Items	Facilities
Landfill gas management	Gas extraction wells concrete pipes with 600mm diameter: 116nos. Gas extraction pipes - PVC200 at 0m elevation: 118 nos. at 8m elevation: 91 nos. at 16m elevation: 55 nos.
Surface water management	Daily/intermediate soil cover: 30cm (Compost is also usable.)
Monitoring	Monitoring items: -settlement of the landfill -leachate quality -landfill gas quality -groundwater -surface water Monitoring facilities -monitoring wells: 4 nos.
Aesthetic design	Mobile screen Daily/intermediate soil cover: 30cm (Compost is also usable.)
Closure and post-closure	Final soil cover: 60cm Greening by seeding the final cover with grass
Landfill equipment	Bulldozers (300hp class): 4 nos. Sprinkler trucks (15,000liter class): 2 nos. Excavators (85hp class): 2 nos.

c.1 Key Design Data

Key data for landfill design are the same as those of Etapa IV.

- bulk density of waste after compaction in landfill: 800kg/m^3
- operation schedule of landfill: 24 hours/day, 365 days/year
- life year of trucks and heavy equipment: 7 years
- life year of building and civil works: 30 years
- exchange rate: US$ 1.00 = 9.1pesos
- daily (intermediate) soil cover: 30cm
- final landfill elevation: 24m

c.2 Landfill Capacity

Capacity of the planed landfill is 30,242,000 m^3. Of the capacity, 29,032,000 m^3 will be occupied with waste and 1,210,000 m^3 with soil.

All the waste disposed of in 2002, 2003 and 2004, and part of waste in 2007 are to be placed in the lift of 0-8m elevation. The rest of waste in 2007 and all waste in 2008 are to be disposed of in the lift of 8-16m elevation. The remaining capacity of the landfill after 2010 will be 7,598,000 m^3 for waste disposal, i.e., 6,078,000 ton of waste (See Table 8-36).

It should be noted that the calculation of landfill capacity does not take the settlement of subsoil and waste into account.

Table 8-36: Waste Disposal Amount in Etapa V

Unit: 1,000m^3

Elevation	Landfill capacity	Waste disposal amount						Remaining capacity
		2002	2003	2004	2007	2008	Total	
0-8m	14,720	4,511	4,366	4,231	1,612		14,720	0
8-16m	9,220				2,563	4,151	6,714	2,506
16-24m	5,092							5,092
Total	29,032	4,511	4,366	4,231	4,175	4,151	21,434	7,598

c.3 Site Preparation

When the site is prepared for landfill, it is important to properly seal the salt making wells on the site in order to avoid potential risk of leachate to deeply infiltrate into the stratum under the landfill. Bentonite or other equivalent materials will be used to seal them.

c.4 Access

i. Access to the Site

An access road of 605m will be constructed from the autopista to the site. The road has dimensions of:

- Carriage width: 20.0m
- Sidewalk width: 4.0m at both sides
- Shoulder width: 1.0m at both sides
- Pavement: asphalt t =10cm, gravel t =40cm

ii. Access in the Site

A ring road will be constructed along the filling area at 0m elevation. The road functions as a main road in the site, and connects the access road to inner roads. Also the ring road will be utilized as a maintenance and monitoring road. In order to access to waste unloading areas, inner roads in the filling area at 0m elevation will be constructed.

At 8m and 16m elevation, inner roads and outer roads establish a network to secure accessibility to waste unloading areas.

Dimensions of ring road:

- Carriage width: 20.0m
- Sidewalk width: 4.0m at both sides
- Shoulder width: 1.0m at both sides
- Pavement: asphalt t =10cm, gravel t =40cm

Dimension of inner and outer road:

- Carriage width: 9.0m
- Shoulder width: 0.5 m at both sides

- Pavement: volcanic porous rocks or equivalent material, t =30cm

c.5 Landfill Layout

Landfill has facilities to operate sound waste disposal management. The facilities proposed are:

- a gate.
- weighbridges (2) and a control room.
- a tire washing pit.
- a site office.
- a garage.
- a car park.
- a parking area for heavy equipment and/or a storage yard.

Layout of the landfill are shown in Figure 8-18, and waste transport control facilities are presented in Figure 8-19.

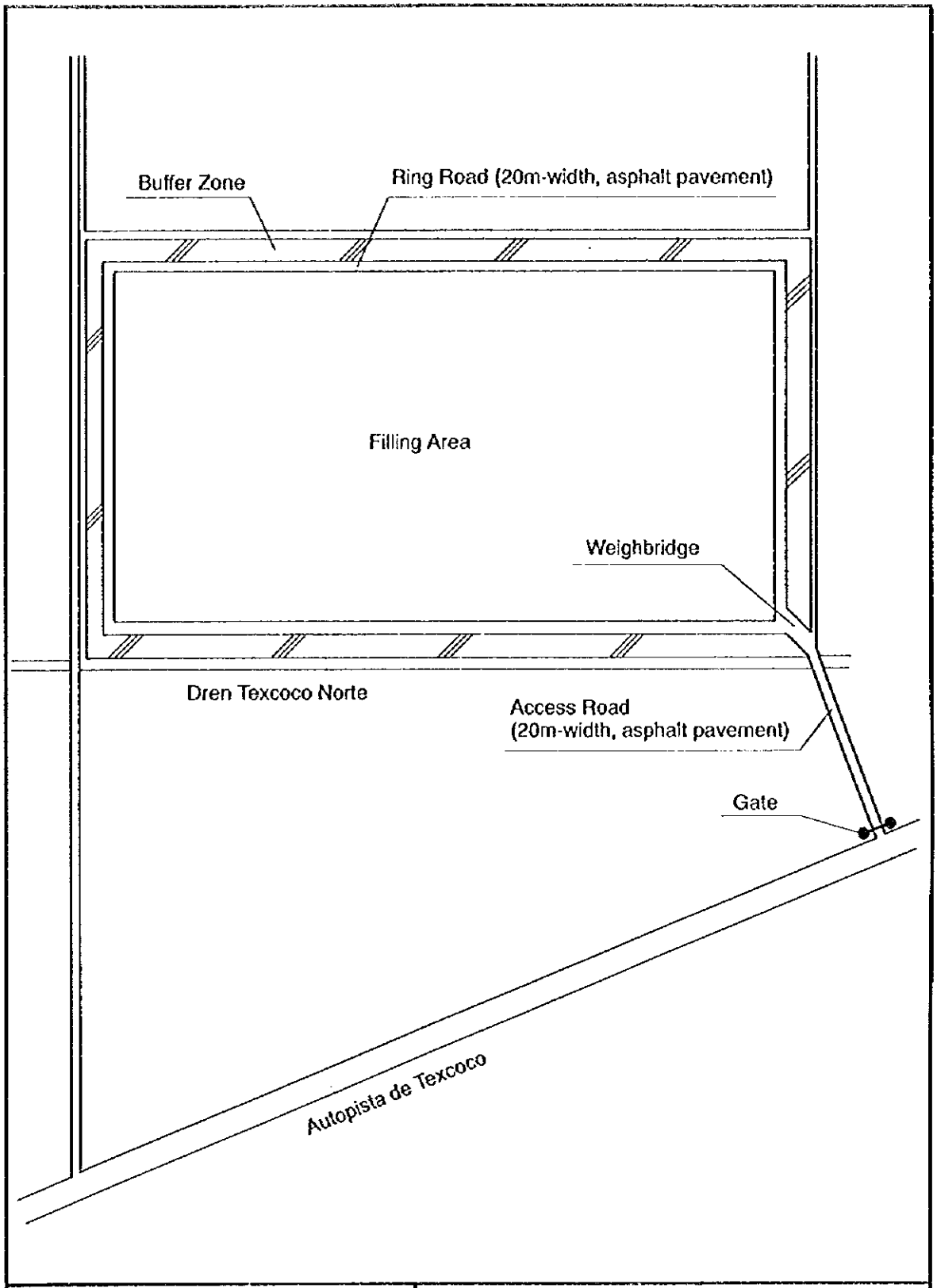


Figure 8-18:

Landfill Layout of Etapa V

KOKUSAI KOGYO Co., Ltd.

