Chapter 4

Current Situation of Solid Waste Management

4 Current Situation of Solid Waste Management

4.1 History of Solid Waste Management

4.1.1 Collection and Haulage

By the end of 19th century in Mexico, police inspectors were in charge of the cleaning services with mules and cleaning carts. Around the middle of the same century, regulations were established to locate waste dumping sites.

In 1934, the Cleaning and Transportation Union was formed, which in the future would turn into Section 1 of the Only One Union of Workers for the DF, with 1,600 members.

The first Code of the Cleaning Service for the DF was promulgated in 1941, which was invalid until 1988.

In 1946, the Cleaning Office started to take charge of sweeping and waste collection works.

In 1976, the Collection System and Garbage Treatment Office was incorporated into new General Directorate of Urban Services (DGSU), which was regarded as a supportive institution for the cleaning and transportation offices of the delegations. During the next several years, however, the functions of the DGSU were gradually decentralized, and finally it was dismissed.

In 1984, the DGSU came back and the transfer system was strengthened through the acquisition of equipment and the construction of new facilities.

Since then, there were no major changes in the collection service, although waste to be collected has increased fivefold since 1950, when waste amount was about 2,000 ton/day from the population of about 3.96 million. In fact, some delegations have made diverse attempts to bring modifications to the collection routes, stopping points, and collection schedules, but all these efforts have not been successful. This is mainly because the truck drivers, who are virtually the decision makers to design their "optimum" collection system and distribute the pre-scavenged materials, do not cooperate.

4.1.2 Treatment and Final Disposal

The modern history of treatment and final disposal system in the DF is summarized in Figure 4-1.

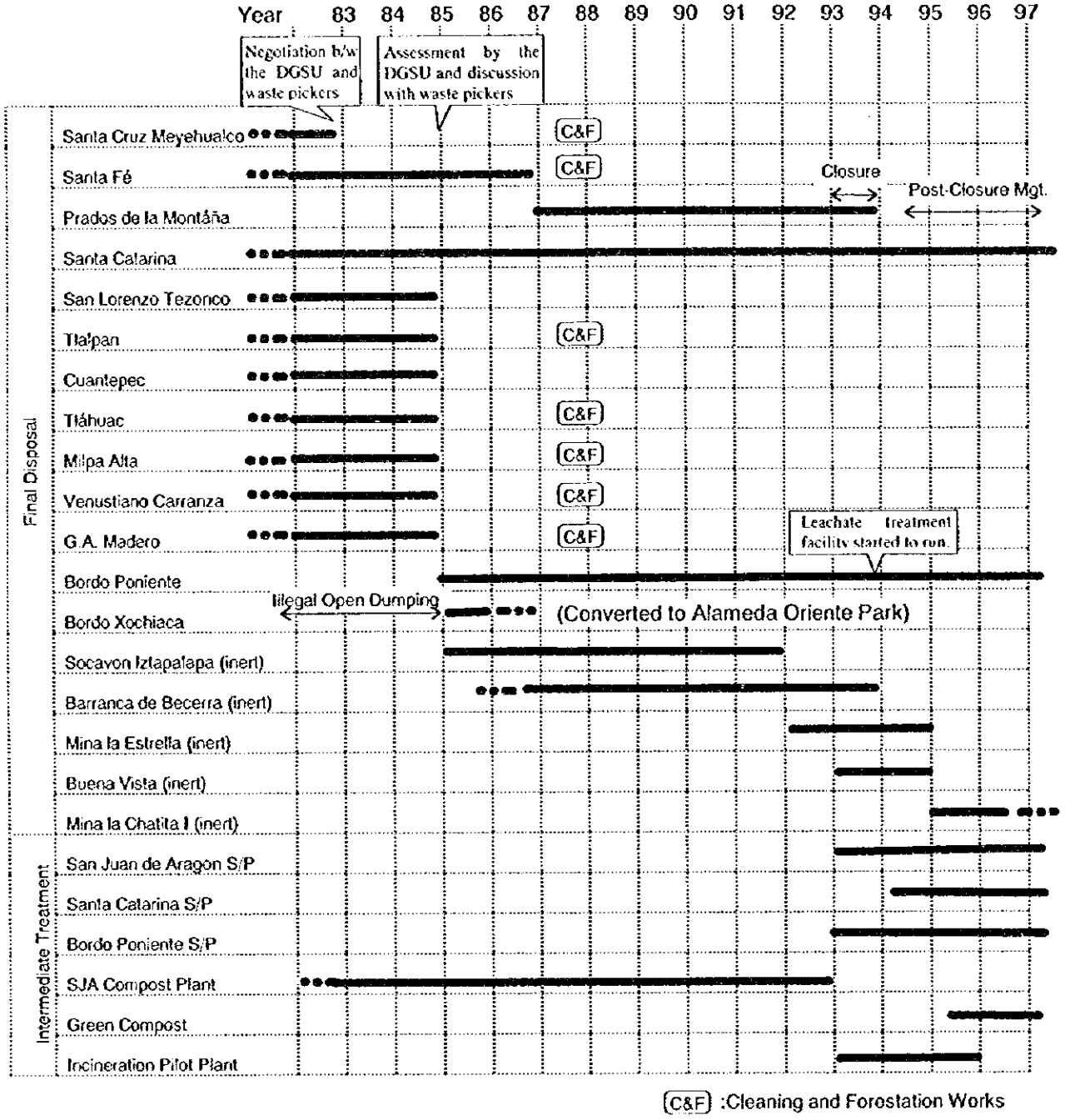


Figure 4-1: Waste Treatment and Disposal in Last 15 Years

4.2 Waste Stream

4.2.1 Introduction

a. Outline of Waste Stream

There are found various features in the stream of municipal solid waste in the DF.

1. Wastes are collected at source and transported to the transfer stations, S/Ps or directly to the final disposal sites by the delegations, while waste transport from the transfer stations to the S/Ps or final disposal sites, and that from the S/Ps to the final disposal sites are carried out by the DGSU.
2. Wastes collected by private sectors or individuals are done through the same routs as the delegations.
3. At the S/Ps run by the DGSU, the recyclables with market values are recovered, and the residuals are further transported to the final disposal sites.
4. Wastes generated at hospitals in the DF are collected by private sectors. General wastes similar to domestic wastes are directly brought to the final disposal sites, while biological infectious wastes are first disinfected and transported to the final disposal sites and pathological wastes are incinerated.
5. Illegally dumped wastes in the DF are collected and transported to the final disposal sites by the DGSU. Illegal dumping is often found in places such as:

    - Roads.
    - Vacant lands.
    - Cliffs.
    - Valleys.

    It should be noted that because there are not many rivers or open drainage channels.
6. Self disposal of wastes at households by burning, burying or composting is not common and the waste amount disposed of at households is considered negligible.
7. Recycling is practiced during the collection, and intermediate treatment processes. The mainly recovered materials include steel scrap and cans, aluminum scrap and cans, cardboard, paper and plastics. Material recovery is conducted by the following people.

    - Collection by crew.
    - Sweepers.
    - ex-pepenadores.

Taking these features into account, the waste stream is illustrated in Figure 4-2.

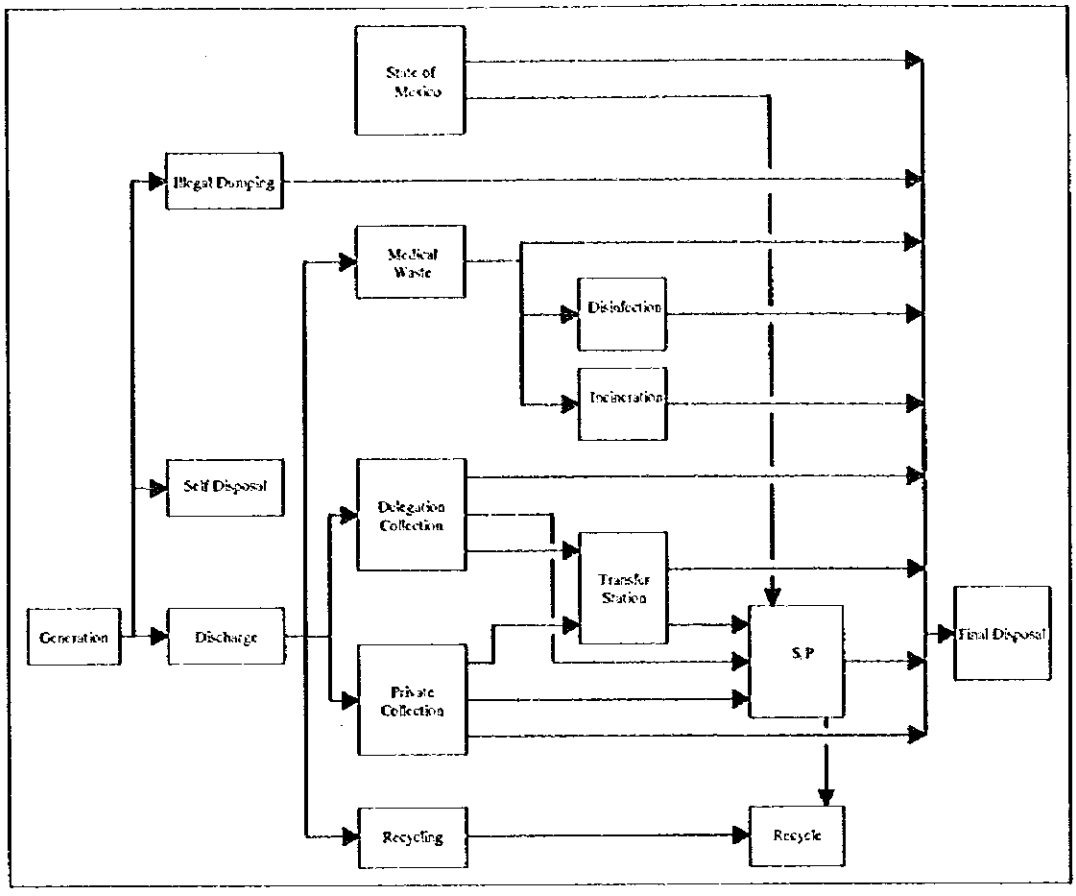


Figure 4-2: Present Waste Stream

b. Definition of Terms for Waste Stream

Definition of specific terms used in Figure 4-2 is given below.

- Generation

Waste amount of "generation" refers to the amount of waste generated in the whole DF.

- Illegal Dumping

Waste amount of "illegal dumping" refers to the amount of waste dumped where waste should not be thrown away.

- Self Disposal

Waste amount of "self disposal" refers to the amount of waste which is generated by households and disposed of by the waste generators themselves by such means as burning, burying or composting.

- Delegations Collection

Waste amount of "delegations collection" refers to the amount of waste collected by the delegations of the DF.

- Private Collection

Waste amount of "private collection" refers to the amount of waste collected not by the delegations but by private sectors or individuals.

- Recycling

Waste amount of "recycling" refers to the amount of waste which is recycled during the collection process or in the S/Ps.

- Transfer Station

"Transfer station" refers to a facility in which waste collected by the delegations, private sectors or individuals is transferred to a large trailer.

- S/P

An "S/P" is a facility where recyclable materials are recovered from collected wastes.

- Final Disposal

The site of "final disposal" is a facility where collected waste and waste residues from the S/Ps are disposed of.

- The State of Mexico

Some or almost all of wastes generated in 11 municipalities of the State of Mexico are transported to the final disposal sites operated by the DGSU. Waste amount from "the State of Mexico" refers to the amount of waste from those municipalities, namely:

- Atenco
- Chalco
- Chiautla
- Chiconcuac
- Cuatitlan Izcalli
- Ecatepec
- Ixtapaluca
- Nezahualcoyotl
- La Paz
- Texcoco
- Valle del Chalco

4.2.2 Waste Composition and Generation Ratio

a. Waste Composition

The DGSU has been investigating municipal solid waste composition of wastes generated from five sectors with totally 19 sub-sectors in the DF, as shown in Figure 4-3. Wastes are classified into 35 and the obtained data are utilized for SWM control.

Consequently, the present study is to follow the same waste classification as the DGSU.

Table 4-1 is the result of the waste composition survey by the DGSU.

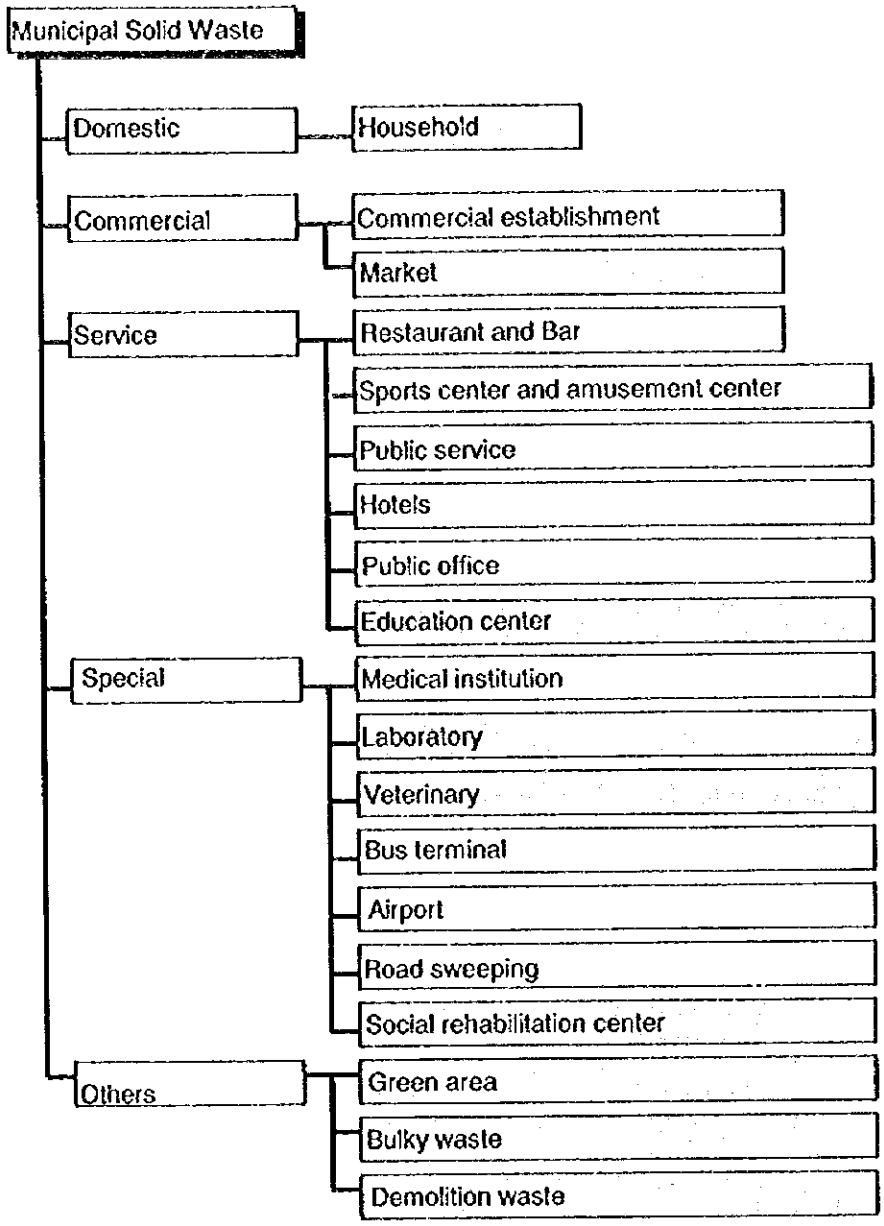


Figure 4-3: Sectors and Sub-Sectors of Waste Sources

Table 4-1: Waste Composition

(unit: %)

Composition	Domestic	Commercial		Service													Others			Total
	Household	Commercial	Market	Restaurant and Bar	Sports center and amusement	Public service	Hotels	Public office	Education center	Hospital	Laboratory	Veterinary	Bus terminal	Airport	Road	Social rehabilitation center	Green Area	Bulky waste	Demolition waste/Small repair	
1 Spatula										1.97										0.03
2 Cotton	2.15	0.07	0.83			0.38	0.03	2.99	0.17	1.97	10.38	5.57								1.30
3 Cardboard	5.36	11.51	5.29	5.97	11.04	23.18	3.77	11.20	8.98	8.30	8.01	2.56	4.34	5.31	3.66	5.06	4.00			6.68
4 Leather	0.11			0.02		3.69			0.04											0.11
5 Paper container	1.96	1.97	2.22	1.43	5.18	1.98	0.76		6.05	1.07		0.69	0.55		6.53	0.52	3.12			1.91
6 Vegetable fiber	0.06	1.79	2.63			1.13	0.08	0.01	0.78	0.20										0.69
7 Synthetic fiber	1.43	0.29	0.89	0.04			0.01	0.24		0.27	3.10				0.10					0.85
8 Gauze										3.77	5.74	5.94								0.05
9 Bone	0.08	0.44	1.11			0.21			0.67	0.07		0.38								0.27
10 Vinyl	0.20	1.07	0.16			0.36	0.18	0.83	1.33	2.07										0.37
11 Disposable syringe										2.80	1.31	1.38								0.04
12 Cans	1.58	0.31	1.47	0.25	1.23	3.10	0.52	0.28	4.89	1.73		2.31	4.53	3.17	4.77					1.24
13 Ceramics	0.37	0.12	0.09	0.45	0.29		0.18	0.08	2.01										2.09	0.30
14 Wood	0.10	1.20	1.17	0.67		6.72		0.01	3.92	0.43		4.82	0.29				5.12	20.00	1.53	1.24
15 Construction waste	0.63			0.52	0.09		2.89						1.24						95.27	2.14
16 Metal	1.39	2.59	0.07	0.92	5.65	0.71	1.79	0.15	0.40	1.90		0.69			0.41		2.86	50.00		2.56
17 Nonferrous metal	0.06	0.51				1.30		6.54		0.07	1.18	1.31					2.29			0.49
18 Paper	1.19	5.31	1.87	1.54	3.57	18.75	9.21	37.61	14.33	6.57	17.23	9.88	9.10	6.41	5.41	3.11	6.82		0.97	4.41
19 Newspaper	4.61	5.95	4.54	0.95	3.17	15.50	5.24	11.91	6.99	4.37	11.97	20.64	6.07	15.34	9.71	7.73	2.22			4.96
20 Toilet paper	8.78	1.94	4.27	3.40	9.59	4.20	8.16	1.99	10.72	11.00	9.62	7.38	15.20	8.92	9.52	4.65				5.89
21 Disposable diaper	3.37	0.14		0.08	0.09	0.32	0.89		0.30	1.43			1.94							1.62
22 X-ray film										0.30										0.00
23 Plastic film	6.24	5.38	1.50	3.08	7.13	2.14	3.58	0.16	1.95	3.27		0.44	5.34	3.91	5.38	2.00	9.29		0.14	4.53
24 Hard plastic	4.33	3.94	2.96	1.26	15.34	1.39	1.69	0.88	2.69	0.97	8.64	1.63	3.08	5.46	6.62	1.26	4.00			3.49
25 Polyurethane	0.16	0.11	0.08	0.03		2.70			0.67	0.76	2.17	2.56								0.16
26 Foamed polyurethane	0.78	0.12	0.46	0.35	0.72	1.85	0.16	0.11	0.46	1.70	2.27	1.06	1.10	1.18	1.22		1.23			0.58
27 Food waste	34.66	38.73	63.08	74.43	16.17	5.71	43.23	21.22	16.02	26.96	1.74	3.31	30.44	16.32	7.67	42.49				37.70
28 Garden waste	5.12	0.15	0.05	0.08	0.42	0.59	3.66	0.30	6.32	1.30	1.89	0.56		1.53	11.46	7.46	25.36			3.18
29 Sanitary napkin		0.17						0.04	0.63		1.61		0.01			2.00				0.04
30 Rags	0.64	0.20	0.30	0.12	1.14		1.72	0.31	1.02	0.50	1.84			4.88		3.00		30.00		1.22
31 Bandage										0.36					0.02					0.01
32 Color glass	4.00	1.77	0.30	1.53	4.67	2.81	3.09	0.26	2.44	6.70	4.86	2.00	3.45	8.07	8.64	0.42				2.62
33 Transparent glass	6.77	5.18	0.44	2.82	11.76	1.28	8.52	0.76	4.66	5.63	3.05	0.94	7.79	7.14	8.37	0.95	0.85			4.61
34 Fine fraction	1.21	0.07	3.97	0.03	2.75		0.26	0.01	0.73	0.43	0.03			3.61	4.02		26.30			1.71
35 Others	2.66	8.97	0.25	0.03			0.38	2.11	0.83	1.13	3.36	23.95	5.53	8.75	6.49	19.35	6.54			3.00
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.0	100.00	100.00	100.00	100.00	100.00	100.00	100.0	100.00	100.00	100.00	100.00	100.00

b. Generation Ratio

Generation ratio at each source surveyed by the DGSU is shown in Table 4-2. The present study will adopt the same generation ratio.

Table 4-2: Generation Ratio

Type of Source Generation	Classification	Generation Ratio	
Domestic	Household	0.616	kg/Person/Day
Commercial	Commercial Establishment		
	- Auto Service Shop	637.000	kg/Establishment/Day
	- Department Store	368.000	kg/Establishment/Day
	- Commercial Place	6.650	kg/Establishment/Day
	Market		
	- Meat Market	4.430	kg/Stall/Day
	- Vegetable Market	7.920	kg/Stall/Day
	- Grocery store	1.025	kg/Stall/Day
	- Food Preparation	14.960	kg/Stall/Day
	- Various	0.803	kg/Stall/Day
	- Shifting Market (Tianguis)	575.800	kg/Tianguis/Day
Service	Restaurant and Bar	25.442	kg/Establishment/Day
	Sports Center and Amusement Center		
	- Amusement Center	1.230	kg/Employee/Day
	- Sports Center	2.620	kg/Employee/Day
	- Cultural Center	0.330	kg/Employee/Day
	Public Service		
	- Services Office	3.460	kg/Establishment/Day
	- Repair and Maintenance Service	1.940	kg/Establishment/Day
	- Gas station	53.120	kg/Establishment/Day
	Hotel		
	- Five-star hotel	1,016.900	kg/Establishment/Day
	- Four-star hotel	218.500	kg/Establishment/Day
	- Three-star hotel	16.810	kg/Establishment/Day
	Education Center		
	- Kindergarten	0.040	kg/student/Day
	- Elementary School	0.055	kg/student/Day
	- Job Training Center	0.060	kg/student/Day
	- Junior High School	0.065	kg/student/Day
	- Technical School	0.060	kg/student/Day
	- Senior High School	0.060	kg/student/Day
	- University	0.070	kg/student/Day
	- Public Office	0.413	kg/Employee/Day
Special	Medical Institution		
	- 1st. Level	1.279	kg/Consultory Room/Day
	- 2nd. Level	4.730	kg/Bed/Day
	- 3rd. Level	5.390	kg/Bed/Day
	Laboratory	6.340	kg/Laboratory/Day
	Veterinary	1.700	kg/Employee/Day
	Bus Terminal	2,103.000	kg/Terminal/Day
	Airport	28,887.000	kg/Airport/Day
	Road Sweeping	125.530	kg/km/Day
	Social Rehabilitation Center	0.540	kg/Person/Day
Others	Green Area	0.00993	kg/m^2/Day
	Bulky Waste	28.850	kg/Ton-Solid Waste/Day
	Demolition Waste and Small Repair	20.850	kg/Ton-Solid waste/Day

4.2.3 Waste Stream Analysis

The waste amount of each component for the waste stream was calculated and summarized in Figure 4-4.

It was revealed that the waste generated in the DF in 1997 amounted to 11,422 ton/day and waste from the State of Mexico was 777 ton/day. 1,929 tons of waste were recycled daily and 10,276 ton/day were disposed of.

As for waste collection, the DGSU collected 8,867 ton/day of waste while the private sector and individuals collected 912 ton/day. Wastes of 8,558 ton/day of the total of these two went to the transfer stations prior to the final disposal sites.

The S/Ps received 4,913 tons of waste per day, 496 tons of which were recycled.

