Table 3.2.3a Public Opinion on Waste Collection Fee

		Average fee presently collected per house (Cordobas/month)	Average amount residents are willing to pay (Cordobas/month)	Difference
Residential Area	Low income group	7.3	10.5	44% up
	Middle income group	14.0	13.7	2% down
	High income group	65.4	52.5	20% down
	Weighed Average	11.8	13.2	19% up

Note: The average fee presently collected and the amount residents are willing to pay were calculated in accordance with the following population ratio:

High : 4%
Middle: 33%
Low : 63%

g. Public Cooperation

- Approximately 36 % of the interviewees have had guidance on proper waste discharge methods (Q7-1).
- Nearly 100 % of the interviewees understand the necessity of public cooperation and are willing to participate. (Q7-2, 7-4, 7-5, 7-6)
- Almost 50 % of the interviewees think that the municipality should take actions that would encourage public cooperation (Q7-7).

3.3 Investigation of Present Disposal and Newly Proposed Landfill Sites

3.3.1 Investigation of the Present Disposal Sites

a. Topographic Survey

The topographical map of the Acahualinca disposal site was drawn up by the Study team according to the following conditions:

- Survey area: 130 ha (covers the whole area of the Acahualinca disposal site (approximately 40ha))
- Scale: 1:1,000

The topographical map is presented in the data book.

b. Geological Survey

ba. Work Method

The geological survey of the Acahualinca disposal site was carried out as follows:

i. Boring

- Number of boreholes : 5 boreholes
- Depth of the boreholes: 2 points/50m
  3 points/30m

ii. Penetration Test

- Number of penetration tests: 5 points
- Total depth of test: 190 meters
- Interval of penetration test: every 1 meter

iii. Laboratory Test

Three samples from three different layers for laboratory testing was taken at each borehole. The following laboratory tests were conducted for samples taken from the boreholes:

- Permeability test
- Grain size analysis
- Triaxial compression test
- Consolidation test

iv. Drawing a columnar section

bb. Findings

bba. Subsoil Characteristics

The five combined boreholes clearly showed the subsoil characteristics at the site. In boreholes 1, 2 and 4 waste layers like those found in the sanitary landfill were found from 3.90m, 7.0m, and 12.0m respectively. Boreholes 3 and 5 on the shore of Lake Managua contained natural soil.

In general, soil found in the borehole sites was made up of fine sands, silts, fine silty gray and brown color sands interccalated with soft, dark, highly compressed pumice layer from which unaltered samples were taken in boreholes 1, 2 and 3.

All standard penetration test carried out in the 5 borehole sites were taken up to a depth of 17m. High resistance to further penetration was encountered beyond this point.

The borehole log indicating the Standard Penetration Test results, water level, and geological distributin is enclosed in the data book.

bbb. Laboratory Results and Summary

- Permeability Test

The results of the permeability test are shown in the data book.

- Grain Size Analysis

Tests were carried out on the 6 Shelby samples. The corresponding grading curves as well the respective calculation for determining the percentage of soil are shown in the data book.

- Triaxial Compression Test

The triaxial unconsolidated undrained test (UU) was carried out. The results of the calculations of the specific values of the test carried out as well as unitary Stress Strain Curves in % – Stress are shown in the data book.

- Consolidation Test

Based on the compressibility curve of each sample, the pre consolidation load was determined by the empirical method. The results of consolidation tests are shown in the data book.

c. Land Use Survey

The land use survey was conducted to determine the present land use conditions of the existing disposal site and their surroundings.

The land use maps prepared are in the data book.

d. Environmental Survey on Present Disposal Site

The environmental survey was conducted to determine the present environmental condition of the disposal site.

da. Survey Methods

The environmental survey method consisted of water quality survey, sediment survey, ambient survey, noise survey and traffic volume survey, all of which are shown in Table 3.3.1a.

Table 3.3.1a Survey methods

	Water Quality Survey	Sediment Survey	Ambient Survey	Noise Survey	Traffic Volume Survey
Sampling Points	– leachate : 4 points – well : 5 points – borehole : 5 points – lake : 5 points	– Managua lake: 3 points – Acahualinca lake: 3 points	boundary of Acahualinca disposal site	boundary of Acahualinca disposal site and its access road	access road to Acahualinca disposal site
Sampling Number	38 samples(19 points times 2 samples)	6 samples(6 points times 1 samples)	1 point	2 points	1 point
Analysis Item	Pb, As, Cd, Cr+6, Hg, PCB, Cu,pH, COD, BOD, T–N, SO4–2, Cl–	Cu, Zn, Cd, As, SS, P,Pb, Hg	Dust, SPM, Ammonia, Methane	– land filling work noise – transportation truck noise	Traffic volume
Analysis Method	Standard Methods for the examination of water and wastewater including bottom sediments and sludges, 18th edition, New York, APHA–AWWA–APCF	Standard Methods for the examination of water and wastewater including bottom sediments and sludges, 18th edition, New York, APHA–AWWA–APCF	– The value of Dust was measured using a plastic pan. – The value of SPM was measured by the difference in weight of the filter before and after the experiment. – The Ammonia was detected by using a test tube. – Methane was analyzed using a portable analyzer of combustible gas.	Instruments used:Noise meter(RION NL–04) Survey Time :Every 5 seconds for 10 minutes every hour for 24 hours	The traffic volume of each vehicle category, hours and distance were measured.
Sampling Dates	– 1st:2 and 3 June in 1994 – 2nd:17 June in 1994	2 June in 1994	– Dust, SPM: 26 May to 2 June 1994 – Ammonia, Methane 24 June 1994	20 May 1994	8:00am 19 May to 8:00am 20 May 1994

db. Findings

dba. Water Quality Survey

There are no environmental guidelines for water quality in Nicaragua. Guidelines for drinking water. The comparison table of the water quality survey data and permissible values specified by the guideline is presented in Table 3.3.1b. The results are summarized as follows.

- Water temperature – all results exceed the maximum value of the guideline.
- pH – maximum value of lake water exceeds the guide value of the guide–line.
- SO_4^{-2} – all results, except for the minimum value of well water, exceed the maximum value of the guideline.
- Cl^- – all maximum values, except for well water, exceed the maximum value of the guideline.
- Pb – all maximum values exceed the maximum value of the guideline.
- As – all maximum values exceed the guide value of guideline.
- Cd and Cr^{+6} ; All results did not exceed guide value of the guideline.
- Hg – all maximum values exceed the guide value of the guideline.

Table 3.3.1b Evaluation of the Results of Water Quality Analysis

Item	Unit		Leachate	Well	Bore-hole	Lake	Guideline	
							Guide Values	Maximum Values
Water Temp.		Maximum Minimum	36 30	33 29	35 28	32 28.5	12	25
pH		Maximum Minimum	8.1 7.3	7.9 7.3	7.9 7.0	9.5 7.0	6.6–8.5	-
SO_4^{-2}	mg/l	Maximum Minimum	2,900 625	1,525 140	3,800 625	900 250	25	250
Cl^-	mg/l	Maximum Minimum	1,357 110	229 63.5	833 90	394 39.4	25	250
Pb	mg/l	Maximum Minimum	0.14 N.D.	0.12 N.D.	0.02 N.D.	0.1 N.D.	-	0.01
As	mg/l	Maximum Minimum	0.04 N.D.	0.02 N.D.	0.03 N.D.	0.05 N.D.	0.01	-
Cd	mg/l	Maximum Minimum	N.D N.D.	N.D. N.D.	N.D. N.D.	N.D. N.D.	0.005	-
Hg	mg/l	Maximum Minimum	0.4 N.D.	0.27 N.D.	0.39 N.D.	0.4 N.D.	0.001	-

N.D.: Not Detected

dbb. Ambient Survey

There are no environmental standards or regulations concerning the ambient quality in Nicaragua. However, there is a reference level given by the Panamerican Network for Air Contamination Sampling. The survey results were compared with this reference level and is presented in Table 3.3.1c.

Result of dust fall and SPM exceeded reference level.

Table 3.3.1c Results of Ambient Survey

Items	Result of Survey	Reference Level
Dust Fall ($mg/cm^2/30$ days)	0.77	0.5
SPM (mg/m^3)	0.13	0.1
Ammonia (ppm)	N.D.	-
Methane (ppm)	0.0 - 0.5	-

N.D. : Not Detected

dbc. Noise Survey

There are no environmental standards or regulations concerning noise in Nicaragua. The World Health Organization (WHO) in its document entitled " Environmental Health Criteria 12 - NOISE " recommends that the community/urban daytime (Leq) value should not exceed 55 dB(A) beyond which annoyance would increase. The comparison table of noise survey data and permissible values specified by the WHO is presented in Table 3.3.1d.

The noise value recorded in survey point N-1 exceeded the value given by WHO.

Table 3.3.1d Evaluation of Noise Survey Results unit:dB(A)

No. of Survey point	Day (7 to 19)	Night (19 to 7)	Value of WHO
N - 1	73.7	61.4	55
N - 2	50.8	49.4	-

Note: The values for day and night are average values.

dbd. Traffic Volume Survey

The maximum rate of waste collection vehicles was less than 10% of the total traffic volume except at section D. At section D, the maximum rate of waste collection vehicles was 48.7% per hour (between 10:00am and 11:00am); however the total traffic volume was less than 700 units per day as there are few residential houses along the road leading to the present disposal site.

3.3.2 Investigation of the Acahualinca Newly Proposed Landfill Site

a. Topographical Survey

The topographical map covering the whole area of the ANPLS (Acahualinca Newly Proposed Landfill Site) was drawn at a scale of 1:2,000 based on the survey data obtained. This is included in the data book.

b. Geological Survey

The geographical survey of the ANPLS was conducted and the contents of the survey are as follows:

ba. Boring

- Number of boreholes : 3 boreholes
- Depth of the boreholes : 20 meters

bb. Penetration Test

- Number of penetration tests : 3 points
- Total depth of tests : 60 meters
- Interval of penetration tests : every meter

bc. Laboratory Tests

- Permeability test
- Unconfined compression test
- Triaxial compression test
- Consolidation test

c. Land Use Survey of the Surrounding Area

The land use survey was conducted to determine the present land use conditions in the ANPLS and its surroundings. The land use map prepared is presented in the data book.

d. Environmental Survey

An environmental survey was conducted to determine the present environmental condition in the ANPLS. The environmental survey method consisted of water quality survey, sediment survey and ambient survey, all of which are shown in Table 3.3.2a.

Table 3.3.2a Survey methods

	Water Quality Survey	Sediment Survey	Ambient Survey
Sampling Points	- leachate : 3 points - well : 3 points - borehole : 3 points - waterway : 2 points - lake : 3 points	- Managua lake: 2 points	boundary of Acahualinca disposal site
Sampling Number	28 samples(14 points times 2 samples)	2 samples(2 points times 1 samples)	1 point
Analysis Item	Pb, As, Cd, Cr+6, Hg, PCB, Cu, CN, pH, COD, BOD, OD, T-N, SO4-2, Cl-, HCO3-, Na+, K+, Ca2+, Mg2+ and SS	Cu, Zn, O-P, T-Hg, Cd, As, SS, P, Pb, Hg, and PCB	Dust, SPM,
Analysis Method	Standard Methods for the examination of water and wastewater including bottom sediments and sludges, 18th edition, New York, APHA-AWWA-APCF	Standard Methods for the examination of water and wastewater including bottom sediments and sludges, 18th edition, New York, APHA-AWWA-APCF	- The value of Dust was measured using a plastic pan which was fixed by metal fittings 2.5m above ground level. The result of dust fall was converted for the value of 7 days into the value of 30 days. - The value of SPM was measured by the difference in weight of the filter before and after the experiment. The result of the SPM was given a total value of 7 days.
Sampling Dates	- 1st:23 and 24 November in 1994 - 2nd:30 November in 1994	24 November in 1994	5 to 12 December 1994

3.4 Other Field Surveys

3.4.1 Survey on Private Contractors

The MSWM system in Managua is entirely operated by the municipality. The municipality owns and operates all equipment for public cleansing services, manages personnel, and determines waste fees and revenues sources. Sometimes most industries, building contractors, slaughterhouses, shops and households transport and dispose their wastes directly to the Acahualinca disposal site.

Before the election of the current municipal government, SWM activities were performed by a municipal company holding a semi-autonomous economic and administrative status. The present government expressed its desire to introduce privatization and the Managua Municipality accepted the policy in December 1994. Since the municipality does not have concrete plans on how to carry out privatization, the Study Team prepared a proper privatization plan for MSWM under the management of the municipality. The privatization of the MSWM for Managua Municipality is presented in Chapter 7 and Section I of the Annex.

3.4.2 Survey on Scavengers

a. Survey Objectives and Methods

The objectives of this survey are:

- to determine the system and the organization concerning scavengers;
- to determine the present working condition and environment;
- to determine the present role of scavengers in SWM;
- to forecast the social impact of the Master Plan

In order to obtain these objectives, the following surveys were conducted:

- An interview with 30 scavengers at the Acahualinca disposal site using a questionnaire
- Attendance survey of scavengers for three days at the Acahualinca disposal site and surrounding areas;
- Interview survey of the authorities of the Municipality and Ministry of Health

b. Findings

The results of the survey are presented in Section E.2 of Annex E. The following are findings from the Survey:

ba. The Present Role of Scavengers on MSWM

The scavengers at the Acahualinca disposal site contribute to the achievement of the following:

- reduction of solid waste disposal amount
- collection of different types of recyclable materials
- supply empty bottles to local food manufactures for use as containers, thereby reducing dependence on imports

bb. The System and the Organizations of Scavengers

There are no associations concerned with workers in the final disposal site. The scavengers at the Acahualinca disposal site work independently although at times they operate in groups, in particular the young and members of the same family.

The activities of scavengers in and around the disposal site are not covered by municipal laws, ordinance, or regulation.

bc. The Present Working Condition and Environment

Almost all the scavengers attend the site without adequate heath protection. The municipal waste disposed in Acahualinca is a mixture of different materials, some of which can be very harmful to the health of those who have had contact with these wastes. These harmful wastes may be hospital (infectious) wastes or human excreta.

bd. Social Impact of the Master Plan

The number of scavengers working at the Acahualinca disposal site is growing every year. Currently, approximately 250 scavengers are dedicated to sorting activities. Approximately 60% of them have worked at the landfill site for more than five years, while the remaining 40% started to work within the past four years as a consequence of the precarious economic situation of Nicaragua and the lack of formal employment opportunities.

It will be very difficult for these people to change their way of living and to find

new jobs. Also the Municipality of Managua will face serious problems if they hinder access to the landfill. The society of Managua will also face extra social problems if the scavengers lose their means of existence. Therefore, scavenging should be considered as an activity that may greatly influence the SWM system.

be. Recycling Amount through Scavengers

The amount of reusable materials sorted and taken from the Acahualinca disposal site was estimated at approximately 2.4 tons per day based on the following surveys:

- interview survey with scavengers
- disposal waste amount survey

c. Measures for Improvement of Working Environment of Scavengers

The following adverse conditions concerning scavenging works were recognized at the site:

- No proper protection measures from hazardous wastes.
- Scavengers are working close to bulldozers and compactor trucks.
- Children are working as scavengers.

Although improving the working environment of scavengers, as mentioned above, is necessary in view of social welfare and public health, basically these improvement measures should be taken by scavengers themselves: they should establish an association and make such improvement measures a requirement. The role of the municipalities shall be in assisting their efforts by means of subsidies and planning of improvement measures considering their financial capabilities. Furthermore, the scavenging activities at disposal site are undesirable and it should be eventually eliminated for sound final disposal operation in the Study Area.

Although scavenging is in the informal sector of the MSWM, it contributes to the recycling of reusable materials (resource recovery) and the reduction of the disposal amount. On the other hand, scavenger activities in the disposal site impede proper landfill operation. In addition, the elimination of the scavengers from disposal site may cause social problems due to the deprivation of their means of existence.

These contradictory aspects should be considered to set up improvement measures for the working environment of scavengers. Considering the limited finances of the Municipality for final disposal operations, these improvement measures shall be taken in a stepwise approach as shown below.

Step 1: Establishment of scavenger registration and control system in the Acahualinca disposal site in order to avoid scavenging by minors and pregnant women.

Step 2: Separation of working area for scavenging in order to avoid accidents, involving landfill equipment and people, and to improve landfill operation efficiency. The separate disposal of hazardous wastes shall also be conducted.

Step 3: Promotion of recycling activities outside the municipal landfill (prohibition of scavenging at the municipal landfill)

The scavenging work at a municipal landfill is not desirable in terms of landfill operation efficiency and the security and health of the scavengers. Consequently, to eliminate scavenging at the landfill and improve the working environment, the municipality should take the following measures:

- establishment of source segregation system for recyclables and non-recyclables
- promotion of recycling activities outside of municipal landfill by scavengers by means of providing subsidies for acquiring push-carts or other tools for recycling activities
- set-up recycling places

3.4.3 Compost Market Survey

a. Objectives of the Survey

The use of organic materials as soil fertilizer will help soil condition and form a well-balanced ecological system. Composting is now being considered from two angles: the intermediate treatment of municipal solid waste and the reutilization of the organic component of municipal solid waste.

The major aim of a composting project is to convert a large proportion of solid wastes into a marketable product for agriculture, e.g., soil conditioner and fertilizer. Thus, marketability and demand for compost are the most important aspects in determining its viability. In order to know the size of compost product in the municipal waste market, a market study was conducted.

b. Findings

ba. Chemical Fertilizer Consumption

Almost all farmers use fertilizer for agricultural production; the estimated chemical fertilizer consumption in the study area is approximately 2,800 tons/year.

bb. Pilot Project for Composting in Acahualinca

Under the guidance of a Dutch expert, a pilot project for composting started in April 1993 at Acahualinca.

Production is approximately 4.8 tons/month and it takes an average of about 105 days to carry out composting.

From the chemical analysis data, it appears that the quality of compost produced in Acahualinca is not necessarily good.

bc. Pilot Project for Composting in La Colonia Central America

The pilot project site area is only 0.18 ha. With the financial support of the Amsterdam Municipality, the pilot project continued until March, 1994. Five people started working on the project but only two people were left in January 1995. The project produced 1.35 - 2.25 tons a month. The required composting period is 80-90 days, from organic waste collection to packing of compost.
The retail price of compost is C$30/45kg. The worker's pay was not sufficient as it averages C$ 50/month.

bd. Future Demand of Compost

About 50% of the farmers interviewed were not aware that compost can be produced from solid waste.