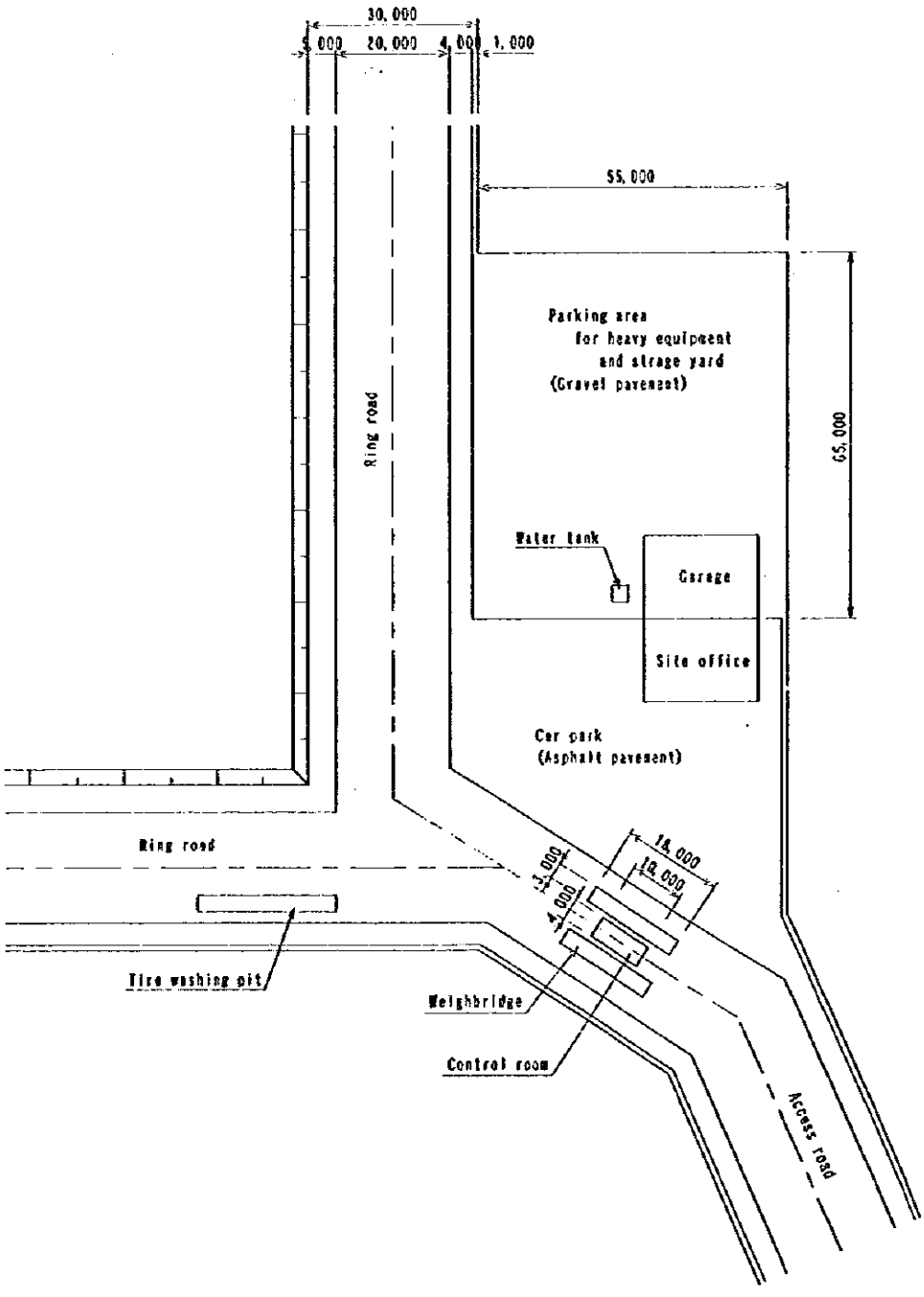


Figure 8-19:

Plan of Waste Transport Control Facilities

KOKUSAI KOGYO Co., Ltd.

c.6 Leachate, landfill Gas and Surface Water Management

Management of leachate, landfill gas and surface water is to take the same manner as that of Etapa IV (Refer these sections in the Vertical Expansion Plan of Etapa IV).

15 submergible pumps will be installed in order to spray estimated 196,000m^3/year of leachate.

c.7 Monitoring

Monitoring should be conducted in order:

- to know condition of waste decomposition.
- to know environmental quality.
- to reflect data monitored to future landfill plans.

i. Monitoring of Waste Decomposition

Monitoring the settlement of the landfill is important in this site. Settlement will be caused by decomposition of waste and subsidence of the subsoil. Data obtained by this monitoring can be useful for the future landfill operation and land use after closure.

In addition to the monitoring of settlement, it is recommendable to monitor leachate and landfill gas quality which can show the progress of waste decomposition. The recommended monitoring program is shown in Table 8-37.

ii. Monitoring of Environmental Quality

This monitoring will be conducted in view of environmental protection. It is recommended to monitor the quality of:

- groundwater at upstream and downstream of the site.
- surface water of drainage canals around the site at upstream and downstream.

In order to get samples of groundwater, four monitoring wells with 40m in depth are to be installed around the landfill because direction of the groundwater under the site is indefinite. The recommended monitoring program is presented in Table 8-37.

iii. Recording of Monitoring Data

Data obtained should be recorded in a proper manner, e.g., use of an uniform style of recording sheet, and appropriate data keeping during operation and after closure.

Table 8-37: Recommended Monitoring Program

Subject	Monitoring item	Frequency (per year)
Settlement	Elevation of lift(s)	1
Landfill gas	Temperature	2
	CH_4	2
	CO_2	2
	N_2	2
	O_2	2

Monitoring item	Frequency (per year)		
	Leachate	Groundwater	Surface water
Temperature	2	1	1
Color	2	1	1
pH	2	1	1
BOD_5	2	1	1
COD	2	1	1
T-N	2	1	1
T-P	2	1	1
Cl	2	1	1
CN	1	1	1
Cd	1	1	1
Cu	1	1	1
Pb	1	1	1
Cr(VI)	1	1	1
Hg	1	1	1
As	1	1	1

c.8 Aesthetic Design Consideration, Closure and Post-Closure Care

The same manner as Etapa IV will be taken, such as mobile screens, daily soil cover, final cover, etc. What should be noted for the design of Etapa V is that 70m width of buffer zone is to be secured in order to mitigate harmful effects of landfilling on the surroundings.

c.9 Landfill Equipment and Operation

The same equipment and the same manner of operation as Etapa IV will be employed in Etapa V. The equipment will be used alternately in Etapa IV and Etapa V.

c.10 Sequence of BP-V Construction

In view of current problems related with leachate in the BP-IV, improvement in design and construction sequence should be elaborated for the BP-V project. The bottom impermeabilization should be a holistic: i.e., it should be continuous from one cell to another and to the roads bottom as well and its outer anchorage should be in such an elevation that the leachate generated from the buried wastes should always be contained in the holistic bottom impermeabilization.

In order to attain a holistic impermeability and to carry out efficient landfilling operation and leachate management for the BP-V project, the following components should be carried out in an appropriate sequential manner:

a. Site preparation work
b. Impermeabilization

c. Leachate collection and drainage line along outer road slope bottom
d. Inner road on impermeabilization
e. Leachate collection and drainage line on the inner road slope bottom
f. East-west inner roads and leachate drainage line
g. Construction of leachate suction pit with vertical pump-up shaft
h. Off-limits marking around suction pits
i. Landfilling operation (0.0 meter to 8.0 meter elevation)
j. Approach road (from 0.0 meter to 8.0 meter elevation) construction
k. Expansion of vertical shaft and landfilling of off-limits marking area
l. Leachate pump-up and spray (and/or impound) at 8.0 meter elevation

c'. Outer road and leachate drainage line along it (8.0 meter elevation)
d'. Inner road (8.0 meter elevation) construction
e'. Inner road as leachate collection and drainage line (8.0 meter elevation)
f'. East-west inner roads and leachate drainage line
g'. Extension of vertical pump-up shaft (8.0 meter elevation)
h'. Off-limits marking around vertical shafts (8.0 meter elevation)
i'. Landfilling operation (8.0 meter to 16.0 meter elevation)
j'. Approach road (from 8.0 meter to 16.0 meter elevation) construction
k'. Expansion of vertical shaft and landfilling of off-limits marking area
l'. Leachate pump-up and spray (and/or impound) at 16.0 meter elevation

c''. Outer road and leachate drainage line along it (16.0 meter elevation)
d''. Inner road (16.0 meter elevation) construction
e''. Inner road as leachate collection and drainage line (16.0 meter elevation)
f''. East-west inner roads and leachate drainage line
g''. Extension of vertical pump-up shaft (16.0 meter elevation)
h''. Off-limits marking around vertical shafts (16.0 meter elevation)
i''. Landfilling operation (16.0 meter to 24.0 meter elevation)
j''. Approach road (from 16.0 meter to 24.0 meter elevation) construction
k''. Expansion of vertical shaft and landfilling of off-limits marking area
l''. Leachate pump-up and spray (and/or impound) at 24.0 meter elevation

