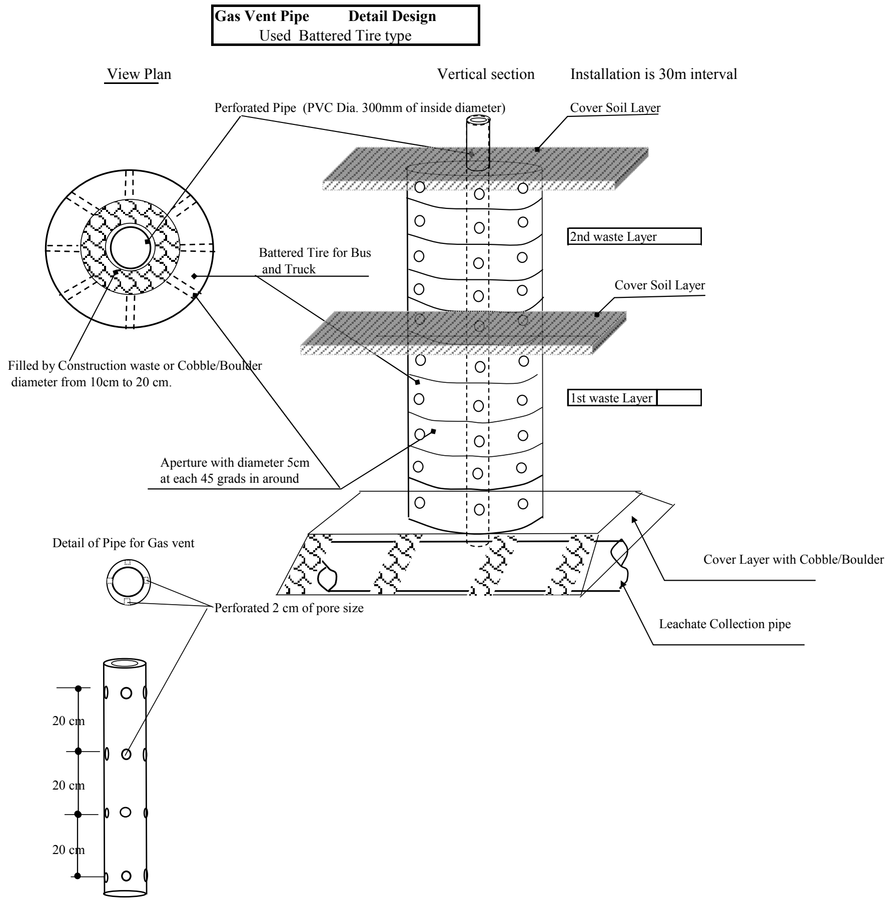


Figure 9 Liner and Leachate Collection facility

- Gas Vent Facility

Perforated PVC gas vents with a diameter of 300 mm are to be laid every 30 m. They are to be protected by cobbles of approximately 10 cm in diameter in a 1m x 1m shaft at each vent.



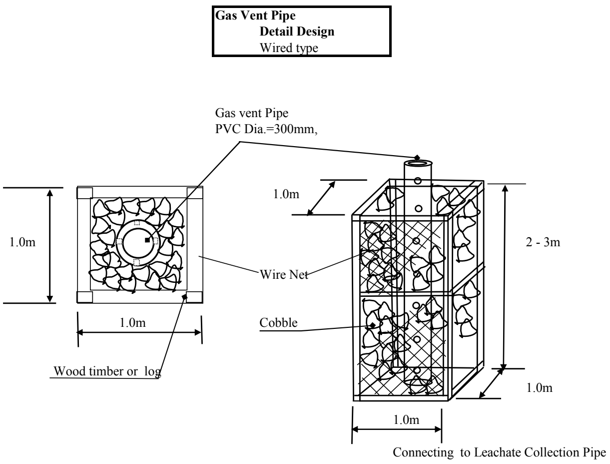
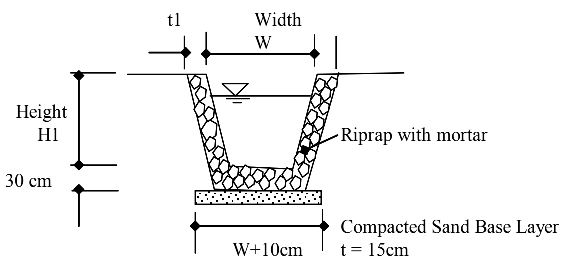


Figure 10 Gas Vent Pipe

- Strom water drainage facility

To reduce rainwater flowing into the landfill area, a storm water drainage facility is to be constructed at the top of the enclosure embankment and around the landfill area. However, a storm water storage pond is not required.

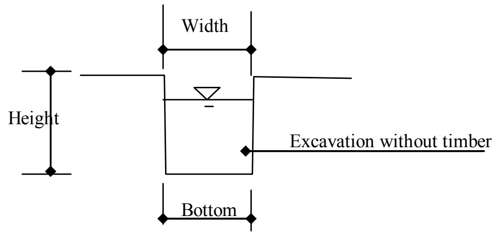
Riprap with mortar Type



(unit : cm)

Width	Height	Bottom	Thickness
50	50	30	15
100	50	30	15
100	100	80	20
200	100	80	30

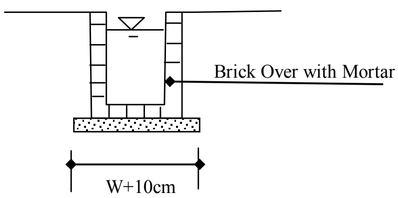
Without timber Type



(unit : cm)

Width	Height	Bottom
50	50	30
100	50	100
100	100	100
200	100	200

Brick Over Type



(unit : cm)

Width	Height	Bottom	Thickness
50	50	30	15
100	50	30	15
100	100	100	20
200	100	80	30

Figure 11 Dimension of Rain Storm Drainage

- Leachate treatment ponds

Also to be constructed, with the New Site-1 and New Guanabacoa final disposal sites, are the anaerobic pond, aerated lagoon and two maturation ponds. For the expansion of Calle 100 final disposal site only one pond, with the same volume as the anaerobic pond, is proposed for the storage of leachate considering that its life is only four (4) years and there is no leachate treatment system in the existing landfill area. However, the leachate storage pond is not to be constructed.

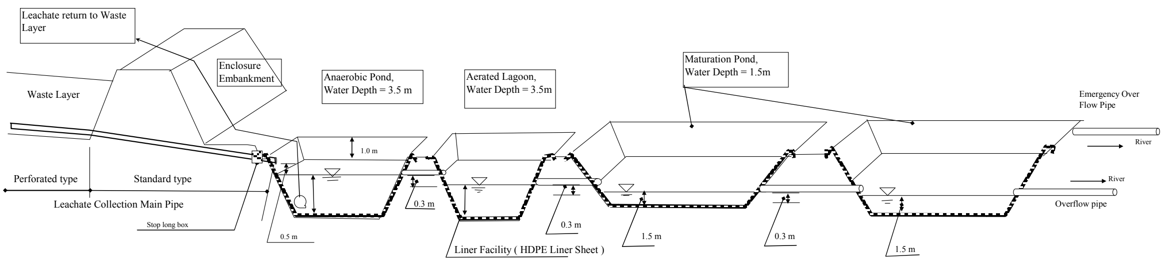


Figure 12 Dimension of Leachate Treatment Pond

- Leachate recirculation facility

Leachate stored in the anaerobic pond is to be re-circulated to the landfill area by using a rubber hose of 75 mm diameter.

- Wire Fence for boundary

A wire fence is to be installed along the boarder of the final disposal site to keep out illegal waste disposers and animals.

- Truck scale and its office

Considering the number of waste hauling vehicles is high, two sets of truck scales with a measurement capacity of 50 ton are to be installed at each final disposal site in order to weigh the loaded and empty weight of the vehicles without wasting time. The recorder of the truck scale is to be connected to a computer in the administration office for compiling and analyzing the recorded data for calculation of hauled waste volume, procurement of appropriate cover soil and future planning, which is the most fundamental to waste management.

- Operation and maintenance facilities

A parking lot for heavy equipment and a work space for a mobile workshop, fuel supply facility and car washing facility are to be constructed.

- Littering preventing fence

A mobile fence with height of 2m is to be installed near the landfill operation area to prevent waste from littering during the landfill operation. It is to be shifted according to wind direction.

2) Closure work of existing landfills

- Gas vent

After excavating the waste reclaimed area at four (4) m depth, perforated PVC pipe of 300 mm of diameter with cobles are to be laid every 30 m.

- Final Cover Soil

To reduce the penetration of rainwater into existing waste reclaimed layer, a 30cm layer of clay layer and a 30 cm layer of soil is to be laid on the existing waste reclaimed layer.

A storm water drainage system with a 2 % of slope is to be constructed in order to promote swift drainage outside of the reclaimed land. Sodding work is to be implemented for the prevention of surface soil erosion.

- Wire fence

A wire fence is to be installed along the boarder of the closed existing landfill to keep off waste disposers and animals.

- Entrance gate

A 3m high entrance fence and gate will be constructed.

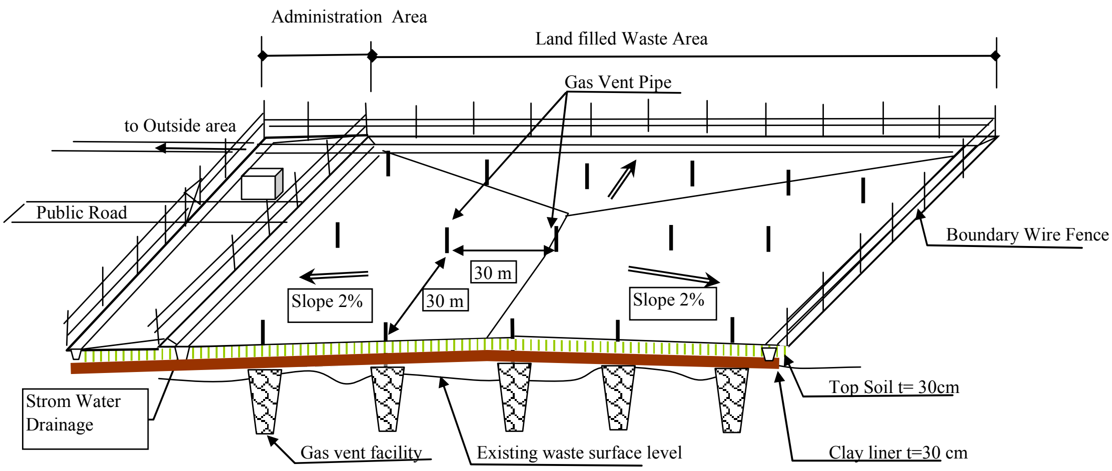


Figure 13 Dimension of Leachate Treatment Pond

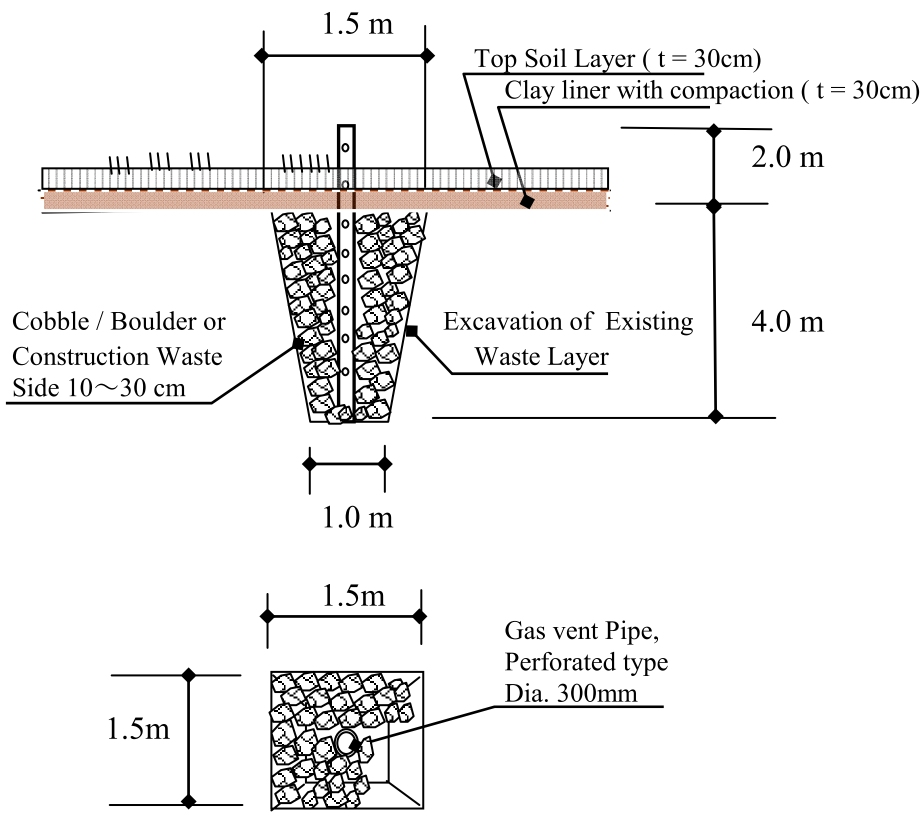


Figure 14 Gas Venting Facility for Existing Landfill Closure

Figure 15 shows the concept of order of land filling.
Figures 16 and 17 show the procedure of the push down method and the push up method, respectively.

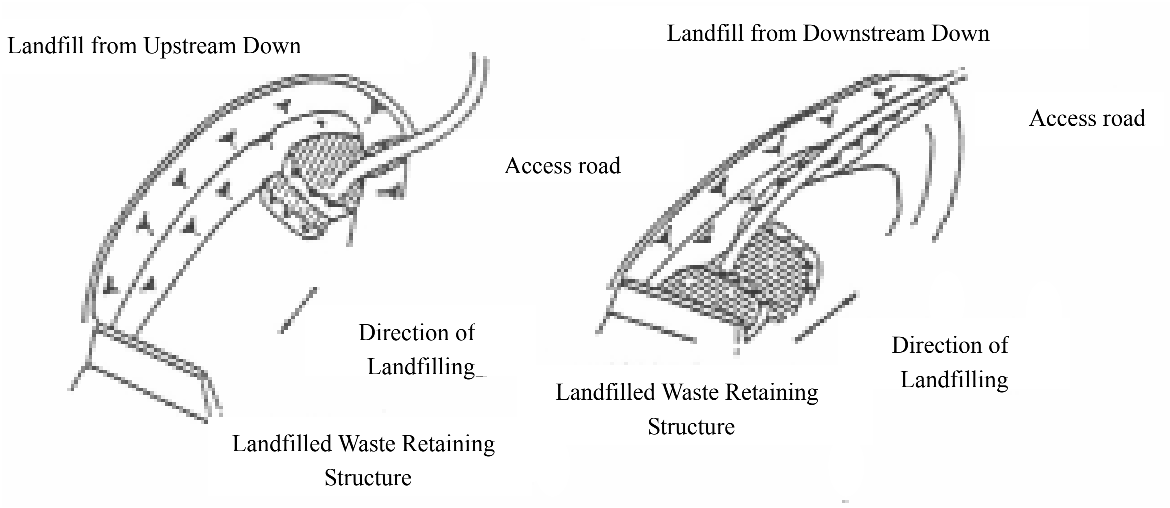


Figure 15 Concept of Order of Land-filling.

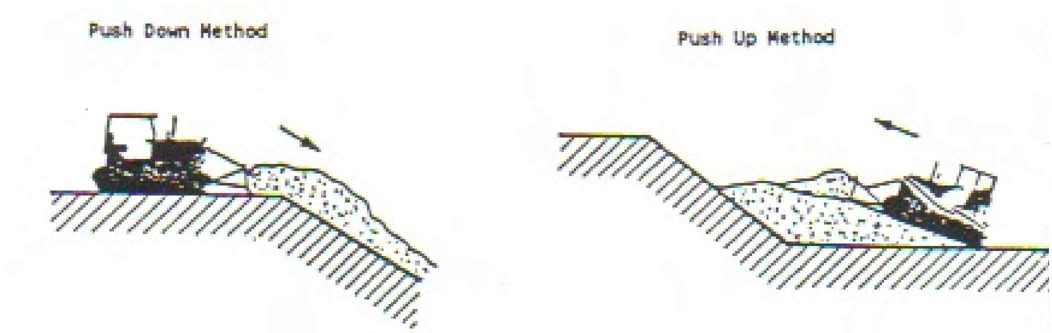
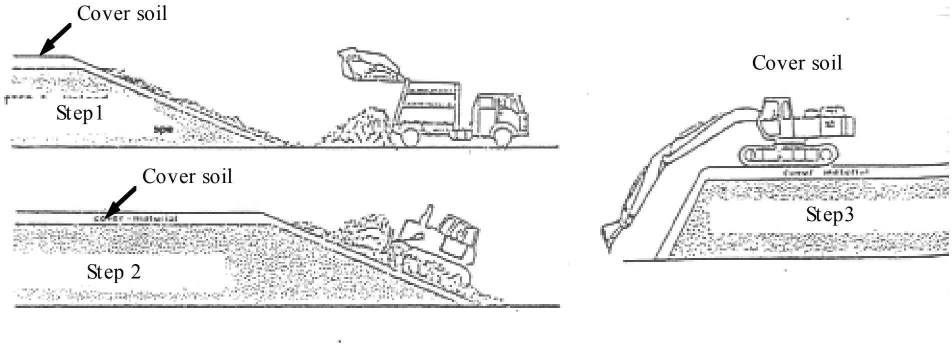


Figure 16 Spreading/Compacting Method



Step 1: Unloaded solid waste on top of slope
Step 2: Spread in thin layers (approximately 60 cm)
Step 3: Compact by running tractor over waste layer 2 to 5 times

Figure 17 Push up Method

Figure 18 shows the cell method.

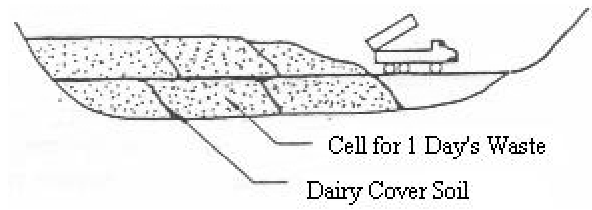


Figure 18 Cell Method

3) Cover Soil

The options for procurement of cover soil are as follows:

- Use of waste construction materials (estimated at 240 tons/day)
- Use of part of the bulky waste (estimated at 260 tons/day)
- Use of part of the decomposed waste layers at existing landfill sites.

The provincial landfills, namely Calle 100, Guanabacoa and Ocho Vias, have been used since 1976 and it is estimated that approximately 16.7 million m^3 of waste have been accumulated in them since 1976 (Table 5.10.1). Supposing that decomposition of organic matter has been completed in 10% of the accumulated waste, there would be 1.67 million m^3 of reclaimed soil available for cover soil. This will be almost equal to 9 years of cover soil requirement for the Calle 100 Extension, New Site 1 and New Guanabacoa landfills. (Approximately 1.76 million m^3)

However, the following points need to be confirmed before this source of cover soil can be judged as satisfactory:

- Stability of the land to be reclaimed
- Leachate test of soil to be reclaimed.

It has been reported that, when the waste disposal first began, many kinds of waste, including hazardous waste, were dumped into the existing landfills. Therefore the possibility of pollution by hazardous substances should be checked by leachate analysis in laboratories.

If procurement of cover soil from existing landfills is not feasible, cover soil has to be taken from other places. Table 1 shows the surveys required for closure works, improvement, and the possibility of using cover soil from existing landfills.

Table 1 Survey Items for Closure Works, Improvement and Possibility of Using Cover Soil from Existing Landfills

Item	Survey	Objectives	Survey method			Remarks
			Calle100	Guanabacoa	Special period dumping sites	
			(Plan for improvement and closure, investigation of possible vertical extension and conversion of disintegrated waste to covering soil)	(Plan for improvement and closure, investigation of conversion of disintegrated waste to covering soil)	(Plan for improvement and closure)	
1.Topographical survey	Plane survey and preparation of topographical map with a scale of 1/1000	To estimate landfill height and waste amount, and establish slope conditions	To modify existing map prepared in 2000 with a scale of 1/2000	To modify existing map to the current conditions	To modify existing map to the current conditions	To prepare ground plan with a scale of 1/500 to 1/1000, including existing data collection
	Section survey and preparation of section plan	To estimate landfill height and waste amount, and establish slope conditions	East-west direction: 80 points, south-north direction: 50 points including Almendas river	East-west direction: 15 points, south-north direction: 30 points including access road and Kambere river	Points at every 20m depending on the size of site	Measurement is done at every 20m in principle.
2.Survey of dumped waste properties	Disintegration level of dumped waste, analysis of waste properties, specific gravity, unit weight per volume, moisture content, ignition loss, N value, compression and consolidation test, elution test	To know disintegration level and possible conversion to covering soil, subsidence at the time of vertical extension, soil mechanical stability of waste	Around 15 points. One point per 4 ha for each disposal year, 4 m^2 per point, coring soil is removed and waste below it is sampled.	About 10 points. Sampling is done for every 2 ha of waste layer. Covering soil is removed and waste below it is taken as a sample.	Sampling at 3 points depending on the size of site	
3.Soil survey of existing soil	Preparation of column diagram through boring survey, soil physical properties, N value, permeability coefficient, particle size distribution	To establish existing soil conditions, especially lower part of dumped waste	Around 10 points in landfill site and its vicinity	Around 10 points in landfill site and its vicinity	Same as left	
4.Flow direction of groundwater and its quality analysis	Water quality analysis, measurement of flow direction of groundwater	To know flow direction of groundwater and its pollution conditions	Water quality monitoring wells installed both upstream and downstream of groundwater with several points for each.	Same as left	Same as left	Including existing data collection
5.Leachate survey	Flow measurement and water quality analysis（BOD, SS, COD, pH, EC and others）	Leachate contained in waste layer: to know its quality, water level and flow direction	Quality and quantity analysis of leachate in monitoring wells and seeping outside the waste layer	Same as left	Same as left	
6.Analysis of emitted gas	To locate gas emission, gas analysis, emitted amount and concentrations	To secure safety at excavation and to know disintegration level of waste, and judge whether gas vent is necessary or not.	To know gas emission conditions, constituents of gas, concentrations and amount	Same as left	Same as left	

- Use of excavated soil from expansion of Calle 100.

Another possibility is to use excavated soil from the expansion of Calle 100. The excavated soil volume is estimated to be approximately 2 million m^3. Of this volume, only approximately 0.3 million m^3 is to be used for construction of enclosure embankments of the first and second stages. The balance of 1.7 million m^3 of soil could be used for cover soil. (Refer to Data Book C2)

C. Final Disposal:

C3 Outline of Construction and Expansion of Landfill

C3. OUTLINE OF CONSTRUCTION AND EXPANSION OF LANDFILL

1. New landfill site

1.1 Current situation

1) Geological Condition

Since the site is not fixed, facilities were designed based on the following assumptions. Assumed geological, topographical and soil conditions:

- Geological condition: A suburban area located approximately 10 km southwest of Calle100
- Soil condition: There is a sandy soil layer mixed with conglomerate which is suitable for cover soil from ground level to minus 5 m depth.
- Under the layer to minus 13 m depth from ground level, there is clay liner mixed with sandy-silt with water permeability of 10^{-4}cm/sec.
- Groundwater level : Groundwater level exists from ground level in the rainy season to minus 10 m.
- Access road : An asphalt paved access road with two lanes is to be constructed from the neighboring main road. However, it is not included in M/P of design and cost estimation.
- Buffer zone : A buffer zone of 200 m is required from the surrounding roads to ease impacts on the lives of the surrounding residents and the natural environment. Existing plants and low height trees are to be used.

1.2 Construction procedure

- The landfill area is to be divided into two areas in accordance with operation startup years.
- The landfill administration facilities, security facilities and main on-site roads are to be constructed in the first stage construction. Landfill area, related roads, drainage facility and leachate collection and treatment facilities are to be constructed in each stage of construction.

1.3 Land development of landfill area

Approximately a 5 m depth from the surface is to be excavated. Its slope is 1:1.5. Excavated soil is to be temporarily stockpiled at the site and is to be used for construction of the enclosure embankment and as cover soil. Bern and storm water drainage systems to prevent erosion by surface water are to be constructed on the fill slope.

2. New Guanabacoa Landfill

2.1 Current situation

- The candidate land was decided upon and procured by the DPPF. The DPSC has started design for a planned starting of operation at the beginning of Y 2007.
- The Study Team comprehensively reviewed the plan and the design of the Cuban Side in order to assist with the completion of the design based on the plan. In the proposed Master Plan, the Study Team would also include operating procedures.
- At the end of June 2005, the Cuban side completed the outline of design, except for the leachate treatment system
- The Study Team shall propose a M/P reviewing the plan and design by Cuban side.

2.2 Topographic condition

The finally chosen disposal site is located at approximately 10 km southeast from Havana Bay and at 1km from a belt highway and an access road is connected to the belt highway. The existing dumping site at Calle 100 is 18 km west and the one at Guanabacoa is 7 km north.

2.3 Geological conditions (from a groundwater survey done by the Cuban side)

- Groundwater level is four to six meters from the current ground level.
- The existing salty clay soil, partly with sand, in the site shows a permeability coefficient of approximately 10^{-4} or 10^{-5} cm/sec based on the geological survey report done by Cuban side. At a part of the site, the survey says that there is a high fluctuation in the groundwater level, which suggests that there are some parts with high water permeability.
- The site is located on the north hilly areas of an orchard and is 75 to 80 m above the sea. The slope to north is approximately 3 % (Horizontal distance: 350 m, height difference: approximately 15 m)
- The west side is a slightly steep slope of approximately 5 %. The slope is from north to west and approximately 3 to 5 %.
- The Las Palmas reservoir is located at approximately 200 m towards northwest from the north end.
- This final landfill is in the water table of the reservoir. The reservoir is constructed for agricultural water and flood control.

- In south of the land, there is a quarry, which is controlled by the Ministry of Mining. The DPPF and DPSC have a plan to use this quarry as the expansion area of a new Guanabacoa disposal site in the future. The staring year for this is uncertain.
- For a part of eastern slope the ground water level is high, which may be due to the influence of an existing irrigation pond and a pumped groundwater irrigation facility located to the south of the site.
- However, since the pond will be filled up during construction, the groundwater level will be drop by up to 3 m, which is the water depth of the pond.

2.4 Plan by Cuban side

The plan is to excavate the soil at the disposal site to a depth of three to four meter. Leachate collection pipes of 200 mm diameter and gas discharge pipes of 100 mm diameter are to install at every 50 m.

2.5 Proposed Construction Plan by the JICA Study Team

- The soil will be excavated up to three (3) to four (4) meter depth.
- The excavated soil is used to construct the bank with 3.5 m height and 3 m width at its top. The ratio of the outside to inside slope is one to two.
- Refer to the drawing of a typical section of enclosure embankment.

2.6 Construction procedure

The land is divided into two areas. The east side and west side are the first and second stages, respectively. Administration facilities, security facilities and main roads are to be constructed in the first stage. Landfill area, related roads, drainage facility and leachate collection and treatment facilities are to be constructed in each stage of construction.

The valley to the west side of the site is candidate land for future expansion, however, since this valley is located upstream of the Las Palmas reservoir, a liner system and leachate treatment system will be vital.

(1) Land development and construction of the enclosure embankment

1) First stage

Terrace slopes of approximately 4 m depth from the surface will be constructed in sequence from the west and north top by cutting into the gentle east-facing slope. An enclosure embankment is to be constructed at the east and north side of the site by using the excavated soil. Since most of the excavated soil is to be used for construction of the enclosure embankment and divider, cover soil will be hauled from outside of the site. Bench and storm water drainage are to be constructed at the fill slope for prevention of erosion by surface water. Storm water drainage is also to be constructed around the cut surface to prevent rainwater flowing into the cut area.

2) Second stage

A terraced slope is to be constructed by cutting the gentle north slope up to approximately 4m depth from the surface one after another from south top. Two enclosure embankments are to be constructed in north and west by using excavated soil. Excess soil is to be stored at the site and used for cover soil.

(2) Liner and leachate collection facilities

After the preparation and compaction works of the excavated site a liner composed of HDPE sheet with geo-composite is to be laid over the area. A protection layer of 30 cm, composed of sandy soil selected from the excavated soil, is to be laid on top of the liner. Leachate collection pipes are to be laid on the protection layer. Collected leachate flows into leachate treatment ponds constructed in each stage, where it is stored and treated. Leachate is to be returned to landfill site by a re-circulation pump.

(3) Gas Vent

Gas vents are to be connected with the leachate collection pipes and extended in height in accordance with the progress of landfill.

3. Calle 100 Landfill Expansion Area

3.1 Current situation

(1) Geological Condition

Site: East side of existing landfill.

Topography: Within the existing Calle 100 landfill site, the unused area is approximately 24 ha, of which 17 ha will be used as landfill area. However, the design was conducted under the assumption that 20 ha could be used for landfill area. There is a slope of 5 % from west to east.

Soil Condition: According to existing groundwater and geological survey results, the site is considered to consist of a silt clay layer mixed with sand with a water permeability of 10^{-4} to 10^{-5} cm/sec.

Ground water: According to the survey result, groundwater level is approximately minus 5 m from the current ground surface during the dry season. In Y1999, the survey year, water leakage from a 1,000 mm diameter water supply pipe, which was laid near the on-site road for existing landfill area and inflow of storm water from outside of east side might have influenced the groundwater level. In formulation of the M/P, the groundwater level was assumed to be minus 7 m from ground level. The reasons are the follows:

- In Y2005, the water supply pipe was shifted by approximately 300 m from near the existing on-site roads to the west.
- The groundwater level will drop by the construction of a drainage system for storm water from the border and the expansion area.

A separation distance of 20 m is necessary for water supply pipes with diameter of 1,000 mm which was shifted to west side according to Cuban regulation.

There is a highway to Havana International Airport approximately 300 m west from the expansion area. It is necessary to prevent foreign tourists from directly looking at the site from the highway. Therefore, construction of a structure that exceeds 50 m above sea level is not desirable because the height of the existing highway at east side is approximately 50 m above the sea level.

(2) Land development and construction of the enclosure embankment

The site is to be divided at south and north. The 10 ha northern side is for the first stage and 8 ha southern side is for the second stage.

1) First stage

The soil is to be cut with a slope of 1:1.5, keeping a distance of 30 m from the shifted water pipe, up to a depth of approximately 4 m from the ground level. The first bank is where the liner, leachate collection system and vertical gas vents are to be laid. The second to fifth banks are to be constructed by using the excavated soil. Excavated soil is to be used for construction of the enclosure embankment, divider and for cover soil. Excess soil will be used for closure work at the existing Calle 100 and special period dumping sites. Bern and storm water drainage are to be constructed at the fill slope for prevention of erosion by surface water. Storm water drainage is also to be constructed around the cut surface for prevention of rainwater from inflowing into cut area.

4. Existing landfill Closure

4.1 Existing Special Dumping Closure

The area for final cover soil, i.e., excluding the administration facility and on-site roads, is estimated to be 95 % of landfill area because landfill area itself is small, 0.5 to 2 ha.

Clay and soil for the final cover will be hauled from outside the site.

4.2 Existing Landfill Closure

As for closure works for the Calle 100 and Guanabacoa landfill sites, the area for final cover soil is defined as the area excluding the administration and maintenance facilities, on-site roads, and area to be reused.

C. Final Disposal:

C4 Condition of Cost Estimate for Landfill

C4. CONDITION OF COST ESTIMATE FOR LANDFILL

1. Assumptions and Methodology for Cost Estimation

1.1 Cost Estimation System in Cuba

The system used for Cost Estimation in the Republic of Cuba when construction projects are being established is called "PRECON", and the system is applied to any general public work. It is possible to register with this system, using its labor unit price, construction material costs, etc., and to do product calculations on its database.

The cost of the Master Plan was estimated according to PRECON and documents of cost estimation in the Pilot Project and other existing facilities.

The unit prices of civil work and architectural work were based on the cost estimation system "PRECON", (in Spanish this is Instrucción del Sistema de Precios de la Construcción) written by the Ministry of Construction in Cuba.

The unit price, as of October 2004, has been used as the product price for calculating estimates for:

- The "New Guanabacoa Disposal Site" that the Cuba side plan as the place for the final disposal site.
- The cost estimate and plan for the Pilot Project of the Campo Florido Landfill Site

1.2 Unit Cost and Labor Cost in Cuba

The construction unit prices for the New Guanabacoa final disposal site that the Cuban side designed are in a list shown below in Table 1.

Table 1 Cuban Unit Cost of Construction

Work Division	Unit Price* (Cuban Peso)	Unit	Note (Price:2004 year)
Excavation Work	2	m^3	Use Hesvy Eqipment
Transport Material out of site	2	m^3	$10m^3$ Truck, under 1km
Macadamise Road Work	330	m^3	Tick 18cm
Asphalt Pavement Work	5	m^2	Tick 5cm
Water Ghanell setting Work	20	m^2	Depth and width under 1m by Concrete
Installation of Concrete Pipe Work	90	m	Pipe Dia. 450mm-600mm
Leachate Collection Pipe Installation Work	120	m	PVC 100mm－250mm
Ventilation Pipe Installation Work Division	40	m	Use ductile Cast-iron pipe
Material Transportation Work	16	m^3	Earth, Sand and Macadam

Source: Memoria Descriptiva de Vertedero NuevoGuanabacoa, DCH, 2004/Mar./26)
*Note: The unit price includes the material costs, labor cost and cost of using heavy equipment.

The labor unit price in Cuba has followed the outline below according to PRECON. Furthermore, the operation costs for machinery, including fuel has been split into material cost, labor cost, and establishment cost, and these have been included to establish the PRECON base data.

1.3 Portion of Foreign Currency and Local Currency

The price level of the cost estimation is as of 2004. The cost includes a foreign currency (FC) portion and a local currency (LC) portion. FC and LC are estimated in US dollars and Cuban peso. Mainly, goods and services that are available in the local market are estimated in LC and goods and services imported from other countries are estimated in FC. However, when the allocation of the FC portion and the LC portion is difficult due to the unknown allocation of costs, the ratio of FC to LC has been set up as 60% FC and 40% LC. This set up is on the basis of the rough estimate by a local design company for the pilot project.

1.4 Components of the Construction Cost

The direct construction is estimated fundamentally with the following components by PRECON.

Table 2 Components of the Construction Cost

(1) Net Construction Cost in Work Site	(a) + (b)
(a)Direct Construction cost (include 10% of temporary facility)	Land fill Construction Work Civil Work : Landfill Work : Embankment, Collection pipe work, Gas Ventilation pipe work Pond Work: Leachate Pond, Installation of Aerator and Circulation Pump, Road Work : Architectural and other work : Carrying Waste Control Office, Administration Office and Work-Shop, Compost Facility and Guard Facility
(b)Indirect Construction cost in site work	Rate of 25% for Direct Construction Cost : (a) x 25%
(c)Construction Fee	Rate of 15% for Indirect Cost: (a+b) x 15%
(2) Off site Construction Cost	
(a) Administration and Compensation	The rate of 2% of FC and 5% of LC of (1)
(b)Administration expenses	3% of LC of Direct Construction Cost (1)
(c)Engineering Service	10% x Net Construction cost of New Construction work
(d)Physical contingency	10% x Total Direct construction cost

2. Summary of cost for the Landfill Part

2.1 Summary of Direct Costs for the Landfill Part

Table 3 Direct cost for landfill part in M/P

(Unit : x1000)

Item	Construction Cost		Equipment cost included heavy equipment		OM cost			TOTAL			
	CUP	US$	CUP	US$	CUP	CUC	US$	CUP	CUC	US$	TOTAL*
Landfill Construction and Expansion	18,632	28,421	0	7,718	12,151	4,498	1,030	30,783	4,498	37,169	42,850
Existing Landfill Closure	8,205	5,539	0	0	0	0	0	8,205	0	5,539	5,855
Maintenance Tool Equipment	0	0	0	275	1,757	118	13	1,757	118	288	474
Total	26,837	33,960	0	7,993	13,908	4,616	1,043	40,745	4,616	42,996	49,179

Note : * ; CUP : CUC : US$ = 26 : 1: 1

Table 4 Breakdown of Direct Costs for Construction and Operation Area for New Landfill and Expansion in M/P

(Unit : x1000)

Item	Construction Cost		Equipment cost included heavy equipment		OM cost			TOTAL			
	CUP	US$	CUP	US$	CUP	CUC	US$	CUP	CUC	US$	TOTAL*
New Site 1 Landfill	6,542	6,089	0	1,367	4,597	2,095	139	11,139	2,095	7,595	10,118
New Guanabacoa Landfill	4,856	8,722	0	1,937	2,891	924	85	7,747	924	10,744	11,966
Calle 100 Landfill Expansion Area	7,234	13,610	0	4,414	1,706	890	56	8,940	890	18,079	19,313
Calle 100 Landfill existing Area	0	0	0	0	2,957	588	750	2,957	588	750	1,452
Total	18,632	28,421	0	7,718	12,151	4,498	1,030	30,783	4,498	37,169	42,850

Note : * ; CUP : CUC : US$ = 26 : 1: 1

Table 5 Breakdown of Direct Costs for Construction for Closure Landfill Work in M/P

(Unit : x1000)

Item	Construction Cost with operation		
	CUP	US$	TOTAL*
10 Special Period Landfill Closure	3,308	2,217	2,344
Calle 100 at Existing Area	2,852	1,945	2,055
Calle 100 in Expansion Area	303	202	214
Existing Guanabacoa Landfill	1,742	1,175	1,242
Total	8,205	5,539	5,855

Note : * ; CUP : CUC : US$ = 26 : 1: 1

Note: The estimated cost excludes contingency and engineer service fee.