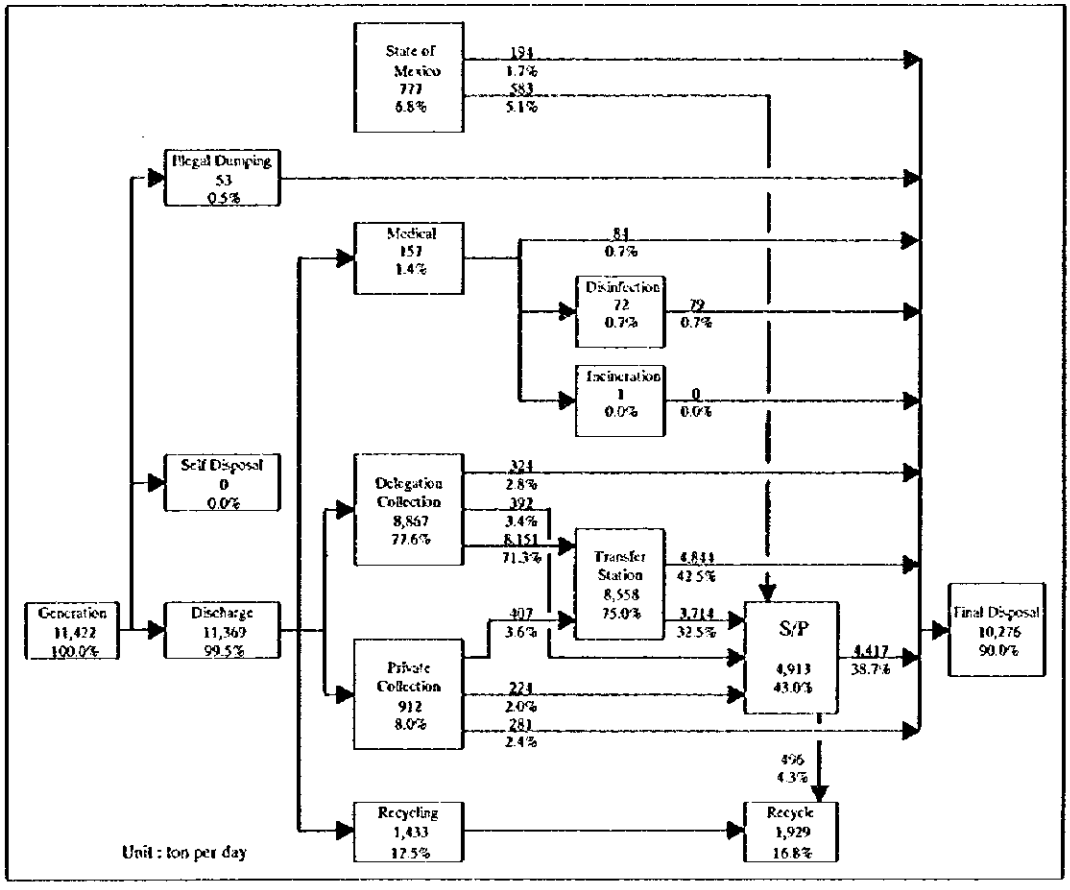


Figure 4-4: Waste Stream in 1997

4.3 Technical System

4.3.1 Discharge and Storage System

a. Storage in Houses

A clear correlation exists among the type of domestic storage that is used and the user's socio-economic level.

It is difficult for waste storage containers, which are used for example in the "barrios" and "popular colonies", to fulfill the sanitary requirements such as: easy to handle, large enough, properly capped, light and easy to clean. In fact, it is commonly observed that they use sacks, baskets, wheelbarrows, boxes and all type of inappropriate containers for the storage of the garbage.

On the other hand, in residential areas with higher income level, more attentions are given to the containers used to store the wastes. Therefore in general terms, they use plastic containers with cover and appropriate capacity (manufactured exclusively for this function), normally plastic bags are located in their interior in order to contain the garbage in it with more comfort, and they normally empty them every two days.

b. Storage in Other Source

In areas and installations of great waste generation, it is very common to employ metallic containers or any other material of big dimensions, either movable or stationary. Their volumes usually vary from 1 to 3 m^3, although there are other types of larger dimensions (up to 6 m^3). Their handling requires specialized vehicles and, on occasion, high sophistication. The loading system of these containers can be mechanical, hydraulic, or pneumatic. Hydraulic systems are prevalent.

4.3.2 Collection and Haulage System

Collection of municipal wastes generated is the responsibility of respective delegations and most of them are delivered by the Section 1 to the transfer stations managed by the DGSU (Exceptions are wastes that are brought directly to the final disposal sites or the S/Ps by some delegations due to their vicinity).

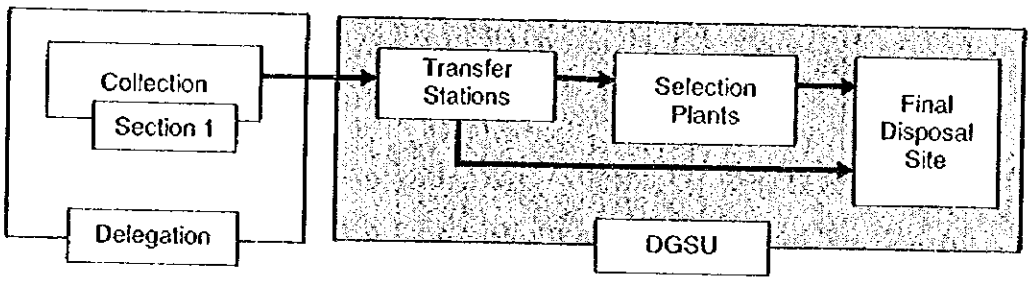


Figure 4-5: Present Collection and Haulage System

However, in July 1998, the GDF and Section 1 signed an agreement that the Section 1 would withdraw its collection service from markets, primary schools, public residence units and parks from January 1999. It was decided in October 1998 that the delegations are to be in charge of employing private sectors through contracts for the wastes collection for those public institutions (or hereafter "Sub-System").

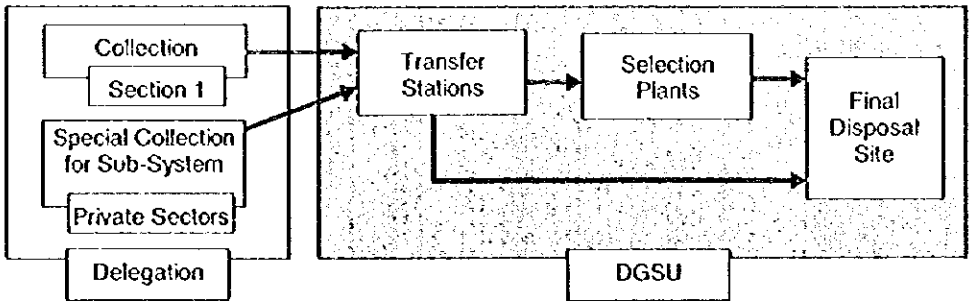


Figure 4-6: New Collection and Haulage System

Wastes brought to the transfer stations are, after visual inspection, destined to one or the other below:

- S/Ps.
- final disposal sites.

Large-size trailers (70m^3) are employed for the transport from the transfer station to one of the two destinations.

4.3.2.1 Collection System

a. Collection Method

Regarding the collection methods, it can be said that the corner collection (with bell) is still popular, although there also exist door-to-door collection, curb collection and fixed stop collection.

Sweepers begin their working day at 5 AM, yet their official schedule is from 7 AM to 3 PM. They sweep the street from 5 AM to 7 AM, and from that hour they pick the garbage of houses, segregate the most worthy waste in the market and then sell them.

b. Collection Vehicle

By 1998, the waste collection vehicles were more than 2,000 units, as shown in Table 4-3 where it is observed that the biggest percentage is accounted for by rectangular box collection vehicles. The rectangular box and tubular load types, both of which are equipped with compacting mechanisms of back loads, constitute more than 50%.

Table 4-3: Number of Collection Vehicles

Type / Delegation	Front loader	Back loads	Rectangular	Tube type	Dump truck	Mini collector	Total
Loading capacity	$18m^3$,6.5 t	$12m^3$5.0 t	$12m^3$,4.5t* $16m^3$, 4.0t	$12m^3$, 4.5t $16m^3$, 4.0t	8 m^3, 2.5t $16m^3$, 4.0t	$8m^3$,3.0 t	
Alvaro Obregon	4	34	31	17	52		138
Azcapotzalco	7	63	32	34	4		140
Benito Juarez	4	22	66	38	4		134
Coyoacan	5	52	34	32	5		128
Cuajimalpa		10	8	9	4	6	37
Cuauhtemoc	12	94	44	75	26		251
Gustavo A.Madero	7	56	96	76	46		281
Iztacalco	1	37	14	15	25		92
Iztapalapa	2	50	85	42	32		211
M.Contreras		12	6	3	11	29	61
Miguel Hidalgo	3	46	43	37	44		173
Milpa Alta		1			22	3	26
Tlahuac		19	8	4	16		47
Tlalpan		39	21	9	14		83
V.Carranza	8	17	73	19	38	5	160
Xochimilco	6	12	15	6	10		49
Total	59	564	576	416	353	43	2,011

Source: PARQUE VEHICULAR DE RECOLECCION ASIGNADO A LAS DELEGACIONES POLITICA, Enero, 1993, DGSU

Notes : $12m^3$,4.5t* is without compacting mechanism ,$16m^3$,4.0t with compacting mechanism

It is also important to mention that, as shown in Table 4-4, 1,078 out of the 2,011 units have been used for a period of obsolescence of more than 15 years, which are supposed to have been substituted already, not only due to the high maintenance cost that are recorded, but because they technologically imply a risk of inducing inefficiency and high administrative costs.

Table 4-4: Purchase Years of Existing Collection Vehicles

	1965	1966	1967	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	Total
Alvaro Obregon			2	3	5	4		8		38	1		16					13	1			3	13	4	4	4	6	5	7	1	138
Azcapotzalco				10	3	2		8		11	3	11	28	1				7		5		6	9	2	14		14		6		140
Benito Juarez	1			6	7	6		18	1	23	1	9	20				13					3		18	5		9		3		143
Covoacan			1	4	8	1		5		32	1		19				12		2	1		9	9	3	9		4	3	3		126
Cuajimalpa					1			1		5			5	2				4	1				2	1	1	4	15		3		45
Cuauhtemoc	3	1	1	19	18	5	1	26	1	26	2		31	3	22		34					8	12	18	2		19		3		255
Gustavo A.Madero		2	3	10	29	6	1	11	1	77	12		33		1	1	2	7	22	7		9		11	3	11	7	1	13		280
Iztacalco				4		1		5		4	3		16		5			2				4	15	10		2	11		3		85
Iztapalapa				13	4	7		12		23	1		19	7			9					5	30	65	2		7	13		8	225
M.Contreras				1		1		6		2	2		5					2				3	8	2	1		6		3		42
Miguel Hidalgo		1	1	8	20	4	1	10		37		1	17		5	1	19		8			7	4	20			1	3			168
Milpa Alta													1		3			1	1			1	6	3		6	7		3		32
Tlahuac						1	1	3	3				5			1	3	1	5			2	4	3	3	2	14		3		54
Tlalpan				1	3	2		6		9	1		17		4						2		13	6		2	2		4		72
V.Carranza				4	8	1		5		18	5	2	29	5					1			6	39	31			4		3		161
Xochimilco			1	2	1	1		2		7	1		13			1		2	2				7	2					3		45
Total	4	4	9	85	107	42	4	126	6	312	33	23	274	18	40	4	92	39	43	13	2	66	171	199	44	31	126	25	60	9	2,011
															1,087															924	2,011

Source: PARQUE VEHICULAR DE RECOLECCION ASIGNADO A LAS DELEGACIONES POLITICA, Enero, 1998, DGSU

c. Number of Daily Trip

Table 4-5 shows the number of workable collection vehicles allocated to each delegation. Meanwhile, Table 4-6 shows nominal loading capacity of each vehicle type and collection capacity of workable vehicles in total per one trip.

Table 4-5: Number of Workable Vehicles by Delegation

	Front loader	Back load	Rectangular	Tube type	Dump truck	Mini collector	Total
Capacity (ton/trip)	6	5	4.5	4.5	2.5	2	
Alvaro Obregon	4	34	12	6	31		87
Azcapotzalco	7	63	15	24	3		112
Benito Juarez	4	22	46	32	3		107
Coyoacan	5	52	16	17	3		93
Cuajimalpa		10	5	3	2	6	26
Cuauhtemoc	10	90	20	23	11		154
Gustavo A.Madero	7	55	28	35	28		153
Iztacalco	1	36	11	11	19		78
Iztapalapa	2	50	65	23	19		159
M.Contreras		12	3	2	7	29	53
Miguel Hidalgo	3	46	33	23	20		125
Milpa Alta		1			21	3	25
Tlahuac		19	4	4	12		39
Tlalpan		38	11	6	10		65
V.Carranza	8	17	52	11	31	5	124
Xochimilco	6	12	5	2	9		34
Total	57	557	326	222	229	43	1,434

Source: PARQUE VEHICULAR DE RECOLECCION ASIGNADO A LAS DELEGACIONES POLITICA, Enero, 1998, DGSU

Table 4-6: Collection Capacity (ton per trip) of Workable Vehicle Fleet

	Front loader	Back load	Rectangular	Tube type	Dump truck	Mini collector	Total (ton/day)
Alvaro Obregon	24	170	54	27	78	0	353
Azcapotzalco	42	315	68	108	8	0	540
Benito Juarez	24	110	207	144	8	0	493
Coyoacan	30	260	72	77	8	0	446
Cuajimalpa	0	50	23	14	5	12	103
Cuauhtemoc	60	450	90	104	28	0	731
Gustavo A.Madero	42	275	126	158	70	0	671
Iztacalco	6	180	50	50	48	0	333
Iztapalapa	12	250	293	104	48	0	706
M.Contreras	0	60	14	9	18	58	158
Miguel Hidalgo	18	230	149	104	50	0	550
Milpa Alta	0	5	0	0	53	6	64
Tlahuac	0	95	18	18	30	0	161
Tlalpan	0	190	50	27	25	0	292
V.Carranza	48	85	234	50	78	10	504
Xochimilco	36	60	23	9	23	0	150
Total	342	2,785	1,467	999	573	86	6,252

Source: PARQUE VEHICULAR DE RECOLECCION ASIGNADO A LAS DELEGACIONES POLITICA, Enero, 1998, DGSU

Based on the data above, collection vehicles' average trips made per day in respective delegation are summarized in Table 4-7. Average trips become about 1.7 trips/day for the GDF total, ranging from 0.9 trip/day in Azcapotzalco to 2.8 trips/day in Iztapalapa. 10 delegations make less trips than the GDF average.

Table 4-7: Daily Average Trips

	Waste generation amount in 1997(ton/day)*	Collection vehicle capacity(ton/day)	Number of trip
Alvaro Obregon	570	353	1.6
Azcapotzalco	498	540	0.9
Benito Juarez	613	493	1.2
Coyoacan	782	446	1.8
Cuajimalpa	135	103	1.3
Cuauhtemoc	1,221	731	1.7
Gustavo A.Madero	1,551	671	2.3
Iztacalco	444	333	1.3
Iztapalapa	1,994	706	2.8
M.Contreras	218	158	1.4
Miguel Hidalgo	647	550	1.2
Milpa Alta	73	64	1.1
Tlahuac	261	161	1.6
Tlalpan	681	292	2.3
V.Carranza	840	504	1.7
Xochimilco	347	150	2.3
Total	10,875	6,252	(mean value)1.7

Notes: *excluding central market waste

4.3.2.2 Haulage System

a. Transfer Station

With respect to this situation and the necessity of strengthening and providing the efficient SWM service, it is indispensable to have the suitable infrastructure that facilitates the improvement and the uniformity of such services in the whole Federal District in the short term. Transfer stations are a fundamental part of this infrastructure, and 13 transfer stations are presently located in Mexico City.

Table 4-8: Outline of the Transfer Stations

unit: m^2

Name	Premise area*	Floor space*	Green area*	Operation body
Alvaro Obregon	8,000	7,900	3,284	DGSU
Azcapotzalco	8,900	6,607	355	Delegation / DGSU
Benito Juarez	8,804	7,380	1,877	Delegation
Coyoacan	12,187	6,798	2,067	Delegation / DGSU
Cuauhtemoc	6,974	4,420	485	Delegation / DGSU
Gustavo A. Madero	3,000	2,800	5,717	DGSU
Iztapalapa I	9,949	6,746	1,638	DGSU
Iztapalapa II	8,871	4,563	467	DGSU
Miguel Hidalgo	6,426	4,400	570	Delegation / DGSU
Milpa Alta	24,335	5,020	11,395	DGSU
Tlalpan	6,516	6,208	332	DGSU
Venustiano Carranza	8,867	7,507	1,106	Delegation / DGSU
Xochimilco	1,500	1,100	500	Delegation / DGSU

Source : *SOLID WASTE MANAGEMENT IN MEXICO CITY, DDF

Delegation Iztapalapa has two transfer stations; one (Iztapalapa II) is handling wastes from the Central market (Central de Abasto) exclusively.

Those 13 transfer stations are managed by the DGSU or by a delegation, or co-managed by both. Practical operation of the stations are all contracted out to private sectors.

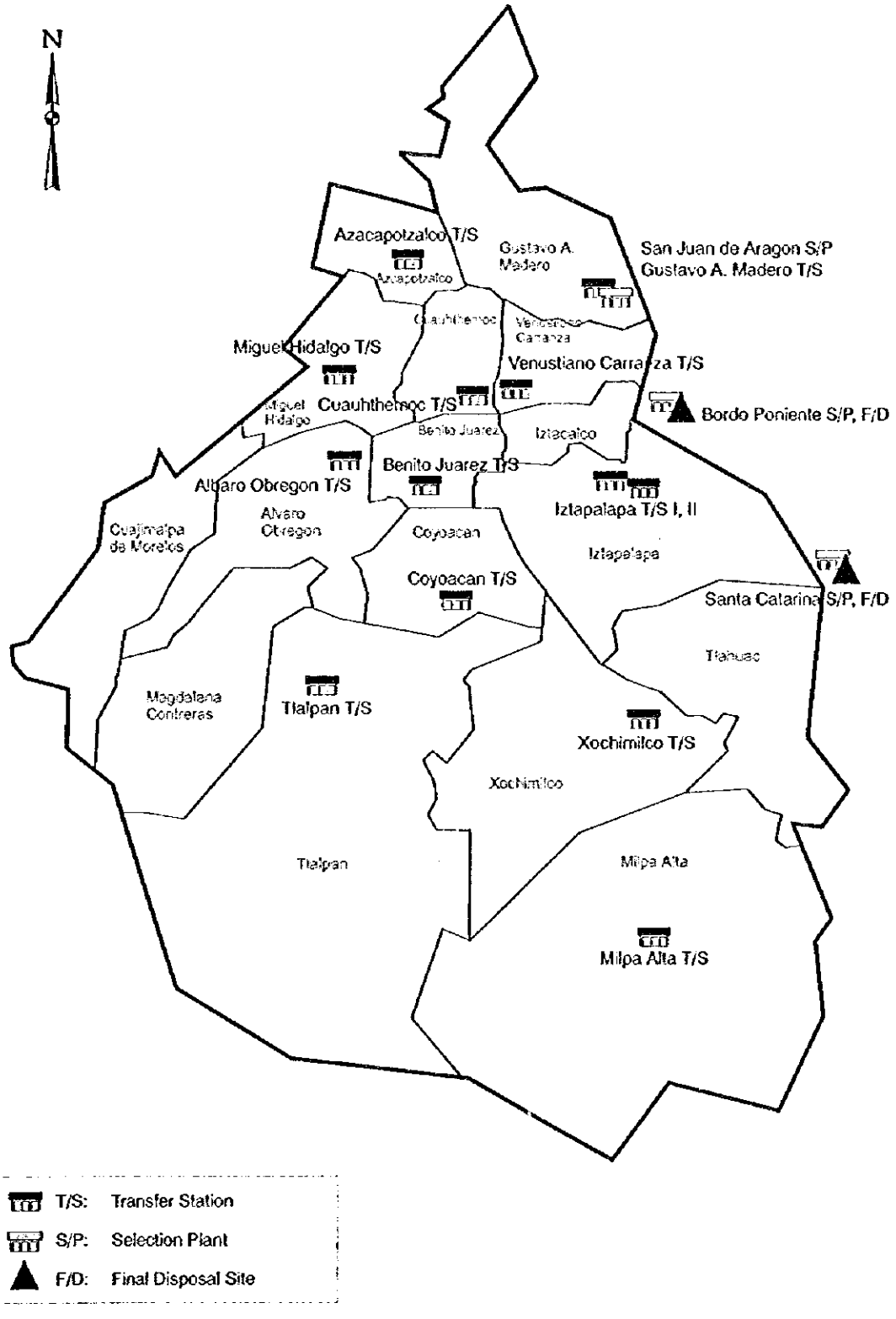


Figure 4-7:
Location Map of Transfer Stations

Table 4-9 shows transfer amount at the respective transfer station. However, non of them has a weighbridge, therefore the incoming and outgoing amounts are only forecast from the number of vehicles recorded and its nominal capacity (or from empirical surveys). Precisely measured transfer amounts (either incoming or outgoing amounts) do not exist to date.

Table 4-9: Transfer Amount

Name	Transfer Record**(ton/day)
Alvaro Obregon	830
Azcapotzalco	728
Benito Juarez	no recorded
Coyoacan	1083
Cuauhtemoc	809
Gustavo A. Madero	416
Iztapalapa I	1000
Iztapalapa II	980
Miguel Hidalgo	584
Milpa Alta	49
Tlalpan	322
Venustiano Carranza	672
Xochimilco	408
Total	7,881

Sources : *SOLID WASTE MANAGEMENT IN MEXICO CITY, DDF
**S/P operation record (Jan. to July/1998), DGSU

b. Transportation

Municipal solid wastes collected by the delegations are mostly gathered in those 13 transfer stations and then transported by large-size trailers ($70m^3$) to the destinations (i.e., final disposal sites or S/Ps). An exception direct transport by collection vehicles in view of the vicinity to the destination. Residues of the three S/Ps are loaded again to the trailers to be transported to the final disposal sites. These transport works are all contracted out to private sectors by the DGSU. The contract works are paid by a combined unit rate (peso/km/ton) on transport distance shown in Table 4-10 and loaded weight. Apart from those $70m^3$ trailers, there are transport fleets (capacity 17 m^3) exclusively employed for construction debris transport.

Table 4-10: Origin to Destination Distance

Unit: km

Origin \ Destination		Landfill Site		S/P		
		Bordo Poniente	Santa Catarina	Bordo Poniente	San Juan de Aragon	Santa Catarina
Transfer station	Alvaro Obregon	29.4	30.3	27.5	-	29.6
	Azcapotzalco	22.8	-	21.1	14.1	30.3
	Coyoacan	31.9	28.7	-	-	27.7
	Cuauhtemoc	19.5	23.4	17.8	-	22.5
	Gustavo A. Madero	13	-	-	-	-
	Iztapalapa I	16.3	17.8	14.7	-	16.7
	Iztapalapa II	16.1	17.6	14.5	-	16.5
	Miguel Hidalgo	32.5	-	-	23.6	-
	Milpa Alta	42.4	-	-	-	-
	Tlalpan	43.3	40.0	41.6	-	40

Origin \ Destination		Landfill Site		S/P		
		Bordo Poniente	Santa Catarina	Bordo Poniente	San Juan de Aragon	Santa Catarina
	Venustiano Carranza	16.6	0.0	14.9	-	0.0
	Xochimilco	35.6	17.3	34.0	-	16.6
S/P	Bordo Poniente	2.0	-	-	-	-
	San Juan de Aragon	13.0	-	-	-	-
	Santa Catarina	26.9	-	-	-	-

Transport trailers employed in the works have a variety in the ownership as follows:

- Tractor unit and trailer box unit are both owned by a private sector.
- Tractor unit is owned by a private sector, and trailer box by the DGSU.
- Tractor unit and trailer box unit are both owned by the DGSU.

Those **trailer box** units are **236** in total, all of which are moving-floor type. Each **trailer box** unit owned by the DGSU has its assigned transfer stations.

Meanwhile, a "global positioning system (GPS)" apparatus is installed on each **tractor** unit to monitor and control the total transportation system. This monitoring and controlling system is managed by an office of the DGSU in the Alvaro Obregon transfer station.

Table 4-11 shows the record of transportation made from January to May in 1998. It reveals that wastes from Cuauhtemoc and Iztapalapa-I transfer stations are mostly transported to Santa Catarina S/P instead of Bordo Poniente S/P which is the nearest S/P from these two transfer stations.

