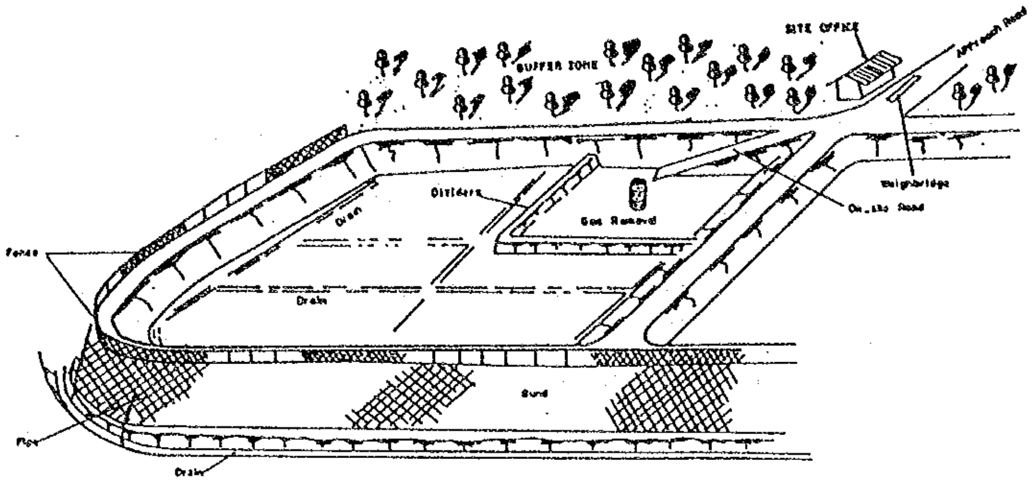
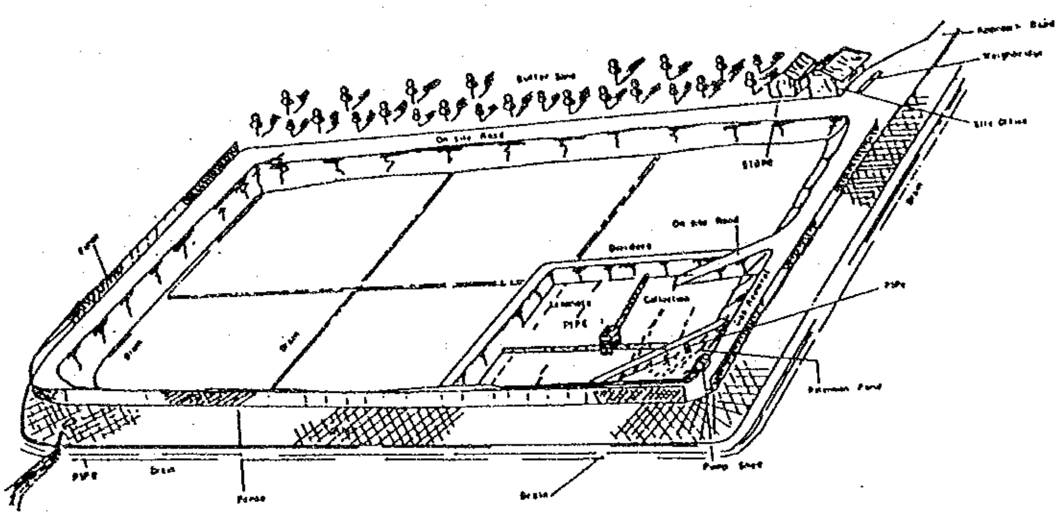
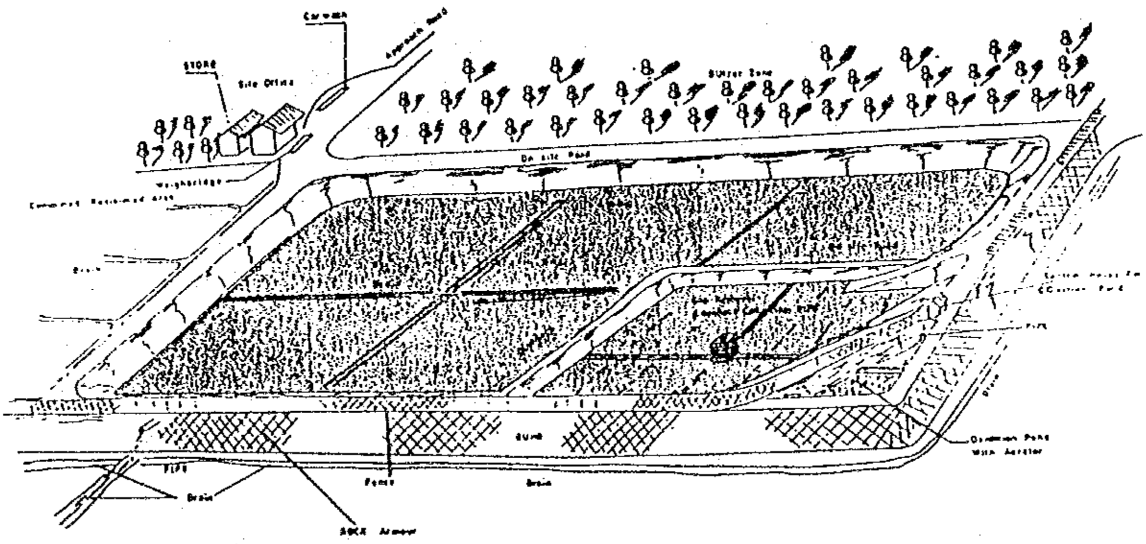


Level 2



Level 3



Level 4

Figure H.3.5b Prospective Illustration of Sanitary Landfill Development and Operation in Level 2, 3 and 4

fa. Level 1; Controlled Tipping

i. target

- introduction of controlled tipping

ii. level to be achieved

- establishment of access to site;
- introduction of cover materials in order to prevent fire and to lessen blown waste and rank odor; and
- introduction of inspection, control and operational recording system of incoming waste.

fb. Level 2; Sanitary Landfill with a Bund and Daily Soil Covering

i. target

- introduction of sanitary landfill

ii. level to be achieved

- establishment of site boundary in order to distinguish the disposal site and to eliminate scavenging;
- execution of sufficient cover over waste disposed;
- establishment of disposal site by the construction of enclosing bund;
- introduction of a divider between present landfill area and future landfill area;
- establishment of drainage system in order to divert storm water and seepage from surrounding area and to reduce leachate;
- introduction of environmental protection facilities in order to lessen direct impact on surroundings such as buffer zone, litter control and gas removal facilities;
- introduction of semi-aerobic sanitary landfill by the installation of gas removal facilities; and
- introduction of amenities for the staff.

fc. Level 3; Sanitary Landfill with Leachate Circulation

i. target

- establishment of leachate control

ii. level to be achieved

- establishment of leachate control by the installation of leachate collection, circulation ad monitoring facilities.
- establishment of seepage control by the installation of liner.
- establishment of semi–aerobic sanitary landfill in order to facilitate the stabilization of waste disposed through the active decomposition in semi–aerobic condition
- establishment of dust prevention system by introducing water sprinkling.

fd. Level 4; Sanitary Landfill with Leachate Treatment

i. target

- establishment of leachate treatment

ii. level to be achieved

- establishment of leachate treatment by the installation of oxidation pond

The above mentioned level of sanitary landfill development and operation are described and tabulated in Table H.3.5a. A comparison on the environmental level to be achieved by each level of sanitary landfill development and operation is made and tabulated in Table H.3.5b.

Table H.3.5a Outline of Sanitary Landfill Development and Operation

Items	Level of Sanitary Landfill				Remarks
	1st	2nd	3rd	4th	
1. Site Development Works					
1.1 Main Facilities					
a. Enclosing Structure					
i. Enclosing Bund		A	A	A	
ii. Divider		B	A	A	- B means that a bund is made of waste disposed and earth
b. Drainage System					
i. Surrounding Drain		A	A	A	
ii. On-site Drain (Surface Water)		A	A	A	- The drain is for the site which is not used for landfill
iii. On-site Drain (Underground Springs)		A	A	A	
iv. Drain for Reclaimed Area		A	A	A	
c. Access					
i. Approach Road	A	A	A	A	
ii. On-site Road	A	A	A	A	
iii. Others	A	A	A	A	- Improvement of existing road network for accessing to the site
1.2 Environment Protection Facilities					
i. Buffer Zone		A	A	A	
ii. Litter Control Facilities		B	A	A	- Movable fence,etc.
iii. Gas Removal Facilities		B	A	A	
iv. Leachate Collection Facilities			A	A	
v. Leachate Circulation Facilities			A	A	
vi. Seepage Control Facilities			B	A	
vii. Leachate Treatment Facilities				A	
1.3 Buildings and Accessories					
i. Site Office	B	A	A	A	
ii. Weigh Bridge	A	A	A	A	
iii. Storage Building			A	A	
iv. Safety Facilities		A	A	A	- Gate, fence, lights, etc.
v. Fire Prevention Facilities		B	A	A	- Water tank, extinguisher, etc.
vi. Monitoring Facilities			A	A	- Monitoring well, etc.
vii. Car Wash			A	A	
2 Equipment					
i. Landfill Equipment	A	A	A	A	
ii. Others			A	A	- Water truck, inspection vehicles, etc.
3 Operation and Maintenance					
3.1 Operation					
a. Personnel	A	A	A	A	
b. Cover Material	B	A	A	A	- B Means insufficient operation
c. Utility					
i. Fuel	A	A	A	A	
ii. Water		A	A	A	
iii. Electricity	B	A	A	A	
d. Chemicals					
i. Insecticide	A	A	A	A	
ii. Monitoring Chemicals			A	A	
e. Others		A	A	A	- Divider, drain for reclaimed area, leachate collection pipes, etc.
3.2 Maintenance					
i. Main Facilities		A	A	A	
ii. Environment Protection Facilities		A	A	A	
iii. Building and Accessories	A	A	A	A	
iv. Equipment	A	A	A	A	

A means the facility is necessary.
B means the facility is necessary under a certain condition, or in case the budget is not enough, the facility might not be provided.

Table H.3.5b Comparison of Environment Level to be Achieved by Each Level of Sanitary Landfill Development and Operational

Items	Level of Sanitary Landfill Development and Operation			
	Level 1	Level 2	Level 3	Level 4
1. Landfill Structure				
1-1 Landfill Structure	- Anaerobic Sanitary Landfill	- Improved Anaerobic Sanitary Landfill.	- Semi-aerobic Sanitary Landfill	- Semi-aerobic Sanitary Landfill
1-2 Achieved Condition	- Leachate generated in solid waste layers is seldom drained but retained, and always keeps landfill in an anaerobic state. Generally, the quality of leachate is not improved over a long time. - Because of inactive decomposition of wastes, prompt stabilization of a landfill is not achievable.	- Through gas removal facilities, the quality of leachate is slightly improved as compared with the Level 1. Almost all of the solid waste, however, is still kept in an anaerobic state. - The rate of decomposition is also slightly improved.	- Leachate accumulated at landfill bottom is promptly discharged through drain pipes (leachate collection pipes). The pipes also permit the natural inflow of air. - This structure facilitates the decomposition of solid waste because of semi-aerobic condition made by drain pipes. The quality of leachate is much improved and generation of offensive odor is reduced further. - Water content of solid wastes disposed is lower than the Level 2.	- Same as the Level 3.
2. Leachate and it's Impacts on Surroundings				
2-1 Leachate Generation Amount	- Leachate is freely discharged out from both landfilling and reclaimed areas because enclosing structure is not set up. - Rain water flows into the landfill from catchment area and it increases leachate amount.	- As for the reclaimed areas, surface water is drained and discharged out. - Rain water from catchment area is diverted into surrounding drains. - A divider limits the area for leachate generation to the working area. - As mentioned above, since the area for leachate generation is limited, leachate amount is also limited to the precipitation on the certain area.	- Same as the Level 2.	- Same as the Level 2.

Items	Level of Sanitary Landfill Development and Operation			
	Level 1	Level 2	Level 3	Level 4
2-2 Leachate Control Facilities	- None	- Enclosing bund and divider prevents direct discharge of leachate.	- In addition to the facilities for the Level 2, there are leachate cycling and monitoring facilities. - Leachate is discharged only during heavy rain from regulating pond. Leachate discharged is therefore, diluted.	- Same as the Level 3 except for effluent which is constantly treated and discharged from oxidation pond.
2-3 Leachate Treatment Facilities	- None	- None	- Retention and regulation ponds may work as oxidation pond.	- Leachate is treated in an oxidation pond with aerator.
2-4 Leachate Quality	- Amount of leachate is high and it's quality is worse than any other levels. Besides that, there shall be negligible improvement on the quality even after a long period of time.	- Amount of leachate is limited because of bund and divider. However, the quality of leachate is not improved after a long period of time.	- Amount of leachate is limited as in the Level 2. - The quality of leachate is improved much faster than the Level 2 because of semi-aerobic landfill condition. - Leachate cycling facilitates purification of the leachate by the wastes disposed. - Since leachate is discharged only during heavy rain, it is therefore, diluted.	- Amount of leachate is limited as in the Level 2 - The quality of leachate to be discharged will be treated in order to meet with an effluent standard.
2-5 Impacts by Leachate				
a. Impacts on Underground water	- The impacts are dependent on the permeability of bottom soil. - If it is a permeable bottom soil, the impacts on underground water is very high because of high pressure head and large amount of leachate.	- The impacts are dependent on the permeability of bottom soil. - The amount of leachate is much less than the Level 1. However, the impacts are still high in the case of permeable bottom soil.	- Liner is laid so as to prevent underground water from leachate seepage. - There is very little underground water contamination.	- Liner is laid so as to prevent underground water from leachate seepage. - There is very little underground water contamination.
b. Impacts on Surface Water	- Because of free discharge of leachate from a landfill site, the impacts on to surrounding water area is very high.	- Discharged of leachate may occur when the divider is overflown and through seepage. - Although leachate amount is limited, impacts on to surrounding water area is still high because of uncontrolled and unimproved leachate.	- Discharge of leachate is made only during heavy rain. - Leachate can be monitored. In case leachate to be discharged would affect the surroundings, the construction of leachate treatment facility is encouraged.	- Effluent from landfill site will satisfy a required effluent standard.

Items	Level of Sanitary Landfill Development and Operation			
	Level 1	Level 2	Level 3	Level 4
3. Others				
3-1 Vector control	- Great generation of flies, insects and rodents. - Great crow gathering. - Odors are constantly generated.	- Vector control is achieved and it is much improved compared to the Level 1.	- Same as the Level 2.	- Same as the Level 2.
3-2 Odors and Gas Production	- Occasional fires occur due to spontaneous ignition.	- It is much better than the Level 1. - No occurrence of fire	- Due to semi-aerobic landfill structure, it is better than the Level 2.	- Same as the Level 3.
3-3 Others	- Litter of wastes and dust. - Deterioration of Landscape. - Noise. - Existence of scavengers.	- It is improved in all aspects.	- In addition to the condition achieved at the Level 2, dust problem is improved by a water sprinkler.	- Same as the Level 3.

H.4 Examination of Technical System Alternatives for HUM (Asuncion and F.Mora)

H.4.1 Presentation of Alternatives

H.4.1.1 Concept

a. Objective Municipalities

The objective municipalities shall only be highly urbanized municipalities, i.e. Asuncion and Fernando de la Mora where any more final disposal site is not able to be acquired within their jurisdiction except for the present Cateura landfill.

b. Technical System Component of Alternatives

The concepts of alternatives for highly urbanized municipalities are summarized in Table H.4.1.1a.

Table H.4.1.1a Concept of Technical System Alternatives for Highly Urbanized Municipalities

Disposal	Intermediate Treatment	Site	Transfer System	Alternative No.
Independent	Incineration	Cateura	without	X-1
Inter-municipal	None	A-2	without	X-2
			with	X-3
		A-5	without	X-4
			with	X-5

ba. Type of System in terms of Final Disposal Site Location

Independent disposal system and inter-municipal disposal system, two types of MSWM system in terms of final disposal location, are taken into account for candidate alternatives.

Independent disposal system means that the wastes generated in the municipality are collected, transported, treated and disposed of inside of the municipality where those wastes are generated.

Inter-municipal disposal system means that more than one municipality construct and operate the final disposal site jointly. In other words, it actually means that the final disposal site is constructed outside of Asuncion and Fernando de la Mora municipalities.

bb. Intermediate Treatment

The independent disposal system requires an intermediate treatment technology because the volume reduction of waste is indispensable due to the difficulties of acquisition of land wide enough. Incineration technology was, therefore, selected as the intermediate treatment technology because the volume reduction ratio is more effective than any other technologies.

bc. Candidate Sites

Cateura area was assumed for the proposed site of the independent disposal system consisting of an incineration plant and a final disposal site for the purpose of this examination.
A-2 and A-5 sites were selected for the candidate site of the inter-municipal disposal system, as decided in the meeting of the Progress Report (1).

bd. Transfer System

In order to examine the optimum haulage system, the alternatives with and without the transfer system were formulated for examination.

H.4.1.2 Alternative X-1

a. Proposed System

An incineration plant at Cateura; and
A sanitary landfill at Cateura

b. Purpose

- Independent disposal
- To minimize the haulage cost
- Sanitary treatment of combustible wastes
- To minimize the landfill area for final disposal
- Improvement of sanitary level of the disposal site

c. Method

Wastes are incinerated at the incineration plant after collection and then its residue is dumped in the landfill site. The proposed site for the landfill and the incineration plant is assumed to be the existing landfill site in Cateura area in Asuncion. Wastes from Fernando de la Mora is also assumed to be treated through the same plant because an adequate site is too difficult to be acquired in Fernando de la Mora.

d. Advantages and Disadvantages

Advantages;

- The life span of the disposal site can be prolonged by reduction of disposal waste volume.
- The required area for MSWM can be minimized.
- The haulage cost of wastes can be saved.
- Incineration is the best method in terms of sanitation.
- Environmental and social impacts to the surrounding areas of the MSWM facility's sites are less than the other technologies.

Disadvantages;

- Initial investment and operation cost of the incineration plant is very expensive.
- High technology is necessary for construction and operation of the incineration plant.
- No local contractor has technology to construct an incineration plant.
- Training of operators is necessary to operate an incineration plant.
- Emission from the incineration plant may pollute air. Environmental protection equipment to clean the fumes emitted is very costly in price and also operation.

H.4.1.3 Alternative X-2

a. Proposed System

An inter-municipal sanitary landfill at the A-2 site without a transfer system

b. Purpose

- Inter-municipal disposal
- Low cost disposal
- To minimize the adverse impacts caused by the landfill operation.

c. Method

Wastes generated in Asuncion and Fernando de la Mora are transported to the sanitary landfill site constructed at A-2 in Chaco with waste collection trucks directly after they are collected. The wastes are disposed of at the sanitary landfill with immediate soil coverage. The leachate are collected and returned to the landfill site for circulation.

d. Advantages and Disadvantages

Advantages;

- Initial investment and operation cost of the sanitary landfill is the cheapest among the MSWM technologies.
- High technology is not necessary for construction and operation of the sanitary landfill.
- Local contractors have sufficient technology and ability to construct the sanitary landfill site with the cooperation from experienced agencies.
- Operation and maintenance is not difficult to be implemented.

Disadvantages;

- The required area for final disposal is very wide.
- Environmental and social impacts to the surrounding areas of the landfill site are considerable.

- The neutralization of wastes disposed requires a long time.
- The future land use of the landfill site is limited.

H.4.1.4 Alternative X-3

a. Proposed System

An inter-municipal sanitary landfill at the A-2 site with a transfer system

b. Purpose

- Inter-municipal disposal
- Low cost disposal
- To minimize the adverse impacts caused by the landfill operation
- To save haulage cost

c. Method

Wastes generated in Asuncion and Fernando de la Mora are transported to the transfer stations to be constructed in or near the urban area with waste collection trucks. Then they are transferred from a collection truck to a transporting vehicle at the transfer station and then transported to the sanitary landfill site at A-2 in Chaco for final disposal. The wastes are disposed of at the sanitary landfill with immediate soil coverage. The leachate are collected and returned to the landfill site for circulation.

d. Advantages and Disadvantages

Advantages;

- Initial investment and operation cost of the sanitary landfill is the cheapest among the SWM technologies.
- High technology is not necessary for construction and operation of the sanitary landfill.
- Local contractors have sufficient technology and ability to construct the sanitary landfill site with the cooperation from experienced agencies.