All of the farmers are interested in the utilization of compost and intends to use compost if test results justify its efficacy.

The retail cost of compost however seems to be the biggest problem concerning compost production and marketing.

c. Conclusions

Based on the survey, it is safe to conclude that the market for compost products from MSW is very limited. It is, therefore, not recommendable to introduce a large scale compost plant as a means of volume reduction and resource recovery of MSW. The reasons are described as follows:

- Other competitive organic fertilizers derived from animal excreta are easily obtained in the region.
- Due to high production costs, subsidies on the sale price will be necessary to make compost from municipal solid waste compete in the fertilizer markets.
- High costs of transportation and labor for the utilization of compost.
- Less volume reduction.
- Possible accummulation of hazardous heavy metals in the soil and secondary environmental pollution in case of mixed collection system.

The pilot composting project under the guidance of the Dutch expert terminated in March 1994. After that ALMA itself carried out a market survey for the operation of a composting plant. ALMA will decide whether they will continue to operate the plant.

d. General Recommendations on Composting Survey

Composting is a very effective measure for volume reduction and source recovery of MSW, and will also finally contribute to expand the life span of the final disposal site.

Therefore, even if composting is not profitable at the moment, the composting experiment should be carried out repeatedly to accumulate the required data that would enable a long term composting.

3.4.4 Survey on Recycling

a. Objectives of the Survey

The survey was conducted in order to:

- understand the present recycling system
- determine the present waste amount recycled
- determine the recent trend of recycling activities
- analyse the present recycling system
- obtain the basic data to forecast the impact of the Master Plan on recycling and also to formulate an appropriate recycling plan

b. Survey Method

To verify the recycling flow diagram in the study area and also to grasp the waste amount, interview surveys were carried out with the following institutions and persons:

- Scavengers
- Waste collectors sorting recyclable materials
- Intermediaries
- Door-to-door collectors
- Factories using returnable containers
- Factories purchasing recycled materials

c. Findings

ca. Present Recycling System

caa. Bottles

The quantity of bottles that are directly reused without undergoing any change in form or function is considered high. Standardization of the uese of bottles, such as bottles for soft drinks and beer factories, has facilitated this level of reuse. Also the high deposit attached to each bottle encourages consumers to return the bottles.

There are no glass factories in the country and demand is high. Importation is expensive and recycling helps create jobs and reduces pressure on foreign

exchange. Moreover, various bottles without deposits are also being reused as containers of local products such as honey, tomato sauce, mustard, etc.

cab. Paper and Cardboard

There are no intermediaries in the recycling of paper and cardboards. Scavengers at the landfill sort paper in small quantities and sell it for domestic use. Paper factories and related enterprises buy the materials directly from the generation sources, e.g.,offices and shops, before they become being contaminated and degraded.

cac. Metals including Iron

Most metals, including recycled iron, is exported to other Central American countries or the United States. Two recycling intermediaries located on the road to the Augusto César Sandino Airport claim to export 60 and 68 tons, respectively, each month. Another intermediary within the Acahualinca landfill says that it exports 150 tons of mixed materials a month.

cad. Aluminum

The price of solid aluminum is quite high, therefore it is well recycled. Aluminum cans are also sorted and sold for 0.77 Cordobas a kilogram (There are approximately 55 cans in one kilogram).

There are no aluminum recycling factories in Nicaragua, therefore the collected materials are sent abroad for recycling.

caf. Plastics

Plastic objects and bottles are sorted at the landfill, but no information about their recycling and reuse was obtained.

cb. Waste Amount Recycled

The waste amount recycled in the study area is estimated to be 12.8 tons per day according to the recycling survey and scavenger survey.

cc. Recent Trends of Recycling Activities

Although it is not new, recycling is becoming an increasingly important part of municipal solid waste management as communities, businesses, and industries battle

against rising costs and are beginning to consider the environmental impacts of improperly handled waste.

The number of scavengers is increasing rapidly due to the high population growth in the country. These people live in poverty (very low income, are mostly illiterate and without job opportunities) and find scavenging their only way of living.

The present socio-economic situation in Nicaragua encourages people to look for ways of living and recycling is actually an option of work. In the formulation of the Master Plan the different recycling options available shall be considered. The development of a recycling program will require strategic planning because the proper implementation of this program may popularize waste management activities among the citizens.

In many communities recycling represents a new waste management option that is unfamiliar to many people. The Municipality of Managua should tap into the desire of citizens and businesses to " do the right thing ", design programs that facilitate recycling, and aggressively promote plans and programs to all members of the community.

Public participation is one of the most important factors that would determine the program's success.

cd. Evaluation of Present Recycling System

The present recycling system functions well. A vast amount of recyclable goods are used by factories as raw materials for manufacturing, although a significant portion of reusable materials are utilized repeatedly in their original state. The collection system highly depends on scavengers, especially because of the absence of a source segregation system. Source segregation and separate collection should be introduced.

3.4.5 Time and Motion Survey

a. Objectives of the Study

Solid waste collection involves intensive work. At the same time, its cost makes up the significant portion of the toal SWM cost. Therefore, the following measures are necessary to improve the collection efficiency:

- Maximum use of truck capacity
- Maximum use of working hours

It is necessary to determine how solid waste collection is presently carried out and to figure out its problems in order to prepare an appropriate improvement plan. This survey was carried out with such objectives.

b. Contents of the Survey

The survey includes:

- collection and haulage time, distance and weight
- type of dustbins and containers used
- working efficiency of collection workers
- collection routes
- level of user cooperation in waste collection activities
- service level
- maintenance and condition of equipment

c. Findings

ca. Time, Distance and Weight of Waste

caa. Working Time

The Time & Motion (T&M) study conducted from May 16th to 21st, 1994, indicates the time required for every activity carried out, which is summarized in Table 3.4.5a.

Table 3.4.5a Time Required Per Activity based on the Time & Motion Survey

unit: minutes

Type of Vehicle	Number of Trips	Cycle Time (minutes)				Total Time
		Collection	Haulage	Unloading	Miscellaneous	
Compactors ($14m^3$)	2	381(68.3)	86(15.4)	28(5.0)	63(11.3)	558(100)
Compactors ($15.3m^3$)	2	289(57.2)	107(21.2)	44(8.7)	65(12.9)	505(100)
Cart Tractors	2	251(62.9)	62(15.5)	24(6.0)	62(15.5)	399(100)
Container Trucks	2	115(31.3)	167(45.4)	37(10.1)	50(13.60	368(100)
Roll-on Roll-off Trucks	3	31(10.1)	194(63.2)	32(10.4)	50(16.3)	307(100)
Wheel Loaders & Dump Trucks	42	234(63.1)	88(23.7)	–	49(13.2)	371(100)

Note: The figures in parenthesis show a breakdown of the time in percentage.

cab. Distance

The distance spent for every activity is summarized in Table 3.4.5b.

Table 3.4.5b Distance based on the Time & Motion Survey

unit:Km

Type of Vehicle	Distance		
	Collection Area	Transportation	Total
Compactors (14m3)	25.6(45.8)	30.3(54.2)	55.9(100)
Compactors (15.3m3)	31.1(34.6)	58.8(65.4)	89.9(100)
Cart Trucks	12.8(29.5)	30.6(70.5)	43.4(100)
Container Trucks	46.7(65.0)	25.1(35.0)	71.8(100)
Roll-on Roll-off Trucks	0(0)	89.9(100)	89.9(100)
Wheel Loaders & Dump Trucks	0(0)	24.5(100)	24.5(100)

cac. Collection amount

The amount of waste collected by the trucks was weighed during the survey by using portable type truck scales owned by the Municipality. However, the

measured data was unreliable.

d. Type of Container

The most commonly used discharge containers for low and middle income residents are nylon sacks (about 80% of the residents). On the other hand, high income residents commonly use plastic bags and drum cans as discharge containers. The work involved in waste collection and the returning of containers is very hard for collectors.

Large generation sources, i.e. markets, hospitals, factories, and public areas, use containers for waste discharge. There are two containers types. The 0.83 m^3 container with a lid collected by screw type collection trucks, and the 15 m^3 container collected by roll-on roll-off trucks. Although the containers were adequate, a lot of the waste was scattered around the containers.

e. Discharge Point

The most popular collection system in residential areas is the curb collection system.

The containers used in this collection system are placed behind markets, hospitals, factories and offices. Some of the discharge points are unsuitable and reduces collection efficiency because of the following reasons:

- parked vehicles near containers
- no space for unloading empty containers
- closed gates

f. Efficiency of Collection Workers and Level of User Cooperation

Before the commencement of collection work, drivers and assistants briefly check and clean the vehicles for approximately 20 minutes. Vehicles are washed and refueled by other staff members in the garage after collection work.

Collection work normally takes six hours, from six in th emorning to twelve noon. Drivers and assistants execute waste collection, haulage and dumping almost continuously during this period except for short breaks. The collection activities and the behavior of the assistants are deemed satisfactory.

The work involved in waste collection and the returning of containers is very hard for collectors. Waste segregation, e.g., bottles, cans, is simultaneously carried out with the collection work. These recyclable materials are placed in sacks hanging at the back of the vehicle. The regular collection work is carried out undisturbed as these activities are carried out smoothly and efficiently.

A study should be carried out to determine if the use of the collection system with $15m^3$ containers is suitable to the area in terms of waste volume and collection frequency.

3.4.6 Installation and Operation of Truck Scale

a. Installation

In order to obtain the disposal amount at the present Acahualinca disposal site, a load cell type truck scale was installed at the entrance of the disposal site.

b. Development of Operation Programs

There are around 150 vehicles using the Acahualinca disposal site and the maximum number of vehicles entering the site per hour is about 30 to 50 units. The operation program of the truck scale was developed taking this number into account.

The purpose of installing a truck scale was to obtain the disposal amount according to waste categories. The wastes hauled and disposed in the Acahualinca disposal site were classified and shown in Table E.6.2a of Annex E.

c. Findings

The findings of a 4 month observation period (August to November 1994) are summarized as follows:

ca. General

caa. Inspection System of Incoming Vehicles

The truck scale is considered to be effective and has been working well since it

was first used. In addition, in a matter of 4 months of operation the truck scake has already registered a total of 1,081 vehicles. It can be said that through this equipment an inspection system for incoming vehicles has been established.

cab. Utilization of Collected Data

For sound solid waste management, the collection of data on waste disposal is very important. Since disposal data in accordance with classification of incoming vehicles (see Table E.6.2a) can be summarized daily, weekly, monthly and annually, this data should be used for proper operation of collection vehicles.

cb. Number of Incoming Vehicles

Table 3.4.6a Salient Features of Incoming Vehicles

Items	Unit	Number	Date
Maximum Number	units/day	269	24/10/1994
Minimum Number	units/day	0	5 days
Average Number	units/day	147	-
Total Number for 4 Months	units	17,928	-
Monthly Maximum	units/month	4,623	October 1994
Monthly Minimum	units/month	4,291	September 1994

cc. Disposal Amount

Table 3.4.6b Salient Features of Incoming Waste Amount

Items	Unit	Quantity	Date
Maximum Daily Incoming Waste Amount	ton/day	1,390.2	24/10/94
Minimum Daily Incoming Waste Amount	ton/day	0	5 days
Average Daily Incoming Waste Amount	ton/day	665.9	———
Total Incoming Waste Amount for 4 Months	ton	81,212.2	———
Maximum Monthly Incoming Waste Amount	ton/month	22,081.4	October 1994
Minimum Monthly Incoming Waste Amount	ton/month	18,337.6	August 1994

cd. Examination of Collection Route

The collection services of the Public Cleansing Office have 86 collection routes. Using the output of the operation program, it is possible to examine the work efficiency of each route.

The inspection of the collection routes should not only consider collection amount but the route condition assigned to each vehicle and the time required for each trip.

ce. ISW (Industrial Solid Waste)

The salient features of ISW disposal is tabulated as follows:

Table 3.4.6c Salient Features of ISW

Items	Units	Quantity	Remarks
Maximum Daily Incoming Waste Amount	ton/day	60.0	16/08/'94
Average Daily Incoming Waste Amount	ton/day	14.1	———
Total Incoming Waste Amount for 4 Months	ton	1713.6	———
Share of ISW in Total Incoming Waste Amount	%	2.4	Total disposal 71,213 ton
Monthly Incoming Waste Amount (Max.)	ton/month	461.3	August 1994
Monthly Incoming Waste Amount (Min.)	ton/month	382.6	September 1994

ISW transported to the Acahualinca disposal site averaged 14.1 tons daily.

Of the 14.1 tons of ISW, 8.9 tons (code Nº 200) were collected by the municipality, and 5.2 tons (code Nº 210 ~ 218) by private sectors carrying out direct haulage.

According to the codes classified by waste type, food waste was the major ISW hauled to Acahualinca, averaging 1.5 tons daily - equivalent to 37% of the total ISW amount transported. Next was construction waste; 1.3 tons daily – equivalent to 25%.

3.4.7 Disposal Waste Amount Survey

The number of incoming vehicles into the Acahualinca disposal site were recorded for 7 days from May 14th to 20th 1994, in order to clarify the following points:

- To find out the proper classification of present incoming waste prior to installation of the truck scale
- To determine the present disposal waste amount
- To observe the actual amount of medical and industrial waste disposed and the type of industrial waste.

The final disposal waste volume obtained from the number of vehicles measured

were converted to weight as shown in Table E.7.1a of Annex E.

3.4.8 Operation and Maintenance of Equipment

The present operation and maintenance services for MSWM equipment and vehicles were studied and presented in Section E.8 of Annex E. The following are the contents of the report:

- Operation and maintenance carried out by the Municipalities
- Comments about problems found in the daily operation and maintenance of equipment
- Specifications of the collection vehicles
- Spare parts dealers and factory representatives
- Inventory of vehicles and equipment as of December 1994

CHAPTER 4

PRESENT MUNICIPAL SOLID WASTE MANAGEMENT

CHAPTER 4 PRESENT MUNICIPAL SOLID WASTE MANAGEMENT

This Chapter describes the evaluation of the present MSWM.

4.1 Waste Stream

4.1.1 Concept of Waste Stream

The waste stream in the Study Area is formulated based on the following surveys:

- WACS (Waste Amount and Composition Survey)
- POS (Public Opinion Survey)
- DWAS (Disposal Waste Amount Survey at Acahualinca D.S.)
- Disposal amount obtained by the truck scale at Acahualinca D.S. from August to November 1994

The waste stream concept is illustrated and shown in Figure 4.1.1a. Solid waste from each generation source is classified into three categories, i.e. recycled, discharged and self-disposed waste. Discharged waste is divided into waste collected by collection services and waste dumped illegally or littered. Collected waste is transported to the disposal site where reusable materials are picked out by collectors and scavengers (churequeros). Wastes disposed at the disposal site are not only those collected by the municipality, but waste hauled directly by factories as well.

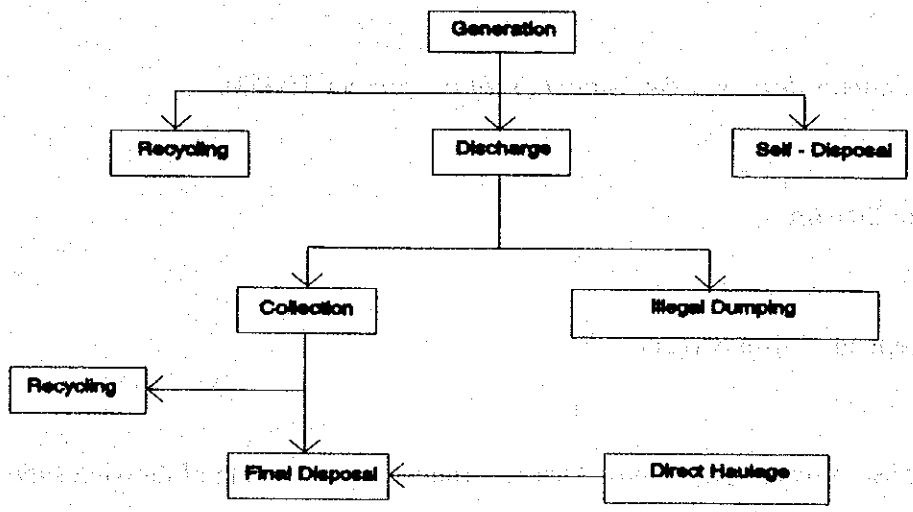


Figure 4.1.1a Waste Stream

4.1.2 Waste Stream

a. Generation Sources

The generation sources in the Study Area are classified as follows:

- Residences (Household Waste)
- Restaurants (Commercial Waste)
- Other Shops (Commercial Waste)
- Markets (Market Waste)
- Offices (Institutional Waste)
- Hospitals (Hospital Waste)
- Roads (Street Sweeping Waste)
- Parks and Green Areas (Park and Green Area Waste)
- Factories (Industrial Waste)

The municipality collects a limited amount of industrial waste.

b. Waste Stream

The waste stream in the municipality in the year 1994 was estimated based on the conditions described below and presented in Table 4.1.2c and Figure 4.2.1a.

ba. Conditions of the Estimation

baa. Generation

The waste generation amount is obtained by the following formula:

GA = WGR x UN

GA	: Generation amount (ton/day)
WGR	: Waste generation ratio (g/unit)
UN	: Unit number

Table 4.1.2a Waste Generation Ratio

	1994
Household	664 g/person/day
Shop	999 g/shop/day
Restaurant	13,828 g/shop/day
Market	3,875 g/shop/day
Institutional	6 g/employee/day
Street Sweeping	49,850 g/km/day
Hospital	2,897 g/bed/day
Park and Green Area	83,800 g/ha/day

Table 4.1.2b Number of Units

Generation Source		Number of Unit
Residential Area		834,427 households
Commercial Area	Restaurants	1,838 shops
	Other shops	393 shops
Markets		6,712 shops
Institutions		38,029 employees
Hospitals		2,175 beds
Roads		331.0 km
Park and Green Areas		16.7 ha

bab. Source Recycling

The food waste recycling rate at generation sources is estimated at 20g/person/day based on the results of the POS. Recycling amount is calculated by the formula below.