Table 4-11: Number of Trips (70m^3 Trailer, Jan./98 to May/98)

Origin \ Destination		S/P				Disposal site				Total
		BP	SJA	SC	Total	BP I	BP IV	SC	Total	
Transfer station	Alvaro Obregon	4,309			4,309		2,351	1	2,352	6,661
	Azcapotzalco	1,002	586	763	2,351		2,808		2,808	5,159
	Benito Juarez		3	680	683				0	683
	Coyoacan	3		4,225	4,228		855	3,351	4,206	8,434
	Cuauhtemoc			2,918	2,918		197	3,081	3,278	6,196
	Gustavo A. Madero	44			44		3,598		3,598	3,642
	Iztapalapa I	173		718	891		6,444	653	7,097	7,988
	Iztapalapa II	2,275			2,275		4,312		4,312	6,587
	Miguel Hidalgo	175	2,352		2,527		3,074		3,074	5,601
	Milpa Alta	4			4		645	2	647	651
	Tlalpan	1,064		984	2,048		190	429	619	2,667
	Venustiano Carranza	1,459			1,459		3,368	9	3,377	4,836
	Xochimilco	4		742	746		285	2,074	2,359	3,105
S/P	Bordo Poniente				0		10,185		10,185	10,185
	San Juan de Aragon				0		10,261		10,261	10,261
	Santa Catarina	2			2		9,742		9,742	9,744
Total		10,514	2,941	11,030	24,485	0	58,315	9,600	67,915	92,400

4.3.3 Processing, Treatment and Recycling System

As for processing, treatment and recycling facilities in Mexico City, a municipal SW incinerator and a composting facility which are used to be operated and maintained in the DGSU's premises of San Juan de Aragon are no more operated today. The facilities presently operated are the only three manual-sorting Selection Plants (S/Ps) in Bordo Poniente, San Juan de Aragon (SJA) and Santa Catarina.

a. Incinerator

Competitive tender for the construction of the municipal SW incinerator was held in 1979. On-site fabrication of the incinerator was commenced in 1984, once suspended in 1986 and completed in 1989.

The incinerator facility in SJA was being operated from February 1990 to June 1992 as a pilot facility with the objectives of data compilation on incineration technology. However, both two units have never been operated together, even when an expert dispatched from Switzerland expedited to control the operation.

The principal reason of the failure could be concluded as follows:

An incineration technology apt to drier wastes (common in Europe) was simply imported to Mexico. The size of "drying zone" of the incinerator turned out insufficient for more humid wastes in Mexico especially in rainy season. Incineration without additional fuel (gas) sometimes could be achieved in dry season, while wastes in rainy season almost always required combustion fuel. Consequently planned incineration treatment was not realized with these units.

The two incineration units in SJA are not dismantled to date, and their equipment is comparatively well preserved in view of time passage. However, if municipal waste incineration with this facility will have to be challenged, decent maintenance and considerable modification of mechanical and electric components will be necessary. In addition, in order to clear the new emission norms (drafts for which are presented in Table 4-12), the all incineration structures (from wastes intake to stack) should be replaced. Civil and building structures can only be utilized.

Table 4-12: Comparison of Incineration Test and Draft Emission Limit

		Run-1, MSW, 17/Jun/92	Run-2, MSW, 17/Sept./92	Run-3, MSW, 23/Sept./92	Run-5, MSW, 12/Nov./92	Run-7, MSW, 19/Nov./92	Run-12, MSW, 07/Dec./92	Mean value	Emission limit
Particles	mg/m^3	400.46	123.56	95.13	190.09	13.49	100.14	153.81	30
SO_2	mg/m^3	288.53	n.d.	n.d.	368.84	36.40	135.95	207.43	80
CO	mg/m^3	85.82	194.68	887.53	n.d.	n.d.	n.d.	389.34	63
Nox	mg/m^3	148.48	3.76	n.d.	n.d.	n.d.	n.d.	76.12	300
HF	mg/m^3	n.d.	n.d.	4.40	n.d.	n.d.	n.d.	4.40	5
HCl	mg/m^3	4.98	238.15	108.82	n.d.	n.d.	n.d.	117.32	15
PCDF	mg/m^3	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d	0.00000015
PCDD	mg/m^3	n.d.	n.d.	n.d.	0.000035	0.000003	n.d.	0.0000190	0.00000015
Total HC	mg/m^3	58.92	420.80	5.67	5.74	12.44	12.21	85.96	-
Pb	mg/m^3	0.07284	0.40730	0.29135	0.43123	0.09360	1.26040	0.42695	0.7
Cu	mg/m^3	0.00525	0.01467	0.01102	0.03799	0.00680	0.12030	0.03267	0.7

		Run-1, MSW, 17/Jun/92	Run-2, MSW, 17/Sept./92	Run-3, MSW, 23/Sept./92	Run-5, MSW, 12/Nov./92	Run-7, MSW, 19/Nov./92	Run-12, MSW, 07/Dec./92	Mean value	Emission limit
Cr	mg/m^3	0.00063	1.26400	2.32854	0.01372	0.02930	0.01890	0.60918	0.7
Mg	mg/m^3	0.0007051	0.0388000	0.3198290	0.0093210	n.d.	0.0083460	0.07540	0.7
Ni	mg/m^3	0.0003234	2.5210000	1.9619400	0.0077383	0.0147900	0.0046900	0.75175	0.7
As	mg/m^3	0.0004400	0.0001000	0.0002116	0.0007035	0.0002250	0.0010400	0.00045	0.7
Cd	mg/m^3	0.0003205	0.0315980	0.0046200	0.0256770	0.0115700	0.0162000	0.01500	0.07
Hg	mg/m^3	n.d.	0.0022500	0.0014560	0.0043967	n.d.	n.d.	0.00270	0.07
Sn	mg/m^3	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d	0.7
Ag	mg/m^3	0.0000799	0.0013000	0.0009734	0.0028139	n.d.	0.0039900	0.00183	-
Fe	mg/m^3	0.0423980	6.0800	10.9807	0.3381977	0.17727	0.3460	2.99409	-

n.d.: not detected

Possibility of converting this incinerator into a medical waste incinerator was once examined by the DGSU in beginning of the 1980's. The conversion was, however, judged to be unfeasible in view of limited modifiable functions and performance expected of the units.

b. Composting

Only one composting facility currently operated by the DGSU is a windrow compost plant with 18,000m^3/year processing capacity. It currently produces limited output of 2,300m^3/year compost exclusively from gardening wastes (e.g., pruned tree branches and grasses) brought from GDF's public park maintenance.

This facility carries out composting quality control based on the values recommended by the Compost Counseling in Texas, since norms or standards on compost are not established in Mexico today. Compost sample from this facility are monthly sent to the Compost Counseling in Texas for analyses.

Carbon/Nitrogen (C/N) ratio of the compost products ranges 20 to 30. Animal manure are proportioned to the garden wastes to adjust nitrogen contents. Experiments of animal carcass decomposition in garden wastes composting have achieved appreciable results.

A municipal SW composting facility (nominal capacity 750 ton/day windrow system) was once operated in the SJA site adjacent to the incinerator, which was dismantled in 1993. The manual sorting lines on the facility intake were not dismantled but modified as a part of the material recovery lines of the currently operated S/P.

This composting facility, constructed by a Swiss company (Buheler Miag), employed the system of:

- mixed municipal wastes feeding.
- magnetic sorting (ferrous material removal).
- recyclable material manual sorting.
- composting the residues.

However, the compost products contained substantial amount of glass and plastics, and as a result, did not achieve quality required for marketable fertilizer.

Consequently it only had an use of soil conditioner in the public parks and green areas.

c. Selection Plants (S/Ps)

Three S/Ps are currently operated for recovering recyclable materials from mixed municipal wastes. Outline of the S/Ps are shown in Table 4-13. A weighbridge is installed at the Bordo Poniente S/P and the SJA S/P respectively. The Santa Catarina S/P is not equipped with a weighbridge, its waste flow amounts (at entrance and exit) are derived from recorded transport trips multiplied by estimated wastes load per transport.

Table 4-13: Outline of S/P

	Bordo Poniente	San Juan de Aragon	Santa Catarina
Year of establishment	July/1994	July/1994	March/1996
Site area	9,500 m^2	8,000 m^2	5,600 m^2
Durability	15 years	15 years	15 years
Weighing system	Weighbridge	Weighbridge	Number of vehicles(not installed weighbridge)
Capacity	2,000 ton /day	2,000 ton/day	1,500 ton/day
Number of sorting line	4 lines	4 lines	3 lines
Capacity per line	500 ton/day	500 ton/day	500 ton/day
Working hour	24hours/3shifts, Monday to Friday	24hours/3shifts, Monday to Saturday	24hours/3shifts, Monday to Friday
Number of workers	400 persons (ex-waste picker from Prados de la Montana)	500 persons (ex-waste picker from Prados de la Montana)	400 persons
Labor organization	"Frente Unico de Pepenadores A.C."	"Asociacion de Selectores de Desechos Solidos de la Metropoli, A.C.	"Union de Pepenadores del DF Rafael Gutierrez Moreno, A.C."
Number of picking worker	42 persons/line	42 persons/line	62 persons/line
Recovered materials	Paper, Cardboard, Plastics, Glass, Steel sheet, aluminum, Copper, Iron, Tortilla, Junk, Mattress, Tire, Cloth	Paper, Cardboard, Plastics, Glass, Steel sheet, aluminum, Tortilla, Junk, Mattress, Tire, Cloth	Paper, Cardboard, Plastics, Glass, Steel sheet, aluminum, Copper, Iron, Tortilla, Junk, Mattress, Tire, Cloth

Initial objectives of installing these S/Ps were not only the promotion of recycling activities but also and mainly, the social welfare development (i.e., to improve working environment of waste-pickers by turning waste-pickers at open air dumping sites into recycling plant workers). The S/Ps today continue to hold the characteristics of social welfare installations.

Table 4-14 shows recovery ratios of respective plants, which are as low as 4% to 6%. Meanwhile, waste composition surveys periodically carried out by the DGSU revealed that recyclable wastes account for about 37% on average at generation sources. Reasons of low recovery rate in the S/Ps could be as follows:

- About 14% recoverable materials are beforehand collected by sweepers and crews of collection vehicles.

- Only materials with higher market values are recovered in the S/Ps (materials with less or no market values are not recovered, although they are recyclable).
- Cleaner and purer materials (less contaminated and less deformed) are targeted in recovery, therefore recovery ratio goes lower (i.e., quantitative recovery is not targeted).
- As input wastes are mixed municipal wastes, wastes fed in conveyors can easily form an inter-mingled thick layer on the sorting lines, which consequently lowers the sorting efficiency.
- Velocity of sorting line conveyors is so fast as about 20 meter/min., thus impeding appropriate recovery of materials.

In addition, working spaces of sorting areas in all three S/Ps are insufficient.

Table 4-14: Annual Recovery Amount and Ratios in 1997

Unit: ton/year

	Bordo Poniente	San Juan de Aragon	Santa Catarina	Total
Annual input amount	609,973.77	700,470.05	455,438.30	1,765,882.12
Annual recovery amount	32,040.05	30,646.21	30,169.24	92,855.50
Recovery ratio(%)	5.3	4.4	6.6	5.3

Operation and maintenance (O&M) costs of respective S/Ps in 1997 compiled by the DGSU is shown in Table 4-15. It gives the unit cost of O&M (per S/P recycled waste tonnage) of 1,126 Pesos/ton on average.

Table 4-15: Operation and Maintenance Cost in 1997

		Bordo Poniente	San Juan de Aragon	Santa Catarina	Average
Unit cost for recycling	pesos/ ton recovered	1,061	1,083	1,237	1,126
	pesos/ ton input	50.40	53.69	50.49	51.45

Sources : Costos de los Servicios Urbanos 1997, DGSU

Table 4-16 summarizes O&M costs in 1996 estimated for the respective S/Ps.

Table 4-16: Estimated Operation and Maintenance Cost in 1996

	Bordo Poniente	San Juan de Aragon	Santa Catarina	Total
Annual input amount	618,858	627,399	234,771	1,431,028
O&M cost (pesos)	22,020,077	25,232,160	6,145,062	53,407,299
Unit cost (pesos/ ton input)	35.60	40.22	26.17	(Ave.) 36.06

Sources : Dereccion Construccion y Mantenimiwnto Subdireccion de Mantenimento de Instalaciones y Equipo Plantas de Selection y Aprovechamento de Residous Solidos Costos de Operacion y Mantenimiento Ejercicio 1996 DGSU

4.3.4 Street Sweeping System

As for street sweeping in the DF, the DGSU is in charge of trunk roads sweeping, in which mechanical sweepers and manual sweeping are mainly employed. Each delegation is in charge of secondary roads, where manual sweeping is dominant.

Cleansing of public parks and green areas is mainly managed by the delegations and partly by the DGSU, where manual cleansing and sweeping are employed.

Table 4-17: Street Sweeping Waste Generation Amount

Delegation	Daily sweeping length (km/day)	Street sweeping waste amount (kg/day)
Alvaro Obregon	88.95	11,166
Azcapotzalco	49.03	6,155
Benito Juarez	84.76	10,640
Coyoacan	75.30	9,452
Cuajimalpa	27.59	3,463
Cuauhtemoc	102.66	12,887
Gustavo A.Madero	245.85	30,862
Iztacalco	81.89	10,280
Iztapalapa	136.20	17,097
M.Contreras	27.30	3,427
Miguel Hidalgo	159.17	19,981
Milpa Alta	24.84	3,118
Tlahuac	51.72	6,492
Tlalpan	0.00	0
V.Carranza	69.30	8,699
Xochimilco	48.84	6,131
Total	1,273.40	159,850

Source: Estudio Preparatorio sobre el Manejo de los Residuos Sólidos para la Ciudad de México "Anexo J-1"

Table 4-18: Waste Generation Amount from Green Area

Delegation	Area (m^2)	Waste generation amount (kg/day)
Alvaro Obregon	792,000	7,865
Azcapotzalco	492,000	4,886
Benito Juarez	1,083,000	10,754
Coyoacan	868,000	8,619
Cuajimalpa	86,000	854
Cuauhtemoc	680,000	6,752
Gustavo A.Madero	4,155,000	41,259
Iztacalco	670,000	6,653
Iztapalapa	874,000	8,679
M.Contreras	115,000	1,142
Miguel Hidalgo	7,069,000	70,195
Milpa Alta	78,000	775
Tlahuac	148,000	1,470
Tlalpan	3,232,000	32,094
V.Carranza	766,000	7,606
Xochimilco	172,000	1,708
Total	21,280,000	211,310

Source: Estudio Preparatorio sobre el Manejo de los Residuos Sólidos para la Ciudad de México "Anexo J-1"

4.3.5 Final Disposal System

4.3.5.1 General Site Condition

The existing final disposal sites for the DF are Santa Catarina (SC) and Bordo Poniente Etapa IV (BP IV). SC is located at about 16 km from the DGSU office on the Mexico-Puebla highway. BP IV is located about 4 km north-east of Mexico city international airport.

4.3.5.2 Geological Condition

BP IV is located on the Texcoco ex-lake area, where an underground aquifer is highly saline and not-suited for drinking purposes. Which has a comparative advantage than any other locations that stands on a potable aquifer.

Meanwhile BP IV stands on very soft, highly compressible, clayey layers of about 60 meters thickness. It implies that if landfill is embanked in a thick layer in one operation in a short period, landslide and/or slope failure will easily take place. Therefore, the following are principally required in order to maintain safe operation of solid waste landfill on such a soft and compressible ground:

- thinner landfilling operation.
- time passage for stable ground subsidence and consolidation.

SC is located on the outer slope of an ex-volcano caldera. Although major groundwater exploitation is not exercised near the SC site today, it is a disadvantage of SC site that it stands near on a water aquifer from which potable water is currently taken.

4.3.5.3 Landfill Structure

a. Bordo Poniente Etapa IV (BP IV) Site

BP IV employs the bottom impermeabilization with single high-density-polyethylene (HDPE) membrane (1.0 mm thick) sheet. The membrane is anchored in the edge of the surrounding road (see Figure 4-8).

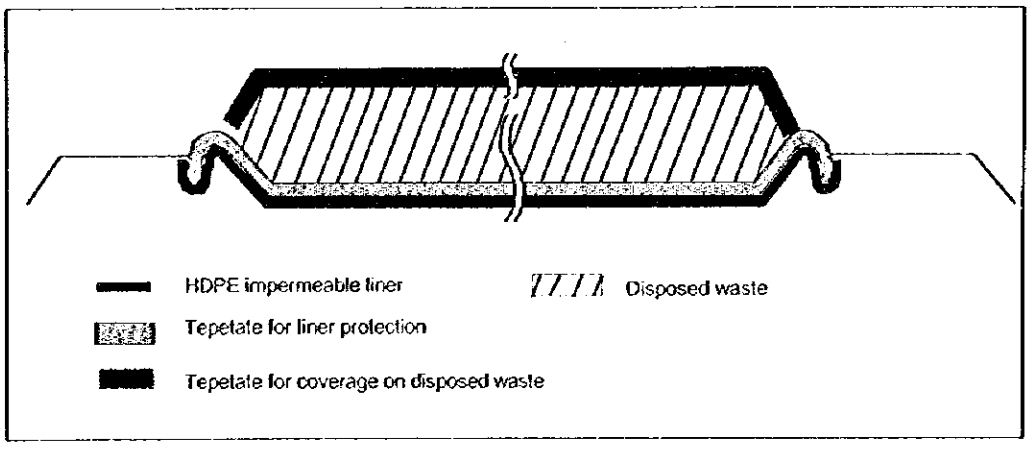


Figure 4-8: Landfill Structure of Bordo Poniente Etapa IV

The soil called "tepetate", which is basically clayey silts materials, is spread and compacted over the membrane for preventing a damage on the membrane by landfilling operation.

Once SW are disposed up to the same level of surrounding embankment road, the cell receives materials suited for large trailers' traffic (e.g., construction debris). From that level, waste are disposed of, compacted and shaped to the design level (i.e. 8 meter high) at once and receive the final soil (tepetate) cover of 30 cm thickness.

Although BP IV employs the bottom impermeable liner, it does not yet employ leachate collection piping system. At present, leachate is seeping out at cells' slope bottom on to the surrounding road. **It creates a problem of operation today and the near future that the road condition is being deteriorated especially when it rains.**

The BP IV landfill structure will start to install biogas removal facilities (e.g. chimneys) in 1998.

b. Santa Catarina (SC) Site

SC initially did not employ the bottom impermeable liner. In the beginning of year 1997, when the landfill level was raised to reach to the road under which water main pipe is located, SC landfill employed the following for impermeabilization:

- mortar spray on the hill slopes and synthetic impermeable layer on the roads.
- single HDPE membrane (1.0 mm thick) sheet on the mortar-lined slope.

The waste is carefully dozed toward the slope liner when the landfill face is vertically raised.

SC employs leachate collection piping system for the upper part where the impermeable liner is installed. The leachate collected through the piping is impounded at the 2 Nos. of leachate storage lagoons. Leachate in the lagoons are transported to the evaporation lagoon in BP by cistern trucks.

SC employs biogas removal facilities (i.e. chimneys) which are 104 in total today (1997) the internal is about 50 meter to each other in the area of about 15 ha (i.e., about 7 chimneys per hectare). The depth of biogas removal chimneys varies from 25 meters to 33 meter.

Figure 4-9 below (not to the scale) shows a general view of SC landfill structure.

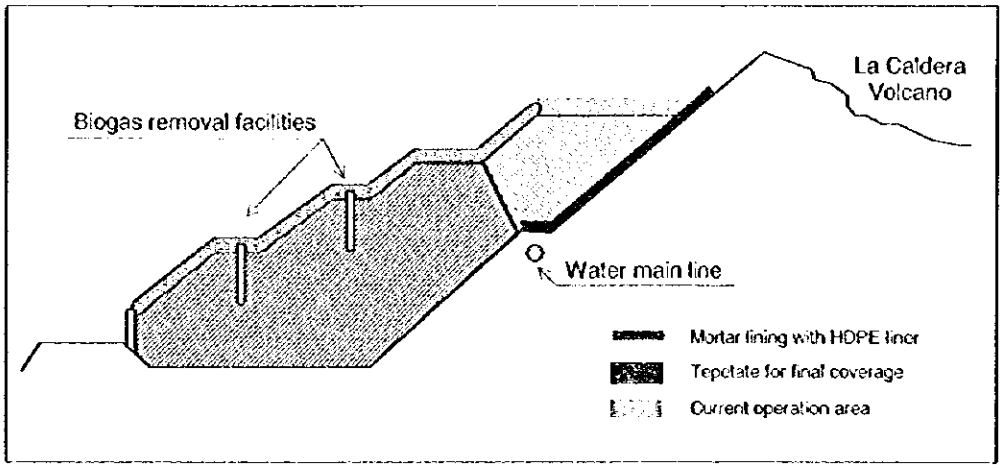


Figure 4-9: Landfill Structure of Santa Catarina Site

Table 4-19 below summarized the landfill structure of BP IV and SC.

Table 4-19: Landfill Structure of BP IV and SC.

Item	BP IV	SC
Bottom impermeable liner	HDPE liner (1.0 mm thick)	Mortar lining and HDPE liner (1.0 mm thick) for upper slope only
Leachate collection system	No yet	Yes (partly)
Leachate treatment system	Transport to BP evaporation lagoon by cistern trucks	Transport to BP evaporation lagoon by cistern trucks
Biogas removal facility	No yet	Yes
Top liner	Not planned	20 cm vegetation soil layer on 30 cm tepetate layer

4.3.5.4 Landfilling Operation

Both BP IV and SC are currently applying bulldozers for waste accumulation and compaction. BP IV operates 24 hours continuous operation. Meanwhile SC operates from 6:30 a.m. to 6:30 p.m. from Monday to Friday and 6:30 a.m. to 2:00 p.m. on Saturdays (6 days a week). It is estimated that BP IV and SC daily receives about 9,000 tons and 2,000 tons respectively.

Table 4-20: Landfilling Operation of BP IV and SC

Item	BP IV	SC
Working hours	24 hours	12 hours
Working days	7 days a week	6 days a week
Working equipment	Bulldozer 12 Nos. Vibro-Compactor 3 Nos. Backhoe 1 No. Pay Loader 3 Nos. Dump Truck 12 Nos.	Bulldozer 3 Nos. (D8N) Motorgrader 1 No. (12-G) Vibro-compactor 1 No. (CA-25) Dump truck 3 Nos. ($12m^3$)
Weighbridge control	Yes	No
Daily disposal volume	about 9,000 ton/day	about 2,000 ton/day
Working cell size	• Rainy season "80m x 750m" to "100m x 500"m • Dry season "230m x 400m" to "250m x 800"m	Basically whole area of about 5 ha

Item	BP IV	SC
Daily soil coverage	about 1,200 m^3/day Basic practices	about 340 m^3/day Not sufficient
Items of Contract-out	all items	all items

One of the most important practices of landfilling operation is the daily soil coverage. Both BP IV and SC employs tepetate, but the two sites are different in the intensity of the soil coverage practices.

a. Bordo Poniente Etapa IV (BP IV) Site

In theory, landfill operation should employ "daily soil coverage", which means waste disposed should be covered with soil daily either it is on a working face or on a final shaping of a cell.

- It must be a matter of course that final shaping of a cell receives the soil coverage. However,
- Although daily cover must be performed theoretically over the dumping areas after every journey in order to reduce the adverse effects caused by uncovered solid waste until final disposal activities re-start, in the BP IV case, it is convenient to analyze and determine the real need for such practice on dumping areas of cells which operate continuously 24 hours a day.

In view of the above discussion, it can be evaluated that BP IV in general achieves appropriate operation practices of soil cover on waste.

b. Santa Catarina (SC) Site

Meanwhile, SC disposal site still today admits material recovery by waste pickers group on its landfill area, which impinges on practices of daily soil coverage on disposed waste. Consequently, disease vectors such as flies and mosquitoes are observed and furious odors are evident on the working cells in SC.

Since SC site has slope impermeabilization, the waste is carefully dozed toward the slope liner when the landfill face is vertically raised.

4.3.5.5 Landfill Management

Landfill management can normally be referred to the management for **mitigating** negative environmental impacts of landfill (e.g., hygiene and safety control for people related to the landfill site, or such as leachate/biogas/odor management etc.). However, in addition to the mitigation management, there are **precautious** ways of the landfill management, for example environmental monitoring (of air, ground and surface water, landfill subsidence), and there are also **active** ways of landfill management in view of: long term effect of disposed waste; and future reuse of the sites.

Therefore, the current landfill management of BP IV and SC will be diagnosed herewith by categorizing into the following 3 categories.

a. Mitigation Management
b. Precaution Management
c. Active Management

a. Mitigation Management

Mitigation management of the final disposal system can be referred to:

- Hygiene control and Safety control (incl. Waste-pickers control).
- Leachate management (incl. Surface water control).
- Biogas management.
- Odor management.

Table 4-21: Landfill Mitigation Management of BP IV and SC

Item	BP IV	SC
Hygiene control	OK	Need to be improved
Safety control	OK	Rooms for improvement
Leachate management	Need to be improved	only partial
Surface water management	Rooms for improvement (e.g., road condition)	appropriate
Biogas management	No yet	Yes
Odor management	appropriate (with soil coverage and buffer zone)	Need to be improved

b. Precautious Management

As for precaution measures of final disposal system, BP IV employs groundwater monitoring (piezo-meters, periodical sampling and laboratory analysis of leachate), and ground movement monitoring.