2.2 Summary of Project Cost for Landfill Part

Table 6 Total Cost for Landfill Part in M/P

(Unit : x1000)

Item	Construction Cost included Engineer service		Equipment cost included heavy equipment		OM cost			TOTAL			
	CUP	US$	CUP	US$	CUP	CUC	US$	CUP	CUC	US$	TOTAL*
Landfill Construction and Expansion	21,469	33,057	0	8,104	12,151	4,498	1,030	33,620	4,498	42,191	47,981
Existing Landfill Closure	9,417	6,521	0	0	0	0	0	9,417	0	6,521	6,883
Maintenance Tool Equipment	0	0	0	289	1,757	118	13	1,757	118	302	488
Total	30,886	39,578	0	8,392	13,908	4,616	1,043	44,794	4,616	49,014	55,352

Note : * ; CUP : CUC : US$ = 26 : 1: 1

Table 7 Total Project Cost for Construction of Landfills

(Unit : x1000)

Item	Construction Cost included Engineer service		Equipment cost included heavy equipment		OM cost			TOTAL			
	CUP	US$	CUP	US$	CUP	CUC	US$	CUP	CUC	US$	TOTAL*
New Site 1 Landfill	7,627	7,296	0	1,435	4,597	2,095	139	12,224	2,095	8,871	11,435
New Guanabacoa Landfill	5,607	10,153	0	2,034	2,891	924	85	8,498	924	12,272	13,523
Calle 100 Landfill Expansion Area	8,235	15,608	0	4,634	1,706	890	56	9,942	890	20,298	21,571
Calle 100 Landfill existing Area **	0	0	0	0	2,957	588	750	2,957	588	750	1,452
Total	21,469	33,057	0	8,104	12,151	4,498	1,030	33,620	4,498	42,191	47,981

Note : * ; CUP : CUC : US$ = 26 : 1: 1
** ; OM cost is necessary during 2006 to 2008

Table 8 Total Project Cost for Construction of Landfills

(Unit : x1000)

Item	Construction Cost included Engineer service		TOTAL*
	CUP	US$	
10 Special Period Landfill Closure	3,694	2,498	2,640
Calle 100 at Existing Area	3,338	2,358	2,486
Calle 100 in Expansion Area	402	302	318
Existing Guanabacoa Landfill	1,982	1,364	1,440
Total	9,417	6,521	6,883

Note : * ; CUP : CUC : US$ = 26 : 1: 1

2.3 Disbursement Schedule for Landfill Part

Table 9 shows the schedule and Table 10 shows total cost of the landfill part.

Table 9 Total Project Cost for Landfill Part in M/P

(Unit : x 1000)

Project	Total Price (Y2006 - Y2015)				Y 2006				Y 2007				Y 2008				Y 2009				Y 2010			
	TOTAL	CUP	CUC	US$	TOTAL	CUP	CUC	US$	TOTAL	CUP	CUC	US$	TOTAL	CUP	CUC	US$	TOTAL	CUP	CUC	US$	TOTAL	CUP	CUC	US$
1.Final Disposal site																								
A. Construction of New Site 1 Landfill																								
1. Construction Cost	6,341	6,542	0	6,089	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3,764	4,356	0	3,596
Contingency Cost (10% of Construction Cost)	634	654	0	609	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	376	436	0	360
2. Procurement of waste management equipment	527	0	0	527	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	198	0	0	198
Contingency Cost (5% of Procurement Cost)	26	0	0	26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	10
3. Procurement of Equipment for landfill Operation	840	0	0	840	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Contingency Cost (5% of Procurement Cost)	42	0	0	42	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4. Engineering Service (included Survey cost and tender)	380	172	0	373	0	0	0	0	27	13	0	26	102	50	0	100	42	19	0	41	111	30	0	110
5. Administration	235	259	0	225	0	0	0	0	15	20	0	14	63	75	0	60	26	29	0	25	68	45	0	66
6. O/M Cost	2,411	4,597	2,095	139	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	11,435	12,224	2,095	8,871	0	0	0	0	41	33	0	40	165	125	0	160	68	48	0	66	4,526	4,867	0	4,339
B. Construction of New Guanabacoa Landfill																								
1. Construction Cost	8,909	4,856	0	8,722	0	0	0	0	0	0	0	0	5,392	3,422	0	5,261	0	0	0	0	0	0	0	0
Contingency Cost (10% of Construction Cost)	891	486	0	872	0	0	0	0	0	0	0	0	539	342	0	526	0	0	0	0	0	0	0	0
2. Procurement of waste management equipment	297	0	0	297	0	0	0	0	0	0	0	0	121	0	0	121	0	0	0	0	3	0	0	3
Contingency Cost (5% of Procurement Cost)	15	0	0	15	0	0	0	0	0	0	0	0	6	0	0	6	0	0	0	0	0	0	0	0
3. Procurement of Equipment for landfill Operation	1,640	0	0	1,640	0	0	0	0	0	0	0	0	1,570	0	0	1,570	0	0	0	0	0	0	0	0
Contingency Cost (5% of Procurement Cost)	82	0	0	82	0	0	0	0	0	0	0	0	79	0	0	79	0	0	0	0	0	0	0	0
4. Engineering Service (included Survey cost and tender)	353	106	0	349	0	0	0	0	0	0	0	0	158	42	0	156	0	0	0	0	95	31	0	94
5. Administration	216	159	0	210	0	0	0	0	0	0	0	0	95	62	0	93	0	0	0	0	59	47	0	57
6. O/M Cost	1,120	2,891	924	85	0	0	0	0	0	0	0	0	0	0	0	0	160	415	132	12	160	416	132	12
TOTAL	13,523	8,498	924	12,272	0	0	0	0	0	0	0	0	7,960	3,868	0	7,812	160	415	132	12	317	494	132	166
C. Expansion of Existing Calle 100Landfill																								
1. Construction Cost	13,888	7,234	0	13,610	0	0	0	0	0	0	0	0	13,888	7,234	0	13,610	0	0	0	0	0	0	0	0
Contingency Cost (10% of Construction Cost)	1,389	723	0	1,361	0	0	0	0	0	0	0	0	1,389	723	0	1,361	0	0	0	0	0	0	0	0
2. Procurement of waste management equipment	175	0	0	175	0	0	0	0	0	0	0	0	156	0	0	156	0	0	0	0	0	0	0	0
Contingency Cost (5% of Procurement Cost)	9	0	0	9	0	0	0	0	0	0	0	0	8	0	0	8	0	0	0	0	0	0	0	0
3. Procurement of Equipment for landfill Operation	4,239	0	0	4,239	0	0	0	0	0	0	0	0	3,908	0	0	3,908	331	0	0	331	0	0	0	0
Contingency Cost (5% of Procurement Cost)	212	0	0	212	0	0	0	0	0	0	0	0	195	0	0	195	17	0	0	17	0	0	0	0
4. Engineering Serves (included Survey cost and tender)	463	111	0	459	0	0	0	0	101	20	0	100	363	91	0	359	0	0	0	0	0	0	0	0
5. Administration	184	167	0	178	0	0	0	0	40	30	0	39	144	137	0	139	0	0	0	0	0	0	0	0
6. O/M Cost	1,012	1,706	890	56	0	0	0	0	0	0	0	0	0	0	0	0	532	853	471	28	480	853	419	28
TOTAL	21,571	9,942	890	20,298	0	0	0	0	141	50	0	139	20,051	8,185	0	19,736	880	853	471	375	480	853	419	28
D. Closure of Special Period Dumping Sites except Campo Florido																								
1. Construction Cost	2,344	3,308	0	2,217	0	0	0	0	0	0	0	0	0	0	0	0	2,344	3,308	0	2,217	0	0	0	0
Contingency Cost (10% of Construction Cost)	234	331	0	222	0	0	0	0	0	0	0	0	0	0	0	0	234	331	0	222	0	0	0	0
4. Engineering Serves (included Survey cost and tender)	38	22	0	37	0	0	0	0	16	10	0	16	4	2	0	4	10	6	0	10	7	4	0	7
5. Administration	23	33	0	22	0	0	0	0	10	15	0	9	3	3	0	3	6	9	0	6	4	6	0	4
TOTAL	2,640	3,694	0	2,498	0	0	0	0	26	25	0	25	7	5	0	7	2,595	3,654	0	2,455	11	10	0	11
E. Closure of Existing Calle 100 Landfill Site																								
1. Construction Cost	2,055	2,852	0	1,945	0	0	0	0	0	0	0	0	0	0	0	0	2,055	2,852	0	1,945	0	0	0	0
Contingency Cost (10% of Construction Cost)	205	285	0	195	0	0	0	0	0	0	0	0	0	0	0	0	205	285	0	195	0	0	0	0
4. Engineering Serves (included Survey cost and tender)	138	80	0	135	0	0	0	0	60	35	0	59	14	8	0	14	63	37	0	62	0	0	0	0
5. Administration	88	121	0	83	0	0	0	0	38	53	0	36	9	12	0	9	40	56	0	38	0	0	0	0
TOTAL	2,486	3,338	0	2,358	0	0	0	0	98	88	0	95	24	20	0	23	2,364	3,230	0	2,240	0	0	0	0
F. Closure of Expansion area of Calle 100 Landfill Site																								
1. Construction Cost	214	303	0	202	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Contingency Cost (10% of Construction Cost)	21	30	0	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4. Engineering Serves (included Survey cost and tender)	52	31	0	51	0	0	0	0	23	13	0	22	20	12	0	20	0	0	0	0	0	0	0	0
5. Administration	30	38	0	29	0	0	0	0	16	20	0	15	15	18	0	14	0	0	0	0	0	0	0	0
TOTAL	318	402	0	302	0	0	0	0	38	33	0	37	35	30	0	34	0	0	0	0	0	0	0	0
G. Closure of Existing Guanabacoa Landfill Site																								
1. Construction Cost	1,242	1,742	0	1,175	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Contingency Cost (10% of Construction Cost)	124	174	0	118	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4. Engineering Serves (included Survey cost and tender)	45	26	0	44	0	0	0	0	0	0	0	0	0	0	0	0	20	11	0	20	4	3	0	4
5. Administration	29	40	0	27	0	0	0	0	0	0	0	0	0	0	0	0	13	17	0	12	3	5	0	3
TOTAL	1,440	1,982	0	1,364	0	0	0	0	0	0	0	0	0	0	0	0	33	28	0	32	7	8	0	7
H. Central Work Shop (Maintenance Equipment)																								
3. Procurement of Maintenance equipment Cost	275	0	0	275	0	0	0	0	0	0	0	0	135	0	0	135	0	0	0	0	4	0	0	4
Contingency Cost (5% of Construction Cost)	14	0	0	14	0	0	0	0	0	0	0	0	7	0	0	7	0	0	0	0	0	0	0	0
6. O/M Cost	4	1,757	118	13	4	*0*	*0*	*0*	4	*0*	*0*	*0*	4	*0*	*4*	*0*	4	*251*	*17*	*2*	4	*251*	*16*	*2*
TOTAL	293	1,757	118	302	4	0	0	0	4	0	0	0	146	0	4	142	4	251	17	2	9	251	16	6
G. Calle 100 Existing Area Operation Cost																								
6. O/M Cost	1,452	2,957	588	750	484	*986*	*196*	*250*	484	*986*	*196*	*250*	484	*986*	*196*	*250*	0	*0*	*0*	*0*	0	*0*	*0*	*0*
TOTAL	1,452	2,957	588	750	484	986	196	250	484	986	196	250	484	986	196	250	0	0	0	0	0	0	0	0
TOTAL																								
1. Construction Cost	34,992	26,837	0	33,960	0	0	0	0	0	0	0	0	19,281	10,656	0	18,871	4,399	6,160	0	4,162	3,764	4,356	0	3,596
Contingency Cost (10% of Construction Cost)	3,499	2,684	0	3,396	0	0	0	0	0	0	0	0	1,928	1,066	0	1,887	440	616	0	416	376	436	0	360
2. Procurement of waste management equipment*	1,274	0	0	1,274	0	0	0	0	0	0	0	0	412	0	0	412	0	0	0	0	205	0	0	205
Contingency Cost (5% of Construction Cost)	64	0	0	64	0	0	0	0	0	0	0	0	21	0	0	21	0	0	0	0	10	0	0	10
3. Procurement of Equipment for landfill Operation	6,719	0	0	6,719	0	0	0	0	0	0	0	0	5,478	0	0	5,478	331	0	0	331	0	0	0	0
Contingency Cost (5% of Construction Cost)	336	0	0	336	0	0	0	0	0	0	0	0	274	0	0	274	17	0	0	17	0	0	0	0
4. Engineering Service (included Survey cost and tender)	1,469	548	0	1,448	0	0	0	0	227	91	0	223	661	205	0	653	136	73	0	133	218	68	0	215
5. Administration	805	817	0	774	0	0	0	0	118	138	0	113	330	307	0	318	85	111	0	81	134	103	0	130
6. O/M Cost	6,194	13,908	4,616	1,043	484	986	196	250	484	986	196	250	488	986	200	250	721	1,520	621	42	667	1,520	567	42
TOTAL	55,352	44,794	4,616	49,014	484	986	196	250	829	1,215	196	586	28,872	13,219	200	28,163	6,128	8,480	621	5,182	5,374	6,483	567	4,557

Note: * Total procurement cost of waste management equipment includes the procurement cost of maintenance equipment

Table 9 Total Cost for Landfill Part in M/P (continue)

(Unit : x 1000)

Project	Y 2011				Y 2012				Y 2013				Y 2014				Y 2015			
	TOTAL	CUP	CUC	US$	TOTAL	CUP	CUC	US$	TOTAL	CUP	CUC	US$	TOTAL	CUP	CUC	US$	TOTAL	CUP	CUC	US$
1.Final Disposal site																				
A. Construction of New Site 1 Landfill																				
1. Construction Cost	0	0	0	0	0	0	0	0	2,577	2,186	0	2,493	0	0	0	0	0	0	0	0
Contingency Cost (10% of Construction Cost)	0	0	0	0	0	0	0	0	258	219	0	249	0	0	0	0	0	0	0	0
2. Procurement of waste management equipment	0	0	0	0	0	0	0	0	171	0	0	171	8	0	0	8	151	0	0	151
Contingency Cost (5% of Procurement Cost)	0	0	0	0	0	0	0	0	9	0	0	9	0	0	0	0	8	0	0	8
3. Procurement of Equipment for landfill Operation	770	0	0	770	0	0	0	0	70	0	0	70	0	0	0	0	0	0	0	0
Contingency Cost (5% of Procurement Cost)	39	0	0	39	0	0	0	0	4	0	0	4	0	0	0	0	0	0	0	0
4. Engineering Service (included Survey cost and tender)	63	28	0	62	4	2	0	4	31	30	0	30	0	0	0	0	0	0	0	0
5. Administration	40	42	0	38	3	3	0	3	21	45	0	19	0	0	0	0	0	0	0	0
6. O/M Cost	482	924	419	28	482	923	419	28	482	923	419	28	482	913	419	28	482	913	419	28
TOTAL	1,393	994	419	936	489	928	419	35	3,622	3,403	419	3,072	490	913	419	36	640	913	419	186
B. Construction of New Guanabacoa Landfill																				
1. Construction Cost	3,517	1,434	0	3,461	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Contingency Cost (10% of Construction Cost)	352	143	0	346	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2. Procurement of waste management equipment	170	0	0	170	0	0	0	0	0	0	0	0	3	0	0	3	0	0	0	0
Contingency Cost (5% of Procurement Cost)	8	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3. Procurement of Equipment for landfill Operation	0	0	0	0	0	0	0	0	70	0	0	70	0	0	0	0	0	0	0	0
Contingency Cost (5% of Procurement Cost)	0	0	0	0	0	0	0	0	4	0	0	4	0	0	0	0	0	0	0	0
4. Engineering Service (included Survey cost and tender)	100	33	0	99	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5. Administration	62	50	0	60	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6. O/M Cost	160	416	132	12	160	411	132	12	160	411	132	12	160	411	132	12	160	411	132	12
TOTAL	4,369	2,076	132	4,157	160	411	132	12	233	411	132	86	163	411	132	15	160	411	132	12
C. Expansion of Existing Calle 100Landfill																				
1. Construction Cost	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Contingency Cost (10% of Construction Cost)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2. Procurement of waste management equipment	9	0	0	9	0	0	0	0	9	0	0	9	0	0	0	0	0	0	0	0
Contingency Cost (5% of Procurement Cost)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3. Procurement of Equipment for landfill Operation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Contingency Cost (5% of Procurement Cost)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4. Engineering Serves (included Survey cost and tender)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5. Administration	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6. O/M Cost	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	10	0	0	10	0	0	0	0	10	0	0	10	0	0	0	0	0	0	0	0
D. Closure of Special Period Dumping Sites except Campo Florido																				
1. Construction Cost	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Contingency Cost (10% of Construction Cost)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4. Engineering Serves (included Survey cost and tender)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5. Administration of Construction??	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
E. Closure of Existing Calle 100 Landfill Site																				
1. Construction Cost	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Contingency Cost (10% of Construction Cost)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4. Engineering Serves (included Survey cost and tender)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5. Administration	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F. Closure of Expansion area of Calle 100 Landfill Site																				
1. Construction Cost	0	0	0	0	0	0	0	0	214	303	0	202	0	0	0	0	0	0	0	0
Contingency Cost (10% of Construction Cost)	0	0	0	0	0	0	0	0	21	30	0	20	0	0	0	0	0	0	0	0
4. Engineering Serves (included Survey cost and tender)	0	0	0	0	9	6	0	9	0	0	0	0	0	0	0	0	0	0	0	0
5. Administration	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	0	0	0	0	9	6	0	9	235	333	0	222	0	0	0	0	0	0	0	0
G. Closure of Existing Guanabacoa Landfill Site																				
1. Construction Cost	1,242	1,742	0	1,175	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Contingency Cost (10% of Construction Cost)	124	174	0	118	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4. Engineering Serves (included Survey cost and tender)	20	12	0	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5. Administration	13	18	0	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	1,399	1,946	0	1,325	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
H. Central Work Shop (Maintenance Equipment)																				
3. Procurement of Maintenance equipment Cost	0	0	0	0	0	0	0	0	132	0	0	132	4	0	0	4	0	0	0	0
Contingency Cost (5% of Construction Cost)	0	0	0	0	0	0	0	0	7	0	0	7	0	0	0	0	0	0	0	0
6. O/M Cost	4	*251*	*16*	*2*	4	*251*	*16*	*2*	4	*251*	*16*	*2*	4	*251*	*16*	*2*	4	251	16	2
TOTAL	4	251	16	2	4	251	16	2	143	251	16	141	9	251	16	6	4	251	16	2
G. Calle 100 Existing Area Operation Cost																				
6. O/M Cost	0	*0*	*0*	*0*	0	*0*	*0*	*0*	0	*0*	*0*	*0*	0	*0*	*0*	*0*	0	0	0	0
TOTAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL																				
1. Construction Cost	4,759	3,176	0	4,636	0	0	0	0	2,791	2,489	0	2,695	0	0	0	0	0	0	0	0
Contingency Cost (10% of Construction Cost)	476	318	0	464	0	0	0	0	279	249	0	270	0	0	0	0	0	0	0	0
2. Procurement of waste management equipment	179	0	0	179	0	0	0	0	312	0	0	312	15	0	0	15	151	0	0	151
Contingency Cost (5% of Construction Cost)	9	0	0	9	0	0	0	0	16	0	0	16	1	0	0	1	8	0	0	8
3. Procurement of Equipment for landfill Operation	770	0	0	770	0	0	0	0	140	0	0	140	0	0	0	0	0	0	0	0
Contingency Cost (5% of Construction Cost)	39	0	0	39	0	0	0	0	7	0	0	7	0	0	0	0	0	0	0	0
4. Engineering Service (included Survey cost and tender)	184	73	0	181	13	8	0	13	31	30	0	30	0	0	0	0	0	0	0	0
5. Administration	114	110	0	110	3	3	0	3	21	45	0	19	0	0	0	0	0	0	0	0
6. O/M Cost	670	1,590	567	42	670	1,585	567	42	670	1,585	567	42	670	1,575	567	42	670	1,575	567	42
TOTAL	7,199	5,267	567	6,429	686	1,596	567	58	4,266	4,398	567	3,530	686	1,575	567	58	828	1,575	567	200

Note: * Total procurement cost of waste management equipment includes the procurement cost of maintenance equipment

Table 10 Total Cost for Landfill Part in M/P

(Unit : x1000)

Project Item	Y2006 - Y2015		Y 2006		Y 2007		Y 2008		Y 2009	
	LC	FC	LC	FC	LC	FC	LC	FC	LC	FC
A. Construction of New Site 1 Landfill										
1. Construction Cost	6,542	6,089	0	0	0	0	0	0	0	0
Contingency Cost (10% of Construction Cost)	654	609	0	0	0	0	0	0	0	0
2. Procurement of waste management equipment	0	527	0	0	0	0	0	0	0	0
Contingency Cost (5% of Procurement Cost)	0	26	0	0	0	0	0	0	0	0
3. Procurement of Equipment for landfill Operation	0	840	0	0	0	0	0	0	0	0
Contingency Cost (5% of Procurement Cost)	0	42	0	0	0	0	0	0	0	0
4. Engineering Service (included Survey cost and tender)	172	373	0	0	13	26	50	100	19	41
5. Administration for engineering service	259	225	0	0	20	14	75	60	29	25
6. O/M Cost	4,597	2,234	0	0	0	0	0	0	0	0
TOTAL	12,224	10,965	0	0	33	40	125	160	48	66
B. Construction of New Guanabacoa Landfill	0	0	0	0	0	0	0	0	0	0
1. Construction Cost	4,856	8,722	0	0	0	0	3,422	5,261	0	0
Contingency Cost (10% of Construction Cost)	486	872	0	0	0	0	342	526	0	0
2. Procurement of waste management equipment	0	297	0	0	0	0	0	121	0	0
Contingency Cost (5% of Procurement Cost)	0	15	0	0	0	0	0	6	0	0
3. Procurement of Equipment for landfill Operation	0	1,640	0	0	0	0	0	1,570	0	0
Contingency Cost (5% of Procurement Cost)	0	82	0	0	0	0	0	79	0	0
4. Engineering Service (included Survey cost and tender)	106	349	0	0	0	0	42	156	0	0
5. Administration for engineering service	159	210	0	0	0	0	62	93	0	0
6. O/M Cost	2,891	1,009	0	0	0	0	0	0	415	144
TOTAL	8,498	13,196	0	0	0	0	3,868	7,812	415	144
C. Expansion of Existing Calle 100Landfill	0	0	0	0	0	0	0	0	0	0
1. Construction Cost	7,234	13,610	0	0	0	0	7,234	13,610	0	0
Contingency Cost (10% of Construction Cost)	723	1,361	0	0	0	0	723	1,361	0	0
2. Procurement of waste management equipment	0	175	0	0	0	0	0	156	0	0
Contingency Cost (5% of Procurement Cost)	0	9	0	0	0	0	0	8	0	0
3. Procurement of Equipment for landfill Operation	0	4,239	0	0	0	0	0	3,908	0	331
Contingency Cost (5% of Procurement Cost)	0	212	0	0	0	0	0	195	0	17
4. Engineering Serves (included Survey cost and tender)	111	459	0	0	20	100	91	359	0	0
5. Administration for engineering service	167	178	0	0	30	39	137	139	0	0
6. O/M Cost	1,706	946	0	0	0	0	0	0	853	499
TOTAL	9,942	21,188	0	0	50	139	8,185	19,736	853	847
D. Closure of Special Period Dumping Sites except Campo Florido		0	0	0	0	0	0	0	0	0
1. Construction Cost	3,308	2,217	0	0	0	0	0	0	3,308	2,217
Contingency Cost (10% of Construction Cost)	331	222	0	0	0	0	0	0	331	222
4. Engineering Serves (included Survey cost and tender)	22	37	0	0	10	16	2	4	6	10
5. Administration for engineering service	33	22	0	0	15	9	3	3	9	6
TOTAL	3,694	2,498	0	0	25	25	5	7	3,654	2,455
E. Closure of Existing Calle 100 Landfill Site		0	0	0	0	0	0	0	0	0
1. Construction Cost	2,852	1,945	0	0	0	0	0	0	2,852	1,945
Contingency Cost (10% of Construction Cost)	285	195	0	0	0	0	0	0	285	195
4. Engineering Serves (included Survey cost and tender)	80	135	0	0	35	59	8	14	37	62
5. Administration for engineering service	121	83	0	0	53	36	12	9	56	38
TOTAL	3,338	2,358	0	0	88	95	20	23	3,230	2,240
F. Closure of Expansion area of Calle 100 Landfill Site		0	0	0	0	0	0	0	0	0
1. Construction Cost	303	202	0	0	0	0	0	0	0	0
Contingency Cost (10% of Construction Cost)	30	20	0	0	0	0	0	0	0	0
4. Engineering Serves (included Survey cost and tender)	31	51	0	0	13	22	12	20	0	0
5. Administration for engineering service	38	29	0	0	20	15	18	14	0	0
TOTAL	402	302	0	0	33	37	30	34	0	0
G. Closure of Existing Guanabacoa Landfill Site		0	0	0	0	0	0	0	0	0
1. Construction Cost	1,742	1,175	0	0	0	0	0	0	0	0
Contingency Cost (10% of Construction Cost)	174	118	0	0	0	0	0	0	0	0
4. Engineering Serves (included Survey cost and tender)	26	44	0	0	0	0	0	0	11	20
5. Administration for engineering service	40	27	0	0	0	0	0	0	17	12
TOTAL	1,982	1,364	0	0	0	0	0	0	28	32
H. Central Work Shop (Maintenance Equipment)		0	0	0	0	0	0	0	0	0
3. Procurement of Maintenance equipment Cost	0	275	0	0	0	0	0	135	0	0
Contingency Cost (5% of Procurement Cost)	0	14	0	0	0	0	0	7	0	0
6. O/M Cost	1,757	132	0	0	0	0	0	4	251	19
TOTAL	1,757	420	0	0	0	0	0	146	251	19
I. Calle 100 Existing Area Operation Cost	0	0	0	0	0	0	0	0	0	0
6. O/M Cost	2,957	1,338	986	446	986	446	986	446	0	0
TOTAL	2,957	1,338	986	446	986	446	986	446	0	0
TOTAL		0	0	0	0	0	0	0	0	0
1. Construction Cost (included Contingency 10%)	26,837	33,960	0	0	0	0	10,656	18,871	6,160	4,162
Contingency Cost (10% of Construction Cost)	2,684	3,396	0	0	0	0	1,066	1,887	616	416
2. Procurement of waste management equipment	0	1,274	0	0	0	0	0	412	0	0
Contingency Cost (5% of Procurement Cost)	0	64	0	0	0	0	0	21	0	0
3. Procurement of Equipment for landfill Operation	0	6,719	0	0	0	0	0	5,478	0	331
Contingency Cost (5% of Procurement Cost)	0	336	0	0	0	0	0	274	0	17
4. Engineering Service (included Survey cost and tender)	548	1,448	0	0	91	223	205	653	73	133
5. Administration for engineering service	817	774	0	0	138	113	307	318	111	81
6. O/M Cost	13,908	5,659	986	446	986	446	986	450	1,520	662
TOTAL	44,794	53,630	986	446	1,215	782	13,219	28,364	8,480	5,802

Note: * Total procurement cost of waste management equipment includes the procurement cost of maintenance equipment

Table 10 Total Cost for Landfill Part in M/P (continue)

(Unit : x 1000)

Project Item	Y 2010		Y 2011		Y 2012		Y 2013		Y 2014		Y 2015	
	LC	FC	LC	FC	LC	FC	LC	FC	LC	FC	LC	FC
A. Construction of New Site 1 Landfill												
1. Construction Cost	4,356	3,596	0	0	0	0	2,186	2,493	0	0	0	0
Contingency Cost (10% of Construction Cost)	436	360	0	0	0	0	219	249	0	0	0	0
2. Procurement of waste management equipment	0	198	0	0	0	0	0	171	0	8	0	151
Contingency Cost (5% of Procurement Cost)	0	10	0	0	0	0	0	9	0	0	0	8
3. Procurement of Equipment for landfill Operation	0	0	0	770	0	0	0	70	0	0	0	0
Contingency Cost (5% of Procurement Cost)	0	0	0	39	0	0	0	4	0	0	0	0
4. Engineering Service (included Survey cost and tender)	30	110	28	62	2	4	30	30	0	0	0	0
5. Administration for engineering service	45	66	42	38	3	3	45	19	0	0	0	0
6. O/M Cost	0	0	924	447	923	447	923	447	913	447	913	447
TOTAL	4,867	4,339	994	1,355	928	454	3,403	3,491	913	455	913	605
B. Construction of New Guanabacoa Landfill	0	0	0	0	0	0	0	0	0	0	0	0
1. Construction Cost	0	0	1,434	3,461	0	0	0	0	0	0	0	0
Contingency Cost (10% of Construction Cost)	0	0	143	346	0	0	0	0	0	0	0	0
2. Procurement of waste management equipment	0	3	0	170	0	0	0	0	0	3	0	0
Contingency Cost (5% of Procurement Cost)	0	0	0	8	0	0	0	0	0	0	0	0
3. Procurement of Equipment for landfill Operation	0	0	0	0	0	0	0	70	0	0	0	0
Contingency Cost (5% of Procurement Cost)	0	0	0	0	0	0	0	4	0	0	0	0
4. Engineering Service (included Survey cost and tender)	31	94	33	99	0	0	0	0	0	0	0	0
5. Administration for engineering service	47	57	50	60	0	0	0	0	0	0	0	0
6. O/M Cost	416	144	416	144	411	144	411	144	411	144	411	144
TOTAL	494	299	2,076	4,289	411	144	411	218	411	148	411	144
C. Expansion of Existing Calle 100Landfill	0	0	0	0	0	0	0	0	0	0	0	0
1. Construction Cost	0	0	0	0	0	0	0	0	0	0	0	0
Contingency Cost (10% of Construction Cost)	0	0	0	0	0	0	0	0	0	0	0	0
2. Procurement of waste management equipment	0	0	0	9	0	0	0	9	0	0	0	0
Contingency Cost (5% of Procurement Cost)	0	0	0	0	0	0	0	0	0	0	0	0
3. Procurement of Equipment for landfill Operation	0	0	0	0	0	0	0	0	0	0	0	0
Contingency Cost (5% of Procurement Cost)	0	0	0	0	0	0	0	0	0	0	0	0
4. Engineering Serves (included Survey cost and tender)	0	0	0	0	0	0	0	0	0	0	0	0
5. Administration for engineering service	0	0	0	0	0	0	0	0	0	0	0	0
6. O/M Cost	853	447	0	0	0	0	0	0	0	0	0	0
TOTAL	853	447	0	10	0	0	0	10	0	0	0	0
D. Closure of Special Period Dumping Sites except Campo Florido	0	0	0	0	0	0	0	0	0	0	0	0
1. Construction Cost	0	0	0	0	0	0	0	0	0	0	0	0
Contingency Cost (10% of Construction Cost)	0	0	0	0	0	0	0	0	0	0	0	0
4. Engineering Serves (included Survey cost and tender)	4	7	0	0	0	0	0	0	0	0	0	0
5. Administration for engineering service	6	4	0	0	0	0	0	0	0	0	0	0
TOTAL	10	11	0	0	0	0	0	0	0	0	0	0
E. Closure of Existing Calle 100 Landfill Site	0	0	0	0	0	0	0	0	0	0	0	0
1. Construction Cost	0	0	0	0	0	0	0	0	0	0	0	0
Contingency Cost (10% of Construction Cost)	0	0	0	0	0	0	0	0	0	0	0	0
4. Engineering Serves (included Survey cost and tender)	0	0	0	0	0	0	0	0	0	0	0	0
5. Administration for engineering service	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	0	0	0	0	0	0	0	0	0	0	0	0
F. Closure of Expansion area of Calle 100 Landfill Site	0	0	0	0	0	0	0	0	0	0	0	0
1. Construction Cost	0	0	0	0	0	0	303	202	0	0	0	0
Contingency Cost (10% of Construction Cost)	0	0	0	0	0	0	30	20	0	0	0	0
4. Engineering Serves (included Survey cost and tender)	0	0	0	0	6	9	0	0	0	0	0	0
5. Administration for engineering service	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	0	0	0	0	6	9	333	222	0	0	0	0
G. Closure of Existing Guanabacoa Landfill Site	0	0	0	0	0	0	0	0	0	0	0	0
1. Construction Cost	0	0	1,742	1,175	0	0	0	0	0	0	0	0
Contingency Cost (10% of Construction Cost)	0	0	174	118	0	0	0	0	0	0	0	0
4. Engineering Serves (included Survey cost and tender)	3	4	12	20	0	0	0	0	0	0	0	0
5. Administration for engineering service	5	3	18	12	0	0	0	0	0	0	0	0
TOTAL	8	7	1,946	1,325	0	0	0	0	0	0	0	0
H. Central Work Shop (Maintenance Equipment)	0	0	0	0	0	0	0	0	0	0	0	0
3. Procurement of Maintenance equipment Cost	0	4	0	0	0	0	0	132	0	4	0	0
Contingency Cost (5% of Procurement Cost)	0	0	0	0	0	0	0	7	0	0	0	0
6. O/M Cost	251	18	251	18	251	18	251	18	251	18	251	18
TOTAL	251	22	251	18	251	18	251	157	251	22	251	18
I. Calle 100 Existing Area Operation Cost	0	0	0	0	0	0	0	0	0	0	0	0
6. O/M Cost	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	0	0	0	0	0	0	0	0	0	0	0	0
1. Construction Cost (included Contingency 10%)	4,356	3,596	3,176	4,636	0	0	2,489	2,695	0	0	0	0
Contingency Cost (10% of Construction Cost)	436	360	318	464	0	0	249	270	0	0	0	0
2. Procurement of waste management equipment	0	205	0	179	0	0	0	312	0	15	0	151
Contingency Cost (5% of Procurement Cost)	0	10	0	9	0	0	0	16	0	1	0	8
3. Procurement of Equipment for landfill Operation	0	0	0	770	0	0	0	140	0	0	0	0
Contingency Cost (5% of Procurement Cost)	0	0	0	39	0	0	0	7	0	0	0	0
4. Engineering Service (included Survey cost and tender)	68	215	73	181	8	13	30	30	0	0	0	0
5. Administration for engineering service	103	130	110	110	3	3	45	19	0	0	0	0
6. O/M Cost	1,520	609	1,590	609	1,585	609	1,585	609	1,575	609	1,575	609
TOTAL	6,483	5,125	5,267	6,996	1,596	625	4,398	4,097	1,575	625	1,575	767

Note: * Total procurement cost of waste management equipment includes the procurement cost of maintenance equipment

D. Environmental Survey:

D1 Site Description for IEE

D1. SITE DESCRIPTION FOR IEE

1. Social Environment

1.1 Affected and Related People/Groups

The Province of Havana City had a total population of approximately 2.2 million in mid-2002, representing about 20% of Cuba's population and 26% of its total urban population. The population distribution by municipality is shown in Table 1. The population distribution by age is presented in Table 2. The Municipality of Centro Habana is literally located at the center of the province and has the highest population density of 43,047 persons/km^2. The population of Havana City is older than the rest of the provinces, with 29% of the population being 50 years and over and 12% being 65 years and over.

Table 1 Population of 15 Municipalities in Havana City

Municipality	Total	Male	Female	Population Density (Person/km^2)
Playa	181,256	85,048	96,208	5,011
Plaza de la Revolucion	171,528	78,357	93,171	14,511
Centro Habana	149,476	69,542	79,934	43,047
La Habana Vieja	94,635	44,696	49,939	21,046
Regla	42,391	20,347	22,044	4,624
La Habana del Este	185,543	89,853	95,690	1,280
Guanabacoa	106,292	51,417	54,875	834
San Miguel del Padron	153,956	74,062	79,894	5,999
Diez de Octubre	227,501	105,712	121,789	18,734
Cerro	134,778	62,935	71,843	13,149
Marianao	137,838	65,444	72,394	6,464
La Lisa	127,843	61,978	65,865	3,408
Boyeros	188,881	91,820	97,061	1,407
Arroyo Naranjo	199,542	96,526	103,016	2,402
Cotorro	74,453	36,563	37,890	1,134
Total Havana City	2,175,913	1,034,300	1,141,613	2,992

Note: Data as of 30 June 2002
Source: Territorial Office of Statistics of Havana City

Table 2 Population Distribution by Age Group in Havana City

Age	Total	Male	Female
0-4 years	131,711	67,698	64,013
5-9 years	133,765	68,857	64,908
10-14 years	157,669	80,769	76,900
15-19 years	141,197	70,842	70,355
20-24 years	114,454	56,803	57,651
25-29 years	163,328	80,188	83,140
30-34 years	188,962	91,105	97,857
35-39 years	231,900	111,288	120,612
40-44 years	155,369	73,951	81,418
45-49 years	134,333	62,601	71,732
50-54 years	130,878	60,202	70,676
55-59 years	121,056	55,460	65,596
60-64 years	104,612	47,392	57,220
65-74 years	151,532	65,180	86,352
75-84 years	87,489	33,368	54,121
85 years +	27,658	8,596	19,062
Total Havana City	2,175,913	1,034,300	1,141,613

Note: Data as of 30 June 2002
Source: Territorial Office of Statistics of Havana City

1.2 Land Use and Utilization of Local Resources

Havana City, which has an area of 727 km^2 and population of 2.2 million, is the capital of the Republic of Cuba. The city is the center of all the economic activities of the country as well as the heart of tourism and industry. In fact, the old city area and its fortifications were designated by UNESCO as a world heritage in 1982.