$SRA = 20 \text{ (g/person/day)} \times NP \times 10^{-6}$

SRA :Source recycling amount (ton/day)
NP :Population

bac. Self-disposal

i. Collection Service Area

Based on the above-mentioned survey, the self-disposal rate is estimated at 95g/person/day. The self-disposal amount is calculated by the formula below.

$SA = 95 \text{ (g/person/day)} \times NP \times CCR \times 10^{-6}$

SA	: Self-disposal amount (ton/day)
NP	: Population
CCR	: Collection coverage ratio (%)

ii. Non-collection Service Area

Self-disposal amount in non-collection service area is derived from the following formula:

$SA(non) = (HGA - SRA) \times (1 - CCR/100)$

SA (non)	: Self-disposal amount in non-collection service area (ton/day)
HGA	: Household generation amount (ton/day)

bad. Discharge and Collection

The waste discharge amount (waste collection amount) is obtained by the following formula:

DA(CA) = GA – SRA – SA – SA (non)

DA(CA) : Discharge amount (collection amount) (ton/day)

bae. Recycling Other than at the Source

Based on the recycling and scavenger survey conducted by the Study Team, the amount recycled at locations other than at the source is estimated at 12.8 tons/day.

baf. Direct Haulage

Based on the data obtained by the truck scale at the Acahualinca disposal site, the amount of directly hauled waste is 41.7 tons/day.

bag. Final Disposal

The final disposal amount is calculated by the formula below. The disposal amount is calculated by the data obtained at the Acahualinca disposal site.

FDA = DA – RA + DHA

FDA	: Final disposal amount (ton/day)
DA	: Disposal amount obtained by truck scale (ton/day)
RA	: Amount of recycling other than at the source (ton/day)
DHA	: Directly hauled waste amount (ton/day)

Table 4.1.2c Present Waste Stream in the Study Area

unit: ton/day

Type of Waste		Generation	Source Recycling	Self-disposal	Discharge (Collection)	Recycling	Direct Haulage	Final Disposal
MSW	Household Waste	554.1	16.7	185.2	352.2	-	-	352.2
	Commercial Waste (Restaurant)	25.4	0.0	0.0	25.4	-	-	25.4
	Commercial Waste (Others)	0.4	0.0	0.0	0.4	-	-	0.4
	Market Waste	26.0	0.0	0.0	26.0	-	-	26.0
	Institutional Waste	2.3	0.0	0.0	2.3	-	-	2.3
	Hospital Waste	6.3	0.0	0.0	6.3	-	-	6.3
	Street Sweeping waste	16.5	0.0	0.0	16.5	-	-	16.5
	Park & Green Area Waste	1.4	0.0	0.0	1.4	-	-	1.4
	Directly Hauled MSW	36.6	0.0	0.0	0.0	-	36.6	36.6
	Total MSW	669.0	16.7	185.2	430.5	-	36.6	467.1
ISW	Industrial Waste Collected	8.9	0.0	0.0	8.9	-	-	8.9
	Waste from RIDS	188.0	0.0	0.0	188.0	-	-	188.0
	Directly Hauled ISW	5.1	0.0	0.0	0.0	-	5.1	5.1
	Total ISW	202.0	0.0	0.0	196.9	-	5.1	202.0
Total		**871.0**	**16.7**	**185.2**	**627.4**	**12.8**	**41.7**	**656.3**

Note :Industrial waste collection amount is limited to waste collected by the Municipality.
:RIDS (Registered Illegal Dump Sites)

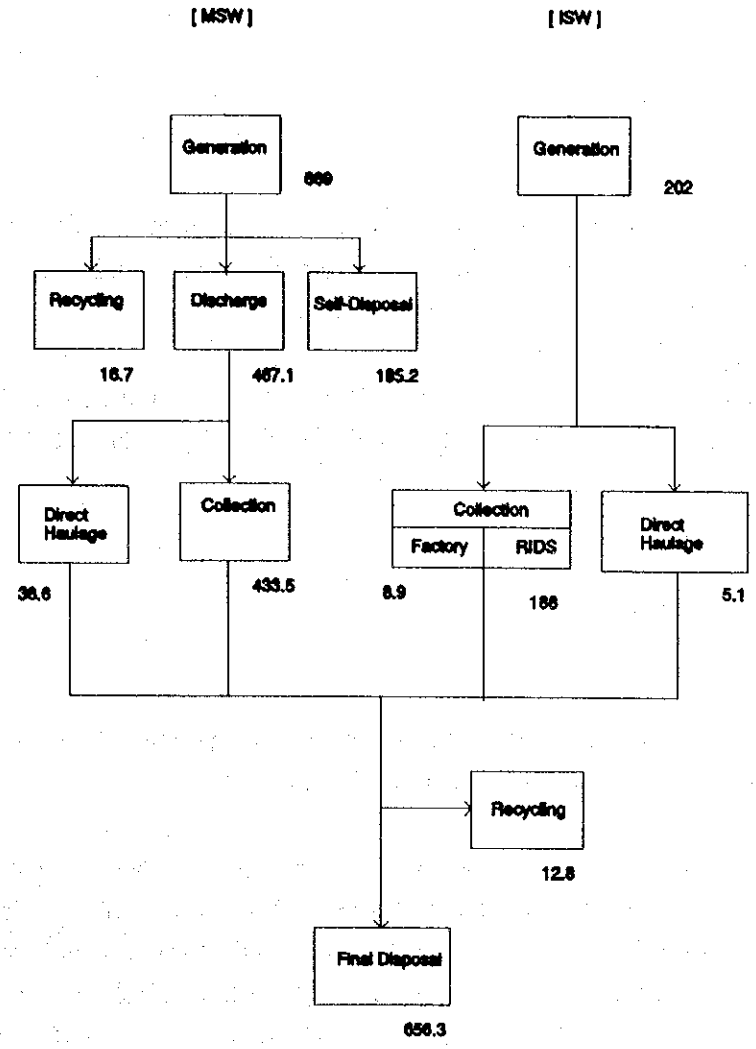


Figure 4.1.2a Present Waste Stream in the Study Area unit: ton/day

4.2 Present MSWM

4.2.1 Technical System

The Study Team was able to determine the present municipal solid waste management system in the Study area based on the results of field surveys, municipal interviews, field reconnaissance and existing data.

The technical system in February 1994 is summarized in Table 4.4.1a in this chapter. This is presented in detail in Tables F.2.1a, F.2.2a and F.2.5a of Annex F.2.

4.2.2 Institutional System

A detailed description of the present institutional system of the municipality is presented in Annex F.3 and summarized below.

a) The piling and collection of street wastes are not carried out by the same head office, i.e, cleansing activities are carried out by the District Coordination Office (DCO) while collection and disposal are carried out by the Public Cleansing Office (PCO) which is directly under the Municipal Works and Services Head Office (MWSHO). Collection is very difficult to coordinate, and in the case of Managua, it is further aggravated by the great number of small waste dump sites scattered all around the city.

b) The financing for MSWM is now very tight, since the national government abolished the charging and collection of waste fees through electricity and telephone bills. Today, the amount of money recovered and the number of units charged directly are very low, not even reaching 20% of the costs.

c) Maintenance of vehicles and equipment for cleansing services is conducted by the Maintenance and Recovery of Equipment Office (MREO) of the MWSHO; MERO is independent of the Public Cleansing Office, a situation that often is the cause of problems in management, because the priorities of the workshop are not always the same as that of the waste management office.

d) The relationship between the Environmental Protection Head Office and the Public Cleansing Office is good and shall be reinforced in matters mainly related to environmental education.

e) There is almost no coordination between the activities of the municipality, the Ministry of Health and the Ministry of the Environment and Natural Resources. This coordination shall be sought, mainly to develop a control and enforcement program for actions related to solid wastes and public hygiene.

f) Training programs shall be established for all employees, since only very few have had the opportunity to attend courses on solid waste issues.

g) The operational and support services control shall be analyzed because while many forms are filled out and a lot of data are collected, control through performance evaluation is seldom made.

h) The municipality shall decide whether to carry out partial or full privatization of the services, in accordance with relevant policies, and studies shall be conducted to evaluate its feasibility.

4.3 Review of Existing Plans and Studies

The following are the existing plans and studies on Solid Waste Management, which have been carried out in the Municipality of Managua that were identified by the Study Team:

- " Evaluation of the Practice of Solid Waste Management in Managua " prepared by Frank Ohresorgen, Director of Programs for Latin America, the International City/County Management Association (ICMA), September 1993.
- " Solid Waste Management Plan for Managua ", prepared by Eng. Koen de Jong, Department of Engineering, Amsterdam, March 1994.

The above-mentioned reports were reviewed by the Study Team and useful issues, conclusions and recommendations were reflected in the planning of this report. Detailed information is presented in Section F.4 of Annex F.

4.4 Evaluation of Present MSWM

4.4.1 Technical System

The evaluation of the present municipal solid waste management in terms of the technical systems are summarized in Table 4.4.1a. As mentioned in the table, the major issues and problems identified with the present MSWM in relation to the formulation of the master plan, are described below:

- improvement of waste discharge method in collection area B
- expansion of collection area
- promotion of container collection system for large generation sources
- improvement of public cleansing work
- consideration of recycling and composting system
- improvement of the present workshop of the Public Cleansing Office
- improvement of sanitary condition of the present disposal site

a. Improvement of Waste Discharge Method in Collection Area B

The discharge system in collection area B needs to be improved for the following reasons:

- the local scenery has been damaged by scattered and accumulating waste
- in sanitary conditions
- illegal dumping of waste, e.g., industrial wastes including hazardous materials.

b. Expansion of Collection Area

In order to extend the collection service to squat areas, the introduction of a proper collection system that would suit the structure of the squat area, i.e, a public container or bell collection system, should be studied.

c. Promotion of Container System for Large Generation Sources

The container collection system is suitable for large waste generation sources, i.e. commercial areas, markets, hospitals, institutions and factories, and as the system

is efficient and reliable, it should be continued. The container capacity, however, should be reconsidered together with increasing the number of vehicles and containers.

d. Improvement of Public Cleansing Work

The present manual street sweeping and park & green area cleansing system is suitable because of the high unemployment rate, therefore it should be extended or implemented where it is not provided.

Installation of containers to store street sweeping and park & green area wastes shall be examined to improve sanitary conditions and for the beautification of the area. In addition, in order to prevent littering, the installation of containers in public areas, e.g., roadsides and parks, is suitable in conjunction with the enforcement of the anti-littering laws.

e. Consideration of Recycling and Composting system

At present, a handful of those in the private sector conduct all recycling activities in the Study Area; one of the possible reasons behind this is the limited market for recycled/reused materials and compost from MSW. For future implementation of a recycling and/or composting facility, it should be examined from a market, public cooperation (waste segregation), finance (MSWM), and facilitation of engagement points of view.

f. Improvement of the Present Workshop of the Public Cleansing Office

In order to establish the efficient use of vehicles and equipment for MSWM, the present workshop at Los Cocos shall be improved to provide preventive maintenance of them. Complex maintenance such as overhauls shall be done either at the central workshop or at private workshops.

g. Improvement of Sanitary Conditions of the Present Disposal Site

In order to preserve the surrounding environment, appropriate measures such as defining site boundary, regular waste covering activities in the disposal area and strict monitoring etc., should be established.

Table 4.4.1a Evaluation of the Present Technical System

Items	Present System	Evaluation
1. Discharge & Storage		
– Source Separation	Not established.	. Discharge and storage should be examined totally from a market of recycling materials, cooperation of residents and finance of MSWM points of view. . The source segregation system of infectious waste in hospitals shall be established.
– Waste Container	. A nylon sack is commonly used in the residential area. . 15m³or 0.83m³ containers are used to collect waste from commercial areas, markets, hospitals, institutions, and factories.	. Nylon sacks are suitable in residential areas as they are cheap, easy to handle and recyclable. . The capacity and size of containers should be examined.
– Discharge Point	. In front of the premises (collection area A). . Discarding at registered illegal dump sites (collection area B).	. The discharge point for collection area A suits the present collection system. . The sanitary condition of the area used for the registered illegal dump site shall improve if the scattered waste around the sites is removed.
2. Collection & Haulage		
– Service Coverage	The service coverage of residential areas is 77.0% of the urban area. . Almost 100% of collection area A is covered (66.7% of the urban area). . About 30.8% of collection area B is covered (10.3% of the urban area).	The collection services shall cover all of the urban area through proper collection system.
– Collection Level		
. System	. Curb collection system in collection area A. . The collection system is a combination of wheel loader and dump truck in collection area B. . Container collection system in commercial areas, markets, hospitals, institutions and factories.	. The curb collection system in collection area A is suitable because of its efficiency. . The container and/or bell collection system shall be examined in collection area B. . The container system is efficient and reliable in these generation sources. The collection capacity shall be improved by replacement and increase in the number of vehicles and containers.
. Frequency	. Thee times a week in most of collection area A. . The collection frequency is not regular in collection area B. . Since the capacity of 15m³ containers is too large for some facilities, it is difficult to establish the collection frequency and route.	It shall be examined considering sanitary aspects and operation cost. The collection frequency and route of 15m³ container system shall be examined by using a truck scale.
. Collection Efficiency	Working hours is normally 6 hours a day.	It shall be examined by using a truck scale.
3. Street Sweeping and Park and Green Area Cleansing Service		
– Responsible Organization	. Street sweeping ... District Coordination Office (DCO). . Park and Green Area Cleansing ... Beautification Head Office(BHO)	
– Cleansing System	Manual	Present manual sweeping and cleansing system is suitable under the condition of high unemployment ratio, so it should be extended or implemented where this service is not provided.

Items	Present System	Evaluation
- Discharge Point	Discarding at registered illegal dump sites.	. Installation of containers for street sweeping and Park and Green Area cleansing shall be examined to improve sanitary conditions and to beautify of the area. . In order to solve littering by citizens, the municipality should install public containers in the core area of the city in addition to the enforcement of the anti-littering regulation.
4. Intermediate Treatment		
- Recycling	The majority of recycling is conducted through the private sector including scavengers at Acahualinca disposal site, collection crew, intermediaries and purchasers. Approximately 13ton/day of reusable materials is recycled in the Study area. Main recyclable materials are glass, iron, aluminum, plastic, paper and cardboard, etc.. These materials are exported to neighboring countries because Nicaragua national market is limited.	Recycling and compositing systems should be examined totally from a market, public participation for source segregation, finance of MSWM and facilitation of engagement points of view.
- Composting	The municipality is executing a pilot project on composting from market waste with a production of 4.8 ton/month. The operation and control of the pilot project should improve the quality and quantity. The use of compost is limited to fertilizing trees along the roadside.	
5. Final Disposal		Based on the present annual amount of the waste disposed at Acahualinca, approximately 220 thousand cubic meters, the present disposal site can be used for a further four or five years.
- Outline		
. Location	Acahualinca	
. Distance	Approximately 10km from the main generation source.	
. Disposal Amount	Approximately 2,000m^3/day (not compacted).	
. Landfill Area	Approximately 40ha.	
. Year of Commencement	1975	
. Working Hour	12 hr/day	
. Method of Landfill	Semi-controlled tipping	
. Number of Landfill Equipment	Bulldozer: 2 units Landfill compactor: 4 units Water tank truck: 2 units	
. Number of Scavengers	Approximately 250 persons	
. Number of Personnel	20 persons	
- Landfill Level	Incoming waste to the disposal site is dumped under the control of a supervisor, based on their experience, without water treatment and waste covering.	
- Sanitary Condition	. As the present disposal area has been formed without prior planning, the boundary of the site is not clearly defined. . As the waste is disposed without covering, lighter wastes are scattered and blown by the wind. . The scavengers illegally live in the site.	.. These present conditions debase the surrounding sites and the quality of sanitation should be improved.
5. O & M for Equipment	At Los Cocos workshop, preventative maintenance procedures are executed such as lubrication and oil exchange. Complex repair and maintenance of collection vehicles and equipment are conducted in the central workshop together with other municipal machinery.	In order to establish the efficient use of vehicles and equipment for MSWM, the present workshop for the Public Cleansing Office shall be improved.

4.4.2 Institutional System

The institutional system of the Solid Waste Management(SWM) activities in the Municipality of Managua, like most Latin American countries, was founded without any specific planning or design. The system spontaneously evolved from several decisions of municipal administrators on responsibilities and powers assigned to various municipal organs and agencies, and their relationship to one another.

The institutional system should be improved as it has been found to have several deficiencies, not only from the organizational point of view but also in its internal communications system and administrative relations with other municipal bodies.

The disposition of the personnel for SWM activities also needs to be improved, since many of the people hired have no formal training or educational background necessary for the development of the activities.

The main findings and the preliminary ideas and alternatives on how to improve the current situation are given hereafter.

a. Findings

The administrative and managerial system for public services in the Municipality of Managua has undergone a complete transformation in the past years as a result of political and economic reconstruction after the civil war.

Before the election of the current municipal government, SWM activities were performed by a municipal company holding a semi-autonomous economic and administrative status. The creation of many different government enterprises to deal with public services such as SWM was devised by the Sandinista government to control the country and municipalities. This administrative system, however, was dismantled by the newly elected municipal government of Managua on the grounds that the excessive degree of independence exercised by these public companies restricts the authority of the head of the municipal government.

Consequently, the old SWM company was abolished and its activities disintegrated into several municipal institutions. The most important of these, the Public Cleansing Office (PCO), which is tied to the Municipal Works and Services Head Office, is in charge of collection and disposal activities.

The Territorial Administration of the District Coordination Office (DCO), which is

directly under the Mayor's Office, shares the responsibilities of the PCO and is responsible for street cleansing works.

Other municipal institutions dealing indirectly with SWM activities are the tax collection head office which is responsible for the collection of service fees, and the Directory of Maintenance and Recovery of Equipment which is also under the MWSHO and on the same administrative level with the PCO.

The money flow of the Municipality of Managua in 1993 is summarized in Figure 4.4.2a, and is distinctly characterized by the following:

(1) The total expenses of the cleansing services cover about 8.8% of the municipal budget.

(2) The expenses of the cleansing services, which is supervised by the PCO under the umbrella of the MWSHO, is approximately 51% of the total MWSHO expenses. The expenses for the street cleansing works which are carried out by the DCO almost equal the collection expenses of PCO.

(3) District taxes are the main financial sources of the Municipality of Managua; taxes from waste only constitute approximately 3% of the total revenue.