SC has 27 pits to monitor the travel of biogas to the surrounding areas.

Table 4-22: Landfill Precautious Management of BP IV and SC

Item	BP IV	SC
Groundwater monitoring	OK	No*
Ground movement monitoring	OK	No*
Leachate analysis	OK	OK
Biogas travel monitoring	No	Yes

* The monitoring is not done by the DGSU but done by Comisión Estatal de Aguas y Saneamiento de Estado de México (CEAS).

c. Active Management

When viewing an objective of stabilizing the disposed waste, "active management" can be referred to several measures of facilitating the decomposition of the waste disposed.

c.1 Leachate Recirculation

An easy, not-costly and effective method for treatment of leachate is to collect and recirculate the leachate through the landfill. During the early stages of landfill operation the leachate will contain significant amounts of TDS, BOD_5, COD, nutrients, and heavy metals. When the leachate is recirculated, the constituents are attenuated by the biological activity and by other chemical and physical reactions occurring within the landfill. For example, the simple organic acids present in the leachate will be converted to CH_4 and CO_2 because of the rise in pH within the

landfill. An additional benefit of leachate recycling is the recovery of landfill gas containing CH_4.

Therefore, leachate recirculation is recommended for BP IV. Meanwhile, since most part of SC does not have bottom impermeable liner, applicability of leachate recirculation for SC site should carefully be examined in terms of whether the SC landfill structure permits leachate to be pumped-up from the interior of landfill and to be poured on the surface part of SC.

Table 4-23: Landfill Active Management of BP IV and SC

Item	BP IV	SC
Leachate re-circulation	Not yet practiced, but recommended.	Not yet practiced. Its applicability to be investigated.

4.3.6 Hospital Waste Management

a. General Aspects

The Institute of Health Services at the DF, together with the GDF, started the elaboration of a systematical program to manage adequately and appropriately the wastes.

Consequently, the collection and disposal of infectious-biological and pathological wastes were given in concession to the private sector. The infectious-biological wastes undergo chemical treatment or sterilization in special places as autoclave and it is sent subsequently to municipal final disposal sites. The original quantity of wastes from hospitals will increase in a 10% when they are finally disposed; this is due to the chemicals that are added to the processes and treatments. On the other hand, the pathological wastes are incinerated and the remnants are hauled to the municipal final disposal sites. The costs of incineration are approximately 4 Pesos/kg (excluding collection services).

The treatment and disposal of the wastes from the hospital are done currently according to the existing norms. On the other hand, it is known that this norm could be modified in 1999. Therefore, a generator of hospital wastes which produces 1 kg/day will be able to perform an adequate treatment, such as the incineration in situ.

b. Regulatory Framework

Infectious-Biological Wastes (IBR), which are generated in health centers (hospital wastes) are considered by the Mexican Official Norms as hazardous. In view of this, all the regulating laws within the juridical framework for the management of hazardous wastes are applicable to them. Likewise, these exists a set of laws specifically applicable to them.

Table 4-24 describes the hierarchical structure of the regulatory framework that is applied in Mexico to the management of the biological-infectious wastes, as well as the federal offices responsible to enforce them.

Table 4-24: Juridical Hierarchy of the Environmental Regulatory Framework for Hazardous Wastes

Legal or Normative Official Ordinance	Responsible Entity within the Federal Executive Office
Political Constitution of the Mexican United States	Secretary of the Government (Governor)
Ecological Equilibrium and Environmental Protection Law (LGEEPA)	Secretary of Environment, Natural Resources, and Fisheries (SEMARNAP)
Regulations of the "LGEEPA", for Controlling Hazardous Wastes	SEMARNAP
Regulations for the Terrestrial Transport of Hazardous Wastes	Secretary of Transport and Communications (SCT)
Mexican Official Norms for Hazardous Wastes	SEMARNAP
Mexican Official Norms for the Hazardous-Infectious-Biological Wastes	SEMARNAP, SCT, Secretary of Health (SS), Secretary of Work and Social Prevision (STPS).

COMMENTS:

1. In general, the Mexican Official Norms are derived and must be structured according with the General Law of Meteorology and Normalization. The Secretary of Commerce and Industrial Foment (SECOFI) is the federal office in charge of their application.
2. The formulation, publication, and enforcement of the Mexican Official Norms depend on the Federal Executive Offices responsible of the issue being study; whenever the Regulatory Impact Assessment-RIA had already been approved by the SECOFI.
3. Other complementary legal ordinances are the General Law of Meteorology and Normalization, as well as the General Law of Health and its regulations related to the Sanitary Control for the disposal of organs, tissues, and corpses

In addition, there are resolutions and judicial decrees or decisions which include ordinances, and/ or obligations applied to hazardous wastes.

c. Generation

The quantity of solid wastes generated in a hospital unit is in function to the diverse activities that are developed within it. Consequently, it will depend on various factors; for instance, the quantity of medical services offered in the establishment of health, the degree of complexity of the medical services, the size of the medical unit, the proportion of the external patients attended, and the quantity of personnel that work in the hospital. It is not easy to establish an estimation of the quantity of wastes produced by a hospital by accounting such a big diversity of factors.

The DGSU has done some research about the generation of hospital wastes. Table 4-25 shows some of the results obtained in those investigations, regarding the generation rate of these wastes. On the other hand, Table 4-26 summarizes the number of medical institutions, beds, and employees in the DF which are factors that define the forecast of hospital waste generation. Table 4-27 shows the estimates of the generation of these wastes (in 1997).

Table 4-25: Hospital Waste Generation Ratio at the Medical Institutions in the GDF

Type of institution		unit	Generation rate	Remarks
Medical institution	Level 1	kg/consultation room/day	1.279	External consultation clinics .
	Level 2	kg/bed/day	4.730	Hospital with less than 50 beds.
	Level 3	kg/bed/day	5.390	Hospital with more than 50 beds.
Laboratory		kg/laboratory/day	6.343	
Veterinary		kg/employee/day	1.700	

Table 4-26: Number of Factors Affecting Total Waste Generation

Institution / Delegation	Medical institution			Laboratory	Veterinary
	Level 1	Level 2	Level 3	Number of Laboratory	Number of employee
	Consultation room	Bed	Bed		
Alvaro Obregon	526	286	2,413	28	63
Azcapotzalco	249	274	1,304	9	35
Benito Juarez	237	1,365	2,297	79	150
Coyoacan	321	210	403	39	85
Cuajimalpa	362	21	0	7	14
Cuauhtemoc	849	2,144	2,877	223	71
Gustavo A.Madero	620	1,991	2,381	64	116
Iztacalco	145	1,004	85	7	44
Iztapalapa	399	1,549	314	28	124
M.Contreras	199	77	200	4	15
Miguel Hidalgo	972	745	1,781	81	56
Milpa Alta	111	11	74	0	3
Tlahuac	285	308	228	0	15
Tlalpan	588	181	2,350	24	84
V.Carranza	487	304	499	28	42
Xochimilco	429	125	0	5	23
Total	6,779	10,595	17,206	626	940

Table 4-27: Daily Waste Generation Amount

Unit : kg/day

Institution / Delegation	Medical institutions				Other institutions			Total
	Level 1	Level 2	Level 3	Total	Laboratory	Veterinary	Total	
Alvaro Obregon	673	1,353	13,006	15,032	178	107	285	15,317
Azcapotzalco	318	1,296	7,029	8,643	57	60	117	8,759
Benito Juarez	303	6,456	12,381	19,140	501	255	756	19,896
Coyoacan	411	993	2,172	3,576	247	145	392	3,968
Cuajimalpa	463	99	0	562	44	24	68	631
Cuauhtemoc	1,086	10,141	15,507	26,734	1,414	121	1,535	28,269
Gustavo A.Madero	793	9,417	12,834	23,044	406	197	603	23,647
Iztacalco	185	4,749	458	5,392	44	75	119	5,511
Iztapalapa	510	7,327	1,692	9,529	178	211	388	9,918
M.Contreras	255	364	1,078	1,697	25	26	51	1,748
Miguel Hidalgo	1,243	3,524	9,600	14,366	514	95	609	14,975
Milpa Alta	142	52	399	593	0	5	5	598

Institution / Delegation	Medical institutions				Other institutions			Total
	Level 1	Level 2	Level 3	Total	Laboratory	Veterinary	Total	
Tlahuac	365	1,457	1,229	3,051	0	26	26	3,076
Tlalpan	752	856	12,667	14,275	152	143	295	14,570
V.Carranza	623	1,438	2,690	4,751	178	71	249	5,000
Xochimilco	549	591	0	1,140	32	39	71	1,211
Total	8,671	50,114	92,740	151,526	3,971	1,598	5,569	157,094

4.4 Social Aspects

4.4.1 Storage and Discharge System

a. Management of Solid Wastes at the Generation Source

In general terms, in the Federal District (and in all the country), a culture for the management of solid wastes at the generation source has not developed yet.

Solid wastes are put together in containers of various types and capacity and dumped.

Domestic storage is carried out mainly and frequently in containers (*botes*) and polyethylene bags. The containers - of different sizes and materials - are used commonly without their covers. When they carry organic wastes, they become malodor spots and if collection delays, they foster the proliferation of harmful fauna.

Regarding the storage of bigger generators, such as businesses and other services, wastes are accumulated in 200-liter *tambos* (drums). In big businesses, some materials such as cardboard boxes, packages, metal and paper among others are recovered for commercial purposes. Segregation of materials is also carried out in some offices with papers, while some hotels do so with bottles and food wastes, which are delivered to waste-pickers with no charge or part of the payment or tip for the collection service.

In middle-income houses, the increase in generation of packages and containers has caused an excessive wastes, whose volume surpasses by far the people's capacity to re-use them. On the other hand, in low-income sectors, people separate some materials when they represent a certain value in order to sell them. Because they usually have to sell them in bulk, separated materials are stored for a long time and occupy a considerable volume of space particularly in small houses.

Besides, due to the fact that there is no separation of wastes at the houses, several commercial businesses and certain health centers, the mixed wastes are dangerously managed by the collection staff and by waste-pickers at the "pre-scavenging" and segregation stages at the recovery plants.

House cleaning and inter-domestic management of solid wastes have always been socially and traditionally left in the hands of the female.

b. Emptying and Handing of the Generated Solid Wastes

Once the wastes are stored, a role of generators is limited to bringing it to a sweeper or a collecting truck; in the worst case, wastes are dumped on public road, on abandoned land, to ravines or water streams, if the collection service is not available.

In the first case, wastes are handed to a sweeper, who works for the GDF and daily sweeps the streets. The relation between the community and the sweeper is close and they trust each other, because it can have lasted for many years, and sometimes the neighbors identify him/her and allow to enter in their houses. The neighbors tip the sweeper per day or weekly. The weekly amount goes from 2 pesos to 15 pesos per house.

In the second case, neighbors bring the wastes when a collecting truck passes by two or three times a week. The relation of the neighbors with the collection team is not as close as that with the sweepers, but they still pay "tips" or "voluntary contribution". In the case of single families, the tip goes from 2 pesos to 5 pesos. When the containers are bigger, more than one or very bulky, the tips go from 6 pesos to 20 pesos.

The commercial stores bring their wastes in drums to the collecting trucks, which makes the service slow and inefficient. The trucks receive a fixed payment monthly or every 15 days, that goes from 20 pesos to 400 pesos per 15 days, and is known as *"finca"*. Its amount can be greater when there exist customary institutionalized *fincas* or establishments with greater waste production.

c. Solid Wastes Segregation Program

This pilot program that was launched in 1996 by the DGSU aims at the separation of solid wastes generated at the source into three categories: organic matter, sanitary wastes and solid recyclable elements (glass, cardboard, iron, aluminum, construction debris and others).

The program currently operated in 13 sites, among which, a DF's government building, Virreinal building and housing unit in the Cuajimalpa delegation were the first ones to have this program implemented in 1996 whereas the DGSU's headquarters, the main building of the Department of Public Safety and the Metro's (subway) Childhood Development Center were included in 1997.

Likewise, it should be mentioned that seven Childhood Development Centers were also implemented as of August 1998, which are located in the delegation Cuauhtemoc and attached to the following public bodies: the Supreme Court of Justice, the Presidency of the Republic, the Ministry of Internal Affairs (Secretaria de Gobernacion), the National Lottery, GDF, Department of Labor and Social Prevention and the National Autonomous University of Mexico (UNAM).

The population that took part directly in these 13 sites adds up to 8,500 people, distributed in 110 office areas, 34 houses and 50 preschool groups.

Table 4-28: Solid Waste Separation Program: Amount Generated During 1998[1]

Wastes	SITE								TOTAL[3]
	Unit	Housing unit	GDF Bldg. No. 1	Vice royal Bldg.	DGSU	Public Safety Bldg.	CDC Metro	7 CDC [2]	
Organic	kg	26,862	21,109	10,857	32,234	59,407	10,168	16,431	177,068
Recyclable	kg	22,290	59,307	35,427	62,320	57,609	6,779	10,083	271,815
Sanitary	kg	8,001	20,105	10,856	12,894	45,006	13,865	10,830	121,557
Total	kg	57,153	100,521	57,140	107,448	160,022	30,812	37,344	570,440
Average generation	kg/inhab. /day	0.833	0.359	0.256	0.282	0.191	0.387	0.255	
Separation efficiency		88%	92%	93%	91%	86%	100%	78%	

(1) Data projected as of the second half of September/98, based on the tendencies observed in period (January 1st - September 15th)
(2) Sites incorporated as of August 17, 1998
(3) In the period of January 1st - September 15th, a total of 384,371 kg in wastes were generated at the 13 sites.
CDC: Childhood Development Center
Source: "Programa de Separacion de Residuos Solidos, Informe de Actividades Septiembre 1998", Secretaria de Obras y Servicios GDF.

The program uses recipients, plastic bags or stick-on logos with different colors, according to the type of waste that will be stored: green for organic wastes, orange-colored for sanitary products, gray in the case of containers or logos, and transparent for recyclable products. The bags, containers and cylinders are supplied by the administration of the participating site.

The separation efficiency at the source is high: 89% at the housing and from 86% to 93% at institutional buildings (Table 4-28). The program has demonstrated the possibilities to diffuse the separation practices, to raise people's consciousness and to promote public participation.

The following objectives of this program are being achieved:

- Increase in the recycling levels.
- Sanitary collection of the wastes.
- Active participation of the community.
- Development of an ecological consciousness in the population.
- Limited decrease in the remained life span of the sanitary landfill.

It is worth mentioning that the incorporation to this program is voluntary, and the site interested in joining it should do so within the following framework:

- DGSU: It coordinates actions, informs the population, monitors, assesses and disposes of the collected waste.
- Participating site: It participates in the process, provides the materials, and prepare the central deposit.

The aforementioned hinders a better performance of the program and has an impact on current costs.

d. Other Projects to Minimize the Wastes

Only a slight part of citizens joins the ecological organizations which make efforts to promote solid wastes segregation programs. These efforts have been carried out independently and in housing units and condominiums.

In the delegation Tlahuac, specially in Villa Centroamericana and INFONAVIT Tlaxcanes housing units, garbage was separated according to the organic and inorganic parameters, so as to minimize the volume of wastes in the final disposal. With organic wastes, there was an intention to elaborate compost to be used as the soil conditioner of green areas and of the delegation. Inorganic wastes were sent to small gathering centers (centros de acopio) in order to commercialize the recovered elements.

Another effort in which private sectors has helped is the installation of gathering centers (centros de acpio) at the supermarket parking lots of Aurrera company. In this program, people bring separated wastes without receiving payment at all, but the fact of having collaborated in the environmental protection. The recovered wastes are mainly tires, glass bottles, paper and cardboard. This is one of the most enduring programs, as operated for three years. Due to the lack of diffusion, however, it has not had the expected impact. In summary, the community efforts to implement solid wastes segregation programs have not been as successful as desired due to several reasons.

Besides, the DGMA, DGSU and INARE carry out actions jointly or independently in search of the minimization and recycling of solid wastes as follows:

- The use of containers financed by France failed due to the opposition of collectors, as they could not receive tips nor separate recyclable material.
- Another effort to place containers at markets was not successful either due to a lack of participation from the public.
- The University of Mexico (UNAM) was not successful in installing containers to separate combustible and non-combustible wastes. The people did not participate.
- The INARE had a relative success in some isolated campaigns.
- A campaign to re-use glass bottles by the soft drinks manufacturers was successful at the beginning, but later it failed due to imposed problems. However, a program of returnable beer bottles was successful.

4.4.2 Collection and Haulage System

a. Sweepers

The sweeper's initial function was sweeping streets and sidewalks of secondary streets assigned by the corresponding delegation, but due to the increase in wastes to be collected and the possibility to increase their revenues, now he/she picks solid wastes of the houses door to door.

There exist sweepers on the payroll (stably hired) and temporary sweepers (hired by periods) in this activity, who are paid by the GDF and adding up to almost 8,500 workers.

Besides, it is estimated that 3,000 or more voluntary sweepers carry out this activity; they rent the garbage carts and drums in order to work. The daily average cost of this rent is approximately 20 pesos.

The sweepers on the payroll earn 2,200 pesos per month, and temporary ones 950 pesos but the volunteers have no salary.

The income obtained by each sweeper per month depends on the socio-economic level of the population attended to and is estimated as follows:

Table 4-29: The Income of Sweepers per Month

Concept	Income per month (Pesos)		
	Formal sweeper	Temporary sweeper	Volunteer sweeper
1. Salary	2,200	950	-
2. Tip or fee	1,000	1,000	1,000
3. Trading of recovered materials	600	600	600
Total	3,800	2,550	1,600

The products recovered are mainly paper, cardboard, aluminum and all types of bottles; yet *chacharas* (home utensils and appliances) represent the higher income. The segregated materials are traded at gathering centers (centros de acopio) of the *colonias* where they work.

There are other types of sweepers that work for the DGSU, through contracted enterprises, and they sweep the primary roads of the city. This personnel is not syndicated and does not belong to the formal economic structure of the workers.

b. Collectors

In order to carry out waste collection, the GDF by means of the delegations employs almost 2,500 formal truck drivers and 3,400 assistants, who belong to Section 1 of the Cleaning Union, which is affiliated to the Only one Workers' Union of the Federal District.

Apart from this formally paid staff, there are "volunteers", who do not earn a formal salary but join the collection teams; they are estimated to be about 4,000 people. These volunteers may not be included in the payroll until they work for as long period as 15 years. They are linked with the formal structure through truck drivers.

The union controls the infrastructure, human resources, organization and operation of the collection and transport system.

The collection process has the following features: the sector which will be rendered the service (in general terms, the distribution of collection trucks is based on *colonias*) is determined by the cleaning unit chief, and the collection frequency is controlled by the truck driver. Although it has been tried to improve the design of the collection routes by specifying such components as stop points and schedules, the cleaning staff comes back to the original method of ringing bells at the previous points where they have been fathering wastes since a long time, at least 15 years ago.

The truck goes over its route and the bell is rung to call the attention of neighborhood, including houses and offices. The assistant receives the wastes and takes care of the

tips left by the users. When the garbage is in a container, it is discharged to the truck, and when it is delivered in bags, he tears them off to spread the wastes on the back of the truck. Within the vehicle, the assistant sorts and separates the wastes. The segregated materials are packed in sacks and bales and placed on the sides and awning of the truck. Aesthetically speaking, the vehicle with these features does not have a good appearance.

At the end of the tour, prior to the discharge at the transfer stations, the by-products are commercialized in one of the 370 gathering centers (centros de acopio) that exist in the DF. Most of these informal places do not pay taxes and buy all types of wastes. Besides, they also commercialize the segregated materials outside the transfer stations by selling them to middlemen, the leader of *pepenadores* (waste-pickers).

This material recovery process in the collection trucks is known as *prepepena* (pre-scavenging). At this stage, the wastes are not highly polluted like those picked at the recovery plants. The most common recovered materials are cardboard, aluminum, paper, mattress, furniture, bottles and *chacharas*.

Each vehicle has a driver (as the key person, therefore he considers the truck belongs to him), one or two assistants paid by the GDF and two or three "volunteers".

The driver distributes the revenue obtained during the tour (tips or *fincas*) and by selling recovered materials: 50% is divided into equal shares among the assistants and volunteers, while the remaining 50% is for the driver.

The following table shows an estimated breakdown of the monthly revenues of the collection team members by their positions. Obviously, if the team has more assistants or volunteers, their revenues will be less.

Table 4-30: Revenues of Driver, Assistant and Volunteer

Position	Income per month (Pesos)				
	Salary	*Finca*/tip	Sales of recyclable products	Payment by sweepers	Total
1. Driver (on the payroll)	2,500	3,500	3,000	750	9,750
2. Assistant (on the payroll)	2,200	1,750	1,500	375	5,825
3. Volunteer r	-	1,750	1,500	375	3,625
				Total	**19,200**

Source: JICA study team

From this total, they pay for additional fuel to that provided by the GDF and minor repairs of the vehicle.

4.4.3 S/P Management System

a. Separation of By-Products

Since 1930 in Mexico City, recyclable by-products have been recovered from the garbage due to economic, instead of ecological, reasons. For a long time, the segregation of by-products was carried out at open dumping sites in unhealthy conditions for the selecting personnel. To cope with this situation, selection plants (S/Ps) were established and have offered better working conditions, since they are roofed facilities with infrastructure required for the selection activity, and they are also furnished with the basic sanitary facilities for workers.

Currently, the DF has three S/Ps with a total installed capacity of 5,500 ton/day.

The organization and operation of the S/Ps is carried out coordinately by the DGSU and the waste-pickers groups. Maintenance of the equipment and facilities, reception of wastes and general coordination of plants are carried out by the DGSU, whereas the selection, conditioning and trading of by-products are carried out by each selecting group (formerly known as *pepenadores*).

Both the operative and maintenance activities of the plants under the responsibility of the DGSU have been contracted with entities of the sector, which include the control of harmful fauna, maintenance of weighbridges, transportation of the waste-pickers groups' staff from the S/P to the housing units and vice versa, and the verification of vigilance services to the facilities.

There are nine small and middle private enterprises contracted for the three plants, which are in charge of the operative activities previously mentioned and employ 415 workers.

Besides, in order to give maintenance to the three S/Ps, there exists a contract with other three private companies, which employ 100 workers.

On the other hand, the DGSU has its own professional, administrative and support staff, which is in charge of the supervision of the contractors' job. The control of operative activities is done by 30 people for the three plants; the supervision of maintenance activities is conducted by other 30 people and the technical, administrative and general maintenance staff is formed of 45 persons.

b. Waste-Pickers' Social Development

The first open dumping sites appeared in the eastern and western zones of the city. The open dumping sites became job sources for hundreds of families that lived on and with the garbage. In order to facilitate their daily work, the waste-pickers placed themselves next to or even inside the dumping sites, forming squatter settlements with no drinking water, sewerage or electric power services. As a consequence, severe health, family and communal problems arose, such as promiscuity, alcoholism, prostitution and drug addictions.

Due to the magnitude of the social problems posed by open dumping sites, the authorities outlined some actions to solve them. These included the closure and sanitation of these sites, and in 1985 they started to operate the Bordo Poniente sanitary landfill.

Through the implementation of the sanitary landfill technique and the arrangement with the waste-pickers groups, it was possible to close the Milpa Alta, Bordo Xochiaca, Tlalpan, Tlahuac, San Lorenzo and Santa Fe dumping sites.

c. Wastes Selection Plants

The sanitary operation of the landfills would implicate the absence of waste-pickers at working faces of landfills. Therefore, the city authorities proposed the installation of the S/Ps with appropriate working conditions for the waste-pickers.

The negotiations and agreements with the waste-pickers groups were reached with difficulty, and the installation of the three S/Ps (at San Juan de Aragon, Bordo Poniente and Santa Catarina) took almost ten years.

c.1 San Juan de Aragon

It has an installed capacity of 2,000 ton/day, with four sorting conveyers in two modules.

The selecting staff of this plant is approximately 500 workers, but the average number or selectors that worked per day was 458 in 1997. This personnel was distributed to three shifts (morning, evening and night shifts).

c.2 Bordo Poniente

It has an installed capacity of 2,000 ton/day, with four sorting conveyers in two modules.

The selecting staff of this plant is approximately 400 workers, but the average number of selectors that worked per day was 350 in 1997. This personnel was distributed to three eight-hour shifts (morning, evening and night shifts).

It is also reported that in seven months of 1997, 950 tons of special wastes - including hazardous wastes - were received in this plant.

c.3 Santa Catarina

It has an installed capacity of 1,500 ton/day, with three sorting conveyers and is under a process to increase its capacity by 1000 ton/day.

The selecting staff of this plant is approximately 400 workers, but the average number or selectors that worked per day was 353 in 1997. This personnel was distributed to two eight-hour shifts, yet in certain periods there was a single shift.

