CHAPTER 5 THE MASTER PLAN

5.1 Objective and Scope of the Master Plan

(1) Objective

The objective of the M/P study is to provide a clean and sanitary living environment and adequate municipal solid waste management (MSWM) service for the citizens and institutions of Havana City. A clean city will also encourage further enhancement of the tourism industry, which is currently the biggest foreign currency-earning industry in both the country and the City.

(2) Planning Horizon

Considering the need for coordination with relevant plans/programs and a practical time range for future projection, the planning horizon of the M/P for MSWM in Havana City was set at the year 2015.

(3) Target waste

The M/P deals with the planning of municipal solid waste (MSW). MSW consists of the following three groups as per the present classification in Havana City:

- Domestic waste
- Commercial waste
- Bulky waste and other wastes

Domestic waste is household waste generated by the people who live in the City through their everyday life.

Commercial waste is defined as the waste generated through businesses and economic activities. It is categorized into four items classified by generation sources; i.e., hotels, restaurants, markets, and other commerce. Among them, hotels and restaurants are regarded as the major waste generation sources of this sector. Almost all waste generated in markets selling agricultural products is regarded as organic decomposable waste.

Bulky waste mainly consists of construction waste and yard waste from the cutting of trees and branches. Construction waste includes building waste, concrete blocks and excavated soil. Street sweeping waste is generated throughout the city. Other bulky objects represent only a small proportion of the total amount of waste generated.

(4) Scope of the M/P

The M/P covers all aspects of MSWM collection, transportation, disposal, and recycling of solid wastes; institutional and organizational frameworks; awareness-raising; and social and environmental considerations. Medical and industrial solid wastes are not included in the scope of the M/P.

5.2 Socio-Economic Framework

5.2.1 Population

(1) Population forecast

1) Total population in Havana City

According to the Oficina Nacional de Estaditicas Centro de Estudios de Poblacion y Desarrollo, the population in Havana City is predicted to decrease from 2.17 million in 2005 to 2.14 million in 2015 as shown in Table 5.2.1.

Table 5.2.1 Projection of Population of Havana City

Year	2005	2010	2015	2020
Population	2,168,404	2,151,562	2,135,747	2,110,256

Source: Projeccion de la Poblacion Nivel Nacinal y Provincial Period 2000-2025, Office of National Statistic Center of Population and Development Study, 1999

2) Population by municipality

The population distribution among municipalities in 2015 is projected as shown in Table 5.2.2 referring to the population trend in previous years and the perspective presented in Esquema de Ordenamiento Territorial (Direccion Provincial de Planificacion Fisica, 1999).

Table 5.2.2 Population by Municipality of Havana City

Municipality		Existing Statistics		Prediction			
		2002	(%)	2005	(%)	2015	%
1	Playa	181,256	8.33%	180,964	8.35%	198,624	9.30%
2	Plaza de la Revolucion	171,528	7.88%	171,970	7.93%	158,045	7.40%
3	Centro Habana	149,476	6.87%	152,595	7.04%	138,824	6.50%
4	Habana Vieja	94,635	4.35%	94,703	4.37%	93,973	4.40%
5	Regla	42,391	1.95%	42,513	1.96%	42,715	2.00%
6	Habana del Este	185,543	8.53%	183,095	8.44%	200,760	9.40%
7	Guanabacoa	106,292	4.88%	105,729	4.88%	115,330	5.40%
8	San Miguel del Padron	153,956	7.08%	153,386	7.07%	130,281	6.10%
9	Diez de Octubre	227,501	10.46%	228,940	10.56%	226,389	10.60%
10	Cerro	134,778	6.19%	134,598	6.21%	132,416	6.20%
11	Marianao	137,838	6.33%	137,349	6.33%	113,195	5.30%
12	La Lisa	127,843	5.88%	126,038	5.81%	113,195	5.30%
13	Boyeros	188,881	8.68%	185,178	8.54%	202,896	9.50%
14	Arroyo Naranjo	199,542	9.17%	197,655	9.12%	183,674	8.60%
15	Cotorro	74,453	3.42%	73,690	3.40%	83,294	3.90%
	TOTAL	2,175,913	100.00%	2,168,404	8.35%	2,135,747	100%

Source of existing statistics: Anuario Estadistico de Ciudad de La Habana 2002, Territorial Office of Statistics of Havana City

Source of total population of Havana City predicted for 2005, 2015: Projeccion de la Poblacion Nivel Nacinal y Provincial Period 2000-2025, Oficina Nacional de Estaditicas Centro de Estudios de Poblacion y Desarrollo, 1999

Note: Population by municipalities were predicted by the JICA Study Team

5.2.2 Economic Perspective

In projecting long-term economic trends of a country, a useful indicator is the government's long-term economic plan. However, Cuba does not have such a plan at present. As of the middle of 2004, many of the official economic data have not been updated.

Therefore it was attempted to project economic growth through analyses of the characteristics of the present Cuban economy, its past trends, and recent worldwide economic conditions.

(1) Gross domestic product (GDP)

In the early 1990s, Cuba's GDP fell by 35%. During the period from 1995 to 2002, the GDP increased by 30% in constant 1995 prices with an average annual increase rate of about 4%. The increase in 2002 (from 2001) fell to 1.2%. The primary factors that have affected the GDP growth are among others:

- World inflation, including changes in the price of oil, sugar and nickel, and
- Balance of payments and debt position.

Cuba's weakness in the areas of basic foodstuffs and manufacturing has caused the expansion of imports many times greater than GDP growth, resulting in deterioration in the balance of trade. Such trade deficit could not be offset by

sufficient inflow of foreign capital investment to Cuba. Since Cuba is not a member country of the World Bank or IMF and most of its external debts are still in a state of moratorium, the possibility of borrowing new long-term capital is limited. Therefore, the shortage of hard currency remains unresolved.

Overall, it is conservatively assumed that the annual GDP growth rate until 2015 will stay below those of the late 1990s, in the range between 0 and 1% annually.

(2) Tourism

According to actual statistics, the number of tourists to Cuba was 1.7 million in 2000. There was a drop in 2002 due to the negative impact on global tourism caused by the September 11 attacks in USA. However, the number of arrivals in 2003 again increased and exceeded 1.9 million.

A projection following this trend predicts an increase to 3 million in 2015. Assuming half of the tourists visit Havana City, the number of tourists visiting Havana is estimated to be some 1.5 million. This upward trend is expected to continue, lifting the arrivals in Havana City to 2 million by 2025.

Table 5.2.3 shows the projected number of tourists to Cuba and Havana.

Table 5.2.3 Trend and Projection of Tourist Arrivals

(Unit: 1,000 persons)

Description	2000	2001	2002	2003	2015	2025
Tourists to Havana City	951	980	959	974	1,500	2,000
Tourists to Cuba	1,774	1,775	1,686	1,906	3,000	4,000
Ratio for Havana City	54%	55%	57%	51%	50%	50%

Source: Ministry of Tourism, Havana City Territorial Office of Statistics; partly estimated by JICA Study Team

Anuario Estadistico de Cuba 2002 (Oficina Nacional de Estadistico, 2003) gives the total number of hotel rooms in Havana City. Also, the number of hotel rooms for international tourists in Havana City is predicted by the Physical Planning Institute of Havana City. Both sets of data are summarized in Table 5.2.4 below. The balance is regarded as hotels accommodating national tourists. The number of hotel rooms for national tourists is predicted to remain at the present level reflecting the situation in the domestic economy.

Table 5.2.4 Prediction of Number of Hotel Rooms in Havana City

Category	Area in City	2002	2003	2005	2015	2025	Annual Increase Rate (2003-25)
International	Marina Hemingway	543	569	624	992	1,575	1.05
	Montebarreto	2,300	2,351	2,456	3,055	3,800	1.02
	Vedado	2,513	2,600	2,783	3,913	5,502	1.03
	Centro traditional	1,376	1,437	1,568	2,426	3,752	1.04
	Cojimar	552	591	679	1,354	2,702	1.07
	Playas del este	1,288	1,429	1,758	4,950	13,940	1.11
	Sub-total	8,572	8,977	9,868	16,689	31,271	1.06
National		4,183	4,200	4,200	4,200	4,200	-
Total		12,755	13,177	14,068	20,889	66,742	-
Ratio to 2002		100%	103%	110%	164%	523%	-

Source of international tourism: Direction of physical planning in Havana City, 2003
Source for total number of rooms in 2002: Anuario Statistics de Cuba 2002
Note: Number in 2003 and 2025 is predicted by Physical Planning Institute. Numbers in 2002, 2005 and 2015 were calculated by the JICA Study Team

5.2.3 Classification of Municipalities by Land Use Type

The municipalities in Havana City are classified into urban and semi-urban areas depending on the occupation rate of land use for agriculture. Municipalities in which the agricultural area occupies more than 25% of the territory are classified as semi-urban areas.

Based on this criterion, seven municipalities are categorized as urban municipalities and the other eight municipalities as semi-urban.

- Urban municipalities: Playa, Habana del Este, Plaza de la Revolución, Centro Habana, Habana Vieja, Diez de Octubre, and Cerro
- Semi-urban municipalities: Regla, Guanabacoa, San Miguel del Padrón, Marianao, La Lisa, Boyeros, Arroyo Naranjo, and Cotorro

5.3 Projection of Future Solid Waste Generation

The projection of quantity of future waste generation is the basic parameter for preparing the M/P. Waste generation quantities at present and in the period toward 2015 (target year of the M/P) have been estimated by considering the solid waste generation mechanism and the socio-economic parameters described in Section 5.2.

Driven by the trend of decreasing population and stagnation (zero growth) of GDP, it is assumed that the overall economic condition of Havana City will not change

significantly up to 2015 except in the tourism sector, which is expected to grow continuously.

5.3.1 Unit Generation Rate and Waste Composition

Table 5.3.1 shows the present unit generation rates of domestic waste and commercial waste, which were derived from the results of a waste quantity survey conducted during the JICA Study. The same survey also revealed the composition ratios of domestic and commercial waste as shown in Table 5.3.2.

As no significant change is expected in the economy, it is assumed that the unit generation rates would remain at the present level during the planning period up to 2015. The composition rates are also not expected to change from the present condition.

Table 5.3.1 Unit Generation Rate of Domestic and Commercial Waste

Generation Source		Unit Generation Rate
Domestic (Household)		0.7 kg/person/day
Commercial	Hotel	1.2 kg/room/day
	Restaurant	31 kg/restaurant/day
	Market	60 t/day in Havana City
	Others	0.3 kg/employee/day

Source: Waste Quantity and Quality Survey conducted by the JICA Study Team, CITMA and DPSC, 2004

Table 5.3.2 Composition Ratio of Domestic and Commercial Waste

Unit: % in weight

Kind of Waste		Generation Source			
		Domestic	Hotel	Restaurant	Office
1	Paper & Cardboard	9	22	22	38
2	Aluminum	1	3	4	1
3	Scrap metals	1	1	2	0
4	Plastics	8	9	8	7
5	Glass	11	13	19	3
6	Textile	1	0	0	1
7	Wood & Yard waste	9	0	0	0
8	Kitchen waste	60	52	45	51
9	Rubber	0	0	0	0
10	Leather	0	0	0	0
11	Others	0	0	0	0
	TOTAL	100	100	100	100

Source: Waste Quantity and Quality Survey conducted by the JICA Study Team, CITMA and DPSC, 2004

5.3.2 Projection of Solid Waste Generation

(1) Municipal solid waste

1) Domestic waste

The quantity of domestic waste generated was estimated based on unit generation rates and population. The estimated quantities by municipality are summarized in Table 5.3.3. Domestic waste generation will decrease owing to decrease of the population.

Table 5.3.3 Estimation of Domestic Waste Generation

Municipality	Population			Domestic Waste (tons/day)		
	2005	2010	2015	2005	2010	2015
Playa	180,964	189,337	198,624	127	133	139
Plaza de la Revolución	171,970	165,670	158,045	120	116	111
Centro Habana	152,595	146,306	138,824	107	102	97
Habana Vieja	94,703	94,669	93,973	66	66	66
Regla	42,513	43,031	42,715	30	30	30
Habana del Este	183,095	191,489	200,760	128	134	141
Guanabacoa	105,729	109,730	115,330	74	77	81
San Miguel del Padrón	153,386	142,003	130,281	107	99	91
Diez de Octubre	228,940	228,066	226,389	160	160	158
Cerro	134,598	133,397	132,416	94	93	93
Marianao	137,349	124,791	113,195	96	87	79
La Lisa	126,038	120,487	113,195	88	84	79
Boyeros	185,178	193,641	202,896	130	136	142
Arroyo Naranjo	197,655	191,489	183,674	138	134	129
Cotorro	73,690	77,456	83,294	52	54	58
Total	2,168,404	2,151,562	2,135,747	1,517	1,505	1,494

Source: Population - Projeccion de la Poblacion Nivel Nacional y Provincial Period 2000-2025, Oficina Nacional de Estaditicas Centro de estudios de poblacion y Desarrollo, 1999

2) Commercial waste

Generation of commercial waste is summarized in Table 5.3.4. The commercial waste generation will increase owing chiefly to the development of tourism. The quantity of market waste was estimated using the data of market waste weighed at the existing recycling plant during December 2003 to February 2004 in the JICA Study. Waste generation in all markets was estimated to be approximately 60 tons/day.

Table 5.3.4 Generation of Commercial Waste

Type of Commerce	Waste Generation (tons/day)			Note
	2005	2010	2015	
Hotels	17	22	25	
Restaurants	2	3	3	
Markets	60	60	60	Constant
Others	100	100	100	Constant
Total	179	185	188	

Source: Estimated in the JICA Study based on the data obtained from waste quantity survey, 2004

3) Bulky waste and others (construction waste, yard waste and street sweeping waste)

Based on the survey data of all the waste transported to the landfill site in eight days of March 2004 in the JICA Study, the quantity of waste under this category was estimated as 520 tons/day.

(2) Industrial and medical waste

Based on the data of industrial and medical waste surveyed during the JICA Study for reference, the quantities of industrial and medical waste generation were estimated as 350 tons/day and 15 tons/day, respectively.

5.4 Long-Term Vision toward 2025

5.4.1 Objective of Formulation of Long-Term Vision toward 2025

The objective of preparing a long-term vision toward 2025 is:

(1) To figure out a long-term economic scenario that will affect MSWM in Havana City

(2) To examine the basic direction of MSWM in Havana City under the given economic scenario.

The long-term vision will constitute a base for formulating the M/P toward 2015.

5.4.2 Alternative Economic Scenarios

Three alternative economic scenarios were worked out as follows:

(1) Optimistic Scenario

(2) Pessimistic Scenario

(3) Intermediate Scenario (Finally, this scenario was adopted.)

The detail of each scenario is described in Table 5.4.1.

Three key factors considered in working out the scenarios were as follows:

(i) Prospect for external economic relations
(ii) Recovery from adverse economic recession experienced after the influence of the dissolution of the Soviet Union
(iii) Prospect for the tourism industry.

As for (i) and (ii) above, different assumptions were made depending on the scenarios. Because of the characteristics of these issues, the prospects are inevitably accompanied by a certain degree of uncertainty and difficulty in prediction. In view of the fact that the situation had remained unchanged for a long time, the Cuban side expressed its prediction that it would be rather difficult to expect quick improvement within a decade, but possible to imagine an improved situation in two decades, say, toward 2025.

As for (iii), the prospect for the tourism industry was assumed bright for all the scenarios in consideration of the sizable tourism resources endowed to Cuba and the recent upward trend of the industry.

Taking account of (i) to (iii) above, the following economic scenario was considered to be most likely:

(1) In the first decade (until 2015), not much change in the economic environment is expected, except in the tourism sector which will continue to grow.
(2) In the second decade (from 2015 till 2025), the economic condition starts to improve, associated with the strengthening of international relationship. By 2025, the country will have an increasing inflow of foreign tourists and direct investment in various sectors, including the tourism industry and possibly some light industry. In consequence, the economic situation in the country will be much improved with increased foreign currency earnings. Per capita income will also increase.
(3) After 2015 till 2025, the population of the City starts to increase owing to migration from other areas accompanied by the increase of employment opportunities.

The above economic scenario is represented by the Intermediate Scenario stated above. Hence, the Intermediate Scenario was selected to formulate a long-term vision of the MSWM.

5.4.3 Long-Term Vision for MSWM

The long-term vision foresees the active implementation of the MSWM sector toward 2025, supported by the improved financial capacity of the Governments,

including the City Government, and also increased capacity-to-pay of citizens and enterprises/organizations.

Toward 2025, the MSWM system of Havana City will be much improved and modernized as summarized below.

(1) Collection of MSW will be done by more modern and appropriate vehicles.
(2) Segregated collection will be widely practiced in the City.
(3) Recycling and composting will be actively conducted.
(4) Sanitary landfills will be in operation.
(5) Self-finance-based enterprises will be in operation with cost recovery.