In terms of land utilization, 304 km^2 (41.8%) is currently used for agriculture, while the remaining 422 km^2 (58.2%) is used for non-agricultural purposes. The data on the land utilization in Havana City are summarized in Table 3.

Based on the data prepared by the Ministry of Agriculture (MINAGRI) it is estimated that the residential area in Cuba totals 2,394 km^2. In Havana City 237 km^2 (32.9% of the total) is urban area, 20.43 km^2 (2.8%) as roads, 27.27 km^2 (3.4%) of industrial area and 25.89 km^2 (3.6%) that is used for water resources and related facilities.

Table 3 Land Use Plan in Havana City

Items	Area (km^2)	Ratio (%)
Agricultural Area	304.30	41.8
Non Agricultural Area	422.84	58.2
Total	727.14	100
Residential Area	237.44	32.9
Roads	20.43	2.8
Industrial Area	27.27	3.4
Water resources and related facilities	25.89	3.6

Source: Delegacion Provincial del MINAGRI, 2002

1.3 Economy

At present there is no calculation available for the Gross Regional Domestic Production (GRDP) of Havana City. Alternative data is available on the production of Havana City, which is as summarized in Table 4.

Table 4 Production of Havana City

(Unit: million Peso at current price)

	2000	2001	2002	2003
State sector	5,308	5,396	5,821	5,079
JV companies	1,029	1,134	1,314	1,472
Trade companies	2,886	2,880	2,798	2,993
Total production (Havana City)	9,223	9,410	9,933	9,543
GDP (Cuba total)	28,206	29,402	29,843	n.a.
Havana City production / Cuban GDP	33%	32%	33%	n.a.

Source: Havana City Territorial Office of Statistics, ECLAC

The total production of Havana City is shown as approximately 10 billion Pesos, or about a third of the Cuban GDP. The composition by industry of the state sector in Havana City is presented in Table 5. The manufacturing sector is the largest, accounting for half of the total production. Construction and transport sectors are the second and the third largest, respectively. In total, these three sectors account for nearly 80% of GDP.

Table 5 Industry Composition of State Entities in Havana City

(Unit: million Peso at current price)

Industry	2000	2001	2002	2003
Manufacturing	2,683	2,871	3,296	2,361
Construction	875	795	782	855
Agriculture	148	99	112	75
Sliviculture	15	35	43	46
Transport	525	504	465	435
Communication	93	100	45	53
Commerce	144	109	150	170
Other production activities	137	157	198	228
Communal services	97	80	80	104
Science and technology	106	132	146	161
Education	5	8	8	9
Culture and art	151	131	87	137
Public health, sport assistance	4	8	9	11
Finance and insurance	161	174	187	201
Administration	15	20	15	17
Other non production activities	151	174	198	216
Total	5,308	5,396	5,821	5,078

Source: Havana City Territorial Office of Statistics

The labor distribution among industries in Havana City is shown in Table 6. Administration is the largest and accounts for 20%. This is followed by manufacturing and commerce, which respectively employ 15% and 14% of the total workforce.

Table 6 Labor Distribution among Industries of Havana City

(Data of 2002)

Manufacturing	134,398	15%
Construction	50,173	5%
Agriculture	29,941	3%
Sliviculture	208	0%
Transport	41,285	5%
Communication	11,876	1%
Commerce	131,482	14%
Other production activities	10,842	1%
Communal services	47,639	5%
Science and technology	17,807	2%
Education	71,207	8%
Culture and art	29,196	3%
Public health, sport assistance	86,148	9%
Finance and insurance	8,737	1%
Administration	179,153	20%
Other non production activities	64,901	7%
Total	914,993	100%

Source: Havana City Territorial Office of Statistics

The production of the 15 municipalities in Havana City is shown in Table 7. Playa, Plaza de la Revolución, Centro Habana, and Habana Vieja are the four main municipalities in terms of industrial production. Those four municipalities accounted for approximately 70% of the total production. The production of joint venture companies and trade companies is also concentrated in these four municipalities. Again, because of joint venture companies and trade companies the production of Habana del Este and Boyeros is also relatively large.

Table 7 Production of 15 Municipalities in Havana City

(Unit: million Peso at current price)

	2000	2001	2002	2003
Playa	1,795	2,100	2,106	2,344
State sector	696	628	627	709
JV companies & trade companies	1,099	1,472	1,479	1,634
Plaza de la Revolucion	1,705	1,667	1,636	1,821
State sector	698	765	782	894
JV companies & trade companies	1,007	902	855	927
Centro Habana	1,575	1,106	2,227	1,343
State sector	591	345	1,382	392
JV companies & trade companies	985	761	845	951
La Habana Vieja	1,097	1,092	1,042	985
State sector	872	887	862	813
JV companies & trade companies	224	205	181	171
Regla	552	637	250	329
State sector	524	602	217	285
JV companies & trade companies	29	35	32	45
La Habana del Este	195	224	243	231
State sector	82	110	117	121
JV companies & trade companies	113	115	126	110
Guanabacoa	121	121	124	134
State sector	119	119	118	126
JV companies & trade companies	3	3	5	8
San Miguel del Padron	102	105	113	102
State sector	99	105	113	102
JV companies & trade companies	3	0	0	0
Diez de Octubre	331	343	328	349
State sector	310	324	310	328
JV companies & trade companies	20	19	18	21
Cerro	449	351	381	382
State sector	401	285	301	289
JV companies & trade companies	48	65	79	92
Marianao	211	230	247	216
State sector	154	155	156	131
JV companies & trade companies	57	75	92	85
La Lisa	173	175	184	207
State sector	160	164	163	171
JV companies & trade companies	13	11	21	36
Boyeros	647	972	757	767
State sector	335	623	386	394
JV companies & trade companies	312	350	371	372
Arroyo Naranjo	77	99	88	103
State sector	77	99	88	103
JV companies & trade companies	0	0	0	0
Cotorro	192	189	205	231
State sector	191	187	199	220
JV companies & trade companies	2	2	6	11
Total Havana City	9,223	9,410	9,933	9,542
State sector	5,308	5,396	5,821	5,079
JV companies & trade companies	3,915	4,014	4,112	4,463

Source: Havana City Territorial Office of Statistics

Other primary economic indicators are summarized in Table 8. The unemployment rate in 2002 improved to 3.3% down from 4.1% in 2001. It should be noted, however, that the official unemployment rates include only those people officially registered as being unemployed. The negative inflation in 1995 and 1996 was partly due to the appreciation of the unofficial exchange rate. After stabilization of consumer prices from 1995 to 2001, inflation accelerated and climbed to 7.0% in 2002 as depreciation of the exchange rate pushed up the peso cost of dollar goods. Cuba's total hard-currency debt in 2002 was nearly 11 billion US$. In terms of external debt, the official debt are almost all bilateral as

Cuba has no access to the major multilateral financial institutions such as the World Bank or the International Monetary Fund (IMF).

Table 8 Other Main Economic Indicators

Other Main Economic Indicators

	1994	1995	1996	1997	1998	1999	2000	2001	2002
Unemployment rate	6.7%	7.9%	7.6%	7.0%	6.6%	6.0%	5.5%	4.1%	3.3%
Inflation *1	0.0%	-11.5%	-4.9%	1.9%	2.9%	-2.9%	-3.0%	-0.5%	7.0%
Unofficial exchange rate (peso/US$) *2	95	32	19	23	21	20	21	26	26
External debts (million US$) *3	9,083	10,504	10,465	10,146	11,209	11,078	10,961	10,893	10,900

*1: A legal but unofficial exchange rate available only domestically, for personal transactions
*2: Computed by the official exchange rate of peso1:US$1
Source: "Economic Study for Latin America and the Carribean", ECLAC

2. Natural Environment

2.1 Topography and Geology

a) Soil contamination and soil erosion

Climatic, genetic and mainly anthropic factors related to the intensified use of the soil and its management have caused the impoverishment of the soil and may be rated as one of the main environmental problems of the capital.

Among the factors degrading the agricultural soil in the province, the use of inadequate farm techniques, irrigation with low quality waters and poor irrigation practices in general, and deforestation have induced erosion, compaction, and salinization of the soil and subsequently caused the present low fertility.

In Almendares-Vento Basin, almost the whole agricultural surface features some degree of erosion. In the area of the basin corresponding to Havana City, the situation is less critical in respect to La Habana province, but there are still zones with severe and very severe potential erosion. There is damage due to low fertility, salinity, and poor drainage.

According to information from the Institute of Soils from MINAGRI, in Havana Bay basin a great part of the agricultural area is affected by erosive processes and 15% already features severe erosion. Likewise, there is damage due to low fertility with a very low rate in the territory of the West Basins (5% of the total territory) where erosion affects 62% of the agricultural surface (almost 20% with strong erosion), 47% features low fertility, and for 20% of the area there is a very low fertility.

In the case of the West Basins, according to geo-environmental studies conducted by the Institute of Geo-Physics and Astronomy, around 1500 ha in La Lisa are affected, although in this case the level of erosion may be rated locally as low to moderate. The situation is similar for south of the Nina Bonita dam. In the Municipality of Playa the damage is in a low or slight category for the whole territory, while in Marianao in some localities it is rated as low to moderate.

2.2 Flora, Fauna and Habitat

a) Natural conditions

Characteristics of the Cuban fauna and flora are the result of the varied microclimatic, edaphic, geological, geomorphologocal, hydrogeologocal and landscape conditions of the island country. Many species are indigenous. A large area of Havana city has been urbanized causing a large reduction in the species of fauna and flora.

b) Reduction of endangered species of flora and fauna

Based on the Cuban categories for the endangered species (IES 2002), there are 14 endangered species of flora in Havana city as shown in Table 9.

Table 9 Endangered Species in Havana City

Name	Categories
Leptocereus wrightii	P
Leptocereus leonis	P
Acromia subinermis	E
Ouratea alaternifolia	E
Cnidoscolus fragans	E
Eugenia atricha	E
Eugenia mollifolia	E
Eugenia serrei	E
Eugenia anafensis	E
Eugenia duplicata	POE
Guapira leonis	POE
Pectis havanensis	POE
Ipomoea excise	POE
Cnidoscolus quinquelobatus	POE

Note: P: Facing a very high risk of extinction in the wild in the near future, E: Not endangered but is facing a high risk of extinction in the wild in the medium-term future. POE: P or E
Source: IES (2002)

According to reports from the National Center of Protected Areas (CNAP) three species of fauna have become extinct and another eight species are threatened as shown in Table 10.

Table 10 Extinguished Species of Fauna in Havana City

Name	Habitat	Categories
Hypolithes Cubensis	*Red shrimp of the coast between Havana Bay and Matanzas.*	*Extinguished*
Cerion fastigatum	*Mollusk of Vedado Coast.*	*Extinguished*
Cerion ricardi	*Mollusk of Tarará Zone.*	*Extinguished*
Cerion numia numia	*Mollusk of Miramar (Playa) zone.*	
Cerion numia chrysalis	*Mollusk of Marianao beach.*	
Cerion numia noriae	*Mollusk of Bacuranao beach (Habana del Este).*	
Cerion tridentatum	*Mollusk of Rincón de Guanabo (Habana del Este)*	
Cerion tridentatum rocai	*Mollusk of Guanabo river mouth.*	
Cerion salvatori striatissimum	*Mollusk of Santa Fé beach*	
Liguus fasciatus arangoi	*Mollusk of Loma de Guanabo*	
Hipolithes cubensis	*Red shrimp of the coast between Havana Bay and Matanzas.*	

Source: the National Center of Protected Areas

c) Natural System of Protected Areas

There are 17 proposed areas to be included in relevant categories of the National System of Protected Areas. The information and location are shown in Table 11 and Figure 1. These areas include ecosystems where there are endemic plant species or vegetal fossils related to specific geologic-geomorphologic conditions, as well as fauna species, including high zoological-archaelogical species in caves and marine-coastal resources.

In general, there are areas of local signification in the categories of Remarkable Natural Element (END), Protected Natural Landscape (PNP) and Managed Flora Reserve (RFM). The Ecological Reserve (RE) "La Coca" has national significance. Of these areas 13 are located in the East Basins of the city.

Other resources that should be preserved include mineral deposits (mainly construction materials), mineral-medicinal waters, zones of high landscape value, mangrove swamps and diving spots.

Table 11 Protected Areas to be included in the National System

No	Name	Category	Area (Ha)
1	*Cojímar River Valley*	RFM	105,14
2	*Bajurayabo Cuabal*	RFM	138,97
3	*Las Minas Cuabal*	RFM	129,80
4	*Colinas de Villareal*	END	1,41
5	*Tarara Cave*	END	0,35
6	*Portier- Lamas Cove*	PNP	215,87
7	*Josefina Island*	PNP	6,15
8	*La Coca*	RE	1392,34
9	*Cobre - Itabo Lagoon*	PNP	774,04
10	*Guanabo Hill*	END	192,28
11	*Celimar – Tarará river coastal thicket*	PNP	53,35
12	*Monte Barreto*	END	12,02
13	*Rincón de Guanabo*	PNP	581,79
14	*Santana Cuabal*	RFM	10.00
15	*El Gato Sima*	END	3.00
16	*Tarará River Valley*	PNP	100.00
17	*Tiscornia*	PNP	5.94

Source: National Center of Protected Areas, 2002

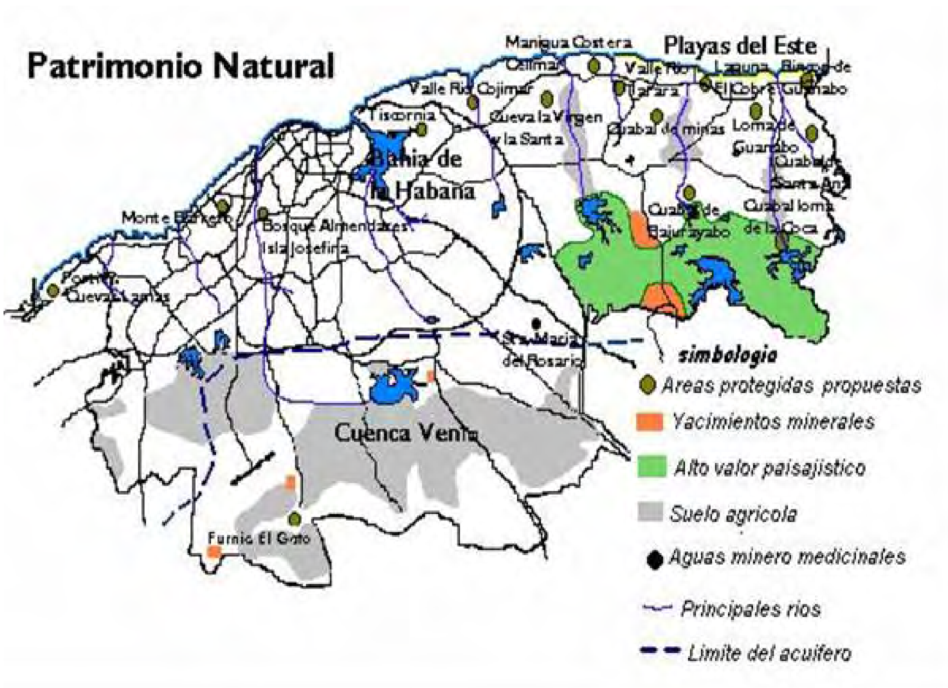


Figure 1 Location of Protected Area in Havana City

2.3 Climate

The climate of Havana City can be characterized from the climatic data of Casablanca and Santiago de las Vegas stations. The maximum temperatures in 2002 were 29.4°C at Casablanca, and 30.5°C at Santiago de las Vegas, while the respective minimum temperatures were 22.3°C and 20.5°C. The maximum and minimum temperatures recorded at Casablanca from 1909 to 2002 were 35.8°C and 8.5°C, respectively.

The annual rainfall in 2002 was 1556.8 mm. During the rainy season (from May to October), monthly rainfalls varied from 79.3 mm to 33.9 mm and the rainfall for these 6 months represented 72% of the annual total. In the rainy season, hurricanes hit Havana City, with the worst storms occurring in September and October.

The relative humidity varies seasonally in accordance with the rainfall pattern. The highest mean humidities occur between June and November, when values are around 80%, while the minimum values are recorded from January to April.

High wind speeds are not prevalent. The annual mean wind speeds are 3 m/s at Casablanca and 1.9 m/s at Santiago de las Vegas. Mean wind speeds are highest during the period of lower rainfall, mainly in March, April and February. Minimum values are recorded between June and September. The predominant wind direction during the year is easterly (for both Casablanca and Santiago de las Vegas stations).

2.4 River Systems

The area of Havana City is divided into four basins (Almendas Vento, East Basin, West Basin and Havana Bay Basin). About 47% of the drinking water consumed by the population in Havana City comes from the ground basin of Vento; between 300 and 350 metric tons are extracted from Ejercito Rebelde dam, which is also an efficient reloading facility for Vento Basin. It is also used extensively for agriculture, especially in Havana City province. The overall basin area is 402.02 km^2, of which 212.51 km^2 (52.8%) is in Havana City province and 189.51 km^2 (47.14%) in Havana City province. More than half a million people live in the Basin. Most main rivers in Havana City flow from south-west to north-east and discharge into the sea. The lengths of the main rivers are shown in Table 12.

Table 12 Main Rivers in Havana City

River	Length (km)
Almendares	46.8
Jaimanitas	11.8
Quibu	11.7
Luyano	10.4
Martin Perez	6.4
Cojimar	22.0
Guanabo	22.1
Itabo	17.0
Bacuranao	21.7

Source: Territorial Office of Statistics of Havana City

3. Pollution

3.1 Present Pollution

a) Water quality

According to data from the Provincial Delegation of INRH, the availability of the water resource in the provincial territory amounts to 326.8 million m^3 of which about 90% is in ground water and the rest in surface water.

The surface water resource is made up by the La Zarza, La Coca and Bacuranao dams. There are also 38 micro-dams for irrigation and recreational use as well as the Ejercito Rebelde dam for the reloading of the Vento Basin. The availability of surface water amounts to 30.6 millions m^3 of which 24.1 millions m^3 is regulated water and 6.5 millions m^3 is non-regulated water.

The potential of ground water in the provincial territory is made up by Jamanitas and Vento Basins with a total volume of 296.2 millions m^3.

The total availability of the water resource is not adequate for the demand of the city. Therefore, water is supplied from sources located in La Habana province.

The main supply source is the Almendares-Vento Basin which provides 48% of the supply to the city and the estimated potential of the ground water resource is 287 millions m^3. Almendas-Vento is located south and the water table is estimated to be about 90 m.

Of the population, 90.7%receive the aqueduct service but 38,145 inhabitants receive the service from cistern trucks due to the inadequacy or bad condition of the water resources (Provincial Direction of the INRH, 2002). The service availability is 10 hours daily on average (every other day in most of the city) and with insufficient pressure, which further demonstrates the an inadequacy of the service.

There is a water treatment plant in good condition associated with each of the three surface sources, which guarantees good quality water with an overall water purification level of 99.1%.

As a measure for the protection of the ground potential, the INRH enacted Resolution 67 of 1990 that prohibits the authorization of new extractions of ground water in Almendares-Vento Basin.

The solution to guarantee the supply of 600 l/sec for the east water treatment plant, without overexploiting the feeding dams, is to transfer water from the San Miguel and Jaruco dams.

The protection of the health of the population has been one of the main work objectives. Guaranteeing the water supply with bacteriological quality at acceptable levels for the WHO (which has made it possible) was considered in the item Human Health and

Environment, as important to continue the trend in the last 5 years for a decreasing incidence of water transmitted deseases.

The city rivers are not used as water supply sources for the population. The present condition of the rivers and dams reflects the impact of the inadequate treatment of fluid residuals as well as other factors such as deforestation, erosion of the banks and the inadequate care of the land.

Along their courses, the main rivers are collectors of home and industrial residuals. Luyano, Martin Perez, Cojimar, Quibu, Jaimanitas, Almendares and their tributaries as well as Tadeo stream feature high levels of degradation in the quality of the water.

Table 13 shows the water quality of Almendares river and Table 14 shows the water quality of Luyano river, Martin Perez river and Tadeo Stream.

Table 13 Water Quality of Almendares River

Sampling points	BOD (mg/L)				DO (mg/L)			
	Nov 2001	May 2002	Sep 2002	Dec 2002	Nov 2001	May 2002	Sep 2002	Dec 2002
Calle 100 Bridge	28	6	9	7	6	3.9	2.7	3.1
Husillo Bridge	35	5	7	6	8	4.1	1.4	3.7
Before La Tropical	47	9	9	6	4	3.5	2.3	2.2
Stone Bridge	59	8	7	7	6	4.1	3.2	2.7
23rd street bridge	39	7	8	9	3.5	3.2	2.5	4.3
Average	41.8	7	8	7	5.5	3.7	2.4	3.2

Source: CENHIC, 2002

Table 14 Water Quality of Luyano river, Martin Perez river and Tadeo Stream

Items	Luyano river			Martin Perez river			Tadeo Stream	
	1985	1996	2002	1985	1996	2002	1985	2002
Water flow, m^3/d	71,970	72,666	114,860	26,093	35,597	62,105	5,247	8,004
BOD, mg/L	546	471	83	22	10	20	36	192
COD, mg/L	1,205	892	138	56	27	43	88	320
T-N, mg/L	-	-	9.3	-	9.0	3.8	61.0	12.4
T-P, mg/L	-	-	-	-	5.1	0.8	34.3	5.1
SS, mg/L	117	189	33	14	35	17	54	10

SOURCE: CIMAB, 2001

As shown in Table 13, the BOD of Almendares river was dramatically improved from 2001, however, the water quality survey of this study shows the BOD quality is worse than indicated above. Therefore, it can not be asserted that the water quality of Almendares River has improved.

Also, the water quality of Luyano River has been improved but the BOD level is still high.

An integrated environmental management is required in order to improve the situation,

3.2 Complaints from the Public

Residents who live near solid waste disposal sites complain about the bad smell and smoke from the sites. In particular there are vehement complaints about the Guanabacoa solid waste disposal site, which is near a residential area.

D. Environmental Survey:

D2 Waste Quality Survey

D2. WASTE QUALITY SURVEY

1. Summary

The Waste Quality Survey, a chemical analysis survey on solid waste, was conducted to assess the chemical condition of solid waste in landfills and/or organic waste from households, markets and composting yards in landfills.

2. Methodology

2.1 Sampling

a) Solid waste from landfills

The samples were taken from the Calle 100 (on June 23, 2004), Ocho Vías (on June 23, 2004) and Guanabacoa (on June 28, 2004) landfill sites. The sampling point locations are shown in Figure 1 to Figure 3.

Figure 1 Location of Sampling Points in Calle 100

Figure 2 Location of Sampling Points in Ocho Vías

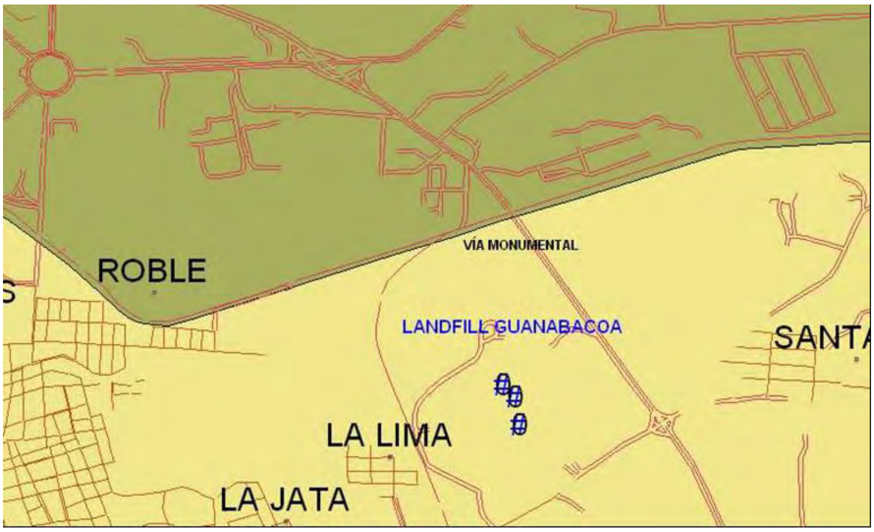


Figure 3 Location of Sampling Points in Guanabacoa

The geographical coordinates of each sampling point are shown in Table 1. In each landfill, samples were taken at three points, denoted as 1, 2 and 3, and at each point at two depths: 15 cm and approximately 0.8-1 m from the surface.

Table 1 Geographical Coordinates of Each Sampling Point

Sampling point	Coordinate readings	
	N	**W**
Landfill Calle 100. Point 1.	23 04 069	082 24 379
Landfill Calle 100. Point 2.	23 04 042	082 24 411
Landfill Calle 100. Point 3.	23 04 109	082 24 275
Landfill Ocho Vías . Point 1.	23 03 186	082 18 052
Landfill Ocho Vías. Point 2.	23 03 229	082 18 030
Landfill Ocho Vías. Point 3.	23 03 230	082 18 082
Landfill Guanabacoa. Point 1.	23 07 458	082 16 420
Landfill Guanabacoa. Point 2.	23 07 440	082 16 394
Landfill Guanabacoa. Point 3.	23 07 393	082 16 393

The samples were collected in nylon bags, labeled, and with the aid of a mobile laboratory, were immediately transported under appropriate conditions to the Department of Environmental Pollution Studies (DECA) of the National Center of Scientific Research (CNIC)[1].

A total of 18 samples were taken and the identification codes are shown in Table 2.

Table 2 Sample Identification

No.	Sample	Code
1	Landfill Calle 100. Point 1. Depth 15 cm	100-1-15
2	Landfill Calle 100. Point 1. Depth 1 m	100-1-100
3	Landfill Calle 100. Point 2. Depth 15 cm	100-2-15
4	Landfill Calle 100. Point 2. Depth 1 m	100-2-100
5	Landfill Calle 100. Point 3. Depth 15 cm	100-3-15
6	Landfill Calle 100. Point 3. Depth 1 m	100-3-100
7	Landfill 8 Vías . Point 1. Depth 15 cm	8V-1-15
8	Landfill 8 Vías . Point 1. Depth 1 m	8V-1-100
9	Landfill 8 Vías . Point 2. Depth 15 cm	8V-2-15
10	Landfill 8 Vías . Point 2. Depth 1 m	8V-2-100
11	Landfill 8 Vías . Point 3. Depth 15 cm	8V-3-15
12	Landfill 8 Vías . Point 3. Depth 1 m	8V-3-100
13	Landfill Guanabacoa. Point 1. Depth 15 cm	Gbcoa-1-15
14	Landfill Guanabacoa. Point 1. Depth 1 m	Gbcoa-1-100
15	Landfill Guanabacoa. Point 2. Depth 15 cm	Gbcoa-2-15
16	Landfill Guanabacoa. Point 2. Depth 1 m	Gbcoa-2-100
17	Landfill Guanabacoa. Point 3. Depth 15 cm	Gbcoa-3-15
18	Landfill Guanabacoa. Point 3. Depth 1 m	Gbcoa-3-100

b) Organic waste for composting

Five samples of organic waste for composting were collected from Calle 100 and Guanabacoa landfills, Boyeros and Playa households and the agricultural market in Cerro. These samples were received in the laboratory on 09/07/2004.

2.2 Methodology

For the characterization of the different samples, the analysis methods of the Office of Solid Wastes of the U.S. Agency of Environmental Protection (EPA) (EPA, 2000) or ISO (ISO 1994, ISO 1995, ONN 1999) were adopted.

The analysis methodology and standard references are shown in Table 3.

[1] DECA is accredited (Register number: 58) by the Cuban National Accreditation Body (ONARC), which is recognized by international accreditation bodies as ILAC.

Table 3 Analytical Methods and Standard References

Analysis	Method	Standard references
Moisture	Gravimetric	EPA. OSW 486.
Ashes	Gravimetric	EPA. OSW 486.
pH	Electrometric	NC 10390:1999
EC	Electrometric	EPA. OSW 486.
Total Carbon	Colorimetric	NC 51:1999
Total Phosphorus	Colorimetric	NC 34:1999
Total Nitrogen	Volumetric	ISO 11261:1995
Grease & Oil	Gravimetric	EPA. OSW 486. Method 9071B
Metals	ICP, Flame photometry	NRIB 1133, DCM PT-08-001, DCM PT-01-006, DCM PT-05-003
Total Cyanide		APHA Standard Methods.
PCB	GC with EC	
Lower calorific value	Calorimetric	
Combustible content	Calorimetric	

The calculation software EXCEL (Microsoft, 2000) and the statistical software package Statgraphic for Windows (StatSoft, 1998) were used to calculate the average ($\bar{x}$), the typical deviation (s), and the relative typical deviation or coefficient of variability (CV, %). For the detection of possible values outside the limits, the Grubbs test was used following the rules described in ISO 5725 (1994).

3. Analysis

The results of the analysis on buried solid waste and organic material are shown in the following tables.

For the buried solid wastes, the samples from the Guanabacoa solid waste disposal site showed high concentrations of Cu, Hg and Cr.

With regard to organic materials, there are no standards for composting in Cuba, therefore the results were compared to the Japanese standard (in terms of Cadmium, Arsenic and Total Mercury).

The results for all samples were less than the Japanese standard values.

Table 3-1 Results of Analysis - Buried Solid Waste

Sampling point	Unit	Calle 100 No1		Calle 100 No2		Calle 100 No3		8 Vias No1		8 Vias No2		8 Vias No3		Guanabacoa No1		Guanabacoa No2		Guanabacoa No3	
Depth(m)		0.15	1	0.15	1	0.15	1	0.15	1	0.15	1	0.15	1	0.15	1	0.15	1	0.15	1
pH	-	8.7	7.3	7.8	7.6	6.3	6.3	8.4	8.6	7.3	8.3	8	8.3	8.6	8.4	8.6	8.7	8.6	7.7
EC	μ S/cm	117	1857	141	1833	2067	1967	738	820	403	353	760	767	397	517	427	407	517	553
Cadmium (Cd)	mg/kg	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.7	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Zinc (Zn)	mg/kg	75	130	480	390	470	1100	1500	940	440	480	740	530	260	490	490	410	480	480
Copper(Cu)	mg/kg	52	65	120	710	60	100	430	400	180	590	200	240	340	1200	65	170	200	330
Lead (Pb)	mg/kg	27	27	360	130	130	340	880	790	440	330	605	240	400	340	200	180	3100	230
Hexavalent chromium (Cr6+)	mg/kg	142	166	320	157	192	197	217	244	212	226	380	329	900	560	618	540	307	400
Arsenic (As)	mg/kg	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6
Total mercury (Hg)	mg/kg	2.7	1.8	1.9	1.9	2.5	2.8	1.3	1.3	0.9	1.0	1.5	1.0	0.9	1.0	1.0	1.3	5.6	7.0
Total cyanide (CN)	mg/kg	2.7	3.1	3.3	3.5	5.6	4.4	3.5	4.1	4.1	4.0	4.9	5.8	4.1	4.1	3.5	3.9	3.5	5.0
PCB	mg/kg	<0.05	<0.05	<0.05	0.10	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.393	0.091	0.465	<0.05	<0.05
Grease & Oil	mg/kg	2,033	1,833	20,967	28,467	28,133	26,300	9,133	12,367	10,900	5,133	9,100	4,867	6,967	11,200	13,000	13,533	22,900	9,567
Moisture	%	20	22	39	51	44	51	14	12	14	13	14	16	18	35	14	10	32	24
Ash content	%	93	94	62	51	50	39	87	88	86	87	86	84	85	75	87	89	70	78
Combustible content	wt%	8	6	38	49	50	61	14	12	14	13	14	16	15	25	13	11	30	22
Lower calorific value	kJ/kg	-	-	-	9569	7150	12662	-	-	-	-	-	-	-	-	-	-	4598	4510

Table 3-2 Results of Analysis - Organic Material

Sampling point	Unit	Calle100	Guanabacoa	Boyero	Playa	Mercado Agropecuario Cerro	Japanese standard for composting
pH	-	6.6	7.6	6.9	6	5.9	-
EC	μ S/cm	162	1200	1200	1683	2567	-
Cadmium (Cd)	mg/kg	<1.0	<1.0	<1.0	<1.0	<1.0	5
Zinc (Zn)	mg/kg	230	<1.0	<1.0	<1.0	<1.0	-
Copper(Cu)	mg/kg	<50	<50	<50	<50	<50	-
Lead (Pb)	mg/kg	110	77	75	88	59	-
Hexavalent chromium (Cr6+)	mg/kg	66	37	37	66	36	-
Arsenic (As)	mg/kg	<0.6	<0.6	<0.6	<0.6	<0.6	50
Total mercury (Hg)	mg/kg	<0.25	<0.25	<0.25	0.27	0.66	2
Total cyanide (CN)	mg/kg	5.6	6.5	7.5	6.5	5.6	-
PCB	mg/kg	<0.05	<0.05	<0.05	<0.05	<0.05	-
Grease & Oil	mg/kg	25,000	17,467	25,867	42,567	20,400	-
Moisture	%	71.0	61.0	88.0	68.0	84.0	-
Ash content	%	29	22	12	8	10	-
Total Carbon	%	42.1	44.8	38.1	53	57.1	-
Total nitrogen (T-N)	%	0.64	2.92	4.32	4.18	9.44	-
Total phosphorus (T-P)	%	0.2	0.14	0.15	0.19	0.23	-
Potassium (K)	mg/kg	11,500	18,600	21,800	8,700	25,600	-
Sodium (Na)	mg/kg	50,300	2,300	1,500	7,200	810	-
Magnesium (Mg)	mg/kg	3,600	5,500	1,900	1,300	2,000	-
Calcium (Ca)	mg/kg	101,300	75,100	45,300	38,500	11,200	-