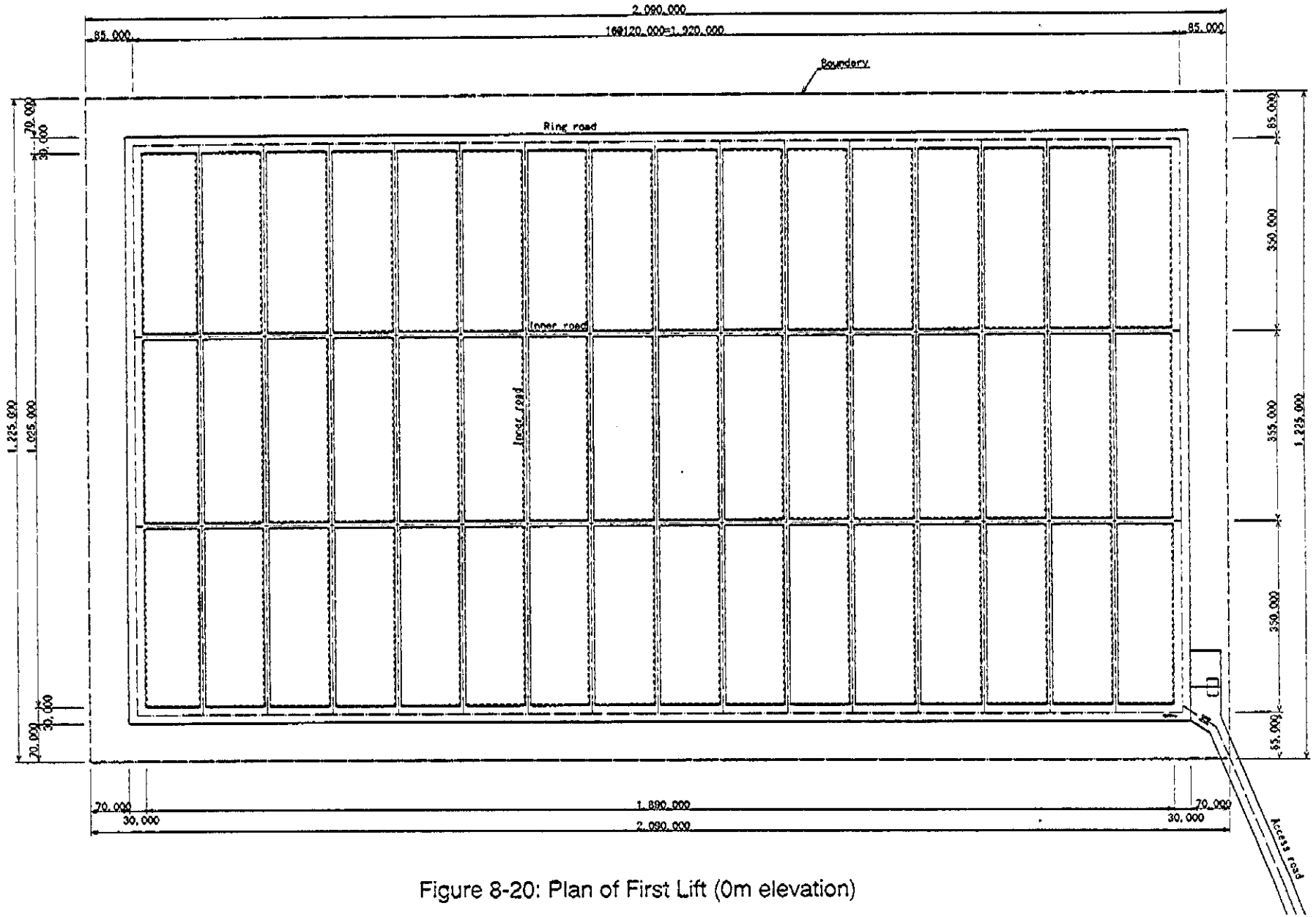


Figure 8-20: Plan of First Lift (0m elevation)

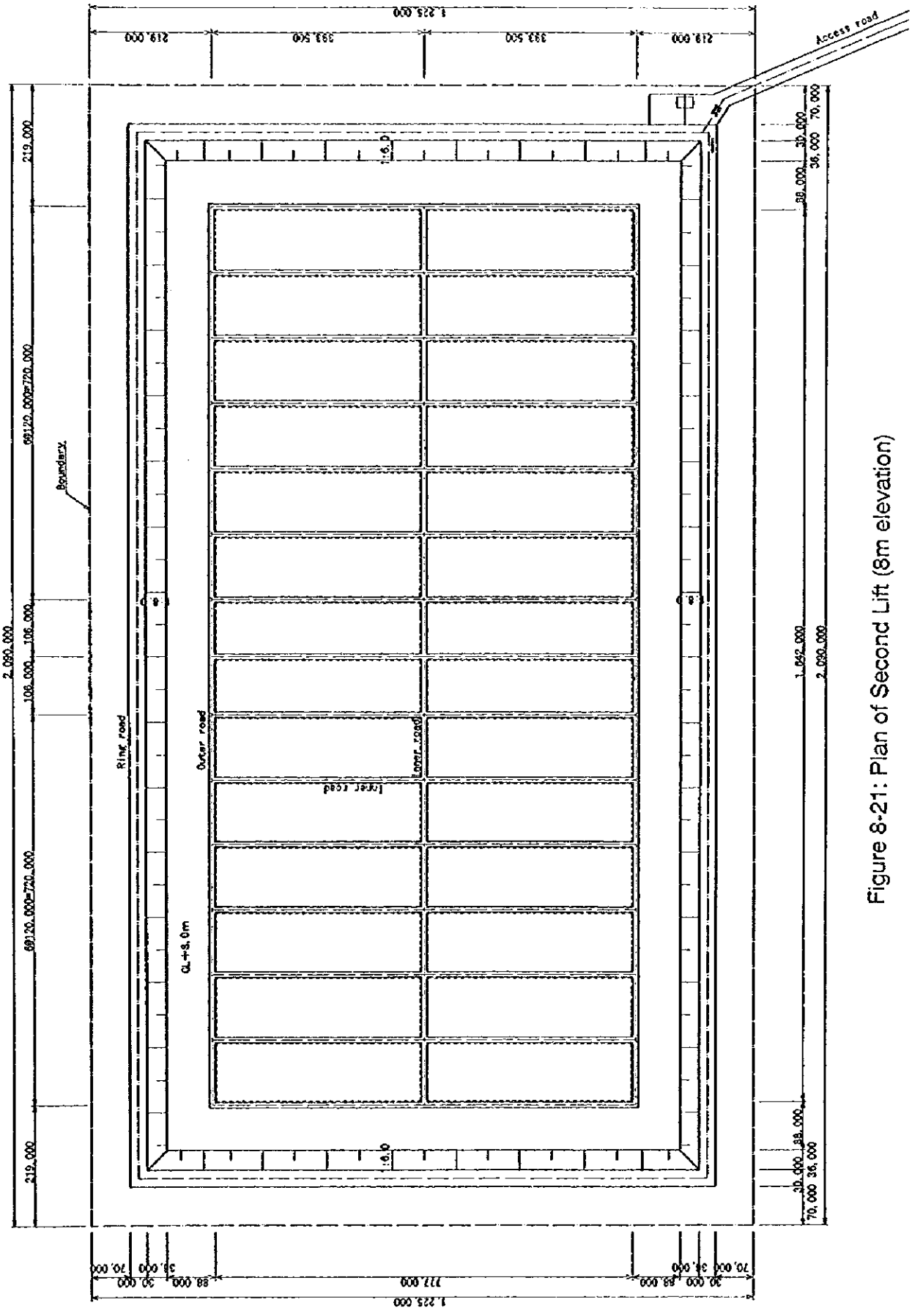


Figure 8-21: Plan of Second Lift (8m elevation)