For the period up to 2015, part of the above undertakings will be realized, which include:

(1) All the special period landfills except Campo Florido will be closed to prevent environmental pollution. Campo Florido landfill will be converted to a landfill for ordinary operation.
(2) The H/C collection system will be largely replaced by collection using vehicles. H/C collection will be continued in limited areas surrounding Campo Florido landfill.
(3) Environment-friendly landfill operation will be commenced at selected landfills.
(4) Recycling and composting will be introduced with an aim of reuse and reduction of MSW.

Owing to the improved financial situation, though limited, a bigger budget allocation, including a foreign currency component, will be realized.

Outlined features of the MSWM long-term vision assumed in the three alternative scenarios are given in Table 5.4.1.

It is noted that the vision in 2025 under the Intermediate Scenario is identical with that in 2015 under the Optimistic Scenario, and the vision in 2015 under the Intermediate Scenario is identical with that in 2015 (and 2025) under the Pessimistic Scenario.

Table 5.4.1 Alternative Scenarios for Economic Situation and MSWM (1/3)

Scenario	Situation in 2015		Vision for 2025	
Optimistic	Economic Condition	MSWM	Economic Condition	MSWM
	After 2005, international relationships will be improved and as a consequence more foreign tourists, more foreign investment and more foreign currency earnings are expected.	■ With the improved economic condition with increased foreign currency earnings, collection vehicles, equipment and parts will be imported together with fuel. ■ In consequence, replacement of the collection/transport vehicles and other equipment for MSWM will be done in compliance with their useful lives. ■ All the MSW will be disposed of by means of sanitary landfill method. ■ Urbanization will proceed to some extent to the east and west. Due to increasing environmental concern of the residents as well as the progress of the urbanization, establishing landfill will be increasingly difficult. Finding the locations outside of Havana City may be necessitated. ■ Thanks to the environmental education and efforts by enterprises and organizations, segregated collection and 3Rs will be intensively practiced. ■ The legal system, where regulations are currently scattered through several documents, will be streamlined, bringing all MSWM related laws and regulations into an integrated format. ■ To further improve the efficiency of MSWM system from collection to final disposal, several enterprises (Auroras) for disposal and technical services will be established. Each enterprise will be operated, aiming at a self-financed basis. DPSC under City Government will remain as government body and will supervise and coordinate the activities of these enterprises. ■ Fees will be collected from the enterprises & organizations with the capacity-to-pay. Though not at full cost recovery, a certain level of cost recovery will be realized. ■ Medical wastes will be separated from other solid wastes from discharge till disposal, using special collection vehicles and basically disposed by means of incineration. ■ Reuse & recycling of industrial waste will be strengthened.	Besides the existing industries of sugar cane refinery, tourism, etc., other industries including light industry will be developed. Overall economic situation and income level will be upgraded.	■ Further improvement of the overall efficiency of MSWM will be attained together with the upgraded environmental protection. ■ Urbanization will further proceed. Due to the increasing environmental concern of the residents as well as the progress of the urbanization, establishing landfill will become more difficult. Finding the locations outside of Havana City is necessitated. ■ Enterprises achieve the target of self-financing. DPSC will continue to supervise and coordinate the activities of those enterprises. ■ Fees will be collected from all enterprises/organizations. Though not on a full cost recovery basis, high level cost recovery will be realized. ■ Medical wastes will be separated from other solid wastes from the point of discharge until disposal, using special collection vehicles and disposed of basically by means of incineration. ■ Reuse and recycling of industrial waste will be further strengthened, adopting “Zero Emission” as target.

Table 5.4.1 Alternative Scenarios for Economic Situation and MSWM (2/3)

Scenario	Situation in 2015		Vision for 2025	
Pessimistic	Economic Condition	MSWM	Economic Condition	MSWM
	Economic conditions took a turn for the worse due to the troubled external relationships after 1961 and further deteriorated again after 1991 influenced by the dissolution of the Soviet Union. These situations will continue. The current economic condition will basically remain as at present, except for the tourism industry which will grow as was the case in recent years.	■ The current MSWM system will basically remain. ■ However, aiming at solving the environmental pollution caused by the landfills, all the special period landfills located near residential areas, except Campo Florido landfill, will be closed. ■ Environment friendly type landfills will be operated. ■ Due to the increasing environmental concern of the residents as well as the progress of the urbanization, establishing landfill will be increasingly difficult. Finding the locations outside of Havana City may be necessitated. ■ Segregated collection and 3Rs will be practiced to some extent.	Same condition as in 2015 will continue.	■ The MSWM system in 2015 will basically remain.

Table 5.4.1 Alternative Scenarios for Economic Situation and MSWM (3/3)

Scenario	Situation in 2015		Vision for 2025	
Intermediate	Economic Condition	MSWM	Economic Condition	MSWM
	Economic conditions in 2015 for this scenario will be identical to those of the Pessimistic Scenario for 2015. Namely, economic condition basically remains the same as in 2005 except tourism industry which will grow as was the case in recent years.	■ The current MSWM system will basically remain. ■ However, aiming at solving the environmental pollution caused by the landfills, all the special period landfill located near the residential area, except Campo Florido and Guanabacoa provincial landfill, will be closed. ■ Environment-friendly type landfills will be operated. ■ Due to the increasing environmental concern of the residents as well as the progress of urbanization, establishing new landfills will be increasingly difficult. Finding locations outside of Havana City may be necessary. ■ Segregated collection and 3Rs will be practiced to some extent.	Economic condition in 2025 of this scenario is identical with the Optimistic Scenario in 2015. Namely, after 2015 (target year of the M/P), international relationship will be improved and in consequence more foreign tourists, more foreign investment and more foreign currency earnings are expected.	■ With the improved economic condition with increased foreign currency earnings, collection vehicles, equipment and parts will be imported together with fuel. ■ In consequence, replacement of the collection/transport vehicles and other equipment for MSWM will be done in compliance with their useful lives ■ All the MSW will be disposed of by means of sanitary landfill method. ■ Urbanization will proceed to some extent to the east and west. Due to the increasing environmental concern of the residents as well as the progress of the urbanization, establishing landfill will be increasingly difficult. Finding locations outside of Havana City may be necessary. ■ Thanks to the environmental education and efforts by enterprises and organizations, segregated collection and 3 R will be intensively practiced. ■ The legal system, where regulations are currently scattered through several documents, will be streamlined, integrating the MSWM related regulations into a few instruments. ■ To further improve the efficiency of MSWM system from collection to final disposal, several enterprises (Auroras) for collection/transport, final disposal and technical services will be established. Each enterprise will be operated with the aim of achieving a self-financed basis. DPSC under City Government will remain as government body and will supervise and coordinate the activities of these enterprises. ■ Fees will be collected from the enterprises/organizations having capacity-to-pay. Though not at full cost recovery, a certain level of cost recovery will be realized. ■ Medical wastes will be separated from the other solid wastes from the point of discharge disposal, using special collection vehicles and disposed of basically by means of incineration. ■ Reuse and recycling of industrial waste will be strengthened.

5.5 Strategies for MSWM in Havana City toward 2015

5.5.1 Basic Strategy

Achievement of environmentally friendly MSWM is the basic strategy for providing a clean and sanitary environment for the citizens.

5.5.2 Components of the Strategy

In line with the basic strategy, the following individual strategies were adopted as the components of the M/P:

(1) Priority of Strategies

- Considering the fundamental solid waste management policy, the waste generated from households and other generation sources should be removed from those generation sources promptly and neatly from the viewpoint of public hygiene.
- Therefore, establishment of an appropriate waste collection and transportation system by improvement of the current system should be considered as having the highest priority.
- Then, introduction of sanitary landfills and suitable operation thereof should be considered because landfills are intensive facilities with various kinds of environmental risks need to be carefully controlled.
- Waste reduction activities such as recycling, composting or home-composting shall be introduced only after the appropriate waste flow from generation source to landfill is secured.

(2) Reduction of MSW quantity

- Recycling and reuse of recyclable materials and composting of kitchen waste will be promoted.
- In the semi-urban areas where households have enough space, home composting will be promoted.
- In urban areas, segregated collection will be introduced, dividing waste into three categories, i.e., recyclable materials, kitchen waste, and other wastes. The recyclable materials could be processed to recycling and the kitchen waste composted. This will concomitantly require constructing recycling plants and community composting yards.

(3) Adoption of environment-friendly landfill systems

- Among the options for waste disposal systems, incineration systems will not be adopted in view of the relatively low calorific value of the municipal solid waste and the requirement for high investment and operation costs.

- Existing landfills currently causing environmental problems will be closed with the provision of adequate soil covering and other environment protection measures as early as possible. Appropriate post-closure land use will be planned.
- Any new landfills will be of an environment-friendly type where the structure and operating method to be adopted will be decided considering the level of risk of environmental pollution at the sites, operation and maintenance (O/M) costs, and the service life of the landfills.

(4) Reinforcement of the maintenance workshops

- The capacity of maintenance workshops will be reinforced to improve maintenance of both collection vehicles and landfill equipment with the aim of reducing equipment failure and associated delays to waste collection and interruptions to landfill operations.

(5) Strengthening of awareness-raising and social consideration

- For the successful introduction of environment-friendly MSWM, cooperation and support from citizens is essential; to achieve this aim, adequate information will be provided to citizens. The opinions of citizens are to be obtained through meetings and workshops. Further, adequate channels will be established to convey those opinions to the policy makers.
- For effective awareness-raising, well-developed community based organizations, such as the Retired Members' Committees of the Communist Party of Cuba (CPC), the Committee for Defense of the Revolution (CDR), the Federation of Cuban Women (FMC) and Delegates of Electoral Districts, will be called upon to play an active role.
- Sufficient time will be allocated to the awareness-raising of citizens. Continuous and repeated awareness-raising will be required to firstly create the understanding of the citizens and secondly to obtain their cooperation for environment-friendly MSWM.

(6) Utilization of domestic products

- Domestically available products will be utilized as much as possible with a view to reducing the requirement for foreign currency for the initial investment and also operation and maintenance. The use of local products will also reduce the time for repair, since spare parts will not need to be imported from abroad.

(7) Staged development

The undertaking of environment-friendly MSWM will be implemented in stages in consideration of the following:

- Review the lessons learned from the initial projects and improve them in the subsequent projects.
- Avoid the concentration of financial outlay into a short period of time to reduce the financial burden on the Government

(8) Reinforcement of organizational structure

To undertake the environment-friendly MSWM in an effective way, the following measures are proposed:

- Separation of the functions of control and operation of the MSWM; i.e., DPSC acts as the supervisory body and Auroras as the service provider,
- Education and training of staff so they gain the knowledge required for conducting environment-friendly MSWM,
- Achievement of good cost performance by enhancing the motivation of staff and workers.

(9) Reinforcement of financial capacity of the operating agency

- The financial management capacity of the operating agency will be reinforced. A system of cost recovery through collection of fees from the service recipients would be one possible solution, subject to the approval of the Government. The setting of tariffs will take into account the capacity-to-pay of the recipients.

(10) Reinforcement of legal system

- Technical standards and guidelines will be prepared to define the technical requirements relevant to the conduct of environment-friendly MSWM. They will cover various aspects of MSWM such as leachate quality, compost quality, landfill specifications, segregated discharge and collection, environmental monitoring at landfills, and so on.
- To encourage the recycling of materials from MSW, DPSC/Auroras will be given authority to sell the recyclable materials directly to the open market, which will, however, be subject to the approval of the Government.

5.6 Summary of Municipal Solid Waste Management Plan

5.6.1 Waste Quantity for Planning

(1) Quantity of municipal solid waste

Table 5.6.1 summarizes the estimated quantity of waste generation in 2005, 2010 and 2015, together with the quantity of waste utilized by recycling and composting and the quantity for final disposal.

The waste generation quantity will not vary much during the period from 2005 to 2015, decreasing slightly from 2,216 tons/day in 2005 to 2,202 tons/day in 2015. This decreasing trend is mainly due to stagnant economic activity as described in Section 5.2. The table assumes that the quantities of commercial waste generated in markets and other businesses, bulky waste, and industrial and medical waste will be almost constant during the period. On the other hand, domestic waste and commercial waste generated in hotels and restaurants are assumed to fluctuate according to basic parameters such as population and development of the tourism sector.

Currently, UPPH and Aurora is collecting some of the industrial waste together with municipal solid waste and disposing of it at not only Ocho Vias landfill but also other disposal sites. However, from the fundamental viewpoint that industries have to treat and dispose of the waste generated by their industrial processes by them under the polluter pays principal, only the municipal waste, including commercial waste, will be the target waste as mentioned in the Scope of Work.

The quantity of final disposal is foreseen to decrease owing to the recovery of recyclable materials and use for composting. Illegal dumping of waste will be reduced to zero by strengthening the law enforcement and raising the citizen's consciousness.

Table 5.6.1 Forecast of Generation and Disposal Quantity of MSW

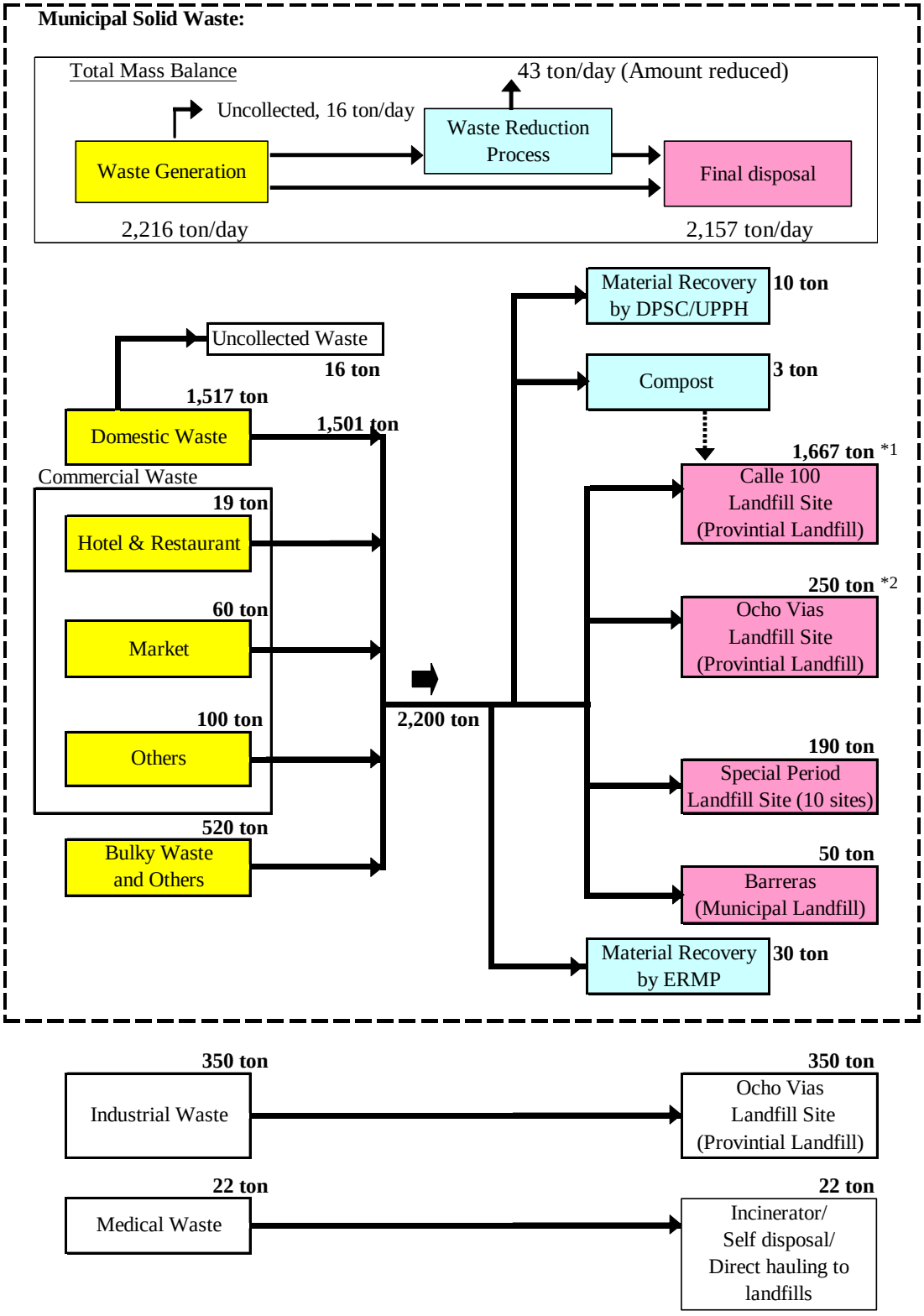
Unit: tons/day

Categories		2005	2010	2015
a.	Generation of MSW	**2,216**	**2,210**	**2,202**
	Domestic Waste *1	1,517	1,505	1,494
	Commercial Waste *2	179	185	188
	Bulky Waste and Others *3	520	520	520
b.	Reduction of MSW	**43**	**166**	**374**
	Material Utilization by DPSC/UPPH	**-**	**-**	**-**
	Material Recovery by DPSC/UPPH	10	13	59
	Production of Compost by DPSC/UPPH	3	45	108
	Loss in composting process *4	-	53	126
	Material Recovery by ERMP Havana City	30	30	30
	Home Composting	-	-	-
	Production of Compost	-	11	22
	Loss in composting process *4	-	14	29
c.	Illegal dumping and self treatment	**16**	**15**	**0**
d.	Final Disposal of MSW: Waste disposed to Landfills (a–b–c)	**2,157**	**2,029**	**1,828**
e.	Generation of Industrial and Medical Wastes	**372**	**372**	**372**
	Industrial Waste	350	350	350
	Medical Waste *5	22	22	22
f.	Total Waste Generation in the City = (a + e)	**2,588**	**2,582**	**2,574**