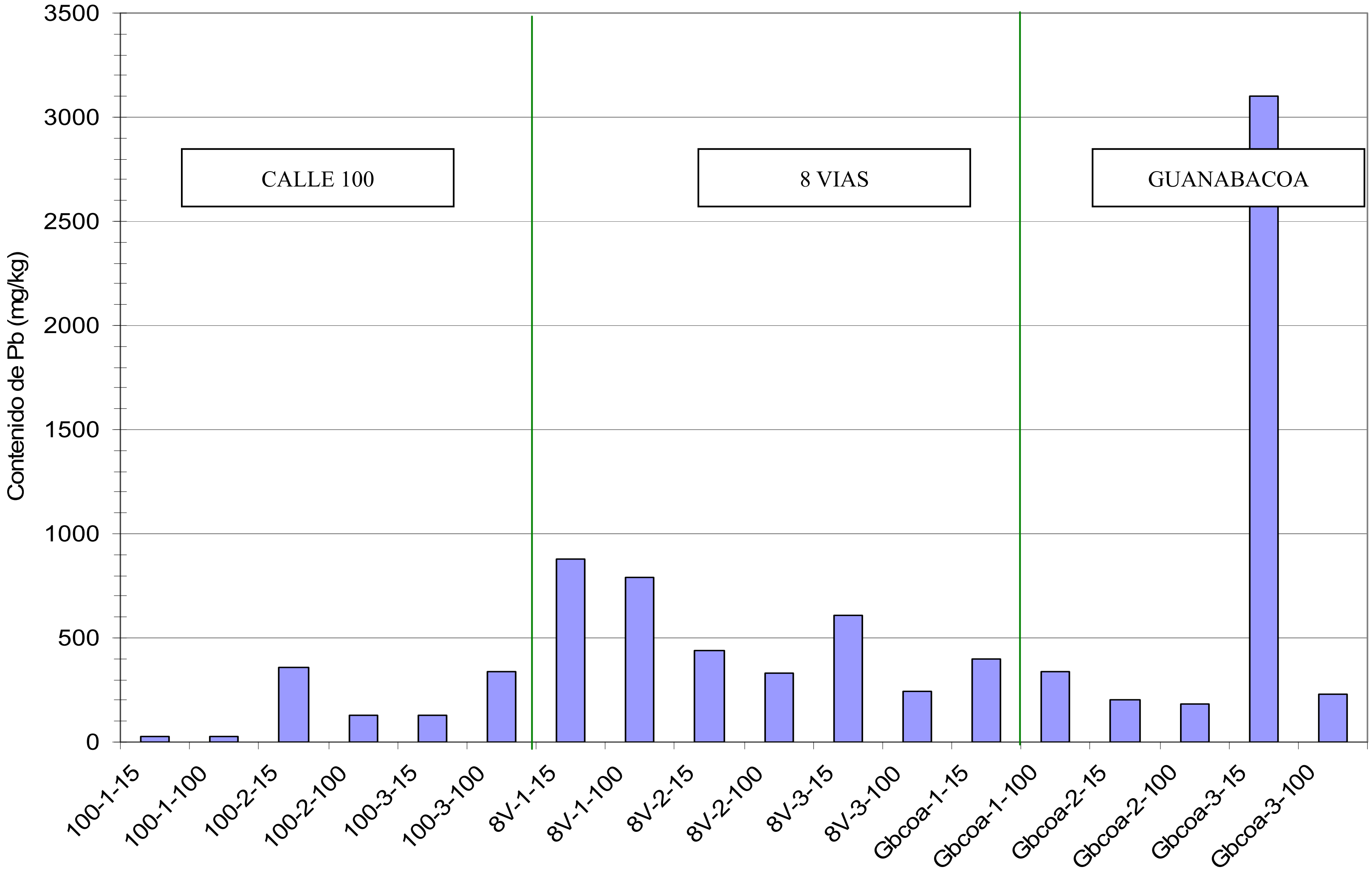


Figure 3-1 Pb Content - Comparison between the Three Landfill Sites

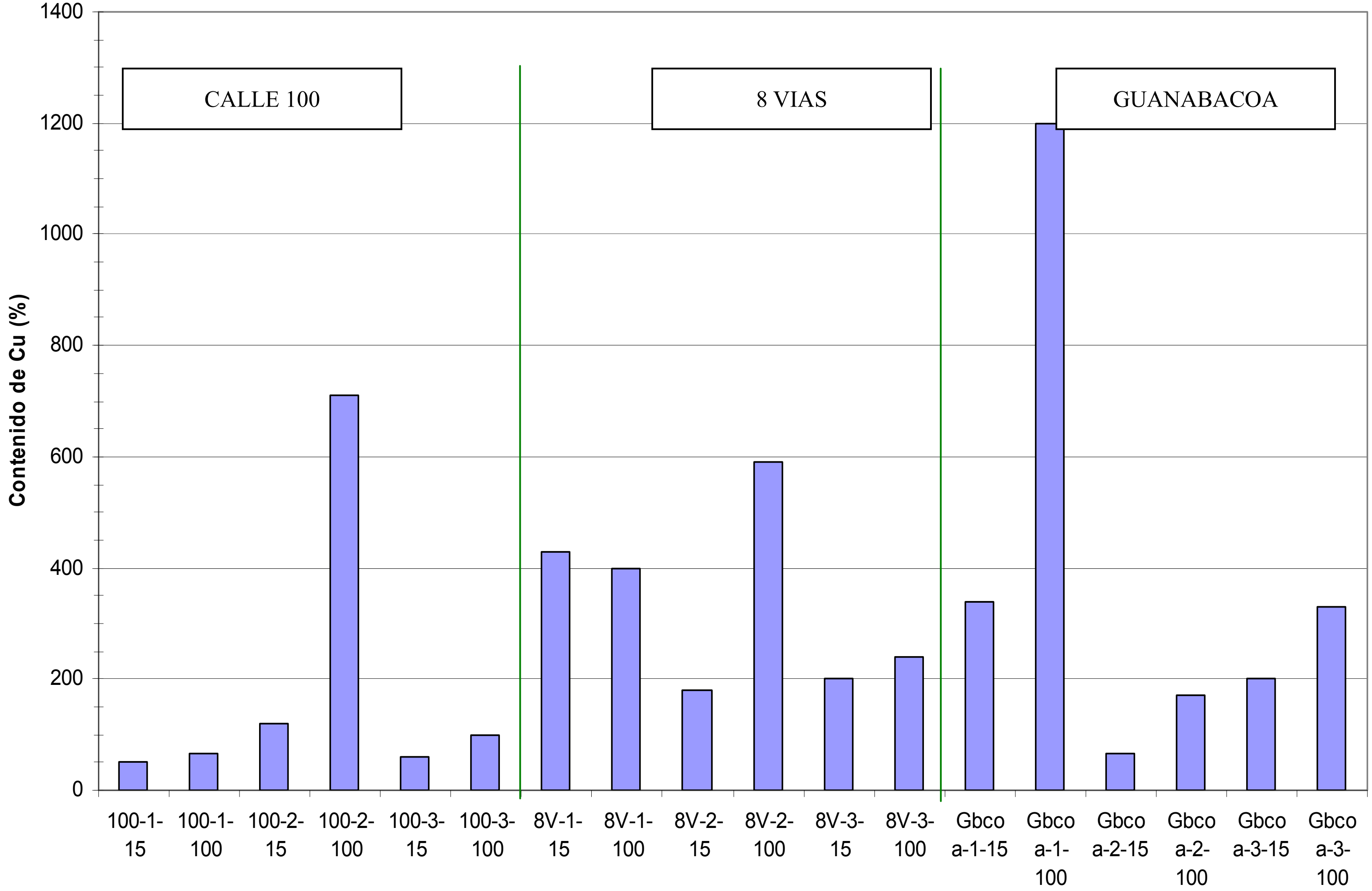


Figure 3-2 Cu Content - Comparison between the Three Landfill Sites

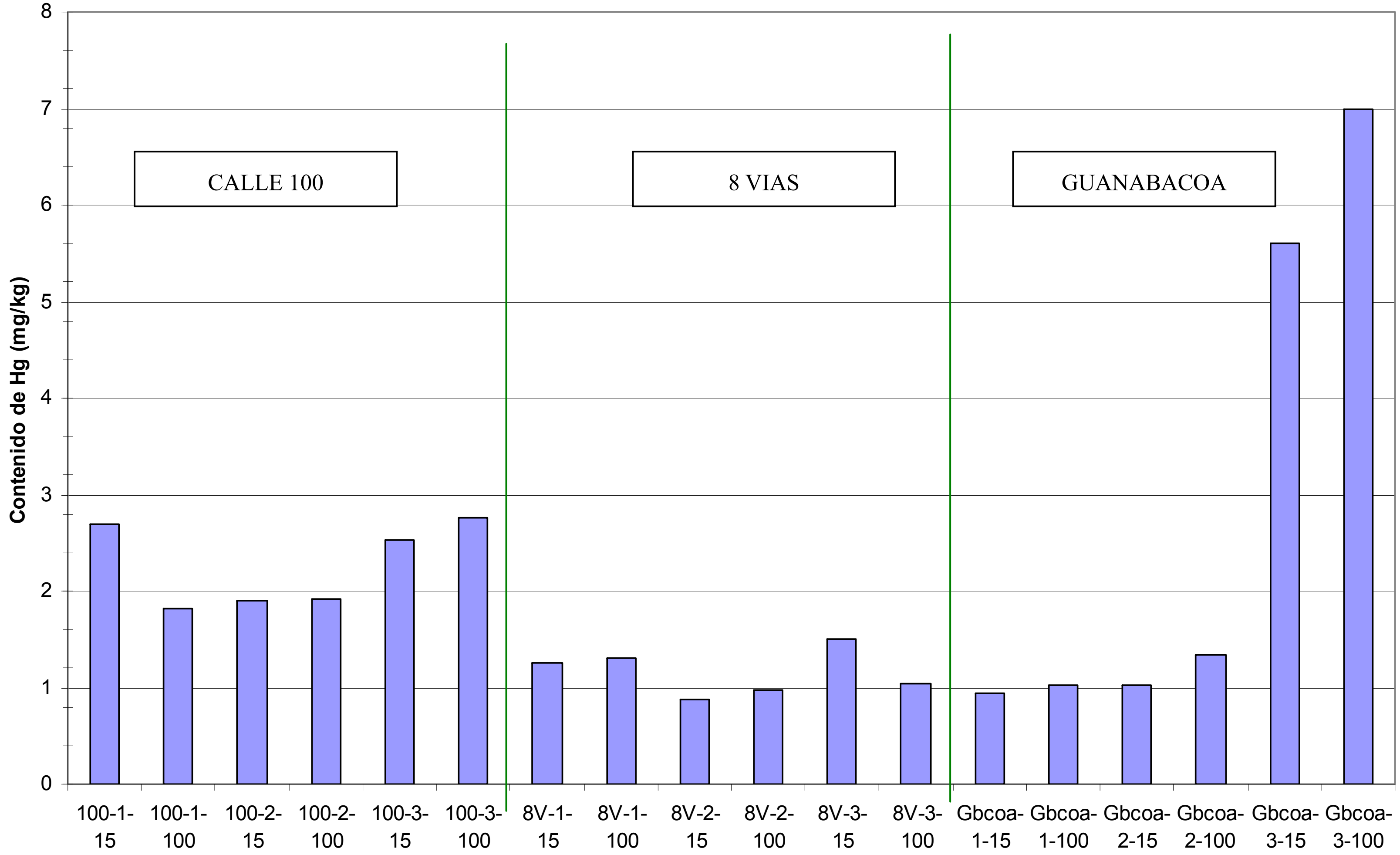


Figure 3-3 Hg Content - Comparison between the Three Landfill Sites

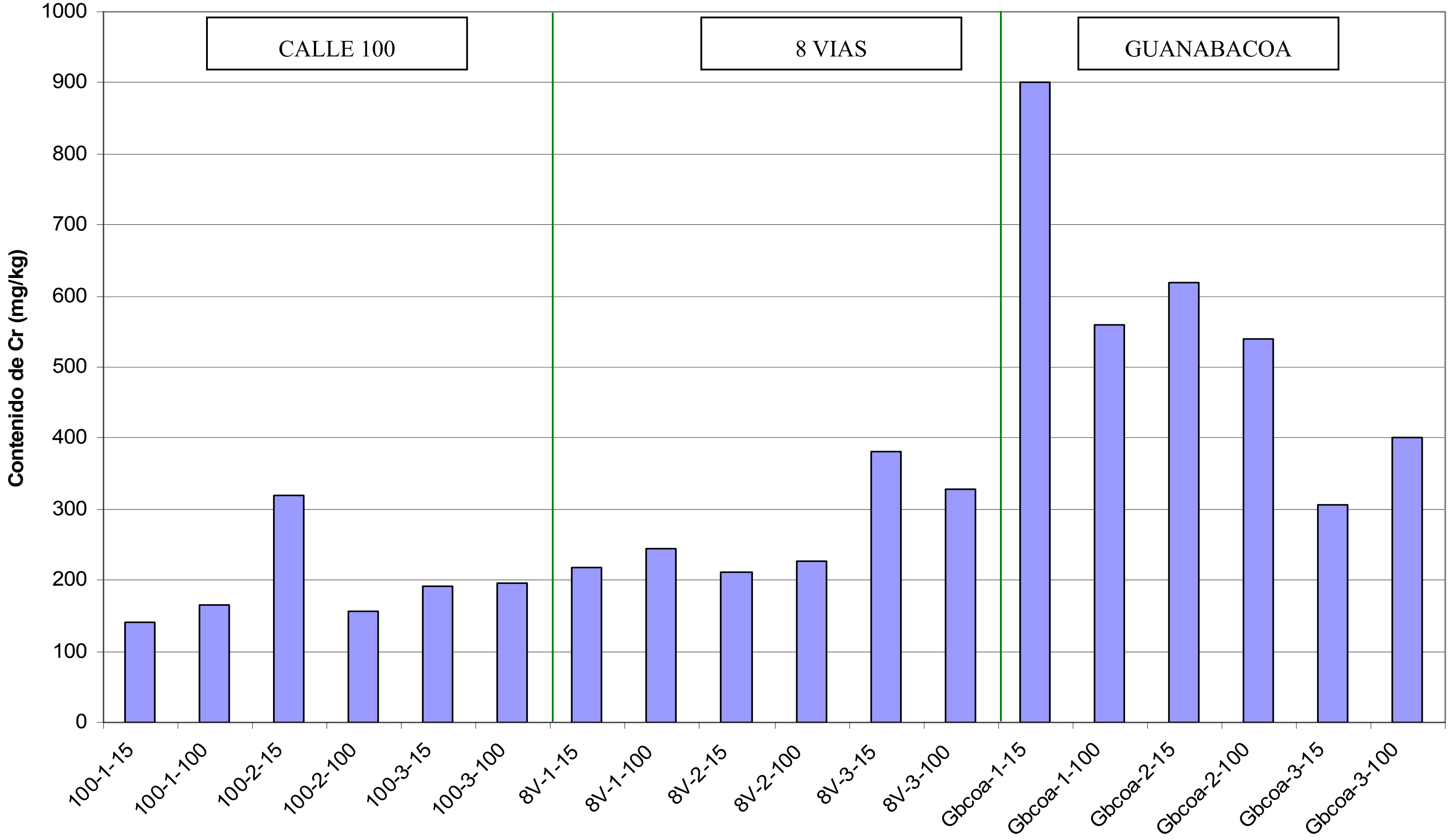


Figure 3-4 Cr Content - Comparison between the Three Landfill Sites

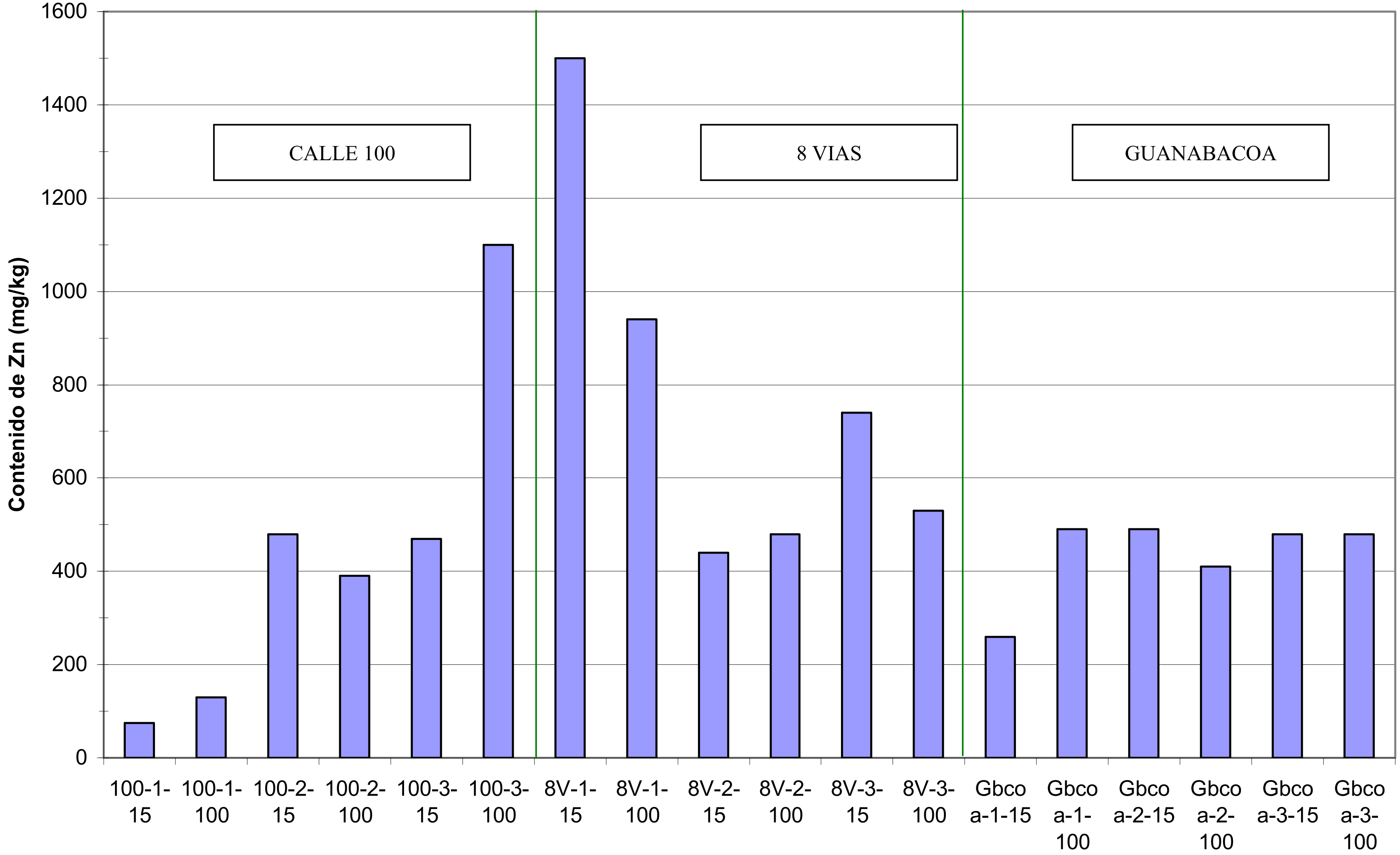


Figure 3-5 Zn Content - Comparison between the Three Landfill Sites

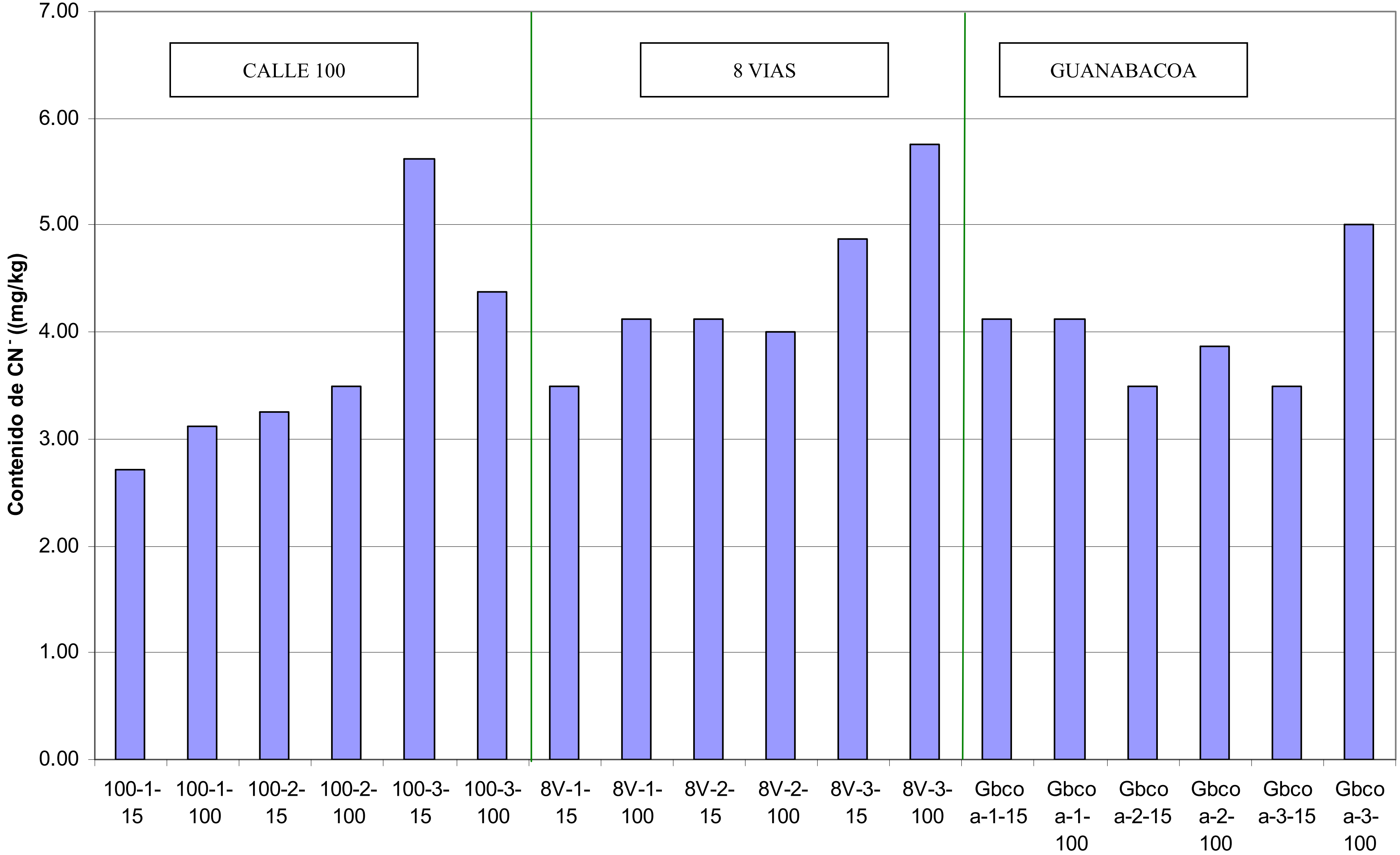


Figure 3-6 CN- Content - Comparison between the Three Landfill Sites

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D. Environmental Survey:

D3 Water Quality Survey

D3. WATER QUALITY SURVEY

1. Summary

A water quality Survey was conducted to assess the environmental impact of the major landfill sites in Havana City on the surroundings. The selected landfill sites were Calle 100, Guanabacoa, Ocho Vias and Campo Florido.

2. Methodology

2.1 Sampling Points

In the Guanabacoa, Calle 100 and Ocho Vias landfills the dry season sampling was carried out in May and June 2004 and the rainy season sampling in October and November 2004. The sampling points at each landfill site are shown in Figure 1 to Figure 4.

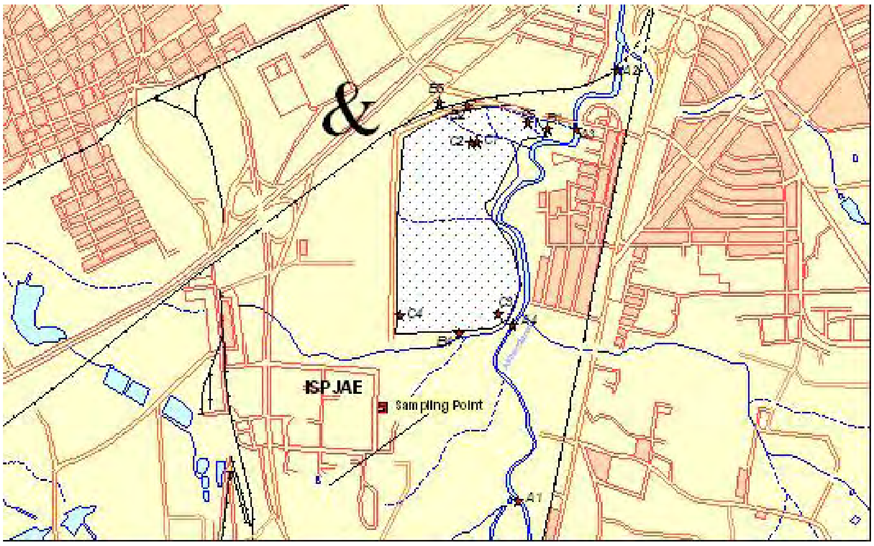

Figure 1 Sampling Points, Calle 100

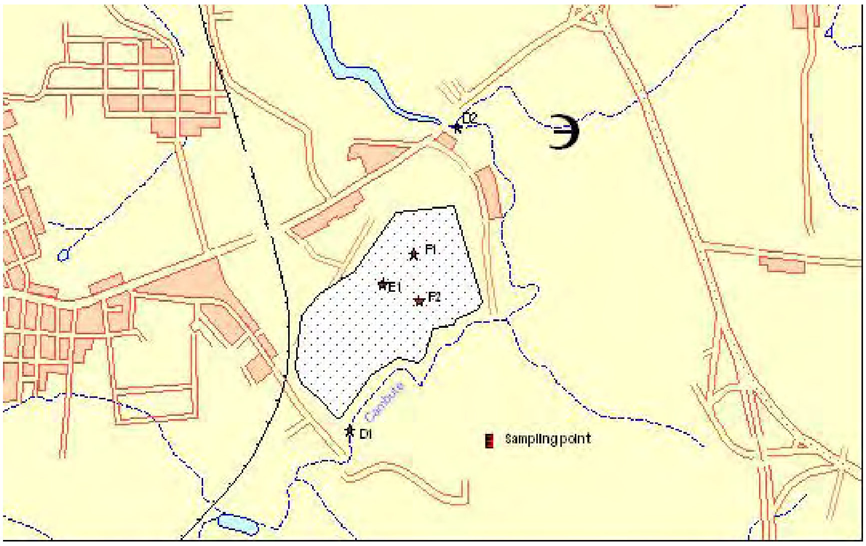

Figure 2 Sampling Point s, Guanabacoa

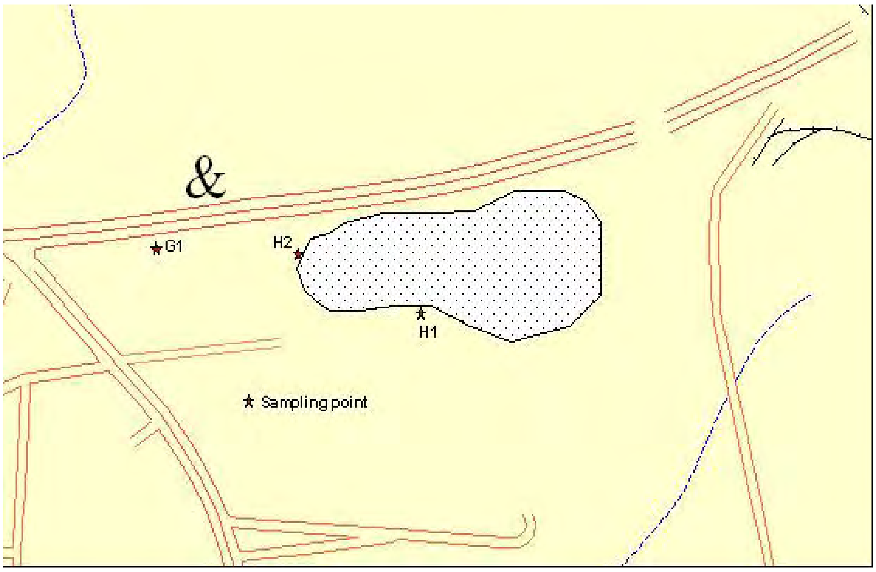

Figure 3 Sampling Points, Ocho Vias

Figure 4 Sampling Points, Campo Florido

Table 1 summarizes the date and time that samples were collected at each sampling point during the rainy season. The geographical coordinates of the sampling points were obtained from GPS.

Table 1 Identification and General Information on Sampling Points

Sampling Point	Water classification	Date	Time	N	W
Calle 100					
C1	Leachate	30/09/2004	10.50 am	23 03 92	082 24 40
C2	Leachate	30/09/2004	10.30 am	23 03 89	082 24 41
C3	Leachate	30/09/2004	12.10 pm	23 03 20	082 24 58
C4	Leachate	30/09/2004	1.10 pm	23 03 43	082 24 33
C5	Leachate	30/09/2004	11.10 am	23 04 02	082 24 28
A1	Almendares River	05/10/2004	11.20 am	23 02 69	082 24 12
A2	Almendares River	05/10/2004	10.10 am	23 04 27	082 24 02
A3	Almendares River	05/10/2004	10.30 am	23 04 13	082 24 16
A4	Almendares River	05/10/2004	10.55 am	23 03 66	082 24 31
B1	Groundwater	03/11/2004	1.10 pm	23 03 53	082 24 24
B2	Groundwater	03/11/2004	12.10 pm	23 04 00	082 24 34
B4	Groundwater	03/11/2004	1.45 pm	23 03 25	082 24 27
B5	Groundwater	03/11/2004	11.05 am	23 04 09	082 24 39
Guanabacoa					
F1	Leachate	28/09/2004	10.40 am	23 07 29	082 16 65
F2	Leachate	28/09/2004	11.05 am	23 07 33	082 16 61
D1	Cambute River	28/09/2004	11.45 am	23 07 62	082 16 34
D2	Cambute River	28/09/2004	12.35 pm	23 07 10	082 16 60
E1	Groundwater	12/10/2004	10.25 am	23 07 13	082 16 37
Ocho Vias					
H1	Leachate	05/10/2004	12.00 m	23 03 05	082 18 25
H2	Leachate	05/10/2004	12.20 pm	23 02 90	082 18 54
G1	Groundwater	12/11/2004	10.25 am		
Campo Florido					
I1	Groundwater	14/11/2004	10.40 am	23 07 39	082 07 39

2.2 Methodology

The leachate samples were collected as single samples at the surface level, according to ISO 5667-10. The surface water samples were collected according to ISO 5667-6, from the Cambute River which surrounds the Guanabacoa landfill and from the Almendares River which surrounds the Calle 100 landfill. The groundwater samples were collected according to ISO 5667-11 from existing wells in the Guanabacoa and Calle 100 landfills and in those that were opened for this study.

The water quality indicators and analytical methods are shown in Table 2.

Table 2 Water Quality Indicators and Analytical Methods

Indicator	Analytical methods
pH and Temp.	Electrometric using a Hanna pH meter model 1430
Odor	Threshold Odor Number using dilution
EC	Using a conductivity meter. Multiline Hanna 2730
DO	Winkler. Azide modification
BOD_5	Dilution and seed during 5 days at 20°C
COD	Potassium dichromate oxidation and closed reflux
TDS, TSS and TVS	Gravimetric methods
Total and Fecal Coliforms	Dilutions. MPN in 100 ml.
As, Cd, Cr, Cu, T-Hg, Pb and Zn	ICP
Cr^{+6}	Colorimetric method.
$T\text{-}CN^-$	Colorimetric method.
$N\text{-}NH_3$	Distillation and titration
$N\text{-}NO_2$	Diazotation. Spectrophotometer
$N\text{-}NO_3$	Cd-Cu reduction and Diazotation. Spectrophotometer
TN	Persulphate oxidation and Cd –Cu reduction
TP	Persulphate oxidation and ascorbic acid. Spectrophotometer
Oil and Greases	FTIR Spectrophotometer
Phenol	4- aminoantipyrine. Spectrophotometer
Detergents	Metilene Blue. Spectrophotometer
Alkalinity	Potentiometric titration
Acidity	Potentiometric titration
Color	Comparison with cloroplatinatum - cobalt scale
Turbidity	Nephelometric method
Air Humidity	Hygrometer, Field measure
Air Temperature	Digital Thermometer

Acidic digestion with $N\text{-}NO_3$ was used to determine the total metal concentration by ICP. When the reported concentrations were found to be below the detection limit they were considered to be equal to the detection limit value for the purpose of the statistical analysis and results comparison.

3. Photographs

For reference, the photographs taken in this survey are shown in Figure 5.

.

	
Sampling at Calle 100	Bore sampling at Calle 100
	
Almendares River near Calle 100	Cambute River near Guanabacoa
	
Leachate Conditions at Ocho Vias	Leachate Conditions at Calle 100

Figure 5 Survey Photographs

4. Analysis

4.1 Dry Season

Tables 3 and 4 show the results of the water quality survey. The overall results show that the water quality of the leachate is the lowest and that of the river water is the highest. The BOD levels were 230 (mg/l) to 2,474 (mg/l) for leachate, 3 (mg/l) to 132 (mg/l) for groundwater, and 11 (mg/l) to 65 (mg/l) for river water. The heavy metal levels in all of the samples were relatively low except for one leachate sample at Calle 100 (C5). This sample (C5) was taken from a creek within the landfill site into which effluent flows from sewage and a nearby car factory. This suggests that the level of heavy metals in this leachate is affected by effluent from the car factory.

The results were compared to the discharge standards for inland surface waters, as there are no environmental standards for leachate, groundwater or river water. For the leachate, the COD, BOD, T-N and T-P levels at all of the sampling points exceeded the acceptable level stated in the environmental standards. In the groundwater samples, B1 and B5 in Calle 100 and E1 in Guanabacoa exceeded the standards for some parameters. For the river water, sample A1 in Calle 100 and D1 and D2 in Guanabacoa also exceeded the standards for some parameters.

Table 3 Results of the Water Quality Survey (Calle 100)

Sampling Items	Unit	Calle 100														Discharge Standard to Inland Surface Water
		Leachate					Ground water(Water Table m)					River				
		C1	C2	C3	C4	C5	B1 (2.1m)	B2 (3.1m)	B3 (1.2m)	B4 (3.1m)	B5 (-)	A1	A2	A3	A4	National Standard (NC27)
pH	-	7.94	8.7	7.9	8.45	7.43	6.35	6.91	7.44	7.05	6.98	7.4	7.46	7.61	7.57	6-9
DO	mg/l	0	0	0	0	0	0.59	1.35	1.37	2.98	2.65	5.45	3.97	0	0	–
EC	mS/cm	16.7	9.42	5.38	9.25	1.58	5.5	2.1	0.87	1.9	4.1	1.15	0.95	0.89	0.99	
TDS	mg/l	10660	7769	4684	5341	919	6154	5606	328	22816	1412	693	651	624	597	–
COD	mg/l	5400	3240	270	947	631	400	49	35	30	369	65	21	32	32	120
BOD	mg/l	2474	1096	230	555	474	122	24	14	10	35	52	12	11	17	60
Suspended Solid (SS)	mg/l	1733	37	59	226	1050	1292	1328	672	9276	1012	37	5	19	15	–
Coliform bacteria(Total coliform)	NMP/100ml	3.0E+00	3.0E+00	3.0E+00	3.0E+00	4.0E+06	2.3E+05	1.3E+05	1.3E+05	1.3E+05	3.0E+05	1.1E+07	3.0E+00	4.3E+04	4.3E+05	–
Coliform bacteria(Fecal coliform)	NMP/100ml	ND	ND	ND	ND	1.5E+05	2.3E+05	1.3E+05	8.0E+04	2.3E+04	8.0E+04	7.3E+03	0.0E+00	3.0E+00	3.0E+00	–
Cadmium (Cd)	mg/l	0.008	<0.005	<0.005	<0.005	0.107	0.023	0.022	0.011	0.014	0.02	<0.005	<0.005	<0.005	<0.005	–
Zinc (Zn)	mg/l	1.163	0.375	0.036	0.297	34.71	0.388	0.267	0.142	0.085	0.138	0.041	0.016	<0.010	<0.010	–
Copper	mg/l	0.432	0.571	0.079	0.445	6.49	0.127	0.099	0.047	0.032	0.03	0.017	0.03	0.015	0.012	–
Lead (Pb)	mg/l	0.53	<0.10	<0.10	<0.10	3.3	0.194	0.154	0.087	0.156	0.176	<0.10	<0.10	<0.10	<0.10	–
Hexavalent chromium (Cr6+)	mg/l	0.3	0.35	0.01	0.04	<0.005	<0.04	<0.04	<0.04	<0.04	<0.04	<0.005	<0.005	<0.005	<0.005	–
Arsenic (As)	mg/l	<0.080	<0.080	<0.080	<0.080	1.002	<0.003	<0.003	<0.003	<0.003	<0.003	<0.080	<0.080	<0.080	<0.080	–
Total mercury (Hg)	mg/l	0.062	0.059	0.027	0.028	1.545	<0.020	<0.020	<0.020	<0.020	<0.020	0.011	0.03	0.015	0.012	–
Total cyanide (CN)	mg/l	0.06	0.06	<0.050	<0.050	<0.050	0.053	0.055	0.061	0.059	0.058	<0.050	<0.050	<0.050	<0.050	–
Ammonium nitrogen (NH4-N)	mg/l	256.67	35.47	13.07	293.53	24.27	62.1	0.1	0.46	0.17	0.2	0.6	0.67	0.61	0.52	–
Nitrate nitrogen (NO3-N)	mg/l	0.36	0.35	0.385	0.34	0.318	0.53	5.06	0.18	0.53	13.16	0.099	0.07	0.052	0.016	–
Nitrite nitrogen (NO2-N)Suspended solid	mg/l	0.22	0.22	0.16	0.28	0.26	0.009	0.12	0.125	0.015	0.009	0.04	0.04	0.06	0.07	–
Total nitrogen (T-N)	mg/l	362.58	58.57	37.33	317.84	40.61	90.91	15.9	8.28	5.9	19	11.76	10.78	8.14	13.39	20
Total phosphorous (T-P)	mg/l	120.37	19.28	12.74	37.28	164.42	4.05	4.38	1.22	13.24	1.85	29.95	18.16	8.25	13.77	10
Grease and oil	mg/l	0.8	0.13	0.06	0.18	22.36	2.4	0.2	0.98	1.57	2.07	4.16	0.68	0.57	0.15	30
Phenol	mg/l	0.6	0.1	0.15	0.1	0.57	0.1	0.13	0.1	0.1	0.1	0.14	0.1	0.1	0.1	–
Detergent	mg/l	0.53	0.38	0.28	1.23	1.76	0.21	0.2	0.2	0.2	0.2	0.74	0.35	0.2	0.32	–
Alkalinity	mg/l	3225	1008	817	1600	433	260	470	470	520	ND	292	275	250	250	–
Acidity	mg/l	842	92	67	392	108	90	70	ND	20	ND	67	42	50	67	–
Temperature	ºC	26.7	27.8	27.4	31.7	34.5	30.9	28.8	29.9	31.4	28.9	28.6	29	27.6	27.7	40
Color	CU	7000	8750	1400	1400	700	250	30	20	10	260	70	30	40	35	–
Murkiness	NTU	406	33.2	31.4	544	405	390	401	150	750	320	149	102	165	58.2	–
Odor	TON	2	2	4	6	1	ND	ND	ND	ND	ND	35	35	50	50	–
Volatile solid	mg/l	2963	913	1145	1152	622	1470	1482	104	1360	428	18	97	17	11	–
Air humidity	%	60	39	39	44	52	59	61	60	59	43	49	50	44	46	–
Air temerature	ºC	34.4	37.1	37.6	35.3	34.6	34.3	34.6	33.9	32.1	33	33.7	36.2	36.2	34.8	–

Note) ND: Not Detected, -: no data: E+00*: ×10*

Table 4 Results of the Water Quality Survey (Guanabacoa, Ocho Vias)