This plant started working in February 1996, one year and eight months after the other two plants started to work.

Apart from the group of selectors in the plant, there exists a group constituted by almost 300 waste-pickers, who separate the products at the working faces of Santa Catarina's controlled landfill. More information on by-products and on personnel attendance could not be obtained, as the leader of the waste-pickers group does not disclose it.

d. Waste-Pickers' Health Conditions

The information of the Secretariat of Health and the DGSU which was included in the 1996 document "Relevance of Municipal Solid Wastes on Public Health" records private medical consultation data, according to the reasons for consultation among the samples of solid wastes pickers in the DF.

Table 4-31 shows that respiratory infections (36.1%) and diseases derived from diarrhea (12.4%) constitute the main causes in external consultation.

Table 4-31: Private Medical Consultations for Waste-Pickers, According to the Reasons for Consultation (%) - DF 1995

Reasons for Consultation	%
Respiratory infections (*)	36.1
Diarrhea related diseases (*)	12.4
Accidents and Violence	9.3
Mycosis	3.1
Urinary tract infections	1.5
genital-urinal disorders	9.9
Parasites	10.9
Tuberculosis	2.1
Other causes	14.7
Total	100.0

Source: SSA and DGSU
(*) Selected Reasons

Regarding cholera, a report by the DGSU informs that due to the outbreak of this disease in the separators' population (waste-pickers), a study on the transmission link was carried out, which in turn showed that a cockroach (*periplaneta americana*) was the carrier of "vibrio cholera". This fact remarked the importance of controlling the harmful fauna that proliferates at the solid wastes accumulations.

The most frequent accidents are the following: wounds by sharp objects on hands, fingers and arms; and contusions and bruises both in the limbs and the head. Besides, burns and dislocations also occur.

All the plants present high concentration of suspended particles or dust. In spite of having been provided with the necessary equipment, the selectors (waste-pickers) do not want to use it.

The scarce data obtained on severe accidents at the three recovery plants show that six accidents took place in the last five years within the electromechanical maintenance personnel. No data on accidents of waste-pickers exist.

e. Selectors (Waste-Pickers) Groups

In Mexico, the hierarchical organization of the waste-pickers group dates from a long time ago, and the head of this organizations is the "leader", historically represented by deceased Rafael Gutierrez Moreno. The current waste-pickers groups or associations have followed this vertical organization scheme to different degrees.

The leader controls the trading process and also determines the distribution of the benefits derived from the functions of the S/Ps. In this distribution, the leader and the *cabos* (supervisors) take a substantial amount of the benefits.

These organizations, whose legal recognition as business associations is not defined yet, are the following:

- San Juan de Aragon: "Asociacion de Selectores de Desechos Solidos de la Metropoli, A.C.
- Bordo Poniente: "Frente Unico de Pepenadores A.C."
- Santa Catarina: "Union de Pepenadores del DF Rafael Gutierrez Moreno, A.C."

These organizations, which pretend to be associations, are not such in fact, as the segregators (waste-pickers) are not partners and the benefits are not distributed as in an normal association. It must be stressed that they are private informal enterprises, which are literally owned by the leaders and pay no taxes, nor do they pay for welfare to the personnel. Informally, however, the leaders employ medical insurance in cases of illness and accidents, for which the waste-pickers must pay 60 pesos each every six months.

The customers of the plants - middlemen between the S/Ps and the by-products' processing industries - have commercial links with the leaders. This relation goes back as far as when there existed open dumping sites. In some occasions, these links are not based on an economic theory of benefit maximization.

In San Juan de Aragon, there is only one purchaser that directly transforms the material purchased and is known as RIMEX (Reciclados Industriales de Mexico), which buys the plastics recovered at the plant.

The industries to which the by-products finally reach are both domestic and international ones. An approximate income estimated from the annual sale of by-products during 1996 is the following:

San Juan de Aragon	$11.7 million
Bordo Poniente	$25.2 million
Santa Catarina	$28.7 million

f. Benefits for Waste-Pickers

As a result of the staggering process of long negotiation with waste-pickers, the benefits and subsidies granted to the waste-pickers by the GDF have been diverse and expensive:

- Investment for the construction and installation of the three S/Ps.
- Operational expenses of the S/Ps.
- Maintenance expenses of the S/Ps.
- The GDF fostered coordination between FIVIDESU and SERVIMET (housing credit institutions) to facilitate waste-pickers the acquisition of houses. Through the FIVIDESU, two housing complexes were constructed: one in Iztapalapa (Avenida 11) and 170 houses out of 550 were endowed; the other

one was built in Tlahuac (Manuel H. Lopez Housing Complex), where 131 houses out of 204 were also endowed.

- With the assistance of the Secretariat of Public Education, 1,200 children and youngsters were registered in the surrounding educational centers of the new complexes.
- The necessary assistance was provided for those waste-pickers that chose an "indemnity", as well as the transfer to the appropriate place for the 127 families that requested so.
- Once the new families moved to the housing complexes, they received further assistance to be incorporated to the society with the help of a social worker per every ten families.
- They are assisted with transportation from their houses to the plant and vice versa.
- The DGSU helped with the loading of recovered by-products to the purchaser's vehicle.

4.5 Institutional, Organizational and Financial System

4.5.1 Institutional System for Solid Waste Management

4.5.1.1 Legislation and Regulation

In Mexico, any issue, like the one referring to environmental aspects, has the legal support given by the **Political Constitution of the Mexican United States** which establishes, in several articles, concepts related to the environment, natural resources and public health. They are listed as follows:

Article 4 establishes the right for every person to protect his/her health; it also points out that imbalance on the ecosystem should not affect the population nor individuals.

Article 24 defines that the use and exploitation of productive resources should be done by paying attention to the conservation of them and also of the environment.

Article 27 establishes the need to conserve natural resources and to pay attention to populated areas with the purpose of preserving and restoring environmental balance.

Article 73 refers to the elaboration of laws regarding the protection of the environment and the restoration of ecological balance.

Within the framework of environmental regulation in Mexico, there are instruments which allow to define criteria to differentiate hazardous waste from non-hazardous ones; as well as powers for Federal, State and Municipal governments to deal with them; and also obligations and specific precepts that are applied to hazardous wastes.

The normative perspective, the participation of a series of organizations and institutions from both the private and social sectors are shown in the following figures.

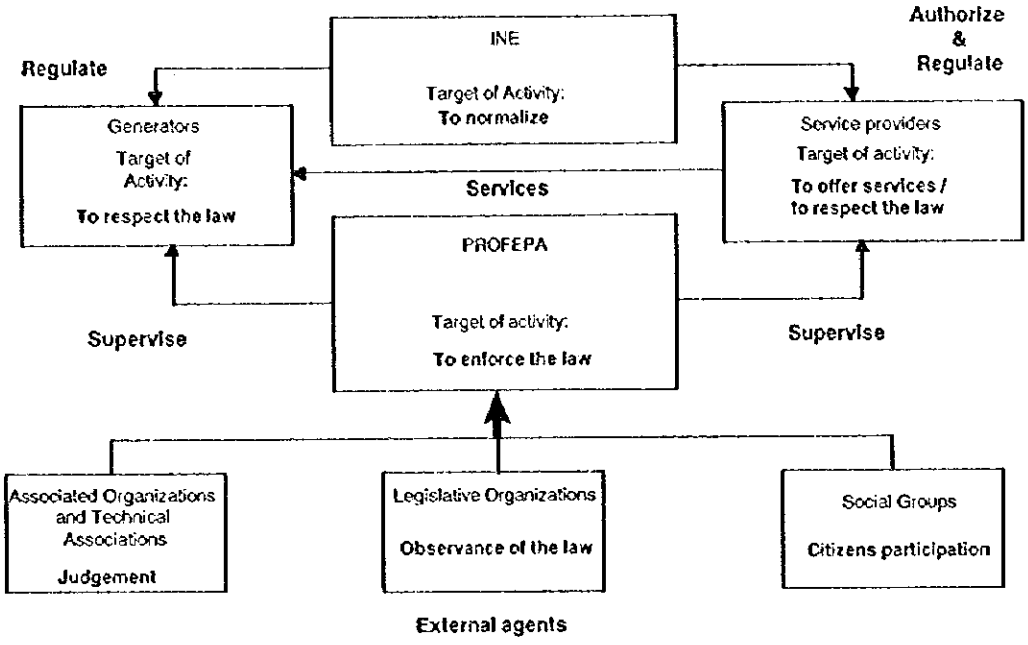


Figure 4-10: Institutional Normative Scheme Regarding Hazardous Waste Control

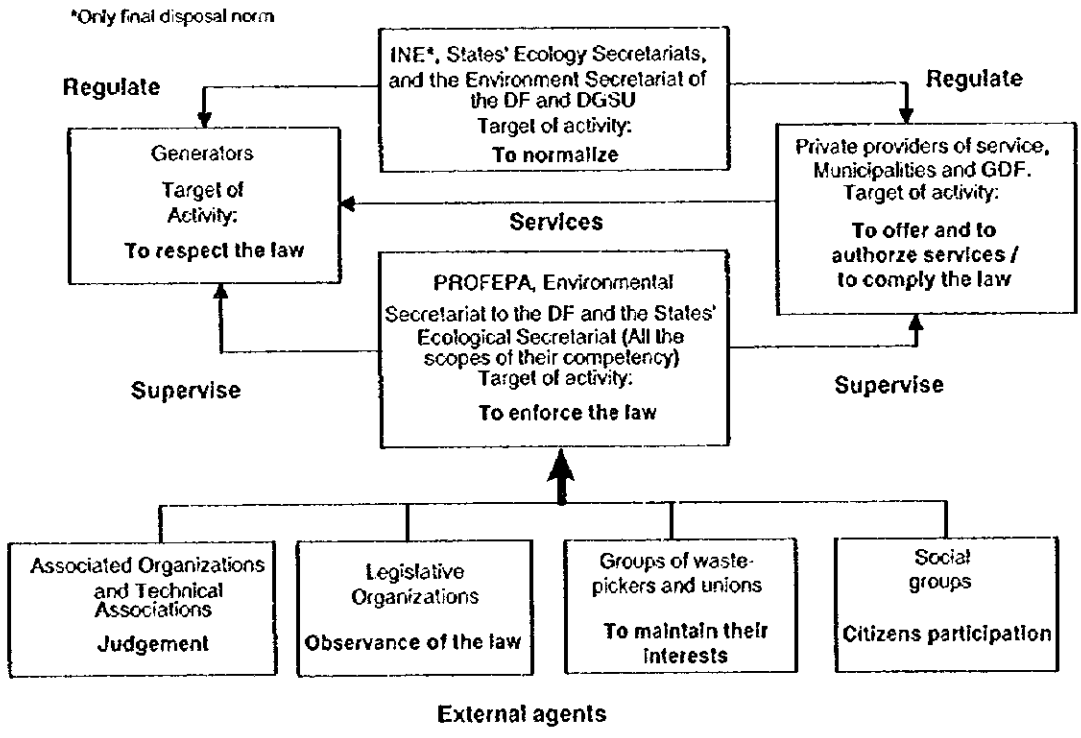


Figure 4-11: Institutional Normative Scheme Regarding Municipal Waste Control

With regards to the **Federal District** exclusively (responsibilities related to operative and regulatory matters), it is convenient to point out that the obligations and powers are granted with the different regulatory instruments to the centralized areas of public administration of the District which have some function under their responsibility.

A Coordination Agreement between the Federal Executive, Mexico State, Department of the Federal District and Semi-governmental Organizations in the energy sector was published on the **17th of September of 1996.** As a result, a **Metropolitan Environmental Commission (CAM)** was created.

This Commission is *"a coordinating organ to plan and to execute activities in the bordering co-urbanized area with the DF in order to protect the environment and the preserve and restore the ecological equilibrium"*.

Among their functions, two of them deal directly with wastes:

IX. To agree and to coordinate the adoption of joint activities which pay attention to the problems of co-urbanized areas such as waste collection, treatment and final disposal.

XI. To prepare and to propose the Metropolitan Environmental Program, as well as the Metropolitan Program for Waste.

Finally, the **Decree** which reforms the Internal Regulation of the Federal District Public Administration (published in the Official Paper of the Federation on the **1st of December 1997)** states the following authority for the **DGSU** in **Article 33,** regarding *municipal solid waste*.

- To establish, in coordination with relevant authorities, criteria and technical norms for solid waste *minimization, collection, transfer, treatment and final disposal* activities; additionally, to restore polluted sites, as well as to establish solid waste *recycling and treatment* systems;
- To undertake studies, projects and the construction, conservation and maintenance of *infrastructure works* for SWM, i.e. transfer stations, selection and re-utilization plants, as well as *final disposal sites*;
- To organize and to undertake solid waste *treatment and final disposal,* as well as the *operation of transfer stations*; and
- To receive *new works which require urban services* and that are executed by other offices, administrative units and decentralized organs of the Federal District.

4.5.1.2 Involved Entities

The participation of several Organization and Institutions from the Public, Private, Social sectors, from the normative perspective, is shown in Figure 4-10 and Figure 4-11.

The **Government Statute of the Federal District** (approved by the **Representatives Assembly in 1989)** stated that such services as below are involved:

I. Public roads street sweeping;

II. Solid waste collection; and

III. The design, instrumentation and operation of storage, haulage, reuse, treatment, and final disposal systems for those wastes.

The operation of transfer, treatment and final disposal systems is **DGSU's** responsibility. In coordination with the political delegations, DGSU is responsible for the execution of primary road network cleansing and the collection of waste accumulated in public roads.

Particularly, the **Political Delegations** are responsible for providing household waste collection service, and secondary and local roads cleansing.

From the all stated above, - regarding management of municipal solid which does not have hazardous characteristics as they are established in the Environmental Regulatory Framework on hazardous solid waste - it is clear that the power to normalize the final disposal of such waste is exercised by **SEMARNAP** through the National Institute of Ecology **(INE)** which is the organization in charge of defining the corresponding Mexican Official Norms **(NOM).**

Now, the **Secretariat of Environment** and the **DGSU** (both of them are within the GDF), as well as the Federative entities of the Mexican Republic are responsible for the norms related to the management of those wastes (excluding their final disposal), within their scope of competency.

The administrative regulation of municipal SW, including their final disposal, is the responsibility of the State Governments, and in the case of Federal District the **Secretariat of Environmental and the DGSU** are responsible for it.

The authorization of all different activities related to the *management* of those wastes in the Mexican Republic is the responsibility of the **Municipal Governments;** meanwhile, in the Federal District, this responsibility is shared by different entities as shown below:

- Waste collection to the **Political Delegations.**
- Waste transfer and treatment to the **DGSU.**
- The establishment of final disposal sites to the **Secretariat of Environment** in conjunction with the **DGSU.**

As the most important member of the Metropolitan Zone of the Mexico Valley, the DF participates and holds the first presidency of the **Metropolitan Environmental Commission (CAM)** which was created in September, 1996.

The permanent members of the Commission are the head of SEMARNAP and the Governors of the DF and the State of Mexico. **The temporally** members are the heads of the Secretariats of the Federal Government and the organizations which are part of this Commission.

The **Internal Regulation** of CAM was published on the 9th of July 1997; it states its organization and operation.

Apart from the CAM, an agreement was signed in 1998 between the GDF and the State of Mexico in order to establish a commission for the management of solid wastes in the metropolitan area.

Finally, the competency of the **Secretariat of Works and Services** regarding the control of non-hazardous municipal solid waste are summarized in the follow table.

Table 4-32: Competencies for Municipal SWM in the DF

COMPETENCIES / ACTIVITIES	WHO NORMALIZES	WHO REGULATES	WHO AUTHORIZES	WHO OPERATES	WHO SUPERVISES
SWEEPING AND CLEANSING	SMA DGSU	SMA DGSU	DELEG. DGSU	DELEG. DGSU	SMA
COLLECTION	SMA DGSU	SMA DGSU	DELEG. DGSU	DELEG. DGSU	SMA
TRANSFER	SMA DGSU	SMA DGSU	DGSU	DGSU	SMA
TREATMENT	SMA DGSU	SMA DGSU	DGSU	DGSU	SMA
FINAL DISPOSAL	INE	SMA DGSU	SMA DGSU	DGSU	SMA PROFEPA

SMA: Environmental Secretariat of the GDF.
DGSU: General Direction for Urban Services of the Works and Services Secretariat of the GDF
INE: National Institute of Ecology, SEMARNAP.
DELEG.: Political Delegations of the DF.
PROFEPA: Office of the Federal Prosecution For the Environment Protection, SEMARNAP.

The management of municipal solid wastes in Mexico city involves, in addition to traditional sweeping, collection and final disposal stages, transfer and treatment (segregation of recyclable products) of wastes. In almost all management stages, apart from the traditional procedures applied to almost the same criteria used in the world, there exists an **informal** process that is not officially recognized by the responsible authorities, while this system is somehow accepted, although sometimes its activities are regarded as irregular.

4.5.1.3 Recent Facts

During the period on which the studies for the Master Plan are being made, the GDF is developing activities in two different fields, which will have an important impact on the SWM System.

The first aspect is aimed at the creation of a **Metropolitan Commission for the Management of Wastes**, which is not related to the CAM. Final disposal of wastes from the DF and from other municipalities consisting the ZMVM is one of the objectives of this commission.

The second aspect is what has now resulted in a recent agreement reached between the GDF and Section I of the Unique Labor Union of the GDF.

4.5.2 SWM Organizational System

This system is shown in the following graphs.