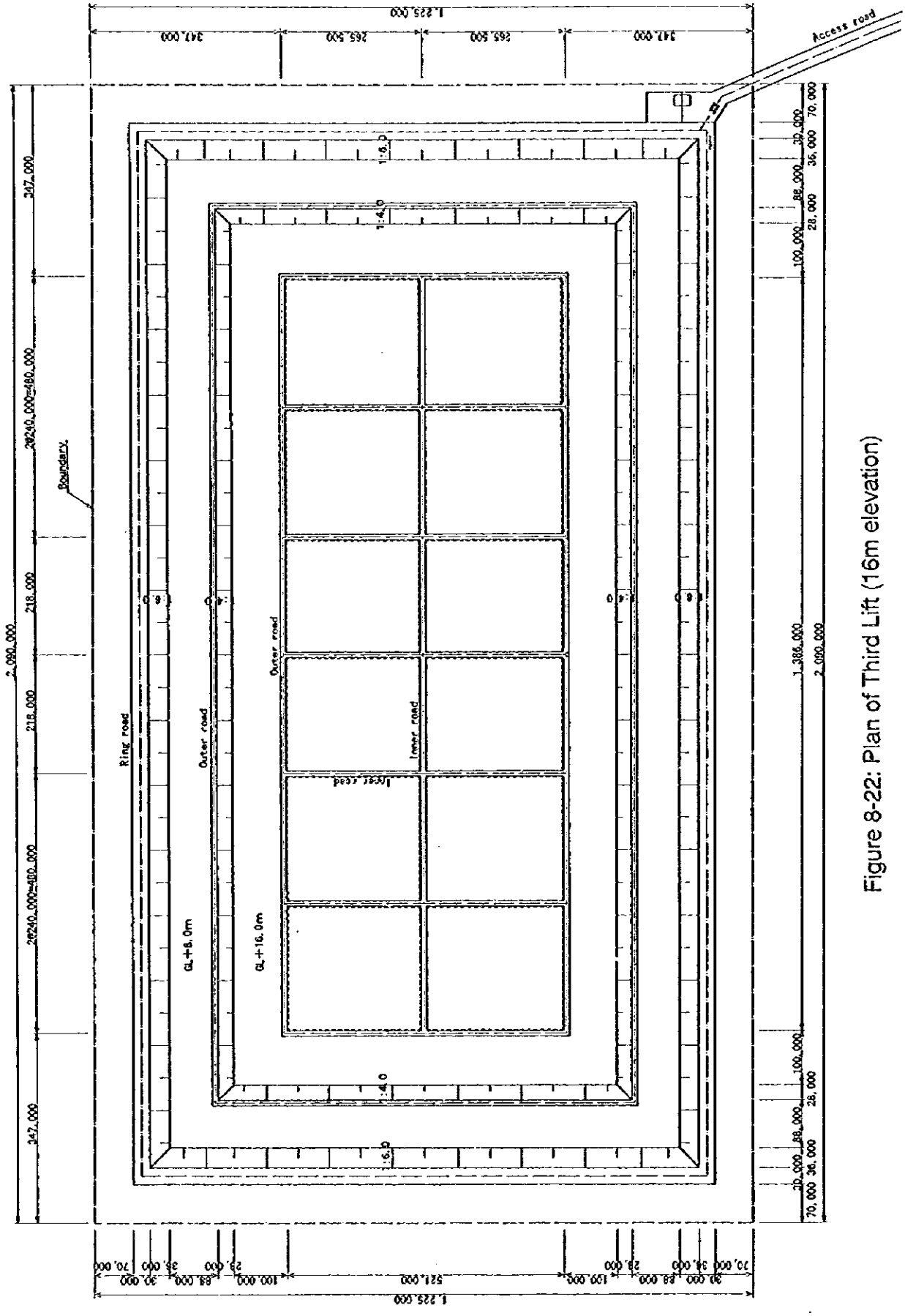


Figure 8-22: Plan of Third Lift (16m elevation)