Note: *1 Household waste
*2 Waste generated from non-industrial business activities
*3 Construction waste, yard waste, trees, branches, etc.
This value was estimated by the assumption that the actual amount measured by the eight-day survey during the Study which was 567 tons/day (ref. Table 3.5.3) was about 10% more than the average because of pre-hurricane season.
Thus, 567 tons/day divided by 110% makes about 520 tons/day
*4 Losses as evaporation and residues
*5 Solid waste generated in hospital, which contains both hazardous and non-hazardous solid waste

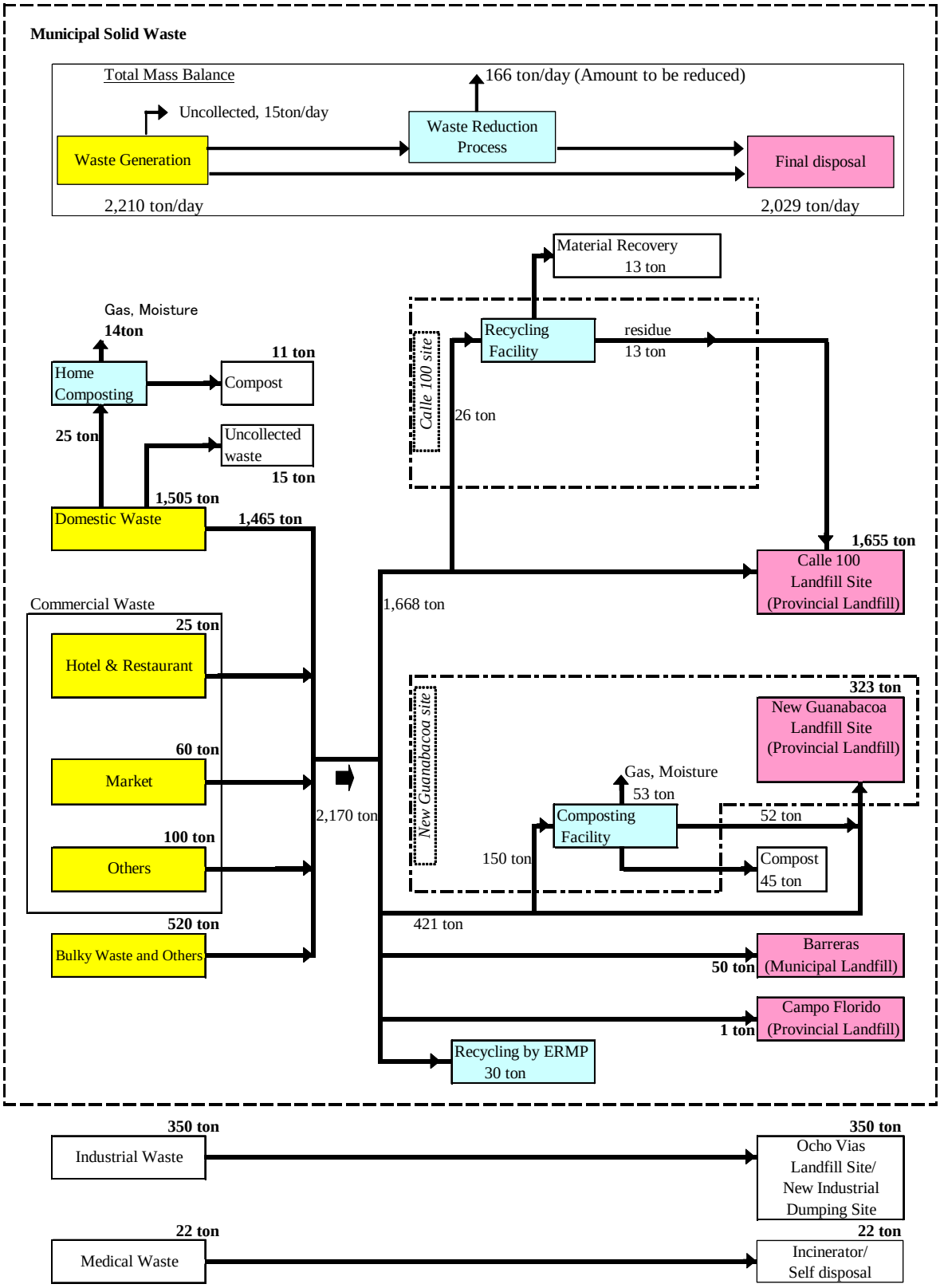
(2) Flow of MSW in year 2015

Figure 5.6.1 shows schematically the flow of waste from generation sources to disposal or production ends in the year 2005, 2010 and 2015. The total waste generation quantity in 2005, 2010 and 2015 is 2,216 tons/day, 2,210 tons/day and 2,202 tons/day respectively as estimated in Table 5.6.1 above. It is estimated that the amount of waste reduction in the solid waste stream in Havana City will be increased as options for MSW reduction are increased.



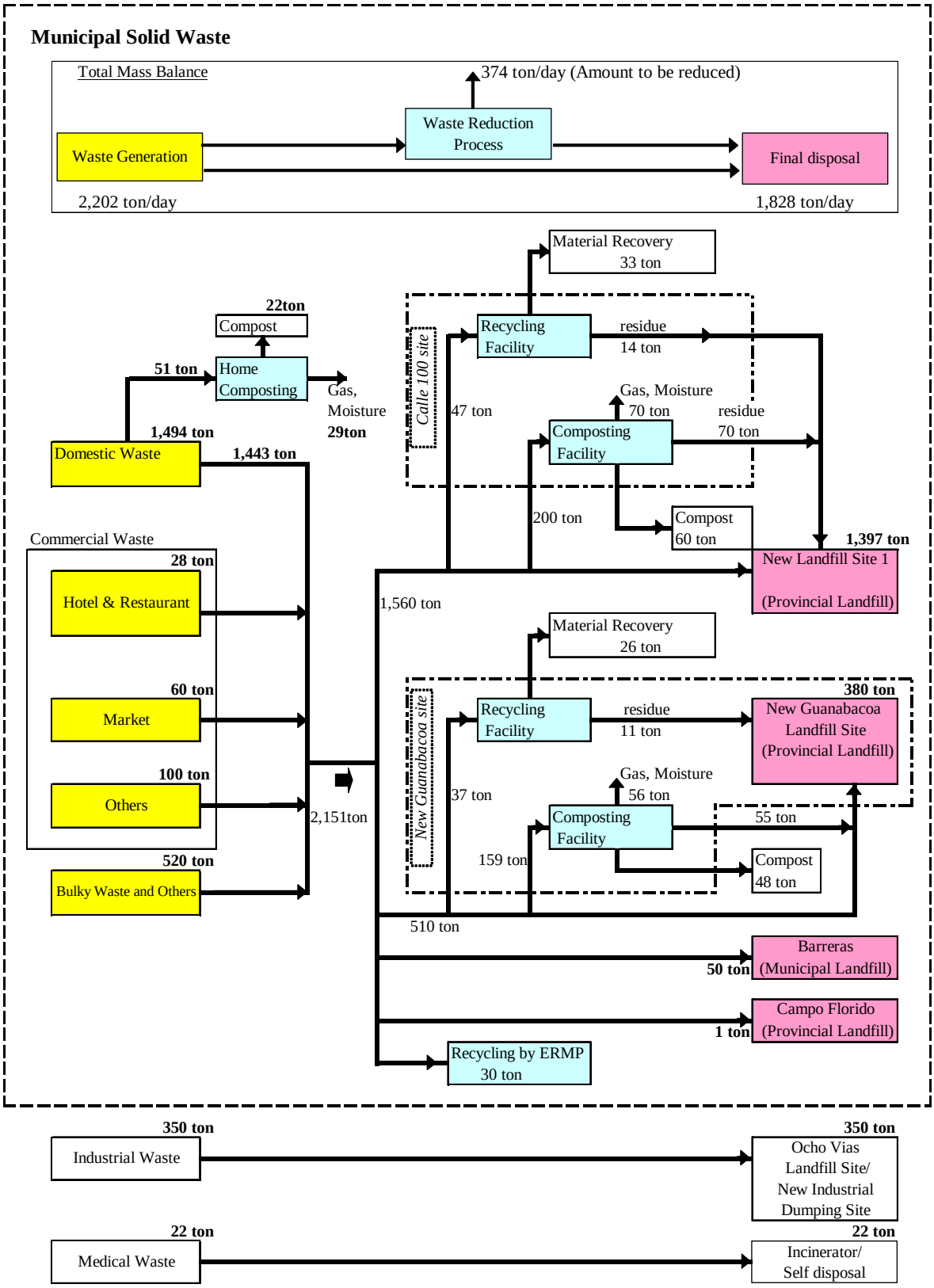
Note: *1. This value includes losses as evaporation in the composting process
*2. Ocho Vias landfill is used for industrial solid waste.
This landfill was used as a temporary site for MSW since Guanabacoa landfill was suddenly closed in 2005
*3. Medical waste is solid waste generated in hospital, which contains both hazardous and non-hazardous waste

Figure 5.6.1 (1) Solid Waste Stream in 2005



Note: Medical waste is solid waste generated in hospital, which contains both hazardous and non-hazardous waste

Figure 5.6.1 (2) Solid Waste Stream in 2010



Note: Medical waste is solid waste generated in hospital, which contains both hazardous and non-hazardous waste

Figure 5.6.1 (3) Solid Waste Stream in 2015

(3) Waste quantity for planning

Table 5.6.2 shows the quantities used for planning the respective works of segregated collection, resource materials recovery, composting and disposal. The figures are chiefly derived from subsections (1) and (2) above.

Of the total waste generation, a considerable portion is collected and hauled by other institutions including industries and commercial enterprises. It was assumed that these institutions that were presently taking care of their solid waste would keep being responsible for their waste collection and transportation in future.

The target for waste collection and transportation in the M/P was set for the waste collected by the public service, namely UPPH/DPSC including Aurora.

A survey was conducted jointly with the JICA Study Team during eight days in March 2004 to investigate the quantity and source of waste transported to the landfill site. The survey revealed that, of the total quantity, the portion collected and transported by the public service agencies (UPPH/DPSC and Aurora) was 940 tons/day.

Waste collection quantity may vary by the extent of introduction of home composting. Since the quantity of home composting is only a fraction of the total quantity, the same quantity, 940 tons/day, was used for planning the waste collection and transportation work throughout the M/P period.

Table 5.6.2 Planning Quantities of Respective Works

Items	2005	2010	2015
MSW Generation Quantity (tons/day)	2,216	2,210	2,202
Waste collection	940	940	940
Segregated Collection (tons/day)		200	624
Phase 1:	0	200	200
- Playa	0	149	149
- Havana del Este	0	51	51
Phase 2:	0	0	424
- Plaza	0	0	121
- Centro Havana	0	0	74
- Havana Vieja	0	0	71
- Cello	0	0	80
- Diez de Octubre	0	0	78
Composting production:	3	56	130
- Composting yards(tons/day)	3	45	108
- Home Composting (tons/day)	0	11	22
Material recovery (tons/day)	10	13	59
Disposal Quantity at Landfill (tons/day)	2,157	2,029	2,178
-Calle 100 (104 ha)	1,667	1,655	Closed
-Guanabacoa	Closed	Closed	Closed
-Ocho Vias (temporary)	250	0	0
-Special period landfill	190	1 *	1 *
-Barreras	50	50	50
-New Site 1	Not exist	Not exist	1,397
-New Guanabacoa	Not exist	323	380

Note: 1. Of 10 landfills, 9 landfills (Electrico, Fraternidad, Guasmas, Lugardita, Prensa Latina, Rincon, El Vidrio, Las Canas, and Los Perros) are to be closed as early as possible and only Campo Florido is to be in service continuously. (marked * above)

2. Disposal quantity includes waste disposed of by other institutions, and hence is larger than MSW generation quantity

5.6.2 Basic Plan of Composting and Recycling Plan

The objective of 3Rs is to reduce the waste volume to be disposed of, reuse the waste, and maximize material recycling. In line with this objective, the M/P proposes composting and resource material recovery as the program of 3Rs.

(1) Composting plan

Based on the quantities for planning in Subsection 5.6.1, community composting plans have been formulated as follows:

- Source of compost: Kitchen waste generated from households, markets and restaurants
- Composting capacity:

	Waste Q'ty	Production (2015)
New Guanabacoa :	159 tons/day	48 tons/day[4]
Calle 100:	200 tons/day	60 tons/day[5]

- Main facilities: Operation yards including storage, buildings/sheds and utilities, and equipment for operation

[4] The other 112 tons/day is loss in production, about half as residue and the other half by evaporation.

[5] The other 140 tons/day is loss in production, half as residue and the other half by evaporation.

Home composting is planned to be 25 tons/day in 2010 and 51 tons/day in 2015, as shown in Table 5.6.2.

(2) Reduction, reuse and recycling (3Rs) concept

DPSC is currently operating a recycling center constructed at the Calle 100 site in 2000. However, the existing recycling center utilized existing old buildings and factories. Therefore, the present facilities and equipment are not of the type that could handle a systematic recycling process. Hence, the plan includes the construction of two new recycling plants, one each in Calle 100 and New Guanabacoa landfills.

Based on the quantities set for planning in Subsection 5.6.1, plans for resource material recovery have been formulated as follows:

- Items for recycling: Aluminum, steel, glass, cardboard, plastic, etc.
- Recycling Center:

Locations	Treatment Capacity
Calle 100:	47 tons/day
New Guanabacoa:	37 tons/day

- Main Facilities: Segregation/storage yards, buildings and utilities, and equipment for the operation.

Total treatment capacity of two plants in 2015 is 84 tons/day (47 tons/day + 37 tons/day) and the expected recovered quantity of recyclables is 59 tons/day.

5.6.3 Collection and Transportation Plan

(1) Coverage of waste collection

The waste collection services provided by DPSC/UPPH, DMSC and other institutions already cover close to 100% of the City's territory. Nevertheless, it seems that a small portion of the population do not put out their waste for collection despite being close to the service. It is assumed that solid waste not put out for waste collection is presently around 3% of all domestic waste. A portion of this non-discharged waste includes the quantity of resource materials being recovered by ERMP of Havana City although it is a faction to the total waste quantity.

In view of the obligation assigned to MSWM, a target collection rate of 100% is adopted in the M/P for the entire City. This rate could be achieved with the deployment of effective services and an improvement in the knowledge and awareness of the population.

(2) Method of collection and transportation

It would be appropriate to adopt a conventional method similar to those currently practiced, namely, the waste is collected and transported by collection vehicles. The collection points are waste bins installed along roads in the urban area or waste-collection points (mostly at each house) in semi-urban areas.

A noteworthy aspect is that most of the existing collection vehicles have already been in use for more than 20 years. At present, UPPH has a total of 65 vehicles, but only 40 are in working condition. In order to ensure continuous and efficient collection and transportation services, the vehicles should be replaced with new ones progressively.

(3) Introduction of segregated collection

With the aim of facilitating the recovery of materials for recycling and composting, segregated waste collection will be introduced to seven municipalities where UPPH currently collects MSW. MSW will be classified into three categories: kitchen waste, recyclable materials, and other waste.

The schedule of introduction of segregated collection is as shown in Table 5.6.3 below. Prior to introduction of this segregated collection with three categories, it is planed to conduct another segregated collection in a pilot scale in Playa Municipality by UNIDO (United Nations Industrial Development Organization) separating in two categories, organic waste and other waste. The result of this pilot study will be reflected to the M/P for revision.

Table 5.6.3 Schedule of Segregated Collection

Municipality	2005-2009	2010-2012	2013-2015
2 urban municipalities: Playa, Habana del Este		→	→
5 urban municipalities: Plaza de la Revolucion, Centro Habana, Habana Vieja, Diez de Octubre, Cerro			→

Note: UNIDO pilot project for 2 category segregated collection is planned to commence before 2010

(4) Review of waste bins

Currently, more than 40% of the waste bins are damaged to a varying extent, which is causing a reduction in operating performance. For instance, compactor trucks take a lot of time for handling bins due to damaged parts. Alignment of bin installations in collection areas is also a subject of planning. In order to improve the operational performance, improvement and re-arrangement of the waste bins should be planned.