- Operation and maintenance is not difficult to be implemented.
- The increase of traffic volume of waste collection trucks can be kept down to a minimum.
- Haulage cost can be saved.

Disadvantages;

- The required area for final disposal is very wide.
- Environmental and social impacts to the surrounding areas of the landfill site are considerable.
- The neutralization of wastes disposed requires a long time.
- The future land use of the landfill site is very limited.
- The sites of transfer stations must be acquired in or near the urban area.

H.4.1.5 Alternative X-4

a. Proposed System

An inter-municipal sanitary landfill at the A-5 site without a transfer system

b. Purpose

- Inter-municipal disposal
- Low cost disposal
- To minimize the adverse impacts caused by the landfill operation

c. Method

Wastes generated in Asuncion and Fernando de la Mora are transported to the sanitary landfill site constructed in A-5 in Chaco with waste collection trucks directly after they are collected. The wastes are disposed of at the sanitary landfill with immediate soil coverage. The leachate are collected and returned to the landfill site for circulation.

d. Advantages and Disadvantages

Advantages;

- Initial investment and operation cost of the sanitary landfill is the cheapest among the MSWM technologies.
- High technology is not necessary for construction and operation of the sanitary landfill.
- Local contractors have sufficient technology and ability to construct the sanitary landfill site with the cooperation from experienced agencies.
- Operation and maintenance is not difficult to be implemented.

Disadvantages;

- The required area for final disposal is very wide.
- Environmental and social impacts to the surrounding areas of the landfill site are considerable.
- The neutralization of wastes disposed requires a long time.
- The future land use of the landfill site is limited.

H.4.1.6 Alternative X-5

a. Proposed System

An inter-municipal sanitary landfill at the A-5 site with a transfer system

b. Purpose

- Inter-municipal disposal
- Low cost disposal
- To minimize the adverse impacts caused by the landfill operation
- To save haulage cost

c. Method

Wastes generated in Asuncion and Fernando de la Mora are transported to the transfer stations to be constructed in or near the urban area with waste collection trucks. Then they are transferred from a collection truck to a transporting vehicle at the transfer station and then transported to the sanitary landfill site at A-5 in Chaco for final disposal. The wastes are disposed of at the sanitary landfill with immediate soil coverage. The leachate are collected and returned to the landfill site for circulation.

d. Advantages and Disadvantages

Advantages;

- Initial investment and operation cost of the sanitary landfill is the cheapest among the SWM technologies.
- High technology is not necessary for construction and operation of the sanitary landfill.
- Local contractors have sufficient technology and ability to construct the sanitary landfill site with the cooperation from experienced agencies.
- Operation and maintenance is not difficult to be implemented.
- The increase of traffic volume of waste collection trucks can be kept down to a minimum.
- Haulage cost can be saved.

Disadvantages;

- The required area for final disposal is very wide.
- Environmental and social impacts to the surrounding areas of the landfill site are considerable.
- The neutralization of wastes disposed requires a long time.
- The future land use of the landfill site is limited.
- The sites of transfer stations must be acquired in or near the urban area.

H.4.2 Conceptual Design and Cost Estimation

First of all, it should be noted that the purpose of a conceptual design and cost estimation to be carried out in this section was to compare the cost of each technical system alternative for the master plan and to select an optimum alternative for each municipality. There were totally 62 alternatives for comparison. Therefore, the design and estimation work was simplified as much as possible and a more detailed design including modification of the conceptual design and cost estimation was done at the Feasibility Study stage.

H.4.2.1 Premises

a. Objectives

Based on the results of the examination of system component (refer to the Section 3.2), this section presents conceptual design and estimates for the following systems and facilities for MSWM in Asuncion and F.Mora:

- Storage and collection system.
- Haulage system.
- System for street sweeping.
- Incineration plant.
- Sanitary landfill.

b. Key Assumptions

ba. For design

baa. Key assumptions for design

In the conceptual design of this report, the following key assumptions were set up:

Table H.4.2.1a Key Assumptions for Design

Design Items	Applied Figure	Unit	Remarks
1. Storage and Collection			
1-1 ASG of Waste in Compactor	0.45	ton/m^3	
1-2 ASG of Waste in Dump Truck	0.2	ton/m^3	
1-3 ASG of Waste in Container	0.2	ton/m^3	
1-4 Rate of Operation of Vehicles	0.9		
2. Haulage			
2-1 ASG of Waste in Transfer Vehicle (Compactor Type)	0.5	ton/m^3	
2-2 ASG of Waste in Transfer Vehicle (Non-compaction Type)	0.2	ton/m^3	
3. Street Sweeping			
3-1 Manual Sweeping			
3-2 Collection done by Compaction			
4. Incineration Plant			
4-1 Residues Rate	35	%	
4-2 Heat Recovery Rate	60	%	
4-3 Commencement of Operation	2001	year	All MSW except for street sweeping waste
4-4 Capacity	31	tons/hour	10.3 tons/hour x 3 units
5. Final Disposal			
5-1 ASG of Incineration Residue	1.1	ton/m^3	After compaction
5-2 ASG of MSW	0.8	ton/m^3	After compaction

Table H.4.2.1b Distance Table for Alternatives

Case	Waste Amount (ton/day)	X-1	X-2	X-3		X-4	X-5	
		Distance (km)	Distance (km)	Distance (A) (km)	Distance (B) (km)	Distance (km)	Distance (A) (km)	Distance (B) (km)
1. Asuncion	569	6.4	37	5	32	31	5	26
2. F.Mora	113	11.0	37	5	32	31	5	26

(Note) Distance(A) is it from generation to a transfer station and Distance(B) is from the transfer station to the landfill.

bab. Waste stream

In order to carry out the conceptual design and cost estimation, the waste streams for Asuncion and F.D.L. Mora in the year 2006 for each alternative are presented in Tables H.4.2.1c and H.4.2.1d.

Table H.4.2.1c Waste Stream for MSW in Asuncion in the Year 2006

Alternatives	Unit	X-1	X-2	X-3	X-4	X-5
a. Generation	ton/day	742	742	742	742	742
b. Self Disposal	ton/day	143	143	143	143	143
c. Recycling at Generation	ton/day	30	30	30	30	30
d. Collection Amount (a-b-c-e)	ton/day	496	496	496	496	496
e. Street Sweeping	ton/day	73	73	73	73	73
f. Waste amount at T/S (d+e)	ton/day	-	569	569	569	569
g. Recycling	ton/day	26	26	26	26	26
h. Waste amount to the Incineration Plant (d-g)	ton/day	470	-	-	-	-
i. Residue from Incineration (h x 0.35)	ton/day	165	-	-	-	-
j. Other Waste	ton/day	37	37	37	37	37
k. Waste Amount at Final Disposal Site per Day (e+i+j)or (f-g+j)	ton/day	275	580	580	580	580
l. Waste Amount at Final Disposal Site per Year (k x 365)	ton/-year	100,193	211,700	211,700	211,700	211,700

Table H.4.2.1d Waste Stream for MSW in F.Mora in the Year 2006

Alternatives	Unit	X-1	X-2	X-3	X-4	X-5
a. Generation	ton/day	152	152	152	152	152
b. Self Disposal	ton/day	32	32	32	32	32
c. Recycling at Generation	ton/day	7	7	7	7	7
d. Collection Amount (a-b-c-e)	ton/day	103	103	103	103	103
e. Street Sweeping	ton/day	10	10	10	10	10
f. Waste amount at T/S (d+e)	ton/day	-	113	113	113	113
g. Recycling	ton/day	7	7	7	7	7
h. Waste amount to the Incineration Plant (d-g)	ton/day	96	-	-	-	-
i. Residue from Incineration (h x 0.35)	ton/day	34	-	-	-	-
j. Other Waste	ton/day	0	0	0	0	0
k. Waste Amount at Final Disposal Site per Day (e+i+j)or (f-g+j)	ton/day	44	106	106	106	106
l. Waste Amount at Final Disposal Site per Year (k x 365)	ton/year	15,914	38,690	38,690	38,690	38,690

bb. For cost estimation

bba. Basic consideration

The cost comparison of each technical system alternative was done as the annual MSWM cost in 2006. Consequently, the following assumptions were taken for the cost estimation:

i. Although the executing body of MSWM for each municipality differs at present, it is assumed that a same type of executing body (e.g. a department of a municipality) will operate it.

ii. The cost comparison was carried out by means of the O & M (Operation and Maintenance) cost in the year 2006 which includes depreciation of all facilities and equipment related to the MSWM of each municipality.

iii. The cost estimation was done based on the price in August 1993. The exchange rate was 1US$=1,756.52 Gs.

iv. The estimated cost did not include interest and tax. Although the actual cost should include them, they were excluded because the purpose of the cost comparison was to select the optimum alternative. The actual cost was estimated at the Feasibility stage.

bbb. Annual working days and working efficiency

The annual working days were determined as follows;

- total days per year	:	365	
- Sunday	:	53	
- Public holiday	:	15	
total working days	:	**297**	**days/year**

The working hours of equipment is assumed to be 8 hours per day. The rate of operation of equipment is assumed to be **0.9**.

bbc. Life span of equipment and facilities

	Life Span (years)
Container	5
Truck and Heavy Equipment	7
Machinery	15
Building and Civil Works	30

Note: The life span of other facilities for the disposal site depends on the period of its operation.

H.4.2.2 Storage and Collection System

a. Objective wastes and Collection Amount

aa. Objective wastes

The objective wastes dealt by the storage, collection and haulage plan are as follows;

- Household
- Commercial waste
- Market waste
- Institutional waste
- Street sweeping waste
- Hospital waste (non-infectious)

ab. Collection amount

The waste collection amount in 2006 is shown in Table H.4.2.2a.

Table H.4.2.2a Waste Collection Amount in 2006 unit : ton/day

Type of Waste	Asuncion	F.Mora
- Household waste	394	88
- Commercial waste	58	15
- Market waste	20	0
- Institutional waste	2	0
- Hospital waste (non-infectious)	22	0
Total	496	103

b. Storage system

ba. Storage system

A storage system assumed for MSW in this section is summarized in Table H.4.2.2b.

Table H.4.2.2b Assumed Storage System

Category of Wastes	Asuncion	F.Mora
Household Waste	Plastic Bag	Plastic Bag
Commercial Waste	1.0m³ Container	1.0m³ Container
Market Waste	1.0m³ Container	-
Institutional Waste	Plastic Bag	Plastic Bag
Street Sweeping Waste	1.0m³ Container	1.0m³ Container
Hospital Waste (Non-infectious)	1.0m³ Container	-

bb. Required number of containers

The number of containers required is calculated by the following formula;

$$Qc = Qw \times 7/Qd/E/ASG \text{ (unit)}$$

Qc : Number of containers required (unit)
Qw : Waste collection amount (ton/day)
Qd : Number of working days per week = 6 (day)
E : Rate of efficiency = 0.8
ASG : Apparent Specific Gravity = 0.2

Consequently, the number of required containers for Asuncion and F.Mora is calculated as follows:

Municipality	Total Number (unit)	For Street Sweeping (unit)
Asuncion	1,262	533
F.Mora	183	73

c. Collection system

ca. Collection system

A collection system assumed in this section is as follows:

Category of wastes	Collection vehicle	Type of bin
Household Waste	Compactor $13m^3$	Plastic bag
Commercial Waste	Compactor $13m^3$	Public Container $1.0m^3$
Market Waste	Compactor $13m^3$	Public Container $1.0m^3$
Institutional Waste	Compactor $13m^3$	Plastic Bag
Street Sweeping Waste	Compactor $13m^3$	Public Container $1.0m^3$
Hospital Waste (Non-infectious)	Compactor $13m^3$	Public Container $1.0m^3$

cb. Estimation of required number of collection vehicles

The required number of collection vehicles according to the alternatives was calculated based on the following conditions and procedures:

i. As for the present use of the collection vehicles in the Study area, they are not properly used and actually over used (e.g. most of vehicles work for more than 12 hours per day). Therefore, the required number of vehicles could not be calculated based on the present number of vehicles.

ii. As described in the previous section, it is assumed that vehicles will work 297 days/year and 8 hrs/day, and the rate of their operation is 0.9.

iii. The required time for the collection work differs with the collection area. Since the rear loading compaction truck with $13m^3$ of capacity is the dominant collection vehicle for Asuncion and F.Mora, the work efficiency of this type of vehicle is applied to the estimation of required number of collection vehicles.

iv. According to the data observed by the truck scale at the Cateura landfill from September 28 to October 4 1993, the average time required for one cycle of collection work by a $13m^3$ compactor was 211 minutes, and the average collected amount was 5.356 ton/trip.

v. The collection work consists of the following works:
   - collection
   - haulage
   - discharge
   - miscellaneous

   Based on Time & Motion (T & M) study conducted in August 3rd to 11th 1993, the average time sharing of each work was summarized in Table

H.4.2.2c.

Table H.4.2.2c Collection Time of Compaction Truck ($13m^3$) observed by Time& Motion Survey

unit : minutes

Date	Number of Trip	Cycle Time (minutes)				Total Time
		Collection	Haulage	Discharge	Miscellaneous	
3rd August	1	172	25	7	21	225
4th August	2	185	46	18	36	285
5th August	2	224	86	12	40	362
7th August	2	239	73	15	57	384
9th August	3	245	33	23	48	349
11th August	3	217	126	22	49	414
Total	13	1,282	389	97	251	2,019
Average	1	99	30	7	19	155
Time Share		63.50%	19.27%	4.80%	12.43%	100.00%
Applied Time for One Cycle		**135**	**41**	**10**	**26**	**211**

Since one cycle time at the T & M study may not represent the actual cycle time, the cycle time (211 min.) observed by the truck scale was applied to the study.

vi. Based on the applied time for one cycle of collection work, the required number of collection vehicles was calculated ; i.e. the required time for collection, haulage and discharge will differ in accordance with alternatives.

With the above-mentioned procedures, the required number of collection vehicles for each alternative is calculated and tabulated in Table H.4.2.2d.

Table H.4.2.2d Required Number of Collection Vehicles

Alternative No. / Municipality	X-1	X-2	X-3	X-4	X-5
Asuncion	49 (6)	81 (9)	47 (4)	74 (9)	47 (4)
F.Mora	12 (2)	17 (2)	11 (1)	16 (2)	11 (1)

Note : The figure with parentheses is the required number of vehicles for street sweeping services. The number does not include spare vehicles.

d. Cost estimate

da. Method

The collection cost in 2006 of each alternative was estimated in accordance with the following methods:

- The total collection cost in 1993, which is the O & M expense excluding depreciation cost of equipment, of the city of Asuncion was calculated based on it in 1992 considering 17.8% of the inflation rate.
- The unit cost of collection work (Gs/ton) was calculated by dividing the total collection cost by the total collection amount observed by the truck scale.
- Since the present collection cost includes little depreciation cost of equipment, the depreciation cost was calculated and added based on the price in 1993 and life span. The depreciation cost of collection vehicles counts some spare vehicles by means of the rate of their operations (0.9).
- Upon consideration of haulage distance, work efficiencies, etc., the time share of each work item (collection, haulage, discharge and miscellaneous) for each alternative was estimated based on the present time share of collection work by the compactor $13m^3$.
- Unit collection cost (Gs/ton) for each alternative was calculated based on collection time and collection amount of one cycle time.

db. Unit cost

According to the above mentioned method, the unit collection cost for each alternative was calculated and tabulated in Table H.4.2.2e and H.4.2.2f.

Table H.4.2.2e Unit Collection Cost of Alternatives for Asuncion

Alternative / Items	X-1		X-2		X-3		X-4		X-5	
	without Con-tainer	with Con-tainer	without Con-tainer	with Con-tainer	without Con-tainer	with Con-tainer	without Con-tainer	with Con-tainer	without Con-tainer	with Con-tainer
Collection Time (min.)	134	67	134	67	134	67	134	67	134	67
Haulage Distance (km)	6.4	6.4	37	37	5	5	31	31	5	5
Haulage Time (min.)	41	41	163	163	32	32	139	139	32	32
Discharge Time (min.)	10	10	10	10	10	10	10	10	10	10
Miscellaneous Time (min.)	26	26	26	26	26	26	26	26	26	26
Unit Cost (1,000 Gs/ton)	21.3	18.9	33.7	31.3	20.4	18.0	31.3	28.8	20.4	18.0
Collection Amount (ton)	396	100	396	100	396	100	396	100	396	100
Total cost (millon Gs.)	3,083	690	4,868	1,141	2,950	657	4,518	1,052	2,950	657
	3,773		6,009		3,607		5,570		3,607	

Table H.4.2.2f Unit Collection Cost of Alternatives for F.Mora

Alternative / Items	X-1		X-2		X-3		X-4		X-5	
	without Con-tainer	with Con-tainer	without Con-tainer	with Con-tainer	without Con-tainer	with Con-tainer	without Con-tainer	with Con-tainer	without Con-tainer	with Con-tainer
Collection Time (min.)	134	67	134	67	134	67	134	67	134	67
Haulage Distance (km)	11	11	37	37	5	5	31	31	5	5
Haulage Time (min.)	71	71	163	163	32	32	139	139	32	32
Discharge Time (min.)	10	10	10	10	10	10	10	10	10	10
Miscellaneous Time (min.)	26	26	26	26	26	26	26	26	26	26
Unit Cost (1,000 Gs/ton)	24.3	21.9	33.7	31.3	20.4	18.0	31.3	28.8	20.4	18.0
Collection Amount (ton)	88	15	88	15	88	15	88	15	88	15
Total cost (millon Gs.)	781	120	1,082	171	656	98	1,004	158	656	98
	901		1,253		754		1,162		754	

H.4.2.3 Haulage System

a. Considerations for planning

For the plan of a transfer station, the following items are to be considered;

aa. Transfer waste amount

- Calculation of transfer waste amount
- Seasonal fluctuation of transfer waste amount

ab. Capacity requirements

- Number of working days (days/week)
- Peak month in terms of waste generation (i.e. transfer amount)

ac. Type of transfer stations

- Direct re-loading
- Indirect re-loading
  . With storage (pit & crane or reception yards)
  . Without storage (bailing or compaction)

ad. Facility design

- Incoming conditions
  . Type and number of collection vehicles.
  . Working days and hours.
- Operation plan
- Equipment requirements
- Accessory requirements
- Sanitary requirements
- Civil works

ae. Transportation plan

- Access condition
- Working hours
- Type of vehicles
- Number of vehicles

af. Calculation of bill quantity

- Based on the design of transfer station and operation and maintenance plans.

ag. Operation and maintenance plan

- Personnel requirements
- Utilities requirements

ah. Cost estimations

- Based on the calculation of bill of quantity and construction price data collected.

b. Determination of capacity requirements

ba. Calculation of transfer waste amount

In order to start planning, the transfer waste amount of a transfer station shall be calculated. The total transfer waste amount in the year 2006 of the cities of Asuncion and F.Mora is calculated as 682 ton/day.

bb. Determination of capacity requirements

With the present road and geographical conditions of Asuncion and F.Mora, at least two transfer stations seems to be necessary. The capacity requirement of each transfer station is calculated by the following manner:

- Average daily transfer waste amount of each transfer station in the year 2006 is assumed as 341 ton/day.
- The annual working days and working hours are set up as 297 days/year and 8 hours/day.
- If the allowance for daily and monthly fluctuation of waste is set up at 1.15, the required capacity of each transfer station is calculated at 480 ton/day and 60 ton/hour by the following formula:

$$341 \times 365 \div 297 \times 1.15 = 482 \text{ ton/day} \longrightarrow \text{Say } 480 \text{ ton/day}$$
$$480 \div 8 = 60 \text{ ton/hour}$$

c. Selection of type of transfer stations

ca. Type of transfer stations

Depending on the method used to load transfer wastes onto transport vehicles, transfer stations may be classified into the following types:

caa. Direct re-loading type

In this type of transfer station, wastes collected by each collection vehicle are directly re-loaded into the transportation vehicles or containers.

cab. Indirect re-loading

In the indirect re-loaded type of transfer station, wastes collected are discharged from each collection vehicle at the transfer station.

i. With storage type

As for indirect re-loading with storage type, wastes discharged are once stored at the transfer station then re-loaded into the transport vehicles. There are the following types:

- Pit and crane type with compactor
- Pit and crane type with bailer
- Reception yards type with loading equipment

ii. Without storage type

Instead of storage facilities, this type has a hopper for receiving wastes discharged from collection vehicles. Then, wastes discharged are processed by equipment. These types are classified into the following according to the processing equipment:

- Bailing type
- Compactor type

cb. Considerations for selection of types

In order to select the types of transfer stations, the following aspects are to be considered:

cba. Economic feasibility according to the capacity requirements

- Construction cost
- Operation and maintenance cost
- Number of personnel required for operation

cbb. Easiness and stability in operation

- Reliability of the system
- Storage capability
- Re–loading capability
- Simple operational manual

cbc. Flexibility

- Working hours
- Flexibility in the fluctuation of the amount of waste transferred.
- Flexibility in the break down of the transfer station.

cbd. Safety

cbe. Operation and maintenance

- Easiness in maintenance and repair
- Durability
- Easiness in controlling

cbf. Space of the transfer stations

- Required area

cbg. Environmental acceptabilities

- Environmental impacts on noise, dust and odor
- Sanitation requirements

cc. Selection of type

Based on the above mentioned considerations, the indirect re-loading type with compactor and without storage facilities type is selected for the proposed transfer stations. The reasons are as follows:

- The capacity requirement of the transfer stations is 480 ton/day. The transfer stations are classified as large-scaled transfer stations.
- Collection vehicles proposed in the study are compaction type and large ($13m^3$). Therefore, without compaction facility the proposed transportation vehicles become too big.
- This type of transfer station can transfer large amount of wastes efficiently.
- From the environmental point of view, reception yards and bailing types are not recommended to wastes which contain large amounts of kitchen waste (food wastes).
- Construction of storage facilities requires significant amount of investment.
- This type achieve high efficiency of transfer operation. This means less requirements of space per ton of a transfer.
- It is rather easy to control environmental impacts such as littering, dust, odor and other in this type of transfer stations.

d. Facility design

An indirect re-loading type transfer station with compactor consists of the following facilities and equipment:

- Receiving and feeding facilities
- Compaction equipment
- Accessories
- Civil works

da. Receiving and feeding facilities

The waste receiving and feeding facilities, weigh bridge, platform, receiving hopper, feeder to compaction equipment etc., are provided.
The plan provides a truck scale upon consideration of the number of incoming collection vehicles to the plant during the peak hours in a day.
Receiving hopper provided on each compaction equipment is designed to have sufficient width enabling two vehicles to reach each hopper at the same time, with storage capacity equivalent to waste expected at least 20 minutes during pear hours.

db. Compaction equipment

dba. Number of compaction units

The number of compaction units for each plant must be sufficient to avoid the severe influence in capacity reduction during unexpected failure of equipment.
In this case, considering the scale of plant capacity, two units of compactors are required.

dbb. Design capacity of each compaction unit

The maximum capacity of each compaction unit is made upon consideration of the design conditions below.