(4) The ratio of commercial waste to household waste is 6:1, and the tax imposed on the former is 4 times more than the latter.

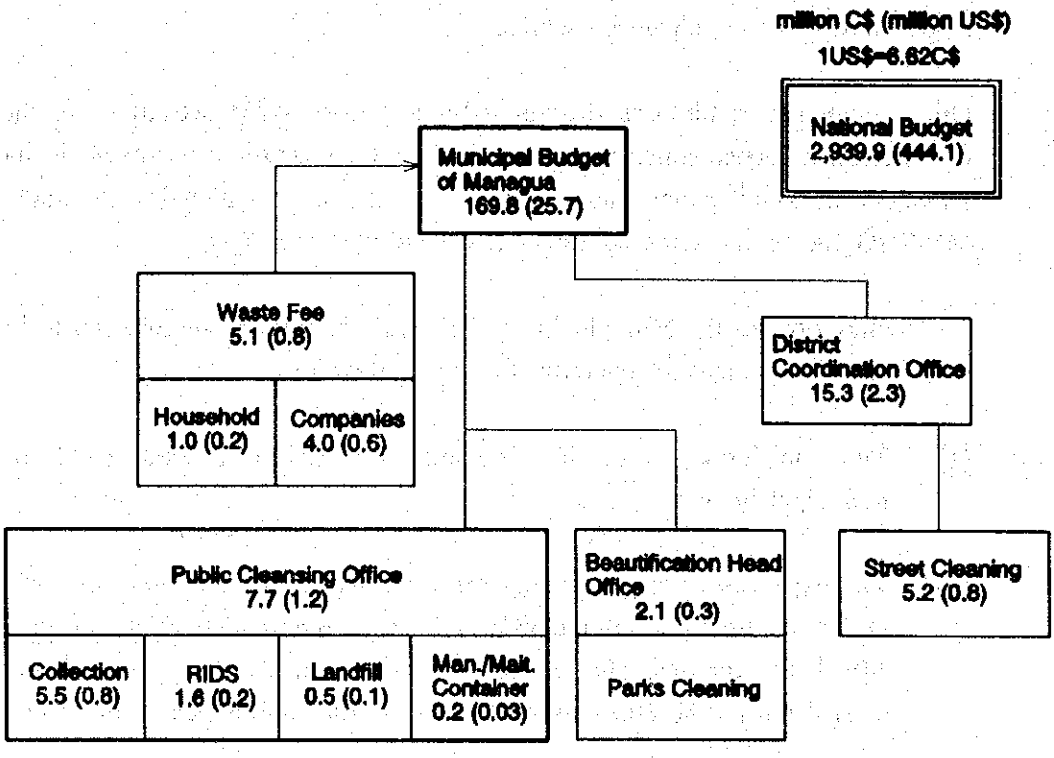


Figure 4.4.2a Money Flow on SWM in 1993

b. Improvement Measures

The most important institutional measure is the reorganization of the municipality's administrative structure so that all SWM (Solid Waste Management) related activities fall under the Public Cleansing Office, especially those related to the activities carried out by the Administrative Coordination.

The reorganization will further coordinate cleansing by the efficient use of equipment and manpower mainly in the removal of RIDS scattered throughout the city.

Although the vehicles and equipment are maintained by a different municipal institution, the efficiency of the fleet operation seems to be unaffected. However, they are more likely to be affected by technical problems. Further, the majority of the equipment and vehicles (mostly those from the former Soviet Union) have no spare parts.

With regard to financial resources, the tax collection system shall be improved probably by integrating them with other municipal taxes, i.e. property tax.

The solid waste collection fee is presently collected through a single system based on a makeshift cadastre using inexperienced personnel, which therefore, results in inefficiency and poor financial resources in contrast to the expenses and the collectible amount.

The improvement measures that shall be specifically taken are:

(1) Enforcement of household fee collection activities; arrangement of residential register; gradual increase of collection fees.

(2) Impartiality in the collection of fees from companies; collection of fees from large companies; shift to a specific system.

(3) Introduction of tipping fee collection at the disposal site.

Measures shall also be taken to improve the handling of affairs within the Public Cleansing Office and among the several Municipal Organizations involved in solid waste activities.

CHAPTER 5

SELECTION OF FINAL DISPOSAL SITES

CHAPTER 5 SELECTION OF FINAL DISPOSAL SITES

This chapter describes the selection process of the final disposal site for the Master Plan.

5.1 Site Selection Method

5.1.1 Flow Diagram of Site Selection

The study flow diagram of the final disposal site selection is shown in Figure 5.1.1a.

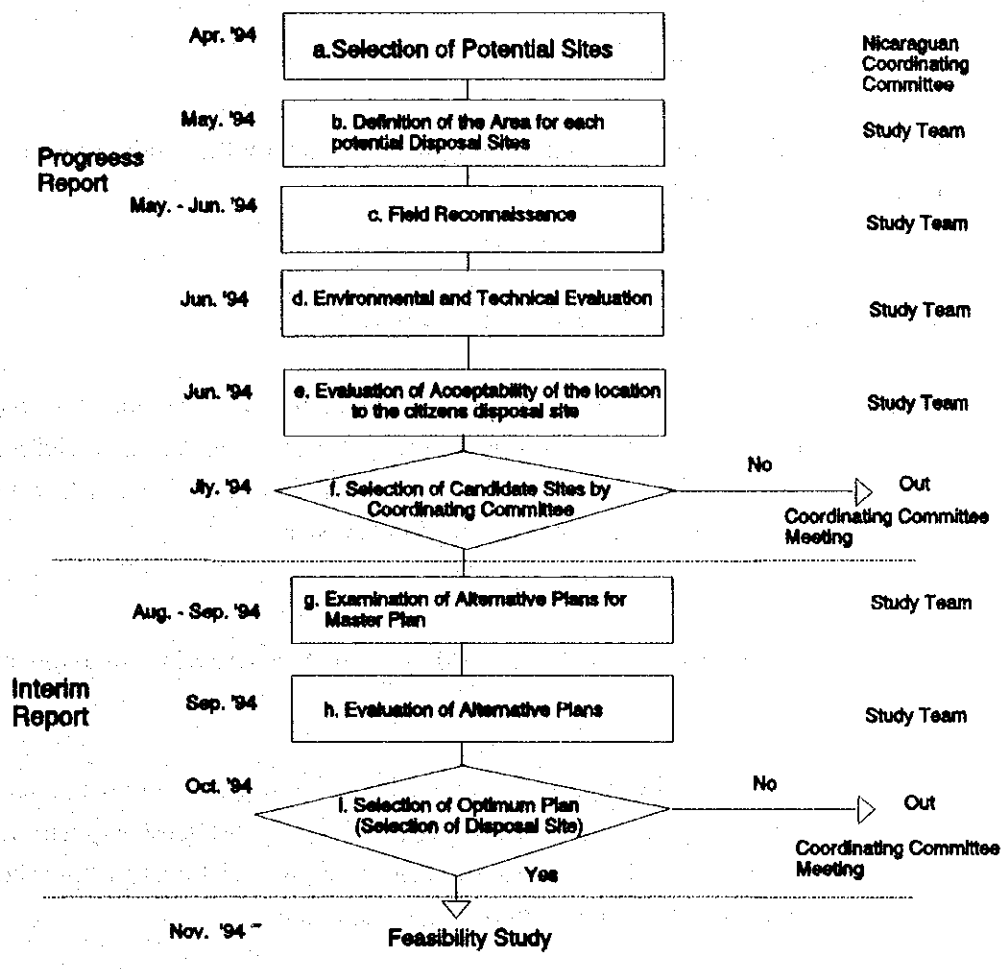


Figure 5.1.1a Work Flow Diagram on Localization of Disposal Site

5.1.2 Selection Method

a. Selection of Potential Sites

Six candidate disposal sites including an area adjacent to the present Acahualinca disposal site were selected from 11 sites by the Nicaraguan Coordinating Committee at the commencement of this study.

b. Definition of the Area for each Potential Site

The Study Team and the Nicaraguan Counterpart defined the area for each candidate site by using a 1 to 10,000 topographical map.

c. Field Reconnaissance

Field reconnaissance was carried out on potential sites by the Study Team in order to collect data for further evaluation.

d. Environmental and Technical Evaluation

Environmental and technical evaluations were conducted on all potential disposal sites. The environmental evaluation is divided into three categories, social impact, environmental pollution, and impact on nature. The technical evaluation covers available area, coverage soil, accessibility and capacity.

e. Evaluation of Citizens' Acceptability of the Construction of Disposal Site Location

It is necessary to gain the approval of the residents in neighboring area concerning the construction and operation of a final disposal site before land acquisition is to be carried out. Evaluation was carried out in terms of social acceptance, and was confirmed with the Nicaraguan coordinating committee.

f. Selection of Candidate Sites by Coordinating Committee in the Meeting of Progress Report (1)

It is important to estimate the overall solid waste management cost, including collection and haulage costs, by potential site. However since it is not practical to estimate the cost for all potential sites, cost evaluation for the candidate sites selected in the Meeting of the Progress Report (1) was carried out in Japan and the results were included in the Interim Report.

g. Examination of Alternative Plans for the Master Plan

There are two alternatives to the master plan: the centralized disposal system and the separate disposal system.

In a centralized disposal system, the waste collected from the Study Area is hauled to one disposal site to reduce construction, operation and maintenance costs. On the other hand, the separate disposal system reduces transportation cost as if entails the haulage of waste collected from each area to the nearest disposal site.

h. Evaluation of Alternative Plans

The technical system alternatives in 2010 were evaluated by the following items.

- technical points of view
- economic and financial points of view
- environmental points of view
- social points of view

i. Selection of Optimum Plan (i.e. Selection of Disposal Site)

The results of the evaluation on the alternative plans were included in the Interim Report submitted in October 1994. In the Meeting of the Interim Report, the Coordinating Committee made a final decision on the selection of the optimum alternative plans as the main system for the municipal solid waste management Master Plan.

5.2 Selection of Potential Sites

5.2.1 Selection of Potential Sites by the Nicaraguan Coordinating Committee

The Nicaraguan Coordinating Committee selected the following six candidate sites before the meeting on the inception report. No specific guidelines mere used for the selection.

- Acahualinca
- Santa Ana
- Cuajachillo
- San Judas
- Villa Fontana
- Esquipula

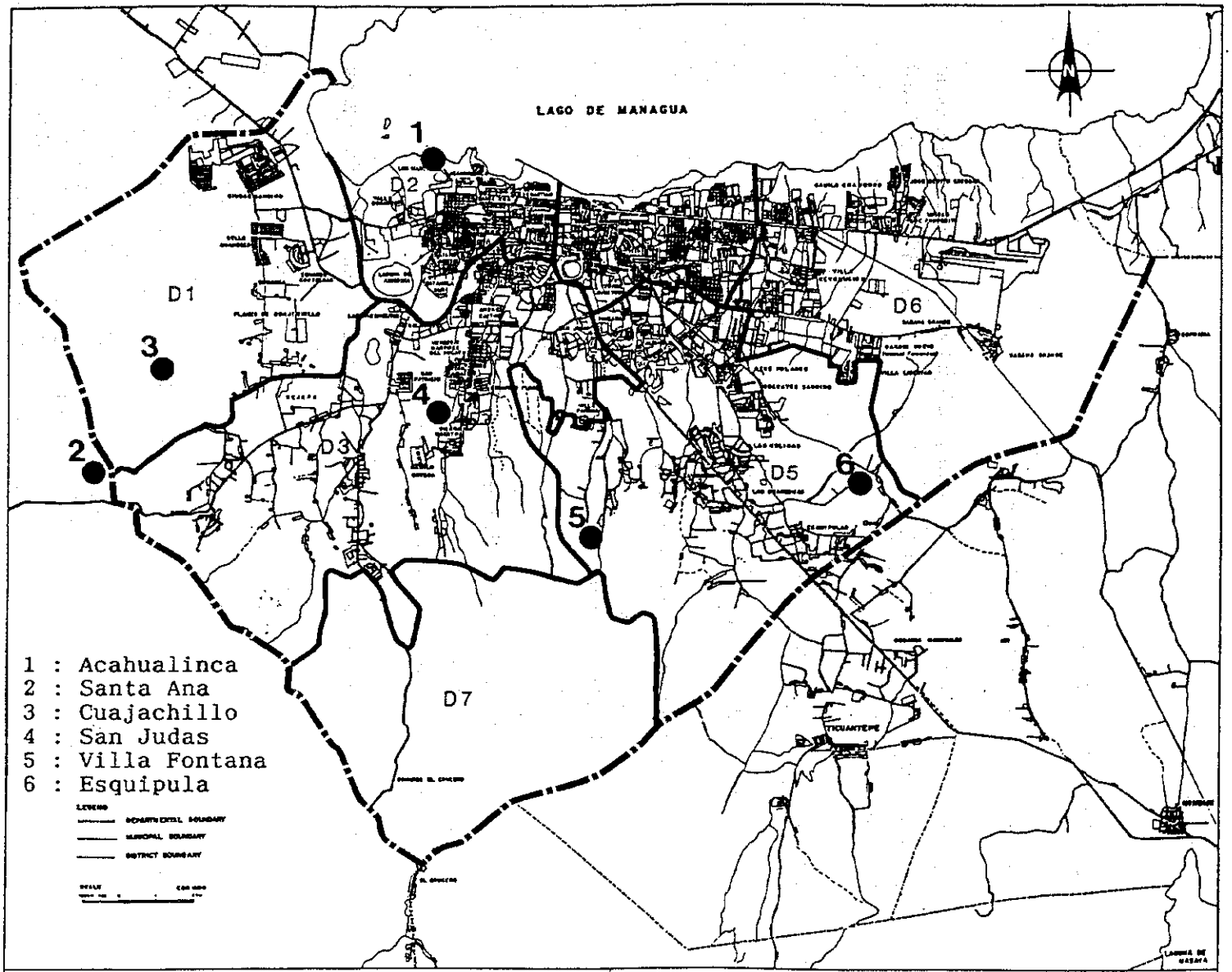
5.2.2 Examination of Potential Sites

The Study Team examined the potential of disposal sites selected by the Nicaraguan Coordinating Committee based on the following guidelines:

- possibility of land acquisition
- possibility of obtaining neighborhood consensus
- compatibility with regional development plan
- economic feasibility
- environmental acceptability

5.2.3 Field Reconnaissance

Field reconnaissance was carried out by the Study Team to get enough data for the evaluation of the six potential disposal sites. The location of each potential disposal site is shown in Figure 5.2.3a and general information on the sites is presented in section G.3 of Annex G.



THE STUDY ON THE IMPROVEMENT OF THE SOLID WASTE MANAGEMENT SYSTEM FOR THE CITY OF MANAGUA

JAPAN INTERNATIONAL COOPERATION AGENCY

Figure 5.2.3a
Location Map of the Candidate Disposal Sites

5.3 Environmental and Technical Evaluation

5.3.1 Evaluation Method

a. Evaluation Method

aa. Items for Method of the Evaluation

The potential sites were evaluated by rating their impacts on social environment pollution, natural environment and technical aspects based on the data collected through field reconnaissance.

ab. Data used for the Evaluation

The following data were used for this evaluation:

- topographical maps (1:10,000)
- cadastral map
- aerial photos (1:40,000)

b. Method of Environmental Evaluation

ba. Items of the Environmental Evaluation

The items used for the environmental evaluation are presented in the left column in Table 5.3.1a.

Table 5.3.1a Environmental Evaluation Items and Indices

Evaluation Items	Description	Indicators
1. Social Environment		
. Community Dispersion	. Separation of a community	. Location and area of communities
	. Disconnection of a community road for commuting to schools and offices	
. Forced removal	. Impact on the residential area	. Location and area of communities
. Religious institutions	. Removal of a church and a cemetery	. Location of churches and cemeteries
. Public facilities	. Impact on schools and hospitals	. Existence of schools and hospitals
. Visibility of landfill site		. Visibility from the community roads
		. Existence of an observatory
		. Existence of scenic places
. Future land use near the site	. Whether inside of future urban area	. Location of the site
. Compatibility with other laws	. Compatibility with land use plan	. Compatibility with the law
	. Other development plans in neighboring	
. Compatibility with other plans	areas	. Compatibility with the other plans
2. Environmental Pollution		
. Waste pollution	. River water and groundwater	. Existence of a river
	Drinking water	. Existence of a well
. Odor		. Location and area of communities
. Noise		. Location and area of communities
. Vibration		. Location and area of communities
3. Natural Environment		
. Collapse of slope	. Collapse of slope	. Condition of present topography
	Existence of steep slopes	
	Existence of eroded area	
. Inundation		. Condition of present topography
. Flora	. Impact on existing flora	. Existence of natural forest
. Fauna	. Change in flora and land use	. Existence of natural forest
. Landscape	. Change in land use of the site	. Present land use

bb. Rating System

The evaluation results were expressed by the number of points given to each evaluation item. 2 points were given to a site where the environmental impact is

low, 1 is given for a medium impact and 0 for a high impact.

The rating system is presented in Table 5.3.1b.

Table 5.3.1b Environmental Evaluation Rating System

Evaluation Indices	Point	Description
Compatibility with law	0 1 2	not compatible negotiable compatible
Compatibility with other plans	0 1 2	not compatible negotiable compatible
Location of site (A)	0 1 2	outside the Study Area - inside of the Study Area
Location of site (B)	0 1 2	inside the urban area within 400 m from the urban area outside the urban area
Neighboring houses	0 1 2	houses exist within the site or many houses exist nearby. a few houses exist within 400 m from the site. no houses within 400 m from the site.
Church	0 1 2	exist in the site. exist within 400 m from the site. none within 400 m from the site.
Cemetery	0 1 2	exist in the site. exist within 400 m from the site. none within 400 m from the site.
School	0 1 2	exist in the site. exist within 400 m from the site. none within 400 m from the site.
Medical facilities	0 1 2	exist in the site. exist within 400 m from the site. none within 400 m from the site.
Visibility from roads	0 1 2	the entire site can be mostly seen from the community road. some parts of the site cannot be seen due to trees or buildings. most of the site cannot be seen from the community road.
Observatory	0 1 2	exist in the site. exist within 400 m from the site. none within 400 m from the site.
Scenic place	0 1 2	exist in the site. exist within 400 m from the site. none within 400 m from the site.
River, stream	0 1 2	exist in the site. exist within 400 m from the site. none within 400 m from the site.
Well	0 1 2	exist in the site. exist within 400 m from the site. none within 400 m from the site.
Present terrain	0 1 2	steep slope in the site gentle slope in or near the site flat land in the site
Natural forest	0 1 2	exist in the site. exist within 400 m from the site. none within 400 m from the site.
Present land use	0 1 2	natural land cultivated land waste land

c. Technical Evaluation Method

ca. Items for Technical Evaluation

The items used for the technical evaluation are as follows:

- total available area for the site
- availability % cover soil
- accessibility to haulage route
- road improvement cost
- land acquisition cost

cb. Rating System

The evaluation result was expressed by the number of points given to each evaluation items. 2 points were given to a site with optimum conditions, 1 for average level, and 0 for the poorest condition. The rating system is presented in Table 5.3.1c.