(5) Procurement of workshop equipment

In order to maintain the condition of collection vehicles and other equipment, the capacity for equipment repair and maintenance shall be reinforced. With this objective in view, the items of equipment and tools to be procured during the M/P period were examined for the maintenance workshops operated by UPPH and DMSCs.

5.6.4 Final Disposal Site Plan

(1) Closure and development of landfills

Of the two existing major landfills, Guanabacoa landfill was closed in March 2005, and Calle 100 landfill (80 ha) has already been declared full and is causing environmental problems. Calle 100 will be closed by the end of 2008. The other nine special period landfills have also been closed already or are scheduled to close by 2008. Closure of existing landfills requires the construction of new landfills.

Table 5.6.4 shows the schedule of closure and development of landfills. Table 5.6.5 shows the schedule of disposal quantities of the respective landfills.

Table 5.6.4 Plan of Closure and Development of Landfills

Existing Landfills	Remained Life (year)	Area (ha)	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Calle 100	1.9	80						Closing						
Guanabacoa	8.1	28			Closing									
Ocho Vias	12.9	30												
Barreras	15.2	10												
Electrico landfill*	6.1	0.5			Closing									
Fraternidad landfill*	8	2			Closing									
Guasmas landfill*	6.8	2			Closing									
Lugardita landfill*	3.9	1.5						Closing						
Prensa Latina landfill*	3.6	2						Closing						
Rincon landfill*	2.9	0.5						Closing						
Las Canas landfill*	4.8	1						Closing						
El Vidrio landfill*	3.6	2.5						Closing						
Los Perros landfill*	3.8	2						Closing						
Campo Florido landfill*	2	0.5												
Proposed Landfills														
New Guanabacoa	-	(18)												
Campo Florido (Extension)	-	(5)												
Calle 100 (Extension)	-	(24)								Closing				
New Site 1	-	(60)												

Waste collected by H/C

* : Special period landfill
( ): Expected area
The waste colleted by horse carts (H/C) will be dumped toCampoFlorido landfill continuously

As shown in Table 5.6.4, the main landfills in operation after 2009 will be four new landfills: New Guanabacoa, Campo Florido (Extension), Calle 100 (Extension) and New Site 1 accepting the waste collected under the M/P, and two existing landfills: Ocho Vias and Barreas.

Table 5.6.5 Schedule of Disposal Quantities by Landfill

Unit: tons/day

Landfills	Remained Volume (m^3)	Y2004	Y2005	Y2006	Y2007	Y2008	Y2009	Y2010	Y2011	Y2012	Y2013	Y2014	Y2015
Calle 100	1,200,000	1,672	1,667	1,661	1,657	1,650	1,721	1,655	Closed				
New Site 1	-								1,650	1,640	1,414	1,408	1,399
New Guanabacoa	-						360	323	323	326	383	382	380
Guanabacoa	1,242,000	360	Closed										
Campo Florido	1,550		110	110	110	110	1	1	1	1	1	1	1
Special period landfill	209,550	80	80	80	80	80	Closed						
Ocho Vias (temporary)	-		250	250	250	250							
Ocho Vias	2,210,000	350	350	350	350	350	350	350	350	350	350	350	350
Barreras	349,000	50	50	50	50	50	50	50	50	50	50	50	50
Total	5,212,100	2,512	2,507	2,501	2,497	2,490	2,482	2,378	2,374	2,367	2,198	2,191	2,180
Total (covered by M/P)		2,112	2,107	2,101	2,097	2,090	2,082	1,978	1,974	1,967	1,798	1,791	1,780

Note: Calle 100 shows the quantity of both the existing Calle 100 (80ha) and the Calle 100 Extension (24ha)

The following give an outline of respective landfills:

1) Existing Calle 100 (80 ha)

The Calle 100 landfill, the largest existing landfill in Havana City, is located in Marianao Municipality about 10km from the old town. Since its establishment in 1976, the landfill has received the waste from 10 municipalities under the control of DPSC. In 2004, 67% of the waste generated in Havana City was disposed of in this landfill.

There is a highway alongside the Calle 100 landfill site and it provides convenient traffic access to the site. Currently, 1,667 tons/day of MSW are being hauled to this site and the yearly total quantity will reach about 609,000 tons (2005).

Currently, this landfill causes environmental problems, such as offensive odors, spontaneous combustion, water pollution affecting the water quality of the Almendares River, all of which impacts on the living conditions of local residents.

For environmental reasons, the landfill is planned to be closed by the end of 2008. Calle 100 is located close to the urban area. The closure plan will include environmental protection measures such as soil covering, installation of gas extract pipes, surface drainage systems, and vegetation cover. Land utilization after the closure will also be a subject of the M/P.

2) Calle100 Extension (24 ha)

Calle 100 landfill site has a remaining capacity to receive MSW for approximately four to five years. After the closure of the existing landfill MSW will be transferred to the most recently expanded part of the dumping area (24 ha).

Construction of the landfill extension (24 ha) will be completed by the end of 2006. It is expected that this site can start fully receiving MSW from the beginning of 2007. Calle 100 Extension will be utilized for four years until the New Site 1 mentioned in 3) below starts operation in 2011.

3) New site 1

The new site is planned at the southwestern part of the City, but the exact location has not yet been determined. The site will have an area of about 60 ha. The site is referred as New Site 1 in the M/P.

Construction of New Site 1 is planned for completion at the end of 2010 to take over the function of Calle 100 Extension (24 ha). New site 1 will have a receiving capacity of 1,650 tons/day (2011). The type and structure of the landfill will be environmentally friendly and will feature oxidation ponds, leachate treatment system and liner facilities to reduce the environmental impact on neighboring areas as much as possible.

4) Guanabacoa

The existing Guanabacoa landfill (18 ha) was closed in March 2005 by DPSC and CITMA, since it has caused negative environmental impact on the neighboring area. This landfill received 360 tons/day of MSW in 2004. Since the closure, the MSW is being hauled temporarily to Ocho Vias and Campo Florido landfills until the New Guanabacoa landfill is in place.

The closure plan takes into consideration environmental protection measures similar to those described for Calle 100 landfill.

5) New Guanabacoa

After Guanabacoa landfill is closed, MSW will be hauled to New Guanabacoa landfill, which is due to start operation at the beginning of 2009. Land acquisition for the New Guanabacoa landfill has been completed (18 ha) and the basic planning begun. The landfill will be planned to be an environmental-friendly landfill type installed with liner facilities, oxidation ponds and a leachate treatment system, the same as for New Site 1.

6) Barreras

Barreras landfill (10 ha), a municipal landfill, receives 50 tons/day of MSW. Currently, MSW and a part of the industrial waste are transported to this landfill.

This existing landfill will be used continuously because it still has sufficient capacity for use toward 2015.

7) Special period landfill (SPL)

A total of 10 SPLs, mostly small-scale (0.5 to 2.5 ha), were put in service as temporary landfills for use for a limited period until a large-scale landfill is constructed. The SPLs are located in the neighborhoods of collection areas with the aim of having a short transportation distance, but these SPLs are now causing environmental problems at each site due to their proximity to the town area.

Three SPLs were closed by the middle of March 2005, and six other SPLs are planned for closure by the end of 2008. Waste from source areas previously dumped at the nine SPLs will be disposed of at Calle 100 and New Guanabacoa after the closure of the SPLs. The closure of SPLs will be conducted in an environmental-friendly manner, similar to that used for Calle 100 and Guanabacoa, so that environmental problems can be avoided after the closure.

8) Campo Florido

The existing Campo Florido landfill (0.5 ha) is receiving MSW from its neighboring area and also MSW that was previously hauled to Guanabacoa. Since the capacity of this landfill is limited, there is a plan to expand the area (4.5 ha). After the extension, the landfill site will be utilized to receive the waste from the Guanabacoa area for one year until New Guanabacoa is put in operation in 2009. Afterwards, the Campo Florido landfill will be utilized only for the disposal of waste collected by H/C in the Campo Florido area (ref. Table 5.6.4 for the schedule for Guanabacoa and Campo Florido).

(2) Basic component of landfill system

1) Introduction of semi-aerobic landfill system

In order to minimize the negative environmental impact caused by landfill, it is proposed to introduce a semi-aerobic landfill system. The semi-aerobic landfill system is effective in reducing the potential environmental risks of landfill operations by accelerating the stabilization of dumped waste.

The semi-aerobic landfill will be provided with a leachate collection system and a verification system. A leachate recirculation pump will also be provided to transfer the leachate back to the landfill area for reduction of leachate volume and improvement of leachate quality.

2) Introduction of soil covering

Currently, soil covering is not carried out in the existing landfills, thereby causing environmental problems. It is proposed that soil covering be used in

the new landfills to control such problems as littering of waste, offensive odors, breeding of vermin, and spontaneous combustion of dumped waste.

3) Introduction of the section landfill concept

In the operation of new landfills, it is proposed to adopt waste disposal in segmented cells, each divided by soil embankments. The introduction of section landfill is expected to achieve advantages such as reduction of leachate volume and early stabilization of the landfill.

4) Concept of proposed landfill system

The following planning concept will be adopted for new landfills (excluding extension of Campo Florido):

- Disposal method: Waste disposal in segmented cells with soil covering
- Waste Disposed: MSW, non-hazardous industrial waste and incinerated residue of medical waste
- Main Facilities:
  - Waste retaining structure
  - Leachate collection system
  - Gas ventilation system
  - On-site road
  - Truck scales, vehicle washing facilities
  - Liner facilities
  - Leachate treatment system (e.g. aerator and recirculation pump)
  - Environmental monitoring facilities and equipment
- Post-Closure Management: Leachate collection/treatment and environmental monitoring should continue for as long as leachate is generated and the land level has not stabilized

5.6.5 Environmental Monitoring Plan

The Environmental monitoring mentioned below will be carried out by a specialized laboratory in Havana City on a contract basis. Waste Analysis Laboratory (LARE) of DPSC shall act as the organization responsible for the planning and evaluation of the environmental monitoring. In addition, LARE will also conduct the monitoring of basic items at the landfill. Therefore, some portable environmental monitoring equipment suitable for the purpose will be prepared by LARE in the future.

- Items of monitoring: Water quality (groundwater, surface water, and leachate), gas generation, odors, noise, etc.
- Locations of monitoring: As shown in table below.

Facility	Location
Dumping sites	New Ganabacoa Campo Florido New site 1 (exact location has not fixed) Ocho Vias Calle 100
Closed dumping sites	Calle 100, Guanabacoa, Special period landfill
Recycling Plant	New Guanabacoa, Calle 100
Composting Yards	New Guanabacoa, Calle 100

5.7 Recycling Plan

5.7.1 Planning Policy

(1) Introduction of 3Rs concept

Current difficulties in the MSWM of Havana City include the burden of solid waste collection due to insufficient equipment and fuel and the limited availability of final disposal sites. The reduction of waste is a good means of relieving the burden on equipment and extending the life span of existing landfills.

"Reduce, reuse, and recycle", termed the 3Rs, is a strategy well known to be effective for the improvement of MSWM. The 3Rs will be promoted in the MSWM of the City with the objectives of not only reducing the waste to be treated in MSWM but also recovering resource materials from MSW.

(2) Planning policy

Recycling will be promoted as one of the 3R activities with appropriate awareness-raising activities for the waste generators. The following are incorporated in the planning policy in promoting recycling in Havana City.

1) 3Rs will be introduced as a good means of supporting the MSWM system

It is recognized that recycling will produce income for MSWM on the premise that the recovered materials can be sold to the recycling market.

ERMP currently conducts the 3Rs activity, but mainly focusing on the industrial sector and not so much on the MSW source. There is potential for material recovery from MSW to which little attention has been paid.

2) Active participation of waste generators is required in order to achieve material recovery.

Once various waste types are mixed at generation sources, it becomes difficult to separate recyclable materials. The recyclable materials are easier to pick up in the upper stream of waste flow, i.e., generation sources.

3) Establishment of firm recycling market

Recovery of recyclable materials is worth conducting only if they are reused or utilized as raw material for re-production of commodities. As much as possible, the existing recycling market will be encouraged to absorb an increased quantity of recyclable resources.

5.7.2 Materials and Quantity to be Recycled

(1) Materials to be recovered from MSW

Materials in the recycling plan of this M/P are defined as the resources collectable from segregated MSW. Five kinds of material, as shown in Table 5.7.1, are classified as resources to be separated for reuse and recycling. The table also shows the ratio of recoverable quantity to the generated waste, which was revealed from the waste quantity survey conducted during the JICA Study in April and September-October 2004.

Table 5.7.1 Kind of Materials and Ratio of Recovery as Resources

Category	Kind of Materials To be Recovered	Ratio of Recovery as Recyclable Material
Glass	Drink bottles	90%
Aluminum	Drink cans	90%
Metals	Drink cans, food containers	90%
Plastic	Bottles	10%
Paper	Cardboard	20%

As stated before, recyclable materials will be collected in seven municipalities where segregated collection will be applied.

(2) Reuse and recycle quantity

Based on the physical composition of target materials in MSW shown in Table 5.3.2, and the estimated waste amount to be collected by the public services (ref. Table 5.6.1), the quantity of resource to be recovered for reuse and recycling is calculated by the equation below.

$Q_R = Q_W \times R_{PC} \times R_{DU} \times r$

Q_R (tons/day): Resource recovered from solid waste
Q_W (tons/day): Quantity of total waste collection
R_{PC} (%): Percent of subject material contained in waste generation (ref. Table 5.3.2)
R_{DU} (%): Ratio of recoverable quantity of each material (ref. Table 5.7.1)
r (%): Percent of subject material recovered during the recycling process

The estimated quantity of resource separated for reuse and recycling is shown in Table 5.7.2.

The quantity of recyclable materials was estimated from the proportion of recyclable resources contained in the MSW as determined from the waste quantity and composition survey conducted under the JICA Study in 2004.

With the introduction of segregated waste collection, recovery of the recyclable materials from household waste will be possible from 2010 onwards. In addition, another source of recyclables production is the existing local recycling system that has been operated by ERMP for a long time.

As shown in Table 5.7.2, the quantity of recyclable materials that will be recovered from SMW in 2015 is estimated to be 59 tons/day. An additional 30 tons/day of recyclable materials will be collected by ERMP. In total, the quantity of recyclable materials will be 89 tons/day in 2015.

Table 5.7.2 Estimated Quantity of Resource Recoverable for Reuse and Recycling

Unit: tons/day

Source of Waste		2005		2010		2015	
		Collected Waste	Recyclables Recovered	Collected Waste	Recyclables Recovered	Collected Waste	Recyclables Recovered
Households		1,517	NA	1,505	10	1,494	49
Commerce	Hotels & Restaurants	19	10	25	3	28	10
	Markets	60		60		60	
	Others	100		100		100	
Bulky waste and others		520	0	520	0	520	0
Material Recovery by DPSC			10		13		59
Material Recovery by ERMP			30		30		30
Total Collected Quantity		**2,216**		**2,210**		**2,202**	
Total Recovered Quantity			**40**		**43**		**89**
Recycling Rate in MSW			**1.8 %**		**1.9 %**		**4.0 %**

Note: "NA" means 'data not available'

*1 Collected waste is the total quantity collected through mixed and segregated waste collection.

*2 Recyclables recovered is the quantity recycled through the segregated waste collection and ordinary ERMP recycling system.

5.7.3 Recycling Plan

(1) Demand and supply of recycled materials

The current system of recycling in Cuba aims to utilize recyclable resources within the country. Only the surplus will be sold to the international market.

According to the statistics of ERMP of Havana City, all the recovered material has been utilized in local industries so far. This situation indicates that the demand for recycled materials in the domestic industrial sector exceeds the present supply.

(2) Resource segregation at generation source

Three categories of segregation are proposed as shown in Figure 5.7.1. Resource materials for recycling are recovered from the first category, "Recyclable Materials".