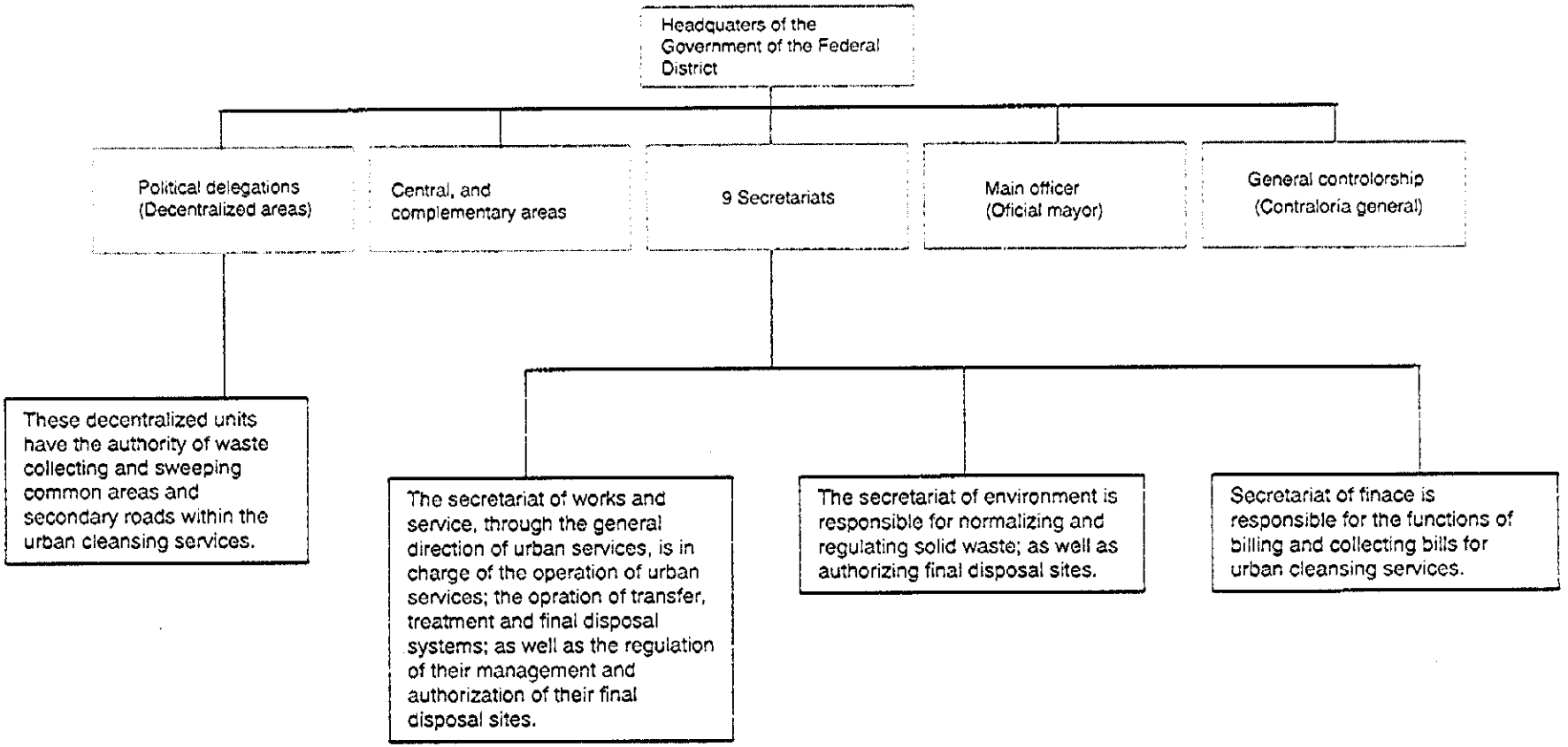


Figure 4-12: Organic Structure of GDF, Showing the Offices Responsible for SWM

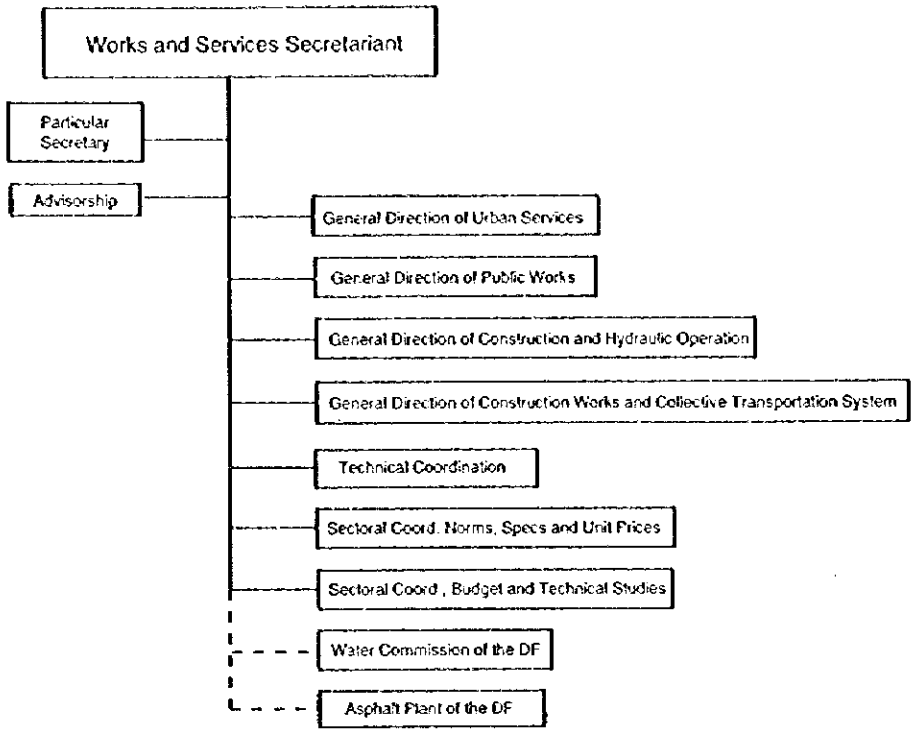


Figure 4-13: Organic Structure of Secretariat of Works and Services

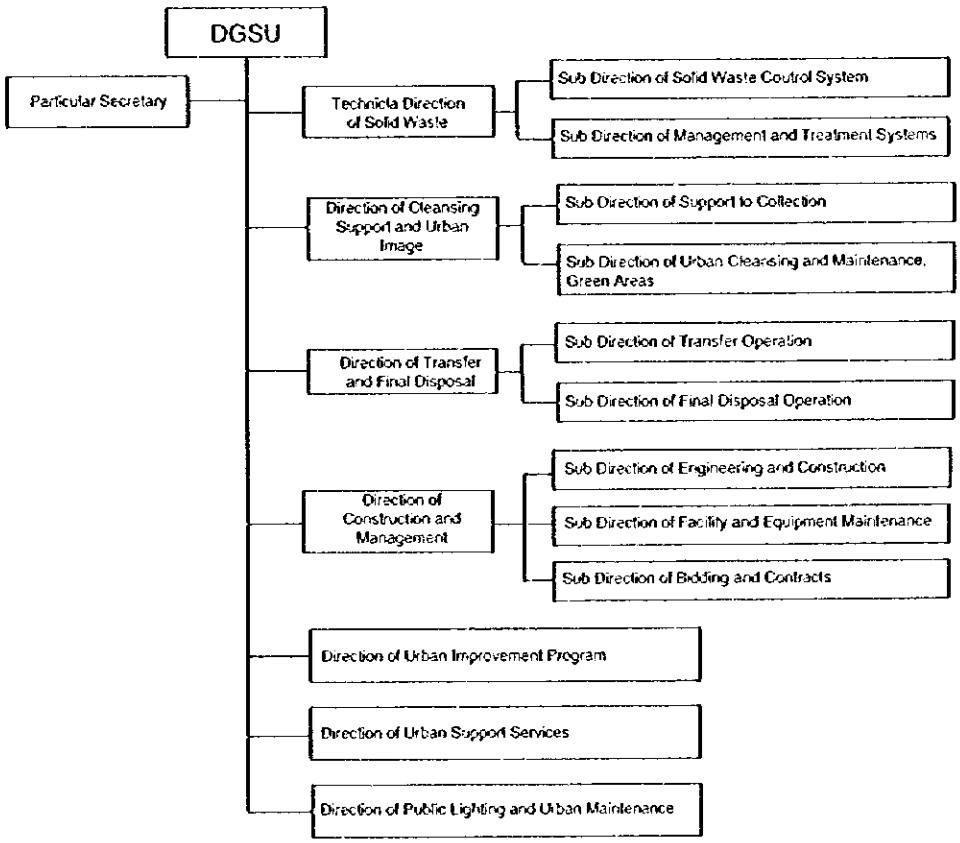


Figure 4-14: Organic Structure of DGSU

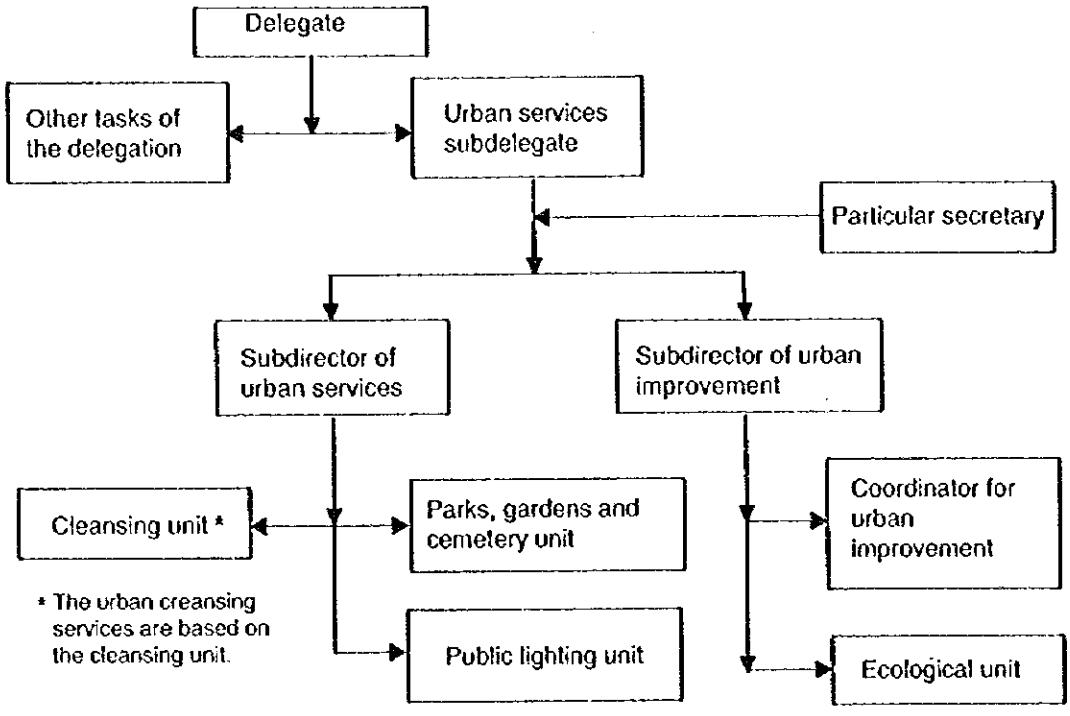


Figure 4-15: Delegations Structure: Example - Benito Juarez Delegation

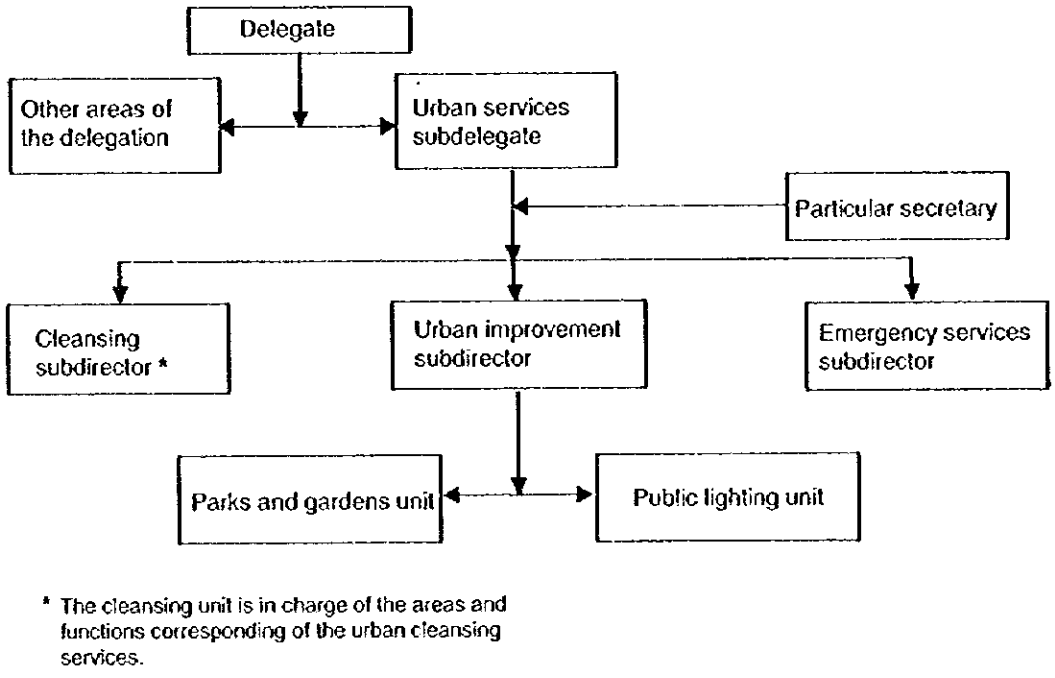
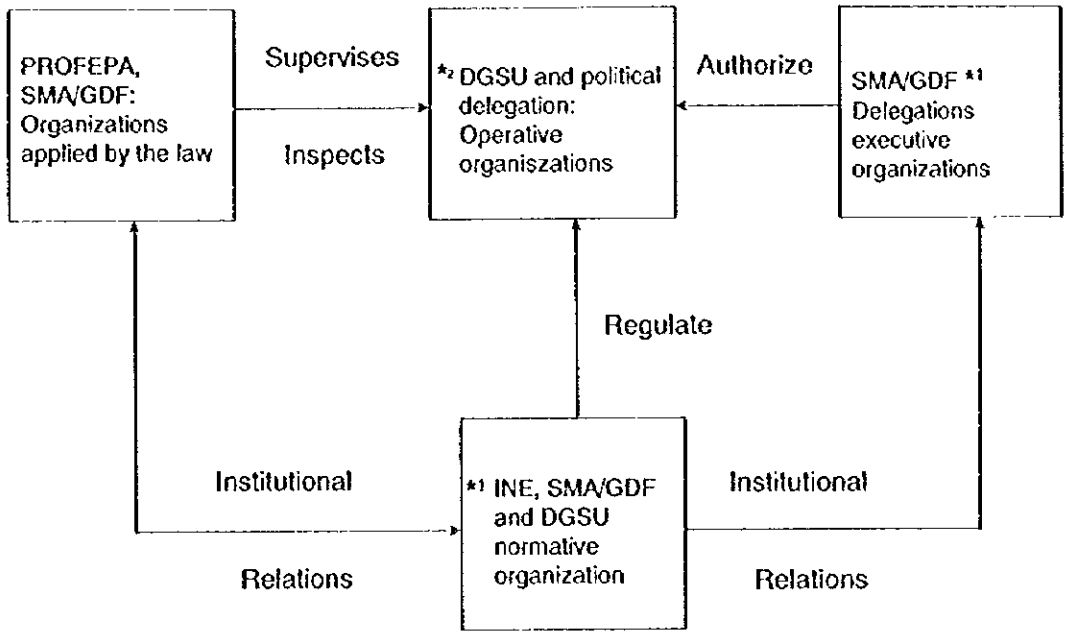


Figure 4-16: Delegations Structure: Example - Miguel Hidalgo Delegation



*1 Only in the part of final disposal
*2 Only final disposal, treatment and transfer

Figure 4-17: Functional Structure of Municipal SWM in the DF

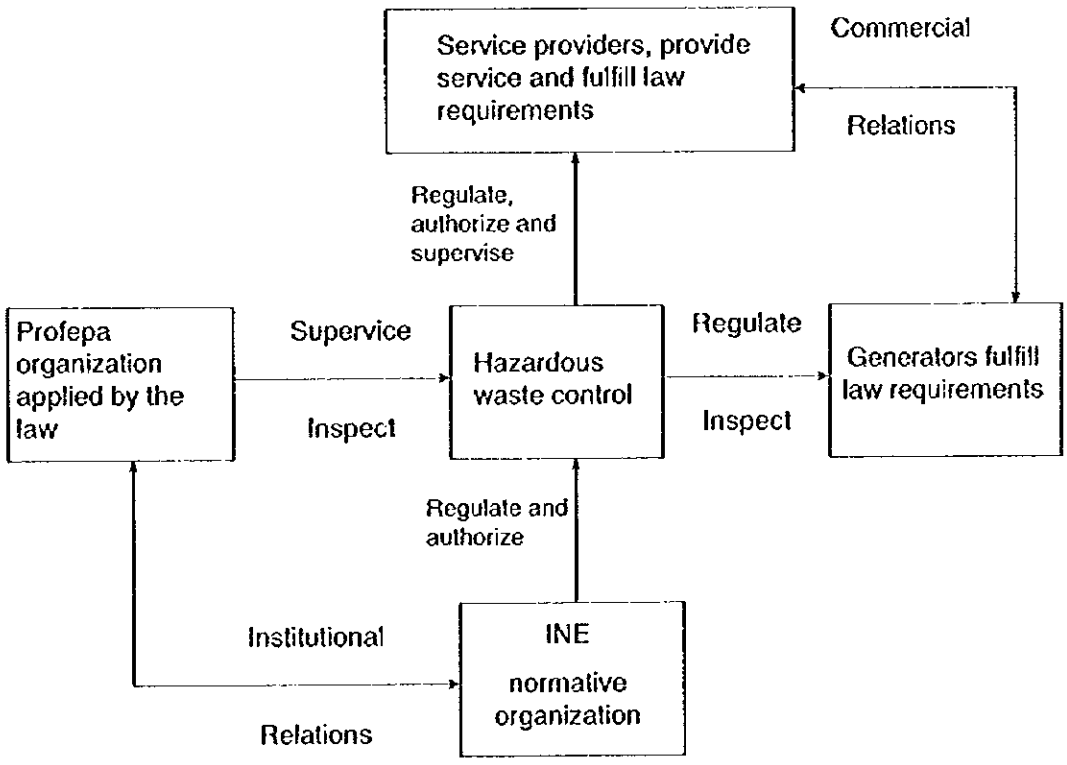
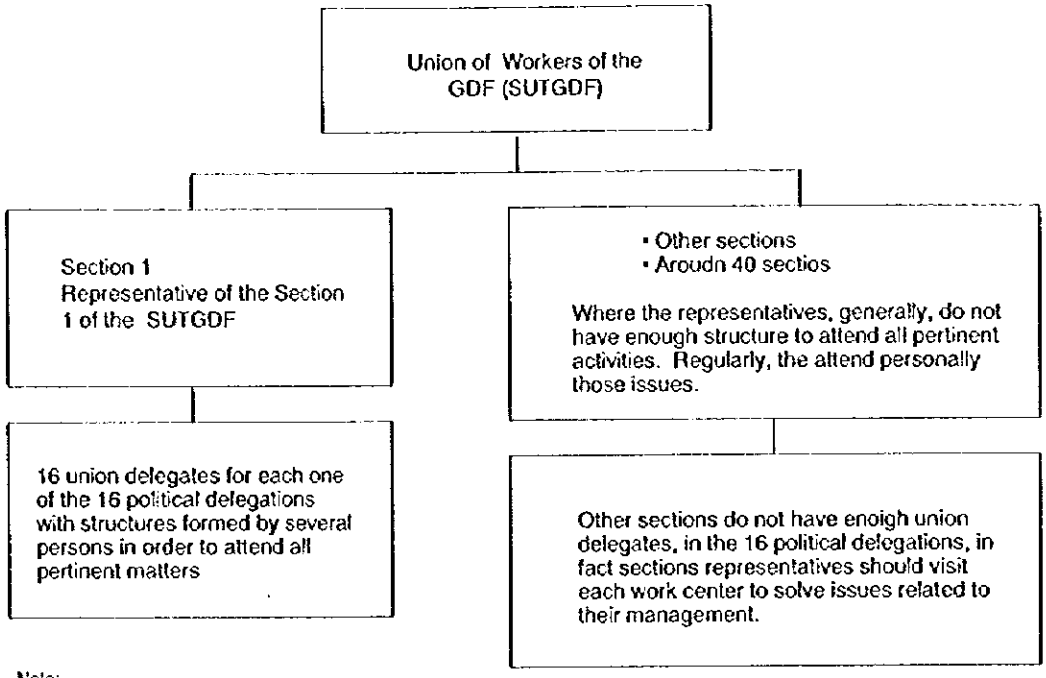


Figure 4-18: Functional Structure of Hazardous SWM in the DF



Note:
In the DGSU, there is no representative union coming from Section 1 of SUTGDF, because for the most part, based personnel (which has union support) is assigned to sections No.5, No. 10 (ECOLOGY), and No. 9 (public works), but mainly to No 8 (Public Lighting).

Figure 4-19: Summarized Structure of the Unique Labor Union in the DF Emphasizing on Section No. 1

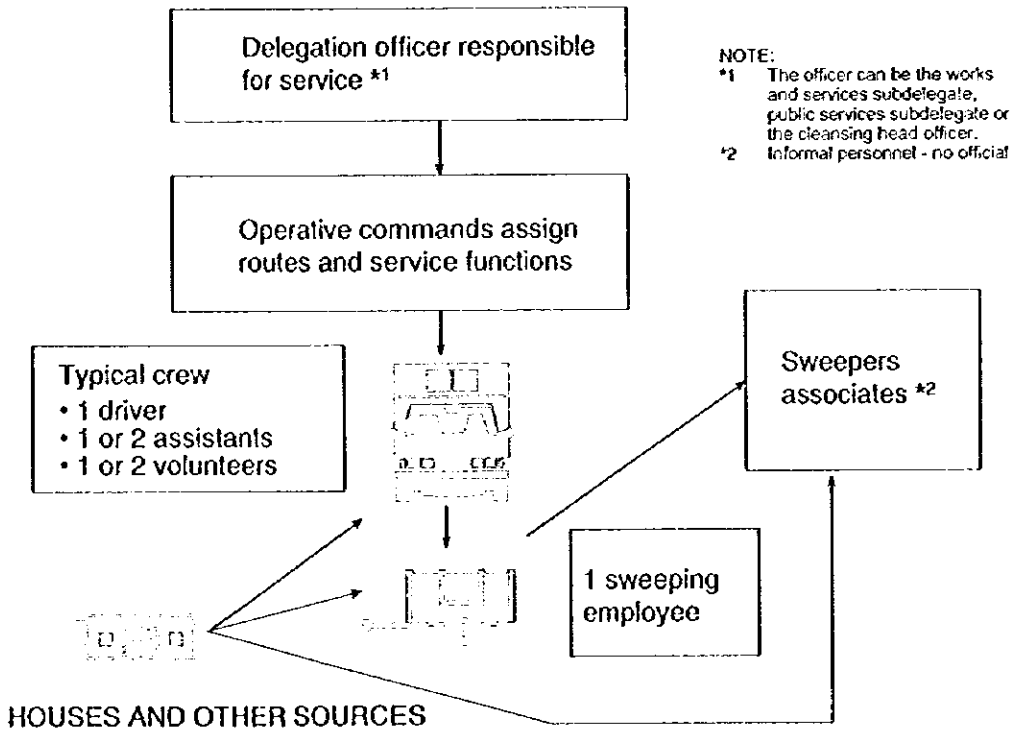


Figure 4-20: Simplified Functional Structure of Solid Waste Collection Service

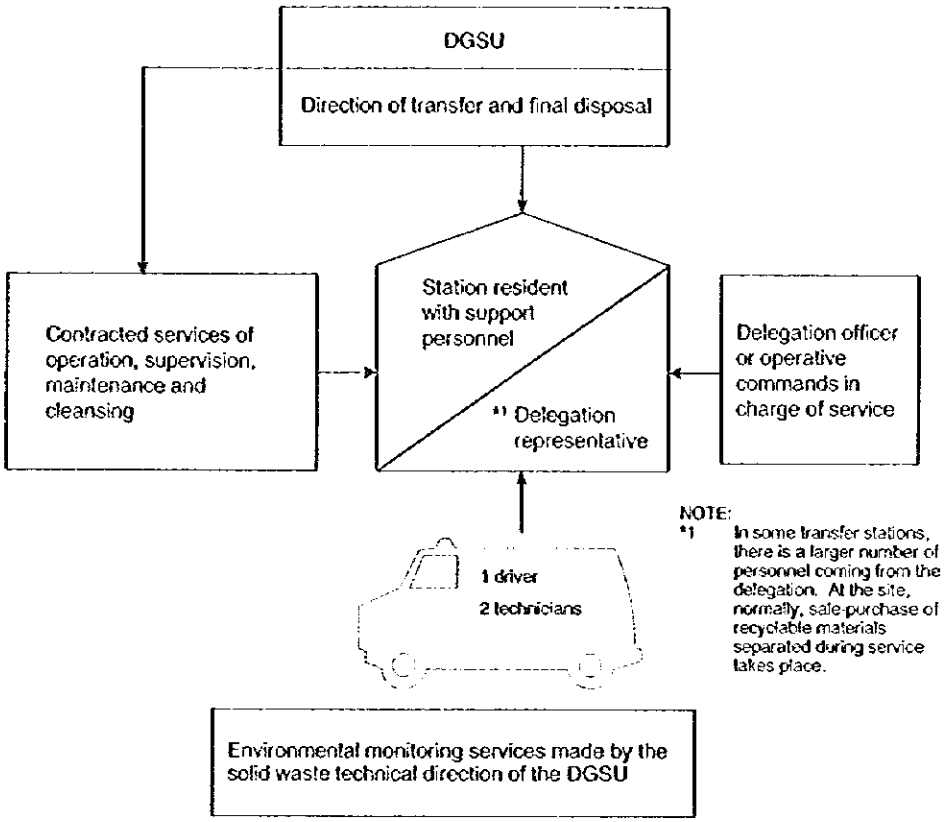


Figure 4-21: Simplified Functional Structure of a Transfer Station

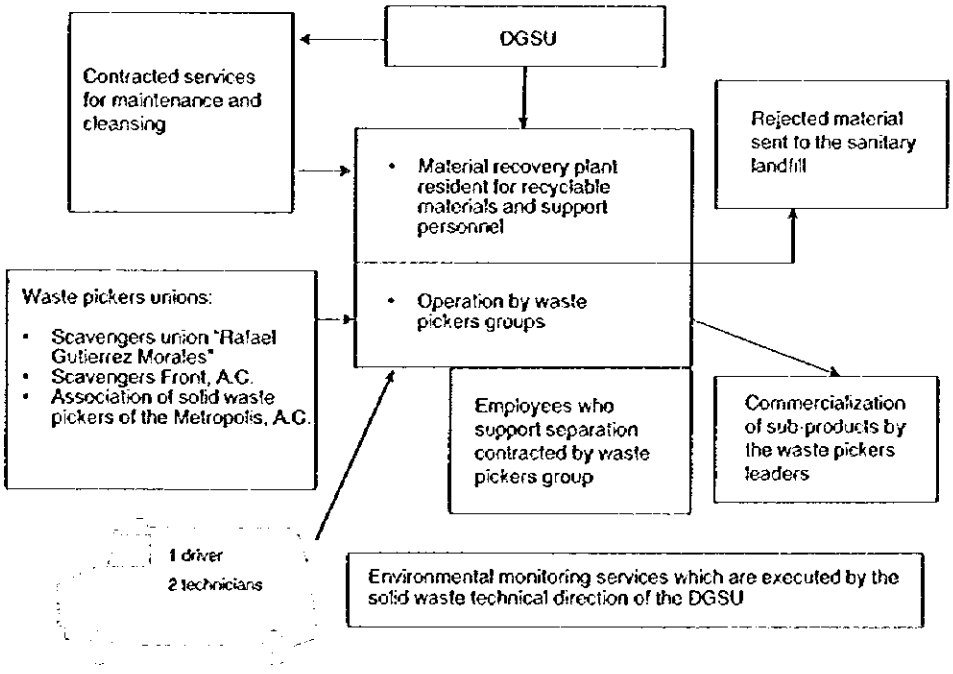


Figure 4-22: Simplified Functional Structure of a S/P

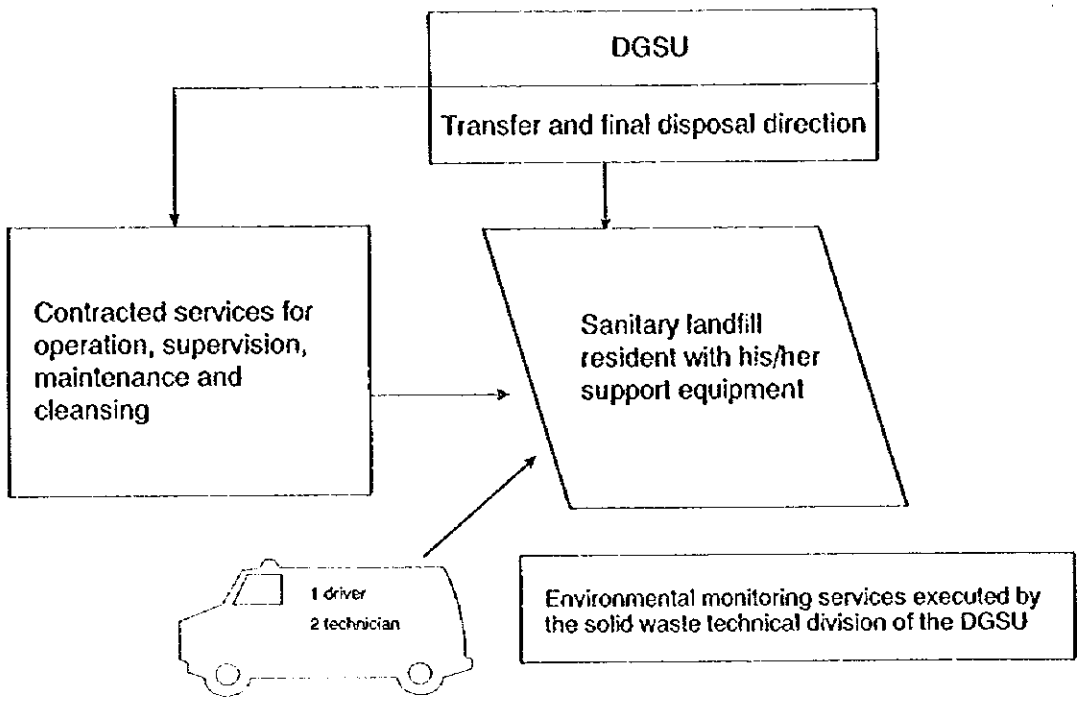


Figure 4-23: Simplified Functional Structure of Bordo Poniente Sanitary Landfill

4.5.3 Financial System

4.5.3.1 Financing Scheme

The Secretariat of Finance and Public Credit (SHCP, HACIENDA) is responsible for developing federal budget, while ensuring that investment priorities are reflected in the budgets of federal agencies, whereas the National Development Bank for Public Works and Services (BANOBRAS) functions as the major source of finance for municipal solid waste investment and technical assistance. Financial resources under the auspices of international lending agencies, inter alia, the World Bank (WB), the Inter-American Development Bank (IDB), and International Fund for Agricultural Development (IFAD), and bi-lateral aid agencies are coordinated by SHCP and distributed, in line with the National Operative Program (AOP), to each of project implementing agencies through BANOBRAS, SEDESOL, the Infrastructure Fund (FINFRA, a trust body incorporated in BANOBRAS), and Nacional Financiera (NAFIN, government-owned National Development Agency). Fiscal transactions take place through the use of fiscal resources directly channeled by SHCP to SEDESOL, SEMARNAP, and the states and municipalities in a bid to finance the "Unique Development Agreements" prepared by the State Planning Committees (COPLADES) and the Municipal Planning Committees (COPLADEMUN).