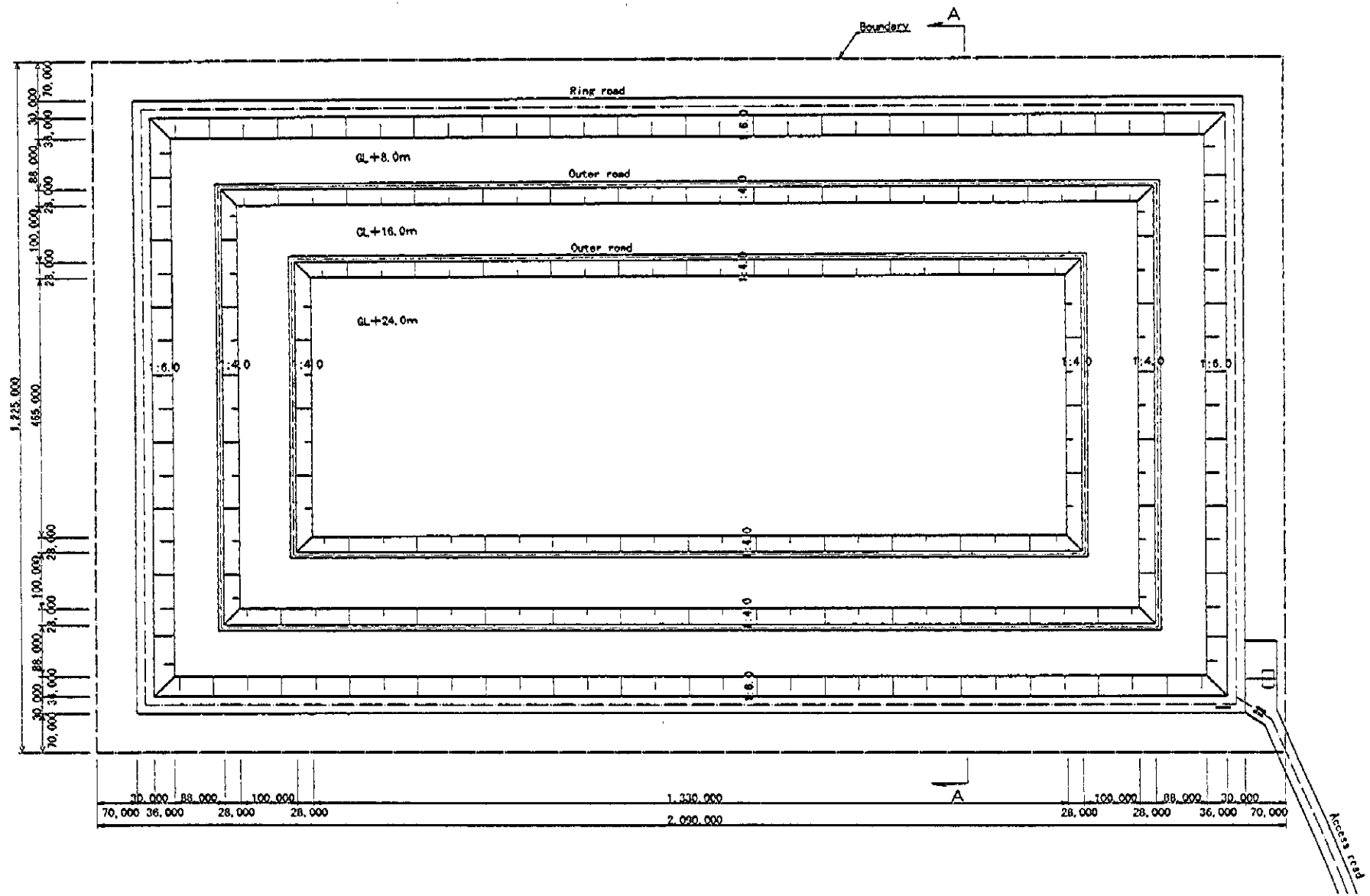


Figure 8-23: Plan of Finished Landfill

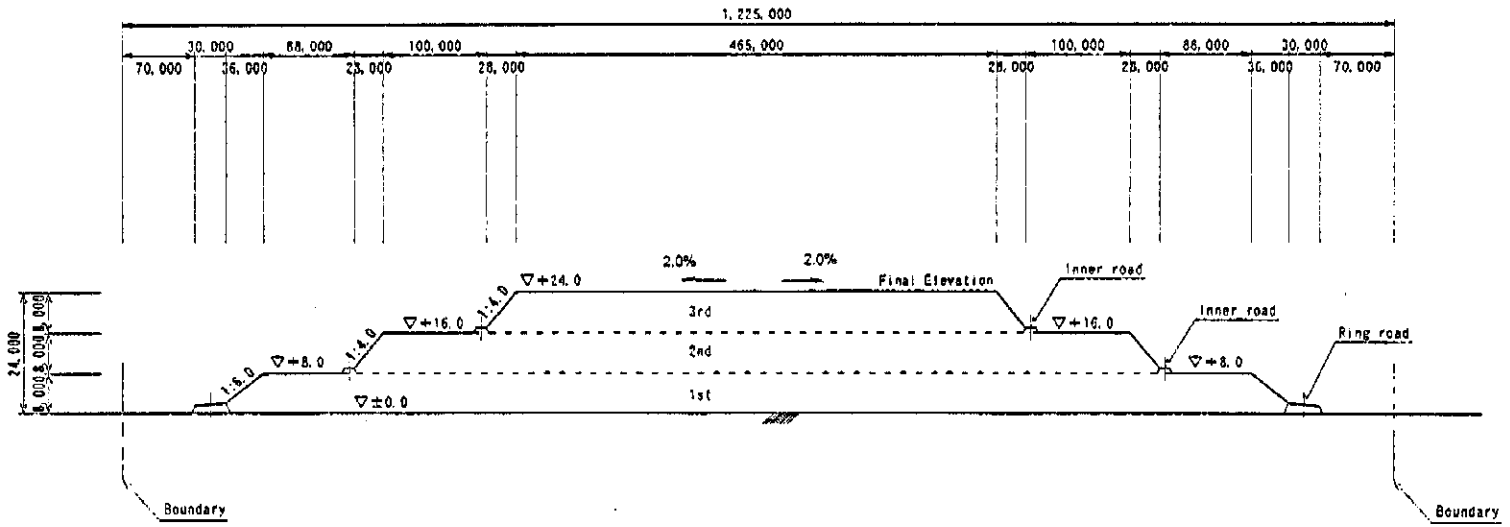
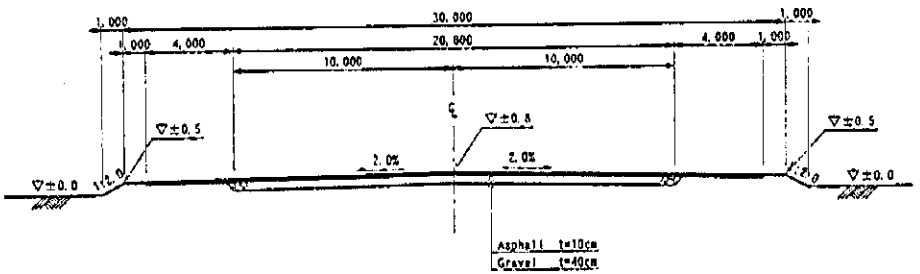
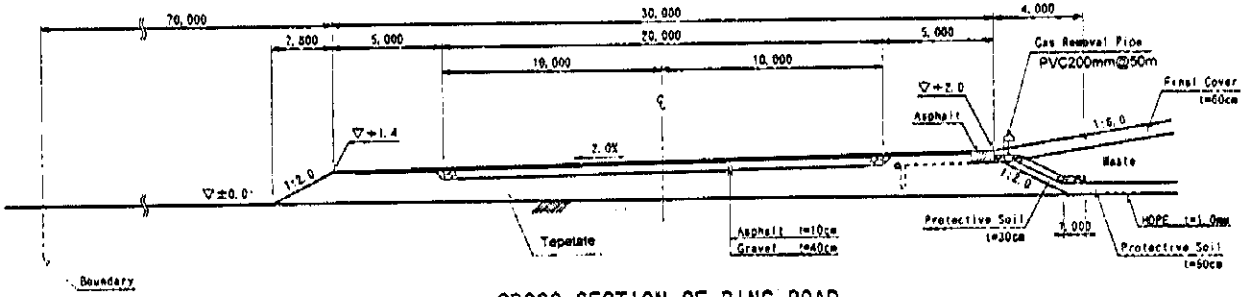


Figure 8-24: Cross Section



CROSS SECTION OF ACCESS ROAD



CROSS SECTION OF RING ROAD

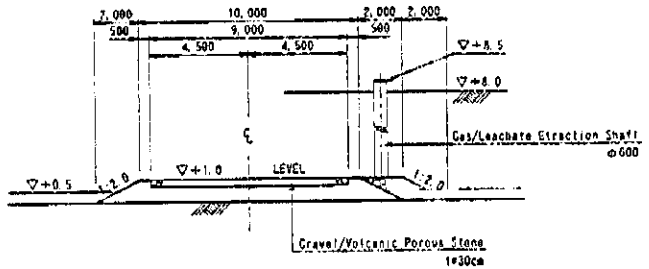


Figure 8-25: Cross Section of Roads

c.11 Cost Estimation

Table 8-38 and Table 8-39 summarize the costs for the New Landfill Development (Etapa V). The costs estimated for Case 1 was US$ 41,205,000, while Case 2 was US$ 42,249,000.

Table 8-38: Summary of Costs for A New Landfill Development (Case1)

unit: US$ 1,000

Year	B/D	D/D	Con. (Ini.)	Con(Rec)	Equip.	O&M	Land fee	Total
1999	41							41
2000		204						204
2001		162	4,068				231	4,461
2002				7,464		707	231	8,402
2003				7,224		707	231	8,162
2004				7,001		801	231	8,033
2005						13	231	244
2006						70	231	301
2007		139		3,915	2,777	720	231	7,782
2008				2,022		777	231	3,030
2009						13	231	244
2010						70	231	301
Total	41	505	4,068	27,626	2,777	3,878	2,310	41,205

B/D: Basic design for construction and equipment.
D/D: Detailed design for construction and equipment. The amount complies costs for supervision as well.
Con. (Ini.): Initial investment cost for construction
Con(Rec): Recurrent cost for construction
Equip.: Landfill equipment
O&M: Operation and maintenance
Land fee: Land rental fee

Table 8-39: Summary of Costs for A New Landfill Development (Case 2)

unit: US$ 1,000

Year	B/D	D/D	Con. (Ini.)	Con(Rec)	Equip.	O&M	Land fee	Total
1999	41							41
2000		204						204
2001		162	4,068				231	4,461
2002				7,464	901	598	231	9,194
2003				7,224	901	598	231	8,954
2004				7,001	901	692	231	8,825
2005						13	231	244
2006						70	231	301
2007				3,915	901	611	231	5,658
2008				2,022	901	668	231	3,822
2009						13	231	244
2010						70	231	301
Total	41	366	4,068	27,626	4,505	3,333	2,310	42,249

B/D: Basic design for construction.
D/D: Detailed design for construction. The amount complies costs for supervision as well.
Con. (Ini.): Initial investment cost for construction
Con(Rec): Recurrent cost for construction
quip.: Landfill equipment
O&M: Operation and maintenance
Land fee: Land rental fee

8.2.3 Cost of Priority Projects

Table 8-40: Cost of Priority Projects, Case of Direct Operation by DGSU (Case 1)