- Waste amount per day in peak month (ton/day)
- Waste amount in peak hour during peak month (ton/day)
- Type, size and loading capacity of secondly transport vehicle
- Number of vehicles going to landfill site (number/hour/compactor unit)
- Required time for compaction per cycle
- Idle time needed for connection/disconnection of vehicle to compactor unit

dbc. Determination of compaction capacity

In each case, upon consideration of design factor that is related to the compression time and idle time, the real capacity of compaction equipment is decided as being capable of compacting 1.5 times of the amount to be compacted during the hour.

dc. Major accessory requirements

For the smooth operation of the plant, the following accessories are required:

- hydraulic oil pump units
- remote operating devices and automatic controllers
- car washing facilities
- waste water treatment facility
- others

Figure H.4.2.3a shows a schematic diagram of a transfer station with compaction equipment.

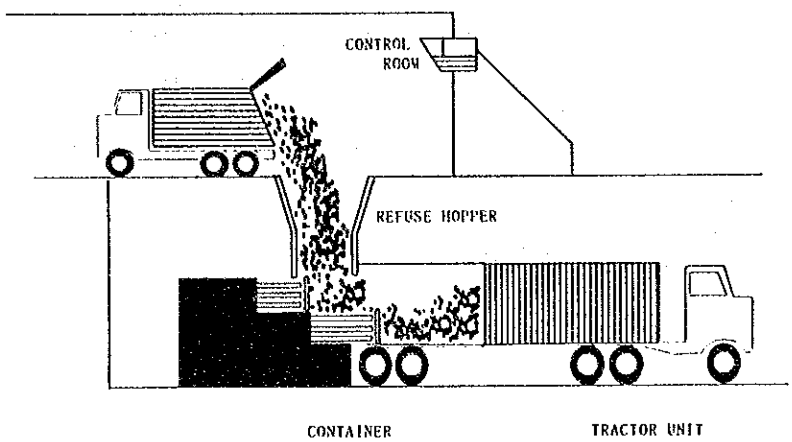


Figure H.4.2.3a Schematic Diagram of Refuse Transfer Operation

dd. Civil works

A two story main building of reinforced and steel structure is provided.
In the main building, the following equipment is installed.

- compaction equipment
- feeder
- hydraulic oil pump unit
- others

An office building with amenity facilities for tractor drivers and truck scale operator, etc., is also constructed.
As for civil works, large parking area for transfer vehicles, ramp way for access to the platform, car washing station, car repair bay etc., are necessary.

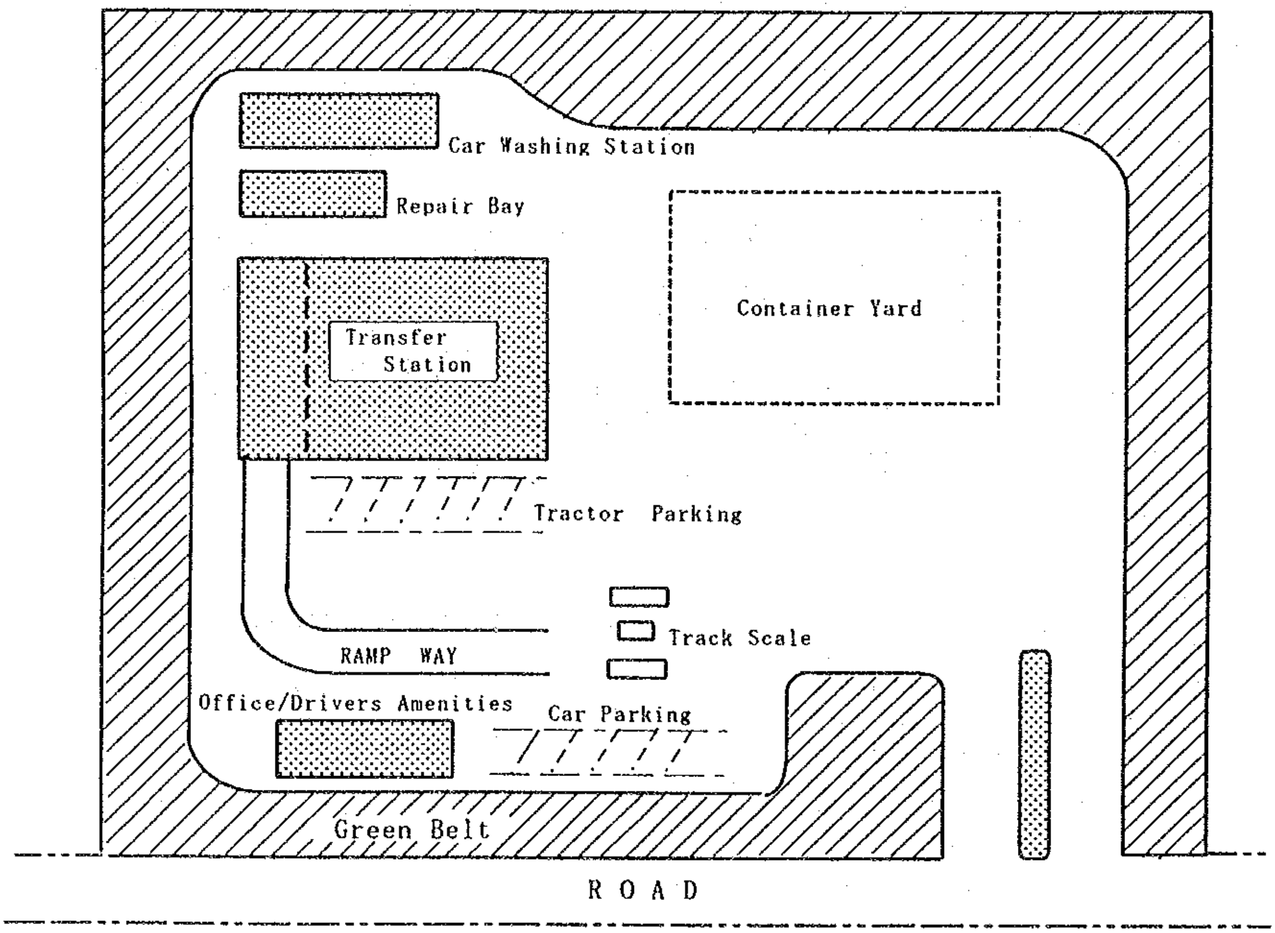


Figure H.4.2.3b Plan of Transfer Station (with Compaction Equipment)

e. Transportation from transfer station

ea. Haulage distance and transfer amount

Transportation from a transfer station is studied on the following four cases for the alternatives study and tabulated in Table H.4.2.3a. The aims of this study is to calculate i. the required number of vehicles and ii. the cost of transportation from the transfer station.

Table H.4.2.3a Haulage Distance from Transfer Station to Disposal Site

Municipalities / Items / Alternative	Asuncion		F.Mora	
	X-3	X-5	X-3	X-5
Disposal Site Haulage Distance (km)	A-2 32	A-5 26	A-2 32	A-5 26
Amount of Waste to be Transferred (ton/day)	569	569	113	113

eb. Design conditions

The following design conditions are established in order to calculate the required number of vehicles and the transportation cost:

eba. Vehicles for transportation

The following specification of compacted container trailer (CCT) is planned to be used for secondary transportation from a large scale transfer station:

- container capacity : 80 m^3
- loading capacity : 40 ton (80 x 0.2 x 2.5)
  (Where 0.2 is the apparent specific gravity and 2.5 is the compaction ratio)

ebb. Driving speed of transportation vehicle

The driving speed of a transportation vehicle is planned to be 30 km/hr.

ebc. Working time

- Total working time is set as 8 hours per day and 297 days per year.

- Loading time is planned as 0.2 hours at a large transfer station.
- Discharging time is set up as 0.3 hours at the disposal site.

ebd. Fuel and lubricant cost

Based on the present haulage study, the cost of fuel and lubricant is assumed to be 209 Gs/km.
Information on transportation, based on the above mentioned basic data is shown in Table H.4.2.3b.

ec. Number of transportation vehicles required

Using the previous information, the following items are calculated.

eca. Total number of trips per day

Total number of trips per day = Average transfer amount per day / Loading capacity of a vehicle

ecb. Number of trips per vehicle per day

The number of trips for each vehicle in a day (8 hours/day) is determined by the formula below.

Number of trips per vehicle per day = 8 hours / one cycle time per vehicle

ecc. Number of vehicles required per day

Number of vehicles required per day = (Total number of trips per day) / (number of trips per vehicle per day)

The number of vehicles required per day is based on the average transfer amount per day.

ecd. Stand-by vehicles

Stand-by trailers are needed during the maintenance and reparation period. Spare containers should also be prepared to effectively execute secondary transportation. In order to cope in case of emergency, stand-by trailers and spare containers may also be considered.

ece. Planned number of vehicles

Planned number of vehicles is calculated by the formula below:
(Total No. of trips per day / No. of trips per vehicle per day) + (Stand–by vehicles)
Results are shown in Table H.4.2.3b.

Table H.4.2.3b Calculation of Cycle Time and Planned Number of Vehicles and Container for Transfer Station (480 ton/day)

Items	X–3	X–5	Remarks
(1) Destination	A–2	A–5	
(2) Average out–going amount of waste from transfer station (ton/day)	341	341	
(3) Estmated Capacity of waste (ton/day)	480	480	
(4) Type of vehicle	CCT	CCT	
(5) Loading capacity (ton/vehicle)	40	40	
(6) One–way distance (km)	32	26	
(7) Round–trip distance (km)	64	52	(6) x 2
(8) Design Speed (km/hr)	30	30	
(9) Time for Round–trip (min)	128	104	(7)/(8)
(10) Loading time (min)	12	12	
(11) Discharge time (min)	18	18	
(12) Cycle time (min)	158	134	(9)+(10)+(11)
(13) Total number of trips required per day	11	11	(2)/(5) x 365/297
(14) Number of trips per vehicle per day	3	4	8 hr/(12)
(15) Number of vehicles required per day	4	3	(13)/(14)
(16) Waste amount which can be hauled per day (ton/day)	480	480	
(17) Number of trailers planned	5	4	1 spare vehicle
(18) Number of containers planned	8	6	2 containers per trailer (15) x 2

(Note) * CCT: Compacted Container Trailer (80 m3 x 0.5 = 40 ton)

f. Cost estimate

fa. Construction cost of transfer station

The construction cost of the transfer station which consist of the buildings, compaction equipment, hydraulic oil pump and other facilities required, is estimated in Table H.4.2.3c

Table H.4.2.3c Construction Cost of Transfer Station

Items	X-3	X-5
Waste amount (ton/day)	341	341
Design Capacity (ton/day)	480	480
Compactor's Capacity (ton/hr)	45	45
Equipment (compactor, etc.) (Gs/year)	32,000,000	32,000,000
Civil Works (Gs/year)	146,000,000	146,000,000
Total Cost per year (Gs/year)	178,000,000	178,000,000
Unit cost per ton (Gs/ton)	1,430	1,430

fb. Transportation cost

Transportation cost are calculated based on the unit haulage cost (209 Gs/km) and the results are shown in Table H.4.2.3d.

Table H.4.2.3d Transportation Cost from Transfer Station

Items	X-3	X-5	Remarks
(1) Waste amount (ton/day)	341	341	
(2) Distance (km)	32	26	
(3) Total number of trips per day	11	11	
(4) Total number of trips per year	3,267	3,267	(3) x 297
(5) Total transportation length per year (km)	229,968	186,872	(2) x (4) x 1.1
(6) Fuel & lubricant cost (mil. Gs/year)	48	39	(5) x 209
(7) Number of trailer truck	5	4	
(8) Number of 80 m³ container	8	6	
(9) Depreciation of trailer & container (mil. Gs/year)	441	341	
(10) Number of drivers	7	6	
(11) Cost for drivers per year (million Gs/year)	84	72	
(12) Total cost per year (million Gs/year)	573	452	
(13) Unit cost per ton (Gs/ton)	4,603	3,631	

fc. Operation and maintenance cost

For the operation of each transfer station, manpower and utilities are required as shown in Table H.4.2.3e.

Table H.4.2.3e Manpower and Utilities for Transfer Station (480 ton/day)

Items	Quantity
Manpower (persons)	
Manager	2
Engineer	2
Operator	6
Worker	8
(Total)	18
Utilities	
Electricity(Mw/year)	650
Water (m^3/year)	3,300

Table H.4.2.3f Operation Cost of Transfer Station (480 ton/day)

Items	X-3	X-5
Waste amount (ton/day)	341	341
Capacity of Transfer Station	480 ton/day	480 ton/day
Operation Cost per year (mill.Gs/year)	264	264
Unit Operation Cost (Gs/ton)	2,120	2,120

fd. Outline of transfer station

The outline of the transfer station is as shown in Table H.4.2.3g and total operation cost of transfer system is calculated and tabulated in Table H.4.2.3h.

Table H.4.2.3g Outline of each Transfer Station

Alternatives Items	X-3	X-5
Capacity of Plant	480	480
Type of Transfer Station	Indirect Reloading Compaction	Indirect Reloading Compaction
1. Mechanical & Electrical Facility		
- Weigh bridge	1	1
- Hopper & Feeder	2	2
- Compaction Equipment Hydraulically operated compactor unit with automatic controller	2	2
- Waste Water Treatment Equipment	1	1
- Others	1	1
2. Civil Works & Building		
- Site Area (m^2)	5000	5000
- Scale of Main Building (m^2)	900	900
- Retaining Wall (H=6m)	30	30
3. Transport Equipment		
- Trailer Truck (40 ton)	5	4
- Container with Compactor (80 m^3)	8	6

Table H.4.2.3h Unit Operation Cost of Transfer System (Compaction Type)

Unit : Gs/ton

Alternatives / Items	X-3	X-5
Unit Construction Cost	1,430	1,430
Unit Transportation Cost	4,603	3,631
Unit Operation Cost of Transfer Station	2,120	2,120
Unit Operation Cost of Transfer System	8,153	7,181

H.4.2.4 Street Sweeping System

a. Objective waste and collection amount

The objective waste is the street sweeping waste and the amount of waste collected by the street sweeping service in 2006 is as follows:

- Asuncion : 73 ton/day
- F.Mora : 10 ton/day

b. Street sweeping system

ba. Sweeping system

The present manual sweeping system is planned to be continued due to the following reasons:

- high unemployment ratio in the Study area; and
- poor road conditions such as relatively narrow streets, low asphalt and concrete pavement area, poor condition of storm water drains and curb stones, lack of parking areas, etc..

bb. Storage system

As for the storage system of swept waste, the 1.0 m^3 public container is proposed.

bc. Required number of containers

The number of containers required for the storage of swept waste is calculated by the following formula;

$$Qc = Qw \times 7/Qd/E/ASG \text{ (unit)}$$

Qc : Number of containers required (unit)
Qw : Waste collection amount (ton/day)
Qd : Number of working days per week = 6 (day)
E : Rate of efficiency = 0.8
ASG : Apparent Specific Gravity = 0.2

Consequently, the number of required containers for Asuncion and F.Mora is calculated as follows:

Municipality	Number (unit)
Asuncion	533
F.Mora	73

bd. Collection system

A collection system for street swept waste is proposed as the 13m³ compaction truck with the public container of 1.0m³.

be. Estimation of required number of collection vehicles

The required number of collection vehicles for each municipality was calculated based on the conditions and procedures described in the Section H.4.2.2, collection system.

With the above-mentioned procedures, the required number of collection vehicles for each municipality is calculated and tabulated in Table H.4.2.4a.

Table H.4.2.5a Required Number of Collection Vehicles for Street Sweeping

Alternative No. / Municipality	X-1	X-2	X-3	X-4	X-5
Asuncion	6	9	4	9	4
F.Mora	2	2	1	2	1

c. Cost estimate

ca. Method

The street sweeping service cost in 2006 of each alternative was estimated in accordance with the following methods:

- The total street sweeping service cost in 1993, which is the O & M expense excluding depreciation cost of equipment, of the city of Asuncion was calculated based on it in 1992 considering 17.8% of the inflation rate.
- The unit cost of street sweeping service work (Gs/ton) was calculated

by dividing the total collection cost by the total collection amount of swept waste observed by the truck scale.

- Since the present street sweeping service cost includes depreciation cost of equipment; it was calculated based on the price in 1993 and life span. The depreciation cost of collection vehicles includes some spare vehicles by means of their operation rate (0.9).
- The street sweeping cost obtained by the above-mentioned methods is divided into street sweeping (manually) cost and collection (1.0m^3 public container) cost.
- The unit street sweeping cost (manually) is simply calculated by subtracting the unit collection cost from the unit street sweeping service cost.
- Upon consideration of haulage distance, work efficiencies, etc., the time share of each work item (collection, haulage, discharge and miscellaneous) for each alternative was estimated based on the present time share of collection work by the compactor 13m^3.
- Unit collection cost (Gs/ton) for each alternative was calculated based on collection time and collection amount of one cycle time.

cb. Unit cost

According to the above mentioned method, the unit street sweeping service cost for each alternative was calculated and tabulated in Table H.4.2.4b and H.4.2.4c.