Sampling Items	Unit	Guanabacoa				8 Vias	Discharge Standard to Inland Surface Water
		Leachate	Ground water	River		Ground water	
		F1	E1 (16m)	D1	D2	G1 (13.5m)	National Standard (NC27)
pH	-	8.2	7.5	6.94	7.14	7.15	6-9
DO	mg/l	0	0	5.54	5.65	3.5	—
EC	mS/cm	10.48	10.95	0.747	0.778	0.76	
TDS	mg/l	7842	4840	532	592	1852	—
COD	mg/l	1578	1483	42	92	19	120
BOD	mg/l	584	132	31	65	3	60
Suspended Solid (SS)	mg/l	670	1476	10	9	1600	—
Coliform bacteria	NMP/100ml	9.1E+04	1.1E+05	2.4E+04	4.3E+03	4.0E+02	—
	NMP/100ml	9.1E+04	2.0E+04	2.4E+04	4.3E+03	ND	—
Cadmium (Cd)	mg/l	<0.005	0.03	<0.005	<0.005	0.018	—
Zinc (Zn)	mg/l	0.617	1.4	<0.010	<0.010	0.46	—
Copper	mg/l	0.399	0.528	<0.010	0.014	0.056	—
Lead (Pb)	mg/l	<0.10	0.472	<0.10	<0.10	0.099	—
Hexavalent chromium (Cr6+)	mg/l	0.012	<0.04	0.011	0.011	<0.04	—
Arsenic (As)	mg/l	<0.080	<0.003	<0.080	<0.080	<0.003	—
Total mercury (Hg)	mg/l	0.093	0.028	0.013	<0.010	<0.020	—
Total cyanide (CN)	mg/l	0.058	0.055	0.055	0.055	0.061	—
Ammonium nitrogen (NH4-N)	mg/l	5.13	20.4	0.2	0.21	0.16	—
Nitrate nitrogen (NO3-N)	mg/l	0.41	1.077	0	0	2.62	—
Nitrite nitrogen (NO2-N)Suspended solid	mg/l	0.21	0.012	0.066	0.071	0.107	—
Total nitrogen (T-N)	mg/l	59.86	30	0.742	1.065	3.27	20
Total phosphorous (T-P)	mg/l	56.91	16.01	13.63	4.84	1.35	10
Grease and oil	mg/l	0.03	3.82	1.57	0.05	0.19	30
Phenol	mg/l	0.1	0.1	0.1	0.1	0.02	—
Detergent	mg/l	0.29	0.2	0.2	0.2	0.2	—
Alkalinity	mg/l	59.24	ND	33.33	16.67	210	—
Acidity	mg/l	0	ND	1391.67	316.67	5	—
Temperature	°C	29.1	33.5	26.3	27.3	29.6	40
Color	CU	22500	2000	25	20	5	—
Murkiness	NTU	315	300	52.4	79.5	20	—
Odor	TON	6	50	ND	ND	ND	—
Volatile solid	mg/l	965	1480	47	84	266	—
Air humidity	%	57	62	67	78	67	—
Air temerature	°C	30	31.2	26.9	33.4	28.9	—

Note) ND: Not Detected, -: no data: E+00*: ×10*

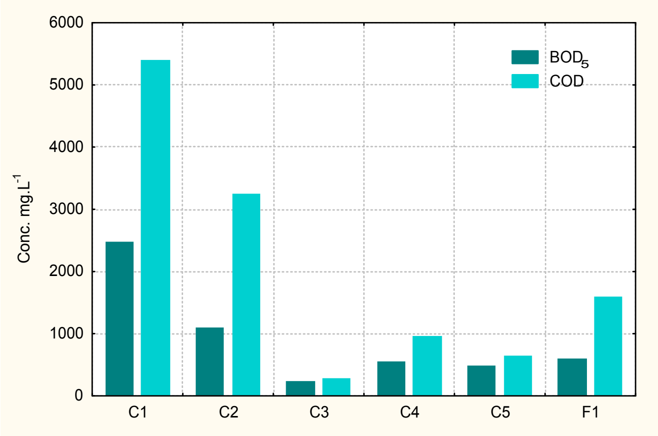

Figure 6 BOD$_5$ and COD Variations in Leachate

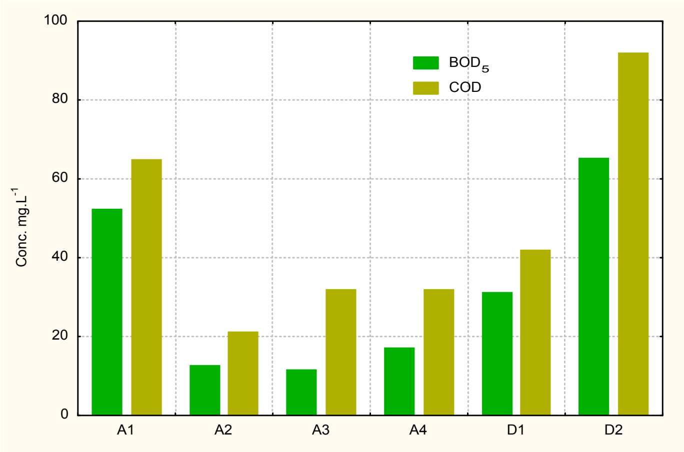

Figure 7 BOD$_5$ and COD Variations in Surface Water

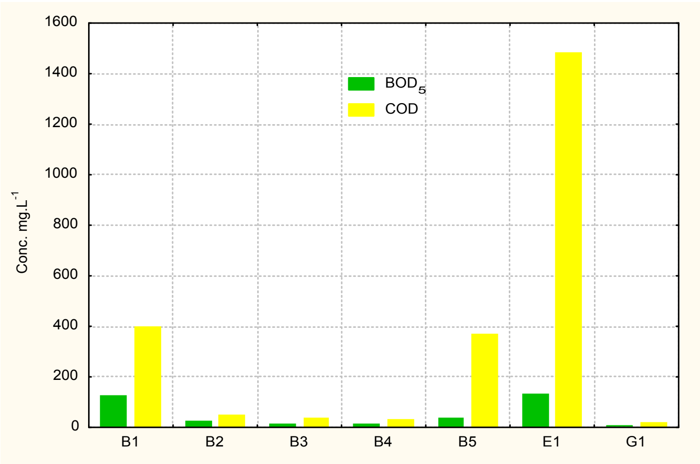

Figure 8 BOD$_5$ and COD Variations in Groundwater

4.2 Rainy Season

Tables 5 and 6 show the results of the water quality survey for the rainy season. The overall results show that the water quality of leachate is the lowest and that of river water is the highest. The BOD levels were 168 (mg/l) to 1,128 (mg/l) for leachate, 372 (mg/l) for groundwater, and 11 (mg/l) to 46 (mg/l) for river water.

Comparing the results for the rainy season to those for the dry season, no particular trends are recognized. The results for the rainy season were lower for one sample, but higher for the other samples.

Table 5 Results of the Water Quality Survey (Calle 100)

Sampling Items	Unit	Calle 100													Discharge Standard to Inland Surface Water
		Leachate					Ground water(Water Table m)				River				
		C1	C2	C3	C4	C5	B1 (2.1m)	B2 (3.1m)	B4 (3.1m)	B5 (-)	A1	A2	A3	A4	National Standard (NC27)
pH	-	7.80	8.35	8.22	7.80	7.50	6.86	7.1	7.2	7.15	7.23	6.83	6.84	6.96	6-9
DO	mg/l	0	0	0	1.68	1.17	1.6	0.9	1.1	0.5	0.82	0.66	0.5	0.83	–
EC	mS/cm	13.13	8.61	7.86	6.80	1.31	2.2	1.4	3.8	6.1	0.82	0.87	0.87	0.91	
TDS	mg/l	7770	5989	4874	3919	706	376	90	75	591	524	205	288	311	–
COD	mg/l	1999	1478	1152	748	564	46	66	54	591	61	61	43	52	120
BOD	mg/l	1128	917	1128	536	174	6	12	15	38	32	46	21	29	60
Suspended Solid (SS)	mg/l	1280	87	232	57	50	1294	888	724	2190	40	37	30	29	–
Coliform bacteria(Total coliform)	NMP/100ml	2.1E+04	2.9E+05	4.3E+04	4.6E+05	4.3E+04	5.0E+05	4.3E+05	1.7E+04	2.4E+04	9.3E+05	1.1E+06	2.4E+05	9.3E+05	–
Coliform bacteria(Fecal coliform)	NMP/100ml	1.5E+03	2.4E+04	7.5E+03	9.3E+04	4.3E+03	4.3E+05	2.3E+04	1.7E+04	9.1E+03	9.3E+05	1.1E+06	2.4E+05	4.3E+05	–
Cadmium (Cd)	mg/l	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	–
Zinc (Zn)	mg/l	0.706	0.301	0.288	0.315	0.051	0.169	0.267	0.066	0.069	0.017	<0.01	0.015	0.013	–
Copper(Cu)	mg/l	0.288	0.253	0.214	0.303	<0.01	0.136	0.060	0.030	0.040	<0.01	<0.01	0.039	0.011	–
Lead (Pb)	mg/l	0.12	<0.1	<0.1	<0.1	<0.1	<0.1	0.10	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	–
Hexavalent chromium (Cr6+)	mg/l	0.161	0.228	0.550	0.671	0.296	<0.005	<0.005	<0.005	<0.005	0.008	0.090	0.011	<0.005	–
Arsenic (As)	mg/l	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	–
Total mercury (Hg)	mg/l	0.060	0.046	0.025	0.029	0.026	<0.02	<0.02	<0.02	0.021	<0.01	<0.01	<0.01	<0.01	–
Total cyanide (CN)	mg/l	0.053	0.076	0.061	0.058	0.055	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	–
Ammonium nitrogen (NH4-N)	mg/l	73.31	80.25	111.48	108.81	10.65	0.071	4.35	3.56	2.94	6.17	5.67	3.99	4.11	–
Nitrate nitrogen (NO3-N)	mg/l	0.01	0.012	0.01	0.04	0.01	0.35	0.35	0.35	0.35	<0.01	0.03	0.04	0.02	–
Nitrite nitrogen (NO2-N)	mg/l	0.004	0.004	0.058	0.054	0.002	0.009	0.009	0.066	0.071	0.005	0.047	0.054	0.035	–
Total nitrogen (T-N)	mg/l	116.79	105.32	158.60	133.83	19.19	2.54	12.61	16.76	45.73	9.54	14.26	8.44	28.77	20
Total phosphorous (T-P)	mg/l	1.53	35.65	1.21	2.81	3.61	1.43	1.24	3.09	4.19	4.52	2.44	7.66	8.46	10
Grease and oil	mg/l	3.16	0.84	4.40	0.32	1.20	0.20	0.41	0.25	0.49	0.80	0.08	0.09	0.00	30
Phenol	mg/l	0.245	0.063	0.036	0.036	0.052	<0.036	<0.036	<0.036	<0.036	<0.036	<0.036	<0.036	<0.036	–
Detergent	mg/l	<0.2	<0.2	<0.2	<0.2	0.56	<0.2	<0.2	<0.2	0.63	0.32	0.23	0.38	0.35	–
Alkalinity	mg/l	1089	1397	1640	1205	456	1485	1485	1460	1530	255	238	272	261	–
Acidity	mg/l	641	198	319	306	95	550	600	598	558	17	22	28	24	–
Temperature	°C	33.4	27.4	31.6	28.3	28.3	30.4	30.4	30.5	35.6	27.4	26.6	27.7	26.7	40
Color	CU	3500	7000	7000	1750	140	420	62	70	435	70	30	25	30	–
Murkiness	NTU	140	28	500	6	20	100	550	215	230	6	1	2	3	–
Odor	TON	3	3	5	8	3	20	3	3	20	25	25	50	50	–
Volatile solid	mg/l	7528	1004	938	274	100	376	90	69	534	180	48	178	140	–
Air humidity	%	78	64	40	34	59	46	51	52	53	50	72	46	45	–
Air temerature	°C	30.9	32.2	38.6	44.9	33.9	33.1	35.7	35.8	31.6	35.0	30.6	36.5	36.0	–

Note) ND: Not Detected, -: no data: E+00*: ×10*

Table 6 Results of the Water Quality Survey (Guanabacoa, Ocho Vias, Campo Florido)

Sampling Items	Unit	Guanabacoa					8 Vias			Campo Florido	Discharge Standard to Inland Surface Water
		Leachate		Ground water	River		Leachate		Ground water	Ground water	
		F1	F2	E1 (16m)	D1	D2	H1	H2	G1 (13.5m)	I1	National Standard (NC27)
pH	-	7.09	7.50	7.32	7.72	7.75	7.28	7.47	6.98	7.08	6-9
DO	mg/l	0.00	0.00	0.9	5.29	5	0	0	2.0	2.65	–
EC	mS/cm	4.86	4.13	10.04	0.43	0.79	3.9	3.6	0.86	5.08	
TDS	mg/l	3666	2754	1422	283	223	2596	2144	68	837	–
COD	mg/l	1130	1478	1082	39	30	226	304	6	54	120
BOD	mg/l	923	984	372	19	11	168	206	2	21	60
Suspended Solid (SS)	mg/l	208	132	3986	31	37	38	130	356	133	–
Coliform bacteria(Total coliform)	NMP/100ml	9.3E+05	4.3E+05	5.0E+05	1.5E+04	4.3E+04	2.4E+04	9.3E+04	1.3E+04	2.4E+06	–
Coliform bacteria(Fecal coliform)	NMP/100ml	2.4E+05	9.3E+04	2.0E+03	1.5E+04	4.3E+04	2.4E+04	2.3E+03	3	2.4E+06	–
Cadmium (Cd)	mg/l	<0.005	<0.005	0.009	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	–
Zinc (Zn)	mg/l	0.120	0.211	3.960	0.012	<0.01	0.068	0.068	0.055	0.042	–
Copper(Cu)	mg/l	0.185	0.079	3.610	<0.01	<0.01	0.017	0.019	0.021	0.024	–
Lead (Pb)	mg/l	<0.1	0.14	0.97	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	–
Hexavalent chromium (Cr6+)	mg/l	0.144	0.225	0.120	<0.005	<0.005	0.220	0.280	0.067	<0.005	–
Arsenic (As)	mg/l	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	–
Total mercury (Hg)	mg/l	0.085	0.073	0.026	<0.01	<0.01	0.086	0.056	<0.02	<0.02	–
Total cyanide (CN)	mg/l	0.054	0.080	0.065	<0.05	<0.05	0.055	0.061	<0.05	<0.05	–
Ammonium nitrogen (NH4-N)	mg/l	8.94	35.82	21.2	1.17	0.31	22.7	2.87	0.057	1.33	–
Nitrate nitrogen (NO3-N)	mg/l	0.01	<0.01	1.09	0.02	0.03	0.01	0.01	0.35	0.73	–
Nitrite nitrogen (NO2-N)	mg/l	0.015	0.002	0.009	0.020	0.053	0.004	<0.005	0.018	0.524	–
Total nitrogen (T-N)	mg/l	32.26	51.41	37.57	36.44	3.60	30.67	4.97	4.04	5.48	20
Total phosphorous (T-P)	mg/l	15.29	1.64	9.45	2.06	12.30	12.36	5.32	0.34	2.96	10
Grease and oil	mg/l	0.13	0.26	4.36	0.00	0.00	0.23	0.49	0.01	0.27	30
Phenol	mg/l	0.038	0.159	0.188	<0.036	<0.036	0.036	0.036	<0.036	<0.036	–
Detergent	mg/l	<0.2	0.21	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	0.20	–
Alkalinity	mg/l	1055	919	4079	267	275	244	303	1080	1175	–
Acidity	mg/l	138	169	359	84	44	26	33	655	510	–
Temperature	°C	30.7	32.2	33.4	28.5	32.0	29.5	32.2	30.1	21.2	40
Color	CU	1400	1400	1400	60	60	233	233	20	20	–
Murkiness	NTU	140	26	310	5	8	34	45	256	21	–
Odor	TON	3	3	50	nd	nd	3	3	3	10	–
Volatile solid	mg/l	746	292	1422	166	36	174	666	68	222	–
Air humidity	%	52	58	64	46	58	51	57	54	53	–
Air temerature	°C	35.6	36.6	32.2	33.6	33.5	37.9	33.5	28.1	35.2	–

Note) ND: Not Detected, -: no data: E+00*: ×10*

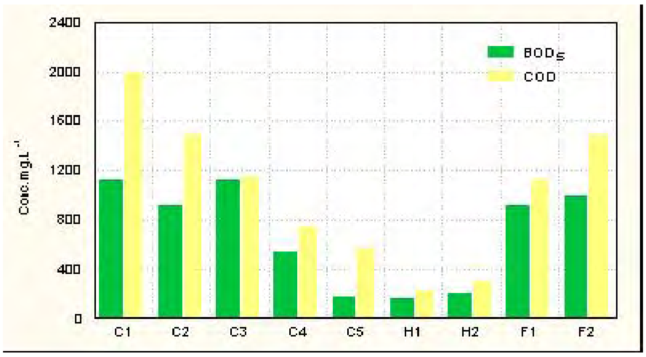

Figure 9 BOD$_5$ and COD Variations in Leachate

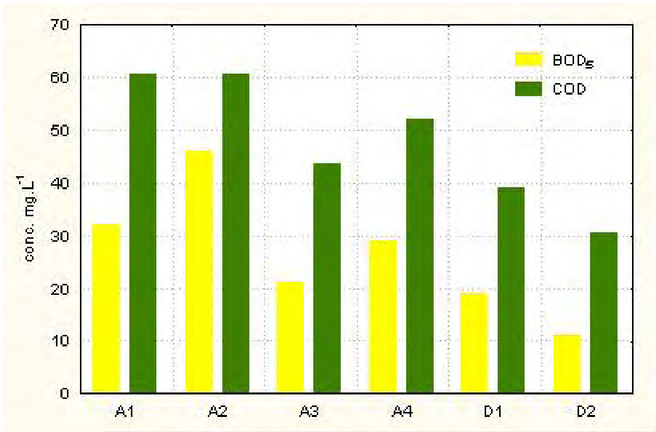

Figure 10 BOD$_5$ and COD Variations in Surface Waters

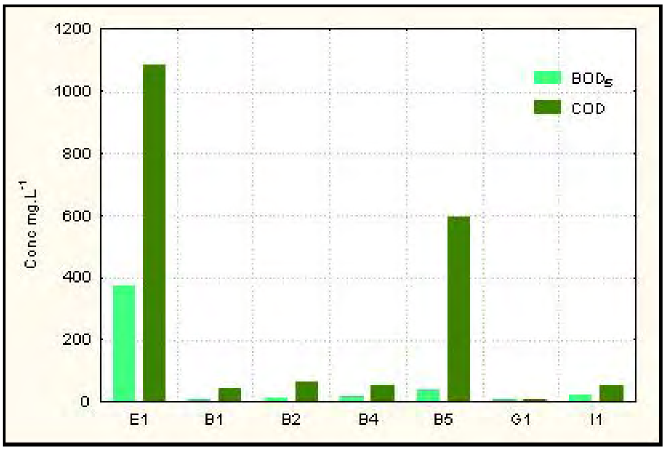

Figure 11 BOD$_5$ and COD Variations in Groundwater

5. Examination

- The leachate samples from Calle 100 and Guanabacoa landfills were found to be in the acidogenic phase according to the high levels of organic matter, BOD_5 and COD.
- All of the leachate samples were anoxic. This indicates that the leachate is in an anaerobic phase.
- The EC and pH values of the leachate were consistent with the values reported for leachate in different countries.
- In relation to the nitrogenous compounds, the ammonia levels indicate that the leachate is presently in a more reduced form than an oxidized form.
- The TN and TP concentrations in the leachate were higher than the Cuban criteria, which was used as a comparison.
- Sampling point C5 has different conditions than the other leachate sampling points. As this point receives wastewater from other pollution sources this may affect the quality of the sampled water.
- There is no statistical difference between leachate samples at Guanabacoa and Calle 100 landfills, either inside each group.
- Surrounding waters are oxygenated at the surface level, although they have high BOD_5 and COD values.
- Surface waters are polluted before they pass through the landfill areas.
- EC values in the groundwater are higher than the Cuban criteria for water supply.
- The groundwater contains a high level of organic matter indicating the possible infiltration of leachate.
- The groundwater contains bacteriological pollution with elevated fecal material, except in sampling point G1.
- In the groundwater reduced forms of nitrogenous compounds prevail and there are high concentrations of TN and TP.
- The concentrations of organic compounds, such as detergents and phenol, were lower than the detection limits, but oil and greases were higher than the Cuban criteria for water supply.
- The concentrations of Cd and Pb were higher than the Cuban criteria for water supply.

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D. Environmental Survey:

D4 Data of Diseases

D4. DATA OF DISEASES

The most frequent diseases occuring in 2002 were acute respiratory diseases (4,504,237 cases), acute diarrhea (887,901), chickenpox (16,791), viral hepatitis (14,150), blennorrhagia (12,883) and intoxication by food (9,752).

The main causes of death were heart-related diseases (19,078 deaths in 2002), malignant tumors (17,490), brain diseases (7,656), influenza and pneumonia (5,227), chronic lower airway diseases (2,284), suicides (1,594), diabetes (1,447), and cirrhosis and other liver-related diseases (963).

The main causes of death in children under one year old were perinatal diseases (427), congenital anomalies (274), accidents (33), influenza and pneumonia (29) and bacterial meningitis, while the main causes of death in children one to four years old in 2002 were accidents (65), congenital anomalies (37), malignant tumors (31), influenza and pneumonia (9) and heart diseases (8).

Source: Statistics yearbook of Cuba, 2002 - National office of statistics

E. Institution and Organization

E. INSTITUTION AND ORGANIZATION

1. Administrative Organization of the Government in Relation to MSWM

The figure below shows the organization of the Government in Cuba and the Havana City Province in relation to solid waste management, and the arrangement of the individual institutions in charge of the operational and control tasks within the government structure.

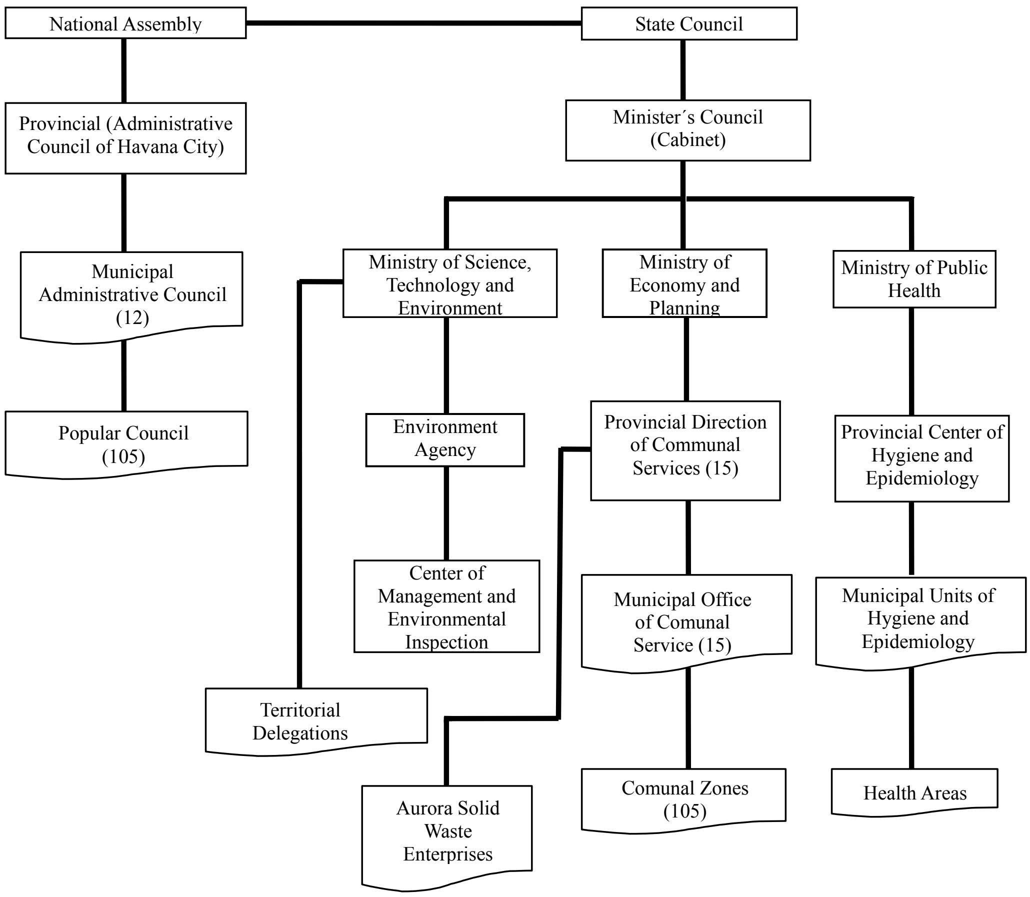

Figure 1 Structure of the Government in Cuba and Havana City

2 Staff of DPSC and CITMA Delegation

Table 1 presents the number of staff directly engaged in MSWM in Havana City, i.e., excluding administrative personnel and managers.

Table 1 Number of Staff Engaged for MSWM in Havana City

Province and Municipalities	Street Sweepers	Sanitation	Collection	Supervisors	Total
UPPH/DSPC			528 *		528
Municipalities					
Playa	377	47	40	29	493
Plaza AURORA	284	84	24	13	405
Centro Habana	138	20	15	9	182
Habana Vieja AURORA	196	33	13	17	259
Regla	44	15	35	-	94
Habana Este	114	87	27	6	234
Guanabacoa	109	10	104	17	240
San Miguel	93	-	114	12	219
10 de Octubre	165	-	74	-	239
Cerro	111	-	88	9	208
Marianao	105	-	50	4	159
Lisa	140	-	107	26	273
Boyeros	83	35	122	-	240
Arroyo Naranjo	223		145	28	368
Cotorro	90	-	117		207
Total	2272	331	1603	182	4388

* Container collection trucks drivers, roll-on roll-off truck drivers, workshop maintenance, disposal sites and recycling plant workers.

The number of staff in the CITMA delegation in Havana Province is shown in Table 2 and the qualifications of the CITMA Havana City delegation staff are shown in Table 3.

Table 2 The Number of Staff in the CITMA delegation in Havana City Province

Unit	Number of Employees
Head Office	5
Analysis and Information	2
Design Office	3
Biomedical and Biotechnology	6
Municipal Specialists	16
Knowledge management	15
Environment	10
Science and Technology	5
Administration	16

Table 3 Qualifications of the CITMA Havana City Delegation Staff

Level	Staff
University	59
Medium	6
Workers	6
Administrative	1
Support	2

3. Proposal for the enactment of new legislation

3.1 MSWM Regulations for Havana City Province

Chapter I – Objective and Definitions

1.1 Objectives

These regulations are set forth in order to establish the norms and guidelines concerning the solid waste management public service in Havana City Province, in particular the citizen's role, duties and obligations, as well as the government functions and responsibilities.

(1) These regulations apply to the activities and operations of the integrated solid waste process, from its generation in the social and economic sectors to its final disposal.

(2) Radioactive solid waste, hazardous or toxic solid waste and industrial waste not compatible with regular collection are not covered under these regulations.

(3) These regulations are established under the authority of the National Environmental Law, law No. 81 of July 11, 1997.

1.2 Terms and Definitions

For the purposes of these Regulations, the following definitions apply:

- Collection - Activity of picking up the solid waste from the generators, undertaken by the service provider.
- Collection Ordinary Service – The type of domestic collection service that can be provided according to the capacity of the service provider and that does not match any type of service designated as "special".
- Demolition debris - Solid waste from civil construction activities.
- Final disposal - The process of isolating and confining solid wastes in specially designated places designed to avoid pollution and other hazards to human and animal health and the environment.
- Generator – Individual people or institutions that produce solid waste and are the users of the collection service.
- Hazardous solid waste - Solid waste that may, due to its infectious, flammable, toxic, explosive, corrosive, radioactive, or combustible characteristics cause harm or risk to human health or deteriorate the environment to levels that can harm human health. The containers, bottles and/or packs where these wastes have been stored are also hazardous.
- Integrated management of solid waste - A set of operations and rules aimed to adequately, from an environmental point of view, dispose of solid waste according to

its characteristics, volume, origin cost, treatment, possibilities of treatment, recovery, re-use and final disposal.

- Large producers or generators - Non-household generators producing more than one cubic meter of solid waste per month.
- Leachate - A liquid that results from water collecting contaminants as it trickles through wastes, agricultural pesticides, or fertilizers. In a solid waste landfill, it is the liquid generated by the biological decomposition of the biodegradable portion of solid waste, and the percolation of water through it.
- Management - Set of activities from generation to disposal of the solid waste, including source segregation, presentation for collection, collection, transportation, storage, treatment and disposal of solid waste.
- Micro Route - Description of collection vehicle route by street and block for service provision.
- Non-residential user - Individual or institution that generates solid waste from the commercial, industrial or service activity, not classified as residential and that receives regular collection.
- Parks and gardens solid waste - Solid waste from the cleaning and sweeping of gardens and parks, including branch trimmings, and grass trimmings from public spaces.
- Presentation - Activity of the generator in relation to packing, and identifying the solid waste for its storage and later transfer to the service provider for recycling, collection transportation, treatment and disposal of solid waste.
- Public Space - Designated areas for public transit, vehicular or not, that are part of the city infrastructure and that comprise the streets, avenues, alleys, bridges, parks, etc., used for public transit and leisure.
- Public spaces cleansing - Removal of solid waste from public spaces through mechanical or manual sweeping.
- Public spaces washing - Removal of solid waste from public spaces using water under pressure.
- Recoverable solid waste - Any material, object, substance or solid element that is useless for its generator, but could possibly be reincorporated into a productive process.
- Recycler – Individual or enterprise that renders the public service of reusing solid waste either as the same object or as a raw material.
- Recycling – Process through which recovered solid wastes are reused or are used as raw materials and/or reincorporated into the economic cycle.
- Residential user - Individual person or institution that generates solid waste in a residential household and receives regular collection services.

- Reuse – The extension of the useful life of recovered solid wastes through processes, operations and techniques to utilize the materials in the same original function or in any related function without the need for any additional transformation processes.
- Service area – Geographical division of the urbanized area of a city for collection and street sweeping service planning.
- Sanitary landfill - Sanitary landfills are land disposal sites for non-hazardous solid wastes in which the waste is spread in layers, compacted to the smallest practical volume, and a cover material applied at the end of each operating day.
- Sanitation – Activity related to the collection, transportation, treatment and disposal of solid waste that is, by its nature, composition, size, volume and weight, not ordinarily able to be collected, handled, treated or disposed of by the service provider.
- Service frequency - The number of times during a week that the collection service is provided to the customers.
- Small generators or producers – Non-residential producers that generate less than one cubic meter of solid waste per month.
- Solid Waste Container - Metallic or plastic storage box for the temporary storage of solid waste from the community. The containers are provided with a lid and are suitable for being handled by mechanical lifting devices.
- Solid Waste - Municipal waste, which originates from residential, commercial, institutional and/or industrial sources and includes semi-solid sludge, household hazardous waste and any other substances that are typically disposed of in municipal-type landfills.
- Segregated collection – The classification of the solid waste at the site of its generation, aimed toward its recycling.
- Storage - Action of a user to temporarily store the solid waste in a bag, wastebasket, etc., until the time of collection by the public service.
- Storage Unit – Designated fenced and/or enclosed area where the containers in which the generator stores the solid waste are located.
- Street Sweeping - Set of activities with the purpose of making the public spaces free from solid waste and litter.
- Transfer stations - Facilities built to manage and transfer solid wastes from the collection trucks to other larger trucks especially designed to haul the waste to the final disposal site or to a treatment facility.
- Treatment – Set of operations, processes or techniques through which the characteristics of the solid waste are modified in order to increase the possibility of its reuse, or in order to minimize the environmental impacts and risks to human health.
- User – Individual or institution that receives the public service. Either the owner of the real estate or the direct receiver of the service.

- Zone – The geographical division of the urban area of a municipality constituting the operational unit area for service provision.

Chapter II – Roles, Duties, Responsibilities and Obligations

2.1 General Requirements

(1) Responsibility for solid waste collection and disposal in Havana City Province lies with the DPSC together with the 15 DMSCs, one in each province.

(2) Responsibility for the generation and storage of solid wastes lies with the generators, that is the citizens in general and those responsible for the commercial and industrial facilities that generate solid waste.

(3) It is the responsibility of each generator to endeavor to:

1) Reduce the amount of solid waste generated through the rational use of resources and through technologies, methods and practices that favor the minimization of its generation, and the reuse and recycling, whenever possible, of unavoidable wastes.

2) Collaborate in the segregated collection process for solid waste where this method of collection is practiced.

(4) Solid Waste Management System Components

The solid waste management system is an integrated set of activities comprised of:

- Collection services, using communal containers or by door-to-door service;
- Transportation system using suitable vehicles;
- Cleaning of streets and other public spaces;
- Solid waste treatment, which includes recycling and energy recovery from solid waste;
- Final disposal in sanitary landfills.

(5) Solid Waste Management Services-Methods of Provision

Solid waste management services may be provided either as:

1) Ordinary services – Collection of waste from households, markets, hospitals, or light commercial activities, through the use of street containers or door-to-door; routine street sweeping, washing services, including tunnel and beach cleaning and ultimate disposal in sanitary landfills.

2) Extraordinary services – Collection from large waste generators; cleaning at festivals and public meetings; collection of demolition debris and large bulky items.

2.2 Citizens' Responsibilities

The generators of solid wastes, as a whole, have an important part to play in solid waste management activities and therefore they are requested to comply with the following guidelines:

(1) Storage of Solid Waste

Regular solid waste shall preferably be stored in plastic bags. If plastic bags are not available, solid waste shall be stored in paper sacks or wrapped in paper, prior to collection in containers or by the collection trucks.

(2) Presentation for Collection (non-container areas)

1) In the areas where there are no street containers, and collection is made door-to-door, waste shall be placed on the sidewalk one hour before the scheduled time for collection on the fixed collection days.

2) In the areas where segregated collection is practiced, the recyclable items shall be presented separately from the non-recyclable items.

(3) Communal Container Area Procedures

1) Citizens are not permitted to dispose of wastes outside of the collection containers.

2) It is the full responsibility of the citizens concerned not to place hazardous or toxic wastes in the collection containers.

3) Responsibility for hospital and other health sector units' solid waste storage containers shall be shared between each generator and the DPSC/DMSC.

(4) Storage and Waste Conditioning in Markets, Cemeteries and Slaughterhouses

Markets, slaughterhouses, and cemeteries shall have internal procedures for solid waste management before presenting the waste for collection at the time and place specified by the DPSC/DMSC.

2.3 Collection Procedures

(1) Collection operation: shall be carried out such that there are no environmental impacts or nuisances to citizens, especially with respect to the production of odors, noise and/or dust.

(2) Collection route, hours and frequencies: shall be informed to the citizens through the use of a public information system.

(3) Collection of demolition debris, bulky items, furniture and other large items: shall be carried out once a month according to a schedule which shall be made available to the citizens.

2.4 Transportation Requirements

(1) Vehicle Requirements: vehicles transporting solid wastes shall be kept clean and shall be provided with all of the safety systems and markings to identify the operator.

(2) Vehicle and Environmental Controls: Vehicles transporting demolition debris, refuse, garbage and any other kinds of solid waste shall be covered to impede the discharge of debris and dust into public spaces.

2.5 Cleaning of Streets and Public Spaces

(1) The responsibility for keeping the streets and other public spaces clean lies with both the citizens and the street sweeping sector of the DMSCs.

1) Civil construction and demolition work shall be executed in such a way that it does not impair the walkways or produce dust that could disturb the neighborhood comfort and well being.

2) Street vendors of sandwiches, ice creams, and general foodstuffs shall keep a receptacle for litter in the vendor's cart or nearby. The receptacle shall be lined with a plastic bag.

3) Animal owners are responsible for cleaning up feces produced by their animal in public spaces and are also responsible for the disposal of the corpses of their dead animals.

(2) It is forbidden to dispose of, or to allow for the disposal of solid waste, especially demolition debris, dead animals and tree branches, in vacant lots, on the seashore, river banks, or any public space, in a way that could impair the landscape, or that could harm the environment, the safety or the people's and animal's health, especially where this leads to the proliferation of mosquitoes or other insects.

(3) Litter Control; citizens shall not dispose of litter, especially plastic bags, old newspaper, food wrappings and cigarette boxes, in the streets or other public spaces.

2.6 Recycling and Recovery

(1) Objectives: the main objective of recycling is to reduce the amount of waste being collected and disposed of into sanitary landfills.

Recycling and materials recovery in Havana City is the responsibility of the government with the participation of the community.

(2) Recyclable Materials: recyclable materials are those that can be reused or that can be used as a source of raw material for processing and manufacturing, such as glass bottles, aluminum cans, plastic bottles and other metallic goods.

(3) Recycling Methods: recycling of solid wastes can be made through segregated collections or processing plants.

1) The preferable recycling method is through segregated collections, where recyclable materials and goods are segregated by generators and placed in separate containers for collection by the public service.

2) Recycling in processing plants is made through sorting the recyclable materials and goods manually or by mechanical means.