Unit : US$ 1,000

			1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Total
BP Etapa IV	B/D		33	0	0	0	0	0	0	0	0	0	0	0	33
	D/D & S/V		0	298	0	0	0	0	0	0	0	0	0	0	298
	Construction		0	7,902	2,164	0	0	0	1,883	1,874	0	0	1,773	1,528	17,124
	Equipment		0	2,777	0	0	0	0	0	0	0	0	0	0	2,777
	O & M	Contract out	0	0	0	0	0	0	0	0	0	0	0	0	0
		Direct	0	0	728	111	21	111	728	818	21	111	728	818	4,195
	Land fee		0	0	425	425	425	425	425	425	425	425	425	425	4,250
	Total		33	10,977	3,317	536	446	536	3,036	3,117	446	536	2,926	2,771	28,677
BP Etapa V	B/D		41	0	0	0	0	0	0	0	0	0	0	0	41
	D/D & S/V		0	204	162	0	0	0	0	0	139	0	0	0	505
	Construction		0	0	4,068	7,464	7,224	7,001	0	0	3,915	2,022	0	0	31,694
	Equipment		0	0	0	0	0	0	0	0	2,777	0	0	0	2,777
	O & M	Contract out	0	0	0	0	0	0	0	0	0	0	0	0	0
		Direct	0	0	0	707	707	801	13	70	720	777	13	70	3,878
	Land fee		0	0	231	231	231	231	231	231	231	231	231	231	2,310
	Total		41	204	4,461	8,402	8,162	8,033	244	301	7,782	3,030	244	301	41,205
Landfill Total			***74***	***11,181***	***7,778***	***8,938***	***8,608***	***8,569***	***3,280***	***3,418***	***8,228***	***3,566***	***3,170***	***3,072***	***69,882***
Composting	B/D		50	0	0	0	0	0	0	0	0	0	0	0	50
	P/P		10	10	0	0	0	0	0	0	0	0	0	0	20
	D/D & S/V		0	164	99	33	33	0	0	0	13	2	0	0	344
	Construction		0	0	2,376	551	551	0	0	0	0	0	0	0	3,478
	Equipment		0	0	2,548	520	0	0	0	0	0	2,441	520	0	6,029
	O & M	Contract out	0	0	0	0	0	0	0	0	0	0	0	0	0
		Direct	0	0	0	662	820	820	820	820	820	820	820	820	7,222
	Land fee		0	0	33	33	33	33	33	33	33	33	33	33	330
	Total		60	174	5,056	1,799	1,437	853	853	853	866	3,296	1,373	853	17,473
Total			***134***	***11,355***	***12,834***	***10,737***	***10,045***	***9,422***	***4,133***	***4,271***	***9,094***	***6,862***	***4,543***	***3,925***	***87,355***
Initial Investment															
BP Etapa-IV			***33***	***10,977***											***11,010***
BP Etapa-V			***41***	***204***	***4,230***										***4,475***
Composting			***60***	***174***	***5,023***	***1,104***	***584***								***6,945***
Total			***134***	***11,355***	***9,253***	***1,104***	***584***								***22,430***

B/D : Basic design, D/D :Detailed design, S/V :Supervision, P/P : Pilot project, O&M : Operation and maintenance

Table 8-41: Cost of Priority Projects, Case of Contract-Out (Case 2)

Unit : US$ 1,000

			1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Total
BP Etapa IV	B/D		33	0	0	0	0	0	0	0	0	0	0	0	33
	D/D & S/V		0	298	0	0	0	0	0	0	0	0	0	0	298
	Construction		0	7,902	2,164	0	0	0	1,883	1,874	0	0	1,773	1,528	17,124
	Equipment		0	0	0	0	0	0	0	0	0	0	0	0	0
	O & M	Contract out	0	0	1,499	0	0	0	1,499	1,499	0	0	1,499	1,499	7,495
		Direct	0	0	21	111	21	111	21	111	21	111	21	111	660
	Land fee		0	0	425	425	425	425	425	425	425	425	425	425	4,250
	Total		33	8,200	4,109	536	446	536	3,828	3,909	446	536	3,718	3,563	29,860
BP Etapa V	B/D		41	0	0	0	0	0	0	0	0	0	0	0	41
	D/D & S/V		0	204	162	0	0	0	0	0	0	0	0	0	366
	Construction		0	0	4,068	7,464	7,224	7,001	0	0	3,915	2,022	0	0	31,694
	Equipment		0	0	0	0	0	0	0	0	0	0	0	0	0
	O & M	Contract out	0	0	0	1,499	1,499	1,499	0	0	1,499	1,499	0	0	7,495
		Direct	0	0	0	0	0	94	13	70	13	70	13	70	343
	Land fee		0	0	231	231	231	231	231	231	231	231	231	231	2,310
	Total		41	204	4,461	9,194	8,954	8,825	244	301	5,658	3,822	244	301	42,249
Landfill Total			***74***	***8,404***	***8,570***	***9,730***	***9,400***	***9,361***	***4,072***	***4,210***	***6,104***	***4,358***	***3,962***	***3,864***	***72,109***
Composting	B/D		50	0	0	0	0	0	0	0	0	0	0	0	50
	P/P		10	10	0	0	0	0	0	0	0	0	0	0	20
	D/D & S/V		0	164	99	33	33	0	0	0	13	2	0	0	344
	Construction		0	0	2,376	551	551	0	0	0	0	0	0	0	3,478
	Equipment		0	0	1,250	177	0	0	0	0	0	1,142	177	0	2,746
	O & M	Contract out	0	0	0	1,051	1,186	1,186	1,186	1,186	1,186	1,186	1,186	1,186	10,539
		Direct	0	0	0	101	124	124	124	124	124	124	124	124	1,093
	Land fee		0	0	33	33	33	33	33	33	33	33	33	33	330
	Total		60	174	3,758	1,946	1,927	1,343	1,343	1,343	1,356	2,487	1,520	1,343	18,600
Total			***134***	***8,578***	***12,328***	***11,676***	***11,327***	***10,704***	***5,415***	***5,553***	***7,460***	***6,845***	***5,482***	***5,207***	***90,709***
Initial Investment															
BP Etapa-IV			***33***	***8,200***											***8,233***
BP Etapa-V			***41***	***204***	***4,230***										***4,475***
Composting			***60***	***174***	***3,725***	***761***	***584***								***5,304***
Total			***134***	***8,578***	***7,955***	***761***	***584***								***18,012***

B/D : Basic design, D/D :Detailed design, S/V :Supervision, P/P : Pilot project, O&M : Operation and maintenance

8.3 Institutional Plan

8.3.1 Alternatives

8.3.1.1 The Sanitary Landfill (SL)

The situation to locate the SL in the lake Texcoco area is sensitive and is subject to restrictions and audits by federal entities and by the GDF, and occasionally by authorities from the state of Mexico. The use of the land owned by the National Water Commission (CNA) was authorized under the commitment of the GDF to carry out work, monitoring and maintenance tasks in the long term. The alternation in the uses

of Etapas IV and V would be a technical decision made according to the features of the soil.

For such reason, the DGSU will have a continuous presence at the site. Therefore it would not be very interested to give concession of the construction of infrastructure, operation and maintenance of SL to a private enterprise, and contracting out such services would be convenient.

On the other hand, these conditions suggest that the concessions are not so attractive to private enterprises as the referred contracts.

The institutional alternatives induce the analysis of three options:

- **SL.1 - Direct administration and operation** by the GDF through the DGSU.
- **SL.2 - Direct administration** by DGSU, and operation through **contracts.**
- **SL.3** - To create a **parastatal entity** to manage and operate the SL; either directly or not.

To be noticed that the investment in the sanitary landfills will be on the part of the GDF in any alternative chosen, and be carried out in Phase I. Besides, the selection of the alternative of operation of the SL will be effective as of year 2002 (Table 8-39).

8.3.1.2 The Composting Plant (CP)

The composting plant is a production unit of a scarcely attractive industry due to the difficulty to sell the product or unless the potential consumers are correctly oriented and convinced of the need for compost.

As long as it is industry, the CP is part of a waste flow, but it is also clear that it is not a simple urban cleaning activity.

There is a lack of financial and administrative autonomy for a public sector entity to manage and direct a self-sustainable industrial enterprise. Meanwhile, it should be considered that the economic self-sustainability of the compost industry depends on the purchase of the product by the GDF.

The investment on the CP will be carried out by the GDF in Phase I. However, its operation and commercialization of the compost product will be analyzed and chosen from one of the following options, with its operation beginning as of year 2002 (Table 8-42):

A1. Direct operation by DGSU.

A2. Operation contracted out by DGSU.

B. Parastatal.

C. Concession.

8.3.2 Evaluation of the Alternatives

It could be said in advance that the superiority of a parastatal entity is not that much in the case of the management of a SL, where there exists no commercial or industrial activity, and the high, intrinsic indirect costs are not diluted in such a small body.