Table H.4.2.4b Street Sweeping Service Cost of Alternatives for Asuncion

Items / Alternatives	Unit	X-1	X-2	X-3	X-4	X-5
1. Unit Street Sweeping Cost	1,000 Gs/km/year	3,487	3,487	3,487	3,487	3,487
2. Unit Collection Cost	Gs/ton	18,914	31,265	17,996	28,841	17,996
3. Collection Amount	ton/year	26,645	26,645	26,645	26,645	26,645
4. Collection Cost	1,000 Gs/year	503,964	833,056	479,503	768,468	479,503
5. Unit Collection Cost	1,000 Gs/km/year	1,680	2,777	1,599	2,562	1,599
6. Unit Street Sweeping Service Cost (1 + 5)	1,000 Gs/km/year	5,167	6,264	5,086	6,049	5,086
7. Street Sweeping Service Length	km	300	300	300	300	300
8. Total Cost (6 x 7)	million Gs/year	1,550	1,879	1,526	1,815	1,526

Table H.4.2.4c Street Sweeping Service Cost of Alternatives for F.Mora

Items \ Alternatives	Unit	X-1	X-2	X-3	X-4	X-5
1. Unit Street Sweeping Cost	1,000 Gs/km/year	3,487	3,487	3,487	3,487	3,487
2. Unit Collection Cost	Gs/ton	21,901	31,265	17,996	28,841	17,996
3. Collection Amount	ton/year	3,650	3,650	3,650	3,650	3,650
4. Collection Cost	1,000 Gs/year	79,939	114,117	65,685	105,270	65,685
5. Unit Collection Cost	1,000 Gs/km/year	1,999	2,853	1,642	2,632	1,642
6. Unit Street Sweeping Service Cost (1 + 5)	1,000 Gs/km/year	5,486	6,340	5,129	6,119	5,129
7. Street Sweeping Service Length	km	10	10	10	10	10
8. Total Cost (6 x 7)	million Gs/year	219	254	205	245	205

H.4.2.5 Incineration Plant

a. Introduction

Incineration is a very hygienic and efficient method for waste treatment. The main reasons are as follows:

- Disinfection of the waste.
- Great reduction of the weight and volume of combustible waste. The method reduces the pressure on finding areas for new landfills and is prolonging the life of existing landfills.
- Recovery of heat energy. Energy from waste incineration can be utilized for the production of district heating and/or electricity, and the income from sale of energy contributes considerably to the economics of the plant.

Modern incineration and flue gas cleaning technology makes waste incineration an environmentally acceptable form of waste treatment and makes it possible to locate plants even in urban areas, leading to reduced transportation costs for waste.

b. Design Data

Though incineration is a versatile treatment method the waste has to fulfill some basic requirements. The main requirement is the lower calorific value. Approx 7,000 kJ/kg (1700 kcal/kg) is the recommended lowest value for obtaining reasonable combustion without additional fuel. Another requirement is that bulky combustible waste needs to be reduced in size by shredding prior to combustion.

ba. Calorific Value

In relation to this study a survey on waste composition and quantity were carried out in July 1993 and in January 1994. The results appear in Section I.1.3 in Annex I. The calorific value of MSW excluding street sweeping and bulky wastes is forecasted as follows:

Year	Lower Calorific Value (kcal/kg)
	Mixed
1993	1,192
2000	1,452
2006	1,697

The lower calorific value of domestic waste (approx. 1,192 kcal/kg in July 1993) appears to be below the recommended lowest value (1700 kcal/kg). There are a number of methods to increase the calorific value of waste which is brought to an incineration plant. Some of these methods are mentioned below:

- Separate collection system for the higher calorific municipal wastes could be introduced. This system should remove non-combustibles from wastes taken to an incineration plant. Also, separate collection of vegetable matter should be considered. This option has the possibility of agreeing with proposals for composting the vegetable fraction. However, the cost of separate collection systems is high and the total financial viability of such a scheme would require careful study.

- Municipal solid waste could be supplemented with selected high calorific value wastes from industry and commerce, such as paper, cardboard, plastics, etc.. Alternatively, the problem with the low calorific value of the waste could be solved either by using supplementary fuels or residuals from a possible composting plant.

- A feed stock preparation plant could be installed to process the municipal waste prior to incineration. Such a plant would have to be adapted to the conditions in the Study area, but would likely include a screening plant to separate out material less than about 50 mm in size, which would comprise mainly soil and glass.

Forecasts for the waste composition has been prepared based on the data of Japan, Brazil, Malaysia and the anticipated changes of lifestyle, economic and social conditions in Paraguay.
Since this study is to compare the MSWM cost in 2006 and to select an optimum technical system alternative, the present mixed collection system is assumed to be applied in future. The following technical description and cost estimates for the incineration plant is based on an assumed lower calorific value of 1700 kcal/kg by the year 2006.

bb. Working Hours

It is assumed that the incineration plant will operate in 3 shifts, 24 hour/day; 7 days a week. Thus the annual operational availability of the plant is assumed at 8,000 hours. The thermal plant efficiency is assumed as 0.6.

bc. Waste Quantity

The quantity of municipal solid waste which is expected to arrive at the incineration plant has been estimated below.

Table H.4.2.5a Quantity of Municipal Solid Waste for Incineration

Municipality / Year	Asuncion (tons/year)	F.Mora (tons/year)	Total (tons/year)
2001	161,900	28,200	190,100
2006	181,000	37,600	218,600

c. Required Capacity

Assuming 10% variation from month to month of the generated waste quantity and year 2006 to be the target year the overall capacity of the incineration plant is calculated as follows:

$$\frac{218{,}600x1.1}{8{,}000}=31\ tons/hour$$

or 3 incineration lines, 10.3 tons/hour each.

d. Technical Description

Several incineration technologies have been developed, but today the most appropriate is considered to be the movable grate incineration system based on mass burning of waste without pretreatment, (except for bulky combustible waste). Other incineration technologies employing fluidized bed technology or RDF have been developed, but technical problems, high costs and limited data and experience leave the mass burning principle as the most reliable solution.

Conventional mass incineration of waste without prior sorting or shredding and with a movable grate incineration is undoubtedly the most widely used and the best tested technology for the thermal treatment of waste. In combination with an advanced flue gas cleaning system this technology is developed and tested, and can meet the demands of technical performance and environmental standards which are now required in the developed countries. Furthermore, the moving grate incinerator is very versatile and is able to accommodate large variations in waste composition. An example of a typical mass-burn incinerator is shown in Figure H.4.2.5a. The essential plant parts are described below:

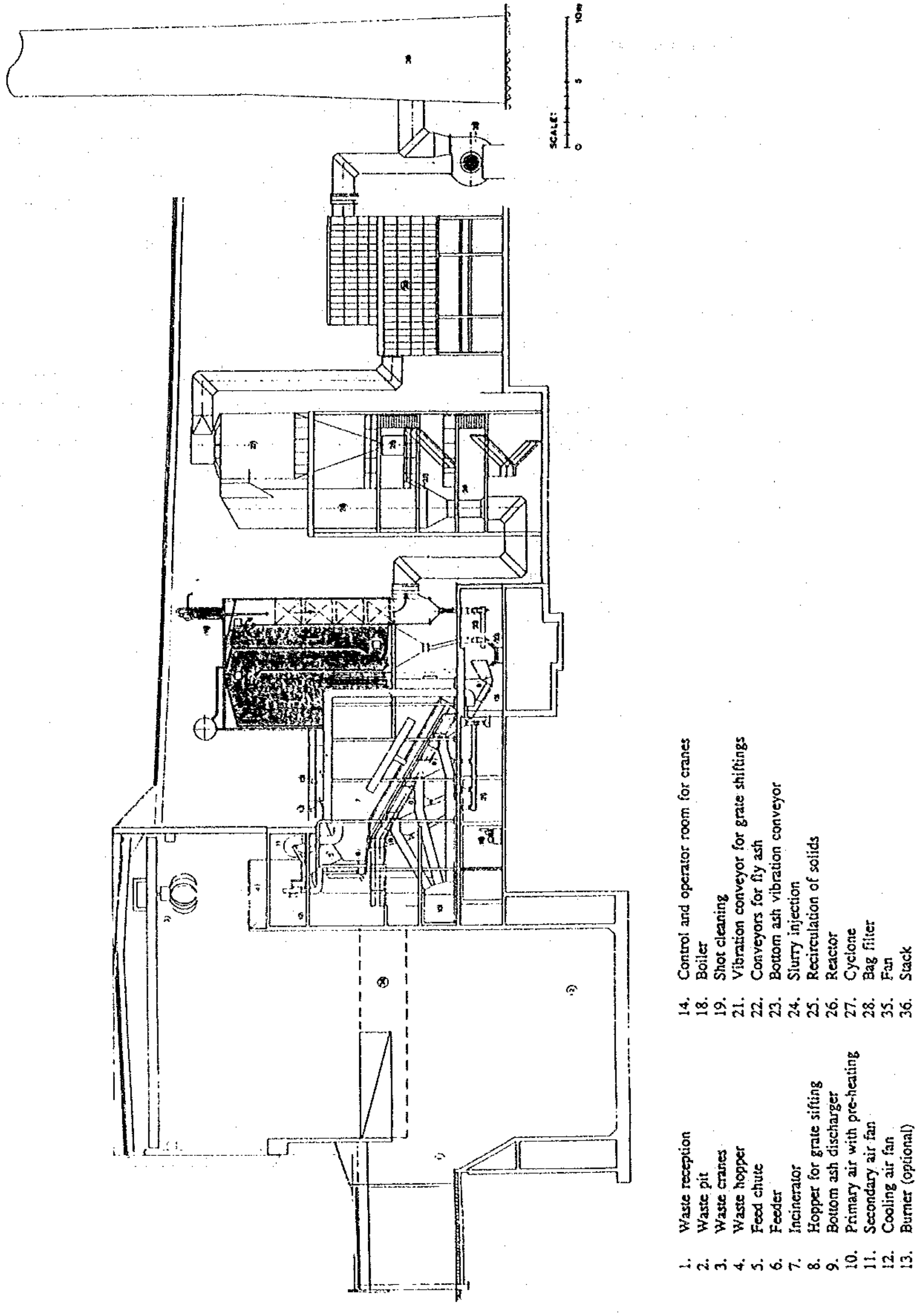


Figure H.4.2.5a Conceptual Layout of the Incineration Plant

da. Reception Area

The reception facilities comprises:

- Access road;
- Truck scales and their control house;
- Installations for waste control; and
- Building for waste reception including paved area in front of the building facilitating easy access and unloading of the trucks.

db. Waste pit and cranes

The waste pit should be designed for storing waste which is collected during weekdays but incinerated during the weekend. The capacity of the waste pit is calculated as follows:

$$\frac{218{,}600x1.1x3}{0.25x52x7} = 7{,}927 cu.m ------\rightarrow Say \quad 8{,}000 m^3$$

Overhead cranes including drivers cabin are recommended for feeding the incinerator lines. The cranes must as a minimum have a capacity corresponding to the design capacity of the incineration plant. The cranes will also be used for mixing the waste before feeding and for removing of waste from the unloading area. These functions will require 2 cranes with the capacity 20 tonnes/hour or 40-50 cu.m/hour per crane.

dc. Combustion Plant

The capacity of the combustion plant should be divided into at least 2 lines. As estimated earlier the required capacity is 3 treatment lines each 10.3 tons/hour. The combustion plant, which is installed in new building facilities, comprise the following installations:

- Waste hopper and feed chute.
- Grates. In order to obtain an adequate drying and total combustion of the waste from the Study area, a relative long grate, with a long drying/heating section is required. Further, the combustion plant might be furnished with a rotary kiln if the waste includes material of varying composition and material difficult to burn such as vegetables, compact paper, coarse pieces of wood, etc.
- Furnace room. The geometry of the furnace room must be selected

according to the character of the waste. The basic requirements for the furnace are adequate temperatures (950–1,050°C), good mixing of the flue gasses in the furnace and correct heat load (GJ/m^2).

- Combustion air blowers (primary, secondary and cooling air). Installation for pre-heating of the combustion air is assumed due to the relative high water content of the waste.
- Bottom ash discharger and sluice.

dd. Waste Heat Boiler and Steam Turbine Generator

The waste heat boiler plant comprises:

- Waste heat boiler;
- Superheater;
- Water feed equipment;
- Economizer; and
- Automatic control equipment.

The steam turbine generator plant comprises:

- Steam turbine generator;
- High pressure steam header; and
- Low pressure steam header.

The condensing plant comprises:

- High pressure steam condenser;
- Low pressure steam condenser;
- Condensate tank; and
- Deionizer (demineralizer).

de. Flue gas Cleaning System

Today, different flue gas cleaning systems are available. The basic systems are:

- The dry system
- The semi-dry system
- The wet system

The above systems have advantages as well as disadvantages. All systems are adequate in relation to the current developed countries standard. Generally, a semi-dry scrubber will yield better results than a dry scrubber, and it is usually possible to obtain an acid gas reduction of 95% with a reasonable lime consumption.

df. Equipment for handling of Slag and Ash Products.

The equipment for handling of slag and ash comprise vibrating conveyors, screw conveyors and slag hoists.

dg. Auxiliary Equipment

This equipment includes the following:

- Instrumentation
- Monitoring and control system
- Hydraulic installations
- Compressor installations
- Low and high voltage installations
- Fire fighting installations and equipment
- Drainage systems
- Heating and air conditioning
- Lighting
- Cleaning facilities
- Supply systems (air, water, electricity, etc.)

dh. Buildings and Site

For the incineration plants the required building areas is approximately 6000 sq.m.. Furthermore, internal roads and open areas are required.

di. Waste Flow

Input to and output from an incineration plant is indicated in Figure H.4.2.5b.

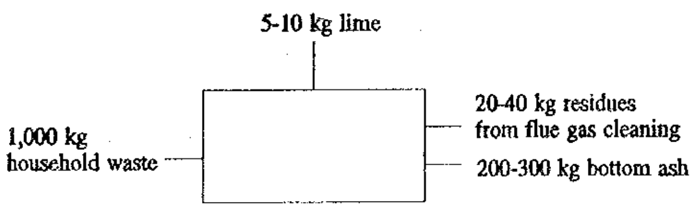


Figure H.4.2.5b Input and Output in Weight Fractions from an Incineration Plant assuming a Semi Dry Flue Gas Cleaning System

dj. Output of power generation

The output of power generation is calculated by the formula below:

$Qe = Qset \times Uqe$

Qe	: Output of power generation (kw/hour)
Qset	: Steam amount at the entrance of turbine (ton/hour)
Uqe	: Power generation per unit steam amount (kwh/ton)

$Qset = Qs - Qso$

Qs	: Total steam generation (ton/hour)

$$Qs = Bc \times Wi \times Lcv \div Hg \times 1/1000$$

Qso	: Total steam consumption other than it for power generation (ton/hour)
Bc	: Efficiency of boiler = 80%
Wi	: Waste incinerated amount = 25,000 kg/hour
Lcv	: Lower calorific value of waste = 1,700 kcal/kg
Hg	: Calorific value of generated steam = 575 kcal/kg

Consequently, the total steam generation is calculated as follows:

$Qs = 0.8 \times 25{,}000 \times 1{,}700 \div 575 \times 1/1000 = 59.13$ ton/hour

Since the total steam consumption other than it for power generation (Qso) is 15% of the steam amount at the entrance of turbine (Qset). Then,

$Qset = 59.13 \times (1 - 0.15) = 50.26$ ton/hour

Finally, the output of power generation (Qe) is calculated as follows:

$Qe = 50.26 \times 160$ (kw/ton) = 8,041.6
Say **8,000 kw/hour**

c. Cost Estimates

Based on the described conceptional lay-out, this Section presents cost estimates for the construction and operation of the incineration plant at Cateura. All estimates are elaborated assuming price level as described in the Section 2.4.2.

Table H.4.2.5b Initial Investments for Incineration Plant, 31 tonnes/hour capacity

Capacity: 31 tonnes/hour	PRICE LEVEL IN	
Mechanical and electrical equipment and civil works	Developed Countries MILL US$	Paraguay MILL.Gs
- Furnaces, boilers, steam turbine generator, semi-dry flue gas cleaning systems incl. bag filters and blowers.	37.5	
Computerized operation/monitoring system:		
- Various machinery cranes, shredder, truck scale, compressors etc.:	3.2	
- Construction works incl. waste silo, buildings (approx 6000m^2), chimney, earth works, roads etc:(a)		7,900
- Design, supervision and training:	3.8	1,100
- Miscellaneous 10%:	4.5	1,200
TOTAL: Investments	49.0	10,200

Note: Investment for purchase of land and connection fees (sewerage, electricity, water etc.) are not included.

Table H.4.2.5c Operation Costs for Incineration Plant, 31 tonnes/hour capacity

Capacity: 31 tonnes/hour	Price level in Paraguay mill. Gs/year
Operation costs in 2006	
- Labor Costs (50 persons):	270
- Lime, electricity etc.:	1,350
- Transportation cost of residues	80
- Maintenance:	1,500
- Administration (15%)	480
TOTAL: Annual operation costs	3,680

d. Summary of Incineration Plant

Summary of the described incineration plants is presented in the tables below, including quantity of waste treated, output, investments and operation costs and revenue from sale of generated electricity. Mixed collection is assumed.

Table H.4.2.5d Summary for Incineration Plant, Capacity 218,600 tons/year

Capacity of plant at 8,000 working hour/year		218,600 tonnes/year
Investment		49.0 mill. US$ + 10,200 mill. Gs
Annual operation costs (average year 2000 to 2010)		3,680 mill. Gs
Year	Waste received (tonnes/year)	Electricity Generation Revenue from Sale of Electricity
2006	218,600	8,000 kw/hour 1,431 mill. Gs/year

H.4.2.6 Sanitary Landfill

a. Introduction

It is generally recognized that a sanitary landfill is the basic element for modern solid waste management. Thus, it is acknowledged that a considerable quantity of waste has to be disposed of even if efforts are provided to reuse (recycling) or utilize (incineration, composting) the waste. The sanitary landfill is, therefore, included in all the alternative plans.

As a first step towards modern solid waste management, the metropolitan area of Asuncion is recommended to strengthen the landfill activity minimizing the environmental impact. Having the requirements for the sanitary landfill clarified and proper design and operation implemented, it is possible to draw the attention to other treatment method.

This section presents the conceptual layouts and cost estimates for landfills in accordance with the concept of the alternative plans.

The location of the proposed landfill sites of the each alternative plan are shown in the following figure.

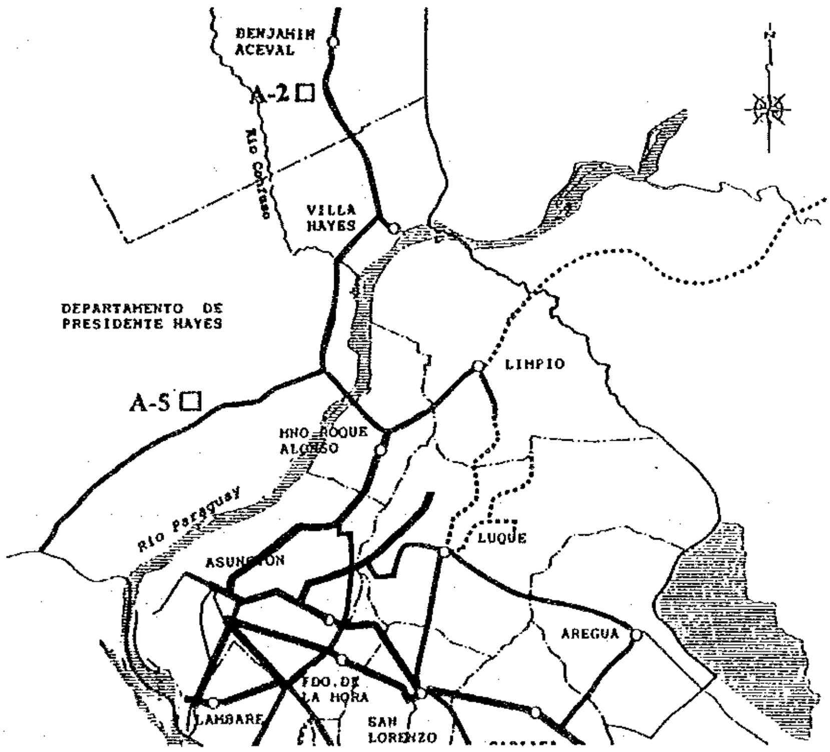


Figure H.4.2.6a Locations of the Landfill Sites of Each Alternative Plan

b. Design Data

ba. Alternative X-1

The following assumptions are set up for calculation of the waste quantity for final disposal.

- The proposed landfill site receives waste carried from Asuncion and Fernando de la Mora.
- The operation of the incineration plant will commence in 2001.
- The final disposal amount consists of the following:
  - The residue from the incineration plant which is 35 % of the total amount of the collection waste.
  - Industrial wastes (other wastes)
- The operation of the new sanitary landfill will commence in the beginning of 1997.

The waste quantities for final disposal are summarized as follows.