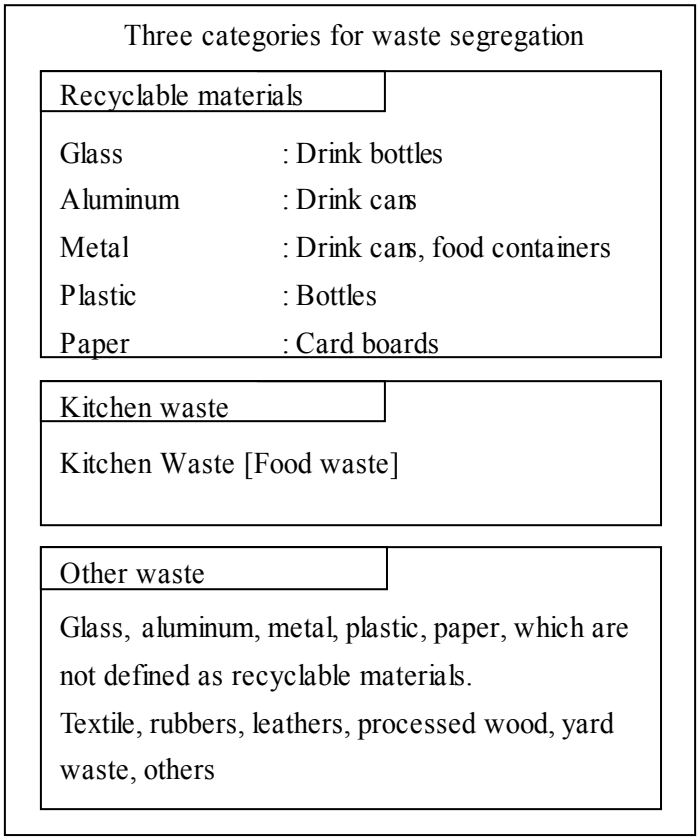


Figure 5.7.1 Waste Segregation Proposed for MSWM in Havana City

(3) Establishment of new recycling plants

1) Location of plant

The establishment of two new recycling plants, one located in Calle 100 and the other in New Guanabacoa, is proposed for the following reasons:

- The establishment of new plants will be in accordance with the introduction of segregated MSW collection because the resources will be recovered from the collected waste and transported by segregated collection. The segregated collection will be introduced in two phases, the 1st phase in 2010 and the 2nd phase in 2013.
- As the area of segregated collection will cover a wide area from east to west in the City, establishment of two plants will reduce the load on transportation.
- Recycling plant shall be located close to the landfill that can receive residue from the material recovery at the plant. As the landfills are located some distance from residential areas, the plant will not cause odor problems for the neighboring areas. In this regard, the New Guanabacoa landfill site is an ideal location for installing the recycling plant servicing the eastern part of the City.

- In the western part, New Site 1 landfill is the main landfill to be operated toward 2015. However, the location of New Site 1 is too far from the area of collecting the resources. On one hand, Calle 100, located on the western side of the City, has enough land area outside the currently operating landfill. This area will be available, even after closing the existing landfill. Even if the residue remaining after material recovery processing needs to be transported to the New Site 1 landfill, the quantity will be less than the case of hauling all the collected resource waste.

2) Required equipment for the recycling plant

Table 5.7.3 and Table 5.7.4 show the items of equipment to be installed in the new recycling plant.

Table 5.7.3 Necessary Equipment for the New Recycling Plant in Calle 100

Equipment	Qty		Usage	Remarks
	2010-2012	2013-2015		
Pressing Machine for Aluminum *1	1	1	Pressing for waste compaction	1.0 – 2.0 m^3
Pressing Machine for Metal	1	1		0.5 m^3
Pressing Machine for Cardboard	1	1		1.5 m^3
Pressing Machine for Plastic	1	1		1.5 m^3
Loaders	3	3	Transport of materials inside the Plant	
Trucks	2	4	Transport of resources	4 t
Belt Conveyor	Lot	Lot	Supply and delivery of separated materials	Y 2010: 26m Y 2013: 31m
Truck Scales*1	1	1		

Note: *1: Equipment currently used in existing recycling center

Table 5.7.4 Necessary Equipment for the New Recycling Plant in New Guanabacoa

Equipment	Qty	Usage	Remarks
	2013-2015		
Pressing Machine for Aluminum	1	Pressing for waste compaction	1.0 – 2.0 m^3
Pressing Machine for Metal	1		0.5 m^3
Pressing Machine for Cardboard	1		1.5 m^3
Pressing Machine for Plastic	1		1.5 m^3
Loaders	3	Transport of material inside the Plant	
Trucks	3	Transport of resources	4 t
Belt Conveyor	Lot	Supply and Delivery of separated materials	31m
Truck Scales*1	1		

Note: *1: Common use of equipment installed for New Guanabacoa landfill

3) Plant installation schedule

Plant will be installed to the following schedule:

Table 5.7.5 Installation Schedule of Recycling Plants

Unit: Plant capacity in tons/day

Description	2005	2010	2013
Existing recycling center at Calle 100	10	-	-
Calle 100	-	47	47
New Guanacacoa	-	-	37
Total plant capacity	10	47	84

4) Managing organization and required number of staff

Currently, the unit for recycling and final disposal in the UPPH of DPSC has responsibility for material recovery. This unit will take over the management and operation of new recycling plants. The necessary number of staff for operation of the new recycling plants is shown in Table 5.7.6.

Table 5.7.6 Number of Staff for Operation of Recycling Plants

Responsibility	Plant in Calle100		Plant in New Guanabacoa
	2010-2012	2013-2015	2010-2015
Management	1	1	1
Administration	3	3	3
Drivers for Trucks	6	12	9
Operators for Loaders	9	9	9
Equipment Operators	36	36	36
Workers for Material Recovery	54	82	64
Others	5	10	10
Total	114	153	132

(4) Awareness-raising and environmental education program

Community participation is vital, not only in the promotion of recycling activities, but also for successful waste management. Proper segregation of recyclable materials is a primary requirement for recycling, especially at the household level. In order to attain successful segregation of resource materials, the cooperation of the residents is paramount.

The proposed program for awareness-raising and education of the residents is described in Section 5.12.

5.7.4 Implementation Schedule and Cost Estimate

(1) Implementation schedule

Figure 5.7.2 shows the schedule of implementation of recycling activities and

associated segregated collection of waste. Awareness-raising and education programs will start one year ahead of the introduction of segregated collection. The schedule assumes that the Government would authorize the DPSC to sell the recovered materials directly to the recycling market.

Measures	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Resource Segrigation at Generaton Source											
Preparation for Introduction of Segregation											
Segregated Collection (1st phase): 2 munisipalities											
Segregated Collection (2nd phase): 7 municipalities											
Operation of Recycling Plant											
New Recycling Plant: Calle 100											
New Recycling Plant: New Guanabacoa											
Campaign of Awareness Raising and Education											
Resource Selling by DPSC to Free Market											

Figure 5.7.2 Schedule of Recycling Activities

(2) Cost estimate

Table 5.7.7 shows the estimated cost of the implementation of the recycling plan covering both the construction and O/M works. The total cost over ten years amounts to US$4.3 million and CUP18.1 million, respectively.

Table 5.7.7 Cost Estimate of Recycling Plant

CUP/US$ thousand, constant prices

Items	Category	Unit	2006-2010	2011-2015	Total
Recycling Plant (Calle 100)	Capital Cost	US$	2,313	0	2,313
		CUP	2,243	0	2,243
	O/M Cost	US$	28	140	168
		CUP	1,630	8,150	9,780
Recycling Plant (New Guanabacoa)	Capital Cost	US$	0	1,690	1,690
		CUP	0	1,669	1,669
	O/M Cost	US$	0	84	84
		CUP	0	4,422	4,422
Total		US$	2,341	1,914	4,255
		CUP	3,873	14,241	18,114

Note: The capital cost does not include engineering cost, physical contingency and administration cost.

5.8 Composting

5.8.1 Planning Policy

In addition to the plan for recycling, composting will also be promoted as a component of the 3Rs activities; composting reduces the quantity of waste disposal and recycles organic materials. The planning policy for composting will incorporate the following:

- Establishment of sustainable composting methods
- Secure a firm market for compost product
- Provision of an appropriate public awareness program

5.8.2 Compost Production Quantity

(1) Type of composting

The production of compost will be promoted in two ways. One is home composting, which is to be practiced in each household in semi-urban areas. The other is the compost processing performed in the centralized composting yards which utilize kitchen waste collected from the municipalities.

(2) Materials for composting

It is planned to use kitchen waste as the material for composting so as to exclude other waste containing potential hazardous substances. Waste generated in markets (agricultural markets) is categorized as kitchen waste. Other organic materials such as textiles and branches of trees should not be included because of the difficulty of decomposition.

(3) Application of home composting

Home composting, the composting practiced by people in households, is planned in semi-urban areas of the City. The municipalities having agricultural areas of more than 25 % of their total area are defined as semi-urban areas. Most households in semi-urban areas seem to own space for home composting and also have access to a farming area that consumes the compost produced.

Considering that this is the first experience of home composting for most of the people and that some of households will not be willing to introduce home composting, it is planned to introduce it gradually with the expansion rates as shown in Table 5.8.1.

Table 5.8.1 Plan of Introduction of Home Composting

	2005	2010	2015
Ratio of introduction of home composting in semi-urban areas	0%	7.5%	15%

Note: The figures show the ratio of number of households to which home composting will be introduced compared with total households.

(4) Operation of composting yard

Composting in centralized yards is planned for kitchen waste generated from urban households, hotels, restaurants and markets. The waste will be collected from seven municipalities where segregated collection will be introduced. The outline of segregated collection is described in Section 5.9.

(5) Quantity of compost production

The quantity of home compost produced is calculated by the following equation:

$$Q_{CP1} = Q_W \times R_{PC} \times R_T \times (1 - r_L)$$

Where, Q_{CP1} (tons/day) : Compost production by home composting
Q_W (tons/day) : Quantity of domestic waste generation in semi-urban area
R_{PC} (%) : Ratio of kitchen waste to total domestic waste
R_T (%) : Planned ratio of number of households to which home composting is introduced (ref. Table 5.8.1)
r_L (%) : Loss in processing in forms of gas and humidity

The quantity of compost produced in composting yards is calculated by the following equation:

$$Q_{CP2} = Q_{W\,ij} \times R_{PC} \times (1 - r_R - r_L)$$

Where, Q_{CP2} (tons/day) : Compost production in community composting yards
Q_W (tons/day) : Amount of waste collected by segregated collection
R_{PC} (%) : Ratio of kitchen waste in MSW
r_R (%) : Ratio of residue generated in processing
r_L (%) : Loss in processing in forms of gas and humidity

The quantities of compost produced are summarized in Table 5.8.2. The total quantity of compost production in 2015 is estimated as 130 tons/day.

Compost production in 2005 shows the quantity of compost produced by the existing system without segregated collection as mentioned in Sub-section 3.4.1.

Table 5.8.2 Quantity of Compost Production

Unit: tons/day

Type of Composting	Waste Source	2005		2010		2015	
		Collected Kitchen Waste	Compost Production	Collected Kitchen Waste	Compost Production	Collected Kitchen Waste	Compost Production
Community Composting	Municipalities covered by segregated collection	0	3	150	45	359	108
Home Composting	Households in semi-urban areas	-	0	-	11	-	22
Total		-	3	-	56	-	130

5.8.3 Composting plan

(1) Demand and supply of compost products

1) Present use of product

Regarding the present production of compost at the existing UPPH plant, both the quantity and quality are not reliable because of inadequate facilities and the mixed collection of waste. The produced compost cannot be sold to the market due to the low quality, and it is used for soil coverage or base soil for vegetation at the landfill site.

On the other hand, humus produced from animal manure, vermin compost, is regarded as satisfying the quality required for agriculture. As a result, humus is sold for agricultural use though the quantity is small.

2) Demand for compost

The Government has a policy of minimizing the use of chemical fertilizer and is encouraging the use of organic materials as a substitute.

According to MINAGRI, potential demand for organic materials as soil conditioner for farmland is estimated as 529,000 tons/year. The area of farmland requiring organic materials is currently 10,560 ha in Havana City.

On the other hand, the estimated supply of compost will be 130 tons/day or 47,000 ton/year in 2015 as stated above. This rate of compost production is only a fraction of market demand, and hence deemed to have sufficient marketability provided that the quality of the product meets the market demand.

(2) Plan for composting yards

1) Capacity for receiving waste

Community composting yards shall have the capacity to receive all the kitchen waste generated from households and markets in the proposed segregated collection area. The receiving capacity was estimated so as not be less than the maximum daily quantity of kitchen waste collection in 2015. The required capacity of the two yards is shown in Table 5.8.3.

Table 5.8.3 Waste Receiving Capacity of Proposed Composting Yard (2015)

	Receiving Capacity (tons/day)
Composting Yard in New Guanabacoa	159
Composting Yard in Calle100	200
Total	359

2) Location of composting yards

It is proposed to establish two composting yards, one located at Calle 100 landfill and the other at the New Guanabacoa landfill. The reason for selecting these sites is just the same as described for the selection of recycling plant sites (ref. Subsection 5.7.3).

3) Plan of composting yard

The simplest procedure for composting will be applied, consisting of receiving, crushing, fermentation, maturing, and sieving. Table 5.8.4 shows the plan for establishing the composting yards in New Guanabacoa and Calle 100.

The kitchen waste brought in as raw material for composting will be crushed and passed through the first screening. Leaf mold or yard trimming is added to the screened organic materials as a moisture conditioner. Then, it is fermented for 3 to 4 weeks and matured for 2 to 3 weeks.

Table 5.8.4 Plan of the Composting Yard

Site	New Guanabacoa Yard	Calle100 Yard
Establishment and Operation Start	Y 2010	Y 2013
Required Equipment	Grinder machine, screening machine (4 inch), screening machine (2 inch), screening machine (3/8 inch), dump truck, loader	
Processing Capacity (tons/day)	159 tons/day	200 tons/day
Estimated Production (tons/day)	47 tons/day	60 tons/day

4) Managing organization and required number of staff

The UPPH of DPSC has a unit responsible for management and operation of landfills including existing composting yards. This unit will be assigned as the unit responsible for the operation of new composting yards to be established. The numbers of staff needed for the operation of new composting yards have been estimated as shown in Table 5.8.5.

Table 5.8.5 Number of Staff for Operation of Composting Yards

Responsibility	New Guanabacoa Yard	Calle100 Yard
	2010-2015	2013-2015
Management/ Administration	1	1
Drivers for Trucks	9	9
Operators for Loaders	9	9
Equipment Operators	12	12
Others	8	13
Total	39	44

(3) Plan for home composting

Home composting utilizes a molded compost bin or bin assembled from plastic materials, wood, steel wire mesh or cartons. Those bins will be manufactured in Cuba using imported plastic resin or steel, or other materials that are available in the country. DPSC will supply this essential equipment to the households that would be willing to introduce home composting.

An essential component for successful implementation of home composting is that the households actively exercise daily care and adhere to the process for home composting. For this purpose, DPSC shall provide the households with instructions regarding the proper method of composting, the use of compost bins and other tools, and the benefits from composting. This awareness-raising and education activity shall be carried out on a continuous basis. The awareness-raising program shall be accompanied by a technical guidance and support system regarding home composting method and technology. This technical guidance system will be established by DPSC.

Campaigns for promoting home composting shall also be held periodically, selecting strategic areas in each municipality. Trained DPSC staff will visit the target community and demonstrate the production of compost.

Table 5.8.6 Plan for Home Composting

Applied Area	8 Municipalities in semi-urban areas of Havana City (Habana del Este, Guanabacoa , San Miguel del Padron, Marianao, La Lisa, Boyeros, Arroyo Naranjo, and Cotorro)
Necessary Equipment	Compost bins: (approx. 43,000 units in total toward 2015)
Method of Promotion	- Explanation to residents during distribution of compost bins - Campaign for home composting - Continuous provision of information regarding home composting through community based organizations such as CDR
Estimated Quantity of Home Compost	22 tons/day in whole city in 2015
Use of Compost	Soil conditioner for gardens and farms in residences or neighborhoods.

5.8.4 Implementation Schedule and Cost Estimate

(1) Implementation schedule

The following schedule is proposed for implementation of the composting plan.

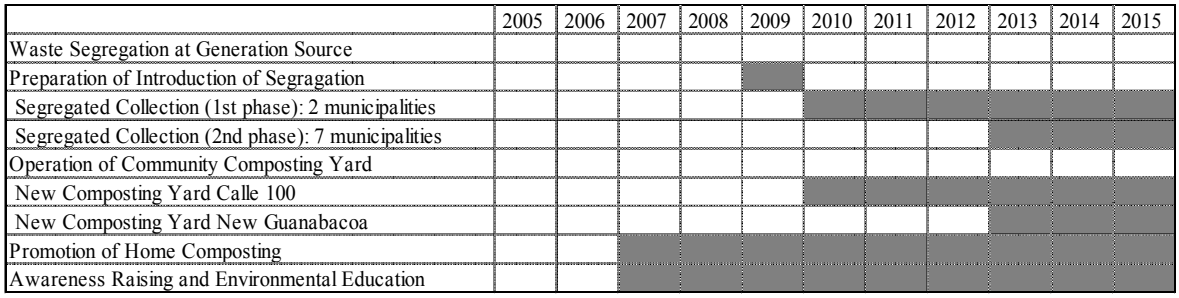


Figure 5.8.1 Schedule of Community and Home Composting

(2) Cost estimate

The cost of the composting plan has been estimated as shown in Table 5.8.7. The total cost in ten years (2006-2015) is estimated to be US$5.1 million and CUP10.4 million.