Meanwhile, this superiority would become unquestionable in case that the same parastatal entity is granted the SL and the CP.

Yet the operational costs of the option **SL1** are slightly more advantageous than those of the **SL2** option, it is noticed that the former might bring about the syndication of the workers of Sección 1, which in turn would affect the continuity of the final disposal process with an eventual labor strike.

For the compost industry, the option **C.- concession** would be favorable for the development of the technology of production and use of compost, since the commercialization of the product would determine the survival of the enterprise.

To make this private entity more appealing, the GDF would guarantee the consumption of a certain amount of the product.

In view of a possibility that private entities do not show interest in the composting plant, the alternative **B.- parastatal** appears to be better than the **A1. - direct administration** by the GDF from the industrial aspect of this enterprise for the following reasons:

- capacity to set its own entrepreneurial policy and the prices for the private market.
- free management of the revenues generated by its economic activity.
- own property which would be allowed for financial transactions.
- administrative authority and the obligatory internal control and auditing, which leads to a correct assessment of its performance.
- its own identity and minor political interference.
- competition to fix the salaries and fringe benefits, as well as to enter collective and individual contracts that will regulate the labor relations of the entity with its workers (Art. 63 and 64 of the Organic Law).

The autonomy degree of a parastatal entity in the Federal District has improved considerably due to the Organic Law for Public Administration for the Federal District, particularly in regard to the administration of staff and salaries, which are very sensitive items that are mentioned in this Study.

Another critical item is the acquisition of goods and the contracting of services. In this regard, the same code for the direct administration is kept, but the existence of internal control and external surveillance, as well as their higher rank than a Direction allow the parastatal entities to manage this critical topic with more autonomy.

The intrinsic cost of a parastatal administration is high, due to the fact that its autonomy requires internal and external surveillance bodies, a board of directors, accounting systems, juridical consulting and management of human, financial and material resources similar to those in a Secretariat (which dilutes its costs among several bodies). However, costs can be cut down with greater productivity of the resources applied due to its autonomy and the minor political interference. Therefore, the advantages of a parastatal entity increase proportionally with the resources involved, the commercial relations and its productive activities.

The appropriate parastatal modality would be a **decentralized body (DC)**, since the land would be owned by the GDF only and the main purpose for it would be rendering a public service instead of making profits.

Table 8-42: Options for the Operation of CP and SL

	Phase 1 (1999 - 2001)	Phase 2 (2002-2004)	Phase 3 (2005-2010)	2011-
Composting Plant	Investment by DGSU 1st Priority Financing	A1. Direct operation by DGSU, or A2. Operation contracted out by DGSU. Analysis of four options: A. Status quo (DGSU), either A1 or A2., B. Parastatal and C. Concession and prepare B or C if this options is chosen.	A1, A2, B or C.	A1, A2, B or C.
Final Disposal	Investment by DGSU 1st. Priority Financing	SL1. Direct operation by DGSU, or SL2. Operation contracted out by DGSU. Analysis of three options: Status quo (DGSU), SL1 or SL2 and SL3. Parastatal and prepare SL3 if this option is chosen.	SL1, SL2 or SL3.	SL1, SL2 or SL3.

Note: This table shows the alternatives proposed by the JICA team, which will be further analyzed by the GDF.

8.3.3 Conclusion

The GDF has financial resources to invest in both SL and CP, taking in consideration the short term to the depletion of the SL/Etapa IV. The GDF thus may choose direct administration or parastatal form - for this last option, a decentralized organism taking over the SL and the CP would be the most suitable; however, the probable span of time and political difficulties to attain the legal acts, the budgetary and administrative resources required to constitute a parastatal, seem to indicate **direct administration** as the most opportune form to manage the SL and the CP.

The weak points of the direct administration would be attenuated through contracting out infrastructure works and operation and maintenance services. In the course of time, it will be possible to evolve to better alternatives, previously evaluated as anticipated in Table 7-23 of the Master Plan.

8.4 Public Education Plan

8.4.1 Introduction

The Public Education Program presented in item G.2.4.2 provides for the guidelines and steps to develop this important component in the process for the implementation of the Master Plan, up to the year 2010. The said proposal outlines the objectives, components, phases, executing unit and programs for the Master Plan as a whole.

Table 8-43 summarizes the Public Education Program to be implemented in the 1999-2010 period.

Table 8-43: Public Education Program

Phase 1 1999-2001	Phase2 2002-2004	Phase 3 2005-2010	Phase 4 2011
• Creation of the Executing body within the GDF • Preparation of the educational programs with the participation of delegations • Information to the community • Sensitization and talks • Starting the educational program for the separation at the source within the subsystem • Starting the training program for the personnel • Promotion of the environmental education in elementary schools	• Intensive education for the separation at the source of organic and recyclable material, according to the plan established • Staff training • Fostering of the school education • Education for the separation at the source of recyclable materials within the delegations	• Continuation of the training program • Continuation of the program for the separation at the source (system working in the delegations) • Continuation of the maintenance stage of other educational projects • Intermediate evaluation (2005) • Intermediate readjustment of the program	• Final assessment (2011) • Readjustment of the Public Education Program

8.4.2 Education Plan for Priority Projects

Next, the educational activities to be developed are outlined to facilitate the implementation of the projects whose feasibility studies were conducted during Phase II of the Study.

a. Priority Projects

The selection of the Priority Projects that are planned to be implemented in the short term (Phase 1: from 1999 to 2001) are shown in the Master Plan. Consequently, during the second study work in Mexico, the feasibility studies of the three priority projects were conducted: Composting Plant, Etapa IV and Etapa V of Bordo Poniente sanitary landfills.

The feasibility of the composting plant relies mainly on the separation of organic material at the source. Likewise, the separation of recyclable materials at the source will bring a longer useful life span of the sanitary landfill. In this separation of materials, community participation -specially from children- will provide sustainability to the process. Besides, training of the personnel involved in the three projects will also be required.

b. Specific Education Plan for Priority Projects

Within the Public Education Program shown in the previous items, the component of the Public Education Plan that facilitates the implementation of the three priority

projects is shown next. Therefore, such plan will have to encompass three main elements:

- Separation at the source.
- Personnel training.
- Promotion to the school education.

Table 8-44 shows the educational plan for the priority projects during the period 1999-2010.

Table 8-44: Educational program for Priority Projects

Educational components	Phase 1 1999-2001	Phase 2 2002-2004	Phase 3 2005-2010
1. Composting Plant			
1.1 Education to market traders to separate organic resources at the source.			
1.2 Education of users in the subsystem on the separation of garden wastes and organic material at the source.			
1.3 Education of users in the delegations on the separation of garden wastes and organic material at the source (Activity subject to a greater demand of the composting plant).			
1.4 Staff training in public parks to prepare pruned tree branches and organic material to be delivered in the collection.			
1.5 Training of separate collection staff for organic material and composting plant personnel on SWM, occupational health and environmental protection.			
2. Sanitary landfills (Etapa IV and V)			
2.1 Education of users in the subsystem on the separation of recyclable wastes at the source.			
2.2 Education of users in the delegations on the separation of recyclable wastes at the source (50% of population in the year 2010).			
2.3 Training the new staff for the collection of recyclable products and the sanitary landfill personnel (IV and V) on SWM, occupational health and environmental protection.			
3. Foster the environmental and school education			

Intensive educational stage

Education maintenance stage

c. Communication

Public education and the promotion of the educational program must be a continuous process. An effective educational and promotion program must be outlined taking into consideration the community needs. A significant amount of time and energy could be saved by analyzing public education activities that have been developed in other communities and learning from their success, such as the Solid Waste Separation Program implemented and executed by the DGSU.

Those in charge of making decisions can review the educational activities and materials utilized in other programs to sensitize the public in general. The techniques used in these campaigns to promote an idea or a new behavior can be modified to express an idea for the management of solid wastes.

The DF has several channels of communication such as the following:

- Central mass media such as newspapers, radio broadcasting and TV channels.
- Direct instruments such as posters, brochures, strip cartoons, expositions, picture shows and explanatory videos.
- Talks in schools and neighborhood associations.
- Bill contests.

Another important communication channel is represented by the associations of residents of the 16 delegations, since they can take the message to the neighbors in all the districts of the city.