Table H.4.2.6a Final Disposal Amount from 1997 to 2006 unit:ton

	Residue	Other Waste Disposed	Total
Asuncion	460,731	706,987	1,167,717
Fernando de la Mora	145,105	100,908	246,016
Total	548,889	807,895	1,356,784

bb. Alternatives X-2 and X-3

The following assumptions are set up for calculation of the waste quantity for final disposal.

- The proposed landfill site receives waste carried from Asuncion and Fernando de la Mora.
- The operation of the new sanitary landfill will commence in the beginning of 1997.

The waste quantities for final disposal are summarized in the following table.

Table H.4.2.6b Waste Amount of Final Disposal for Alternative X-2 and X-3

Year	Municipal Waste Collected		ISW Disposed	Final Disposal
	Asuncion (ton/year)	Fernando de la Mora (ton/year)	(ton/year)	(ton/year)
1993	146,365	14,600	11,680	172,645
1994	151,840	16,529	11,836	180,206
1995	157,315	18,459	11,993	187,766
1996	162,790	20,388	12,149	195,327
1997	168,265	22,317	12,306	202,888
1998	173,740	24,246	12,462	210,449
1999	179,215	26,176	12,619	218,009
2000	184,690	28,105	12,775	225,570
2001	188,523	30,295	12,897	231,714
2002	192,355	32,485	13,018	237,858
2003	196,188	34,675	13,140	244,003
2004	200,020	36,865	13,262	250,147
2005	203,853	39,055	13,383	256,291
2006	207,685	41,245	13,505	262,435
Total 1997-2006 (ton)	1,894,534	315,464	129,367	2,339,363

bc. Alternatives X-4 and X-5

All assumptions for alternatives X-4 and -5 are same as alternatives X-2 and X-3 except the proposed location of the landfill site. The proposed location of the landfill is 1.2 km west of the Rio Negro in Villa Hayes, as shown in Figure H.4.2.6a.

c. Required Capacity of Landfill Sections

ca. Alternative X-1

V1, the required capacity of the landfill section for waste received for 10 years from 1997 until 2006, is calculated as follows, assuming that the unit weight of the waste compacted in a landfill is 0.8 ton/m^3 and the unit weight of the residue of incineration is 1.1 t/m^3.

$$V1 = \frac{548,889}{1.1} + \frac{807,895}{0.8} = 1,508,859 \ cu.m$$

The required volume of soil for covering wastes is calculated as follows, assuming the required volume of soil for daily cover excluding final cover is 16.5 % of the total waste volume disposed.

$$V2 = 1,508,859 \ x \ 0.165 = 248,962 \ cu.m$$

Hence, the required capacity of the landfill section is calculated as follows.

$$\Sigma V = V1 + V2 = 1,757,821 \ cu.m$$

cb. Alternatives X-2, X-3, X-4 and X-5

V1, the required capacity of the landfill section for waste received for 10 years from 1997 until 2006, is calculated as follows, assuming that the unit weight of the waste compacted in a landfill is 0.8 ton/m^3 and the unit weight of the residue of incineration is 1.1 t/m^3.

$$V1 = \frac{2,339,363}{0.8} = 2,924,204 \ cu.m$$

The required volume of soil for covering wastes is calculated as follows, assuming the required volume of soil for daily cover excluding final cover is 16.5 % of the total waste volume disposed.

$$V2 = 2,924,204 \ x \ 0.165 = 482,494 \ cu.m$$

Hence, the required capacity of the landfill section is calculated as follows:

$$\Sigma V = V1 + V2 = 3,406,698 cu.m$$

d. Technical Description

The landfill site should be made up with the following facilities.

- **Main Facilities**

  . Enclosing structure:
  Enclosing bund/divider
  . Drainage system:
  Surrounding drain/on-site drain(surface)/on-site drain (under-ground)/drain for reclaimed area
  . Access:
  Approach road/on-site road/improvement of existing road

- **Environmental protection facilities**

  . Buffer zone
  . Litter scatter control facilities
  . Gas removal facilities
  . Leachate collection facilities
  . Leachate circulation facilities
  . Seepage control facilities

- **Building and accessories**

  . Site office
  . Weigh bridge
  . Storage building
  . Safety facilities:
  Gates/fences/street lights
  . Fire prevention facilities:
  Water tank, extinguisher,
  . Other:
  Parking lot/greenery/car wash, etc.

da. Enclosing Structure

The purpose of the enclosing structure is to store wastes and to control leachate from waste in a landfill site. There are some kinds of enclosing structures.

- **Enclosing Bund**

The enclosing bund which is banked with earth around the filling area is required to be provided to prevent seepage of rainwater. Because the disposal site is located on flat land in order to carry out sanitary landfill, enclosing the landfill site will be a bund for the prevention of rain water infiltration.
The dimension of enclosing structure is set up as follows.

.	Gradient of Slope:	1 in 2
.	Crest of Embankment:	5.0 m
.	Height of 1st Bund:	5.0 m
.	Height of 2nd Bund:	2.5 m
.	Material of Bund Structure:	Soil

- **Divider**

The divider which is made of soil is provided inside the enclosing bund to block rain water seepage through the waste dumped. The purpose of a divider is to reduce quantity of leachate.
The dimension of enclosing structure is set up as follows.

.	Gradient of Slope:	1 in 2
.	Crest of Embankment:	1.5 m
.	Height of Bund:	1.5 m
.	Material of Bund Structure:	Soil for Level 3 Waste inside and soil outside for Level 2

db. Drainage System

A drainage system has a very important role to maintain the site and roads in good condition and also to minimize influence by rainwater to leachate control facilities. Different types of drainage are adopted for the concept of this alternative examination, as described below:

- **Surrounding Drain**

The surrounding drain is generally provided around the landfill to intercept the all rain water draining from the landfill area and to seep out of the site. The dimensions which are adopted for this examination are shown below.

.	Top Width:	5.0 m
.	Bottom Width:	2.0 m
.	Gradient of Slope:	1 in 1
.	Depth:	1.5 m
.	Surface of Drain:	No lining

- **On-site Drain (for surface water)**

The on-site drain is provided to keep the working area dry in the landfill site surrounded with an enclosing band. This is an open drain without lining.
The dimensions of the on-site drain for surface water which are adopted for this examination are shown below:

. Top Width:	2.0 m
. Bottom Width:	1.0 m
. Gradient of Slope:	1 in 1
. Depth:	0.5 m
. Surface of Drain:	No lining
. Interval of installation:	Every 100 m

- **On-site Drain (culvert)**

The on-site drain is to drain out rain water from inside the enclosed area with bands to the surrounding drain in the outside.
The dimensions of the on-site drain of culvert which are adopted for this examination are shown below:

. Pipe Diameter:	0.6 m
. Wing wall:	Concrete walls are provided in both ends

- **Intercepter Drain for Reclaimed Area**

The intercepter drain is provided to intercept surface water on the completed area of landfill. Intercepting surface water can work to prevent seepage of rain water into waste layer and also to protect slope of enclosing band.
The dimensions of the intercepter drain which are adopted for this examination are shown below.

. Top Width:	2.0 m
. Bottom Width:	1.0 m
. Gradient of Slope:	1 in 1
. Depth:	0.5 m
. Surface of Drain:	No lining

dc. Access

- **Approach Road (Outside)**

This road is provided at the entrance of the landfill site so that the waste collection trucks to enter and exist the site without any disturbance to the public traffic. The dimensions of the approach roads which are adopted for this examination are shown below.

- Carriageway width: 7.0 m
- Shoulder width: 1.0 m at both sides
- 3 paved layer in the carriage way

  Top layer: 5 cm of asphalt binder course
  Middle layer: 15 cm of crushed stone base course
  Bottom layer: 15 cm of sand or laterite sub–base course

– Approach Road (Inside)

The approach road (inside) is a temporary road for landfill works which is provided in the site except for a slope road. The dimensions of the approach roads which are adopted for this examination are shown below.

- Thickness of paved road: 0.5 m
- Width of paved road: 4.0 m
- Material: Crushed stone

– On–site Road

The on–site road is a slope road which connects the top of bund and the working area and roads. Its dimension is same as the approach road (inside).

dd. Environmental Protection Facilities

The facilities are for the prevention of primary and secondary pollution outbreak during and after completion of landfill operations.

– Buffer Zone

Buffer zone is provided between the disposal site and the residential area for the purpose of;

- Screening the landfill site from residents,
- Reducing the noise and vibrations emitted during landfilling operation,
- Reducing odors, and
- Balancing the site with the natural surroundings in a harmonious fashion.

The buffer zone is formed with a green belt made of plants and its width is 50 m.

- **Litter Scatter Prevention Facilities**

Litter control within the landfill site follows the same measure as is taken for disaster and pest control, wherein principally the covering material acts as the main agent. Nevertheless, there looms the inevitability of litter scattering during the landfill operations before the covering material has been placed. As a means of prevention, a movable fence to catch flying litter will be put up.

- **Gas Removal Facilities**

For the organic matters present during landfilling operations, decomposition occurs by microbes and results in the production of water, gas and inorganic chlorides. If the landfill structure houses aerobic matters, this gives rise to aerobic bacterial activity therefore the decomposition is early; carbon dioxide, water, ammonia etc. are produced, without a problem. On one hand, if the structure houses anaerobic matters, this gives rise to anaerobic bacterial activity with slow decomposition, thus odors and combustible gases, such as methane, carbon dioxide, hydrogen sulphide and ammonia, badly affecting the environment.

Generally, as for the outbreak of gas in landfill sites, gushing and exhausting are common at weak points on the boundary surface between landfill sites and surrounding structures. Disaster prevention measures, which are represented by gas removal facilities, are necessary at points where gas pockets burst unexpectedly occurs and thus producing fires, odors etc..

As for gas removal facilities, as shown below, there are three types under consideration: by evacuation, by pumping and by ventilation. Within these designs, the most economical gas removal facility, the one by evacuation, has been selected.

The completed landfill site gas removal facilities have been designed at 3-4 positions per hectare. As for disaster prevention measure, the gas removal facilities make counteraction quite possible. However, the covering material is the most important factor, as it is necessary to not leave waste exposed over a long term.

- **Leachate Collection Facilities**

Their purpose is to collect rainwater contaminated by waste, the water within waste as well as decomposed polluted water and send it to the leachate control facilities. At the same time, they play a shield-like role for the prevention of deterioration of the surrounding areas by the permeation or discharge of contaminated water. Moreover, depending on the joining of the leachate collection facilities to the gas removal facilities, it is also possible to expand the aerobic area within the landfill layer.

As for the leachate collection facilities, depending on the topography, the configuration on the landfill and the structures, there are many combinations considered. The functions are classified below:

- Horizontal leachate collection

  Leachate collection which doesn't allow for leachate to result to rest in the landfill site is based on a down flowing, natural type of collection. The facilities will be established at the bottom of the landfill site.

- Vertical leachate collection

  The landfill layer is thick thus suggesting that the time it takes for leachate to reach the bottom of the landfill site for collection is long. In this case, a vertical leachate collection facility will also be established.

- Leachate drain pipe

  This is discharging the leachate collected by the site's inner facilities to the outside.

  The slope and the vertical gas removal facilities will be used as a substitute for the vertical leachate collection facilities.

– **Leachate Circulation Facilities**

Leachate discharged into the surface and underground flow is a pollution source for the surrounding environment. The leachate amount is determined in relation with the water input within the landfill site (rainfall, surface water and spring water).

– **Seepage Control Facilities**

Seepage control facility is a lining sheet provided on the bottom of the landfill area to prevent a leachate seepage.

de. Building and Accessories

These facilities include a site office, a truckscale, safety facilities, fire prevention facilities, storage building, monitoring facilities, car washing, etc.

df. Slope Turfing

This is to protect slope erosion and also to harmonize the landfill into nature.

e. Cost Estimates

ea. Basic Condition for Cost Estimates

The following assumptions are set up as the basic conditions for cost estimation.

- The land acquisition cost is excluded.
- The cost of borrow soil is 10,000 Gs/m^3 if delivered to the site.
- The particular conditions of the site are not taken into account.

eb. Method of the Cost Estimation

The work quantities are taken out from the conceptual design of each alternative plan prepared based on the technical descriptions described in this section and also some site conditions.

ec. Alternative X-1

eca. Arrangement of Sanitary Landfill in Cateura

The estimated final disposal amount from 1997 to 2006 is 1,356,081 tons and the required capacity of landfill section is 1,756,797 m^3. Therefore, the required area of the proposed landfill is 37 ha. The arrangement of the sanitary landfill in Cateura is presented below.

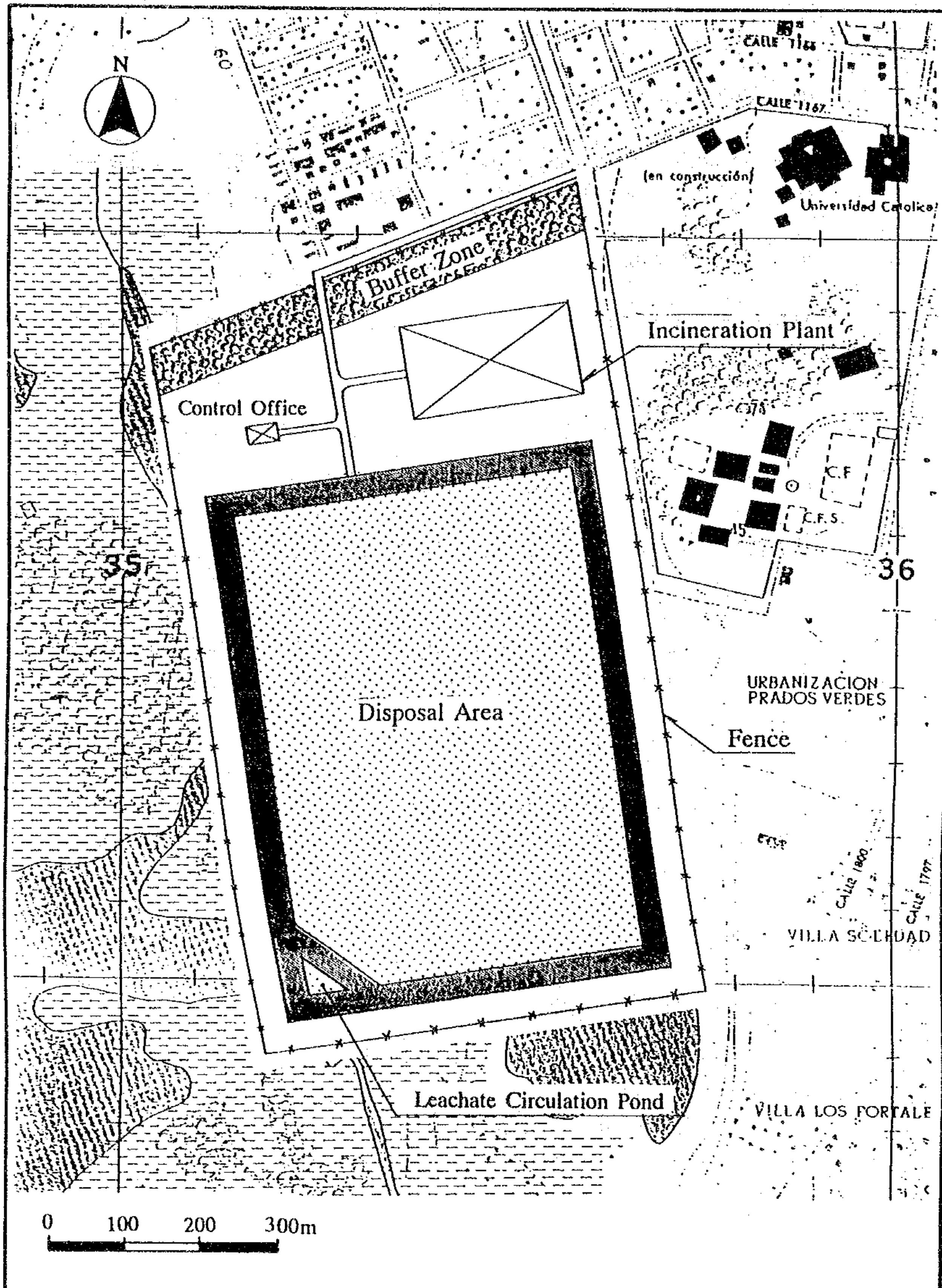


Figure H.4.2.6b Arrangement of Sanitary Landfill in Cateura

ecb. Investment Cost

Total investment cost of the landfill which is presented in Figure H.4.2.6b is estimated as shown in Table H.4.2.6c.

Table H.4.2.6c Total Investment of Landfill in Alternative X-1
Total Disposal Amount: 1,356,784 m^3

No.	Items	unit	Quantity	Amount (mill.Gs)
1.	**Main Facilities**			4,743
1.1	Enclosing Structure			3,525
1.1.1	Enclosing Bund H=5m	m	2,153.00	2,422
1.1.2	Enclosing Bund H=2.5m	m	2,104.00	789
1.1.3	Divider	ha	26.34	314
1.2	Drainage System			107
1.2.1	Surrounding Drain	m	2,293.00	48
1.2.2	On-site Drain (for surface)	ha	26.34	11
1.2.3	On-site Drain (for culvert)	no	4.00	33
1.2.4	Drain for Reclaimed Area	ha	26.34	15
1.3	Access			1,110
1.3.1	Approach Road (Outside)	m	100.00	29
1.3.2	Approach Road (Inside)	m	8,516.00	903
1.3.3	On-site Road	no	11.00	179
2.	**Environmental Protection Facility**			4,406
2.1	Buffer Zone	m2	29,161.00	23
2.2	Litter Removal Facilities	ha	26.34	120
2.3	Gas Removal Facilities	ha	26.34	47
2.4	Leachate Collection Facilities	ha	26.34	830
2.5	Leachate Circulation Facilities	Ls	1.00	140
2.6	Seepage Control Facilities	m2	263,400.00	3,245
3.	**Building and Accessories (10%)** Including Site Office, Weigh Bridge, Storage Building, Safety Facilities, Fire Prevention Facilities, Monitoring Facilities, Car Wash, etc.			915
4.	**Slope Turfing**	m^2	38,258.00	291
5.	**Miscellaneous (20%)**	ha		2,071
	Total of Direct Cost			12,425
	General Expense and Overhead (30%)			3,727
	Total of Construction Cost			16,152
	Design and Supervision (10%)			1,615
			Investment Total Cost (mill.Gs)	17,767
			Investment Unit Cost (Gs/ton)	12,448

ecc. Operation and Maintenance Cost

In compliance with the design level of landfill, the operation and maintenance cost in 2006 is estimated in Table H.4.2.6d.

Table H.4.2.6d O&M Cost of Landfill in 2006 of Alternative X-1
Disposal Amount in 2006: 103,743 ton

Item	Quantity	Amount (mill.Gs)
Machinery		
Bulldozer, 21 ton class	2	159
Backhoe, 0.7 m^3 class	0	0
Water tanker	1	41
Pick up	1	20
Dump truck	0	0
Water pump	2	4
Labor		
Foreman	1	12
Truckscale operator	2	14
Machine Operator	4	48
Mechanic	0	0
Unskilled Worker	6	41
Material		
Soil for covering waste	16,772	168
Insecticide	1	9
Regent for Monitoring	1	4
Diesel	153,252	74
Oil and lubricant	1	3
Utility		
Water	1	2
Electricity	1	4
Total O&M Cost (mill.Gs)		603
O&M Unit Cost (Gs/ton)		5,812

ecd. Total Disposal Cost

The total disposal cost consisted of investment and O&M cost is summarized in Table H.4.2.6e.

Table H.4.2.6e Total Disposal Cost of Alternative X-1

Item	Total Cost	Total Cost in 2006	Unit Cost
Investment Cost	17,767 mill. Gs	1,359 mill. Gs/year	13,100 Gs/ton
O & M Cost	N.A.	603 mill. Gs/year	5,812 Gs/ton
Total	N.A.	1,962 mill. Gs/year	18,912 Gs/ton

ed. Alternatives X-2 and X-3

eda. Arrangement of Sanitary Landfill in A-2 Site

The estimated final disposal amount from 1997 to 2006 is 2,339,363 tons and the required capacity of landfill section is 3,411,571 m^3. Therefore, the required area of the proposed landfill is 43.5 ha, even though the acquired land area is 85 ha. The arrangement of the sanitary landfill in A-2 site is presented below.