Besides, BANOBRAS' own resources are destined to the states and municipalities to carry out specific projects in villages with less than 100,000 inhabitants. Likewise, some resources are channeled to finance private concessionaires of the urban solid

waste services, while the possibility to extend these resources to some waste generators, such as hospitals, is being studied.

4.5.3.2 Financial Reporting System

The public and the government are concerned that the funds raised by taxes, fees and charges levied by governments have been used efficiently and effectively for the purposes intended. Provided that these revenues have been used for capital investment, public interest would be again concerned with the extent of their use and allocation among priorities. With this in view, the emphasis on cost concept rather than revenue of fixed assets would be more appropriate in the public sector, whereas the thrust of commercial activities in the private sector is upon revenue or profitability and overall strength of entities.

In Mexico, and many others alike, a paucity of accountability at state and municipality government levels has led to a less-managed public information system and somewhat critical public and government regarding the level of stewardship and responsibility attributed to DF, state, and municipality governments.

4.5.3.3 Public Accounting

Accounting and financial reporting system currently used by DGSU and other administrative branches under DF government is, in principle, a cash accounting system which records income (state government budget) and expenditures only when cash is received and dispensed from the special account opened at the Mexican banks. There are four kinds of accounts in place to manage and report the large quantities/value of assets and a number of money transactions of each project transactions, vis-à-vis, Cash Account (cash transaction), Store Account (quantity account), Dead Stock Account (inventories and other non-durable current assets), and Machinery and Equipment Account (fixed assets). The implication of depreciation of fixed assets is little considered.

With the issuance of Letter of Credit (L/C) to Banco de México by Secretary for Treasury and Controller, annual expenditures are confined to the maximum amount what Budget Allotment Letter defines. By way of curtailing annual expenditures of each scheme/project as the foregoing, there is no budget balances at the end of fiscal year which are carried forward as opening balances of the following year.

4.6 Assessment of the Present Condition and Confirmation of Key Issues

4.6.1 Technical System

4.6.1.1 Discharge[1] and Storage System

Mixed storage and mixed discharge are the dominant practices in the present systems. However, in order to promote "recycling activities" and "final disposal amount reduction" as key elements for resource conservation, "source separation" of wastes becomes indispensable. On the other hand in the present situation, there is no specific regulation nor guideline for this purpose oriented waste containers. Waste generators (general public and institutions) are independently use their recipients such as dust bin and plastic bag.

"Source separation" requires: people's conscience and dedication; strict observance of discharge manners; changes in discharge/storage containers; and so forth. Therefore, it takes long time to popularize the "source separation" practices until it becomes as a prevalent custom.

Introduction of a "source separation" program to the general public is planned:

- First, pilot projects should be similarly implemented to the general public.
- Second, results of the pilot projects should be analyzed to plan the introduction scheme.

and then

- The introduction scheme should be carefully planned and meticulously implemented with detailed components.

4.6.1.2 Collection and Haulage System

a. Collection System

Mixed discharged municipal wastes are collected by the present "mixed collection" system. Collection of municipal wastes is the responsibility of respective delegations. There are many places and occasions in which collection time and frequency are far from constant.

Total collection vehicles in 16 delegations are 2,011. 1,087 vehicles out of them have been used for the service more than 15 years after their purchase (The oldest in the list was purchased in 1965). Therefore, their breakdown frequency is very high and the recurrent costs on maintenance and repairs are significant.

Average trips made by the workable collection vehicles (1,434 vehicles) are about 1.7 trip/day. 10 delegations are with figures of average trips per day lower than this figure. (Table 4-7)

Such low work efficiency of vehicles will be attributable to the following:

[1] Discharge is the internal disposal of wastes after the generation and separation with recyclable materials. For the generator, this is known as rejected wastes.

- many vehicles are older and damaged in most parts, therefore the breakdown frequency is high; and
- waste-picking (material recovery) is practiced by vehicle crews on the collection routes, therefore, much time are spent on waste-picking than waste loading or vehicle movement.

For the future case of introducing "source separation" and "separate collection" instead of present "mixed discharge" and "mixed collection", it is required to review such aspects as, collection methods, types of collection vehicles, and so on.

b. Transfer Station

Incoming and outgoing wastes volumes at transfer stations are not measured but only estimated from nominal capacities of vehicles/trailers and their numbers. Therefore, the transfer station management in line with those estimated volumes has a serious self-limitation that is only within the reach of estimation. Therefore, as soon as possible, a **weighbridge** should be installed in every transfer station in order to manage it with realistic figures of volumes recorded.

Recording of incoming and outgoing wastes volumes, and operation and maintenance of respective transfer stations are contracted out to private sectors. Management reports of respective stations, submitted by the private sectors to the DGSU and/or delegations, presently do not have a standard report format. Report formats are different from each other and therefore, total monitoring and management of transfer stations are very difficult and require significant amount of laborious examination. At least from today, **a single common format for data compilation** (of incoming/outgoing amounts, O&M expenses, etc.) should be established and utilized in order to manage, review and improve the transfer station operations.

c. Transportation System

Transportation are all contracted out to private sector. The contracted service is paid based on the established rates of load weight and regulated distance (the distance from a transfer station to an S/P or a final disposal site is fixed, according to which distance the service is paid, not to the actual distance transported).

Real-time control is employed for operation of trailers through GPS apparatus. However, since actual load weight is not measured (only estimated), management of transportation efficiency is only in a range of estimation.

4.6.1.3 Processing, Treatment and Recycling System

a. Incineration

From 1990 to 1992, a pilot incineration plant for municipal SW was operated with effluent gas treatment facilities. However, required incineration performance was not obtained from the plant. The failure was mainly attributable to the fact that the plant was not designed to suit to the waste composition in Mexico, which calorific value is in a low range of 1,200 kcal/kg.

When in future an incineration plant is installed, it is required to clear the 1997 established emission norms (NOM-ECOL/95). Consequently, significantly

expensive emission treatment facilities (such as wet-type absorption and bag-filter facilities) are needed to be equipped.

b. Composting

The failure of the composting facility, which had been operated by the delegation Gustavo A. Madero since 1974 and was dismantled in 1993, might be attributable to management problems that:

- The compost was not easily commercialized because of impurities (such as glass and plastics) mixed in them.
- Low production performance of the plant was due to financial shortage of the delegation for operation and maintenance.
- Meanwhile, the technical problem of the compost product quality should be mainly because mixed municipal wastes were fed to composting processes.

Therefore, when in future a composting plant is installed, it is required to introduce and practice "**source separation**" and "**separate collection**" of organic wastes, in order not to repeat the same mistake.

c. Selection Plant (S/P)

First of all, the problem of the very low material recovery rate of the S/Ps is due to feeding **mixed municipal wastes.** In addition to that, the problem of present operation practices is very **excessive waste feeding** into the recovery lines:

- Waste layer thickness on sorting lines, a major determinant of selection efficiency, is as thick as 40 cm to 50 cm. Therefore, workers are unable to visually identify materials to be targeted in the initial moment, and have to stir and open the waste layer by hands. Consequently they loose more time for picking materials.
- Velocity of the sorting line conveyors is as fast as about 20 meter/min. Together with the above effect, the material recovery efficiency is lowered further.

The original design of S/Ps specified the optimum operation particulars as: 8 to 14 meter/min. conveyor velocity; 20 cm waste layer thickness; and 0.35 to 0.40 kg/liter weight volume ratio. However, compliance with these design particulars did not enable to keep promises of wastes input amounts (to S/Ps) with the ex-scavengers groups. Consequently conveyors velocity become about 20 meter/min and waste layer thickness about 50 cm thick respectively.

Hence, if in the future wastes input amount in the S/Ps is decreased, working condition on sorting lines will be improved and material recovery efficiency will be raised.

Besides, the Santa Catarina S/P is not equipped with a **weighbridge,** which is the problem of not understanding the precise incoming/outgoing wastes flow.

4.6.1.4 Final Disposal System

The Bordo Poniente final disposal site employs a bottom impermeable liner (HDPE, 1.0 mm thick) and devises to minimize the landfill working face. It practically realizes a sanitary landfill and therefore, operational problems are very few.

The Santa Catarina final disposal site, although having a wider landfill working face, complies with measures of sanitary landfill such as: biogas removal, final soil cover with vegetation soil layer, and leachate collection lines (partial). In practices, technical problems are few. On the other hand, present about 5 ha working face plays a role of material recovery places of waste-pickers, which is an open air, therefore, it invites vectors of flies and mosquitoes and offensive odors.

a. Service Life of Landfill Site

The municipal SW final disposal sites presently in service in DF are Santa Catarina and Bordo Poniente "Etapa IV". The Santa Catarina site is expected to be closed soon due to the very limited remaining capacity. The Bordo Poniente "Etapa IV" is estimated to serve until January or February 2001. Therefore, sites for new final disposal need to be assured soon.

Although the landfill elevation of Bordo Poniente "Etapa IV" is presently regulated up to 8 meters height under an agreement with the CNA, if this agreement is revised to allow further landfilling up to 32 meters elevation, by paying specific technical attention to the geological conditions, additional landfill capacity of about 33,000,000m^3 could be assured.

This restriction comes from several geotechnical studies carried out since the landfill started to be operated, which concluded that the 8 meters height restriction was necessary in order to protect the structures and functions of the Gran Canal nearby. Therefore, in order to revise this restriction and to secure an additional landfill capacity of about 33,000,000m^3, prudential and meticulous geological examination should be performed to prove its technical viability.

On the other hand, the additional 33,000,000m^3 landfill will correspond to 6.5 years services, and it could not cover the services until the M/P target year 2010. Therefore, apart from the Bordo Poniente Etapa IV vertical expansion project, a new future final disposal site needs to be secured.

b. Leachate Management

b.1 Leachate Collection

Although the presently operated Bordo Poniente Etapa IV landfill employs HDPE impermeable bottom liners, a leachate collection facility is not yet installed. Therefore, leachate inside the buried wastes layer is not sufficiently drained but is seeping out at cells' slope bottom on to earth-excavated roadside ditches or on to roads. The roadside leachate seepage is partially collected by cistern trucks, however its majority is infiltrating into the ground as a consequence, although the landfill is provided with bottom impermeable liners.

In order to prevent this phenomenon, leachate collection lines should be installed in the landfill layers to facilitate drainage of leachate to opt its management.

b.2 Leachate Treatment and Disposal

Current limited leachate treatment by the DGSU is by: (i) physical-chemical treatment; and (ii) evaporation pond, both of which are in the Bordo Poniente area. The former requires substantially high operation and maintenance costs, and the latter sometimes suffers from over flowing of leachate from the pond.

Average annual precipitation in Mexico city is about 600 mm/year, meanwhile annual evapotranspiration reached about 1,800 mm/year, which is about four times as much as precipitation. In general, a major factor of leachate generation is the precipitation. Where in Mexico city the evapouranspiration as high as four times of precipitation might optimize leachate circulation inside the landfill site as a cost-effective leachate treatment method, which is especially applicable to Bordo Poniente (leachate spraying on the landfill surface).

4.6.2 Institutional System

4.6.2.1 Scope of Competency

The DF is divided into 16 administrative units **(Political Delegations)** which have functions restricted by what is established on the GDF's regulations. However, these units will become autonomous; the extent of this autonomy should be established by the DF's legislation. This situation will initiate with the elections of the Federation's president and the Governor of the DF in the year 2000. The person in charge of the executive office in the Delegations will also be elected by citizens election at the same time.

The **ZMVM** or **ZMCM** is not an administrative nor political entity, but a co-urbanized area which consists of the DF and some municipalities in the State of Mexico. For coordination purposes, they jointly undertake plans, projects and integrated actions.

The municipalities co-urbanized with and adjacent to the DF were the objective of the coordination agreement signed among the DDF (currently GDF), the Government of the State of Mexico (which acted as a representative of the municipalities), and the Federal Government and semi-governmental Organizations too. As a result, an **Environmental Metropolitan Commission (CAM)** was created which has coordinating and orientation functions for plans, projects and joint actions related to the regional environment.

4.6.2.2 Legislation, Agreements and Public Entities Involved

Legal facts relevant to SWM in Mexico are shown in Annex C.

a. Federal Scope

The **agreement** signed between the former DDF with the **National Water Commission (CNA):** by means of which the DF was authorized to use 1,000 hectares located in a Federal Area where the Texcoco Lake project is being developed. This authorization allows the DF to use the facilities to treat and dispose of non-hazardous waste.

b. Metropolitan Scope

Within the Metropolitan scope, the **Environmental Metropolitan Commission (CAM)** should coordinate planning, project and execution of joint actions by the entities involved (municipalities and the DF). Furthermore, it should elaborate and propose a Metropolitan Program for Waste.

c. DF Scope

- The GDF statute has been recently issued. Due to this situation it voids some of previous precepts.
- It assigns to the central organs (such as the DGSU) planning, organizational, normative, control, evaluation and operational functions related to:
  - ♦ provision or concession of public services which provide general coverage to the city; as well as those which have inter-delegation impacts with high technical specialty.
  - ♦ determination of Delegations participation systems with respect to the provision of public services with general characteristics such as waste collection in primary roads.
- It assigns to central organs (DGSU) the provision of public services which cover the whole city or which can have a multi-delegation impacts.
- It allows attributions mentioned previously, such as those with technical-operative characteristics, to be assigned to decentralized organs which are not the Delegations.
- It assigns to the Delegations their functions established in DF Organic Law, as well as those attributed to them through an agreement with the Governor - under any hypothesis, attention should be paid to the following basic principles:
  - ♦ to provide services taking into account the particular characteristics of each Delegation.
  - ♦ to provide opinion on service concession which has effects on the Delegations.
  - ♦ to issue and to revoke licenses, permits, and authorizations.
  - ♦ to provide services executed by or affecting more than one delegation.

4.6.2.3 Other Influential Legal Norms and Practices

a. Labor Legislation

Labor legislation that rules over the GDF employees is divided into three groups. The first one works with full loyalty, is provided with highest payment and various benefits (such as bonus, gifts, medical insurance and life insurance), and is placed on trust administrative position. The second one is granted with all benefits (bonus, gifts, medical services, vocational allowance, food, coupon, SAR, etc.), and total work stability, but with low paying jobs. Finally, the last one is composed for "*eventual workers*" who do not have the guarantee of work stability, no benefit with low paying jobs (less than 6 months contact).

Undoubtedly, labor instability hinders the appropriate planning in the long run for both parties, and this situation also leads to the rotation of temporary workers, affecting their professional progress and increasing the GDF's administrative costs.

The second group with total stability and "trust" compromises with the Administration is strengthen by joining an Union; they acquire political power and complement their salaries with informal income coming from the population as "propinas" and "fincas". Their power is increased by bringing additional personnel close to each one, such as family members and friends. These persons help with the task assigned to the employee as "*volunteers*" who do not have any labor link. These "volunteers" as "*eventual workers*", turn out to be the employees' subordinate, and this situation is maintained as they share the informal incomes.

This labor regime reduces the influence that "trust" administrators can exert over stable employees or volunteers; this is true also for eventual workers (even though it seems different). On the other hand, this situation increases the influence of the unionized group. As a result, the informal structure is strengthened.

It can be assumed that a vindicative action for the workers' right will serve well to the Justice. It would be favorable for *eventual* workers who are contracted for the less than six months and for *volunteers* who have no formal ties, but work openly for GDF for long and continuous terms.

b. Contract of Services

The private sector widely participates in the activities carried out by the DGSU, given the fact that in 1996, 70% of operative budget was executed by private enterprises, and in 1997 the percentage increased to more than 80%.

The **Political Constitution** (art. 134) establishes that "acquisitions, renting, or alienation of any type of goods, provision of services of any nature and contract of works to be done, should be awarded or done through public bidding".

The **Law of Acquisition and Public Works**, published in the Official Gazette of the Federation on December 30, 1993, rules this matter.

It has been determined that 80% of amount derived from contracts should be consequence of "public bidding". On the other hand, the other 20% should be obtained as a consequence of "restricted invitations" for three or more providers or by "exemption of bidding". Obviously, the last two methods are a smoother path than the first one, and they are applied in urgent or very special situations.

There is no legal restriction regarding *duration* of contracts for services, but in order to surpass the current exercise, a prior authorization from the Finance Secretariat is necessary.

Probably for the reason mentioned previously, almost all the DGSU contracts are done for a short term, between three to six moths, or sometimes even less. This is a comfortable advantage, but it causes a number of disadvantages, such as the ones to be mentioned below (among many others):

- The bidder will not invest on new or specialized equipment when he/she signs a contract, which does not ensure repayment for the lifespan of that equipment;

- The GDF has to invest to acquire equipment; and then contract out their operation. Short term contracts do not make it feasible for the contractor to acquire this equipment.
- Maintenance can not be provided with due attention as a consequence of the GDF's short term operation equipment contract which lasts between two to four months usually.
- Contractor can not hire high-level specialized personnel when the contract is short term.
- All expense which includes costs of short term contract will be very high; unless the bidder assumes that contract will be renewed.
- Costs of bids are high, for both the GDF and bidders, and these costs are included in proposed prices and administrative costs.

It is recommended to award contracts with long term which correspond to the lifespan of equipment involved and to the requirements for expert personnel well trained for the assignments.

In order to save useless administrative costs, it is also recommended to have turn-key contracts; in other words, the contractor should judge possibility of sub-contracts and the DGSU should refrain from taking part in small and diversified contracts which might result in administrative loads and high costs.

4.6.2.4 Informal Entities in SWM

From the description detailed in Annex C, the following is commented:

- Sweepers, sweepers' "voluntary" helpers and formal collectors' "voluntary" helpers informally intervene in the sweeping and collection process, spurred by the distribution of tips and *fincas* and, in the second place, by the distribution of the revenues from the selling of recyclable products.
- On the streets, other people conduct "pre-scavenging" activities, picking recyclable products from the wastes before the collectors arrive;
- At each S/P, productive operations including separation, internal haulage and pre-processing, and the storage and trading of materials, are activities conducted by the waste pickers' Association, that have a permission from the GDF.
- At the Santa Catarina landfill, discharged wastes are left open-air for waste picking by the waste-pickers of the local association, under an informal agreement reached with the GDF (on the next day, these wastes are disposed of at the landfill).
- Several hundreds of informal "collection centers" (centros de acopio) informally receive and trade the recyclable products provided by the collectors and pre-scavengers;

- Trading of recyclable products is mostly informal among the aforementioned persons and the retail purchasers; which could be reviewed during the market research for recyclable products.

Regularization of this framework would be obviously traumatic or unfeasible. However, this can be done partially and step by step.

For a regular **commercialization**, appropriate fiscal and tax measures are required under the economic and social interest of material recycling. A political decision in this regard will imply the reviewing of the corresponding financial legislation.

To regulate the **remaining activities**, it is primarily required the **institutionalization of the persons involved** into juridically empowered entities which will execute the activities.

4.6.2.5 Assessment of the Resulting System in Mexico City

The legislative and institutional structure targeted for SWM is well elaborated and appropriate. Some points regulated in the past by the Cleaning Code (Reglamento del Servicio de Limpia) must be **reviewed** in regards to the existing legal basis.

Some administrative policies and practices, such as staffing and service hiring, must be deeply reconsidered.

Contracts must be more economic and less complicated for the GDF and the contractors, in accordance with the critique and suggestions from **section C.6.2.3.** Contracts will become more forcible when the GDF develops a policy of contracting out collection services and other services, which imply greater investments in equipment and labor. In this moment, not only will the contract period and contents be the appropriate; also, an **insurance** for the performance of the service to be submitted on the contract day will be convenient for both parties.

Yet the modalities allowed by the law are not changed, **labor relations** should also be reviewed, in the search of justice for both parties, with rights and obligations perfectly outlined and controlled. However, a radical change will only be feasible in the long run, for a total overcome of the informal structure that the SWM is currently bearing.

The weak points of labor legislation helped enhancing or creating the **dominant informal structure** in the SWM system, which seems to have origin in a traditional political system that helps politically well commanded groups; and economic support of "no charge" status established in the Cleaning Code (Reglamento de Limpieza); and on the other hand, the fair acknowledgment by the citizen that the service is being rendered to them.

There is no doubt that the citizen pays the servant for the effective service rendered and with a negotiated or agreed price. This fact is very important, and must be the basis for any transformation or upgrading in the SWM. It can be said that the informal system fostered the "culture of payment" with a high degree of social justice. The culture of payment will allow a gradual formalization of the system towards a legal concession of the residential collection service; however, the formalization of the payment system will demand a well elaborated fee plan, based on cadasters and on a careful social-

economic survey, along with a research of the current payments (tips and *fincas*). Meanwhile, it is necessary to accept that the formalization of the payment as a tax would be disastrous in economic terms, and would destroy most of the achievements of the informal system.

Back to the institutional and legal structure affecting the SWM system, the urgent need to **regulate the DF's Environmental and Organic Law** should be emphasized again. The regulation must be compatible with the SWM system **M/P** and amended *before* the new political-administrative institutionalization of the DF (i.e. the direct election of delegation executives), establishing fair and consistent concepts that will not derogate nor void the work done. After this regulation and based on the Organic Law, the **Treasury Law and the Financial Code (Ley de Hacienda y Código Financiero)** should be reviewed, and therefore the Income and Expenditure Budget Law of the DF.

It is worth mentioning that the aforesaid hypothesis of **specialized and strictly formal Inter-delegational Sub-system** will require **SWM rules** for contracted entities and concessionaires, as well as the citizens such as the duties, rights and sanctions. These rules would be specialized.

To end with, the convenience and justice of integrating in the SWM system the informal persons and entities (that are currently accepted by means of tolerance and irregular concessions) is observed. To do so, they must become legally valid entities that will have their corresponding rights and obligations.

4.6.3 Social Aspects

a. The Community and Solid Wastes

The economic and "plural" socio-cultural features of the population of the DF have a significant impact both on the amount and quality of generated wastes and on their participation to the management of the municipal solid wastes. In effect, if efficiency and efficacy goals are kept for an integral management of public cleansing service, the aforementioned plurality requires that the authorities know how to correctly manage these characteristics.

Among these features, we have the following:

- The high-income sectors of the DF generate more wastes per capita with a greater incorporated value than those generated by lower income sectors.
- In general terms, solid waste management culture at the generation source has not yet developed. However, a better management and storage is being observed nowadays in plastic bags - at middle and high socio-economic levels.
- It must be acknowledged, however, that from ancient times, there has always been the will to keep houses and the surroundings clean, although this objective is not always achieved. This attitude is confirmed at lower income sectors where the population sweeps their roads and organizes themselves to clean clandestine dumping sites in ravines and public areas.

a.1 Attitude towards the Minimization of Wastes

- A probably successful exception is the DGSU's solid wastes pilot separation program being carried out in some public buildings, a housing complex and a preschool educational center, involving around 8,500 persons. However, it must be recognized that, like many pilot programs, the success of the program is a result of financial support by the DGSU for all necessary tasks. Similar and even greater financial backup would be required for the feasibility of a massive and long-term coverage of this program in the DF.

- The proposals to minimize the waste generation form packing and crating in the manufacturing industry are weak, as well as the those to simplify and minimize packages.

a.2 Culture of Payment for the Collection Service Rendered

- Domestic recipients of the collection service directly pay the sweepers or collectors a "voluntary fee" or "tip" every time they bring their waste containers for their collection. The amount of the tips varies according to the amount of solid wastes collected and the socio-economic level of the zone. It is estimated that almost every family pays this "tip".

- Commercial stores, offices and other small, medium or big business entities also pay a fixed "voluntary fee" known as *finca*. The amount goes from 5 pesos to 100 pesos, according to the amount of solid wastes collected, which in turn depends on the size of the establishment. All the business entities with the collection service pay these *fincas*.

- The informal commercial system works efficiently. According to comments of the population, if fees were imposed by the GDF delegations, the system would not function because the population would not pay. The society perceives the garbage collection service as an obligation of the government and that is included within their taxes, although they pay "voluntary" fees (tips and *fincas*) to those who really operate the service.

a.3 Citizens Information and Education

- The society as a whole knows very little about the problem represented by solid wastes, and its participation is limited only to bring the wastes and to pay tips and *fincas*. The overprotective position of the government has fostered this behavior and a lack of interest from the population.

- It is accepted that the population is not deeply involved in the management of solid wastes, due to a lack of transparent information and an access to it. Besides, the general public should also be informed of the problem caused by the management of solid wastes, as well as the functions of the GDF's diverse organizations and cleansing service levels. The diffusion of the information on the separation of solid wastes is a good example of what should be done.