Table 5.3.1c Technical Evaluation Rating System

Evaluation Indices	Point	Description
Total available area for the site	0 1 2	≤ 50 ha 50 ha < A ≤ 100 ha > 150 ha
Availability of cover soil	0 1 2	Not available in the site Available in the site
Accessibility to haulage route	0 1 2	≥ 15 km 15 km > L ≥ 10 km < 10 km
Road improvement cost	0 1 2	> ***C$ ***C$ ≥ V > 0 C$ 0 C$
Land acquisition cost	0 1 2	> ***C$/ha ***C$/ha ≥ V > ***C$/ha ≤ ***C$/ha

5.3.2 Overall Evaluation

The results of the evaluation are presented in Table 5.3.2a.

Table 5.3.2a Evaluation Results

	Social Environment	Pollution	Natural En-vironment	Technical Aspect	Total Score	Rank
Acahualinca	21	7	5	5	38	1
Santa Ana	21	4	3	5	33	2
Cuajachillo	14	5	3	4	26	5
San Judas	15	2	3	4	24	6
Villa Fontana	18	5	3	5	31	4
Esquipilas	14	6	9	3	32	3

5.3.3 Evaluation of the Acceptability of the Disposal Site Location to the Citizens

The candidate sites were selected by the Municipality of Managua based on the possibility of land acquisition, which is the first priority.

When the land is acquired, the acceptance of the citizens of the site location is absolutely required and will be evaluated.

The opinions of citizens all over the world regarding solid waste are given below. Generally, these should be taken into account when trying to obtain the citizen's acceptance of the selected disposal site.

NIMBY	Not in my backyard
NIMFE	Not in my frontyard either
PITTBY	Put it in their backyard
NIMTOF	Not in my term of office
NIMEY	Not in my election year
LULU	Locally undesirable
YIMBY/FAP	Yes, in my back yard, for a price

The items used for evaluation, e.g., social environment, environmental pollution,

natural environment, technical aspect, were not ranked according to importance. However, "Social Environment" will be given special weight if protest from the people is expected. The candidate disposal sites were ranked according to the total number of points acquired in the evaluation (Table 5.2.3a). The ranking of the sites is shown in Table 5.3.3a.

Table 5.3.3a Ranking of Candidate Sites by the total number of points acquired.

Rank	Name of Site	Score
1	Acahualinca	38
2	Santa Ana	33
3	Esquipulas	32
4	Villa Fontana	31
5	Cuajacjillo	26
6	San Judas	24

Based on the above ranking, the Study Team narrowed the number of candidate sites to 3 for the alternative study to be carried out in Japan:

1. Acahualinca
2. Santa Ana
3. Esquipulas

CHAPTER 6

EXAMINATION OF TECHNICAL SYSTEM ALTERNATIVES

CHAPTER 6 EXAMINATION OF TECHNICAL SYSTEM ALTERNATIVES

This chapter describes the selection process of the optimum technical system alternatives for the MSWM Master Plan of the Municipality of Managua.

6.1 Work Flow of the Examination of Technical System Alternatives

6.1.1 Study Flow Diagram of the Examination of Technical System Alternatives

The examination and selection of the optimum technical system alternatives were divided into two stages, that is, Stage A for the examination of technical sub-system components and Stage B for the selection of the optimum technical system alternatives for the Municipality of Managua. The Study flow diagram of these works is shown in Figure 6.1.1a.

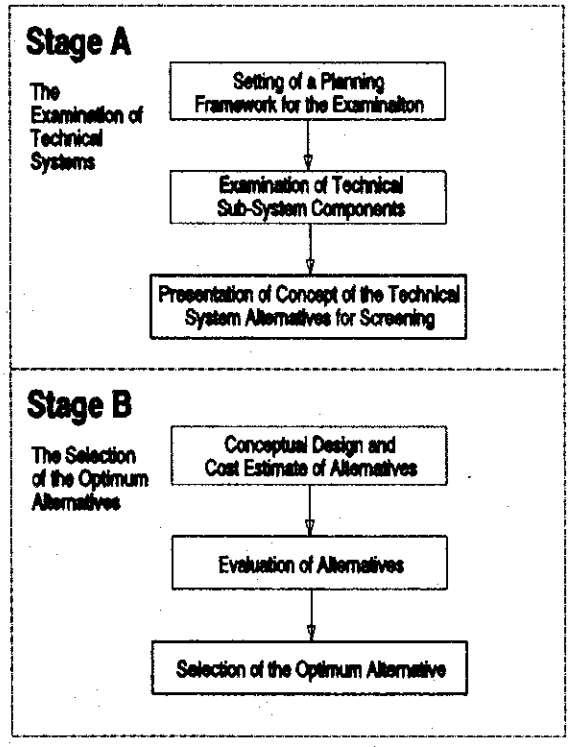


Figure 6.1.1a Study Flow Diagram of the Examination of Technical System Alternatives

a. Stage A : Examination of Technical System Components

aa. Setting up of a Planning Framework for the Examination

The planning framework, i.e. target year, target, future population, forecast on waste amount and composition, future economic and financial conditions, etc., was set up for the examination work.

ab. Examination of Technical Sub-systems Component

The MSWM technical system consists of several sub-systems, i.e., discharge and storage, collection and haulage, intermediate treatment, final disposal, etc.. Each technical sub-system has various components, i.e., incineration, composting, RDF (Refuse Derived Fuel) for intermediate treatment. Various sub-system components were examined and primarily screened for the comparison of technical system alternatives.

Table 6.1.1a Contents of Technical and Institutional System

Contents of Technical System			Institutional System
Technical Sub-system	Technical Sub-system Component		
Discharge and Storage	a.Source Separation	-Mixed discharge -Separate discharge	-Organization and Management
	b.Type of Storage Equi pment	-Bags/sacks -Bucket -Public container	-Legislation and En-forcement
Collection and Haulage (transportation)	a.Collection Frequency		-Finance (revenue source)
	b.Collection Method	-Mixed collection -Separate collection	-Public Cooperation
	c.System Collection Service	-Curb collection -Door to door collection -Bell collection -Public container collection	
	d.Collection Time	-Day collection -Night collection	
	e.Collection vehicle	-Compaction Type -Detachable container type -Standard truck	
	f.Haulage System	-Motor vehicle -Railway -Water Haulage	
	g.Transfer Station		
Street Sweeping and Park and Green Area Cleansing	a.Cleansing Method	-Manual street sweeping -Mechanical cleaning -Vacuum cleaning -Flushing	
Intermediate Treatment	a.Incineration b.Composting c.Refuse Derived Fuel (RDF) d.Pyrolysis e.Ash Solidification f.Size Reduction g.Sorting		
Final Disposal	a.Location of Site	-Centralized disposal -Separate disposal	
	b.Method of Sanitary Landfill	Level 1 : Controlled tipping Level 2 : SL with daily cover Level 3 : SL with leachate circulation Level 4 : SL with leachate treatment	

Note: SL = Sanitary Landfill

ac. Presentation of Technical System Alternatives

After the examination of each technical sub-system, a technical system alternative made up of a combination of selected items was presented.

b. Stage B : Selection of the Optimum Alternative for the Master Plan

ba. Preliminary Design and Cost Estimates of Technical System Alternatives

Preliminary design and cost estimates were carried out for each technical system alternative based upon the selected technical sub-system components.

bb. Evaluation of Alternatives

An optimum technical system was selected by evaluating the following aspects shown in Table 6.1.1b.

Table 6.1.1b Aspects for Evaluation of Technical System

No.	Aspects for Evaluation
i.	Technical point of view
ii.	Economic and financial points of view
iii.	Transactional facilitation points of view
iv.	Environmental points of view
v.	Overall evaluation

The least cost method was applied for the economic evaluation of technical system alternatives, because financial matters might carry more gravity in their implementation than other aspects. This method is acceptable as long as each technical alternative guarantees a certain level of environmental improvement.

However, the approval of the optimum alternative relied on the agreement reached with the Nicaraguan side at the time of the IT/R (Interim Report) meeting. At the same time a discussion was conducted on environmental, technical and social aspects of the technical alternative.

bc. Selection of Optimum Technical System Alternatives (Overall Evaluation of the Technical System Alternatives)

As a result of the overall evaluation of technical system alternatives, and the policies established during the IT/R meeting, the optimum technical system

alternative for the MSWM Master Plan was selected.

6.2 Planning Frameworks for Examination

6.2.1 Target Year, Targets and Population

a. Target Year

The master plan shall cover the period from 1995 to 2010. The target years according to category of plan are as shown in Table 6.2.1a.

Table 6.2.1a Target Year

Category of Plan	Target Year
Master Plan	1995 - 2010
Medium Term Improvement Plan	2001 - 2010
Short Term Improvement Plan for F/S	1997 - 2000
Immediate Improvement Plan	Present - 1996

b. Targets

The targets for the examination are set up and tabulated in Table 6.2.1b.

Table 6.2.1b Targets for Collection, Street Sweeping, Public Cleansing and Final Disposal Services

		Unit	1995		2000		2010	
1.	Population (Urban Area)	Inhabitants		877,817		1,131,052		1,610,943
2.	Collection Coverage	% (inhabitants)	77.0	(659,919)	90.0	(1,017,947)	100.0	(1,610,943)
	Collection Area A	% (inhabitants)	66.7	(585,504)	66.7	(754,412)	66.7	(1,074,449)
	Collection Area B	% (inhabitants)	10.3	(90,415)	23.3	(263,535)	33.3	(563,444)
3.	Street Sweeping Distance	km		331		350		350
4.	Public Cleansing Area (Park & Green Area)	ha		16.7		45		45
5.	Sanitary Landfill Level	-		Level 1		Level 3		Level 4

c. Population Forecast in the Study Area

The future district and urban area population are projected and shown in Table 6.2.1c.

The population projection assumed a population growth of 5.2% from 1995 to 2000, and 3.6% for the period between 2000 – 2010.

Table 6.2.1c District Population Projection by Target Year

District	1995		2000		2010	
	Total	Urban	Total	Urban	Total	Urban
D1	97,720	66,861	125,911	86,149	179,333	122,701
D2	141,700	141,700	182,578	182,578	260,044	260,044
D3	205,571	141,844	264,875	182,764	377,258	260,308
D4	215,356	215,356	277,483	277,483	395,215	395,215
D5	219,915	151,742	283,357	195,516	403,582	278,471
D6	232,339	160,314	299,365	206,562	426,382	294,204
D7	15,003	0	19,331	0	27,532	0
Total	1,127,605	877,817	1,452,900	1,131,052	2,069,347	1,610,943

Source: Population projection estimated by the Study Team based on data provided by CSE and ALMA

6.2.2 Forecast on Future Waste Amount and Composition

a. Forecast Waste Amount

Based on the above-mentioned assumptions, the amount of MSW and other wastes was forecasted. The forecast household on waste generation ratio in the Study area is conducted based on the generation ratio in 1994, and tabulated in Table 6.2.2a. The results of the forecast on waste generation amount are shown in Table 6.2.2b.

Table 6.2.2a Forecast Household Waste Generation Ratio of Household Waste

	Unit	1995	2000	2010
Household Waste	g/person/day	682	769	969

Table 6.2.2b Forecast Waste Generation Amount

unit: ton/day

Generation Source		1995	2000	2010
MSW	Household Waste: Area A	396.4	580.1	1,041.2
	Household Waste: Area B	197.7	289.7	519.8
	Commercial Waste: Restaurant	26.3	33.1	50.3
	Commercial Waste: Others	0.4	0.4	0.4
	Market Waste	26.9	33.9	51.4
	Institutional Waste	2.4	2.9	4.0
	Hospital Waste	6.5	8.3	12.5
	Street Sweeping Waste	16.5	17.4	17.4
	Park & Green Area Waste	1.4	3.8	3.8
	Directly Hauled Waste	37.5	43.4	65.8
	Sub-total	712.2	1,013.0	1,766.6
Other Waste	Industrial Waste	9.2	11.6	17.5
	Directly Hauled Waste	5.7	255.8	387.7
	Illegally Dumped Waste	194.6	-	-
	Sub-total	209.5	267.4	405.2
Total		921.7	1,280.4	2,171.8

Note: Industrial waste amount is limited to waste collected by the Municipality.
Illegally dumped waste amount is limited to waste collected by the Municipality.
Illegally dumped waste was forecasted using directly hauled waste figures.

b. Forecast Waste Composition

ba. Physical Composition

Table 6.2.2c shows the forecasted MSW waste composition in the Study area.

Table 6.2.2c Forecasted MSW Composition

unit: %

Composition	1995	2000	2010
1. Combustibles	**76.6**	**78**	**80**
Kitchen Waste	34.8	35	35
Paper	7.4	9	11
Textile	2.0	2	2
Plastic	4.2	5	7
Grass and Wood	26.1	25	23
Leather and Rubber	2.1	2	2
2. Non-Combustibles	**23.4**	**22**	**20**
Metal	1.8	2	2
Glass	2.9	3	3
Ceramic and Stone	7.5	7	6
Others (Soils, etc.)	11.2	10	9
Total	100.0	100.0	100.0

Note: MSW here excludes street sweeping and bulky waste.

bb. Calorific Value

In case a separate collection system will not be introduced, the future LCV (Lower Calorific Value) of MSW is estimated by multiplying the LCV of combustible waste, including LCV of waste in the wet base, by the ratio of the future physical composition, as shown in Table 6.2.2d.

Table 6.2.2d Forecast on Lower Calorific Value

Year	Lower Calorific Value (kcal/kg)
	Mixed
1995	1,254
2000	1,336
2010	1,494

c. Future Waste Stream

The future waste stream was forecasted in accordance with each alternative and presented in Table 6.5.1c.

6.2.3 Other Pre-conditions

a. Economic and Financial Conditions

GDP growth rate was estimated as follows:

Year	GDP (growth/year)
1995	3.5%
1996	4.0%
1997	4.5%
1998-2000	5.0%
2001-2005	4.5%
2006-2010	4.0%

b. Conditions for Cost Estimation

All cost estimates were based on the prices and exchange rate in June 1994. The mean exchange rate in June 1994 was:

US$ 1.00 = C$ 6.62 = ¥ 103.80

Table H.1 of Annex H presented information on unit prices available in Nicaragua in June 1994.

6.3 Examination of Technical System Components

The conclusions of the examination work are summarized below.

6.3.1 Discharge and Storage

a. Source Separation

Mixed discharge system is suitable because the introduction of either a processing facility, a recycling plant a composting plant is not feasible. The introduction of the separate discharge system will be recommended, however, if the introduction of either one of these facilities is feasible.

b. Type of Storage Equipment

Nylon sacks or plastic bags are suitable waste storage equipment for residential areas as they are cheap, easy to handle and recyclable.

As for the non-collection service area (e.g. urban fringe area), **public containers** shall be introduced due to the lack of access routes for the collection vehicle.

Public containers shall be introduced to large generation sources as well because of a need to increase collection efficiency in these areas.

Public containers shall also be introduced for public area cleansing, including street sweeping in order to maintain the cleanliness of public areas.

6.3.2 Collection and Haulage

a. Collection System

Present **curb collection system**, due to high collection efficiency, is appropriate for area A where infrastructure is well establish.

Collection in area B, predominantly a squat area, shall be by **container or bell collection system**, due to poor infrastructure,e.g., roads and illegal electric outlets.

Present **container collection system** is appropriate for large generation sources such as commercial areas, markets, hospitals, institutions and factories due to high collection efficiency and low cost.

Consequently, the following collection systems shall be provided:

Area A: **Curb collection system** using compactor trucks

Area B: **Container collection system** using hoist trucks or **bell collection system** using compactor trucks

Large generation sources: **Container collection system** using hoist trucks or compactor trucks with container

c. Collection Method

Mixed collection system is suitable because the introduction of either a processing facility, a recycling plant or composting plant is not feasible. The introduction of the separate collection system will be recommended, if any of these facilities are feasible.

d. Collection Time

Day collection is suitable under the assumption that heavy traffic conditions will not disturb the efficiency of waste collection work.

e. Type of Collection Vehicle

Compactor truck is recommended for curb collection system in collection area A, and bell collection system in collection area B, because of the collection work efficiency.

On the other hand, a **detachable container truck** is recommended for container collection system in collection area B because of the area's lack of access roads.

Because large generation sources and public cleansing activities need to increase their collection efficiency the **detachable container truck** shall be introduced.

f. Haulage System

A **motor vehicle haulage system without transfer station** is the recommended haulage system in the Study Area, because of the good roads in the area and since the distance from the main generation sources to the disposal site does not exceed 20 km.

6.3.3 Intermediate Treatment

Upon consideration of the different intermediate treatment systems and the present MSWM in the Study Area, intermediate treatment systems were omitted for the following reasons:

a. Incineration

- The cost was estimated to be more than US$ 26.3 /ton. The highest cost estimated for sanitary landfilling was US$ 8.6 /ton, which included the treatment of leachate.
- There are enough candidate sanitary landfill sites for future disposal operations.

b. Composting

- The market for compost made from municipal solid waste is very limited in the Study Area.

- Other competent fertilizers derived from animal excrement are easily obtained in the region.
- Due to high production cost, subsidies on the sale price would be necessary to make compost from municipal solid waste competitive in fertilizer markets.
- High cost of transportation and labor for the utilization of compost.
- Less volume reduction.
- Possibilities of toxic heavy metals and secondary pollution in case of mixed collection.