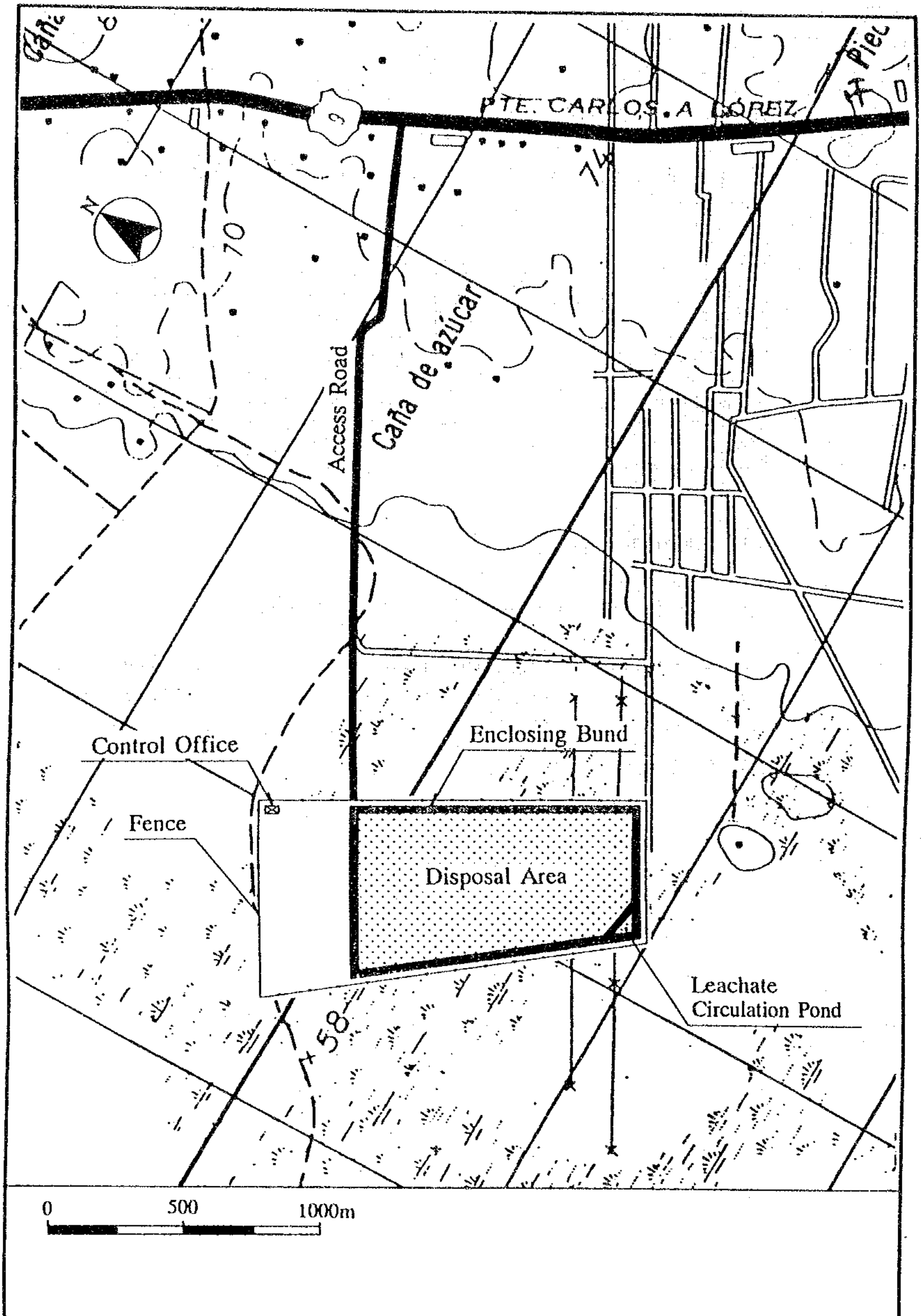


Figure H.4.2.6c Arrangement of Sanitary Landfill in A-2 Site

edb. Investment Cost

Total investment cost of the landfill which is presented in Figure H.4.2.6b is estimated as shown in Table H.4.2.6f.

Table H.4.2.6f Total Investment of Landfill in Alternatives X-2 and X-3
Disposal Amount in 2006: 2,339,363 ton

No.	Items	Quantity	Amount (mill.Gs)
1.	**Main Facilities**		7,243
1.1	Enclosing Structure		4,836
1.1.1	Enclosing Bund H=5m	2,890.00	3,251
1.1.2	Enclosing Bund H=2.5m	2,842.00	1,066
1.1.3	Divider	43.48	519
1.2	Drainage System		156
1.2.1	Surrounding Drain	3,030.00	64
1.2.2	On-site Drain (for surface)	43.48	17
1.2.3	On-site Drain (for culvert)	6.00	50
1.2.4	Drain for Reclaimed Area	43.48	25
1.3	Access		2,251
1.3.1	Approach Road (Outside)	2,600.00	743
1.3.2	Approach Road (Inside)	11,464.00	1,215
1.3.3	On-site Road	18.00	293
2.	**Environmental Protection Facility**		7,143
2.1	Buffer Zone	0	0
2.2	Litter Removal Facilities	43.48	198
2.3	Gas Removal Facilities	43.48	78
2.4	Leachate Collection Facilities	43.48	1,370
2.51	Leachate Circulation Facilities	1.00	140
2.6	Seepage Control Facilities	434,800.00	5,357
3.	**Building and Accessories** (10%) Including Site Office, Weigh Bridge, Storage Building, Safety Facilities, Fire Prevention Facilities, Monitoring Facilities, Car Wash, etc.		1,439
4.	**Slope Turfing**	51,357.00	390
5.	**Miscellaneous** (20%)		3,242
	Total of Direct Cost		19,457
	General Expense and Overhead (30%)		5,838
	Total of Construction Cost		25,295
	Design and Supervision (10%)		2,529
		Investment Total Cost (mill.Gs)	27,824
		Investment Unit Cost (Gs/ton)	11,894

edc. Operation and Maintenance Cost

In compliance with the design level of landfill, the operation and maintenance cost in 2006 is estimated in Table H.4.2.6g.

Table H.4.2.6g O&M Cost of Landfill in 2006 of Alternatives X-2 and X-3
Disposal Amount in 2006: 262,435 ton

Item	Quantity	Amount
Machinery		
Bulldozer, 21 ton class	5	399
Backhoe, 0.7 m^3 class	1	67
Water tanker	1	41
Pick up	2	39
Dump truck	1	43
Water pump	3	6
Labor		
Foreman	1	12
Truckscale operator	2	14
Machine Operator	10	120
Mechanic	1	12
Unskilled Worker	15	101
Material		
Soil for covering waste	43,739	437
Insecticide	1	24
Regent for Monitoring	1	10
Diesel	420,433	202
Oil and lubricant	1	10
Utility		
Water	1	4
Electricity	1	6
Total O&M Cost (mill.Gs)		1,547
O&M Unit Cost (Gs/ton)		5,893

edd. Total Disposal Cost

The total disposal cost consisted of investment and O&M cost is summarized in Table H.4.2.6h.

Table H.4.2.6h Total Disposal Cost of Alternatives X-2 and X-3

Item	Total Cost	Total Cost in 2006	Unit Cost
Investment Cost	27,823 mill. Gs	2,782 mill. Gs/year	11,894 Gs/ton
O & M Cost	N.A.	1,547 mill. Gs/year	5,893 Gs/ton
Total	N.A.	4,329 mill. Gs/year	17,787 Gs/ton

ee. Alternatives X-4 and X-5

eea. Arrangement of Sanitary Landfill in A-5 Site

The estimated final disposal amount from 1997 to 2006 is 2,339,363 tons and the required capacity of landfill section is 3,411,571 m³. Therefore, the required area of the proposed landfill is 43.6 ha, even though the acquired land area is 216 ha. The arrangement of the sanitary landfill in A-5 site is presented below.

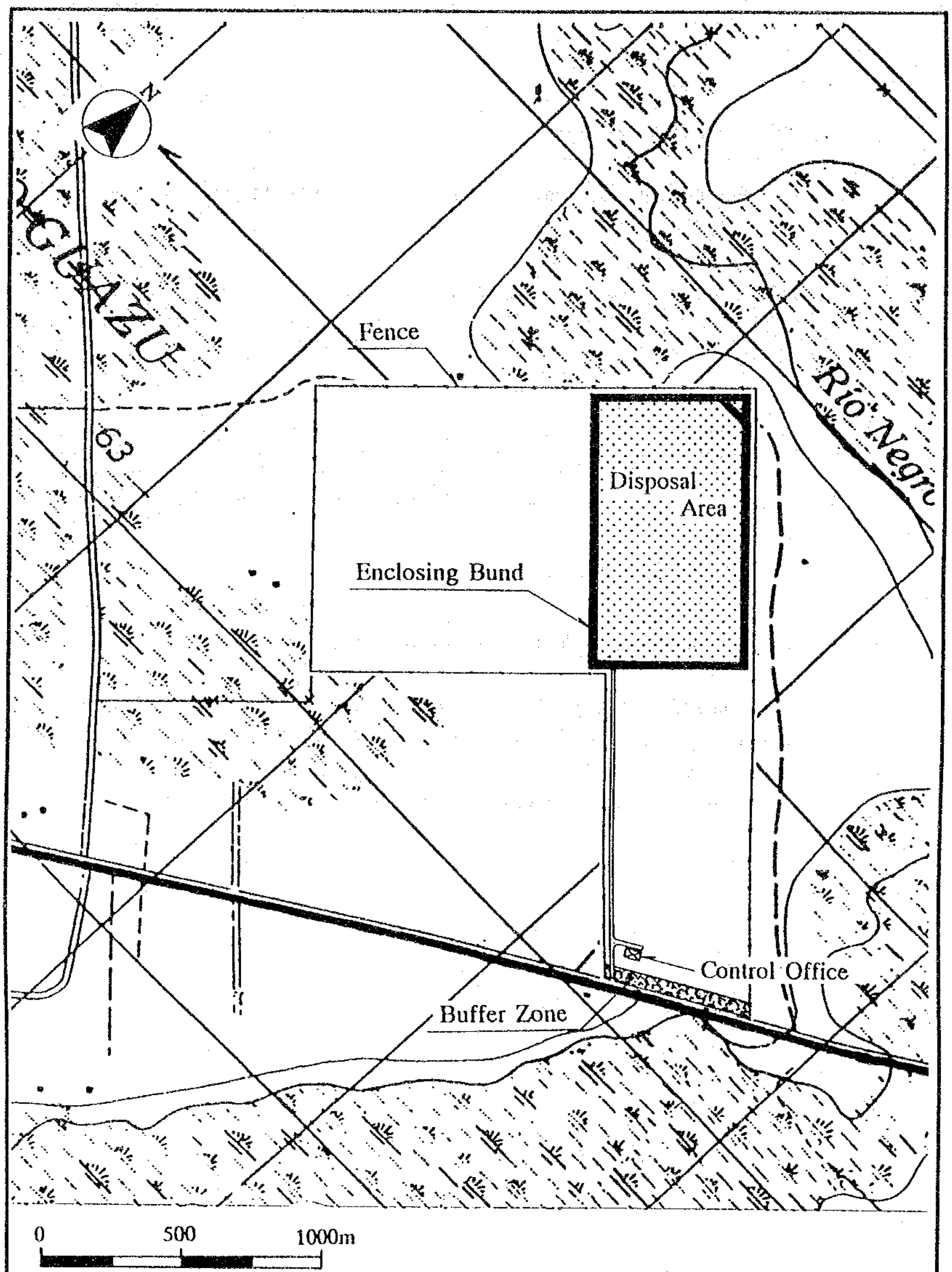


Figure H.4.2.6d Arrangement of Sanitary Landfill in A-5 Site

eeb. Investment Cost

Total investment cost of the landfill which is presented in Figure H.4.2.6d is estimated as shown in Table H.4.2.6i.

Table H.4.2.6i Total Investment of Landfill in Alternatives X-4 and X-5
Disposal Amount in 2006: 2,339,363 ton

No.	Items	Quantity	Amount (mill.Gs)
1.	**Main Facilities**		6,467
1.1	Enclosing Structure		4,793
1.1.1	Enclosing Bund H=5m	2,860.00	3,218
1.1.2	Enclosing Bund H=2.5m	2,812.00	1,055
1.1.3	Divider	43.61	520
1.2	Drainage System		150
1.2.1	Surrounding Drain	2,780.00	58
1.2.2	On-site Drain (for surface)	43.61	17
1.2.3	On-site Drain (for culvert)	6.00	60
1.2.4	Drain for Reclaimed Area	43.61	25
1.3	Access		1,524
1.3.1	Approach Road (Outside)	100.00	29
1.3.2	Approach Road (Inside)	11,344.00	1,202
1.3.3	On-site Road	18.00	293
2.	**Environmental Protection Facility**		7,184
2.1	Buffer Zone	26,000.00	21
2.2	Litter Removal Facilities	43.61	198
2.3	Gas Removal Facilities	43.61	78
2.4	Leachate Collection Facilities	43.61	1,374
2.5	Leachate Circulation Facilities	1.00	140
2.6	Seepage Control Facilities	436,100.00	5,373
3.	**Building and Accessories** (10%) Including Site Office, Weigh Bridge, Storage Building, Safety Facilities, Fire Prevention Facilities, Monitoring Facilities, Car Wash, etc.		1,365
4.	**Slope Turfing**	50,827.00	386
6.	**Miscellaneous** (20%)		3,080
	Total of Direct Cost		18,483
	General Expense and Overhead (30%)		5,844
	Total of Construction Cost		24,027
	Design and Supervision (10%)		2,403
		Investment Total Cost (mill.Gs)	26,430
		Investment Unit Cost (Gs/ton)	11,298

eee. Operation and Maintenance Cost

Table H.4.2.6j O&M Cost of Landfill in 2006 of Alternatives X-4 and X-5
Disposal Amount in 2006: 262,435 ton

Item	Quantity	Amount
Machinery		
Bulldozer, 21 ton class	5	399
Backhoe, 0.7 m^3 class	1	67
Water tanker	1	41
Pick up	2	39
Dump truck	1	43
Water pump	3	6
Labor		
Foreman	1	12
Truckscale operator	2	14
Machine Operator	10	120
Mechanic	1	12
Unskilled Worker	15	101
Material		
Soil for covering waste	43,739	437
Insecticide	1	24
Regent for Monitoring	1	10
Diesel	420,433	202
Oil and lubricant	1	10
Utility		
Water	1	4
Electricity	1	6
Total O&M Cost (mill.Gs)		1,547
O&M Unit Cost (Gs/ton)		5,893

eed. Total Disposal Cost

The total disposal cost consisted of investment and O&M cost is summarized in Table H.4.2.6k.

Table H.4.2.6k Total Disposal Cost of Alternatives X-4 and X-5

Item	Total Cost	Total Cost in 2006	Unit Cost
Investment Cost	26,431 mill. Gs	2,643 mill. Gs/year	11,298 Gs/ton
O & M Cost	N.A.	1,547 mill. Gs/year	5,893 Gs/ton
Total	N.A.	4,190 mill. Gs/year	17,191 Gs/ton

H.4.3 Evaluation

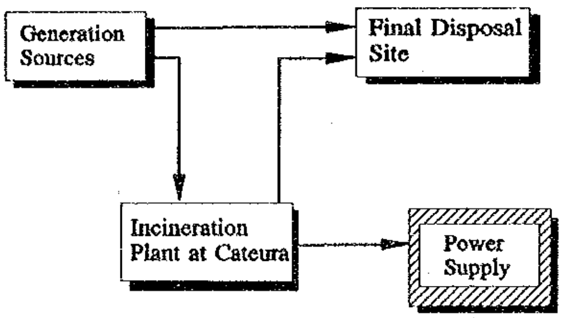
H.4.3.1 Summary of Alternatives

a. Summary of Alternatives Systems

5 Alternatives for each municipality are illustrated below.

aa. Alternative X-1

Independent Disposal
An incineration plant at Cateura; and
A sanitary landfill at Cateura



ab. Alternative X-2

Inter-municipal Disposal
An inter-municipal sanitary landfill at the A-2 site without a transfer system

ac. Alternative X-3

Inter-municipal Disposal
An inter-municipal sanitary landfill at the A-2 site with a transfer system

ad. Alternative X-4

Inter-municipal Disposal
An inter-municipal sanitary landfill at the A-5 site without a transfer system

ae. Alternative X-5

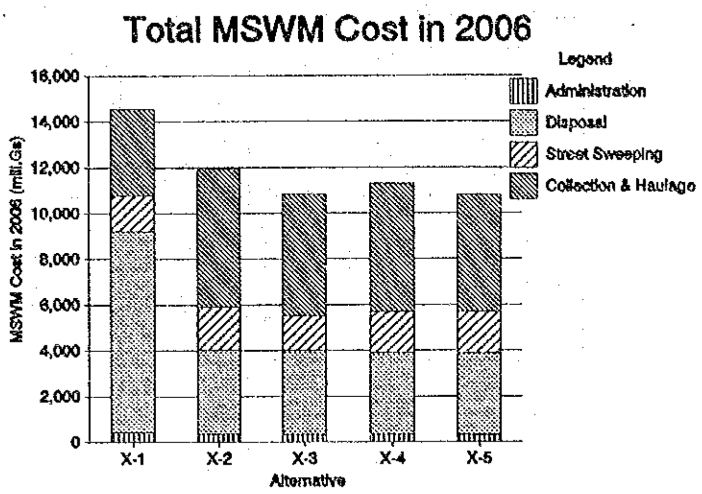
Inter-municipal Disposal
An inter-municipal sanitary landfill at the A-5 site with a transfer system

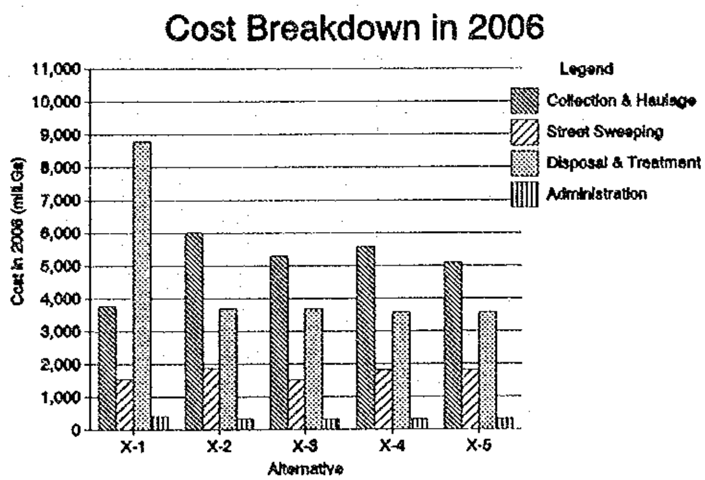
b. Annual MSWM Expenses

The annual MSWM expenses of the 5 alternatives in 2006 for Asuncion and F.Mora are tabulated in Table H.4.3.1a and H.4.3.1b, and illustrated in Figure H.4.3.1a and H.4.3.1b respectively.