- A hindrance for the population to voluntary join a solid wastes management participation program, whose central objective is public health, the preservation of the environment and the provision of the service, is the declined environmental culture. It does not allow them to assess the negative impacts

of solid wastes on health or the environment (water, air and soil). This educational restriction is critical in adult population, who has received general data on this topic during the last few years only.

- For the recent years, issues related to the protection of the environment have been gradually included in educational programs. Although the educational plan proposes that there should be the integrity and continuance of these issues during the primary levels, the efforts to raise a child with the knowledge to properly manage solid wastes are useless if these topics are taught theoretically during only one year without practices or visits to public cleansing services, S/Ps, transfer stations and sanitary landfills. The attitude of the DF population towards solid wastes should be changed so that children are raised to behave as expected when they grow up.

- There is scarce or no information at all to the GDF's cleansing service staff; private contractors of transfer stations, S/Ps, transportation and sanitary landfills; *pepenadores* (waste-pickers) and informal sweeping and collection workers with regards to their health, environmental protection, and industrial safety.

b. Social Aspects in Collection

- The relations between the population and the GDF' sweepers and collectors are acceptable in general terms, and there are no difficulties or conflicts among them. There exists a symbiosis between the service recipients and the workers, and they benefit from each other: the former pay a "voluntary fee" and the latter render a reasonably acceptable waste collection service.

- The relations between the sweeping and collection workers, as they all are registered as a member of the Section 1 Union, do not present conflicts.

- The relation between the service recipients and the GDF is indifferent, and population participation in the management of solid wastes is weak so far. Nevertheless, due to this indifference, the population does not demand for better services, resulting in some social problems:

    - Some population sectors (peripheral zones, squatter settlements, sites difficult to access) with deficient collection services or no service at all. These sectors, yet not very big, represent a social problem.
    - Customs of the population (the family members leave the house early, before handing their solid wastes to the collector). Nevertheless, people has not asked for a change of collection schedule.
    - There are people who litter wastes on public roads, although the number of them has been reduced.
    - As a consequence of the above points, the GDF has to collect almost 800 tons of solid wastes every night from 996 clandestine dumping sites in 301 colonias in 12 delegations, which do not include lower economic level delegations as Cuajimalpa, M. Contreras, Milpa Alta and Tlahuac. Obviously, at these colonias, wastes are dumped at ravines and public areas, and the neighbors pick these wastes through cleaning campaigns with the help of the corresponding delegations.

- ♦ In summary, there exist some DF zones with deficient, sporadic or no collection service, yet this is a small portion and in peripheral zones.

- The most unbearable social problem during the collection process is that the volunteers, sweepers and collectors are informal personnel without salary, social welfare, health insurance, and not even working devices or uniforms. This is a severe problem, because there are almost 7,500 informal sweepers and collection workers.

c. Social Aspects of Wastes Selection

- The waste-pickers groups control the S/Ps, at the high expense of the GDF with regards to financing the investments, current operation and maintenance cost of the plants, as well as other benefits for the waste-pickers. There is no doubt that former waste-pickers (*ex-pepenadores*) are in much better socio-economic conditions than they were when they segregated garbage at open dumping sites 15 years ago. The subsidies paid by the GDF for the S/Ps are in fact being paid by the population of the DF, because part of the taxes levied by the government are allocated to the payment of this service, instead of using these funds to other social benefit projects.

- The waste-pickers groups of the three S/Ps are not legally recognized yet as business associations, although this is being analyzed. Currently, they are organizations that seem to operate as cooperatives, but they are not such, because the waste-pickers (*ex-pepenadores*) do not receive the benefits like cooperative members. Instead, they are private informal enterprises.

- At the San Juan de Aragon S/P, a very small number of workers dedicate to the conditioning of selected wastes and add value to them. They are controlled and paid by the leader. At the Santa Catarina and the Bordo Poniente plants, the same job is done by the private companies with permission by the leaders. In the case of the San Juan de Aragon plant, the salary they earn is unknown, but it is assumed that it is just like or less than the minimum legal wage. They are not provided with the social benefits by law either. Obviously, the socio-economic situation of this group is poorer than those of selectors. Hiring of these formally paid workers may have an intention of "freezing" or even "reducing" the number of the alleged waste-pickers "members".

- Currently, the waste-pickers groups do not give information on how resources are allocated, nor how much their revenues are. However, one of the critical issues arises definitely from the fact that this distribution seems to be unfair and affects those who really works; the former waste-pickers (*ex-pepenadores*).

- The recovered amount of the wastes of the total processed is low (4%-7%), yet it is estimated that the manual selection method currently in place is appropriate. It may be fair to say that solid wastes that enter the plants are "poor", because they have been probably undergone a "pre-scavenging" process during collection.

- The first objective of the selection plants was to eliminate the existence of waste-pickers at open dumping sites. This objective has been achieved mostly

in the DF, with the exception of the Santa Catarina sanitary landfill, which still has waste-pickers, who are headed by the same person as the S/P.

- S/Ps' operation and maintenance is contracted to private sector companies, and the costs for those and energy are high, which imposes a considerable expense on the GDF. The security of the working staff of the contractors must be guaranteed with all social benefits and with necessary equipment to carry out their activity. Transparent contracts and supervision for the compliance with the contract clauses for the benefit of the workers are required.

d. Social Aspects at Other Stages of the Service

- Operation, maintenance and technical control of the 13 transfer stations and the final disposal site are contracted to a great number of small and medium enterprises, that hire in turn 2,000 workers and whose labor relations are directly with the contracted private companies. On the other hand, the DGSU has supervising staff at the transfer stations (80 persons). Additionally, the delegations have personnel at the transfer stations (maybe more than 300 people), whose specific function is not very clear.
- Besides, for urban cleansing at main roads (freeways, avenues, highway accesses and secondary avenues) the DGSU hires contractors.
- Social aspects at these stages are the following:
  - ♦ Insufficient compliance of contracted enterprises with labor obligations for their workers (welfare and complementary benefits).
  - ♦ The possibility of labor conflicts within the contracted companies, which would lead to strikes and demonstrations solutions of these must appear in the contracts for the protection of the service and the GDF.
  - ♦ Lack of staff training and information diffusion to the workers on health and safety within the work places.
  - ♦ Very short-term costly contracts, resulting in instability of the workers and demanding higher training costs for the new staff.
  - ♦ Necessity for more strict and effective control and supervision by the GDF to execute the contracts (which should be as transparent as possible) entered between the GDF and private companies.

e. Conclusions on Social Aspects: Strength and Critical Points

Although the SWM service in the DF does not currently show conflictive social problems, it does present critical underlying points which block the improvements of the system. This situation could affect Master Plan implementation if these problems are not solved or at least mitigated during the period until 2010.

Among those underlying critical social points, we can name the following:

- There are a large number of informal workers without being protected by the labor law.
- Social costs: subsidies for SWM granted by GDF are transferred to the society. As a result, taxes are directed to finance these subsidies instead of going to other broader social benefit projects.

- It is unknown whether there is an equitable distribution of profits among ex-waste-pickers proceeding from revenue of traded recovered materials from S/P.
- Sta. Catarina landfill still operates with waste-pickers.
- In small proportion, there are peripheral areas in the DF where there is a deficient or sporadic collection service.
- Indifference is found in the relationship between service recipients and GDF cleansing staff.
- Weak supervision to enforce labor legislation, social security, and health of workers group of the contracted enterprise.

Table 4-33 summarizes the conclusions on strengths and critical points for social aspects within the current situation of SWM in the DF.

Table 4-33: Conclusions on Social Aspects: Strengths and Critical Points on SWM in the DF

Components	Strengths	Critical Points
• Source Separation and Minimization of Solid Waste	◆ The DGSU undertook successfully a demonstration project of waste source separation which could be extended. ◆ Almost natural separation at the source (markets, parks, public offices, schools, others) is implemented where an immediate separation program could begin immediately.	◊ General citizens does not practice waste separation. ◊ Incipient packing and crating minimization done by industry. ◊ Little information to the public on benefits derived from separation. ◊ There is no culture on waste management at the source.
• Information and Education	◆ Educational programs on the environment and health already established in primary schools.	◊ Little information on negative effects on health and the environment derived from an inadequate SWM. ◊ Limited involvement of society into SWM. ◊ Training given to cleansing personnel is weak. ◊ No information to informal workers. ◊ Environmental culture of the private sector is limited. ◊ Relations among the GDF, residents associations and NGOs are weak.
• Willingness to pay for services	◆ There is a culture of spontaneous willingness to pay which is difficult to achieve in other cities. ◆ Equity: Those who generate more pay more. ◆ Simplicity: Payment is derived from direct calculation of solid waste quantity generated by clients. ◆ Redistribution: Those who have more, pay more ◆ Collection efficiency: zero delinquency.	◊ GDF regulation on payment exemption to those who generate less than 200 kilograms per day. ◊ Current informal payment system.
• Collection and street sweeping	◆ Good relations for mutual benefit (symbiosis) between the community and those who provide the service (collectors and sweepers). ◆ Finance from the GDF is limited regarding current expenditure for sweeping and collection services. ◆ Efficient operation by the informal collection system within the GDF. ◆ Low probabilities that service might be stopped or affected by strikes derived from labor conflicts. ◆ Jobs for a large number of persons who are otherwise unemployed and not-qualified.	◊ Informal operation by, practically, an autonomous entrepreneurial organization within a state structure and organization. ◊ Unfavorable working conditions for 7,500 volunteers (collectors and sweepers), without basic remuneration or social benefits. ◊ Small peripheral areas, irregular settlements, and sites with difficult access which have irregular or no collection services. ◊ Material selection is done on public areas without paying any attention to aesthetics or sanitation ◊ Weak accidents prevention.

Components	Strengths	Critical Points
• Transfer Stations (T/S)	◆ Impact derived from eventual strikes by workers from contracted enterprises is minimal, as a result of the number and size of them.	◊ Difficult to supervise the large number of small and medium size private contractors. ◊ Little fulfillment of existing regulations to protect workers' health and prevent occupational accidents. ◊ Short term contracts which create worker instability and higher costs to the DF and consequently to the society.
• Transportation (between T/Ss, S/P and final disposal sites)	◆ Reduced impact of strikes and standstill. ◆ Possibility of continuous transportation is guaranteed by insurance policies.	◊ Complicated supervision for the execution of contracts by with a large number of enterprises. This supervision includes the following aspects: technology, administration, operation and fulfillment of regulations which protect workers' health and prevent occupational accidents.
• Selection Plant (S/P)	◆ The social-economic conditions of ex-waste-pickers was improved. ◆ Incentive is given (the more material recovered, the more paid).	◊ The objective of operating landfills without waste-pickers has not been yet reached (Sta. Catarina). ◊ Waste-pickers organizations which receive high subsidies from the GDF (capital cost, current cost and other economic benefits) are informal; these organizations do not pay taxes, nor social charges; additionally, they do not inform about revenue redistribution among their members. ◊ Economic burden on the GDF which is finally paid by the society of the DF is excessive. ◊ Personnel hired by waste-pickers organizations has unfavorable working conditions. ◊ Recovered waste amount is between 4 to 7% of the amount processed; this figure is not meaningful regarding the minimization objectives.
• Final Disposal	◆ Contracting several enterprises reduce impact of eventual strikes or standstill. ◆ Possibility of continuous transportation is guaranteed by insurance policies.	◊ Complicated supervision for the execution of contracts with a large number of enterprises. This supervision includes the following aspects: technology, administration, operation and fulfillment of regulations which protect workers' health and prevent occupational accidents. ◊ Short term contracts cause the instability of workers and higher costs for training new personnel. Furthermore, higher costs to the DF and consequently to the society is imposed.

4.6.4 Organizational System

The diagrams of item C.5.2 in Annex C showed the functional structures of the diverse SWM services. It is noted that these services are distributed in accordance with legal precepts: local ones are under the responsibility of the delegations - residential sweeping and collection - those precepts involving several delegations or very specialized tasks are under the jurisdiction of the DGSU - sweeping of primary road network, cleaning of monuments and walls, transfer, separation of recyclable products and final disposal.

It is also observed that all the services are shared by several enterprises and/or third parties to the GDF, as informal structures. This brings as a result small and simple formal organizations, within the delegations and in the DGSU.

The lack of a maintenance and control organization (with respect to supplying of spares) of the collection teams is quite remarkable, which is overcome thanks to the cooperation of informal beneficiaries. This lack is also present in regards to other equipment, but this lack is overcome by contracting operation and maintenance. Meanwhile, more attention to these aspects is recommended, because they may lead to a decrease of productivity and increasing costs, since these equipment are specialized and most of them are imported, which in turn will result in a delay to obtain spare parts or even to modify them. It is also true that service contracting or concession, including necessary equipment, can also be a good solution.

Planning and control of residential collection and street cleaning services are empirical and the informal structure is in charge of them, with the exception of specialized services.

A regulation for service execution and another for public procedure regarding urban cleaning and wastes should be created, including their corresponding sanctions. Likewise, permanent communication with neighbors is necessary such as providing them with information and paying attention to their claims, which would represent a good tool to monitor the services.

Some transfer stations have a certain number of staff from the delegations where these facilities are located, and this number of staff would be reduced, because the services are contracted and supervised by the DGSU.

4.6.5 Ascertainment of Aggregate Unit Cost of Solid Waste Management in DF, 1998

4.6.5.1 Model Configuration, Methodology, and Assumptive Parameters Used

In pursuance of the team's endeavors to figure out the indicative unit cost for the management of solid waste in DF as per 1998 price, the following model configuration and the assumptive parameters have duly been applied. While the deliverable of the investigation comes appear in the last part of the section, it should be noted that those "*aggregate unit costs*" elucidate the summation of the "unit cost" accrued to each phase of processing for solid waste management currently in place, vis-à-vis, capital investments, recurrent costs, and hidden costs.

a. Model Configuration

In line with accounting definition, the cost components and the associated cost centers considered in the estimation of unit cost attributed to the solid waste management service in DF as per 1998 price include the followings.

(1) Annuitized capital investments in recycling plants, transfer stations, and final disposal sites;

(2) Recurrent Costs associated with collection, transfer, transfer stations, selection plants (S/Ps), final disposal sites, deposition of illegal dumping, and sweeping and cleaning of major roads; and

(3) Hidden Costs, or social costs, in the form of "*Tips*" and "*Fincas*"[2]

b. Assumptive Parameters

1. Capital Investment

(1)Incremental Investment, San Juan de Aragon, Peso million, 1993	40.2
(2)Incremental Investment, Bordo Poniente, Peso million, 93	25.9
(3)Incremental Investment, Santa Catarina, Peso million, 93	41.4
(4) Ann Ave Inflation 93-94	8.0%
(5) Exchange Rate, P/$,1993	3.12
(6) Solid Waste ton/day/1993	9,500
(7) Solid Waste ton/year/1993	3,467,500
(8) Economic Life (years)	15
(9) Interest Rate (*cetes*), 1993	15.5%
(10) Annual Average Inflation Rate, 1995-98	27.3%
(11) Social Discount Rate, 1993	7.5%
(12) Unit Cost, Transfer Station, Peso million 1995	4.4
(13) Unit Cost of Truck, US$, 1998	80,000
(15) Unit Cost of Trailer, US$, 1998	200,000
(16) # of Truck	1,800
(17) # of Trailer	200
(18) Landfill Capacities at Bordo Poniente (ton)	34,000,000
(19) Landfill Capacities at SANTA CATARINA (ton)	34,000,000
(20) Land Acquisition Total C. Bordo Poniente (US$ million)	0.2
(21) Construction Total C. at Bordo Poniente (US$ million)	4.4
(22) Equipment Total C. at Bordo Poniente (US$ million)	3.2
(23) Ratio of Cost at Santa Catarina in terms of Bordo Poniente	1.337

2. Recurrent Costs

(1)Waste Collection (1996, million ton)	5.8
(2)Cost of Collection (1996, P million)	483.8
(3)Unit Cost of Collection (1998, US$/t/year)	10.6
(4)Transfer Station Handling Quantity (t/year)	1,584,197
(5)Transfer Station Unit Cost (P./t, 1996)	63.9
(6)S/P Handling Quantity, Bordo Poniente (t/year)	618,858
(7)S/P Handling Quantity, Santa Catarina (t/year) 1/	234,771
(8)S/P Handling Quantity, San Juan de Aragon (t/year)	627,399
(9)S/P O&M Unit Cost, Bordo Poniente (P./ton, 1996)	35.60
(10)S/P O&M Unit Cost, Santa Catarina (P./ton, 1996)	26.17
(11)S/P O&M Unit Cost, San Juan de Aragon (P./ton, 96)	40.22
(12)Dumping Quantity, Bordo Poniente (ton/day)	8,500
(13)Dumping Quantity, Santa Catarina (ton/day)	2,500
(14)Unit Cost for 11,000 ton, Bordo Poniente (US$/ton)	3.0
(15)Unit Cost for 11,000 ton, Santa Catarina (US$/ton)	4.0

[2] "*Tips*" is understood as a kind of pecuniary contribution "occasionally" and "voluntarily" given to waste collectors by households, whereas "*Fincas*" as that paid by entities on rather periodic occasions.

(16)O&M Cost, Cell Production, Bordo Poniente (US$ million)	9.69
(17)O&M Cost, Labor, Bordo Poniente (US$ million)	0.2
(18)O&M Cost, Material, Bordo Poniente (US$ million)	0.3
(19)Inflation in 1997	15.7%
(20)Inflation in 1998	14.0%
(21)Illegal Dumping (t/year)	84,391.2
(22)Unit C of Disposition of Ill. Dumps (P./t,96)	143.3
(23)Unit C of Manual Cleaning (P./km)	223.0
(24)Unit C of Mechanical Cleaning (P./km)	157.3

1/ Based on actual operation of 0.42 year days in 1996

3. Hidden Costs (Tips, 1998)

(1) *Tip* Household per week (peso)	7.0
(2) *Tip* Household per year (peso)	336.0
(3) population	8,500,000
(4) Household ratio	0.7
(5) Household population	5,950,000
(6) Household members	5.5
(7) # Household	1,081,818
(8) Ratio of "Voluntary" Tip Payers	0.81
(9) *tip* Household per month (Peso million)	30.0
(10) *tip* Household per year(Peso million)	294.9
(11) # Entities (93)	314,292
(12) # Entities (98, est., 5% annual increase)	330,007
(13) % Share of Large Entities (94)	1.0
(14) % Share of Medium Entities	5.0
(15) % Share of Small Entities	94.0
(16) # Large Entities	3,300
(17) # Medium Entities	16,500
(18) # Small Entities	310,206
(19) *Fincas*, Large (Peso/week)	500.0
(20) *Fincas*, Medium (Peso/week)	150.0
(21) *Fincas*, Small (Peso/week)	50.0
(22) *Fincas* Total, 1998, P. million/year	942.5
(23) Exchange Rate P/US$ (1998)	9.1
(24) Solid Waste (1998, ton/day)	11,000
(25) Solid Waste (1999, million ton/year)	4.015

4.6.5.2 Indicative Figures of *Aggregate Unit Cost* of Solid Waste Management

In line with the model configuration and the assumptive parameters as noted in the foregoing, the "*aggregate unit costs*" of capital investments on collection, the 13 units of transfer stations, recycling plants, final disposal sites in place being levelized in each of the years up to 2010, as well as the recurrent costs associated with these cost centers, and the hidden costs in the form of "*tips*" and "*fincas*" are figured out at respective of US$ 16.9, US$ 37.8, and US$ 33.9 per ton per annum, thus aggregating to a total of US$ 88.6 as per 1998 price. In lieu of the alternative as reflected above, the unit cost is envisaged to stand as high as at US$ 107.4 per annum per year, with the recurrent costs accrued to the disposition of illegal dumping and cleaning of major roads in view. Numerically expressed, capital costs, recurrent costs, and hidden costs worked out US$ 16.9, US$ 56.7, and US$ 33.9, respectively. Summarized table giving the estimates is provided below.

1. Capital Investment	
1.1 Recycling Plant	2.7
1.2 Collection and Transfer Stations (13 units) *1	13.6
1.3 Final Disposal Site	0.5
Sub-Total	***16.8***
2. Recurrent Costs	
2.1 Collection	16.1
2.2 Transfer Station (13 units)	13.9
2.3 Selection Plants (3 units)	4.6
2.4 Final Disposal Sites (3 sites)	3.2
2.5 Disposition of Illegal Dumping	18.2
2.6 Major Road Cleaning	0.7
Sub-Total (2.1 – 2.4)	***37.8***
Sub-Total (2.1 – 2.6)	***56.7***
3. Hidden Costs (Tips)	
3.1 Household *Tips*	8.1
3.2 Entities *Fincas*	25.8
Sub-Total	***33.9***
"*AGGREGATE UNIT COST*" OF SWM, US$/ton/year/98 price	
Alternative 1: without Illegal Dumping & Major Road Cleaning	**88.6**
Alternative 2: including All Cost Factors	**107.5**

(*1 Inclusive of tracks and trailers in service)

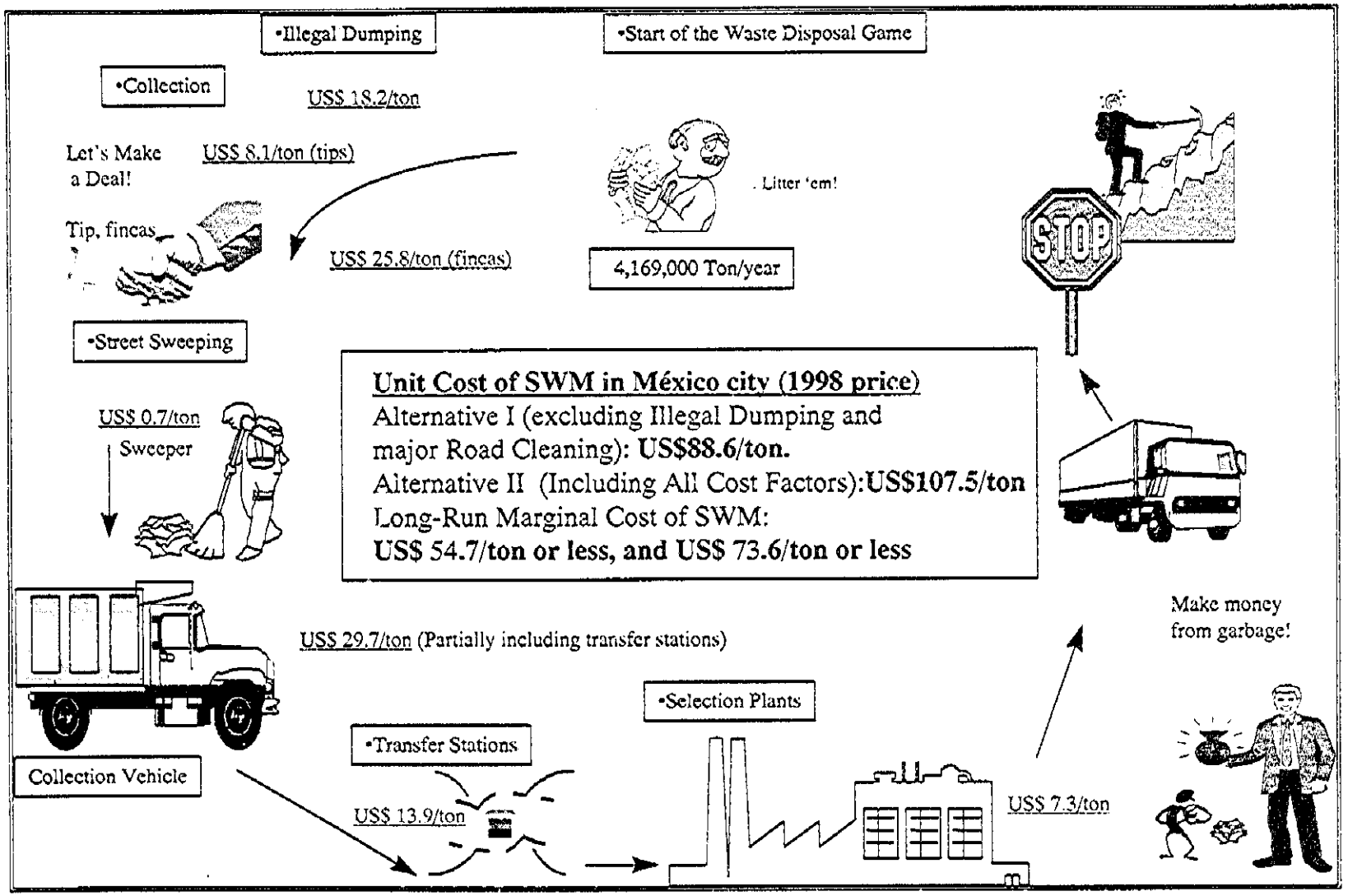


Figure 4-24: Aggregate Unit Cost of Solid Waste Management (2)