6.3.4 Street Sweeping

a. Sweeping System

Manual street sweeping is more suitable because of the high unemployment rate in the Study Area.

b. Main Equipment

The **Detachable container type** is recommended due to the need to increase collection efficiency.

6.3.5 Park and Green Area Cleansing

a. Cleansing System

Manual cleansing is very appropriate due to the high unemployment rate in the Study Area.

b. Main Equipment

Detachable container type is recommended due to the need to increase collection efficiency.

6.3.6 Final Disposal

Sanitary landfill with leachate treatment (Level 4) shall be provided to avoid contaminating groundwater, the drinking water source, and Lake Managua.

a. Selection of a Leachate Treatment Method

The treatment of leachate is an important factor in the study of the Master Plan disposal site facilities because it contaminates groundwater. Accordingly, the results of the survey carried out by JICA in 1993 on groundwater development in Managua City were reviewed and the following were confirmed:

- Groundwater is the only drinking water source of the 1 million population of Managua City
- The groundwater source of Managua City and other water sources that can be utilized originate from the mountain ranges that administratively divide the city, pass through the urban areas and flow north toward Managua Lake.
- Managua City is almost entirely volcanic in geology and covered by extremely permeable scoria layers. The rivers in the area are dry rocky watercourses, except during heavy rain.

Figure. 6.3.6a shows the relationship between groundwater flow and the disposal site candidates.

Based on the conditions stated above, it can be assumed that the leachate discharged by all the candidate disposal sites, except for the Acahualinca disposal site, in the rainy season could contaminate groundwater (drinking water source) through infiltration of the dry river beds.

Groundwater contamination is expected to occur if leachate from disposal sites is discharged without undergoing treatment. Even if leachate is diluted with rain water, the groundwater quality will not satisfy the standard for drinking water.

The installation of water treatment facilities should be considered, in particular, for the Esquipulas candidate disposal site which can possibly cause groundwater contamination, and the Santa Ana candidate disposal site which has a diverse water system and an influence on the downstream basin.

On the one hand, the Acahualinca disposal site is considered to have no effect on groundwater because it is located near Lake Managua, the final destination of

groundwater flow. However, the quality of leachate from the existing Acahualinca disposal site is worse than the water quality of Managua Lake, and is one of the factors that contaminate the waters of Lake Acahualinca. The installation of water treatment facilities in the Acahualinca candidate disposal site, as a means of leachate control, would be desirable therefore.

Given the above conditions, all candidate disposal sites for the Master Plan Study shall be incorporated with leachate treatment facilities categorized under Level 4.

b. Inference regarding methane gas recovery

Methane gas recovery was not examined because of the following reasons:

- It requires 3 to 4 years landfill operation to achieve minimum conditions for methane gas recovery. In addition, it also requires several years to obtain a reasonable amount of gas after the clearance for the production of gas.
- In order to examine the feasibility of the gas production, it is necessary to investigate quantity and quality of gas including the conduct of a test boring work which is not included in the Scope of the Study.
- In order to produce methane gas, the landfill should be anaerobic – a condition that deteriorates the leachate quality. To improve leachate quality a semi-aerobic landfill structure with a liner is proposed in the Master Plan.
- Although the recovery of methane gas at the present Acahualinca landfill is possible, the efficiency of the recovery may be insufficient due to the very permeable bottom layers and the lack of sealing measures for there layers.

6.3.7 Equipment Operation & Maintenance

The present **Los Cocos Workshop** of the Public Cleansing Office shall be improved in order to carry out preliminary maintenance of vehicles and equipment for cleansing service.

6.4 Concept of Technical System Alternatives for Master Plan

In order to select the optimum technical alternative, the candidate technical alternatives composed of technical sub-system were formulated and examined.

As for the formulation of alternatives, the following concepts were introduced:

i. Type of system in terms of final disposal site location

Centralized disposal system and separate disposal system are the two types of MSWM alternatives considered.

In a centralized disposal system, the wastes collected from the Study Area are hauled to one disposal site to reduce construction, operation and maintenance costs. In a separate disposal system, the wastes collected from each area are hauled to the nearest disposal site to reduce transportation cost.

ii. Candidate disposal site

Acahualinca, Santa Ana and Esquipulas were selected as candidate disposal sites by the Coordinating Committee of the Managua Municipality. Alternatives 1,2,3 and 4 are alternatives that recommend the centralized disposal system, while Santa Ana and Esquipulas candidate disposal sites in Alternative 5 were considered for the separate disposal system.

iii. Transfer system

In order to determine the most appropriate haulage system, alternatives with and without transfer station were formulated for examination. In case the distance from the collection area to the disposal site exceeds 20 km, the introduction of a transfer station should be examined to reduce haulage cost. When considering the Santa Ana candidate disposal site, wastes collected from Districts 4, 5, and 6, areas more than 20km away from the disposal site will be hauled to the transfer station primarily, then to the final disposal site.

The candidate alternatives are summarized in Table 6.4.1a and illustrated in Figure 6.4.1a to 6.4.1e.

iv. Components of collection, haulage and street sweeping activities

As the components of collection, haulage and street sweeping activities are not so

different in each alternative, they are not presented as a concept of technical system alternatives.

Table 6.4.1a Concept of Technical System Alternatives

Disposal	Site	Transfer System	Alternative No.
Centralized Disposal	Acahualinca	Without	A-1
	Santa Ana	Without	A-2
		With	A-3
	Esquipulas	Without	A-4
Separate Disposal	Santa Ana & Esquipulas	Without	A-5

Alternative A-1:

Centralized Sanitary Landfill at Acahualinca without a transfer station

Figure 6.4.1a Concept Flow for Alternative A-1

Alternative A-2:

Centralized sanitary landfill at Santa Ana without a transfer station

Figure 6.4.1b Concept Flow for Alternative A-2

Alternative A-3:

Centralized sanitary landfill at Santa Ana with a transfer station

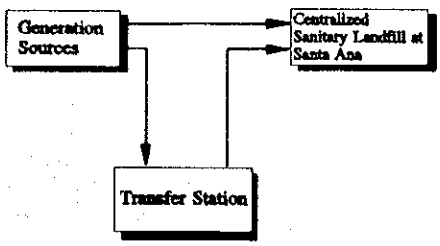


Figure 6.4.1c Concept Flow for Alternative A-3

Alternative A–4

Centralized sanitary landfill at Esquipulas without a transfer station

Figure 6.4.1d Concept Flow for Alternative A–4

Alternative A–5:

Separate sanitary landfill at Santa Ana and Esquipulas without a transfer station

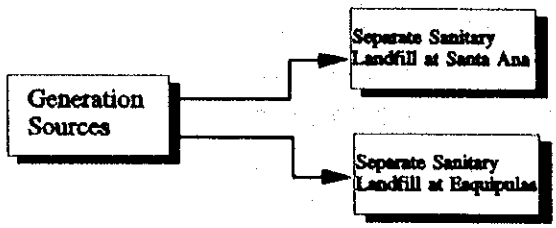


Figure 6.4.1c Concept Flow for Alternative A–5

6.5 Examination of Technical Alternatives

6.5.1 Conceptual Design and Cost Estimation

a. Premise

The conceptual design and cost estimation will be carried out in this section to compare the cost of each technical system alternative for the Master Plan and select the optimum alternative for the municipality. The design and estimation work will be made as simple as possible. In the Feasibility Study stage, the design becomes more detailed and includes the modified version of the conceptual design and cost estimation.

b. Key Assumptions

ba. For Design

baa. Key Assumptions for Design

The following key assumptions are set up for the conceptual design of this report:

Table 6.5.1a Key Assumptions for Design

Design Items	Applied Figure	Unit	Remarks
1. Storage and Collection			
1-1 ASG of Waste in Compactor	0.44	ton/m^3	
1-2 ASG of Waste in Container	0.22	ton/m^3	
1-3 Operation Rate of Vehicles	0.9		
2. Haulage			
2-1 ASG of Waste in Transfer Vehicle (Non-compaction Type)	0.3	ton/m^3	
3. Street Sweeping			
3-1 ASG of Waste in Compactor	0.44		
3-2 ASG of Waste in Container	0.22	ton/m^3	
4. Final Disposal			
4-1 ASG of MSW	1.0	ton/m^3	After compaction

Table 6.5.1b Distance of Alternatives

Alternative	A-1	A-2	A-3			A-4	A-5	
Distance (km)	8.3 from generation to disposal site	18.0 from generation to disposal site	15.8 distance of districts 1-3 to disposal site	5.0 distance of districts 4-6 to transfer station	16.9 transfer station to disposal site	11.0 from generation to disposal site	15.8 distance of districts 1-3 to disposal site	10.0 distance of districts 4-6 to disposal site
Waste collection Amount (ton/day)	1,483	1,483	593	890		1,483	593	890

bab. Waste Stream

In order to carry out the conceptual design and cost estimation, the waste streams in the year 2010 for each alternative were estimated and presented in Table 6.5.1c

Table 6.5.1c Waste Stream for MSW in Managua in the Year 2010

		Unit	Alternatives				
			A-1	A-2	A-3	A-4	A-5
a.	Generation	ton/day	2265.2	2265.2	2265.2	2265.2	2265.2
b.	Self Disposal	ton/day	223.5	223.5	223.5	223.5	223.5
c.	Recycling at Generation	ton/day	47.0	47.0	47.0	47.0	47.0
d.	Collection Amount	ton/day	1,483	1,483	1,483	1,483	1,483
e.	Street Sweeping	ton/day	20	20	20	20	20
f.	Waste amount at T/S	ton/day	0	0	890	0	0
g.	Recycling	ton/day	37.0	37.0	37.0	37.0	37.0
h.	Amount of Direct Haul Waste	ton/day	512.3	512.3	512.3	512.3	512.3
i.	Waste amount at Final Disposal Site per day	ton/day	1958	1958	1958	1958	1958
j.	Waste amount at Final Disposal Site per year (i x 365)	ton/year	714,560	714,560	714,560	714,560	714,560

bb. Location of facilities

The location of the candidate disposal sites and transfer station is shown in Figure 6.5.1a.

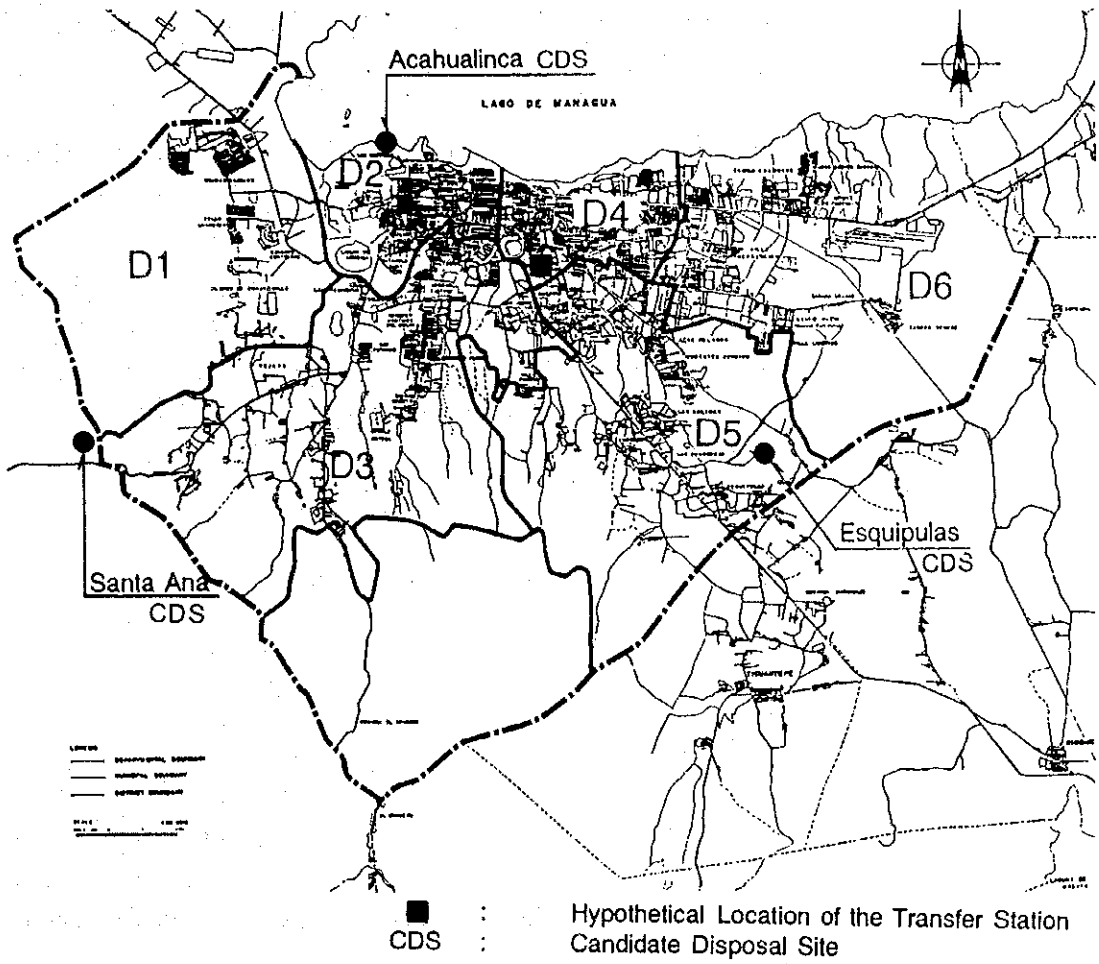


Figure 6.5.1a Location Map of Facilities

bc. Cost estimation

bca. Basic Considerations

The cost comparison of each technical system alternative is carried out to determine the annual MSWM cost in 2010. Consequently, the following assumptions are made for cost estimation:

i. The executing body of MSWM will be the Municipality.

ii. Cost comparison is carried out by means of the O & M (Operation and Maintenance) cost in the year 2010 which includes the depreciation cost of all MSWM facilities and equipment.

iii. Cost estimation is conducted based on the price in June 1994; the exchange rate is US$1=C$6.62.

iv. The estimated cost does not include interest or 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 in the Feasibility Study.

bcb. Annual working days and working efficiency

The annual working days are determined as follows:

- Total days per year	:	365
- Sundays	:	53
- Public holidays	:	15
Total working days	:	**297 days/year**

The equipment will be used for 8 hours a day. The operation rate of equipment is assumed at **0.9**.

bcc. Life Span of Equipment and Facilities

	Life Span (years)
Containers	5
Trucks and Heavy Equipment	7
Machineries	15
Buildings and Civil Works	30

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

6.5.2 Annual MSWM Expenses in 2010

The annual MSWM expenses of the 5 alternatives in 2010 are tabulated in Table 6.5.2a.

Table 6.5.2a Annual MSWM Expenses in 2010

Item	Unit	A-1	A-2	A-3	A-4	A-5
1. Unit Expenses						
1-1 Collection & Haulage	C$/ton	87.57	110.96	102.61	94.16	92.76
1-2 Street sweeping	C$/ton	800.00	802.62	800.27	800.73	801.09
1-3 Park & Green Area Cleansing	C$/ton	3,100.65	3,150.68	3,140.42	3,103.85	3,143.97
1-4 Final disposal	C$/ton	41.33	43.91	43.91	49.07	56.50
1-5 Administration	C$/ton	3.73	3.73	3.73	3.73	56.50
2.Total Expenses						
2-1 Collection & Haulage	C$ million /year	46.60	59.05	54.61	50.11	49.37
2-2 Street sweeping	C$ million /year	5.84	5.86	5.84	5.85	5.85
2-3 Park & Green area cleansing	C$ million /year	5.66	5.75	5.73	5.66	5.74
2-4 Final disposal	C$ million /year	29.55	31.40	31.40	35.09	40.40
2-5 Administration	C$ million /year	2.02	2.02	2.02	2.02	2.02
2-6 Total	C$ million /year	**89.67**	**104.07**	**99.60**	**98.72**	**103.37**

6.5.3 Evaluation

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

- technical
- social
- environmental
- economic and financial

a. Technical Evaluation

aa. Evaluation Conditions

Huge technical differences among the alternatives lie in the introduction of the transfer and final disposal systems, and the location of the disposal site. The technical systems of the alternatives were evaluated according to the following:

- working condition
- operation and maintenance
- construction
- the level of sanitary landfill

The comparison of technical systems for each alternative is shown in Table 6.5.3a.

ab. Evaluation

i. Working condition

Workers involved in solid waste management are engaged in different types of work such as collection, transportation, operation of transfer station and final disposal. The following types of works in particular require improved working conditions to ensure safety and health.

- loading of solid waste into collection trucks
- work in transfer station
- landfill work at disposal site

Since the same technical systems will be applied to the discharge/storage, collection and final disposal activities, there is little difference in the working conditions of

the alternatives.

ii. Operation and maintenance

The difficulties in the operation and maintenance of disposal sites are estimated to be almost the same with every alternative plan. Only few problems can be observed with the operation and maintenance of the transfer station as the work only involve the transportation of large containers.

iii. Construction

The construction of the transfer station will require highly advanced technology. The technology presently used in Nicaragua is good enough for the construction of all facilities except the transfer station.

iv. The level of sanitary landfill

The sanitary landfill target level is Level 4 (sanitary landfill with leachate treatment) for all alternatives. Level 4 will be introduced in A-1 as a countermeasure against the contamination of Lake Managua. On the other hand, Level 4 will be introducted in other alternatives as a countermeasure against the contamination of groundwater, the drinking water source.

ac. Summary of Technical Evaluation

The technical evaluation is summarized in Table 6.5.3a.

Table 6.5.3a Summary of Technical Evaluation

Criteria	Alternative				
	A-1	A-2	A-3	A-4	A-5
a.Working condition	A	A	B	A	A
b.Operation and maintenance	A	A	B	A	A
c.Construction	A	A	B	A	A
d.Level of sanitary landfill	B	B	B	B	B
Overall Assessment	A	A	B	A	A

Note: A: good B: fair C: poor

b. Social Evaluation

ba. Evaluation Factors

Social evaluation of each alternative was conducted based on the following factors:

- possibility of land acquisition
- possibility of obtaining neighborhood consensus
- compatibility with regional development plans

bb. Evaluation

i. Possibility of land acquisition

There are no strict regulations concerning land use in the three candidate disposal sites. Except for Acahualinca the two sites are privately owned, thereby requiring compensation fees if they were to be selected. Santa Ana is under the jurisdiction of Villa El Carmen Municipality. If this site is to be used, negotiations would have to be conducted to incorporate the site within the Managua Municipal boundary as soon as possible.

ii. Possibility of obtaining neighborhood consensus

A neighborhood consensus is necessary for the use of either Santa Ana or Esquipulus because their peripheral areas are inhabited.

iii. Compatibility with regional development plans

Since no urban development master plan is not established in the Study Area, the use of either of the three candidate sites will not face problems concerning this matter.

bc. Summary of Social Evaluation

Social evaluation is summarized in Table 6.5.3b.