Table H.4.3.1a Annual MSWM Expenses in 2006 for Asuncion

Asuncion	Unit	X-1	X-2	X-3	X-4	X-5
1. Total Collection & Haulage	Total (mill.Gs)	3,774	6,009	5,300	5,570	5,097
	Unit (Gs/ton)	18,172	28,933	25,521	26,819	24,542
1.1 Collection & Haulage	Total (mill.Gs)	3,774	6,009	3,607	5,570	3,606
	Unit (Gs/ton)	18,172	28,933	17,368	26,819	17,363
1.2 Transfer Operation & Haulage	Total (mill.Gs)	0	0	1,693	0	1,491
	Unit (Gs/ton)	0	0	8,153	0	7,181
2. Street Sweeping	Total (mill.Gs)	1,550	1,879	1,526	1,815	1,815
	Unit (mill.Gs/km/year)	5.17	6.26	5.09	6.05	5.09
3. Total Disposal	Total (mill.Gs)	8,794	3,694	3,694	3,570	3,570
	Unit (Gs/ton)	42,345	17,787	17,787	17,191	17,191
3.1 Intermediate Treatment	Total (mill.Gs)	8,361	0	0	0	0
	Unit (Gs/ton)	46,194	0	0	0	0
3.2 Benefit	Total (mill.Gs)	-1,185	0	0	0	0
	Unit (Gs/ton)	-6,546	0	0	0	0
3.3 Final Disposal	Total (mill.Gs)	1,618	3,694	3,694	3,570	3,570
	Unit (Gs/ton)	18,912	17,787	17,787	17,191	17,191
4. Administration	L.S.	424	347	316	329	314
Total Cost	(mill.Gs)	14,542	11,930	10,836	11,284	10,797
Unit Cost per Collection Amount	(Gs/ton)	70,019	57,441	52,174	54,332	51,986





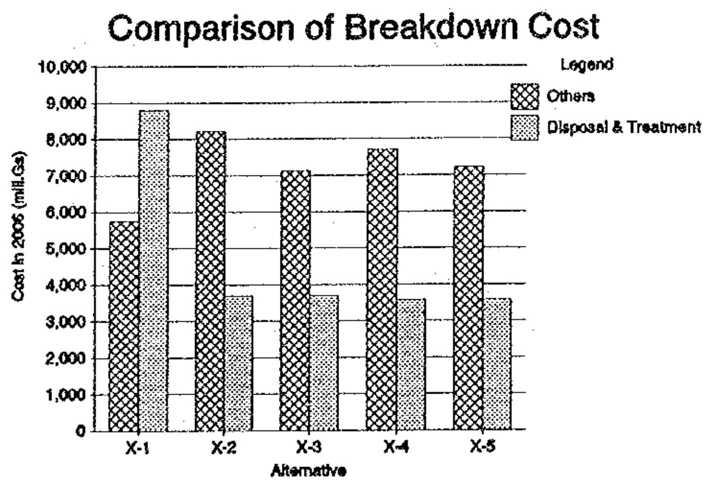
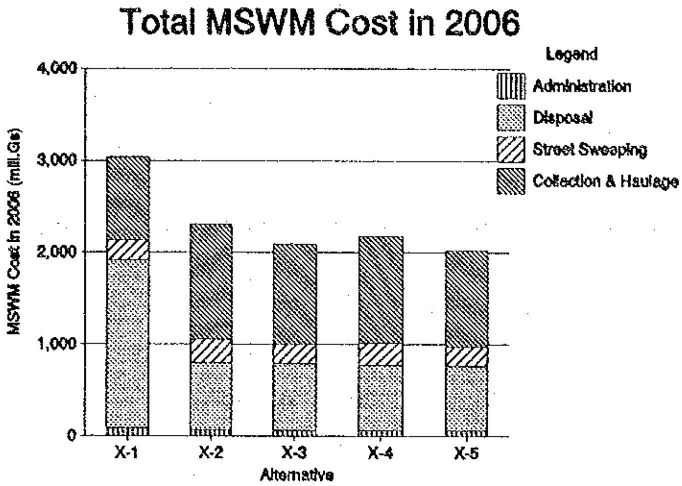
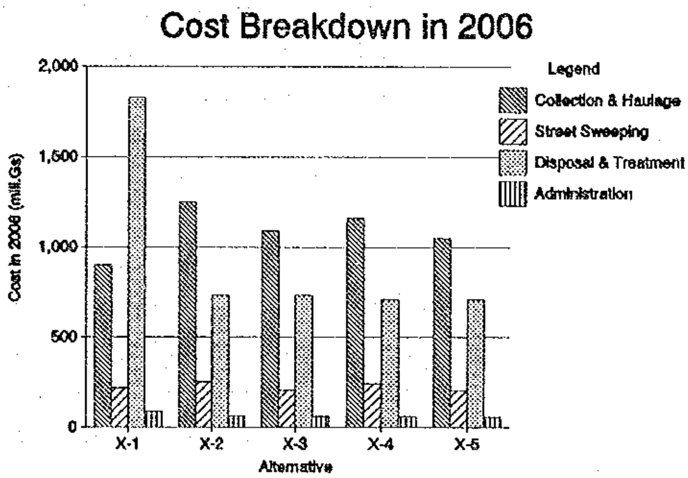


Figure H.4.3.1a Illustration of Annual MSWM Expenses in 2006 for Asuncion

Table H.4.3.1b Annual MSWM Expenses in 2006 for F. Mora

Fernando de la Mora	Unit	X-1	X-2	X-3	X-4	X-5
1. Total Collection & Haulage	Total (mill.Gs)	901	1,253	1,090	1,162	1,050
	Unit (Gs/ton)	21,845	30,379	26,434	28,173	25,458
1.1 Collection & Haulage	Total (mill.Gs)	901	1,253	754	1,162	754
	Unit (Gs/ton)	21,845	30,379	18,281	28,173	18,281
1.2 Transfer Operation & Haulage	Total (mill.Gs)	0	0	336	0	296
	Unit (Gs/ton)	0	0	8,153	0	7,181
2. Street Sweeping	Total (mill.Gs)	219	254	205	245	205
	Unit (mill.Gs/km/year)	5	6	5	6	5
3. Total Disposal	Total (mill.Gs)	1,830	734	734	709	709
	Unit (Gs/ton)	44,380	17,787	17,787	17,191	17,191
3.1 Intermediate Treatment	Total (mill.Gs)	1,737	0	0	0	0
	Unit (Gs/ton)	46,194	0	0	0	0
3.2 Benefit	Total (mill.Gs)	-246	0	0	0	0
	Unit (Gs/ton)	-6,546	0	0	0	0
3.3 Final Disposal	Total (mill.Gs)	339	734	734	709	709
	Unit (Gs/ton)	18,695	17,787	17,787	17,191	17,191
4. Administration	L.S.	89	67	61	63	59
Total	(mill.Gs)	3,039	2,308	2,089	2,180	2,023
Unit Cost per Collection Amount	(Gs/ton)	73,681	55,955	50,660	52,843	49,047





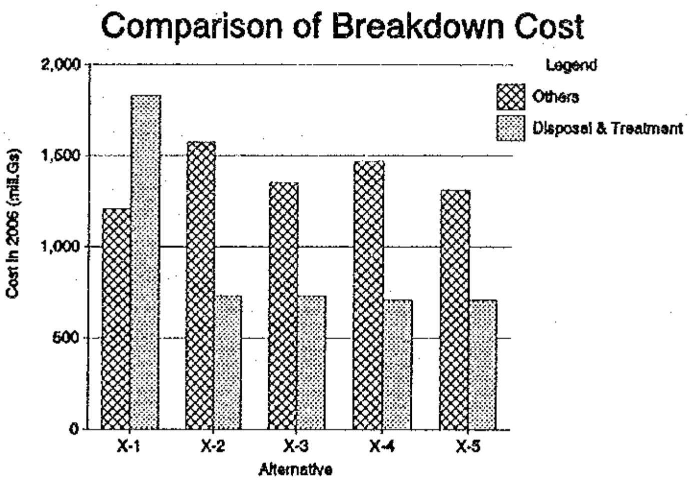


Figure H.4.3.1b Illustration of Annual MSWM Expenses in 2006 for F. Mora

H.4.3.2 Evaluation

a. Method

Generally, the optimum technical system would be selected by evaluating the following aspects:

- technical points of view;
- economical and financial points of view;
- environmental points of view; and
- social points of view.

The evaluation in this report, however, is carried out by stressing financial points of view and the other aspects is only briefly described on some important points. Consequently, the least cost method on the financial aspects; i.e. basically, the alternative which requires the minimum annual expense for MSWM in 2006 is to be selected as the optimum alternative for each municipality. The reasons why we took the method in this report are described below.

- In response to the request from the Paraguayan side, the technical system alternatives for the formulation of MSWM master plan should be prepared for each municipality individually. Each municipality had 4 or 5 alternatives and total number of alternatives comes to 62. This made it very difficult to explain the above-mentioned four items regarding each alternative.
- If each alternative is set up to guarantee a certain level of environmental improvement, the financial aspect dominates the other aspects. Because except for the introduction of an incineration plant (Alternative X-1) it appeared to be no technical difficulty observed in the alternatives presented.
- The social aspects, such as the possibility of inter-municipal cooperation regarding operation of transfer stations, landfill and collection equipment, was subject to the decision done at the time of the IT/R meeting.

b. Evaluation for Asuncion Municipality

ba. Conclusion by the Study Team

As for the optimum technical system for Asuncion Municipality, we propose the Municipality to select the Alternative X-5; that is

Inter-municipal disposal
An inter-municipal sanitary landfill at A-5 with a transfer system.

bb. Evaluation

bba. Summary

The summary of evaluation is as follows:

- Least cost among the 5 alternatives.
- There is no technical difficulty observed in comparison with the other alternatives.
- In the social points of view, there will be some difficulties such as setting-up the inter-municipal disposal site in Chaco; i.e. outside of the jurisdiction of Asuncion Municipality. However, the resolution of these matters was discussed with the Paraguayan side at the IT/R meeting.
- Compared with the present technical system, the proposed system is more environmentally acceptable.

The details of the evaluation are described below.

bbb. Technical Evaluation

i. Working conditions

Workers involved in solid waste management are engaged in different types of work determined by such processes as collection, transportation, operation of transfer station, incineration plant and final disposal. The following three types of works in particular require improved working conditions to ensure both safety and hygiene.

- work in transfer station and incineration plant;
- loading of solid waste into collection trucks; and
- landfill work at disposal site.

Since the same technical systems will be applied to the discharge/storage, collection and final disposal, there is little difference on working conditions among the 5 alternatives. As for the difference among the alternatives, the final disposal amount of Alternative X-1 is one half of Alternative X-2, X-3, X-4 and X-5. Moreover, the working environment at the final disposal site of the Alternative X-1 is much better than in the other Alternatives because humus organic materials can be intercepted before arrival in the final disposal site by the incineration plant.

ii. Operation and maintenance

Operation and maintenance difficulties in the disposal site are estimated to be almost the same with every alternative plan. Operation and maintenance work in Alternative X-1, however, is estimated to be the easiest, because the amount of waste disposed is the least in these areas and because humus organic wastes are incinerated.
Only few problems can be observed in the operation and maintenance work at the transfer stations as they only involve the transportation of large containers.
Incineration control is very important and difficult to operate and maintain. Therefore, its operation shall be made automatic. Nevertheless, the workers must be trained and educated to acquire the skills required for a smooth O & M implementation.

iii. Construction

The construction of the incineration plant and transfer station, in this order, will require highly advanced technology. The technology used in Paraguay presently will be good enough for the construction of all facilities except the incineration plant and transfer station.

iv. Indirect advantage

Future technological development and the upgrading of engineering skills can be expected from the introduction of the incineration and transfer station. The introduction of an incineration plant and transfer station may contribute to the establishment of a foundation for incineration and transfer haulage technology.

bbc. Social Evaluation

i. Possibility of land acquisition

The acquisition of the land for the inter-municipal landfill site seems to be rather easy.

Since the identification of the lands for the transfer stations was not carried out in the 1st Study Work in Paraguay, it will be subject to discussion with the Paraguayan side at the IT/R meeting.

ii. Compatibility with regional development plans

Since the Urban Development Master Plan is not established in the Study area, A-5 site will not meet with problems of this kind. The sites for transfer station will be subject to the IT/R meeting.

iii. Possibility of acquiring neighborhood consensus

Since the nearest residence is located 1,000 m away from the border of the A-5 site, there seems to be no problems on this matter. However, it may require to give some benefits to the Villa Hayes Municipality for the approval of operation. The sites for transfer stations is subject to the IT/R meeting.

iv. Transactional facilitation

Obtaining the approval of the neighborhood and Villa Hayes Municipality would require certain efforts due to the possibilities of adverse environmental impact by the operation of the landfill. Therefore, it is necessary to involve Villa Hayes Municipality for the inter-municipal landfill operation at the A-5 site.

bbd. Environmental Evaluation

i. Surface water pollution, groundwater pollution and soil contamination

There is still a minimum possibility of leachate seepage even if a liner is applied at the proposed landfill to prevent groundwater pollution.

If the possibility may increase in accordance with the final disposal amount, Alternative X-1 will be the least among the alternatives.

The possibility of water pollution occurring at the transfer station is only minimum as part of the waste reception and compaction are completely covered.

ii. Air pollution

The incineration plant can also produce a small amount of air pollution, but its effect on people is within the permissible range because of the installation of a flue gas cleaning system based on the semi-dry principle, which is fully in compliance with the developed country standard.

iii. Odor

Among the facilities, the landfill, followed by the transfer stations, produces a lot of pungent odor.

iv. Dust and scattered wastes

The production of dust and scattered wastes is difficult to prevent in landfill sites regardless of the perfect and immediate execution of the earth coverage operation. The impact is said to be related to the final disposal amount.

v. Traffic noise and safety

This impact is related to the traffic volume to the MSWM facilities. Only a small difference will be observed among the 5 alternatives.

vi. Operation noise

The big sources of noise at the landfill site, incineration plant and transfer stations are heavy construction machines and incoming vehicles, the former being the noisiest.

vii. Impact on landscape

In terms of the required scale for the final disposal site, the impacts of Alternatives X-1 is smaller than the other alternatives.

viii. Others

There is a serious possibility that the environment could get polluted by hazardous wastes, due to hazardous industrial wastes and hospital wastes being disposed of at the landfill site. And this situation will not be improved in Alternatives X-2, X-3, X-4 and X-5. Incineration is the only method that would enable the neutralization of such hazardous wastes. Therefore, the Alternative X-1 is most preferable for environmental protection.

c. **Evaluation for F. Mora Municipality**

ca. **Conclusion by the Study Team**

As for the optimum technical system for F. Mora Municipality, we propose the Municipality to select the Alternative X-5; that is

Inter-municipal disposal
An inter-municipal sanitary landfill at A-5 with a transfer system.

cb. **Evaluation**

The summary of evaluation is as follows:

- Least cost among the 5 alternatives.
- There is no technical difficulty observed in comparison with the other alternatives.
- In the social points of view, there will be some difficulties such as setting-up the inter-municipal disposal site in Chaco; i.e. outside of the jurisdiction of F. Mora Municipality. However, the resolution of these matters was discussed with the Paraguayan side at the IT/R meeting.
- Compared with the present technical system, the proposed system is more environmentally acceptable.

The details of the evaluation are the same as those for Asuncion as described in the previous section.

d. Summary of Evaluation

The summary of alternative evaluation is presented in Table H.4.3.2a.

Table H.4.3.2a Summary of Alternative Evaluation

Municipality	Waste Disposal from 1997 to 2006 (ton)	Waste Disposal in 2006 (ton)	Cost of Each Alternative in 2006 Upper(total cost):mill.Gs Lower(cost in 2006):Gs				
			X-1	X-2	X-3	X-4	X-5
Asuncion	2,023,901 (1,167,717)	221,190 (85,575)	14,542 70,019	11,930 57,441	10,836 52,174	11,284 54,332	10,797 51,986
Fernando de la Mora	315,464 (246,016)	41,245 (15,914)	3,039 73,681	2,308 55,955	2,089 50,660	2,180 52,843	2,023 49,047

Note: Shadow shows the least cost alternative.
Double line shows the second least cost alternative.
( ) shows the amount only for X-1.

H.4.3.3 Financial Evaluation

Financial evaluation consists of the least cost method to be selected among different alternatives for each city estimated in Section H.4.3.1. Further, a comparative analysis was conducted between the least cost alternative and the estimated revenues.

a. Assumptions for revenue estimation

The following assumptions are the bases for estimating the revenues from solid wastes disposal services.

- Beneficiaries are classified into urban households and commercial firms. The latter group includes food shops, other shops, and markets.
- Urban households by Municipality are assumed to grow at the same rate as the population growth of the corresponding Municipality.
- Commercial firms are assumed to grow at the same rate as the growth of the gross domestic product.

- Payments by beneficiaries are based on the division of Municipalities into Highly Urbanized Municipalities (HUM), Urbanized Municipalities (UM), and Less Urbanized Municipalities (LUM).

- Payments by households are based on the Willingness to Pay survey as follows.

  HUM: 8,227 Gs/month.
  UM: 4,160 Gs/month.
  LUM: 3,875 Gs/month.

- Payments by commercial firms (food shops, other shops) are assumed to be the same as in 1992 because of the unreasonable answers given by commercial firms to the Willingness to Pay survey. Since data on payments by commercial firms were available only for Highly Urbanized Municipalities, estimation of payments by commercial firms in Urbanized and Less Urbanized Municipalities were made as proportions of the Highly Urbanized Municipalities. The proportions stated were obtained by dividing the "Willingness to Pay" of households in Urbanized and Less Urbanized Municipalities by the "Willingness to Pay" of households in Highly Urbanized Municipalities. The resulting payments by commercial firms are as follows.

Category	unit	Food Shops	Other Shops
HUM	Gs/month	11,250	25,430
UM	Gs/month	5,689	12,859
LUM	Gs/month	5,299	11,978

- Markets are assumed to pay 50% of payments made by food shops, resulting in the following values for the different types of Municipalities.

  HUM: 5,625 Gs/month.
  UM: 2,845 Gs/month.
  LUM: 2,650 Gs/month.

b. Revenue estimation

Table H.4.3.3a shows the total revenues estimated for the year 2006 on the basis of the above assumptions and 80% collection rate. The Table also includes the breakdown of revenue sources by type of beneficiaries.

c. Comparative analysis

For Highly Urbanized Municipalities, the least cost alternatives in relation to estimated revenues are shown below.

Municipality	unit	Least Cost Alternative	Estimated Revenue
Asuncion	Million Gs.	10,797	18,915
F.Mora	Million Gs.	2,023	3,188

It can be seen that estimated revenues are sufficient to cover total costs of the least cost alternative. Moreover, estimated revenues in the two Highly Urbanized Municipalities can cover the estimated total costs of all the five alternatives considered for each city.

Table H.4.3.3a Estimated Total Revenues in 2006 (Assuming 80% Collection Rate) Unit: 1,000 Guarani

Municipality Type	Household	Food Shops	Other Shops	Market Shops	Estimated Revenues
Highly Urbanized	**12,063,441**	**110,700**	**9,520,015**	**408,726**	**22,102,882**
1. Asuncion	9,887,090	79,380	8,540,086	408,726	18,915,282
2. F.Mora	2,176,351	31,320	979,930	0	3,187,601

H.5 Examination of Technical System Alternatives for UM and LUM (13 Municipalities)

H.5.1 Presentation of Alternatives

H.5.1.1 Concept

a. Objective Municipalities

The objective municipalities shall be 13 municipalities excluding highly urbanized municipalities such as Asuncion and Fernando de la Mora from the study area.

b. Technical System Component of Alternatives

The concepts of alternatives for the 13 municipalities are summarized in Table H.5.1.1a.

Table H.5.1.1a Concept of Technical System Alternatives for the other 13 Municipalities

Disposal System	Site Location	Transfer System	Alternative No.
Independent	within every municipality	without	Y-1
Inter-municipal	A-5 site run by the highly urbanized municipalities	without	Y-2
		with	Y-3
	15 km from the center of the urban area	without	Y-4

ba. Type of System in terms of Final Disposal Site Location

Independent disposal system and inter-municipal disposal system, two types of MSWM system in terms of final disposal location, are taken into account for candidate alternatives.

An independent disposal system means that the wastes generated in the municipality are collected, transported, treated and disposed inside of the municipality where those wastes are generated.

Inter-municipal disposal system means that the multiple municipalities jointly construct and operate the final disposal site.

bb. Intermediate Treatment

Introduction of intermediate treatment technologies is not considered for the 13 municipalities referring to the result of examination of technologies described in Chapter 3, Section 3.2.4.

bc. Assumed Landfill Sites

Chapter 4 in this report recommended that the sanitary landfill in A-5 in Chaco should be developed and operated by Asuncion and Fernando de la Mora jointly as the optimum technical system for those municipalities. Consequently the landfill site in A-5 may be utilized as the inter-municipal disposal site even for each of the 13 municipalities if they wish.

However, the result of examination of the alternatives obviously seems to be unfeasible for some municipalities located in the southern area of the study area because the haulage distance is too far for these municipalities. Therefore, the alternative which includes use of the inter-municipal disposal site located 15 km away from the center of the urban area of each municipalities is added for examination.

bd. Transfer System

In order to examine the most appropriate haulage system for each municipality, the alternatives with and without the transfer system were formulated for examination.

H.5.1.2 Alternative Y-1

a. Proposed System

A sanitary landfill inside of each municipality

b. Purpose

- Independent disposal
- Low MSWM cost
- To minimize the adverse impacts caused by the landfill operation.

c. Method

All wastes are disposed of at a landfill site located within the jurisdiction of each municipality where these wastes is generated, directly after being collected by waste collection trucks. The landfill is operated by each municipality.

d. Advantages and Disadvantages

Advantages;

- Initial investment and operation cost of the sanitary landfill is the cheapest among the MSWM technologies.
- The haulage cost of wastes can be the cheapest.
- High technology is not necessary for construction and operation of the landfill site.
- Local contractors have sufficient technologies and capabilities to construct the final disposal site with the cooperation from experienced agencies.