2.7 Final Disposal – Definition

(1) Responsibility for Final Disposal of Solid Wastes: The final disposal of urban solid wastes is the responsibility of the DPSC; for all other types of waste, responsibility lies with the generator.

(2) Requirements for Land Disposal of Solid Waste: The disposal of solid waste on land shall be made through the sanitary landfill method.

(3) Licensing Disposal Sites and Operations: The licensing of sanitary landfills shall be carried out in accordance with the requirements issued by CITMA, especially the siting of the landfill and the procedures required by the EIA - Environmental Impact Assessment study for this type of construction.

(4) Environmental Control of Final Disposal Sites

(5) Responsibility for Environmental Damage: Environmental damage due to improper management or disposal of solid waste is the responsibility of the entity that caused the damage.

2.8 Citizen Participation

(1) Citizens' Rights

1) Participation- Citizen's have the right to be informed about collection procedures such as time, frequency and routes, as well as how the solid waste is disposed of in the city.

2) Complaints from Citizens- Citizens shall have a clear and easy channel through which to file complaints relating to the solid waste collection and disposal services in the city.

(2) Citizens' Duties – It is of paramount importance that the citizens in general, who are the solid waste generators, are aware of their responsibilities in the solid waste management system, especially in the presentation of solid waste for collection and recycling:

1) Presentation for collection in areas with containers shall be made by placing the solid waste, stored in plastic or paper bags or wrapped in any suitable material, inside the containers.

2) Presentation for collection in areas without containers shall be made placing the solid waste, stored in plastic or paper bags or wrapped in any suitable material, along the foot path on the day and time specified for collection by the public service.

3.2 Regulations and Guidelines for Sanitary Landfill Construction and Operation

1. General

The following guidelines shall be used in the design, construction and operation of sanitary landfills for solid wastes.

These guidelines set the minimum requirements, standards and criteria for the project implementation and operation of sanitary landfills, in order to protect the nearby water bodies, both above and below ground, the atmosphere nearby as well as the sanitary landfill workers.

These guidelines do not apply to hazardous (secure) waste landfills or to landfills serving a population below 20,000 inhabitants.

2. Definitions and Terms

- Aerobic – A life or process that requires, or is not destroyed by, the presence of oxygen.
- Anaerobic - A life or process that occurs in, or is not destroyed by, the absence of oxygen.
- Solid Waste - Non-liquid, non-soluble materials ranging from municipal garbage to industrial wastes that contain complex, and sometimes hazardous, substances. Solid wastes also include sewage sludge, agricultural refuse, demolition wastes, and mining residues.

- Biogas - Gas produced in the gasification process of anaerobic digestion of solid waste.
- Permeability - The rate at which liquids pass through soil or other materials in a specified direction.
- Compaction - Reduction of the bulk of solid waste by rolling and tamping.
- Leachate - Liquid that results from water collecting contaminants as it trickles through wastes, agricultural pesticides, or fertilizers.
- Recycling - The process of minimizing the generation of waste by recovering usable products that might otherwise become waste. Examples are the recycling of aluminum cans, wastepaper, and bottles.
- Sanitary landfills - Sanitary landfills are land disposal sites for non-hazardous solid wastes in which the waste is spread in layers, compacted to the smallest practical volume, and a cover material is applied at the end of each operating day.
- Pathogenic wastes – Solid wastes potentially containing pathogenic microorganisms.
- Segregation – Separation of solid waste components into several categories of materials.
- Life span – Useful life of a piece of equipment or facility.
- Security landfill – Landfill with environmental controls and devices adequate to safely dispose of hazardous solid wastes.
- Covertures – Cover material spread and compacted over the solid waste cells.
- Dump - A site used to dispose of solid wastes without environmental controls.
- Solid Waste - Non-liquid, non-soluble materials ranging from municipal garbage to industrial wastes that contain complex, and sometimes hazardous, substances. Solid wastes also include sewage sludge, agricultural refuse, demolition wastes, and mining residues.
- Underground water - Water present in the subsoil.
- Open Dumping - The action of disposing of solid waste on land, in marshes or water without environmental protection.

3. Legal Framework

CITMA, throughout its provincial delegations, will be the responsible institution for approving the environmental licensing, the site location, the operation methods, and the engineering design as well as for monitoring the operation of the facility.

4. Project Presentation

Presentation of the project will be made under the following headings:

(1) Objective of the Project, Responsible Organization

(2) Project Description

(3) Technical Specifications

(4) Equipment Description

(5) Time Schedule

(6) Cost and Budget

(7) Annexes:

I – Site Selection
II – Geological, Geotechnical and Hydrological Studies
III – Environmental Impact Assessments
IV – Calculations

4 Project Contents

The project shall present the following information, as a minimum:

1. General

1.1 Responsible officer and institution– name and curriculum vitae of project designer and name of responsible institution

1.2 Overall Description – Description of the project shall include:

1.3 Background

- Conception and reasoning
- Site description and access roads
- Information about residues to be disposed of (composition, water content, specific weight
- Area preparation

(1) General

Description of basic project items: Disposal area, type of operations, drainage, facilities, perimeter fences, leachate treatment and disposal, etc.

(2) Infrastructure

Description of the lighting system, water supply, sewerage networks, communication facilities, etc.

(3) Equipment

Description and quantity of equipment to be used.

(4) Operational Planning

- Waste cell construction, cover material placement
- Cover material source, excavation and hauling
- Maintenance plan for service roads
- Cell area preparation plan
- Dust and litter control plan
- Equipment maintenance system
- Residue reception control

(5) Monitoring System

- Leachate monitoring
- Biogas monitoring
- Settlement monitoring

(6) Safety System

- Contingency plan, especially for hurricane season and tropical storms
- Bird control
- Odor control
- Scavenger control

(7) Closing and Post-closing Plan

- Area future use plan
- Water contamination, after closing monitoring plan
- Air pollution control after landfill closing

1.4 Design, Drawings and Plans

The project shall present the following drawing plans:

- Location (scale 1/5000 or 1/10000)
- Land survey of original ground (scale 1/500, 1/1000 or 1/2000)
- Cross sections of different phases of landfill construction (scale 1/200, 1/500, 1/1000 or 1/2000)
- Layout of sanitary landfill (scale 1/500, 1/1000 or 1/2000)
- Ancillary facilities drawings: plans and cross-sections. Scales, workshops, offices, (scale 1/50 or 1/100)
- Plan and details of perimeter fences and walls
- Cell distribution (scale 1/500, 1/1000 or 1/2000)

- Cross-sections of cells and platforms (scale 1/200, 1/500, 1/1000 or 1/2000)
- Surface water drains – plans and construction details (scale 1/500, 1/1000 or 1/2000)
- Gas relief system – placement and construction details
- Drainage system – location and construction details – (scale 1/500, 1/1000 or 1/2000)
- Leachate treatment system (scale variable) – placement and construction details
- Cell construction process (scale variable)
- Landfill bottom sealing process – cross-section
- Final covertures layer – cross-section
- Landscape of finished landfill (scale variable)
- Monitoring well placement and construction details

1.5 Time Schedule

The time schedule shall be presented on a yearly basis, showing the advancement of the waste cells and equipment used.

1.6 Cost and Budget

Cost estimates for the sanitary landfill shall be presented detailing all of the construction materials, facilities, equipment and civil works.

2. Annexes

2.1 Landfill Site Selection

2.2 Geotechnical, Hydrological and Geotechnical Study

2.3 Environmental Impact Assessment – (according to CITMA rules)

3. Calculations

The presentation of data adopted, supported by calculations, is mandatory for:

3.1 Volume Capacity of Landfill

3.2 Type and Equipment to be Used

3.3 Earth Material Needed for Cover

3.4 Leachate Production Estimates over Sanitary Landfill Life Span

4. Mandatory Parameters and Criteria to be used

Projects should comply with the following criteria and design parameters, unless the environmental control agency (CITMA) states otherwise.

4.1 Location

(1) The location of the landfill shall be consistent with the city zoning for this type of activity.

(2) It is recommended that a sanitary landfill should not be located within 3,000 meters of the end of any airport runway used by turbojet aircraft or within 1,500 meters of the end of any airport runway used only by piston-type aircraft. If the landfill does not comply with this requirement, it must be demonstrated that the units are designed and operated so that the unit does not pose a bird hazard to aircraft and, special permission from aeronautical authorities shall be issued.

(3) The sanitary landfill should not be located in wetlands or a floodplain. *Floodplains* are the lowland and relatively flat areas adjoining inland and coastal waters, including flood-prone areas of offshore islands that would be inundated by a 100-year flood.

(4) It is recommended that sanitary landfills should not be located within a radius of less than 500 meters of an urbanized area in the direction of the prevailing wind and 300 meters in the other directions.

4.2 Cell Construction

(1) Waste cells shall be designed with a maximum height of 2.50 meters, and the working face area shall be designed as a function of the daily waste volume, the cell advancement and the frequency of cover. Preferably, each cell should not surpass 300 m^3 of volume of residue, being constructed of sloped layers of maximum 0.60 m in thickness.

(2) Cell slopes should not be steeper than 1V: 2.5H, with 1V: 3H slope being recommended.

(3) Intermediate cover shall have a cohesion and particle size distribution so as to achieve a maximum permeability of 10^{-4} cm/sec, spread in compacted layers of 15 cm thickness.

(4) Special isolated cells shall be designed to dispose of hospital and other health unit solid waste, over the whole life span of the landfill.

(5) In the landfill design, specially located cells shall provide easy and safe access during the rainy season.

4.3 Bottom Layers and Surface Sealing

(1) The bottom impervious layer shall be made of a liner consisting of at least a 60 cm layer of compacted soil with a hydraulic permeability of no more than 10^{-7} cm/sec.

(2) Over the bottom layer shall be placed a leachate drainage system. Over the drainage system shall be a 50 cm thick sand layer in order to protect the drains and any impermeable synthetic material.

(3) If necessary, due to the depth of the water table and/or the natural soil conditions, a synthetic plastic liner shall be used. The synthetic liner shall be made of HDPE – High Density Polyethylene, with a minimum thickness of 1.52 mm. The flexible membrane layer component must be installed in direct and uniform contact with the compacted soil component.

(4) The cell cover layer shall have a minimum thickness of 15 cm, preferably of clay-sand material. Final cover shall have a minimum thickness of 60 cm. In both cases, the thickness is measured for the compacted material.

(5) From the bottom of the landfill to the highest underground water level the layer of unsaturated soil shall have a thickness not less than 50 cm. The level of the underground water shall be measured during the rainy season.

(6) An impermeable layer seal final cover over the landfill shall be applied to reduce rain or surface water infiltration. Accordingly, the top surface shall have a minimum slope of 3% and consist of the following layers, from top to bottom:

- Topsoil, able to support vegetation of non-axial root type, with a minimum thickness of 60 cm;
- Drainage layer at least 25 cm thick, with a permeability higher than or equal to 10^{-3} cm/sec;
- Compact clay layer of 50 cm thickness with a permeability coefficient of less than 10^{-7} cm/sec.

Other impermeable layer systems may be used if approved by the environmental agency CITMA.

4.4 Leachate Treatment and Collection

(1) The leachate from the landfill shall be drained for treatment before discharge to any water body or to the sewerage system. Treatment shall comply with CITMA rules for effluent discharge and with the guidelines presented here.

(2) In order to minimize the amount of leachate to be treated and discharged to the receiving water body, a recirculation may be used, provided that no stability problems may occur in the waste cells.

(3) The drainage system for collection and drainage of leachate shall be placed over the impermeable bottom layer with a dimension and shape that would avoid a water head higher than 30 cm, over the impervious layer.

(4) The treatment system shall achieve a treatment grade of leachate to ensure that the effluent will comply with the water quality of the receiving water body and also comply with the allowable discharge requirements.

4.5 Surface Water Drainage

The sanitary landfill shall have a water drainage system able to support a 50 year return period rainfall. The drainage of the water run-off system shall be inspected after every heavy rainfall event in order to keep the system in full operational status.

4.6 Perimeter Fencing

(1) The sanitary landfill shall have a fence around the entire perimeter in order to prevent any non-authorized personnel or animals from accessing the site and also a gate where a control system will be established to allow employees, vehicles and equipment to enter the site.

(2) Beyond the perimeter fencing a tree wall system shall be installed with a minimum width of 10 meters.

5. Monitoring System

Surface and/or underground water monitoring shall be carried out in the vicinity of the landfill, according to CITMA rules. In any case, the minimum parameters to be monitored shall include:

Total hardness as $CaCO_3$*, Total alkalinity as $CaCO_3$, Suspended solids, Total solids, Specific conductivity, pH*, Total organic carbon*; Suspended Solids, Anions and Cations, Calcium, Manganese, Sulfate, Magnesium, Ammonium, Chrome, Silver, Barium, Copper, Arsenic, Cobalt, Chlorates*, Barium, Thallium, Beryllium, Lead, Nickel, Vanadium, Mercury, Zinc.

* Monthly analysis

6. Closure and Post-closure Operations

6.1 Top Seal Cover

The operator of the sanitary landfill must install a final cover system that is designed to minimize infiltration and erosion. The final cover system must be comprised of an erosion layer underlain by an infiltration layer as follows:

- The infiltration layer must be comprised of a minimum of 50 cm of earthen material that has a permeability less than or equal to the permeability of any bottom liner system or natural subsoil present or a permeability no greater than 10^{-5} cm/sec;
- The erosion layer must consist of a minimum of 15 cm of earthen material that is capable of sustaining native plant growth.

6.2 Closure Care

Following closure of a sanitary landfill, the owner or operator must conduct post-closure care for 30 years, which will consist of:

(1) Maintaining the integrity and effectiveness of any final cover, including making repairs to the cover as necessary to correct the effects of settlement, subsidence, erosion, or other events, and preventing run-on and run-off from eroding or otherwise damaging the final cover;

(2) Maintaining and operating the leachate collection system;

(3) Monitoring the groundwater and maintaining the groundwater monitoring system, if applicable;

(4) Maintaining and operating the gas monitoring system.

5. Alternatives for the Selection of a New Institutional and Organizational Structure

This Chapter presents a discussion on the alternatives for a new institutional and organizational structure in the long-term.

These alternatives are discussed and analyzed in order to present their respective advantages and disadvantages prior to selecting the most appropriate alternative.

5.1 Existing institutional models for solid waste management

Before presenting the possible alternatives for an institutional and organizational system for Havana City, a brief review of the most common existing models for solid waste management institutions are discussed. The emphasis is given to those most common in Latin America, to provide a reference for the proposals to be presented.

It is noted that many different institutional models exist for the provision of solid waste management services. In most instances they are public service institutions or authorities forming part of local (or municipal) governments, but sometimes with a varying degree of private sector participation.

In short, these models could be divided broadly into the following categories:

- Direct municipal administration
- Municipal administration contracting out the services (outsourcing)
- Autonomous government authority – (state enterprise)
- Concession by the government to the private sector
- Free market (private company providers)
- Combined models of the above

Some of these models can accommodate private enterprise participation in the operational services in several formats. They also show a varied degree of autonomy, mainly from a financial point of view, as well as different degrees of accountability to the client, that is to waste generators and the general population.

The operational flexibility, which defines the capacity to respond to unexpected daily problems, also varies depending upon the type of organization selected as outlined below.

Table 4 Solid Waste Management Institutional and Organizational Models

Type of Institution	Private Participation	Degree of Autonomy	Accountability to the Public	Operational Flexibility
a) Direct municipal administration	None	None	Low	Medium
b) Municipal administration contracting out the services	Medium	None	Low	Medium
c) Autonomous Government Authority	None	Medium	Low	High
d) Concession to private sector contractors	High	High	Medium	High
e) Private providers, formal or informal	High	High	High	High
f) Combined model of the above	Variable	Variable	Variable	Variable

In Latin America, the prevailing institutional model in the larger cities is one based on the municipality contracting out (or outsourcing) waste collection and street sweeping activities, referred to as model "b". Recently, a trend towards contracting out disposal services has also occurred. In this way, private contractors are paid to operate sanitary landfills through a tipping fee.

For smaller cities, the most utilized model is based on direct municipal administration (model “a”), in which the solid waste management institution is a division of the public works or public services department of the municipality.

Concession to the private sector, model “d”, although gaining popularity in the water and sanitation sectors, is very rarely used in solid waste management, although some cities are starting to experiment in that direction.

Private independent providers, model “e” have been very popular in the United States of America, where generators are free to choose among available service providers on single and specific contracts. This model is becoming more popular in some large cities in Latin America, but only for the large scale generators such as shopping centers, hotels, super markets, service stations and light industries where waste production is at least 1 m^3 per day per unit.

The autonomous government authority, model “c”, was very popular in larger cities throughout the 1980s and 1990s. However, institutions are now contracting out services to the private sector to a greater degree, and this has developed into an example of a “combined system” or type “f”.

In general, numerous variations of these models now exist in Latin America. Two or three different models are usually combined, such as a governmental authority contracting out to a private contractor only the domestic collection activities, or assigning to private companies those markets associated with the large generators, that is, those institutions producing more than 1 m^3/day of waste per unit.

An important issue relating to the determination of a solid waste management system institutional model is the method of financing the services, as this is a recurring problem in the proper delivery of adequate services in Latin America.

In this regard, there are several possibilities, such as:

- No charge to the customers, the budget of the solid waste management institution being provided by the government treasury.
- General tax charged for several public services, including solid waste management, imposed on households, usually according to the property value. The amount collected is transferred to the solid waste management institution, and is usually supplemented by the treasury budget.
- Direct specific tax for household collection, according to some parameters related to solid waste generation, such as number of people in the household, surface area of the household and the kilowatts of energy used in household.

- Direct contract between the generator and the service providers, with charges usually being defined by the amount of waste to be collected and frequency of collection.

The most common financing scheme for solid waste management in Latin America is the general tax system, where part of the income from the municipal authority is directed to the solid waste management system budget. In this case, the amount contributed does not have any relationship to the amount of waste generated by each customer, that is, the waste generators.

At present there is a trend in the larger cities to use a taxing system that provides an incentive to minimize waste generation, at least in the large generator institutions. This leaves them to freely contract the solid waste collection with private service providers.

There are, however, some problems related to directly charging people for the services provided, such as:

- Part of the population in Latin America (the poorest people) cannot afford to pay for the services.
- In the case of non-payment by the customers, it is not possible to interrupt the service in a similar manner to other public services, for example water and sewage, electricity and telephone. Furthermore, any service interruption could lead to a sanitary problem as the waste will continue to be generated and will be discarded into public spaces.

Because of the above situation, when this type of charging has been implemented in Latin American cities high arrears have been experienced, sometimes exceeding 50%. A solution to the arrears problem has been to attach the solid waste bill to the water or electricity bills, providing that the solid waste component is paid together with the water or electricity account.

5.2 Alternatives for the Havana City Solid Waste Management Institutional Model

Of the alternative institutional and organizational models available and suitable for the conditions in Latin America, a new institutional model for solid waste management in Havana City can be selected from the following alternatives:

- A model remaining basically as it is today, that is with the DPSC and DMSCs as government offices and the Aurora enterprises in charge of some selected areas of the city.
- Extend the concept of the municipal Aurora enterprise to the other municipalities of the city, until it embraces the entire Havana City territory, resulting, finally, in one Aurora enterprise for each municipality (fifteen in total).
- Set up a variation to model (b), dividing the city into a few areas, with similar characteristics, and establishing three Aurora enterprises.

- Set up Aurora enterprises, based not on the territorial aspects of each area, but rather on the respective activities of each such as collection, disposal, etc. Under this proposal, there would be one Aurora for the collection activities in the entire city, another for street sweeping, another for vehicle operation and maintenance, another for recycling and composting and another for planning and engineering. This alternative could also split the collection and street sweeping activities on a territorial basis.
- Set up only one Aurora Company, in the Havana City Province, which would take care of all solid waste management activities in the entire city, that is, one Aurora encompassing the fifteen municipalities of the city.
- Create a joint venture with a foreign company, in order to set up a business-like company for solid waste management.

At this point in the Master Plan study, a proposal is being developed that will reflect the most appropriate model for Havana City, based on the advantages and disadvantages of each approach outlined above. This is discussed below.

(1) Alternative A – UPPH – DPSC/DMSC – Aurora

Summary: The present situation with various agencies and levels of government working on different activities, with localized improvements.

Advantages:

- In this case the situation would remain the same as it is at present without the need for any changes and therefore without the administrative costs relating to such changes. In many instances, the present system has proven to be capable of carrying out the basic tasks, at an apparently low cost, and without any direct financial burden on the majority of customers.

Disadvantages:

- Most of the problems relating to the poor operational response for waste collection and street sweeping and the poor quality of landfill would remain.
- Accountability to the population would also remain dubious, as there are many different institutions and levels of government involved in the different phases of service provision.
- Financing of the activities would probably also remain uncertain and deficient, as it is at present.
- Coordination between different agencies and levels of government would remain difficult, leading to a less than optimal use of resources.

(2) Alternative B – Solid waste management carried out by 15 Aurora enterprises

Summary: Extending the concept of the Aurora enterprise from the present two municipalities to all fifteen municipalities in the Havana City Province.

Advantages:

- The Aurora enterprise has shown that it can improve solid waste management, as observed in two municipalities in Havana City. The experience acquired through the operation of Aurora Plaza and Aurora Habana Vieja could be extended to other parts of the city, until this structure covers the entire city.
- In this alternative, transition to the new model would be a smooth, step-by-step process up until the year 2015, and would be carried out at a pace sufficiently slow enough to provide the necessary administrative measures to replace the existing institutional framework.
- Furthermore, the existence of fifteen Aurora enterprises would foster competition between themselves, leading to more efficient enterprises, and therefore to a more efficient system as a whole.

Disadvantages:

- The main disadvantage of this alternative would be the fragmented system with high administrative costs, as each Aurora enterprise would have its own head and administrative staff. This situation would waste financial resources, which are very scarce in Cuba.
- Planning disposal operations would be very difficult, since it would be impossible to have one disposal site for each Aurora.
- From a financial point of view, there would be an imbalance between the Auroras. Those located in the most affluent areas, where customers deal with hard currency, could charge in free convertible Pesos. The income of these Auroras would be far greater than those serving the residential periphery areas, where customers are not dealing with convertible Pesos.

(3) Alternative C – Three Auroras – East, Center and West – System

Summary: In this case, three full Aurora enterprises would be set up, one in the eastern part of the city, one in the center, and another in the west. Each one would have its own administration as well as its own disposal site, trucks, equipment, workshops and warehouses.

Advantages:

- Under this system, the network would not be so fragmented, but at the same time it would foster competition between the three Aurora enterprises.

- Another advantage is that each Aurora would be autonomous in respect of its main task, that is, to collect and dispose of solid waste.

Disadvantages:

- The disadvantages of this alternative are the same, although to a lesser degree, as those for alternative "B". There would be some uneconomical aspects due to the reproduction, in each enterprise, of the administrative and head staff, thereby increasing the cost of the overall system.
- Another disadvantage relates to the difficulties involved with the selection and construction of disposal sites, as available sites are becoming progressively more difficult to find in the Havana City Province.

(4) Alternative D – Setting up Aurora Enterprises According to Function and Territory

Summary: Three Aurora enterprises would be set up, each one taking care of waste collection and street sweeping in the eastern, central and western part of the city. In addition, one new Aurora enterprise would be created for waste disposal in landfills, including recycling operations, and another new Aurora would be established to provide the vehicles and equipment for the three regional Auroras.

In this option, the function of the DPSC would be to control and monitor the activities of the several autonomous Aurora enterprises, as well as concentrating on the enforcement of the public cleaning regulations using inspectors.

Advantages:

- An advantage of this alternative lies in the fact that each enterprise would specialize and concentrate on its own affairs; therefore probably achieving a higher level of expertise in its respective specialist function.
- Another advantage is that all segments of the solid waste management system, especially the disposal and recycling/composting operations, would have the same level of importance.
- From the viewpoint of final waste disposal, there would be no territorial limitations in finding a suitable location for the landfill.
- The financing of each enterprise would be autonomous, with each having its own budget and being able to collect fees from its customers in Cuban Pesos or in MLC as well as being able to obtain income from the sale of recycled goods and compost materials.

Disadvantages:

- The main disadvantage of this option would be the difficulty of coordinating between the enterprises, as support activities in each institution would be subject to a different chain of command.

- Furthermore, there would also be the same disadvantages as those associated with alternative “B”, and to a lesser degree, alternative “C”, that is, the reproduction of the administration and head staff in the several Auroras, leading to some diseconomies of scale.

(5) Alternative E – Establishment of Only One Aurora Enterprise for the Entire City

Summary: Only one institution would be established, encompassing all of the solid waste management activities, for the entire Havana City Province. This would be a single enterprise devoted entirely to solid waste management and all of its operational aspects, with its own support activities and staff. This enterprise would be responsible not only for waste collection, street sweeping and sanitary disposal within the entire territory of Havana City Province, but also for recycling and composting activities.

Advantages:

- Being the only institution dealing with all aspects of solid waste, it would also be the only entity responsible for all related problems, increasing its accountability to the population.
- Planning the activities would be easier, especially in relation to solid waste disposal, as the entire city would be subject to only one authority.
- Several economies of scale would occur, especially in the management of resources and administrative and head staff.
- In this case, the new enterprise would have its own budget, being able to collect fees from its customers in Cuban Pesos as well as in MLC and to raise income from the sale of recycled goods and compost materials.

Disadvantages:

- One disadvantage of this alternative would be the lack of competition as the enterprise would have a monopoly over all solid waste services in Havana City, and there could be the possibility of corruption. In many instances this situation has lead to reduced efficiency in the medium and long term.
- Another disadvantage would be difficulties in the control and supervision of operations over such a large area.
- From the participation point of view, in this case, the municipal and communal zones would not be part of the system and therefore would not participate in the day-to-day operations.

(6) Alternative F – Joint Venture with a Foreign Investor

Summary: A government/private enterprise would be set up in the format of a joint venture, as previously undertaken in the water and sanitation sector and the telephone sector. The format should be similar to alternative "E" – (one Aurora only for the entire city) although it would not be a 100% state owned enterprise but rather a "joint venture" with a foreign enterprise.

Advantages:

- The main advantage of this alternative would be to bring capital, technology and expertise to the new solid waste management company, in the same fashion as in the water and sewerage enterprise "*Aguas de La Habana*", and many others in the communication, energy and tourism sectors.
- Introducing a foreign company specialized in solid waste management would probably increase the productivity of the personnel in charge, and therefore the efficiency of the whole system.

Disadvantages:

- The disadvantages of this option lie in the high costs usually associated with this option, as the foreign investor would also be seeking a profit on their investment.
- A corollary of the above situation would be the unemployment of a number of the staff, as the main goal of the enterprise would be making money (partly through reducing costs).
- The highest constraint would be to find a foreign investor willing to take the financial risk of such a deal.
- Another disadvantage would be the difficulties involved in charging waste generators a realistic fee, which many could not afford to pay.

Table 5 Summary of Organizational and Institutional Framework Proposals

Organization		Brief summary	Advantages	Disadvantages
A	DPSC, DMSC and UPPH, as usual	DPSC and the DMSCs in charge. Aurora enterprises in charge of a few selected areas.	• No financial or administrative costs for providing a change • Service provision as it is • No direct cost to citizens	• Present problems remain • Accountability dubious • Financing poor • Coordination difficult
B	Municipal Auroras (fifteen)	Extend the concept of Aurora to each one of the 15 municipalities of Havana	• The Aurora model is an assurance of improvement • Foster competition among them	• System fragmented • Planning disposal operations very difficult • Financial imbalance
C	Municipal Territorial Auroras (three)	Set up three Auroras, each one encompassing four or five municipalities. Variant of the above model, dividing the city into a few areas.	• Some degree of competition • Already analyzed and approved by provincial government	• Diseconomies of scale • Constraints for selecting landfill area
D	Aurora enterprises, according to function	Set up Aurora enterprises according to function and territory. More specifically, create three regional Auroras, east, west and center, in charge of collection and street sweeping; one Aurora for disposal and recycling and one for supplying vehicles and equipment.	• Raise level of importance for disposal • Provide flexibility and autonomy to the different units • Each enterprise would concentrate on its own business • Experience with the existing Auroras would be utilized. • Competition would be created.	• Possible coordination problems between the different enterprises • Some loss in economies of scale
E	One Aurora for all the city	One Aurora Company Provincial Enterprise taking care of all the solid waste management activities in the whole city.	• Higher accountability • Easier planning, including planning for disposal • Economies of scale • Easier to collect direct fees	• Lack of competition • Large area and several activities to be coordinated • Municipalities and communal zones not participating
F	Joint venture enterprise	Create a joint venture with a foreign company in order to set up a profit making company for solid waste management.	• Bring capital and expertise • Improve efficiency	• Higher cost of service • Difficulties in finding an investor • Unemployment • Difficult to set a realistic fee • Financial risk

(7) Background for the Selection of the Best Solution for Havana City

The institutional model to be proposed shall reflect the needs of the system based on specific characteristics, the main ones being outlined below in Table 6.

Table 6 Desirable Characteristics of MSWM Institution Model

Item	Characteristics
Tasks and duties	Concentrated only on solid waste management activities
Scope of Work	The integral cycle of solid waste management
Personnel	Own staff, properly trained and with adequate salary and working incentives plan
Operation	Easy to be managed, without administrative burdens
Budget	Enough to carry all the needs of the system, sustainable and secure
Final Disposal	Able to be implemented in a 15 municipality system
Cost and efficiency	Compatible with the prevailing economic conditions of the Republic of Cuba
Public participation	Open to a high degree of public participation
Administration style	The least bureaucratic possible, due to the nature of the activity

Taking into consideration the above conditions and the current socio-economic characteristics of the Republic of Cuba, several institutional models could be proposed that meet these needs.

In order to choose which would be the best model, the following evaluation criteria were considered:

1) Financial viability – It is necessary to have a secure income to cover the investment and current expenditures. (This is in fact a very important problem in any city, and some remarks on it are presented in Annex 2.13-1).
2) Secure budget – Although a budget for solid waste management services is always fixed, the disbursements are not always made at the required pace. This item is closely linked to the financial viability.
3) Specialization of work – The more specialized the institution, the better, in terms of maximizing the gains from the expertise of its staff.
4) Economies of scale – In some solid waste management activities, such as sanitary landfills and workshops, there are important economies of scale that should be taken advantage of.
5) Administrative ease – In a system where the logistics are so complex, the lower the bureaucracy and administrative burdens, the better.
6) Minimum overall cost – The overall cost of the system represents the cost to the Province of Havana City, and therefore a minimum total cost should be envisaged in all cases.
7) Citizen's acceptance – It is important to obtain citizen's acceptance of the institutional model in order to implement an accepted charging system.
8) Public participation – In solid waste management systems, public participation is fundamental in achieving good performance.
9) Adequacy with the Cuban administrative system – The proposed model should align with other existing models of the Cuban government that have proven to be effective.

10) Provision of competition – Competition fostered by comparison helps to improve the quality of services provided.
11) Ability to overcome the problem of final disposal site selection – In Havana, as in many other cities, the location of landfills and other processing and disposal facilities may present a great problem that will need to be overcome. Therefore, a less restricted landfill location should be easier to manage.

(8) Selection of the Best Suitable Solid Waste Management Organization

Taking all of the above factors into consideration, a matrix was established in order to select the best possible institutional arrangement for the solid waste management system for Havana City. The options were graded based on the following criteria:

Score points:

- Optimum: 3 points
- Average: 2 points
- Poor: 1 point

Table 7 Selection of Best Alternative for MSWM in Havana City

Alternative ⇒ / **Criteria ⇓**	**A) DPSC, DMSC and UPPH, as usual**	**B) Municipal Auroras (fifteen)**	**C) Municipal Territorial Auroras (three)**	**D) Aurora enterprise according to function and territory**	**E) One Aurora for the whole city**	**F) Joint venture enterprise**
Financial viability	1	1	2	3	2	1
Secure Budget	1	2	2	2	1	2
Specialization of work	2	2	1	3	2	3
Economies of scale	2	1	2	2	3	3
Administrative ease	2	1	2	2	3	3
Accountability to the citizens	1	3	2	2	2	2
Accountability to the government	2	2	2	3	2	3
Minimum Overall cost	2	1	2	2	1	1
Citizen's acceptance	3	3	2	2	2	1
Public participation	2	3	3	3	2	2
Adequacy in relation to the Cuban Administrative system	3	3	3	3	2	2
Provision of competition	1	3	3	3	1	1
Ability to locate final disposal sites	**3**	**1**	**1**	**3**	**3**	**3**
Sum of points	**25**	**26**	**27**	**33**	**26**	**27**
Ranking	**4**	**3**	**2**	**1**	**3**	**2**

The selection exercise shows that the best alternative for Havana City's solid waste management system, at this time, would be the setting up an organization based on the

Aurora model, however, not only based on territorial area but also on specialized functions. That is alternative “D”.

(9) The Proposed New Institutional Organization

The proposed new institution in charge of all solid waste management activities in Havana City and two other DPSC units will be composed of:

1) Three regional territorial Aurora enterprises in charge of the collection of all kinds of urban waste and street sweeping activities. These three enterprises will be located in the eastern, central and western parts of the Havana City territory. The division into three territorial Auroras is due to geographical reasons and is currently also used for the division of other public service providers such as water, sanitation and telephone services.
2) One additional Aurora enterprise, in charge of disposal facilities as its area of operation, that is, the sanitary landfill.
3) One further Aurora enterprise providing the collection trucks and other equipment to the regional Aurora collection and street sweeping enterprises.

   The DPSC unit in charge of producing market flowers and rendering services including garden establishment and maintenance would remain as a budget unit within the DPSC as it will also be the unit in charge of the industrial production of some products used by the municipalities, such as bins and garden chairs.

F. Financial Situation

F. FINANCIAL SITUATION

1. Government Expenditure on SWM

The state government budgets and the fiscal balances are summarized in Table 1.

Table 1 State Budget and Fiscal Balance

(Million pesos at current prices)

Year	1999	2000	2001	2002	2003
REVENUE					
Direct Taxes	3,555	3,977	4,354	4,473	4,797
Profits tax	1,333	1,535	1,718	1,686	1,860
Employment tax	817	970	1,102	1,150	1,189
Personal income tax	289	291	286	301	325
Social security contributions	1,115	1,181	1,248	1,336	1,424
Indirect Taxes	6,336	6,732	6,386	7,259	8,097
Sales tax	5,786	6,131	5,722	6,620	7,333
Service tax	550	602	665	639	763
Non-taxation income	3,528	4,206	4,294	4,465	4,655
Payments by state enterprises	1,515	1,554	1,661	1,981	2,176
Other non-tax income	2,014	2,653	2,633	2,485	2,478
TOTAL REVENUE	13,419	14,915	15,034	16,197	17,548
EXPENDITURE					
Current expenditure for budgeted activity	8,122	9,233	10,406	11,469	12,629
Education	1,830	2,095	2,369	2,752	3,297
Public health	1,553	1,684	1,797	1,923	2,028
Defense	752	880	1,274	1,262	1,267
Social Security	1,786	1,786	1,870	1,985	2,054
Administration	457	509	565	611	603
Housing and community services	684	763	827	874	961
Productive area	157	173	164	150	186
Culture and arts	191	234	311	396	476
Science and technology	128	154	164	168	228
Sports	141	158	163	197	223
Social assistance	158	179	215	398	481
Other activities	518	620	687	755	825
Change in inventory and accounts payable	-232	-	-	-	-
Current expenditure for enterprise activity	2,670	3,076	2,622	3,286	3,493
Subsidy for loss	770	586	393	862	1,201
Subsidy for price difference	1,781	2,219	1,434	1,425	1,660
Subsidy for sugar price and cane producers			466	662	356
Fund for production stabilization	-	100	-	-	-
Other allocation	118	171	329	337	277
Economic assistance to agricultural cooperatives	200	99	64		
Capital spending	2,063	1,749	1,990	1,949	2,083
Extraordinary spending	556	-	-	-	-
Fund for budget stabilization	-	1,000	140		
Reserve					
Financial operation	421	430	550	489	418
TOTAL EXPENDITURE	14,031	15,587	15,771	17,193	18,622
Balance	-612	-672	-738	-997	-1,074
GDP	26,147	28,206	29,557	30,680	32,337
Balance % of GDP	-2.3%	-2.4%	-2.5%	-3.2%	-3.3%

Source: "Statistics yearbook of Cuba 2003" National Office of Statistics

The fiscal deficit gradually increased and reached 3.3% of GDP in 2003, which is regarded as still being at an endurable level. Increases in tax rates, together with new taxes, user charges and price increases on non-essential goods were introduced in those years. Direct taxation was reintroduced, and a new tax-collecting system was developed.

Large spending items were education, public health, social security, and subsidies for state enterprises. It is noted that the expenditure for housing and community services, which included MSWM, increased by 40%, from 684 million pesos in 1999 to 961 million pesos in 2003. This increase exceeded the overall expenditure increase (33%) and the GDP increase (24%) during the same period.

The increase in state current expenditure on SWM is shown in Table 2. The expenditure more than doubled from 138 million pesos in 2000 to 285 million pesos in 2004. CUC and CUP are added up at par. It is understood that most of the salary expense was paid in CUP.