Table 6.5.3b Social Evaluation

Criteria	Alternative				
	A-1	A-2	A-3	A-4	A-5
a. Possibility of Land Acquisition	A	C	C	B	C
b. Possibility of Getting Neighborhood Consensus	A	B	B	B	B
c. Compatibility with Regional Development Plans	A	A	A	A	A
Overall Assessment	A	B	B	B	B

Note: A: good B: fair C: poor

c. Environmental Evaluation

ca. Items for Evaluation

The items for evaluation are listed in Table 6.5.3c, and pertain to the social environment (9), natural environment (8), and pollution (6).

Table 6.5.3c Items for Evaluation

Categories	Social Environment	Natural Environment	Pollution
Items	(1) Resettlement (2) Economic Activities (3) Traffic and Public Facilities (4) Community Separation (5) Remains and Cultural Property (6) Water Right and Right to Common (7) Public Health Condition (8) Waste (9) Natural Disaster	(1) Topography and Geology (2) Soil Erosion (3) Groundwater (4) Flow Condition of Lakes, Marshes and Rivers (5) Coastal Zone (6) Flora and Fauna (7) Meteorology (8) Landscape	(1) Air Pollution (2) Water Condition (3) Soil Contamination (4) Noise and Vibration (5) Land Subsidence (6) Offensive Odor
Total	9	8	6

cb. Environmental Conservation Measures

The proposed alternative subjects for evaluation were limited to the environmental conservation measures indicated in Table 6.5.3d.

Table 6.5.3d The Environmental Conservation Measures as the Basis for Evaluation

Alternative	A-1, A-2, A-3, A-4, A-5	A-3
Environmental Items	Disposal Site	Transfer Station
Air Pollution	- Implementation of dust reduction measures, i.e., water sprinkling and surface compaction. - Installation of gas exhaust pipes. - Covering of waste layers. - Use of treated leachate for sprinkling.	- Nothing in particular
Water Pollution	- Installation of seepage control facilities. - Installation of leachate treatment facilities.	- Transfer of domestic waste water and water used to wash the floor of the working place to the final disposal site for treatment
Noise and Vibration	- Reduction of the noise created by the heavy machineries for landfill works and transportation vehicles. - Operation speed control and better clutch control.	- Work will be carried out in enclosed areas; noise will be minimized as much as possible. - Work space will be enclosed. - Better clutch control.
Offensive Odor	- Covering of soil - Sanitary landfill	- Constant washing of the floors of the work place - Avoid long term waste storage - Transfer wastes in enclosed areas to avoid the spread of offensive odor - Work space will be enclosed
Landscape	- Construction of a buffer zone (planting trees). - Establish a land use plan which incorporates the desires of the locals and is compatible with surrounding land use. - The construction of an artificial shore line for Acahualinca Lake.	- Construction of a buffer zone (planting trees). - Establish a land use plan which incorporates the desires of the locals and is compatible with surrounding land use.
Traffic	- The accurate installation of traffic control indicators at exits and entrance areas; disposition of a guard. - Selection of hauling route to considerably reduce impact on surrounding traffic - Educate operators on safe driving	- Accurate installation of traffic control indicators at exits and entrance areas; installation of traffic lights and disposition of a guard. - Selection of hauling route to considerably reduce impact on surrounding traffic - Educate operators on safe driving

cc. General Evaluation of alternatives

The results of the general evaluation of the 5 alternatives on environmental issues are shown in Table 6.5.3e.

An optimum alternative is an alternative with the least impact on the environment. The best alternative for the City of Managua is one which bears the least impact on groundwater, the city's water source. A-1 was found to satisfy this requirement, whereas the other 4 alternatives failed. Alternative A-1 was also observed to have the least impact on other environmental items in comparison with the other alternatives.

Table 6.5.3e General Evaluation of Alternatives

	Alternative				
	A-1	A-2	A-3	A-4	A-5
a. Social Environment	A	B	B	A	B
b. Natural Environment	B	B	B	B	B
c. Pollution	B	C	C	C	C
Overall Assessment	B	C	C	B	C

(A:almost without any impact, B:small impact, C:has an impact)

d. Financial and Economic Evaluation

da. Financial Evaluation

daa. Evaluation Method

Financial evaluation was carried out by determining the alternative with the least cost, since their benefits do not significantly differ and evaluation can only be carried out qualitatively. The alternative that would satisfy the environmental standards, which is the same for all alternatives, with the least cost shall be selected as optimum alternative.

The financial feasibility of MSWM was studied by taking into account the waste disposal cost affordable to the residents according to the Public Opinion Survey Results.

dab. Expenses

The costs to be financially evaluated will be taken as the waste disposal cost of Managua City in the year 2010. These include Operation and Maintenance Cost, and Depreciation Cost; interest rates are excluded.

dac. Evaluation Result

Table 6.5.3f shows the cost of every alternative. Alternative A-1 is selected as the optimum alternative as it brings about the least cost.

Table 6.5.3f Financial Evaluation

unit: mill.C$

Alternative		A-1	A-2	A-3	A-4	A-5
Total cost (including depreciation cost)		89.67	104.08	99.60	98.73	103.37
Collection, transportation expenses		46.60	59.05	50.48	50.11	49.37
Transfer station expenses		-	-	4.13	-	-
Street cleansing expenses		5.84	5.86	5.84	5.85	5.85
Park cleansing expenses		5.66	5.75	5.73	5.66	5.74
Final disposal expenses		29.55	31.40	31.40	35.09	40.40
Management expenses		2.02	2.02	2.02	2.02	2.02
O&M cost		37.93	45.60	41.03	39.88	41.26
Evaluation using the least cost method	Total cost	1	5	3	2	4
	O&M cost	1	5	3	2	4

e. Overall Evaluation

The overall evaluation of each aspect i.e. technical, social, environmental and financial are elaborated hereafter.

A-1 is the best alternative and was highly evaluated for the following aspects in contrast to other alternatives.

- disposal site acquisition is simple as it is municipal property
- no impact on drinking water
- least cost alternative

However, the operation of a disposal site will debase the aesthetic view of Lake Managua. In order to solve this problem, the following shall be conducted:

- daily covering of incoming waste
- establishing suitable future land plan for the site
- construction of a buffer zone

Overall evaluation is summarized in Table 6.5.3g.

Table 6.5.3g Overall Evaluation

Criteria	Alternative				
	A-1	A-2	A-3	A-4	A-5
a. Technical Evaluation	A	A	B	A	A
b. Social Evaluation	A	B	B	B	B
c. Environmental Evaluation	B	C	C	B	C
d. Financial Evaluation	A	C	B	B	C
Overall Assessment	A	C	B	B	C

Note: A: good B: fair C: poor

In addition to the above-mentioned advantages, leachate treatment will not be required for Alternative A-1 as sanitary landfill Level 3 can be implemented. The reasons are:

- The cost for the investment and operation and maintenance of sanitary landfill Level 3, is cheaper than Level 4: C$ 39.3 million and C$ 1.34 million/year, respectively.
- Sewage load sewage in Lake Managua is considerably heavier than leachate from the landfill. For the improvement of lake water quality, sewage treatment is more desirable than leachate. If a sewage treatment plant is constructed in the future, the leachate can also be treated in this plant.

CHAPTER 7

THE MASTER PLAN

CHAPTER 7 THE MASTER PLAN

This chapter describes the goal, target and strategies of the Master Plan for the Municipality of Managua. It also gives an account of the technical and institutional systems for the municipality up to the target year 2010.

7.1 Planning Framework

7.1.1 Goal, Targets and Strategy

a. Goal

For the formulation of the MSWM draft master plan, the following is proposed as the Master Plan's objective:

[Development and Realization of a Beautiful and Sanitary Environment in the City of Managua towards the 21st Century through Citizens' Participation and Establishment of Self-sustainable Solid Waste Management]

b. Targets

In order to realize the goal, the targets for the Municipality are set up and tabulated in Table 7.1.1a.

Table 7.1.1a Targets for Collection, Street Sweeping, Public Cleansing and Final Disposal Services

		Unit	1995		2000		2010	
1.	Population (Urban Area)	Inhabitants		877,817		1,131,052		1,610,943
2.	Collection Coverage	% (inhabitants)	77.0	(675,919)	90.0	(1,017,947)	100.0	(1,610,943)
	Collection Area A	% (inhabitants)	66.7	(585,504)	66.7	(754,412)	66.7	(1,074,449)
	Collection Area B	% (inhabitants)	10.3	(90,415)	23.3	(263,535)	33.3	(536,444)
3.	Street Sweeping Distance	km		331		350		350
4.	Public Cleansing Area (Park & Green Area)	ha		16.7		45		45
5.	Sanitary Landfill Level	-		Level 1		Level 3	Level 4	

c. Strategy Elements

The goal is to be obtained specifically through:

1. Establishment of a self-sustainable solid waste management system.

2. Provision of collection services in the urban area of the Municipality of Managua, including the illegal settlement areas, and establishment of a reliable collection system under which regular services can be provided.

3. Construction of sanitary disposal site employing sufficient measures for human and environmental protection.

4. Establishment of efficient street sweeping and public area cleansing systems.

5. Improvement of the Waste Fee System under the Beneficiary-Pay-Principle where service recipients pay waste fees and tipping fees are established according to household financial capabilities.

6. Introduction of proper privatization for MSWM in order to reduce municipal and residential burden.

7. Establishment of proper legislation and regulations through the modification and revision of existing ones.

8. Establishment of proper coordination among the several institutions on both national and municipal levels dealing with solid waste management, mainly to ensure legislation enforcement.

9. Establishment of roles befitting the organizations involved in solid waste management.

10. Strengthening management and administration systems.

11. Development of public participation and education programs.

12. Development of solid waste management human resources.

13. Securing funds for capital investment for the equipment and facilities necessary for the realization of the goal, specially during the time of take off.

7.1.2 Target Year and Population

a. Target Year

The master plan shall cover the period between 1995 to 2010. Upon consideration

of the limited resources of the municipality for SWM, the goal of the master plan shall be pursued in a stepwise manner. The period of the plan is divided into the following three stages.

Table 7.1.2a Target Year

Category of Plan	Target Year
Master Plan	1995 - 2010
- Medium Term Improvement Plan	2001 - 2010
- Short Term Improvement Plan for F/S	1997 - 2000
- Immediate Improvement Plan	Present - 1996

b. Population Forecast in the Study Area

Population is the most essential factor in the formulation of the Study for the improvement of SWM and the physical development plan for the municipality of Managua.

Population projections are basic data for development planning and estimation of future solid waste generation amount for the improvement of SWM. Population statistics, which are directly related to the solid waste collection coverage, were carefully discussed with ALMA which decided to adopt the Study Team's present population base to project future population and plans on SWM.

The future district and urban area population are projected as shown in Table 7.1.2b. and illustrated in Figure 7.1.2a.

A population growth of 5.2% was assumed from 1995 to 2000 and 3.6% for the period between 2000 - 2010. Given these growth rates, the population of Managua municipality is projected to increase by 1.4 times the present population by 2000 and 1.9 times by 2010, reaching a total of about 2 million inhabitants.

Table 7.1.2b District Population Projection by Target Year

District	1995		2000		2010	
	Total	Urban	Total	Urban	Total	Urban
D1	97,720	66,861	125,911	86,149	179,333	122,701
D2	141,700	141,700	182,578	182,578	260,044	260,044
D3	205,571	141,844	264,875	182,764	377,258	260,308
D4	215,356	215,356	277,483	277,483	395,215	395,215
D5	219,915	151,742	283,357	195,516	403,582	278,471
D6	232,339	160,314	299,365	206,562	426,382	294,204
D7	15,003	0	19,331	0	27,532	0
Total	1,127,605	877,817	1,452,900	1,131,052	2,069,347	1,610,943

Source: Population estimates of the Study Team based on data provided by CSE and ALMA

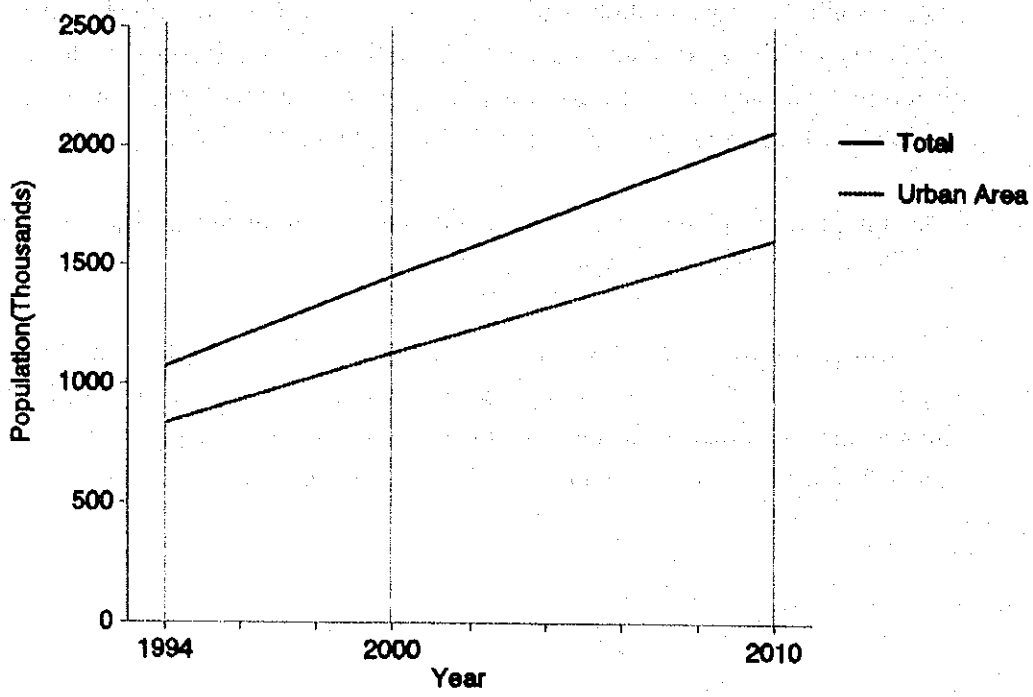


Figure 7.1.2a Population Growth in the Study Area

7.1.3 Future Waste Amount and Composition Forecast

a. Conditions of Forecast

aa. Types of Waste to be Forecasted

The types of waste to be forecasted are:

i. MSW

- Household waste
- Commercial waste
- Market waste
- Institutional waste
- Street sweeping waste
- Hospital waste (non-infectious waste)
- Parks and green area waste

ii. Other waste

- Industrial waste
- Directly hauled waste

ab. Increase in Generation Ratio

Based on Japanese statistics regarding the relation between GDP and waste generation per capita per year, the generation ratio increase rate was estimated as follows:

[Generation Ratio Increase Rate (%)] = GDP x 0.55

Accordingly, a 2.4% increase in waste generation per capita per year can be expected in the planning period 1995 - 2010.

ac. Increase in Population

The most direct influence on waste generation is the change in population. The estimated annual population growth rate in the Study Area planning period is tabulated in Table 7.1.2b.

b. Forecast on Future Waste Amount

ba. Methodology for the Forecast

For the type of wastes to be forecasted, the following assumptions were made:

i. Household waste

Waste generation will be projected as follows:

[Waste generation] = [Generation Ratio] x [Population]

ii. Commercial, market, institutional and hospital waste

Present generation amount of waste is forecasted to increase in accordance with the growth rate of GDP.

iii. Street sweeping and park & green area waste

The present generation ratio of street sweeping and park and green area waste is forecasted to remain fixed. These waste amounts will increase in accordance with the extension of street sweeping distance and public area cleansing.

iv. Other waste

Other wastes, i.e. industrial waste and directly hauled waste, will increase in accordance with the growth rate of GDP.

bb. Forecast on Waste Amount

Based on the above-mentioned assumptions, the forecast on MSW and other wastes was made. The forecast household waste generation ratio in the Study Area was conducted based on the generation ratio (664 g/person/day) surveyed by the Study Team in 1994, and tabulated in Table 7.1.3a. The results of the forecast on waste generation amount are shown in Table 7.1.3b.

Table 7.1.3a Forecast Household Waste Generation Ratio

	Unit	1995	2000	2010
Household Waste	g/person/day	682	769	969

Table 7.1.3b Forecast on Waste Generation Amount

unit: ton/day

Generation Source		1995	2000	2010
MSW	Household Waste: Area A	396.4	580.1	1,041.2
	Household Waste: Area B	197.9	289.7	519.8
	Commercial Waste: Restaurant	26.3	33.1	50.3
	Commercial Waste: Other	0.4	0.4	0.4
	Market Waste	26.9	33.9	51.4
	Institutional Waste	2.4	2.9	4.0
	Hospital Waste	6.5	8.3	12.5
	Street Sweeping Waste	16.5	17.4	17.4
	Park & Green Area Waste	1.4	3.8	3.8
	Directly Hauled Waste	37.5	43.4	65.8
	Sub-total	712.2	1,013.0	1,766.6
Other Waste	Industrial Waste	9.2	11.6	17.5
	Directly Hauled Waste	5.7	255.8	387.7
	Illegally Dumped Waste	194.6	-	-
	Sub-total	209.5	267.4	405.2
Total		921.7	1,280.4	2,171.8

Note: Industrial waste amount is limited to waste collected by the Municipality.
Illegally dumped waste amount is limited to waste collected by the Municipality.
Illegally dumped waste was forecasted using directly hauled waste figures.

c. Forecast on Waste Composition

ca. Forecast Waste Composition

A change in the composition of waste is expected due to the marketing of new products and different consumption patterns.

Table 7.1.3c compares the results of the WACS on household waste and MSW composition with the 1991 data for Rio de Janeiro, Brazil, by the Applied Research Center of COMLURB (Rio de Janeiro Municipal Public Cleansing Company), 1987 data for Penang, Malaysia, 1972 data for Tokyo, Japan, and the 1993 data taken in Asuncion, Paraguay.