Table 5.8.7 Cost Estimate for the Composting Plan

CUP/US$ thousand, constant prices

Items	Category	Unit	2006-2010	2011-2015	Total
Composting (Calle 100)	Capital Cost	US$	0	2,140	2,140
		CUP	0	2,190	2,190
	O/M Cost	US$	0	105	105
		CUP	0	2,196	2,196
Composting (New Guanabacoa)	Capital Cost	US$	1,610	0	1,610
		CUP	1,834	0	1,834
	O/M Cost	US$	35	175	210
		CUP	693	3,465	4,158
Home Composting	Capital Cost	US$	440	550	990
		CUP	0	0	0
Total		US$	2,085	2,970	5,055
		CUP	2,527	7,851	10,378

Note: The capital cost does not include engineering cost, physical contingency and administration cost.

5.9 Collection and Transportation Plan

5.9.1 Planning Policy

Suitable collection service can help make life comfortable for citizens and keep the scenery of the city beautiful. Needless to say, this kind of service can improve public health and the regional environment.

The basic planning policies of the collection/transportation system are as follows:

- Achievement of full coverage of collection area for whole city
- Establishment of a sustainable collection/transportation system depending on the characteristics of the urban area and semi-urban area.
- Promotion of a segregated collection system to attempt the 3Rs
- Selection of a suitable type of waste bin in consideration of the use of domestic products
- Selection of suitable types of collection vehicle including the improvement of the present horse and cart collection system
- Improvement of the capability of the existing maintenance workshop

5.9.2 Basic Planning Conditions

(1) Review of present collection and transportation work

1) Study on the appropriate type of collection vehicle

The type of collection vehicles appropriate for use in Havana City was examined from the viewpoint of collection efficiency and cost performance of the vehicles.

Figure 5.9.1 shows a comparison of collection efficiency of six different types of collection vehicles according to the results of the time and motion survey conducted during the JICA Study in 2004.

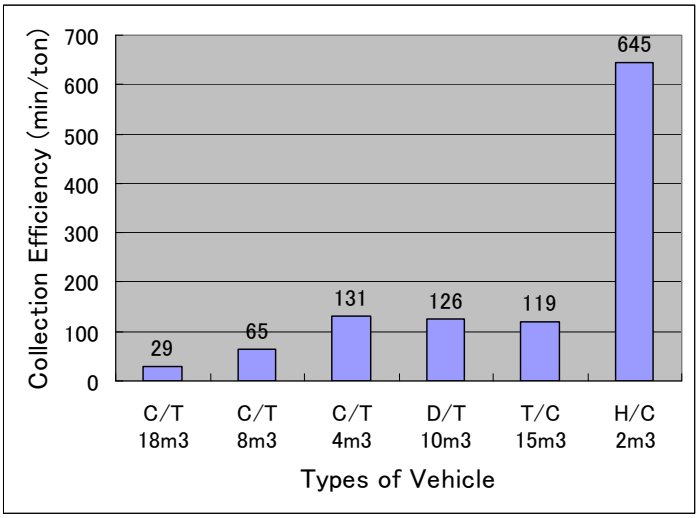


Figure 5.9.1 Collection efficiency based on Time and Motion Survey

Compactor trucks (C/T) with a capacity of 18 m^3 showed the highest performance and it took only 29 minutes for collecting and transporting one ton of waste during the survey. Horse driven cart (H/C) took 645 minutes because of their smaller carrying capacity and lower speed than other types of mechanical transportation equipment.

On the other hand, the unit operation cost, as Figure 5.9.2 shows, is only US$333 per year for H/C with capital cost and US$224 without capital cost (O/M cost only) under current operational conditions. The operation of 18m^3 C/T will cost more than US$2,000 per year without considering the capital cost. If the capital cost is considered, the annual cost is about US$35,000.

This operation cost is based on the salary of the driver and operator and annual maintenance cost, but does not include the fuel cost.

Actual operation cost for mechanized vehicles like C/T will increase more by the fuel cost.

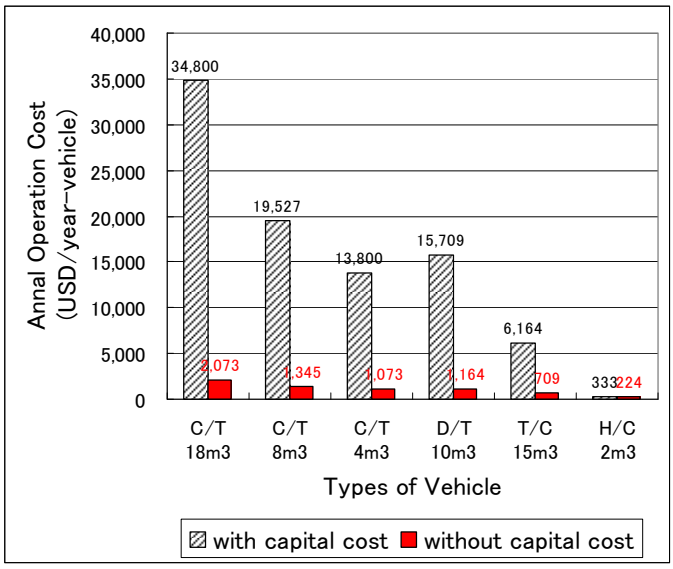


Figure 5.9.2 Estimated Unit Operation Cost per Vehicles

Another comparison was made, as shown in Table 5.9.1, to grasp the required number of other types of vehicles if they were to provide the same daily performance as 18 m^3 C/T. According to the time and motion survey, 18 m^3 C/T can, on average, carry 9.12 tons per trip, make 1.9 trips per day, and cover 125 km per day. This means the collection performance per day is to be 1,140 tons-km, while H/C can only make 2 tons-km per day. This gives 570 units of H/C will be needed to carry the same load as one 18 m^3 C/T.

Unit operating costs per transportation of 1ton-1km were also estimated as shown in Figure 5.9.3. The unit cost of H/C is much higher than that of other mechanical collection vehicles in both with and without considering the initial cost.

According to the DPSC, the fuel consumption rate of 18 m^3 C/T is about 3 km per liter. Considering this, an 18 m^3 C/T consumes about 42 liter in a 125 km-drive when loaded to 17.3 tons (9.12 x .9). If the fuel price is 1US$/liter, US$0.023 per ton-km will be added to the estimated unit operation cost, but it is still lower than H/C.

Considering those estimates, it was finally concluded that 18 m^3 C/Ts would be the appropriate type of collection vehicle for collection and transportation in urban areas.

Table 5.9.1 Comparison of Cost Performance for Vehicle and Collection Systems

Type of Vehicle	Collection System	Collection performance (ton-km/day)	Number of Vehicles Required
(1) 18m^3 C/T	Station collection	1,140	1.0
(2) 8m^3 C/T	Station collection	500	2.3
(3) 4 m^3 C/T	Door to door	250	4.6
(4) 10 m^3 D/T	Door to door	236	4.8
(5) 15 m^3 T/C	Door to door	209	5.5
(6) 2 m^3 H/C	Door to door	2	570

Note: (i) C/T: compactor truck; D/T: dump truck; T/C: tractor cart; H/C: horse and cart
(ii) Collection performance: the value is shown with the unit of ton-km based on the result of time and motion survey during the Study.
(iii) Number of vehicles required: Number of units if each vehicle will take the same performance per day of 18 m^3 C/T

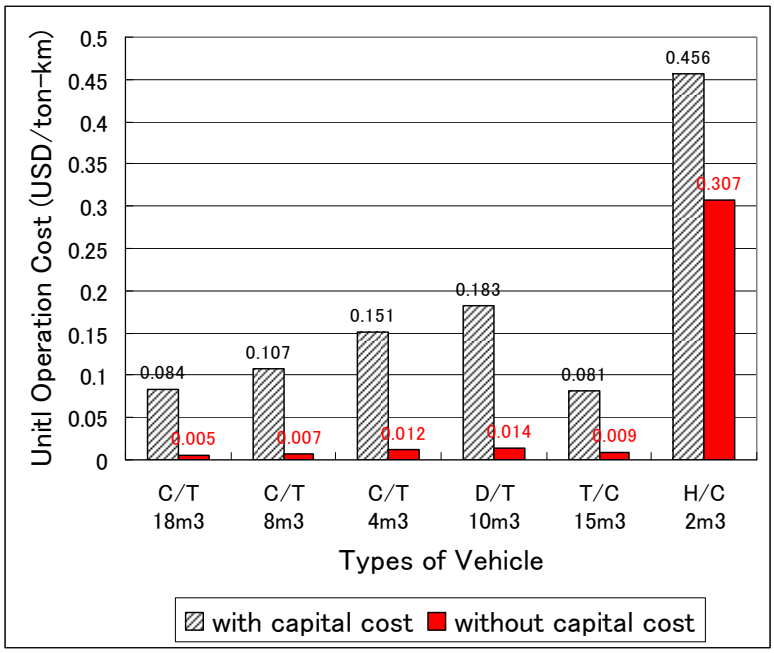


Figure 5.9.3 Estimated Unit Operation Cost per Performance

2) Working hours of collection vehicles

In order to secure adequate time for maintenance work, the average working hours of collection vehicles should be reduced to 8 hours per day from the current 9 hours by increasing the efficiency of collection work. The remaining one-hour is allotted to vehicle maintenance work.

The improvement in work efficiency could be pursued through: (i) improved vehicle performance from proper maintenance, (ii) improved bin conditions and alignments, and (iii) adequate planning of collection routes and intervals.

3) Use of steel waste bins

Two types of bins are considered: the HDPE bins currently in use and steel bins as an alternative. The cost effectiveness of the two types of bins is considered to be almost the same. The steel bins cost more at procurement, but have a longer service life, while vice versa in the case of HDPE bin.

Taking into account the following, steel bins will be used henceforward by gradually replacing the present HDPE bins:

- Steel bins can be manufactured in Cuba. While the material has to be imported, this still reduces the foreign currency requirement compared with HDPE. They can also be repaired locally.
- Use of steel bins, which are strong, would reduce the interruption of collection service due to the breaking of waste bins

(2) Projected MSW quantity

The quantity of MSW to be collected by the UPPH and the DMSC is projected to be 940 ton/day for the M/P planning period till 2015, being the same as the quantity in 2004. As previously mentioned, the rest of the waste generated in Havana City will be collected and hauled by other institutions such as industries and commercial enterprises.

The projected waste quantity for each municipality is shown in Table 5.9.2.

Table 5.9.2 Projected MSW quantity of each Municipality (2005-2015)

	Municipality	Operating Agency	Projected Waste Quantity (ton/day)
1	Playa	UPPH	149
2	Plaza de la Revolución	UPPH	121
3	Centro Havana	UPPH	74
4	Habana Vieja	UPPH	71
5	Regla	DMSC	26
6	Habana del Este	UPPH	51
7	Guanabacoa	DMSC	40
8	San Miguel del Padrón	DMSC	36
9	Diez de Octubre	UPPH	78
10	Cerro	UPPH	80
11	Marianao	DMSC	64
12	La Lisa	DMSC	48
13	Boyeros	DMSC	42
14	Arroyo Naranjo	DMSC	48
15	Cotorro	DMSC	14
-	Total	-	940

(3) Future transportation plan

Guanabacoa landfill and three special period landfills (SPLs) were closed in 2005.

According to CITMA's plans that existed during the JICA Study in 2005, the existing Calle 100 (80 ha) would be closed in 2006. After that, the main landfills will be Calle 100 Extension landfill (24 ha) to be opened in 2007, New Guanabacoa landfill in 2007 and New Site 1 to be opened in 2011, respectively.

However, when the M/P was finalized for the F/R in March 2007, these future planning conditions for the M/P were changed with the assumption that no investment for the construction of New Guanabacoa landfill and Calle 100 Expansion landfill or for the closure of the existing landfills would be made in 2006 and 2007. This means the existing landfills will be used until 2009 when the new landfill sites will be constructed.

Table 5.9.3 shows landfills that will receive waste generated in each municipality during the M/P period. Tables 5.9.4 and 5.9.5 show the quantities of MSW transportation to landfill sites in 2010 and in 2015, respectively. Figures 5.9.4 and 5.9.5 show the MSW transportation plans in 2010 and 2015, respectively.

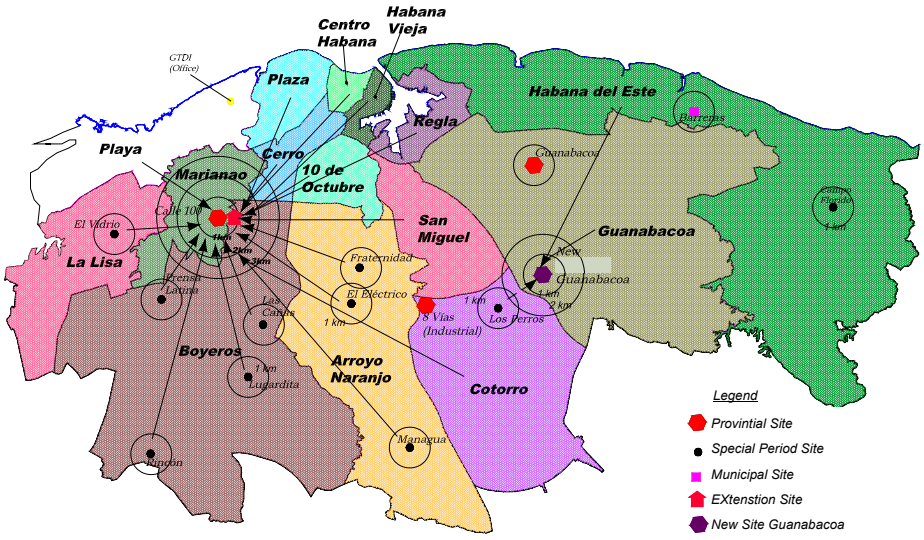


Figure 5.9.4 New MSW Transportation Routes in 2010

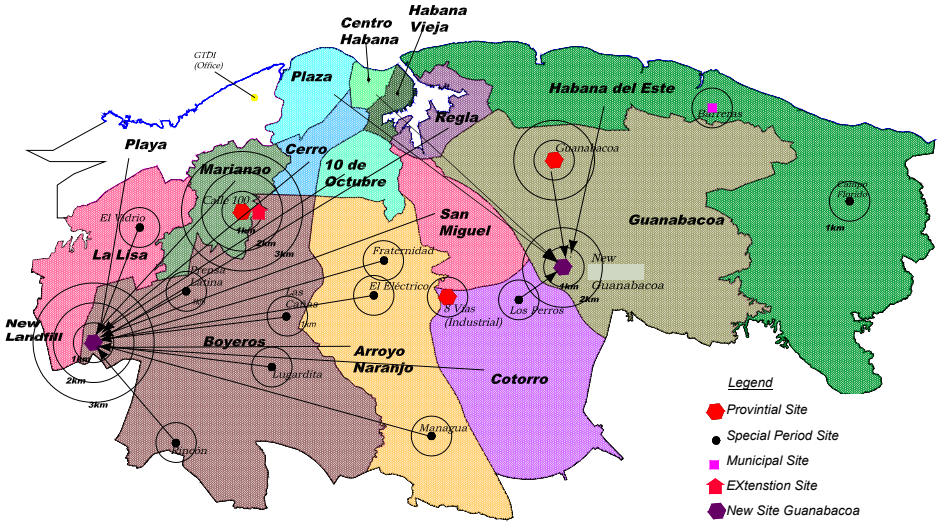


Figure 5.9.5 New MSW Transportation Routes in 2015

Table 5.9.3 Landfills Used for Disposal of MSW Generated in Each Municipality

(In the Case of Mixed Waste Collection)

	Municipality	2006-2008	2009	2010	2011-2012	2013-2015
1	Playa	Calle 100	Calle 100 Ex	Calle 100 Ex	New site1	New site1
2	Plaza de la Revolución	Calle 100	Calle 100 Ex	Calle 100 Ex	New site1	New site1
3	Centro Habana	Calle 100	Calle 100 Ex	Calle 100 Ex	New site1	New site1
4	Habana Vieja	Calle 100	Calle 100 Ex	Calle 100 Ex	New site1	New site1
5	Regla	Calle 100	Calle 100 Ex	Calle 100 Ex	New site1	New site1
6	Habana del Este	Ocho Vias	New G.	New G.	New G.	New G.
7	Guanabacoa	Ocho Vias	New G.	New G.	New G.	New G.
8	San Miguel del Padrón	Calle 100	Calle 100 Ex	Calle 100 Ex.	New site1	New site1
9	Diez de Octubre	Calle 100	Calle 100 Ex	Calle 100 Ex	New site1	New site1
10	Cerro	Calle 100	Calle 100 Ex	Calle 100 Ex	New site1	New site1
11	Marianao	Calle 100	Calle 100 Ex	Calle 100 Ex	New site1	New site1
12	La Lisa	Calle 100	Calle 100 Ex	Calle 100 Ex	New site1	New site1
13	Boyeros	Calle 100	Calle 100 Ex	Calle 100 Ex	New site1	New site1
14	Arroyo Naranjo	Calle 100	Calle 100 Ex	Calle 100 Ex	New site1	New site1
15	Cotorro	Calle 100	Calle 100	Calle 100	New site1	New site1

Note: New G.: New Guanabacoa, Calle 100 Ex: Calle 100 Extension.