Table 2 State Expenditure on SWM

(Million pesos at current prices *)

	Year	2000	2001	2002	2003	2004**
Collection	Operation	91	83	93	115	180
	Salary	39	43	44	51	83
	Total	131	126	138	166	262
Final disposal	Operation	6	6	7	12	14
	Salary	2	3	4	5	9
	Total	8	8	11	16	23
Total	Operation	97	89	101	127	193
	Salary	41	46	48	56	92
	Total	138	135	149	183	285

* CUC and CUP are added up at par.
** Figures are budgeted amounts.
Source: Ministry of Economy and Planning

The Havana City budgets are shown in Table 3. The total expenditure increased steadily until 2002, reaching 1,590 million pesos and dropped in 2003 to 1,352 million pesos. The expenditure of Havana City was approximately 8% of the state expenditure. The fiscal balance has been continually in surplus in recent years. Large spending items in current expenditures were education, public health, and housing and community services. The expenditure for housing and community services, including MSWM, has been nearly stable since 1999, fluctuating between 200 million pesos and 250 million pesos.

Table 3 Havana City Budget

(Million pesos *)

	1998	1999	2000	2001	2002	2003
Revenue						
Current revenue (transferred)	818	971	1,057	1,131	1,263	1,270
Sales of special circulation product	55	109	135	166	159	164
Public service tax	74	79	79	75	83	91
Profit tax	83	96	107	130	136	143
Personal income tax	74	80	79	72	72	74
Resource tax	221	279	290	306	319	327
Other tax	31	37	35	36	39	31
Rates	2	4	8	5	5	4
Non tax income	112	110	117	131	188	191
Income from properties	116	125	153	158	205	193
Current transfer	13	9		13	16	5
Income from operation	41	38	40	40	41	46
Capital transfer	12	9	6			
Extraordinary income	217	189	141	143	487	88
Participatory income	101	39	38	36	25	39
Budget transfer from State	116	150	103	107	461	49
Total revenues	1,035	1,160	1,198	1,274	1,749	1,358
Expenditure						
Current expenditure for budgeted activity	789	923	1,014	1,097	1,322	1,347
Education	215	261	297	348	423	409
Public health	317	365	393	437	474	488
Administration	38	42	44	45	46	44
Housing and community services	150	200	219	213	247	230
Productive area	12	9	8	6	11	16
Culture and arts	12	13	16	22	29	41
Science and technology	1	1	1	1	1	1
Sports	16	16	17	17	22	24
Social assistance	27	30	31	33	48	75
Other activities	1	3	15	26	53	20
Change in accounts payable and others	-1	-18	-27	-51	-30	
Enterprise activity	9	7	11	6	12	5
Subsidy for loss	9	5	4	4	0	
Other allocation		2	7	3	12	5
Investment	155	98	107	136	256	206
Total expenditures	953	1,028	1,132	1,239	1,590	1,352
Surplus	82	132	66	35	159	6

* CUP and CUC are added up at par.
Source: "Statistics Yearbook of Havana City 2003" Havana City Territorial Office of Statistics

The Havana City data for capital investment is shown in Table 4. More than 100 million pesos per year were allocated for community services during 2000 to 2003.

Table 4 Havana City Capital Investment in Community Services

(Million pesos *)

	2000	2001	2002	2003
Community services	129	228	117	110
Industry	272	151	79	97
Construction	25	12	16	26
Agriculture and fishery	4	2	1	2
Silviculture	8	16	14	20
Transport	84	106	47	70
Communication	11	9	101	100
Commerce	118	172	48	46
Other productive activities	4	3	4	2
Science and technology	14	10	7	5
Education	22	62	140	80
Culture and arts	76	25	11	15
Public health	20	46	48	98
Finance and insurance	12	46	35	16
Administration	90	218	154	198
Other non productive activities	17	31	25	20
Total	905	1136	846	905

* CUP and CUC are added up at par.

Source: "Statistics Yearbook of Havana City 2003" Havana City Territorial Office of Statistics

2. External Debt and ODA

Cuba's hard-currency debts are summarized in Table 5. The year-end balance was around US$11 billion during 1997-2001. As Cuba has no access to multi-lateral financial institutions such as the World Bank, the International Monetary Fund or the Inter-American Development Bank, most of its debts were bilateral.

Table 5 External Debts in Hard Currencies

(CUC million at current prices)

	1997	1998	1999	2000	2001
Official bilateral	5,853	6,248	5,737	5,669	5,727
Intergovernmental	1,512	1,601	1,640	1,837	1,836
Development assistance loan	209	220	204	254	352
Export credit with government guarantee	4,132	4,426	3,893	3,578	3,539
Official multilateral	521	575	17	17	17
Financial institutions	2,577	2,687	3,456	3,270	3,103
Bank loans and deposit	2,297	2,573	3,187	2,942	2,833
Medium and long term	1,116	1,362	1,909	1,701	1,598
Short term deposit	1,181	1,211	1,278	1,241	1,235
Import credits	280	113	269	327	271
Supplier credits	1,169	1,673	1,845	1,985	2,026
Other credits	26	27	23	21	20
Total	10,146	11,209	11,078	10,961	10,893

Source: "Statistics Yearbook of Cuba 2003", National Statistics Office

The latest available data for Cuba's ODA receipt is shown in Tables 6 and 7.

Table 6 ODA Receipt Classified by Assistance Type

(US$ million)

Donor	1997	1998	1999	2000	2001
Food assistance	9.7	6.8	3.4	3.2	15.5
Emergent assitance	29.4	40.7	26.0	20.2	11.1
Technical cooperation	27.0	22.2	25.3	31.1	56.7
Technical cooperation related with investment	0.3	0.9	1.3	1.1	2.6
Investment	0.0	0.0	1.0	0.2	10.2
Total	66.4	70.6	56.9	55.8	96.6

Source: UNDP

Table 7 ODA Receipt Classified by Donor

(US$ million)

	Donor	1997	1998	1999	2000	2001
Bilateral	Canada	6.5	10.0	6.1	8.6	13.0
	Netherlands	1.1	0.0	0.0	0.0	12.5
	Italia	6.3	0.5	2.4	1.9	7.1
	Norway	0.0	1.0	0.3	0.0	3.1
	Spain	7.8	8.3	8.2	4.7	2.6
	Germany	1.1	0.6	0.0	0.7	2.5
	Japan	0.0	9.1	0.2	0.1	1.7
	Sweden	1.2	1.2	1.5	0.0	1.7
	Belgium	0.0	0.0	0.0	0.0	1.4
	UK	0.7	0.3	0.0	0.0	1.0
	France	0.0	0.8	1.7	3.6	0.5
	Switzerland	0.2	0.2	0.0	0.0	0.6
	Other countries	0.2	0.1	0.0	0.0	0.0
	Total Bilateral	25.1	32.1	20.4	19.6	47.6
Multilateral	EU	14.5	15.1	17.8	17.0	28.7
	UNDP	2.6	1.1	1.3	1.7	2.9
	PMA	6.6	3.7	5.2	2.6	2.4
	UNFPA	1.2	0.6	0.3	0.3	1.9
	UNICEF	1.8	1.9	1.4	1.5	1.8
	FMAM	0.2	0.2	0.2	1.2	1.5
	OPS OMS	1.6	1.2	1.3	1.1	1.4
	OIEA	0.7	0.6	0.5	0.2	1.3
	FAO	1.2	0.8	0.9	1.0	1.2
	Other UN systems	1.3	0.7	1.5	1.4	3.3
	Other multilateral	0.2	0.1	0.9	0.9	0.6
	Total multilateral	30.7	24.3	31.2	28.9	47.0
NGO		9.6	15.4	5.3	7.4	2.1
Total ODA		66.8	73.8	56.9	55.8	96.6

Source: UNDP

Cuba received development assistance of less than US$100 million per year from 1998 through to 2001. The technical cooperation area brought in the largest amount of ODA in 2000 and 2001, accounting for 56% and 59% of the total respectively. Cuba's main sources of development assistance were the European Union and the United Nations. Of the bilateral assistance disbursed in 2001, Canada and Holland stood out, although the aid amounts were just over US$10 million.

The situation in 2005 became rather harsh. For example, since 2003 EU nations have stopped giving bilateral ODA to Cuba for political reasons. The EU was not supposed to consider resuming the ODA to Cuba until Cuba officially asked the EU for assistance.

Spain, as a member of the EU, followed the wait-and-see policy of the EU. Hence, no direct Spanish government-to-government ODA has been extended to Cuba. Instead, various Cuban projects were financed by Spanish autonomous regions, universities, NGOs, etc. Spain's ODA totaled about US$15 million in 2004, of which, financing by such indirect sources accounted for 88%.

Unlike the EU, Canada's ODA was not halted but the amount was rather small, reflecting the politically difficult situation between Cuba and the EU, and between Cuba and the USA. The ODA from Canada in 2003 amounted to about US$7 million, of which 50% was direct government-to-government assistance. The remaining half was channeled through multilateral organizations under the UN, NGOs, universities, and the private sector.

Japan's ODA to Cuba was also modest. Major areas for assistance were cultural cooperation and grass-roots cooperation. Japan's ODA amounted to about US$4 million in 2002.

Taking account of the aforementioned donor situations, it would hardly be expected that ODA funds from a particular country or financial institution could single-handedly finance a large-scale project in a lump sum. However, if a large-scale project was split into several components, or its implementation was phased, the project financing could become easier because the annual disbursements would be smaller.

3. SWM Organizations in Havana City

In Havana City, there are tiers of SWM service providers, namely, UPPH (SWM department of the provincial government), Auroras (independent profit units), and DMSC (SWM department in the municipal governments).

The two Aurora companies (Aurora Plaza de la Revolución and Aurora Habana Vieja) are self supporting entities and were established to cover the municipalities of the same names. In those municipalities there exist considerable sized areas of non residential clientele bases. Small scale "Aurora" budget units were created in three municipalities (Miramar, Guanabao, and Cayo Hueso) where the number of foreign currency earning customers was not as high as in Habana Vieja and Plaza de la Revolución. Aurora budget units collect charges from non-domestic users and are located within the municipal offices and collect

SWM fees from non-domestic users. In the other municipalities where no Aurora companies or Aurora budget units exist, the municipality's UPPH is substituted for the Aurora. Tariff collection activities are relatively thorough only in the business territories of Aurora Habana Vieja and Aurora Plaza.

Financial data for the SWM service providers was not fully available. Limited financial data was made available to the Study Team, which is analyzed subsequently.

3.1 SWM Unit Costs in Havana City

The SWM unit costs in Havana City are summarized in Table 8.

Table 8 SWM Unit Costs in Havana City

	Sweeping		Collection		Landfill		Total		
	CUP ($Peso/m^2$)	CUC ($Peso/m^2$)	CUP (Peso/ton)	CUC (Peso/ton)	CUP (Peso/ton)	CUC (Peso/ton)	CUP (Peso/ton)	CUC (Peso/ton)	Total* (Peso/ton)
UPPH			315.93	2.41	39.48	0.25	355.40	2.67	358.07
Aurora Plaza de Revolución	4.89	0.11	44.18	1.73			90.66	2.76	93.42
Aurora Habana Vieja	6.66	0.19	39.56	1.81			148.03	4.96	152.98
DMSC + 3 Small Scaled Auroras	5.41	0.03	66.18	0.72	2.32	0.06	115.72	1.68	117.40
Average of Havana City	5.98	1.03	119.19	1.57	9.90	0.13	161.21	2.09	163.30

*CUP and CUC are added up at par.

The SWM services can be divided on the basis of the service providers (UPPH, Aurora Plaza, Aurora Habana Vieja, and DMSC, including small scale Auroras). The SWM services can also be broken down into three activities, namely, sweeping, collection, and landfilling[1]. The SWM costs comprise two portions, which are the convertible peso (CUC) portion and the local peso (CUP) portion. The triple-currency situation in Cuba adds complication to the cost accounting. Pesos, both CUP and CUC, are the official currency of Cuba. US dollars had been widely accepted as well up to 2004. In November 2004, with the introduction of a 10% levy for US dollar cash transactions, use of US dollars waned in Cuba and instead, CUC use became more dominant. CUC were exchangeable into US dollars at a rate of US$1.08:CUC1 as of May 2005. Furthermore, CUP had been circulating in daily life. There existed an exchange rate between CUC and CUP, which was unofficial but authorized only for small transactions by individuals. This exchange rate was CUC1:CUP24 as of May 2005.

The SWM unit cost of Havana City was CUP161/ton and CUC2.09/ton in 2003. If the then official exchange rate of CUP1:CUC1 was applied, the total SWM unit cost of Havana

[1] It should be noted that the sweeping cost is indicated at CUP/m2 and CUC/m2 instead of CUP/ton and CUC/ton, which is in accordance with the practice in Cuba. When computing the total SWM cost, it is presupposed that the total solid wastes collected include those collected by sweeping.

City would be US$163/ton. The sweeping cost was CUP5.98/m^2 plus CUC1.03/m^2, or total US$7/$m^2$. The collection cost was CUP119.19/ton plus CUC1.57/ton, or total US$121/ton, applying the exchange rate of CUC1:CUP1. The landfilling cost was CUP9.90/ton plus CUC 0.13/ton, or total US$10/ton. Percentage wise, the SWM cost of Havana City could be broken down into sweeping (20%), collection (74%), and landfill (6%). These levels are comparable with the situation in other countries (Table 9).

Table 9 Global Perspective on SWM Costs versus Income

	Units	Low-income country	Middle-income country	High-income country
Average waste generation	ton/cap. yr	0.2	0.3	0.6
Average income from GNP	US$/cap. yr	370	2,400	22,000
Collection cost	US$/ton	10 - 30	30 - 70	70 - 120
Transfer cost	US$/ton	3 - 8	5 - 15	15 - 20
Sanitary landfill cost	US$/ton	3 - 10	8 - 15	20 - 50
Total cost without transfer	US$/ton	13 - 40	38 - 85	90 - 170
Total cost with transfer	US$/ton	16 - 48	43 - 100	105 - 190
Cost as % of income	per cent	0.7 - 2.6	0.5 - 1.3	0.2 - 0.5

Source: World Bank, "Guidance pack - private sector participation in municipal solid waste management", SKAT, 2000

The Cuban average per capita GDP was US$2,881 in 2002[2]. As Cuba can be classified as a low or middle income country, the total SWM cost exceeding US$100/ton can be regarded as rather high. It is noted that the SWM cost at UPPH is extremely high. This is because the UPPH bears a considerable part of the vehicle and equipment maintenance costs incurred in the collection process.

3.2 SWM Expenditure of Havana City

The total SWM expenditure of Havana City was CUP157 million and CUC1.99 million. The SWM expenditure is broken down into personnel costs (salary, social security, and labor force utilization tax), materials, clothing and provisions, fuel and energy costs, administrative costs, and depreciation and investment (Figure 1).

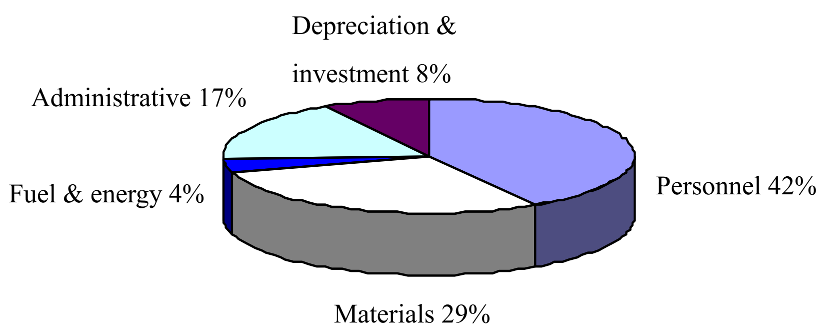

Figure 1 SWM Expenditure Composition of Havana City

2 Source: "Statistical Yearbook for Latin America and the Caribbean 2003", ECLAC.

All of the personnel costs were paid in CUP. Fuels and lubricants were also paid in CUP[3]. Personnel costs accounted for the biggest part of the total cost, which was closely correlated with staff deployment. The total SWM revenues were CUP28 million and CUC1.75 million. The resultant deficits of CUP159 million and CUC0.24 million were mostly financed by general funds of the state and local governments.

3.3 SWM Expenditure of UPPH

The total expenditure was CUP62.2 million plus CUC0.467 million, which added up to 62.7 million pesos, applying the exchange rate of CUP1:CUC1. This accounted for 39.4% of the total SWM expenditure of Havana City. The total expenditure can be divided into personnel costs (33%), materials (32%), fuel and energy costs (3%), administrative costs (23%), and depreciation and investment (8%).

3.4 SWM Expenditure of Aurora Plaza de la Revolución

Aurora Plaza de la Revolución is an independent profit organization which covers the municipality of the same name. The total expenditure was CUP6.741 million plus CUC0.198 million, which added up to 6.939 million pesos, applying the exchange rate of CUP1:CUC1. This accounted for 4.4% of the total SWM expenditure of Havana City. The total expenditure can be divided into personnel costs (88%), materials (3%), clothing and provisions (1%), fuel and energy costs (2%), administrative costs (6%), and depreciation and investment (1%).

3.5 SWM Expenditure of Aurora Habana Vieja

The total expenditure was CUP5.995 million plus CUC0.201 million, which added up to 6.196 million pesos, applying the exchange rate of CUP1:CUC1. This accounted for 3.9% of the total SWM expenditure of Havana City. The composition of the expenditure is personnel costs (83%), materials (7%), clothing and provisions (1%), fuel and energy costs (2%), administrative costs (4%), and depreciation and investment (4%).

3.6 SWM Expenditure of DMSC and Small-Scale Auroras

DMSCs and three small-scaled Auroras are combined in the cost accounting due to the difficulty of account separation under the current accounting information system. The total expenditure was CUP81.910 million plus CUC1.123 million, which added up to 83.034

[3] For example, the SWM sector of Havana City could purchase gasoline at CUP 0.3-0.4/liter when the market price was CUC 0.8-0.9.

million pesos, applying the exchange rate of CUP1:CUC1. This accounted for 52.3% of the total SWM expenditure of Havana City. The composition of the expenditure is personnel costs (41%), materials (30%), fuel and energy costs (5%), administrative costs (15%), and depreciation and investment (10%).

4. Analysis of SWM Tariffs

Havana City started charging solid waste fees in 1997 when Aurora companies (Aurora Plaza and Aurora Habana Vieja) were created as independent profit organizations. Tariff setting work is the charge of Aurora Plaza. Aurora Habana Vieja is not involved as it is less adept at cost accounting than Aurora Plaza. The tariff proposal prepared by Aurora Plaza was confirmed by the DPSC, DPEP, and DPFP. It was the MEP and the MFP that finally approved the tariffs and promulgated the joint resolution. The latest tariff review was carried out in late 2004 and the new tariffs were approved in February 2005. The solid waste collection tariffs are summarized in Table 10.

Table 10 Present Solid Waste Collection Tariffs

Collection type / Customer type	Curbside collection	Collection by exclusive bin *2
Households	CUP 0.4/person/month *1	Not applicable
Cuban institutions without CUC earnings	CUP2.1/account/day	CUP3.8/bin/day
Cuban institutions with CUC earnings	(CUP1.1 + CUC1)/account/day	(CUP2.3 + CUC1.5)/bin/day
Foreigners and tourism	CUC1/account/day	CUC4/bin/day

*1: Although the tariff is set, actual payments are made by the municipal governments.
*2: Non-domestic users (commercial, industrial, service, etc.) dispose solid wastes either to communal containers or to exclusive containers.

The current tariffs are principally applied to all inhabitants and entities in the business territories of "Aurora" companies, which are the municipalities of Habana Vieja and Plaza de Revolución. The two Aurora companies (Aurora Habana Vieja and Aurora Plaza) are self supporting entities and have been established to cover the municipalities where there are non-residential clientele bases of considerable sizes. Small scale "Aurora" budget units were created in three municipalities (Miramar, Guanabao, and Cayo Hueso) where the number of foreign currency earning customers was not as high as in Habana Vieja and Plaza de Revolución. Aurora budget units collect charges from non-domestic users and are located within the municipal offices and collect SWM fees from non-domestic users. In the other municipalities where no Aurora companies or Aurora budget units exist, the municipality's UPPH is substituted for the Aurora. The actual tariff collections are only relatively thorough in the business territories of Aurora Habana Vieja and Aurora Plaza.

The MSW collection tariffs can be divided into the CUP part and the CUC part. This bi-currency tariff structure is a result of the tariff setting in 2005. The MSW management service costs are composed of the CUP cost and the CUC cost. These bi-currency costs are reflected in the current tariff to the maximum extent, thus the tariffs maintain the bi-currency structure.

The tariff for households is set at CUP 0.4 per person per month and is applied to most Cuban households. Although the tariff for households is set, the inhabitants are not actually charged. Instead, the payments are made by the municipal governments. This is a way of compromising between the Auroras' need to ensure self sustainability by collecting MSW fees from service recipients and Havana City's policy not to let the households pay MSW fees. Tariffs for services other than solid waste collection are summarized in Table 11.

Table 11 Tariffs for Other SWM Services

Type of service	Non- CUC earner	CUC earner
Manual cleansing (solid waste collection and site cleansing)	8.45 CUP/ m^3	8.45 CUC/ m^3
Manual and machine cleansing (solid waste collection and site cleansing)	7.6 CUP/ m^3	7.6 CUC/ m^3
Manual cleaning, solid waste collection, and cleansing by water truck (weekly)	300 CUP/ account/ month	300 CUC/ account/ month
Daily sweeping and twice-a-week claensing by water truck	350 CUP/ account/ month	350 CUC/ account/ month
Cleansing by water truck (weekly)	150 CUP/ account/ month	150 CUC/ account/ month
Cleansing by water truck (twice-a-week)	300 CUP/ account/ month	300 CUC/ account/ month
Cleaning by water truck	30 CUP/ trip	30 CUC/ trip
Manual street cleansing	6 CUC/ 000 m^2	6 CUC/ 000 m^2
Road sprinkling	3.6 CUP/ hectare	3.6 CUC/ hectare
Cleansing of bus stop	3.6 CUP/ bus stop	3.6 CUC/ bus stop
Cleansing of fountain and monument	118.35 CUP/ site	118.4 CUC/ site
Tipping fee at dumping site	0.5 CUP/ tonne	0.5 CUC/ tonne
Cleansing and maintenance of park and avenue	3 CUP/ 000 m^2	3 CUC/ 000 m^2
Machine sanitizing of event site	0.0558 CUP/ m^2	0.056 CUC/ m^2
Manual sanitizing of event site	0.048 CUP/ m^2	0.048 CUC/ m^2

Source: DPSC

It should be noted that the tipping fee is set at CUP 0.5/ton. However, this tariff is not actually enforceable. Vehicles carrying solid wastes, whether belonging to UPPH or not, are free to enter the landfill sites and dump wastes without paying any fees. This is because the current tariffs have been set in accordance with the activities of the Aurora. Thus the tipping fee at the landfill is just a nominal fee because the Auroras are not involved in landfilling.

The Aurora's tariff setting process follows the revenue requirement method. Generally there are two methods of pricing SWM services, which are the marginal cost method and the revenue requirement method. Under both methods, the tariff level should be set adequately and the tariff structure should be rational, so that the SWM service operator can operate and expand the system in a technically efficient and financially sound manner.

The marginal cost method is to price at marginal cost, where the SWM service operator would regularly calculate the cost of supplying the next unit of service, and price the product accordingly. The marginal cost can be calculated for long-term as well as short-term time frames. The revenue requirement method is to calculate the revenue required by the operators to meet their financial obligations, and then to reasonably apportion the revenue requirement between the different customer groups.

The appropriateness of the tariffs can be determined by three factors: (i) cost coverage requirements; (ii) objective price level; and (iii) ability of the service users to pay for the SWM services.

The most understandable example of the cost coverage requirement would be the "full cost recovery" where service users and/or polluters are required to contribute all of the operation costs for the SWM. The operation costs may or may not include depreciation costs which can be interpreted as capital costs. Whether or not the capital costs should be included in the operation costs depends on the SWM policy of the service provider or its superior organization.

In the case of Aurora's tariff setting, the cost accounting contains the costs of the required materials, labor inputs, depreciation, indirect costs, and a margin of 15%. However this cost calculation is based on full capacity utilization, which is not necessarily the case for the Aurora. As a result, unit costs and computed tariffs tend to be inflated. Therefore the estimated input costs have to be checked to determine if they are consistent with the actual costs incurred.

The Study Team presented a tariff setting simulation model to the Cuban side at the capacity building workshop. The results of simulations under three scenarios are shown below.

The first scenario is the case where the present SWM tariffs are applied to the entire Havana City area. The results showed that the cost recovery rate is 38% for the CUC cost portion and 14% for the CUP cost portion. The second scenario is the case where the full cost recovery is achieved with cross-subsidies only from non-household users to household users. To realize this situation, the tariffs would have to be raised exorbitantly. The inhabitants would be charged CUP2 per person. A company using an exclusive bin would have to pay as much as CUC40 + CUP1700 per bin. The third scenario is the situation where 50% cost recovery is achieved with a certain cross-subsidy. The tariffs would be CUP2 per person for household users. A company which earns no foreign currency and uses exclusive bins would have to pay about CUC10 + CUP100 per bin. A company earning foreign currency and using exclusive bins would pay about CUC70 + CUP600 per bin. All these results are based on the cost data for the year 2003. However, this data contains various estimations due to the lack of information. Therefore more precise data should be applied and the tariff model should be refined when employed as a reference in actual tariff setting.

The second factor in determining the appropriateness of a tariff is the objective price level. The objective price level can be gauged through a comparison with other tariffs. Other tariffs include the prices of other utility services such as water supply, sewerage, electricity, gas and telephone (not cellular but line telephone). The other utility tariffs are summarized in Table 12.

The inhabitants in Aurora's business territory are charged CUP 0.4/person/month for solid waste collection services, which can be converted into CUP2/household/month for an average sized household of four family members. This level can be regarded as appropriate if compared with the water charge of CUP4 or sewerage charge of CUP1.2 per household. The solid waste tariff could appear quite low if compared with the electricity tariff which is CUP40/household as an estimated average monthly bill. It should be reiterated that the solid waste charge is not actually collected from inhabitants. Municipal governments pay Aurora on behalf of the inhabitants.

Table 12 Utility Tariff Comparison

Service type (Provider)	Tariff for local currency earners *a	Tariff for foreign currency earners *a	monthly pay *b
Solid waste collection (Aurora)	*Domestic* CUP 0.40 person/ month *Industry (discharge to collective use container)* CUP 1.00 account/ day *Industry (discharge to private container)* CUP 2.00 account/ day	*Domestic and industry (discharge to collective use container)* CUC30.00 account/ month *Industry (discharge to private container)* CUC4.00 account/ day	CUP1.6 *c
Water (Aguas de La Habana)	*Domestic (unmetered)* CUP 1.00 person/ month *Domestic (metered)* CUP 0.25/ m^3 up to 3 m^3 CUP 0.50/ m^3 between 3-4.5 m^3 CUP 0.75/ m^3 between 4.5-6 m^3 CUP 1.00/ m^3 between 6-7.5 m^3 CUP 1.50/ m^3 for > 7.5m^3 *Commercial* CUP 1.20/ m^3 *Industry* CUP 0.35-0.60/ m^3	*Domestic* CUC1.00 / m^3 *Commercial* CUC1.20 / m^3 *Industry* CUC0.35-0.60 / m^3	CUP4
Sewerage (ditto)	30% of water bill	30% of water bill	CUP1.2
Electricity (Eléctrica Ciudad Habana)	*Domestic* CUP 0.09/ kWh up to 100 kWh/ month CUP 0.20/ kWh between 101-300 kWh/ month CUP 0.30/ kWh for > 300 kWh/ month *Non domestic users* CUP 3 to 5/ kW/ month for each contracted kW + CUP 0.02 to 0.083/ kWh used	*Domestic* CUC0.1215 / kWh *Tourism, commerce and telephone companies* CUC3 / kWh/ month for each contracted kW + CUC0.095 to 0.17 / kWh used	CUP40
Gas (Compañía de Gas Licuado, Compañía de Gas Manufacturado)	*City gas user (domestic, metered)* CUP 0.11/ m^3 *City gas user (domestic, unmetered)* CUP 1.05/ person/ month CUP 1.95/ 2 persons/ month CUP 2.90/ 3 persons/ month CUP 3.85/ 4 persons/ month *LP gas user (domestic)* CUP 7/ 10kg bottle CUP 31.50/ 45kg bottle *City gas user (state company)* CUP 0.1224/ m^3 *LP gas user (state company)* CUP 8.404/ 10kg bottle CUP 37.818/ 45kg bottle	*Diplomats and foreign firms* CUC0.24 / m^3 *JV companies* CUC0.1370 / m^3	CUP7
Telephone (ETECSA)	*Domestic* CUP 6.25/ line up to 300 minutes/ month *State company* CUP 9.95/ line up to 300 minutes/ month	*Domestic and JV companies* 10 CUC/ line up to 300 minutes/ month	CUP20

*a: Effective in October 2004
*b: Estimated average monthly bill per household
*c: Aurora receives payment from municipalities based on the number of inhabitants. Households do not actually pay.

The third factor, namely the ability of the service users to pay for the SWM services, can be examined in comparison with the prices of basic daily necessities (Table 13). The solid waste fee of CUP 0.4/person/month or CUP1.6/household/month should not be expensive when compared with prices of those basic necessities.

Table 13 Prices of Basic Daily Necessities

Item	Price
Public telephone	CUP 0.05 / 3 minutes
Bus	CUP 0.4 / ride
Taxi (share-ride type)	CUP 1.0 / ride
News paper	CUP 0.2 / copy
Rice	CUP 10.0 / kg
Eggs	CUP 3.0 / medium size egg
Bread	CUP 10.0 / pound
Cola	CUP 9.0 / can
Local tobacco (mild)	CUP 9.0 / box

Note: prevailing market prices in October 2004
Source: Survey by the Study Team

The ability of the service users to pay for the benefits of SWM services can also be measured by the proportion of the service charge of the total available income of the potential users. Table 14 shows the estimated average household income and expenditure.

Table 14 Household Income and Expenditure

(CUP/month)

Income		Spending	
From husband		Purchase of food and other necessaries by ration book	50
Monthly salary	300	Rent	30
Bonus	50	Electricity	40
From wife		Telephone	20
Monthly salary	300	Gas	7
Bonus	50	Water & sewerage	5
From retired person		Transportation	30
Pension (120 pesos/oldster)	60	Food	300
Total	760	Toileteries	70
		Cloths	60
		Recreation	60
		Medicine	60
		Others	28
		Total	760

Note: An average household is estimated to comprise 4 members (husband, wife, 1.5 children and 0.5 oldster).
Source: Estimate by the Study Team

The solid waste bill does not appear in the list of expenditure items because households are not actually paying this. Instead, the municipal governments pay on behalf of the households. The solid waste bill of CUP2, if this was paid by households, would account for 0.3% of total household spending. This level will be considered low enough for households not to feel burdened.

The willingness to pay is not necessarily consistent with the ability to pay because it depends mainly on the individual's awareness and evaluation of the benefits stemming from the SWM services. Furthermore individuals have a common tendency to underestimate their capability to pay the charges. Usually, water and electricity provide more visual and evident benefits, while benefits of SWM services are more intangible as represented by general sanitation and aesthetic improvements. Especially in Cuba, where the majority of the inhabitants are not actually paying the SWM charge, the willingness of the individuals to pay for the SWM services could not be as explicit as their willingness to pay for water and electricity. Conducting a willingness to pay survey was not possible in this study due to Cuba's institutional difficulties. However the Study Team confirmed at the sensitization meetings for the pilot project that the inhabitants showed a clear willingness to pay for better SWM services.

5. Financial Balance of Segregated Waste Collection, Composting and Recycling Works

5.1 General

Segregated collection of waste enables the production of compost and collection of recyclable materials. These activities derive a monetary benefit through the sale of products and by reducing landfill costs due to the smaller quantity of waste to be disposed. To examine the relative merits of the works, the cost and benefit (income) balance was studied as described below.

5.2 Monetary Benefit Accrued from the Works

5.2.1 Compost production

(1) Quantity of Community Compost

This M/P envisages the production of two types of compost: community compost and home compost. Since the home compost concerns the production and use of compost within each household, the product has no market value and therefore this section deals only with the benefits of community composting. The total production of compost from 2010 to 2015 based on the M/P is estimated at 167,000 tons.

Table 15 Compost Production

Site	Production (tons)	Notes
Calle100	65,700	2013-2015
New Guanabacoa	101,470	2010-2015
Total	167,170	

(2) Selling unit price

There is no official market price for compost made from MSW in Havana City at present. However, the MINAGRI sets a sale price of CUP 2,500 per ton for compost made from agricultural organic waste. The analysis of cost and income for community compost was prepared based on the following three alternative cases of selling unit prices.

Table 16 Selling Unit Price of Compost

Case	Case 1	Case 2	Case 3
Selling Unit Price (CUP/ton)	500	830	1,250

(3) Ratio of saleable compost

The study adopted a conservative assumption that not all of the compost produced would be sold until the quality is fully accepted by the market. It was assumed that the saleable quantity as a ratio of the total production would gradually increase with the improvement of production quality as shown in Table 17 below.

Table 17 Ratio of Saleable Compost

Year	Y2010	Y2011	Y2012	Y2013	Y2014	Y2015
Ratio	0.3	0.4	0.45	0.5	0.55	0.6

5.2.2 Recyclable Materials

(1) Quantity of recyclable materials

Table 18 below shows the estimated quantity of recyclable materials to be collected through the segregated collections. These will be processed at the proposed two recycling plants. Almost all of the collected materials will be sold to ERMP or through alternative routes if made available.

Table 18 Estimated Quantity of Recyclable Materials

Resource materials	Unit	Quantity
Plastic	tons	4,934
Paper	tons	12,298
Aluminum	tons	4,150
Glass	tons	51,252
Steel	tons	3,180
Total		75,814

(2) Unit selling price of recycled materials

The unit selling price for recyclable materials is based on the existing market price established by ERMP as shown in the table below.

Table 19 Unit Selling Price of Recycled Materials

Material	Unit	CUP	US$
Plastic	CUP/ton	700	-
Paper	CUP/ton	160	-
Aluminum	US$/ton	-	600
Glass	CUP/ton	80	-
Steel	US$/ton	-	35

5.2.3 Cost savings at final disposal site

By undertaking recycling and composting, it will be possible to reduce the volume of waste and thereby prolong the service life of the final disposal site. The savings are made up of construction cost savings and O/M cost savings at the landfill. The estimated amount was determined by using the following unit prices:

Table 20 Unit Prices Used for Estimating the Landfill Cost Savings

	Item	CUP/ton	US$/ton
Unit cost of landfill (Capital and O/M cost)	Construction	4.1	6.8
	O/M	6.6	0.3
Total		10.7	7.1

5.3 Construction and operation costs

The estimated costs cover the construction and O&M costs for the composting and recycling plants and the incremental costs of segregated collection, including the additional collection vehicles required. Depreciation costs were calculated based on the capital cost of buildings, civil structures, utilities, vehicles and equipment.

5.4 Results of Financial Balance

Table 21 shows the balance of the costs and income, estimated in the manner described above, expressed as a total cost incurred during the project period (2010-2015). As shown in the table, the cost-income balance is positive in all three alternative cases (Case 1 to Case 3) when applying the exchange rate of CUP1=US$1 for the calculation of the total equivalent cost. If the exchange rate is CUP26=US$1, the balance is negative in Case 1 and Case 2, and turns positive only in Case 3.

Table 21 Balance of Income and Costs during the Project Period (2010-2015)

Items	Case 1		Case 2		Case 3	
	CUP	US$	CUP	US$	CUP	US$
A: Income	54,011,000	4,336,000	81,649,000	4,336,000	116,823,000	4,336,000
B: Cost	24,813,060	6,792,796	24,813,060	6,792,796	24,813,060	6,792,796
Balance (A-B)	29,197,940	-2,455,796	56,835,940	-2,455,796	92,009,940	-2,455,796
Comparison (A-B) in total equivalent cost:						
US$ 1=CUP 1	26,742,144		54,380,144		89,554,144	
US$ 1= CUP 26	-1,332,798		-269,798		1,083,048	

Note: 1. Balance＝Income – Cost 2. Case: refer to Table 2 above

On the premise that the exchange rate of CUP26=US$1 is the prevailing rate on the free market, the viability of the proposed work does not appear too favorable based on the foreseeable conditions (e.g. Case 1 in the above table). The viability is largely dependent on the selling price of compost. The table indicates that the viability could be improved with the gradual improvement of the compost quality coupled with an increase in the selling price to a level of CUP 1,250/ton.

Along with the framework plans envisaged by the Cuban side, this M/P proposes to implement the proposed work components (segregated collection associated with composting and recycling) as the core part of establishing an environmentally friendly MSWM. The implementation shall take into account the earliest achievement of improving the compost quality so that the overall operation can achieve positive financial viability.

Table 22 Income and Costs relating to Recycling and Composting

	LC portion (CUP million)	FC portion (US$ million)
Composting income	50.9	0
Recycling income	6.6	6.5
Savings in landfill costs	2.0	1.2
Total income	59.5	7.7
Composting cost	12.9	5.7
Recycling cost	22.0	4.8
Segregated collection cost	25.1	19.8
Total cost	60.0	30.3
Surplus (deficit)	(0.5)	(22.6)

* LC portion and FC portion are added up at par.