Table 7.1.3c Comparison of MSW Composition Data

unit: %

	Managua, Nicaragua 1994		Penang ** Malaysia 1987	Tokyo Japan 1972	Rio de Janeiro 1991	Asuncion Paraguay 1993
	Household Waste from WACS	MSW * from WACS				
1. Combustibles	**75.09**	**76.22**	**88.1**	**89.0**	**79.1**	**72.8**
Kitchen Waste	34.86	34.80	32.8	25.9	33.9	37.4
Paper	5.37	7.07	25.5	35.6	27.1	10.2
Textile	1.87	1.94	3.4	3.2	2.7	1.2
Plastic	3.88	4.00	11.2	6.9	12.7	4.2
Grass and Wood	27.11	26.35	14.4	-	2.0	19.2
Leather and Rubber	2.00	2.06	0.8	0.8	0.7	0.6
Others	-	-	-	16.6	-	-
2. Non-Combustibles	**24.91**	**23.78**	**12.0**	**11.0**	**20.4**	**27.2**
Metal	1.69	1.77	2.6	3.7	3.1	1.3
Glass	2.91	2.91	1.4	7.3	2.2	3.5
Ceramic and Stone	8.07	7.60	0.2	-	0.4	2.5
Others(soils, etc.)	12.24	11.50	7.8	-	14.7	19.9
Total	100	100	100	100	99.5	100
Apparent Specific Gravity (kg/m^3)	200	200	190	N.A	209	215

Note: WACS : Waste Amount and Composition Survey
* : The figure shows the composition of MSW
** Source : "Solid Waste Management Study for Pulau Penang and Seberang Perai Municipalities, August 1989, JICA"

Since there are no available data in the Study Area, data provided by the WACS and other countries were compared assuming that changes in waste composition would generally result in the following waste characteristics inherent in a developed economy:

- Increase in the ratio of combustibles and decrease in non-combustibles
- Decrease in the ratio of kitchen waste and increase in paper and plastics
- Decrease in the ratio of grass and wood and increase in metal and glass
- Decrease in apparent specific gravity

Referring to Table 7.1.3c, the frame of the waste composition in 2010 was set. Table 7.1.3d shows the forecast MSW composition in the Study Area.

Table 7.1.3d Forecast MSW Composition

unit: %

Composition	1995	2000	2010
1. Combustibles	**76.6**	**78**	**80**
Kitchen Waste	34.8	35	35
Paper	7.4	9	11
Textile	2.0	2	2
Plastic	4.2	5	7
Grass and Wood	26.1	25	23
Leather and Rubber	2.1	2	2
2. Non-Combustibles	**23.4**	**22**	**20**
Metal	1.8	2	2
Glass	2.9	3	3
Ceramic and Stone	7.5	7	6
Others (Soils, etc.)	11.2	10	9
Total	100.0	100	100

Note: MSW here excludes street sweeping and bulky wastes.

cb. Forecast on Calorific Value

cba. LCV of the Physical Composition of Each Waste Category

The following calorific values were measured in the WACS:

- for combustibles mixed from 8 generation sources, i.e. residential areas (high, middle and low income), markets, commercial areas (restaurants and others), institutions and roads;
- for each combustible item from the middle income residential area.

The calorific value of wastes differs according to physical composition and how much moisture, combustible and ash it contains, and the ratio of combustible waste and ash depends on the physical changes that take place. Table 7.1.3e shows our survey data on mixed combustibles and the 1972 data in Japan.

Table 7.1.3e Comparison of the Three Contents and LCV

		1994 JICA Study		Japan (1972)
		Household	MSW	
Moisture content	(%)	37.27	37.42	54.1
Combustible content	(%)	27.97	28.64	31.4
Ash content	(%)	34.76	33.94	14.5
Lower Calorific Value Measured (kcal/kg)		1,045	1,092	1,165

The above 1994 data obtained by the JICA Study Team are weighing average figures of mixed wastes, taking the waste generation ratio by each category into account. The moisture content of each data ranges between 10% – 50%. The lower calorific value was determined by taking into account the possibility that the physical composition may vary, because the moisture content is forecast to remain constant.

The higher calorific value (HCV) in dry base of each combustible component of waste from the middle income residential area was also measured and used to calculate the lower calorific values (LCV's) shown in Table 7.1.3f.

Table 7.1.3f HCV in Dry Base and LCV in Wet Base of Each Combustible Waste

	Higher Calorific Value in Dry Base (kcal/kg)	Lower Calorific Value in Wet Base (kcal/kg)
Kitchen Waste	3,640	780
Paper	4,440	2,630
Textile	4,390	1,880
Plastic	9,280	6,690
Grass & Wood	3,320	1,450
Leather & Rubber	5,680	4,600

The LCV of wastes was calculated by the following formula:

$$LCV = (RGa^{*1}*780+RPa^{*2}*2,630+RT^{*3}*1,880+RPl^{*4}*6,690$$

$$+RGr^{*5}*1,450+RL^{*6}*4,600)/100$$

RGa^{*1}; Ratio of kitchen waste in wet weight (%)

RPa*2; Ratio of paper in wet weight (%)
RT*3; Ratio of textile in wet weight (%)
RPl*4; Ratio of plastic in wet weight (%)
RGr*5; Ratio of grass and wood in wet weight (%)
RL*6; Ratio of leather and rubber in wet weight (%)

cbb. Lower Calorific Value Forecast

Using the above mentioned formula, the future LCV of MSW is estimated by multiplying the LCV in Table 7.1.3f by the ratio of the future physical composition shown in Table 7.1.3d.

In case a separate collection system will not be introduced, the LCV of mixed waste is estimated as shown in Table 7.1.3g.

Table 7.1.3g Forecast Lower Calorific Value

Year	Lower Calorific Value (kcal/kg)
	Mixed
1995	1,254
2000	1,336
2010	1,494

d. Future Waste Stream

da. Forecast Conditions

daa. Source Recycling

The rate of food waste recycled (about 3% of the generation amount) at generation sources will be maintained till 2010.

SRA =GA x 0.03

SRA : Source recycling amount (ton/day)
GA : Generation amount (ton/day)
0.03 : Source recycling rate as percentage of generation amount

dab. Self-disposal (collection service area)

Since the same kind of housing style (detached houses) will still be common in the future, the self-disposal rate (about 13% of the generation amount) is estimated to remain the same until 2010. Consequently, the self-disposal amount is calculated by the formula below.

$$SA = GA \times 0.13$$

SA : Self-disposal amount (ton/day)
0.13 : Self disposal rate as percentage of generation amount

dac. Self-disposal (non-collection service area)

Self-disposal amount in non-collection area is calculated using the following formula:

$$SA(non) = GA(non) \times (1-0.03)$$

SA (non) : Self-disposal amount in non-collection area (ton/day)
GA (non) : Generation amount in non-collection area (ton/day)

dad. Discharge (Collection)

The waste discharge amount (waste collection amount) is obtained using the following formula:

$$DA = GA - SRA - SA - SA(non)$$

DA : Discharge amount (ton/day)

dae. Recycling other than at Sources

Recycling will be popularized and its importance will be further acknowledged as the GDP growth rate escalates.

daf. Other Waste

Other wastes hauled to the disposal site will increase in accordance with the GDP growth rate.

dag. Final Disposal

The final disposal amount is calculated by the formula below. The disposal amount is calculated by the data obtained at the Acahualinca disposal site.

$$FDA = DA + DHA - RA$$

FDA	:	Final disposal amount (ton/day)
DA	:	Disposal amount obtained by ALMA (ton/day)
DHA	:	Direct haulage waste amount (ton/day)
RA	:	Amount of recycling other than at sources (ton/day)

db. Future Waste Stream

The future waste streams are presented in Table 7.1.3h and Figure 7.1.3a.

Table 7.1.3h Waste Stream in Managua

Category		Unit	Year		
			1995	2000	2010
MSW	a.Generation	ton/day	712.2	1,013.0	1,766.6
	b.Self Disposal	ton/day	198.1	196.4	223.3
	c.Recycling at Generation Source	ton/day	17.9	26.2	47.0
	d.Collection	ton/day	458.7	747.0	1,430.5
	e.Directly Hauled MSW	ton/day	37.5	43.4	65.8
ISW	f.ISW collected by the Municipality	ton/day	9.2	11.6	17.5
	g.ISW from RIDS	ton/day	194.6	0.0	0.0
	h.Directly Hauled ISW	ton/day	5.7	255.8	387.7
i.	Recycling	ton/day	14.0	20.1	36.4
j.	Waste amount at Final Disposal Site per day	ton/day	692.3	1,037.7	1,865.1
k.	Waste amount at Final Disposal Site per year (jx365)	ton/year	252,690.0	378,761.0	680,762

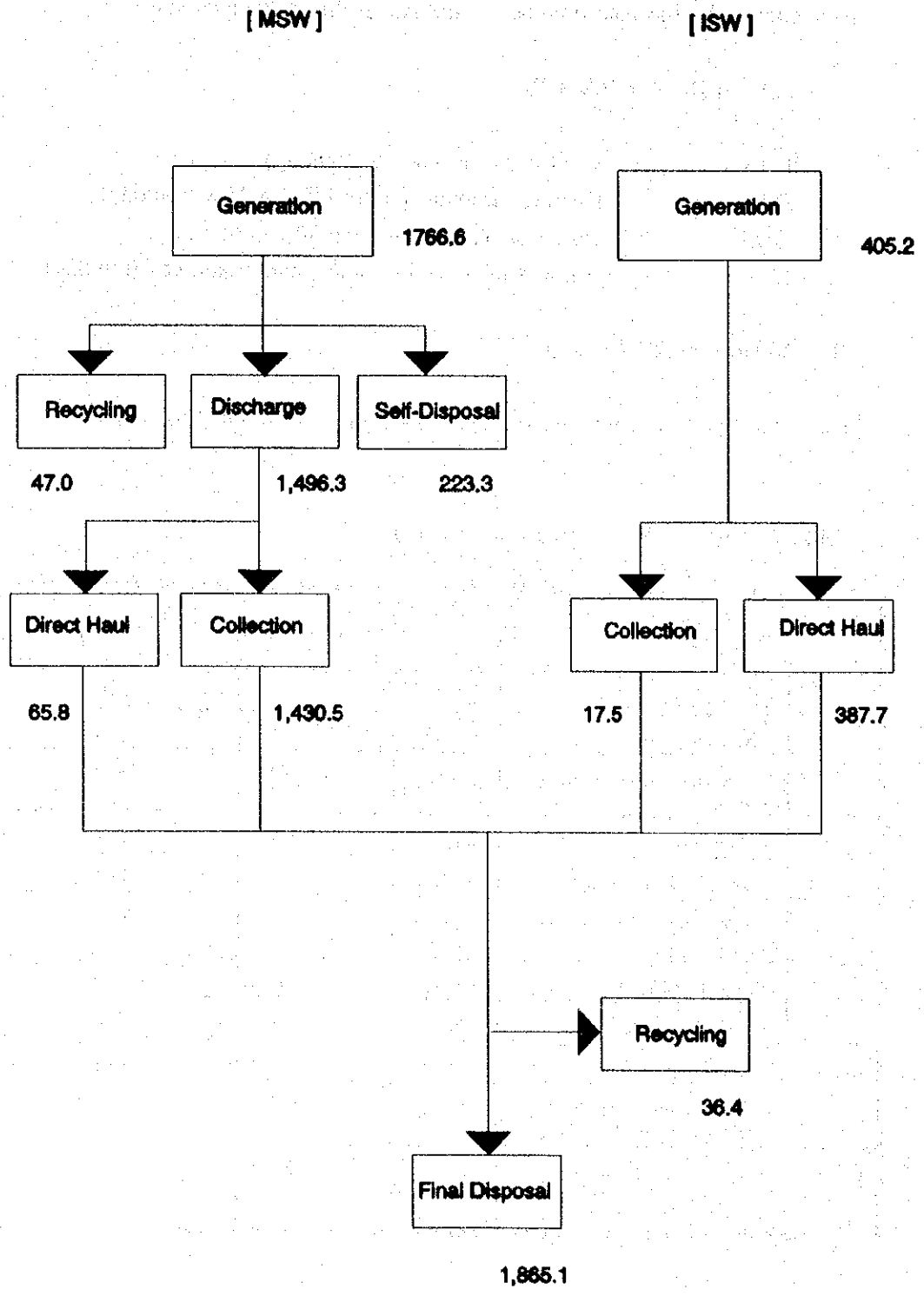


Figure 7.1.3a Waste Stream in 2010 in the Study Area (unit : ton/day)

7.1.4 Other Pre-conditions

a. Economic and Financial Conditions

aa. Economic Growth Rate

It is very difficult to forecast the future economy of Nicaragua because the country is presently changing its economic structure to a market economy. Further, even the use of trend figures of economic variables to describe future scenarios is too risky because for a long period of time the country has been under a controlled regime and civil war.

The formulation of the SWM Master Plan necessitates forecasting future economic figures to estimate waste volume and economic capability, factors relevant to the estimation of the required SWM cost. Therefore, the following assumptions on the future GDP and GRDP were made:

- The actual GDP growth rate will increase to more than 3.5% as the population increase rate exceeds 3%.
- The positive changes in the economy of Nicaragua in 1994 will bring about a 2% to 3% growth rate.
- The development plans for Nicaragua will aim for a 5% economic growth rate in the 1994 - 1995 period.

Based on the above assumptions, the GDP growth rate forecast is as follows:

Year	GDP (growth/year)
1995	3.5%
1996	4.0%
1997	4.5%
1998-2000	5.0%
2001-2005	4.5%
2006-2010	4.0%

In 1992, Managua made up 50% of the GDP, a contribution estimated to increase to 55% by the year 2000. This figure will be adopted until the year 2010 in the Study.

The estimated increase is attributable to the belief that urbanization will attract migrants from rural areas and encourage the convergence of tertiary industries in

Managua City.

Based on the above reasons, the main GDP and GRDP figures per annum were calculated as shown in Table 7.1.4a.

Table 7.1.4a Master Plan Framework

	Unit	1995	2000	2005	2010
GDP	mill.US$	1,784.8	2,245.4	2,798.2	3,404.5
Share of Managua	%	51.9	55.0	55.0	55.0
GRDP in Managua	mill.US$	925.9	1,235.0	1,539.0	1,872.5
Population of Managua	thousands	1,127.6	1,452.9	1,733.9	2,069.3
GRDP per capita	US$	821.1	850.0	887.6	904.9

ab. City Finance and Family Income Estimates

The budget of the city of Managua and the income of families in the city are assumed to be proportional to the GRDP growth rate.

Table 7.1.4b Financial State of Managua Municipality and Family Income

	Unit	1995	2000	2005	2010
Budget of Managua	mill.US$	27.4	36.5	45.5	55.4
Family Income	US$/month	368.6	381.6	389.4	406.2

b. Conditions for Cost Estimation

All cost estimates are conducted taking the following into account:

- The prices and foreign exchange rate are based on the January 1995 rate.

  US$ 1.00 = C$ 7.1183

- Inflation is not taken into account.
- Local laborers whose wages are under C$ 25,000/year are not obliged to pay income tax, but 12.5% social security charge is deducted from the wage.
- Prices for equipment not available in Nicaragua reflect Japanese price levels. These will be presented in CIF prices in C$.

Unit prices for earthworks, concrete works, buildings, etc., were based on the information given by the Ministry of Construction, Managua Municipality and private construction companies.

Table 7.1.4c presents unit prices available in Nicaragua in January 1995.

Table 7.1.4c Unit Prices Available in Managua

DESCRIPTION	UNIT	PRICE
1. Salary, including 12.5% Social Securities Charge		
– manager	C$/pers	4,666
– engineer	C$/pers	3,033
– mechanic	C$/pers	1,604
– driver & clerk	C$/pers	1,410
– worker	C$/pers	992
2. Earthworks		
– Excavation and Compaction: hauling distance = 0 to 50 m	C$/m^3	30
– Excavation, haulage and compaction		
0 – 1km	C$/m^3	34
1 – 5km	C$/m^3	44
5 – 10km	C$/m^3	54
10 – 15km	C$/m^3	64
3. Drainage Works		
– Underground drain including excavation, supply & placing of gravel	C$/m	40
– Underground drain with perforated pipe, including excavation, supply & placing of perforated pipe (D=diameter) and filter material		
D = 100 mm	C$/m	180
D = 150 mm	C$/m	240
D = 300 mm	C$/m	440
– Open ditch w=3.0m, including excavation and shaping	C$/m	290
– Open ditch reinforced concrete w=3.0m, including all works	C$/m	2,600
– Concrete pipe D=600mm, including excavation, foundation, supply & placing concrete pipe and back fill	C$/m	770
– Concrete pipe culvert D=1,200mm, including excavation, foundation, supply and placing concrete pipe and backfill	C$/m	2,200
4. Pavement works		
– 5 cm asphalt concrete	C$/m^2	130
– 20 cm mechanical stable gravel	C$/m^2	
– 20 cm course gravel	C$/m^2	
5. Concrete works, including material and formworks		
– Reinforced concrete	C$/m^3	1,400
– Concrete	C$/m^3	850
6. Building works		
– Garage – a steel structure with steel cladding; including foundation and concrete floor	C$/m^2	1,300
– Office building – of reinforced concrete; including all works	C$/m^2	2,300
7. Miscellaneous works		
– Fence – consists of 2m high galvanized wire mesh erected on galva–nized steel posts each 2.5 m in diameter.	C$/m	270
– Gate – 8 m wide	C$/set	3,600
– Tree height = 2.5 ˜ 3.0 m, including excavation, planting and all works	C$/piece	40
– Turfing – consists of supply of turf and soil and all works necessary	C$/m^2	10
8. Materials		
– Diesel Oil	C$/lt	1.89
– Gasoline	C$/lt	4.00
– Gravel	C$/m^3	94.30
– Sand	C$/m^3	8.28
– Clay	C$/m^3	7.50
– Cement	C$/45 kg	25.59
– Concrete		
150 kg/cm^2	C$/m^3	534.75
210 kg/cm^2	C$/m^3	570.85
– Reinforced bar	C$/kg	4.43
– Electric Power	C$/kwh	0.51