Table 5.9.4 Quantity of MSW Transportation by UPPH and DMSC to Landfill Site in 2010

Unit: ton/day

Landfill (Type of Vehicles)	UPPH	DMSC			Total
	C/T	D/T	T/C	C/T	
Calle 100 Extension	593	30	54	52	729
New Guanabacoa	110	51	27	24	212
C. Florido	0	0	0	1	1
Total	703	81	81	75	940

Note: C/T: Compactor truck, D/T: Dump truck, T/C: Tractor-driven cart.
The C/T for DMSC is newly introduced in place of horse-driven carts (H/C)

Table 5.9.5 Quantity of MSW Transportation by UPPH and DMSC to Landfill Site in 2015

Unit: ton/day

Landfill (Type of Vehicle)	UPPH	DMSC			Total
	C/T	D/T	T/C	C/T	
New Guanabacoa	110	51	27	24	212
New Site 1	593	30	54	52	729
C. Florido	0	0	0	1	1
Total	703	81	81	75	940

Note: C/T: Compactor truck, D/T: Dump truck, T/C: Tractor-driven cart.
The C/T for DMSC is newly introduced in place of horse-driven carts (H/C)

5.9.3 Introduction of Segregated Collection System in UPPH Service Area

(1) Target areas and segregated waste quantity

As stated before, segregated collection of waste will be introduced in seven urban municipalities, two starting in 2010 and the other five in 2013. Community composting yards and recycling plants will be installed at Calle 100 and New Guanabacoa landfill sites.

Segregated waste collected in seven municipalities will be transported to either Calle 100 or New Guanabacoa landfill site as shown in Table 5.9.6. The quantity of segregated waste transported from each municipality is shown in Table 5.9.7.

Figures 5.9.6 and 5.9.7 show the transportation plans for segregated waste in 2010-2012 and in 2013 onward, respectively.

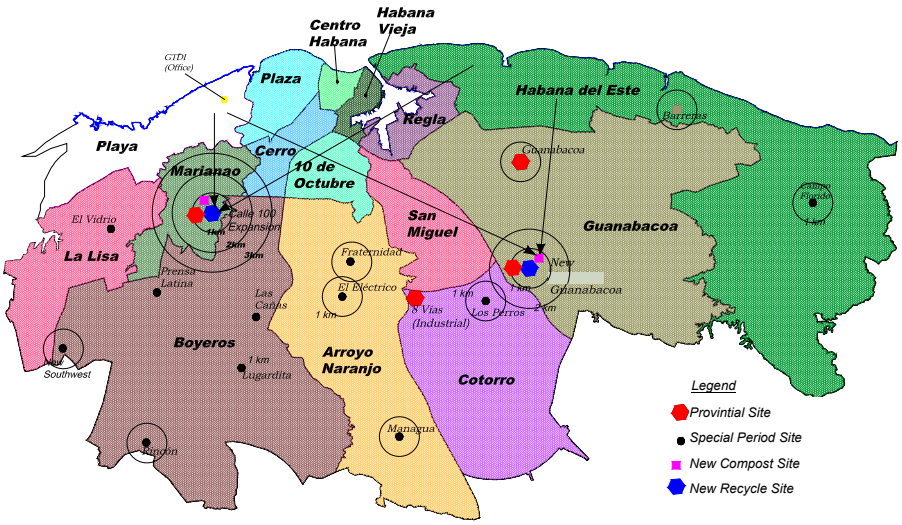


Figure 5.9.6 Transportation Routes for Segregated Waste in 2010-2012

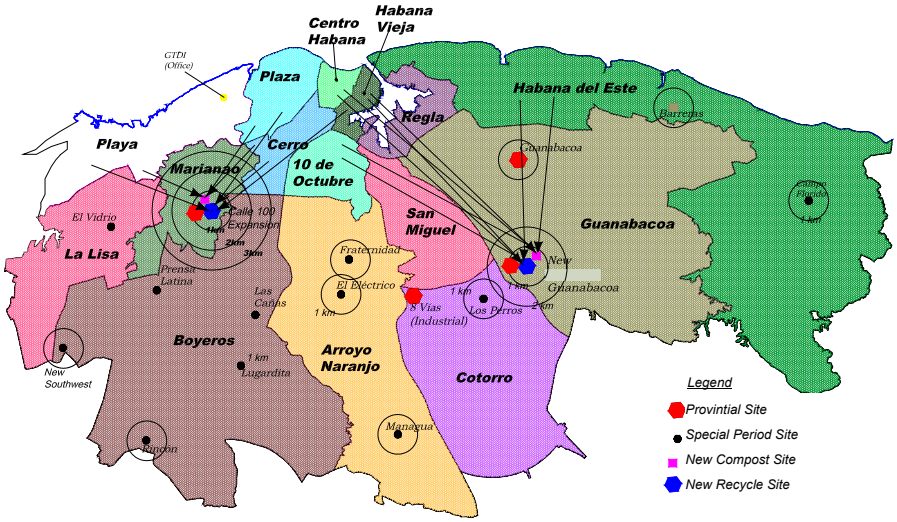


Figure 5.9.7 Transportation System for Segregated Waste in 2013

Table 5.9.6 Landfill Sites Receiving Waste from Segregated Collection Area (7 Municipalities)

No.	Municipality	Type of Waste	2006 - 2008	2009	2010	2011 -2012	2013-2015
1	Playa	KW	Calle 100	Calle 100 Ex	New G*	New G*	Calle 100*
		RM	Calle 100	Calle 100 Ex	Calle 100*	Calle 100*	Calle 100*
2	Plaza de la Revolucion	KW&RM	Calle 100	Calle 100 Ex	Calle 100 Ex	New site	Calle 100*
3	Centro Habana	KW&RM	Calle 100	Calle 100 Ex	Calle 100 Ex	New G	New G*
4	Habana Vieja	KW&RM	Calle 100	Calle 100 Ex	Calle 100 Ex	New G	New G*
5	Habana del Este	KW	Ocho vias	New G	New G*	New G*	New G*
		RM	Ocho vias	New G	Calle 100*	Calle 100*	New G*
6	Diez de Octubre	KW&RM	Calle 100	Calle 100 Ex	Calle 100 Ex	New G	New G*
7	Cerro	KW&RM	Calle 100	Calle 100 Ex	Calle 100 Ex	New site	Calle 100*

Note: New G: New Guanabacoa landfill, Calle 100 Ex: Calle 100 Extension
KW: Kitchen waste, RM: Recyclable material
* shows the transportation to composting yard or recycling plant with segregated collection. Others without * show the transportation of mixed waste to landfill.

Table 5.9.7 Quantity of Segregated Waste from Segregated Collection Area

Unit: ton/day

Municipality	Waste Type	2010	2011	2012	2013	2014	2015
Playa	Resource	20	20	20	20	20	20
	Kitchen	66	66	66	66	66	66
	Others	63	63	63	63	63	63
	Total	149	149	149	149	149	149
Plaza de la Revolución	Resource	0	0	0	17	17	17
	Kitchen	0	0	0	58	58	58
	Others	0	0	0	46	46	46
	Total	0	0	0	121	121	121
Centro Habana	Resource	0	0	0	10	10	10
	Kitchen	0	0	0	37	37	37
	Others	0	0	0	27	27	27
	Total	0	0	0	74	74	74

Municipality	Waste Type	2010	2011	2012	2013	2014	2015
Habana Vieja	Resource	0	0	0	10	10	10
	Kitchen	0	0	0	34	34	34
	Others	0	0	0	27	27	27
	Total	0	0	0	71	71	71
Habana del Este	Resource	8	8	8	8	8	8
	Kitchen	24	24	24	24	24	24
	Others	19	19	19	19	19	19
	Total	51	51	51	51	51	51
Diez de Octubre	Resource	0	0	0	10	10	10
	Kitchen	0	0	0	40	40	40
	Others	0	0	0	28	28	28
	Total	0	0	0	78	78	78
Cerro	Resource	0	0	0	11	11	11
	Kitchen	0	0	0	40	40	40
	Others	0	0	0	29	29	29
	Total	0	0	0	80	80	80
Total	Resource	28	28	28	86	86	86
	Kitchen	90	90	90	299	299	299
	Others	82	82	82	239	239	239
	Total	200	200	200	624	624	624

(2) Transportation of the remaining waste after sorting recyclable material

Residue yielded from composting yards and recycling plants at Calle 100 Extension and New Guanabacoa will be disposed of in each landfill located nearby. After closure of Calle 100 Extension landfill in 2010, the residue from Calle 100 composting yard and recycling plant will be transported to New Site 1 landfill. The transportation plan for residue in 2010 and for after 2015 is shown in Figure 5.9.8 and Figure 5.9.9 respectively.

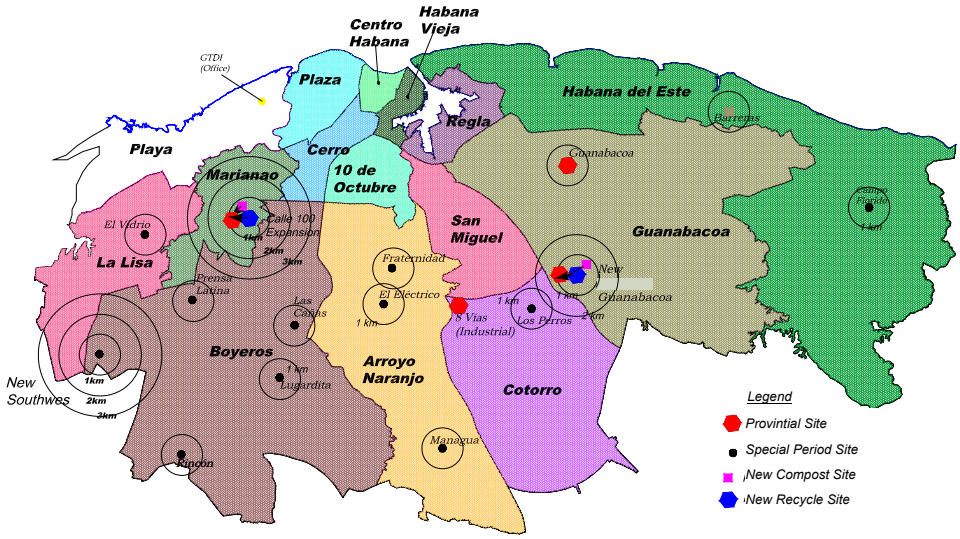


Figure 5.9.8 Transportation System for Remaining Waste in 2010

Note: Remaining waste is disposed of in the respective landfills at Calle 100 and New Guwanabacoa

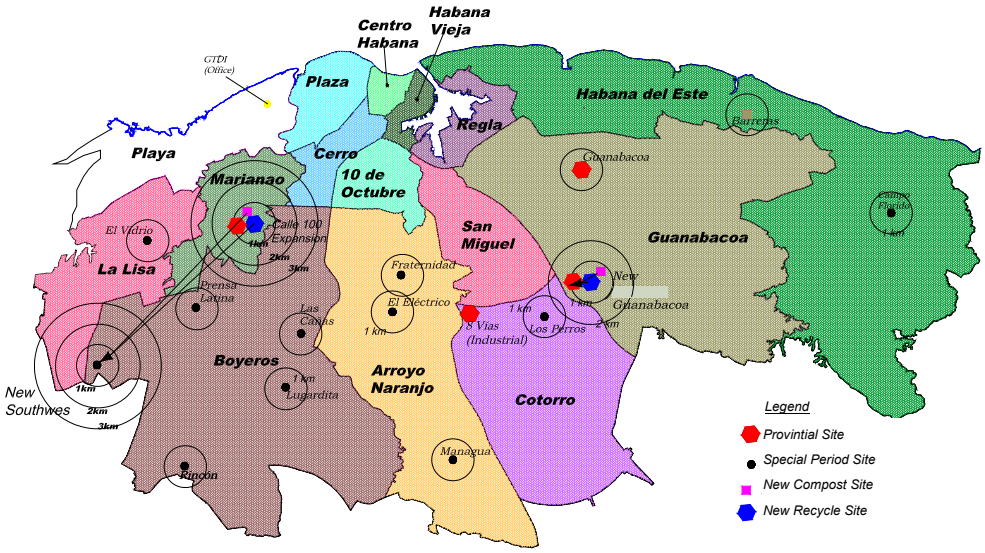


Figure 5.9.9 Transportation System for Remaining Waste in 2015

(3) Conditions of segregated collection

The outline of waste segregation and its collection system are as follows:

- The plan will start in two municipalities (Playa and Habana del Este) in 2010 and in five more municipalities (Plaza, Centro Habana, Habana Vieja, Diez de Octubre and Cerro) in 2013.
- MSW will be segregated into three categories, namely, kitchen waste, recyclable materials and other waste.
- The frequency of segregated waste collection is to be as follows: Kitchen waste 7 days/week, recyclable materials 2 days/week and other waste 5 days/week. The reason for collection 7 days/week is to reduce the number of collection vehicles. On the basis that the ratio of other waste to resource waste is about 2:5, the collection frequency of both waste types was decided.
- The daily maximum waste quantity is calculated on the basis of one day of kitchen waste and two days of other waste in consideration of the collection schedule of both waste types.
- Loading capacity of collection vehicles: 18 m^3 or 7.4 tons (the same as assumed for mixed collection, ref. Supporting Report B2 of the Final Report of the JICA Study)
- Traveling speed of collection vehicles: 55 km/hr (as above)
- Working hours: 8 hours (as above).

(4) Required numbers of vehicles

Segregated collection will require more vehicles than mixed collection. The required number of vehicles will increase in 2010 and 2013, when segregated collection is introduced, as shown in Table 5.9.8.

Table 5.9.8 Required Number of C/Ts

Municipalities	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Playa	13	13	13	13	23	23	23	23	23	23
Plaza de la Rev.	7	7	7	7	7	7	7	13	13	13
Centro Habana	5	5	5	5	5	5	5	9	9	9
Habana Vieja	4	4	4	4	4	4	4	8	8	8
Habana del Este	3	3	3	3	7	7	7	6	6	6
Diez de Octubre	5	5	5	5	5	5	5	8	8	8
Cerro	5	5	5	5	5	5	5	9	9	9
Marianao	2	2	2	2	2	2	2	2	2	2
La Lisa	2	2	2	2	2	2	2	2	2	2
Boyeros	2	2	2	2	2	2	2	2	2	2
Arroyo Naranjo	2	2	2	2	2	2	2	2	2	2
Total No.	50	50	50	50	64	64	64	84	84	84
Total Required No.	59	59	59	59	76	76	76	99	99	99
Existing No. UPPH	**39**	**36**	**34**	**32**	**31**	**24**	**24**	**24**	**24**	**24**
To be purchased in 2006	**0**	0	0	0	0	0	0	0	0	0
To be purchased in 2007	-	**0**	0	0	0	0	0	0	0	0
To be purchased in 2008	-	-	**25**	25	25	25	25	25	25	25
To be purchased in 2009	-	-	-	**2**	2	2	2	2	2	2
To be purchased in 2010	-	-	-	-	**18**	**18**	**18**	**18**	**18**	**18**
To be purchased in 2011	-	-	-	-	-	**7**	7	7	7	7
To be purchased in 2012							**0**	0	0	0
To be purchased in 2013								**23**	**23**	**23**
Purchase Plan	**20**	**3**	**2**	**2**	**19**	**7**	**0**	**23**	**0**	**0**
Deficit	**-20**	**-23**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

Note: (1) Total Required No. includes standby vehicles in consideration of vehicles under repair and maintenance.

(2) The above table includes 18 m^3 C/T units for 4 semi-urban municipalities where use of C/Ts is planned.

(5) Required number of waste bins

The required number of waste bins in the UPPH's service areas for segregated collection has been calculated as shown in Table 5.9.9. In segregated areas, a minimum number of three waste bins will be placed at each site, one for each different segregation category. Total required number of waste bins in 2015 is 32,522, which is 20,802 more than for the case of mixed collection. A total of 10,480 bins and 17,650 bins will be procured during the period of 2010-2012 and 2013 - 2015, respectively.

Table 5.9.9 Number of Waste Bins Required for Segregated Collection

Description	2008-2009	2010-2012	2013-2015
Required Number of Bins (Units)	4,688	14,872	32,522
Number of Bins to be Procured (Units)	4,688	10,184	17,650

Note: All existing HDPE bins will be replaced by steel bins toward 2015. The durable life of steel bins is assumed to be 10 years, and hence no replacement is required during the M/P period.

(6) Cost of segregated collection by UPPH

The total cost of the segregated waste collection system to be established by UPPH is summarized in Table 5.9.10.