The incremental revenue from recycling and composting during the 2006-2015 period was estimated at CUP59.5 million and US$7.7 million, respectively, while the respective costs were expected to be CUP60.0 million and US$30.3 million during the same period. As a result, recycling and composting will bring an incremental deficit of CUP0.5 and US$22.6 million respectively. When added up at par, there will be a net deficit of CUP23.1 million.

During the 2006-2015 period, total solid wastes of 153,300 tons will be diverted for composting and recycling, which will therefore reduce the volume of solid waste to be landfilled by the same amount.

G. Industrial and Medical Waste

G. INDUSTRIAL AND MEDICAL WASTE

1. Industrial SWM

1.1 Types of Industrial Waste

There are 182 factories spread around the city in the different municipalities. Table 1 shows the number of industries in each municipality.

Table 1 Number of Industries

	Municipalities	Nos.
1	*diez de Octubre*	6
2	*Arroyo Naranjo*	8
3	*Boyeros*	28
4	*Centro Habana*	2
5	*Cerro*	17
6	*Cotorro*	21
7	*Guanabacoa*	9
8	*Habana del Este*	4
9	*Habana Vieja*	12
10	*La Lisa*	19
11	*Marianao*	8
12	*Playa*	13
13	*Plaza*	14
14	*Regla*	12
15	*San Miguel del Padron*	9
	Total	182

Source: CITMA

1.2 Quantity of Industrial Waste in Havana City

Surveys of 15 factories were conducted during the months of April and May 2004, while the monitoring of waste in the landfill site (quantity, volume and type of waste, type of vehicles, properties of organization, etc.) was conducted for two weeks in the middle of April. The results of the surveys are summarized in the Data Book.

Although the major factories in Havana City were covered by the surveys, there are some medium and small-sized factories that were not. To estimate the quantity of non-hazardous industrial waste and waste quantity generated by the factories, the statistics records prepared by DPSC/UPPH were used. Based on the surveys and the above assumptions, it is estimated that the quantity of industrial waste generated in Havana City is around 350 tons/day. Examples of the types of hazardous wastes generated from industries and businesses is presented in Table 2.

Table 2 Example of Hazardous Wastes Generated by Industries and Businesses

Waste Generators	Waste Types
Chemical Manufacturers	Acids and Bases Spent Solvents Reactive Waste Wastewater Containing Organic Constituents
Printing Industry	Heavy Metal Solutions Waste Inks Solvents Ink Sludge Containing Heavy Metals
Petroleum Refining Industry	Waste Water Containing Benzene and Other Hydrocarbons Sludge from the Refining Process
Leather Products Manufacturing	Toluene and Benzene
Paper Industry	Paint Waste Containing Heavy Metals Ignitable Solvents
Construction Industry	Ignitable Paint Waste Spent Solvents Strong Acids and Bases
Metal Manufacturing	Sludge Containing Heavy Metals Cyanide Waste Paint Waste

Source: Environmental Protection Agency, Solving the Hazardous Waste Problem: EPA's RCRA Program

2. Medical Waste Management

2.1 Classification of Health-Care Facilities in Havana City

At a national level, the MINSAP is in charge of health-care administration while the provincial authorities of public health, except for the national scale institutions, are responsible at the city level for all aspects of health-care administration, including hospital management. Table 3 shows the volume of generated waste and the number of incinerators installed in the hospitals.

Table 3 Volume of Generated Solid Waste in Hospitals

Hospital	Daily Waste Volume		No. of Incinerators	Notes
	Kg.	Lt.		
Arturo Aballí	369	2,214	1	
Julio Trigo	841	5,046	2	
Inst. Med. Trabajo	94	564	NA	
Gali García	170	1,020	NA	
Enrique Cabrera	615	3,690	1	
William Soler	443	2,658	2	
Carlos J. Finlay	900	5,400	1	
Maternidad Obrera	311	1,866	1	
Juan M. Márquez	410	2,460	1	
Pando Ferrer	250	1,500	NA	
Luis de la P. Uceda	140	840	NA	
Salvador Allende	1,085	6,510	2	QA survey
Pediátrico Cerro	300	1,800	1	
Benéfico Jurídico	174	1,044	NA	
Pediátrico C. Havana	303	1,818	1	QA survey
Santos Suárez	138	828	NA	
Miguel Enríquez	897	5,382	1	QA survey
Clínico diez de Octubre	870	5,220	1	
Rincón	302	1,812	1	
Sanatorio (SIDA)	350	2,100	2	
Leonor Pérez	117	702	1	
Luis Díaz Soto	830	4,980	1	
Materno Guanabacoa	210	1,260	2	
Tarará	80	480	NA	
Materno 10 Octubre	383	2,298	1	
Pediátrico San Miguel	260	1,560	1	
Julio Díaz	410	2,460	NA	
Psiquiátrico de Mazorra	4,100	24,600	1	
Ameijeiras	950	5,700	2	QA survey
Instituto Oncología	450	2,700	1	
Instituto Nefrología	110	660	NA	
Fructuoso Rodríguez	135	810	1	
Fajardo	408	2,448	1	
Freyde Andrade	312	1,872	NA	
Calixto García	1,131	6,786	1	
Joaquín Albarrán	765	4,590	1	
América Arias	273	1,638	1	
González Coro	257	1,542	NA	
Clodomira Acosta	150	900	NA	
Marfán	100	600	NA	
27 de Noviembre	432	2,592	1	
Isidro de Armas	216	1,296	NA	
Sorhegui	200	1,200	NA	
Gustavo López	127	762	NA	
L. Martínez	75	450	NA	
C. Adolescente	22	132	NA	
Barandilla	61	366	NA	
Cardiovascular	86	516	NA	
Lebredo	251	1,506	1	
Lenin	64	,384	NA	
Total	21,927	131,562	35	

Source: CITMA 2003, NA: Not available.
QA Survey: Survey conducted by Study Team in 2004

2.2 Definition of Waste

According to the simplified classification of WHO, hospital generated wastes are classified into three different types: 1) Non-hazardous general waste; 2) Sharp-cutting objects (infected or not), and; 3) Infectious waste (except for infected sharp-cutting objects). In addition, there are also expired medicines, which are a type of medical waste, although their amount is small.

(1) Non-hazardous General Waste (Common waste)

Waste generated in administrative, auxiliary and general activities that does not pose a hazard to health and whose characteristics are similar to those present in common household waste are also called home wastes. This category includes paper, cardboard, boxes, plastics, remains of prepared food and leftovers, materials from the cleansing of yards and gardens, among others.

(2) Sharp-cutting objects (Potentially infectious waste)

Sharp-cutting elements that were used or had been in contact with infectious patients or objects including hypodermic needles, syringes, pasture pipettes, scalpels, hoses, culture plates, whole or broken glassware, etc. This also includes any discarded sharp-cutting objects, even if they have not been used.

(3) Infectious Waste

Waste generated during the different stages of health care (diagnosis treatment, immunization, research etc.) that has been in contact with human or animal patients. Waste represents the different levels of potential hazard according to the level of exposure an individual may have had with the infectious agent causing the diseases.

The Medical Waste Management Regulation defines the categorization of the medical waste as shown in Table 4.

For reference, WHO's categorization of health-care waste is also shown in Table 4. WHO uses "health-care waste" as the terminology to indicate it is medical waste.

Table 4 Categorization of Health-care Waste by WHO

Category	Description	Examples
Infectious waste	Waste suspected to contain pathogens	Laboratory cultures; waste from isolation wards; tissues (swabs), materials or equipment that have been in contact with infected patients; excreta
Pathological waste	Human tissues or fluids	Body parts; blood and other body fluids; fetuses
Sharps	Sharp waste	Needles; infusion sets; scalpels; knives; blades; broken glass
Pharmaceutical waste	Waste containing pharmaceuticals	Pharmaceuticals that have expired or are no longer needed; items contaminated by or containing pharmaceuticals (bottles, boxes)
Genotoxic waste	Waste containing substances with genotoxic properties	Waste containing cyst static drugs (often used in cancer therapy); genotoxic chemicals
Chemical waste	Waste containing chemical substances	Laboratory reagents; film developer; disinfectants that are expired or no longer needed; solvents
Heavy metal waste	Wastes with high content of heavy metals	Batteries; broken thermometers; blood-pressure gauges; etc.
Pressurized containers		Gas cylinders; gas cartridges; aerosol cans
Radioactive waste	Waste containing radioactive substances	Unused liquids from radiotherapy or laboratory research; contaminated glassware, packages, or absorbent paper; urine and excreta from patients treated or tested with unsealed radio nuclides; sealed sources

Source: "Safe management of wastes from health-care activities", WHO, 1999

PART 4 FEASIBILITY STUDY

H. Waste Collection Vehicles

H. WASTE COLLECTION VEHICLES

1. Collection Vehicles

(1) Outline of the priority project

The target year of the selected priority project is 2010. In 2010, waste segregation and recycling activities will start, kitchen waste will be brought into compost yards and recyclable waste will be brought into recycling plants. A high priority project for the collection system is the introduction of a segregated collection system in urban areas by using 18 m^3 C/T vehicles. This selected project is a key component of the master plan for the City.

UPPH will start segregated collection services from 2010 in two urban areas, the target municipalities are Playa and Habana Del Este and the total population is 205,187. MSW will be segregated into three categories, i.e. kitchen waste, recyclable waste and other waste. The frequency of segregated waste collection is as follows: kitchen waste seven days a week, recyclable waste two days a week, and other waste 5 days a week.

Regarding the adopted vehicles, the evaluation result suggests that 18 m^3 C/T collection vehicles are more suitable than other alternatives in urban areas because the collection system requires a smaller number of vehicles for the best sanitary and safe working conditions.

(2) Specifications of Vehicles

An 18 m^3 C/T must consist of a hopper, body, compactor plate and ejection plate to collect 770 liter steel bins. Waste thrown into the hopper is to be crushed by the compactor plate and then compressed and compacted by the ejection plate inside of the body. Collected waste must be able to be discharged horizontally from the rear of the body by operation of the ejection plate. It must be easy to load and discharge as well as easy to clean and maintain.

- 18m^3 C/T waste load capacity is estimated at 7.4 tons
- Lifting arms (both hooking arms and forking arm) with compression devices should be operated by a simple hydraulic system
- Hooking distance for lifting bins is to be adjustable from 1,000 mm to 1,700 mm and accommodate the new steel bins
- The capacity of compression must be to 20-30% of the original volume depending on the type of collected waste
- Lifting capacity of the bin is to be a minimum of 1,000 kg and dumping angle is about 50°

- Electro deposition paint for body, hopper and other parts
- To protect against liquid waste leaking from the C/T, a built-in sewage tank (liquid waste holding tank) as shown in Figure 1 is needed

Liquid waste holding tank

Figure 1 Example of Built-in Liquid Waste Holding Tank

Standard equipment:

- Rear operating lever
- Anti-slip steps and handrails
- Emergency stop device
- Working lamps
- Rotating lamps
- Required spare parts such as tires, a fire extinguisher, repair tools and special repair parts

More technical information is shown in Table 1 and Figure 2, which shows typical dimensions of an 18-20 m^3 C/T.

Table 1 Typical Specification of 18 m^3 C/T Vehicles

Items			Specification
Body capacity			18.0 m^3
Hopper capacity			2.2 m^3
Total body width			Approx. 2,500mm
Total body length			Approx.9,900mm
Body height			Approx. 3,500mm
Shipping Measurement			80 m^3 x 14.5 ton
Gate size (width x height)			2,000 x 1,450 mm
Operation control system			Electrically hydraulic control
Discharging system			Horizontal ejection
Loading time (one cycle)			26 –28 sec
Discharge time			50 sec
Plate thick-ness (mm)	Body	Floor	3.2
		Roof	2.3
		Side	2.7
	Hopper	Side (upper)	4.5
		Side (lower)	4.5
		Bottom	8.0
	Discharge plate		2.1
	Press plate		4.5
GVW			20,000 – 26,000 kg
Recommended wheelbase (mm)			5,800 –6,000
Hydraulic system			2,900 psi
Oil pump			Gear type
Chassis Model (reference.)			ISUZU CXZ81Q (Diesel:340PS)
Tire(reference)			11.00 x 20-16PR
Exhaust Brake(reference)			Air operated
Fuel tank(reference)			400 liter
Max. speed (reference)			90km/h
Min. turning radius (reference)			9.5 m

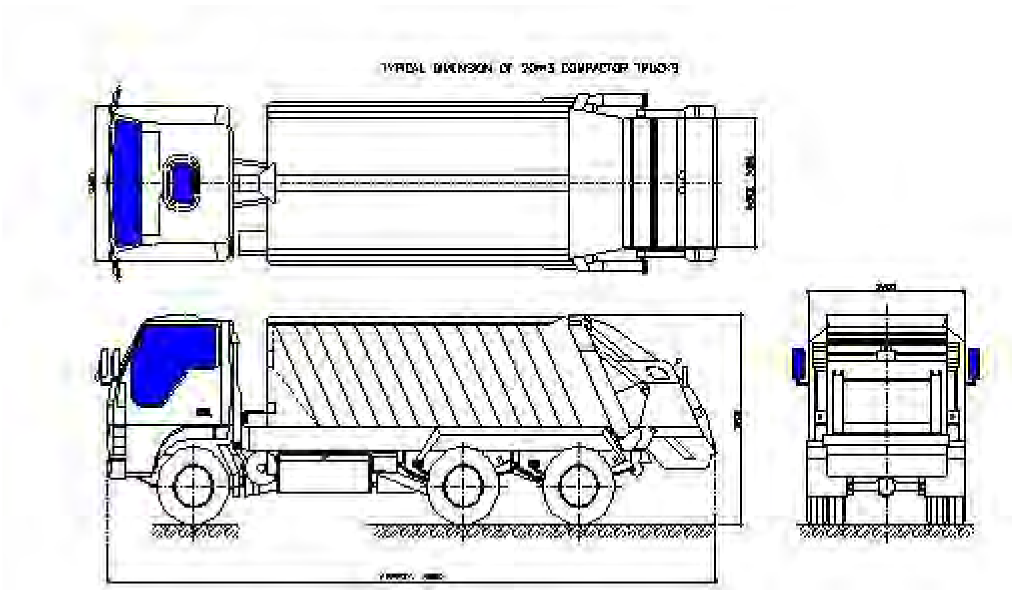

Figure 2 Typical 18-20 m^3 C/T

(3) Required number of C/Ts

The required number of vehicles is shown in Table 2.

Table 2 Required Numbers of Vehicles and Purchase Plan

Items/Year	2006	2010	Total
Total required No.	59	76	-
Existing No. UPPH	39	1 + 31	-
Required No. of New	20	18	38

Table 2 shows that UPPH has to prepare 39 vehicles by 2010. This number includes replacement of old vehicles. The net increase in the number of vehicles for segregated collection is only twelve.

2. Selection of the type of bin lifter

There are three ways to lift bins as shown in Figure 3. Existing C/Ts have arms to collect 770-liter bins. Winch types require more loading time than arm types. The proposed bin lifter has arms (both hooking arms and forking arm) with a holding plate because it is more secure for loading bins at full capacity.

Lifting arms type

Lifting arm type with holding plate

winch type

With hooking arms and forking arm

Side lifter with hooking arms

Figure 3 Various Types of Bin lifter

3. Maintenance work

UPPH has experience with the maintenance work for C/Ts. Following the maintenance instructions of the manufacturer is recommended.

(1) Periodic replacement parts

It is necessary for the hydraulic oil to be changed every six months because it will deteriorate with time. Also, topping-up oil should be of the same type as the original oil and different products must not be used to prevent change in quality due to chemical reactions. Table 3 shows the main parts that require periodic replacement to keep the hydraulic systems working well.

Table 3 Frequency of Replacement Parts

	Name of parts	Frequency of replacement
1	Hydraulic oil	every six months
2	Gland packings	every six months
3	High pressure hoses	every two years
4	Strainers	every two years
5	Return filters	every six months
6	Low pressure rubber hoses	every two years

(2) Periodic inspection

Table 4 shows a data sheet for the inspection of the C/Ts at periods depending on the inspection guideline.

Table 4 Check List for Maintenance Work (1)

Items		Description	Inspection guideline		
			Daily (Morning)	Monthly	Yearly
Vehicles	Engines	Abnormal noise, over heating, oil leaks, fixing conditions etc	◎	○	○
	Drive transmissions		-	○	○
	Travel devices		◎	○	○
	Steerings		◎	○	○
	Breaks		◎	○	○
Hydraulic system	Oil pressure pumps	Abnormal noise	-	○	○
		Oil leaks	-	○	○
		Check for loose bolts	-	○	○
	Hydraulic cylinders	Damage	-		○
		Oil leaks	-	○	○
		Abnormal noise	-	-	○
	Hydraulic oil	Level of oil	○	-	○
		Stain (color)	-	-	○
		Strainer Cleaning	-	-	○
		Replacement of return filter	-	-	○
	Rubber hoses	Damage	-	○	○
		Oil leaks	-	○	○
		Check for loose or missing hoses	-	–	○
	Oil pipe joints	Oil leaks	-	○	○
		Check for loose joints	-	-	○
		Damage	-	–	○
	Hydraulic pressure Oil valves	Pressure	-	○	○
		Oil leaks	○	○	○
		Check for loose valves	-	–	○
		Working condition	○	○	○

Table 5 Check List for Maintenance Work (2)

Items		Description	Inspection guideline		
			Daily (Morning)	Monthly	Yearly
Electrical control system	Operation switchs	Checking of switches	◎	−	○
		Check for loose bolts	−	○	○
		Damage	○	○	○
	Loading control	Adjust operation position	−	○	○
		Check for loose cam bolts	−	○	○
		Check for loose switches	−	○	○
		Check for loose relays and times	−	○	○
	Discharge control	Adjust operation position	−	−	○
		Check for loose closing limit switches for hopper	−	−	○
		Check for loose upper limit switches for lifting	−	−	○
	Wiring	Damage	−	−	○
		Corroded/rusted connectors	−	−	○
	Engine revolution control devices	Adjust operation position	−	−	○
		Check for loose extension wires	−	−	○
Safety equipment / Functional capability	Emergency stop switches	Adjust operation position	−	○	○
		Check for missing switches	−	○	○
	Emergency stop devices	Check operation motion	−	○	○
		Check for Damage to lighting	−	○	○
	Interlock at waste discharge	Check operation motion	○	−	○
		Stain (color)	−	−	○
		Strainer Cleaning	−	−	○
		Replacement of filter	−	−	○
	Loading cycle	Check loading times	○	○	○
	Warning buzzer	Check sound of motion warning buzzer	○	−	○
	Communication buzzer	Check sound	○	○	○
	Fire extinguisher	Check for missing devices	○	−	−
	Hopper lock	Locking condition	○	−	○

Table 6 Check List for Maintenance Work (3)

Items		Description	Inspection guideline		
			Daily (Morning)	Monthly	Yearly
Power transmission system	Drive shaft / universal joints	Checking of switch	◎	–	○
		Check for loose bolts	◎	○	○
		Check for Damage	○	○	○
Loading	Loading operation	Check performance of press plate	○	○	○
		Check for damage or bending of joint parts	-	○	○
		Check roller bearings	-	○	○
		Check guide rails and	–	○	○
		Adjust roller shaft	–	○	○
		Check performance of lifting arms and hooking plate	◎	○	○
Discharge	Hopper operation	Check performance of up-down operation	–	–	○
		Check the cylinders for damage, leaking oil etc	–	–	○
		Check for damage or bends in ejection plate and	–	–	○
		Check clearance of ejection plate and pad abrasion	–	–	○
Turn signals	Turn signals	Check performance of lighting	○	–	–
	Headlights	Check performance of lighting	○	–	–
	Instruments and gauges	Check performance of gauges	○	–	–
Other	Bodies	Check for corrosion portion, damage	-	○	○
		Touch up paint or replace panel	-	○	○
		Check for loose bolts	○	–	–
	Tires and wheels	Check for loose bolts	○	–	–
		Check air pressure	○	–	–
	Tools	Check tools	○	–	–

○- Scheduled activity

◎- Most important

I. Maintenance Workshops

I. MAINTENANCE WORKSHOPS

1. Existing Conditions

It is essential to improve the maintenance workshops for longer and better performance of the collection vehicles. There are 15 maintenance workshops, including one UPPH workshop for C/Ts and fourteen DMSC workshops for T/Cs and D/Ts.

(1) UPPH maintenance workshop

The UPPH workshop has a 10 ha site that includes the workshop and parking lot. The activities of the workshop are to repair and remodel bodies, overhaul engines, perform wheel adjustment, and fix flat tires. However, there are not enough spare parts, and there are few machines and inspection tools.

(2) DMSC maintenance workshop

There is enough space for machine tools; however, equipment is poorly maintained. The work is limited to simple repair work, because of poor machine tools and inspection tools.

2. Policy of Equipment Selection

The necessary units and equipment must be selected to provide the simplest models that can be operated manually or semi-automatically. The main maintenance equipment will be supplied to UPPH to be in the central workshop. DMSC will receive small-scale machine tools and equipment.

3. Improvement plan

In the F/S, the equipment and various tools proposed are those that are of top priority for maintenance of equipment.

(1) Equipment

Related overhauling equipment is important to UPPH because most of the C/T vehicles are over 5 years old, and secondhand C/T vehicles are over 3 to 5 years old. DMSC also needs this type of equipment because most of the T/C and D/T vehicles are 10 to 15 years old.

The required machine tools are listed in Table 1.

- Main equipment consists of flat tire repair equipment, jacks, air compressors, and welding machines for body repairs.
- The equipment will be supplied to UPPH and all DMSC workshops.

Table 1 List of Proposed Equipment for Workshops

Name of Equipment		Specification	UPPH	DMSC
			Units	Units
Equipment				
1	AC Arc Welding Machine	Rated output250A / input 12.7kw 220V60hz, 75-250A,2.6-5.0 steel electrode	1	14
2	Argon Welding Machine	Rated output250A / input220V, 75-250A, 3.0 steel electrode	1	0
3	Engine Arc Welder	Rated output280A / input220V, 30-300A, 2-6 steel electrode	1	0
4	Engine Arc Welder	Rated output 140A / input 25.8V, 30-150A, 2-3.2 steel electrode	1	14
5	Air Compressor	360L/min., 14kg/cm2, 260L Airtank, 3.7kw 220V/60hz w/10m air hose	1	8
6	Engine Generator	Rated output 0.6A / input 100V, 1kw 3600rpm	1	14
7	Oil-changer W/compressor	70L-oil tank,5kg/100L-Min Air, suction capacity 1.2L/min	1	14
8		17 L/min, 6kg/cm2, 1.5kw 220/60hz w/10m air hose	1	14
9	Grease Pump	Manual, 16kg grease Capacity	1	14
10	Battery charger	Input 110V/60hz, output 18-24V,charge 60min, w/battery checker, 2.5m cable	1	14
11	Battery Tester(handy)	12V, dynamo /battery	1	14
12	Tool Kits	Manual Wrench for engine	1	14
13	Tiers Changer(1550)	Max size 1550mm Dia, width700mm, Hub size110-480mmdia, oil motor 2.0kw 220V/60hz, w/Disc tool	0	8
14	Tiers Changer(800)	Air 10kg/cm2, tier size 860mm Dia, width320mm, oil motor 0.75kw 200V/60hz, 10kg/cm2 Compressed air	1	0
15	Tiers repair kit	Rubber/glue/tools	2	14
16	Jack (20t、Manual)	Manual, 20t	1	14
17	Jack(10t, Manual)	Manual 10t-GarageJack, Lifting 400mm	1	14
18	Jack for Transmissions	Manual 0.7t	1	0
19	Extensiob type Jack	Manual 1t, 1000mm long	2	0
20	Impact wrench	Air, bolt size 14mm, torque30-300 N.m	2	14
21	Impact wrench	Air, bolt size 20mm, torque150-650 N.m	2	0
22	Electric Trolley Chain block	Electric、3.0t, 4m-lifting, wind 3.4 m/min(3.75kw), travel 12-24m/min(0.75kw)	1	0
23	Car Washer	20 L/min, 5km/cm2, 0.5kw/110V w/hose and gun	1	14
	Sub-Total		26	212

(2) Various tools

In addition, work tools are necessary to adjust the parts of the vehicles. UPPH has only a few tools and measuring instruments making it very difficult to perform the required work appropriately. The required machine tools are listed in Table 2.

- Main tools consist of spanners, hammers, and wrenches as well as metal materials.
- These tools will be supplied to UPPH and all DMSC's workshops.

Table 2 List of Various Proposed Tools

Name of Equipment		Specification	UPPH	DMSC
			Units	Units
Various Tools				
1	Hexagon wenches	set	2	14
2	Spanners	set	2	14
3	Fils	Flat/round/triangle Files set	2	14
4	Reamers	straight / tapered reamers set	2	14
5	Bits	set	2	14
6	Screw driver	set	2	14
7	Drills	set	2	14
8	Taps	set	2	14
9	Dies	set	2	14
10	Open-end wrenches	set	2	14
11	Nippers	set	2	14
12	Adjustable wench	set	2	14
13	Bench Vises	set	2	14
14	Sledgehammers	set	2	14
15	Hammers	set	2	14
16	Tool Box	set	2	14
17	Cord reel	set	2	14
18	Shovels	set	2	14
19	Grindstones	set	2	14
20	Hacksaws	set	2	14
21	Instrument	Gauges, tape measures, calipers, revolution meter, compass, etc	2	14
22	Safety / Health Control	Goggles, Gloves, Stretchers,masks,etc	2	14
23	Metal Materials	Steel plate, steel round bar, Aluminum round bar, bronze bar, etc	2	2
24	other	Special tools	2	14
	Sub-Total		48	324

(3) Machine tools

The required machine tools are listed in Table 3.

- Machine tools such as lathes, radial drills and milling cutters will be supplied to UPPH.
- Hand drills and grinders will be supplied to the UPPH and 14 DMSC workshops.

Table 3 List of Proposed Machine Tools

Name of Equipment		Specification	UPPH Units	DMSC Units
Machine Tools				
1	Lathes	Semi-Auto C/C2000mm, 40kw 220V/60hz	1	0
2	Lathes	Semi-Auto,C/C1500mm, 38kw 220V/60hz	1	0
3	Radial Drilling	Manual,C/C1000mm, 2.1kw 220/60hz	1	0
4	Precision Surface Grinding Machine	Manual,C/C500mm,10kw 220/60hz	1	0
5	Bench Grinder	Manual, 255mmdia,1kw 220/60hz	0	14
6	Milling cutter (Universal)	Manual, Horizontal, 3.7kw220/60hz	1	0
7	Electric Saw	Manual, Horizontal, 25mmdia, 3.5kw 220/60hz	1	0
8	Electric Cutter (handy)	Steel 1.6mm, 0.5kw, 110/60hz	1	0
9	Bench Drilling Machine	1-6.5mmdia, 5000rpm 1kw, 110/60hz	1	14
10	Electric Drill (handy)	22mmdia, 0.5kw, 110/60hz	1	14
11	Electric Drill (handy)	6.5mmdia, 0.4kw, 110/60hz	1	14
12	Electric Drill (handy)	10mmdia, 2500rpm 0.5kw, 110/60hz	1	14
13	Electric Grinder (handy)	180mmdia, 5000rpm 0.4, 110/60hz	1	14
14	Disc Grinder (handy w/Discs)	100mmdia, 0.7kw, 10,000rpm, 110/60hz	1	14
15	Disc Grinder (handy w/Discs)	150mmdia, 9000rpm 1.1kw, 110/60hz	1	14
Sub-Total			14	112

(4) Mechanical Cleaning Equipment

Useful portable cleaning equipment will be operated by electric power. Bin cleaning work is necessary to keep the bins clean and to control odors. The required mechanical cleaning equipment is listed in Table 4.

- The vehicle has a water tank of 5,000 to 8,000 liters with high-pressure pumps and tracks to pick up washed waste. The bin washing vehicles will be supplied to UPPH.
- The portable cleaning equipment will be useful to both UPPH and DMSC
- UPPH will maintain the bin washing vehicles.

Table 4 List of Mechanical Cleaning Equipment

Name of Equipment		Specification	UPPH Units	DMSC Units
Cleaning Equipment				
1	Mechanical Equipment	Automatic bins wash with 7500L Water Tank	3	0
2	Portable washers	Electric pumps	4	14
3	Bins Washers Vehicles	PVC containers, water spray	4	0
4	Dump Trucks	4 ton	4	4
5	Hand carts	2-160 liter bins and wheels	1,500	0
	Sub-Total		1,519	18

(5) Inspection and communication tools

Motorcycles can be used for inspection and patrols to check the condition of waste collection and illegal dumping.

- The tools will be supplied to UPPH and DMSC offices.

The required inspection and communication tools are listed in Table 5.

Table 5 Lists of Inspection and Communication Tools

Name of Equipment		Specification	UPPH	DMSC
			Units	Units
Inspection and communication tools				
1	Motorcycles	50cc	4	15
2	Handy transceiver	Battery-type, Distance 2 to 5km	10	14
	Sub-Total		14	29

(6) Office and other Equipment

To improve the management capability for collection and transportation, establishment of a database system is very useful. The equipment consists of computers and printers as well as hour meters and odometers for recording daily operation time and distance.

- Communication systems are used to monitor and control collection works.
- The tools will be supplied to UPPH and DMSC offices.

The list is shown in Table 6.

Table 6 List of Office & Other Equipment

Name of Equipment		Specification	UPPH	DMSC
			Units	Units
Office Equipment				
1	Computers	Disk Top	2	15
2	Printers	With FAX machine	2	15
3	Tachometer	24 hr. recording (mileage and time)	140	122
	Sub-Total		144	152

4. Procurement Cost

Based on the price list obtained in Japan and from UPPH, the cost for the equipment is estimated as shown in Tables 7 and 8.

- Total cost is JY 368,370,500
- The ratio of the budget breakdown of UPPH to DMSC is 66% to 34%.
  - Most of the machine tools will be supplied to UPPH.
  - Most of the equipment will be supplied to DMSC.
- Local costs
  - Local costs to install the workshop equipment and the electrical works will be as follows.
  - Electrical work is JY 50, 000,000.
  - Installation of equipment is JY 10,000,000

Table 7 Estimated Cost (US$＝110/JY)

Items	**Cost (JY)**			**Cost (US$)**		
	UPPH	DMSC	Total	UPPH	DMSC	Total
Equipment（F/S）	**7,326,000**	**59,142,000**	**66,468,000**	**66,600**	**537,655**	**604,255**
Various Tools (F/S)	**2,548,000**	**14,236,000**	**16,784,000**	**23,164**	**129,418**	**152,582**
Machine Tools	72,517,500	4,221,000	76,738,500	659,250	38,373	697,623
Cleaning Equipment	143,100,000	22,100,000	165,200,000	1,300,909	200,909	1,501,818
Inspection and communication tools	1,000,000	3,280,000	4,280,000	9,091	29,818	38,909
Office Equipment	21,800,000	24,300,000	46,100,000	198,182	202,909	419,091
S-Total	248,291,500	127,279,000	375,570,550	2,257,196	1,157,082	3,414,278
	66%	34%	-	66%	34%	-

Table 8 Procurement Cost per Phase

Year	2005-2010	2011-2015	Total
Total Budget (US$)	756,836	2,657,441	3,414,277

5. Operation Cost

The biggest cost for maintenance is labor, which accounts for 35%-38% of all costs for mixed collection as shown in Tables 9 and 10. The required number of workmen for segregated collection will be increased by about six.

- Total cost is 1,020,939 Pesos/year (in 2007, mixed collection).
- Expenses per day are 2,797 Pesos/day (in 2007, mixed collection)
- MSW Expenses are 3.0 Pesos/t/day (in 2007, mixed collection)
- Estimated power consumption is shown in Table 13.
    - In 2007 is estimated to be 1,410 kw/hr (5 hrs/day)
    - In 2015 is estimated to be 2,355 kw/hr (5 hrs/day)

Tables 11 and 12 show the operation costs for segregated collection.

Table 9 Summary of Maintenance Costs for Mixed Collection (Pesos) in 2010

Item (Workshop)	Unit cost	Unit	Peso Currency			Remarks
	Peso		Quantity	Price (Mon)	Price (year)	
Labor cost (UPPH)	500	peso/cap	59	29,500	354,000	Only workmen staff 100
(DMSC)	500	peso/cap	41	20,500	246,000	
Water	0.5	peso/m^3	300	150	1,800	
Gas (LPG)	-	peso/liter	-	-	-	
Fuel	0.3	peso/m^3	46,500	13,950	167,400	Engines: 31 units
Power rates	0.1	peso/kwh	42,383	4,238	50,859	
Lubricant	2	peso/liter	8,370	16,740	200,880	5% of fuel
Total				85,078	1,020,939	25peso/U$
Expenses (peso/day)					2,797	365
Expenses (peso/t/d)					3.0	940 t/day (MSW)

Table 10 Summary of Maintenance Costs for Mixed Collection (Pesos) in 2015

Item (Workshop)	Unit cost	Unit	Peso Currency			Remarks
	Peso		Quantity	Price (Mon)	Price (year)	
Labor cost (UPPH)	500	peso/cap	68	34,000	408,000	Only workmen staff 149
(DMSC)	500	peso/cap	61	30,500	366,000	
Water	0.5	peso/m^3	387	194	2,322	
Gas (LPG)	-	peso/liter	-	-	-	
Fuel	0.3	peso/m^3	46,500	13,950	167,400	Engines: 31 units
Power rates	0.1	peso/kwh	70,703	7,070	84,843	
Lubricant	2	peso/liter	2,325	4,650	55,800	5% of fuel
Total				90,364	1,084,365	25peso/U$
Expenses (peso/day)					2,971	365
Expenses (peso/t/d)					3.2	940 t/day (MSW)

Table 11 Summary of Maintenance Costs for Segregated Collection (Pesos) in 2010

Item (Workshop)	Unit cost	Unit	Peso Currency			Remarks
	Peso		Quantity	Price (Mon)	Price (year)	
Labor cost (UPPH)	500	peso/cap	67	33,500	402,000	Only workmen staff 108
(DMSC)	500	peso/cap	41	20,500	246,000	
Water	0.5	peso/m^3	324	162	1,944	
Gas (LPG)	-	peso/liter	-	-	-	
Fuel	0.3	peso/m^3	46,500	13,950	167,400	Engines: 31 units
Power rates	0.1	peso/kwh	42,383	4,238	50,859	
Lubricant	2	peso/liter	8,370	16,740	200,880	5% of fuel
Total				89,090	1,069,083	25peso/U$
Expenses (peso/day)					2,929	365
Expenses (peso/t/d)					3.1	940 t/day (MSW)

Table 12 Summary of Maintenance Costs for Segregated Collection (Pesos) in 2015

Item (Workshop)	Unit cost	Unit	Peso Currency			Remarks
	Peso		Quantity	Price (Mon)	Price (year)	
Labor cost (UPPH)	500	peso/cap	98	49,000	588,000	Only workmen staff 159
(DMSC)	500	peso/cap	61	30,500	366,000	
Water	0.5	peso/m^3	477	239	2,862	
Gas (LPG)	-	peso/liter	-	-	-	
Fuel	0.3	peso/m^3	46,500	13,950	167,400	Engines: 31 units
Power rates	0.1	peso/kwh	70,703	7,070	84,843	
Lubricant	2	peso/liter	8,370	16,740	200,880	5% of fuel
Total				117,499	1,409,985	25peso/US$
Expenses (peso/day)					3,863	365
Expenses (peso/t/d)					4.1	940 t/day (MSW)

Table 13 Estimated Power Consumption

Items	Number of units		Electricity (kw/hr)			Working Hours:	5	Total
	UPPH	DMSC	UPPH	DMSC	Total	UPPH	DMSC	Kwhr/d
Machine Tools	14	112	103	79	182	515	395	910
Equipment	26	212	24	258	282	120	1,290	1,410
Various Tools	48	324	0	0	0	0	0	0
Cleaning Equipment	1,515	18	1	3	4	5	15	20
Inspection and communication tools	14	29	0	0	0	0	0	0
Office Equipment	218	30	0	3	3	0	15	15
S-Total	1,835	725	128	343	471	640	1,715	2,355

The operation cost per phase is shown in Table 14.

Table 14 Operation Cost per Phase

Year	2005-2010	2011-2015	Total
Operation Cost for Mixed (CUP)	5,104,695	5,421,825	10,526,520
Operation Cost for Segregated (CUP)	5,345,415	7,049,925	12,395,340

6. Maintenance Cost

The maintenance cost for spare parts is 5% of the purchase cost of the equipment. Total maintenance cost is shown in Table 15.

Table 15 Maintenance Cost per Phase

Year	2005-2010	2011-2015	Total
Total Budget (US$)	189,210	837,205	1,026,415

7. Recommendations

As for machine tools, it is proposed to provide workshops under the following conditions.

- The first priority is the equipment and various tools for overhauling engines and gas/electric welding machines for vehicle bodies.
- The second priority is mechanical tools and bin washing equipment.

Related overhaul equipment is important because most of the C/T vehicles are more than 5 years old and secondhand C/Ts are more than 3 to 5 years old. The required equipment is described below.

- The main equipment consists of one tire repair set, jacks, air compressors and welding machines for body repairs. The equipment will be supplied to UPPH and all DMSC work shops.
- Machine tools include lathes, radial drills and milling cutters for the UPPH workshop and hand drills and grinders for both UPPH and DMSC workshops.