Disadvantages;

- The required area for final disposal is wide.
- Environmental and social impacts to the surrounding areas of the landfill site are considerable.
- The neutralization of wastes disposed requires a long time.

H.5.1.3 Alternative Y-2

a. Proposed System

An inter-municipal sanitary landfill at the A-5 site without a transfer system

b. Purpose

- Inter-municipal disposal
- Low cost disposal
- To minimize the adverse impacts caused by landfill operation

c. Method

Wastes generated are transported to the sanitary landfill site to be constructed at A-5 in Chaco by waste collection trucks directly after they are collected. The wastes are disposed of at the sanitary landfill with immediate soil coverage. The leachate are collected and returned to the landfill site for circulation.

d. Advantages and Disadvantages

Advantages;

- Initial investment and operation cost of the sanitary landfill is the cheapest among the SWM technologies.
- High technology is not necessary for construction and operation of the sanitary landfill.
- Local contractors have sufficient technology and ability to construct the sanitary landfill site with the cooperation from experienced agencies.
- Operation and maintenance is not difficult to be implemented.

Disadvantages;

- The required area for final disposal is very wide.
- Environmental and social impacts on the surrounding areas of the landfill site are considerable.
- The neutralization of wastes disposed requires a long time.

- The future land use of the landfill site is limited.

H.5.1.4 Alternative Y-3

a. Proposed System

An inter-municipal sanitary landfill at the A-5 site with a transfer system

b. Purpose

- Inter-municipal disposal
- Low cost disposal
- To minimize the adverse impacts caused by the landfill operation.
- To save haulage cost

c. Method

Wastes generated in Asuncion and Fernando de la Mora are transported to the transfer stations to be constructed in or near the urban area with waste collection trucks. Then they are transferred from a collection truck to a transporting vehicle at the transfer station and then transported to the sanitary landfill site at A-5 in Chaco for final disposal. The wastes are disposed of at the sanitary landfill with immediate soil coverage. The waste leachate are collected and returned to the landfill site for circulation.

d. Advantages and Disadvantages

Advantages;

- Initial investment and operation cost of the sanitary landfill is the cheapest among the SWM technologies.
- High technology is not necessary for construction and operation of the sanitary landfill.
- Local contractors have sufficient technology and ability to construct the sanitary landfill site with the cooperation from experienced agencies.
- Operation and maintenance is not difficult to be implemented.

- The increase of traffic volume of waste collection trucks can be kept down to a minimum.
- Haulage cost can be saved.

Disadvantages;

- The required area for final disposal is very wide.
- Environmental and social impacts to the surrounding areas of the landfill site is considerable.
- The neutralization of wastes disposed requires a long time.
- The future land use of the landfill site is limited.
- The site of transfer stations must be required in or near the urban area.

H.5.1.5 Alternative Y-4

a. Proposed System

Inter-municipal landfill site 15 km away from the center of the urban area of each municipality

b. Purpose

- Inter-municipal disposal
- Low cost disposal
- To minimize the adverse impacts caused by the landfill operation.

c. Method

Wastes generated are transported to the sanitary landfill site to be constructed 15 km away from the center of the urban area of each municipality with waste collection trucks directly after they are collected. The wastes are disposed of at the sanitary landfill for immediate soil coverage. The leachate are collected and returned to the landfill site for circulation.

d. **Advantages and Disadvantages**

Advantages;

- Initial investment and operation cost of the sanitary landfill is the cheapest among the MSWM technologies.
- High technology is not necessary for construction and operation of the sanitary landfill.
- Local contractors have sufficient technology and ability to construct the sanitary landfill site with the cooperation from experienced agencies.
- Operation and maintenance is not difficult to be implemented.

Disadvantages;

- The required area for final disposal is very wide.
- Environmental and social impacts to the surrounding areas of the landfill site are considerable.
- The neutralization of wastes disposed requires a long time.
- The future land use of the landfill site is limited.

H.5.2 Conceptual Design and Cost Estimation

First of all, it should be noted that the purpose of a conceptual design and cost estimation to be carried out in this section is to compare the cost of each technical system alternative for the master plan and to select an optimum alternative for each municipality. There are 52 alternatives for comparison in total. Therefore, the design and estimation work was simplified as much as possible and a more detailed design including modification of the conceptual design and cost estimation was done at the Feasibility Study stage.

H.5.2.1 Premises

a. **Objectives**

Based on the results of the examination of system component (refer to the Section 3.2), this section presents conceptual design and estimates for the following systems and facilities for MSWM in Urbanized Municipalities and Less Urbanized Municipalities:

- Storage and collection system.
- Haulage system.
- System for street sweeping.
- Sanitary landfill.

b. Key Assumptions

ba. For design

baa. Key assumptions for design

The key assumption for the conceptual design are shown in Ta5.2.1a and distance table for alternatives is in Table H.5.2.1b.

Table H.5.2.1a Key Assumptions for Design

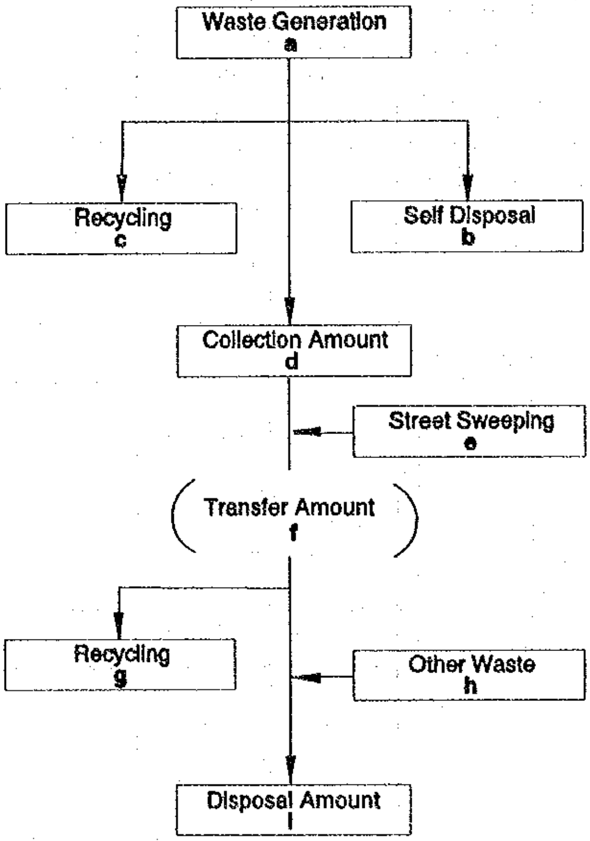
Design Items		Applied Figure	Unit	Remarks
1.	**Storage and Collection**			
1-1	ASG of Waste in Compactor	0.45	ton/m^3	
1-2	ASG of Waste in Dump Truck	0.2	ton/m^3	
1-3	ASG of Waste in Container	0.2	ton/m^3	
1-4	Rate of Operation of Vehicles	0.9		
2.	**Haulage**			
2-1	ASG of Waste in Transfer Vehicle (Compactor Type)	0.5	ton/m^3	
2-2	ASG of Waste in Transfer Vehicle (Non-compaction Type)	0.2	ton/m^3	
3.	**Street Sweeping**			
3-1	Manual Sweeping			
3-2	Collection done by Compactor or Dump Truck			Compactor for UM Dump Truck for LUM
5.	**Final Disposal**			
5-1	ASG of MSW	0.8	ton/m^3	After compaction

Table H.5.2.1b Distance Table for Alternatives

Case	Waste Amount (ton/day)	Y-1	Y-2	Y-3		Y-4
		Distance (km)	Distance (km)	Distance(A) (km)	Distance(B) (km)	Distance (km)
3. Lambare	139	3	38	2	36	15
4. San Lorenzo	160	3	35	2	33	15
5. Capiata	107	4	41	2	39	15
6. Luque	143	5	33	2	31	15
7. M.R.Alonso	67	3	17	2	15	15
8. Villa Elisa	64	3	39	2	37	15
9. Nemby	39	4	44	1	43	15
10. J.A.Saldivar	2	2	47	1	46	15
11. Ita	18	3	58	1	57	15
12. Aregua	5	4	45	1	44	15
13. Limpio	27	4	23	1	22	15
14. Villa Hayes	13	5	21	1	20	15
15. B.Aceval	8	5	31	1	30	15

bab. Waste stream

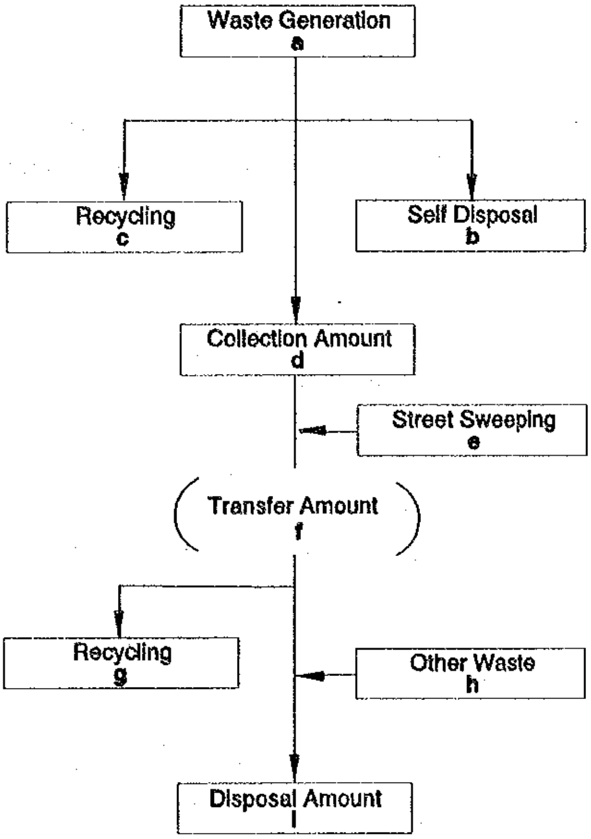
In order to carry out the conceptual design and cost estimation, the waste stream for each municipality in the year 2006 for each alternative is presented in Figures below.



Waste Stream in Urbanized Municipalities

Alternatives	Unit	LAMBARE	SAN LORENZO	CAPITA	LUQUE	M.R.A-LONSO	V.ELISA
a. Generation	ton/day	192	301	209	271	129	101
b. Self Disposal	ton/day	44	127	92	115	56	32
c. Recycling(1)	ton/day	9	14	10	13	6	5
d. Collection Amount(a-b-c-e)	ton/day	133	152	104	139	65	59
e. Street Sweeping	ton/day	6	8	3	4	2	5
f. Waste amount at T/S(d+e)	ton/day	139	160	107	143	67	64
g. Recycling(2)	ton/day	12	21	17	27	13	10
h. Other Waste	ton/day	0	0	0	0	0	0
i. Waste Amount at Final Disposal Site per Day(f-g+h)	ton/day	127	139	90	116	54	54
j. Waste Amount at Final Disposal Site per Year(ix365)	ton/day	46,355	50,735	32,850	42,340	19,710	19,710

Figure H.5.2.1a Waste Stream for MSW in Urbanized Municipalities in the Year 2006



Waste Stream in Less Urbanized Municipalities

Alternatives	Unit	NEMBY	SALDI-VAR	ITA	ARE-GUA	LIMPIO	V.HA-YES	B.ACE-VAL
a. Generation	ton/day	72	6	31	11	63	24	15
b. Self Disposal	ton/day	30	4	12	6	33	10	6
c. Recycling (1)	ton/day	3	0	1	0	3	1	1
d. Collection Amount(a-b-c-e)	ton/day	36	1	16	3	25	11	5
e. Street Sweeping	ton/day	3	1	2	2	2	2	3
f. Waste Amount at T/S(d+e)	ton/day	39	2	18	5	27	13	8
g. Recycling (2)	ton/day	4	0	1	0	3	1	1
h. Other Waste	ton/day	0	0	0	0	0	0	0
i. Waste Amount at Final Disposal Site per Day (f-g+h)	ton/day	35	2	17	5	24	12	7
j. Waste Amount at Final Disposal Site per Year (ix365)	ton/day	12,775	730	6,205	1,825	8,760	4,380	2,555

Figure H.5.2.1b Waste Stream for MSW in Less Urbanized Municipalities in the Year 2006

bb. For cost estimation

bba. Basic consideration

The cost comparison of each technical system alternative is done as the annual MSWM cost in 2006. Consequently, the following assumptions are made for the estimation of cost:

i. Although the executing body of MSWM for each municipality differs at present, it is assumed that a same type of executing body (e.g. a department of a municipality) will operate it.

ii. The cost comparison is carried out by means of the O & M (Operation and Maintenance) cost in the year 2006 which includes depreciation of all facilities and equipment related to the MSWM of each municipality.

iii. The cost estimation is done based on the price in August 1993. The exchange rate was 1 US$=1,756.52 Gs.

iv. The estimated cost does not include interest and tax. Although the actual cost should include them, they were excluded because the purpose of the cost comparison is to select the optimum alternative. The actual cost will be estimated at the Feasibility stage.

bbb. Annual working days and working efficiency

The annual working days are determined as follows;

- total days per year	:	365	
- Sunday	:	53	
- Public holiday	:	15	
total working days	:	**297**	**days/year**

The working hours of equipment is assumed to be 8 hours per day. The rate of operation of equipment is assumed to be **0.9**.

bbc. Life span of equipment and facilities

	Life Span (years)
Container	5
Truck and Heavy Equipment	7
Machinery	15
Building and Civil Works	30

Note: The life span of other facilities for the disposal site depends on the period of its operation.

H.5.2.2 Storage and Collection System

a. Objective wastes and Collection Amount

aa. Objective wastes

The objective wastes dealt by the storage, collection and haulage plan are as follows;

- Household
- Commercial waste
- Market waste
- Institutional waste
- Street sweeping waste
- Hospital waste (non-infectious)

ab. Collection amount

The waste collection amount in 2006 is shown in Table H.5.2.2a, H.5.2.2b.

Table H.5.2.2a Waste Collection Amount of Urbanized Municipalities in 2006

(unit : ton/day)

	Lambare	San Lorenzo	Capiata	Luque	M.R. Alonso	Villa Elisa
- Household waste	122	126	90	113	55	52
- Commercial waste	11	21	14	24	10	7
- Market waste	0	5	0	0	0	0
- Institutional waste	0	0	0	1	0	0
- Hospital waste(non-infections)	0	0	0	0	0	0
Total	133	152	104	138	65	59

Table H.5.2.2b Waste Collection Amount of Less Urbanized Municipalities in 2006

	Nemby	J.A. Saldivar	Ita	Aregua	Limpio	Villa Hayes	B.Aceval
- Household waste	29	1	12	3	16	10	3
- Commercial waste	7	0	3	1	8	1	1
- Market waste	0	0	1	0	0	0	0
- Institutional waste	0	0	0	0	0	0	0
- Hospital waste(non-infections)	0	0	0	0	0	0	0
Total	36	1	16	4	24	11	4

b. Storage system

The storage system assumed for MSW in this section is curb collection system without public containers.

c. Collection system

ca. Collection system

The collection system assumed in this section is as follows:

Area	Collection vehicle	Type of bin
Urbanized Municipalities	Compactor 13 m^3	Plastic bag
Less Urbanized Municipalities	Dump Truck 10 m^3	Plastic Bag

cb. Estimation of required number of collection vehicles

The required number of collection vehicles according to the alternatives was calculated based on the following conditions and procedures:

i. As for the present use of the collection vehicles in the Study area, they are not properly used and are overused (e.g. most of vehicles work for more than 12 hours per day). Therefore, the required number of vehicles could not be calculated based on the present number of vehicles.

ii. As described in the previous section, it is assumed that vehicles will work 297 days/year and 8 hrs/day, and the rate of their operation is 0.9.

iii. The required time for the collection work differs with the collection area. Since the rear loading compaction truck with 13 m^3 of capacity is the dominant collection vehicle for Asuncion and F.Mora, the work efficiency of this type of vehicle is applied to the estimation of required number of collection vehicles.

iv. According to the data observed by the truck scale at the Cateura landfill from September 28 to October 4 1993, the average time required for one cycle of collection work by a 13 m^3 compactor was 211 minutes, and the average collected amount was 5.356 ton/trip.

v. The average amount of waste to be collected by a dump truck 10 m^3 is simply calculated at 2 ton/trip by the formula below.

$$10\ m^3 \times 0.2\ ton/m^3\ (ASG) = 2\ ton$$

vi. The collection work consists of the following works:

- collection
- haulage
- discharge
- miscellaneous

Based on the Time & Motion (T & M) study conducted on August 3rd to 11th 1993, the average time sharing of each work was summarized in Table E.5.3a in Annex E.
Since one cycle time of a compaction truck 13 m^3 at the T & M study may not represent the actual cycle time, the cycle time (211 min.) observed by the truck scale was applied to the study.

vii. Based on the applied time for one cycle of collection work of a compaction truck 13 m^3, the required number of collection vehicles was calculated; i.e. the required time for collection, haulage and discharge will differ in accordance with alternatives.

viii. Except for the collection time, the time required for other works (haulage, discharge miscellaneous) of a dump truck is supposed to be the same as a 13 m^3 compactor truck.

With the above-mentioned procedures, the required number of collection vehicles for each alternative is calculated and tabulated in Table H.5.2.2c and H.5.2.2d.

Table H.5.2.2c Required Number of Collection Vehicles for Urbanized Municipalities

Item	Y-1	Y-2	Y-3	Y-4
Lambare	13 (1)	22 (1)	13 (1)	16 (1)
S. Lorenzo	15 (1)	24 (2)	14 (1)	18 (1)
Capiata	11 (1)	18 (1)	10 (1)	12 (1)
Luque	14 (1)	21 (1)	13 (1)	16 (1)
M.R.Alonso	7 (1)	8 (1)	6 (1)	8 (1)
V.Elisa	6 (1)	10 (1)	6 (1)	8 (1)

Note: The figure with parentheses is the required number of street sweeping services
The number does not include spare vehicles.

Table H.5.2.2d Required Number of Collection Vehicles for Less Urbanized Municipalities

Item	Y-1	Y-2	Y-3	Y-4
Nemby	10 (1)	18 (1)	9 (1)	12 (1)
J.A.Saldivar	1 (1)	1 (2)	1 (1)	1 (1)
Ita	5 (1)	10 (1)	5 (1)	6 (1)
Aregua	2 (1)	3 (1)	2 (1)	2 (1)
Limpio	7 (1)	10 (1)	7 (1)	8 (1)
V.Hayes	4 (1)	5 (1)	3 (1)	4 (1)
B.Aceval	3 (1)	4 (1)	2 (1)	3 (1)

Note: The figure with parentheses is the required number of street sweeping services
The number does not include spare vehicles.

d. Cost estimate

da. Method

The collection cost in 2006 of each alternative was estimated in accordance with the following methods:

- Cost data used in this estimate is based on the results of analysis of the expense of Asuncion in 1992.
- The total collection cost in 1993, which is the O & M expense excluding depreciation cost of equipment, of the city of Asuncion was calculated based on it in 1992 considering 17.8% of the inflation rate.
- The unit cost of collection work (Gs/ton) was calculated by dividing the total collection cost by the total collection amount observed by the truck scale.
- Since the present collection cost includes little depreciation cost of equipment, the depreciation cost was calculated and added based on the price in 1993 and life span.
- Upon consideration of haulage distance, work efficiencies, etc., the time share of each work item (collection, haulage, discharge and miscellaneous) for each alternative was estimated based on the present time share of collection work by the compactor 13 m^3 in Asuncion.
- Unit collection cost (Gs/ton) for each alternative was calculated based on the time required for one cycle of collection work and collection amount of one cycle time.

db. Unit cost

According to the above mentioned method, the unit collection cost for each alternative was calculated and tabulated in the following tables:

Table H.5.2.2e Collection Cost of LAMBARE

Item	Y-1	Y-2	Y-3	Y-4
Collection Time (min)	134	134	134	134
Haulage Distance (km)	3	38	2	15
Haulage Time (min)	19	152	13	60
Discharge Time (min)	10	10	10	10
Miscellaneous Time (min)	26	26	26	26
Unit Cost (1000 Gs/ton)	19	33	18	23
Collection Amount (ton/day)	133	133	133	133
Total Cost per Year (million Gs/year)	929	1579	896	1128