Table 5.9.10 Cost of Segregated Collection by UPPH

Items/Year		2006-2010	2011-2015	Total
Procurement Cost of Vehicles (US$)		5,850,000	3,900,000	9,750,000
Maintenance Cost of Vehicles (US$)		1,261,000	2,918,500	4,179,500
Operation Cost (CUP)		7,228,440	16,729,740	23,958,180
Sub-total	(US$)	7,111,000	6,818,500	13,929,500
	(CUP)	7,228,440	16,729,740	23,958,180
Procurement Cost of Bins (US$)		3,257,280	5,198,440	8,455,720
Maintenance Cost of Bins (US$)		162,864	259,922	422,786
Sub Total		3,420,144	5,458,362	8,878,506
Grand Total	(US$)	10,531,144	12,256,862	22,788,006
	(CUP)	7,228,440	16,729,740	23,958,180

Note: (1) For simplification, all costs of procurement and maintenance were estimated in US$ assuming that the major components of the cost are equipment and spare parts.
(2) Waste bins will be manufactured locally, but the raw material is to be imported from abroad. Cost was estimated in US$ assuming that the major component is the cost for material.

5.9.4 Improvement of Collection and Transportation System in Suburban Area (DMSC Service Area)

(1) Present horse-cart collection area

Horse-driven cart (H/C) is currently used for waste collection in the rural part of semi-urban municipalities. At present, six DMSC offices are managing the operation in the rural areas. H/Cs collect 0.06 tons/hr/unit of waste and the moving speed is about 1.5 to 2.0 km/hr. The collected waste is transported to SPLs located near each collection area.

A change foreseen in this M/P for the H/C collection system is that all the SPLs will be closed by 2008. Afterward, MSW is to be transported to New Site 1, Calle 100 and New Guanabacoa landfills that are located at a remote distance. This suggests that the present H/C system might no longer be used for waste transportation from 2009 onward. DMSC is required to introduce a revised collection system in the area.

The following two options here examined for the revised collection system:

1) Option A: Use of special period landfills as transfer stations

Currently, there are seven steel containers (10 – 18 m^3) installed at the closed SPL areas. A conceivable plan would be to use such closed sites as transfer stations. It was assumed that at least three transfer stations will be needed. Waste collected by H/C would be stored in the containers at the closed site and transported to the final disposal sites (New Guanabacoa and New Site 1) by trucks. The trucks would be of an arm-roll type so that they could handle the waste containers filled with waste.

The cost of these simple type transfer stations is estimated at about US$140,800 based on the DMSC cost data. In addition, DMSC would need additional funding for land acquisition and transportation vehicles.

However, this option was finally discarded based on a cost comparison with Option B described below. The detail of the comparison is shown in Supporting Report B2 of the Final Report of the JICA Study Team.

2) Option B: Replacement of H/C system with C/T system

This option contemplates the introduction of a C/T collection system in place of the present H/C collection system. This system does not require maintenance of the SPL areas as transfer stations, so the land of the closed landfill sites can be used for other purposes.

The collection area is mostly of low population density, where the collection points are scattered over a wide area. In this area, waste collection efficiency per unit of collection vehicle is presumed to be relatively low at about 1 ton/hour/unit. Assuming that the collection duration is 4 hours/day, the collection capacity of the vehicles is 4-5 tons/day/unit. This suggests that an adequate type of vehicle to meet this workload would be a 12 m^3 C/T having a loading capacity of 5 ton.

However, considering the history of the traditional collection system with H/C, a H/C collection system with 1 ton/day/unit capacity will be kept in service in areas near the Campo Florido landfill at the request of local residents.

The required number of 12 m^3 C/Ts is estimated as 24 units as shown in Table 5.9.11. The vehicles shall be procured before the closure of the SPLs by the end of 2006.

Table 5.9.11 Required Number of Collection Vehicles for Replacement of the Present H/C Collection System

Year	2006-2010	2011-2015
Required No. of Units	24	
No. of Units to be Procured	24	0

Note: Type of vehicle: 12 m^3 C/T. No retirement of vehicles is scheduled during the M/P period toward 2015.

3) Comparison of two options

As a result of the cost comparison, Option B was adopted for the following reasons:

- The cost of Option B is less than that of Option A as shown in Table 5.9.12 below, though the difference is marginal
- Land at the three SPLs can be used for other purposes for the benefit of people around the SLP sites.
- Working conditions in Option B are more sanitary than Option A.

Table 5.9.12 Comparison of Options regarding Current Collection/Transportation by H/C

System	Option A	Option B
Collection and Transportation Method	H/C and 10 m^3 D/T (30 nos.) with provision of 3 transfer stations	12 m^3 C/T (24 nos.)
Initial Cost	US$2.52 million	US$2.60 million
O/M Cost to 2015	CUP10.14 million US$0.25 million	CUP5.20 million US$0.26 million

4) Schedule of replacement of H/C system

Notwithstanding the above comparison, it is assumed that the present H/C system would be continued for the time being, at least until in 2006 when the SPLs are closed, according to the presently envisaged schedule or preferably as long as possible at the SPLs where the environmental conditions are still tolerable.

The final decision of selection of Option A or Option B would be subject to the findings of the detailed environmental survey conducted henceforward. It may be that Option A could be adopted for some of the SPLs and Option B for others, varying by the actual environmental conditions of each SPL. In the areas not so far from the three main landfills (New Guanabacoa, Calle 100 and New Site 1), waste collection by H/C can be continued for a prolonged period if so determined.

In addition, the H/C system will remain in the Campo Florido area as for the present situation for inheritance of a short-distance collection option.

For the estimation of overall fund requirements, the M/P tentatively assumed that the collection system of Option B would be put into effect starting in 2007.

However, considering the difficulty of procurement of new vehicles, H/C can remain in the areas close to the designated landfills and be changed slowly one after another.

(2) Other suburban collection areas

In the suburban areas where the waste is presently being collected by T/C, there are two options. One is the introduction of a C/T system, and the other is the continuation of the existing system with T/Cs. The cost comparison shows that the cost of both systems is almost the same. This suggests that the continuation of use of T/Cs seems to have an advantage since the tractor-driven carts can be manufactured locally. Hence, the T/C collection system is adopted as the collection system for the suburban areas.

Since new site 1 landfill site will start its operation in 2011, required number of collection vehicles will increase due to longer transportation distance. The required number of vehicles and cost thereof are shown in Table 5.9.13.

Table 5.9.13 Required Number of Collection Vehicles in Other Suburban Areas

Year	2006-2010	2011-2015	Total
Required No. of Units	81	122	122
No. of Units to be Retired	0	0	0
No. of Units to be Procured	19	41	60
Total Cost (US$)	483,636	1,043,636	1,527,273

Note: Type of vehicle to be procured: 15 m^3 T/C, Number of existing vehicles: 62units

5.9.5 Maintenance of Vehicles and Equipment

(1) Concept of planning

Improvement of the maintenance capability will contribute to increasing the operational efficiency and life span of collection vehicles. The basic concepts of planning the machines and equipment for the maintenance workshop are as follows:

- Equipment preference shall be for the simplest model, manually or semi-automatically operated, to take advantage of easy maintenance.
- Major maintenance equipment shall be installed at the central workshop of UPPH because the central workshop is responsible for maintenance of all C/T vehicles.

- Small and portable types of machine tools and equipment for daily maintenance will be provided at DMSC workshops.
- Cleaning vehicles and environmental monitoring equipment will also be procured for cleaning the vehicles and monitoring the environmental conditions, particularly at landfill sites.
- Office equipment is also required so that the service agencies are able to store the accumulated basic data on solid waste.

(2) Machines and equipment to be procured

The first priority is the equipment and various tools for engine overhaul, and gas/electric welding machines for repair of the bodies of vehicles. The second priority is mechanical tools for general repairs and vehicles for bin washing.

1) Machine tools

The required machine tools are listed in Table 5.9.14. Machine tools such as lathes, radial drills and milling cutters should be supplied to the existing UPPH central workshop. Hand drills and grinders should be supplied to UPPH and 14 DMSC workshops.

2) Equipment

Overhaul equipment is the most important because most of the C/T vehicles, T/Cs and D/Ts are already aged. The required machine tools are listed in Table 5.9.15. The main equipment consists of tire repair equipment, jacks, air compressors and welding machines. The equipment will be supplied to UPPH and all of the DMSC workshops.

Table 5.9.14 List of Machine Tools

Unit: No. of units or sets

Type of Machine Tools		UPPH	DMSC
1-4	Lathes (2), Radial Drill, Precision Surface Grinding Machine	1	0
5	Bench Grinder	0	14
6-8	Milling cutter, Electric saw, Electric cutter	1	0
9-15	Bench drilling machine, Electric Drills (3), Electric Grinder, Disc Grinders (2)	1	14

Note: Above table lists machine tools required for repair and maintenance of collection vehicles.

Table 5.9.15 List of Equipment

Unit: No. of units or sets

Type of equipment		UPPH	DMSC
1-12	AC welding machine, Jack 20t and 10t, Engine arc welder, Engine generator, Oil changers (2), Grease pump, Battery charger, Battery tester, Tool kits, Car washer	1	14
13-18	Argon welding machine, Engine arc welder, Electric trolley chain block, Tire changer, Jack for transmissions	1	0
19	Air compressor	1	8
20	Tire changer	0	8
21-22	Tire repair kit, Impact wrench	2	14
23	Extension type jack, Impact wrench	2	0

Note: Above table lists machine tools required for repair and maintenance of collection vehicles.

3) Tools for repair and maintenance of vehicles

In addition, tools are necessary for repair and maintenance of vehicles. The required tools are listed in Table 5.9.16. The main tools consist of spanners, hammers, and wrenches. Various kinds of metal materials are also required. These tools and materials will be supplied to UPPH and all the DMSC workshops.

Table 5.9.16 List of Tools and Materials

Unit: No. of units or sets

Type of Tools and Materials		Specification	UPPH	DMSC
1	Hex Wrench	-	2	14
2	Spanner	-	2	14
3	Files	Flat/round/triangular file sets	2	14
4	Reamers	Straight/tapered reamer sets	2	14
5 -20	Bits, Screw drivers, Drills, Taps, Dies, Open end wrenches, Nippers, Adjustable wrenches, Bench vises, Sledgehammers, Hammers, Tool Boxes, Cord reels, Shovels, Grindstones, Hacksaws	-	2	14
21	Instruments	Gauges, tape measures, calipers, tachometers, compasses, 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	Others	Special tools	2	14

4) Cleaning equipment

Regular cleaning of waste bins is necessary to keep the bins clean, especially to control odors generated by residual waste in the bins. For this purpose, several types of equipment will be procured. The required cleaning equipment is listed in Table 5.9.17.

The mechanical cleaning vehicle has a water tank of 7,500 liters with high-pressure pumps and a storage tank for the washed waste. The bin-washing vehicle can wash about 100 to 200 bins per day.

Portable cleaning equipment for the collection vehicles is also required so as to keep collection vehicles clean.

Table 5.9.17 List of Mechanical Cleaning Equipment

Unit: No. of units or sets

Type of Equipment		Specification	UPPH	DMSC
1	Mechanical cleaning vehicle	Automatic bin washers with 7,500L water tank	3	0
2	Portable washer	Electric pumps	4	14
3	Bin washing vehicle	PVC containers, water sprays	4	0
4	Dump truck	4 ton	4	4
5	Hand cart	For mounting 2-160 liter bins, with wheels	1,500	0

5) Inspection and communication tools

Inspection of the collection stations and investigating illegal dumping are one of important tasks for the collection-service agencies. Motorcycles are useful for inspection and patrolling to check waste conditions in the City. Inspectors have to carry communications equipment to report problems to the office and take urgent countermeasures. The required equipment is listed in Table 5.9.18.

Table 5.9.18 List of Inspection and Communication Tools

Unit: No. of units or set

Type of Equipment		Specification	UPPH	DMSC
1	Motorcycle	50cc	4	15
2	Hand transceiver	Battery-type, Distance 2 to 5 km	10	14

6) Office and other equipment

Collection and accumulation of operation records is very important for the purpose of improving the management capability for collection and transportation. The items of equipment required are computers and printers as well as meters for collection vehicles that can record daily operation time and distance. The required items are listed in Table 5.9.19.

Table 5.9.19 List of Office & Other Equipment

Unit: No. of units or sets

Type of Equipment		Specification	UPPH	DMSC
1	Computer	Desk top type	2	15
2	Printer	With facsimile machine	2	15
3	Odometers and hour meters	24 hr. recording (mileage and time)	140	122

5.9.6 Staffing Plan

(1) UPPH

The improved collection system requires more staff than the existing system. Table 5.9.20 shows that the number of staff of the UPPH will be increased from the present 517 (2004) to 1,023 in 2015 under the segregated collection system.

Table 5.9.20 Staffing Plan for UPPH

Description		2004	2010		2015	
			Required No.	Balance	Required No.	Balance
Segregated Collection	Collection crew	277	380	103	560	283
	Engineers	40	52	12	56	16
	Tech. staff	130	195	65	210	80
	Workmen	45	91	46	98	53
	Bin cleaning staff	6	56	50	68	62
	Inspectors	18	27	9	29	11
	Data operators	1	2	1	2	1
	Total	517	803	286	1,023	506

(2) DMSC

In the case of the DMSC, the improvement in collection system will help reduce the number of required staff due mainly to the reduction of H/C work crews. Table 5.9.21 shows that the staff will be decreased by 602 in 2015. Although most of the H/C crew workers are only employed on temporary contract basis, DMSC will have to help them to find re-employment.

Table 5.9.21 Staffing Plan for DMSC

Description	2004	2010		2015	
		Required No.	Balance	Required No.	Balance
Collection crew	1,276	405	-871	610	-666
Engineers	44	25	-19	37	-7
Tech. staff	106	41	-65	61	-45
Workmen	40	41	1	61	21
Bin cleaning staff	0	0	0	0	0
Inspectors	165	162	-3	244	79
Data operators	0	15	15	15	15
Total	1,630	689	-941	1,028	-602

5.9.7 Implementation Schedule and Cost Estimate

(1) Implementation schedule

Major milestones in the process of improving the existing collection system are summarized as follows:

- Guanabacoa and three SPLs were closed in 2005, and according to the CITMA's plan, Calle 100 (80 ha) will also be closed in 2008. The main

landfills after 2009 will be Calle 100 Extension (24 ha) up to 2010, New Guanabacoa from 2009 onward, and New Site 1 from 2011 onward.

- Segregated collection systems for two municipalities (Playa and Habana del Este) will start in 2010, and five municipalities (Plaza, Centro Habana, Habana Vieja, Diez de Octubre and Cerro) in 2013.
- UPPH will use 18 m^3 C/T vehicles for the segregated waste collection service.
- Waste bins to be used for segregated collection are 770 liter steel bins. All existing HDPE bins will be gradually replaced with steel bins within 10 years.
- DMSC will introduce a new 12 m^3 C/T collection system in place of the H/C collection system in 2009.
- Waste collection in suburban areas will remain unchanged from the present system, i.e. collection by 15 m^3 T/C.
- Activities for the improvement of maintenance capability should start in 2006. The first priority is to supply equipment for engine overhaul and gas/electricity welding machines for repairing the bodies of vehicles, while the second priority is the supply of mechanical tools for repair/maintenance and bin washing vehicles.

The implementation schedule is shown in Figure 5.9.10.

Implemaintation Schedule		2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Segragation (1)	Playa, H.Del Este					Start					
Segragation (2)	Olaza, C. Havana, H,Vieja, Diez de Ocutubure, Cerro								Start		
18m^3 C/T	Vehicle Purchase Plan	0	0	25	2	19	7	0	23	0	0
12m^3 C/T	Vehicle Purchase Plan	0	0	24	0	0	0	0	0	0	0
15m^3 T/C	Vehicle Purchase Plan	0	0	19	0	41	0	0	0	0	0
770 litter Bin	Waste Bin Replace Plan	0	0	3,516	1,172	7,840	1,172	1,172	15,306	1,172	1,172
Workshop	Purchase Plan	non	non	Machine tools, Equipment	non	Others	non	non	non	non	non

Figure 5.9.10 Implementation Schedule for Waste Collection and Transportation

(2) Cost estimate

The total cost for improvement of the collection system is shown in Table 5.9.22. The disbursement of costs has been estimated according to the implementation schedule described in Figure 5.9.10.

Table 5.9.22 Total Cost for Improvement of Collection System

CUP/US$ 1,000, constant prices

Item	Category	Unit	2006-2010	2011-2015	Total
Collection vehicle	Capital Cost	US$	8,952	4,944	13,895
		CUP	0	0	0
	O/M Cost	US$	1,963	4,349	6,312
		CUP	17,015	39,971	56,986
Bins	Capital Cost	US$	3,257	5,198	8,455
		CUP	0	0	0
	O/M Cost	US$	163	260	423
		CUP	0	0	0
Cost of Workshops	Capital Cost	US$	757	2,592	3,349
		CUP	0	0	0
	O/M Cost	US$	114	837	951
		CUP	3,063	7,020	10,083
Total		US$	15,206	18,181	33,387
		CUP	20,078	46,991	67,069

Note: The capital cost does not include engineering cost, physical contingency and administration cost.