8.4.3 Particulars to be Considered in the Educational Process

Some general elements to develop the Public Educational Program are presented next, specially for the project of separation of wastes at the source.

a. Phases for the Education

It is divided basically into four stages of progressive and accumulative development:

- Sensitization phase.
- Information phase.
- Education phase.
- Monitoring, follow-up and assessment phase.

The common denominator of these phases is communication.

b. Target Population ("Public")

Yet all the population in the DF is the final educational objective, the proposed activities are aimed at different population groups ("public"), according to the plan schedule: These groups are the following:

- Users in the subsystem: population who is rendered the collection service in the subsystem.
- Users in the delegations: population who is rendered the collection service in the delegations.
- Market users: population of tradesmen in the Central de Abasto and markets in the DF.

- Workers: population of workers of the GDF and private entities involved in duties of public parks, separate collection, composting plants and sanitary landfill.
- School population: children that go to elementary schools in the DF.

8.5 Financing Plan

Initially in this sub-section, the analysis and the work deliverables therewith are focused entirely on the assessment of the finance needs associated with the possible institutional alternatives and funding sources, and fiscal impacts on DGSU. This brings about the sequential discussions on and possible prioritization of the implementation alternatives under the binding conditions of coherent constraints of macro-disequilibrium that Mexico currently faces and corresponding fiscal positions of the GDF.

8.5.1 Guiding Principles for Analysis of Finance Needs Assessment

In line with the institutional framework, and the comments from DGSU as well, the indicative fund needs and the associated financing plans in each of the possible combination of project components and finance sources (*Options*) are provided herewith.

a. Configuration

A. Analytical Dimensions

A-1. Overall Project Cost structure
A-2. Financing Requirements and Financing Plan
A-3. Cash Flow Structure

B. Variables and Variations included in Analytical Framework

B-1. Implementation Framework (Cases) and Project Components in concern

Case 1: All three components, vis-à-vis, Final Disposal Sites (FDSs, Etapa IV and Etapa V) and Composting Plant being internalized within DGSU

Case 2: FDSs and Composting Plant are constructed by DGSU and Operated on Contract-Out basis by the private sector business undertaking

With the foregoing in view:

B-2. Institutional Framework by Implementation Framework and Project Components

Alternative 1: FDSs and Compost Plant in Case 1

Alternative 2: FDSs and Compost Plant in Case 1 and Case 2, in that order

Alternative 3: FDSs and Compost Plant in Case 2 and Case 1, in that order

Alternative 4: FDSs and Compost Plant in Case 2

B-3. Financing Sources

Category 1. Own Fund (Equity) Only

Category 2. Equity-Loan Mix

Sub-C 1. World Bank-type (interest capitalized)

Sub-C 2. OECF-type (interest not capitalized)

C. Evaluation Criteria

C-1. Ability to Pay (Aggregate Project Costs)

C-2. Affordability - Annual Cash Outlays within DGSU over the period

b. Schematic Framework - Combination of Variables and Variation

In view of the foregoing, the schematic framework for the analysis in concern will be summarized as follows.

Table 8-45: Institutional Framework (Cases)

		Composting Plant	
		Case 1	Case 2
Final Disposal Sites	Case 1	Alternative 1	Alternative 2
	Case 2	Alternative 3	Alternative 4

Table 8-46: Funding Source

	Own Fund	External Fund: Equity-Loan mix	
		World Bank-type	OECF-type
Alternative 1	Option 1	Option 5	Option 9
Alternative 2	Option 2	Option 6	Option 10
Alternative 3	Option 3	Option 7	Option 11
Alternative 4	Option 4	Option 8	Option 12

c. Operational Presumptions

In proceeding with the analysis of finance needs as spelled out above, presumptions in project operation are reiterated somewhat in detail are set forth herewith.

c.1 Finance Needs for FDSs and Composting Plant (Case 1)

DGSU will be in a position to finance the costs of establishment, initial investment, and operation and maintenance (O/M) either in the form of cash or cash-in-kind.

c.2 Finance Needs for FDSs and Composting Plant (Case 2)

DGSU will, in lieu of operation and maintenance of management and facilities, assume the contract to cover the operation costs accrued under the management of private firms, while presumably keeping a rate of return covenant that ensures the certain rate of profit to the firm.

c.3 Expedient Borrowing of External Fund for Initial Investment

Should GDF/DGSU through the Federal Government of Mexico introduce external loan in a paucity of own fund, the borrowing will only be shed to the initial investment outlays, whereas the remaining recurrent costs are borne out by DGSU.

8.5.2 Financing Plan -- Finance Needs Assessment, Sources of Fund, and Associated Cash Flows

The numerical assumptions set for the finance needs estimation include: (i) project life, (ii) cost recovery, (iii) foreign exchange quotation, (iv) cost estimation (base cost), (v) physical contingency factor, (vi) price escalation factor, (vii) financial terms, (viii) O/M costs, (ix) interest during construction (IDC), and (x) Equity-Loan Mix. Parameters used for the specific estimation are postulated and summarized in Data M in the Data Book. The work outcomes in accounting term are summarized below. Funds from all principal sources are presumably identified as line items in each of the project components in the financing plan, while being set out in terms of foreign currencies for and grouped in the tables herewith.

a. Funding Requirements by Project Component and Funding Source

In the context of the technical cost estimates as reflected in the preceding section, the financial costs of initial investment exclusive of interest during construction (IDC) are estimated at P. 274.8 million (US$ 30.2 million), P. 267.5 million (US$ 29.4 million), P. 286.7 million (US$ 31.5 million), and P. 279.4 million (US$ 30.7 million) as per 1998 price for the Alternatives 1, 2, 3, and 4, respectively. In addition, the aggregate financial costs inclusive of the costs of operation and maintenance worked out respective of P. 767.1 million (US$ 84.3 million), P. 776.2 million (US$ 85.3 million), P. 786.2 million (US$ 86.4 million), and P. 795.3 million (US$ 87.4 million), in that order above. Should the occasion arises, accumulated financial costs of the expedient borrowing of P. 273.0 million (US$ 30.0 million) for initial investment are estimated at respective of P. 1,116.6 million (US$ 122.7 million), P. 1,109.3 million (US$ 121.9 million), P. 1,084.7 million (US$ 119.2 million), and P. 1,084.7 million (US$ 119.2 million) for each of the Alternatives in ascending order from 1 through 4, while assuming the loan conditions of international lending institution[3]. Alternatively, the aggregate financial burden liable to the government of the Federal District (GDF) turned out to be P. 1,547.0 million (US$ 170 million) for each of the Alternatives considered when the fund comes from bi-lateral lending institution.

In a bid to take a glance at a number of figures alike, a summary table providing the above work deliverables, vis-à-vis, the aggregate project costs by project and cost components, and debt service accrued is given below as Table 8-47.

[3] Difference is made due to the variation in disbursement schedule during loan period. Note that, when borrowing is made from international lending institutions, interests accrued during loan period are capitalized, thus making different "principals" and associated amortization in the end of loan period and during repayment period.

Table 8-47: Financial Costs by Combination of Component and Funding Source

	Initial Investment	Recurrent Costs	Total 1/	Amortization	
				World Bank-type	OECF-type
Alternative 1					
Etapa IV	13.3	15.0	28.3		
Etapa V	5.9	28.7	34.6		
Sub-total	19.3	43.7	62.9		
Compost Plant	10.9	10.5	21.4		
Total	30.2	54.1	84.3	122.7	170.0
Alternative 2					
Etapa IV	13.3	15.0	28.3		
Etapa V	5.9	28.7	34.6		
Sub-total	19.3	43.7	62.9		
Compost Plant	10.1	10.5	22.4		
Total	29.4	55.9	85.3	121.9	170.0
Alternative 3					
Etapa IV	9.9	14.0	23.9		
Etapa V	10.6	30.4	41.4		
Sub-total	20.6	44.4	65.0		
Compost Plant	10.9	10.5	21.4		
Total	31.5	54.9	86.4	119.2	170.0
Alternative 4					
Etapa IV	9.9	14.0	23.9		
Etapa V	10.6	30.4	41.1		
Sub-total	20.6	44.4	65.0		
Compost Plant	10.1	12.3	22.4		
Total	30.7	56.7	87.4	119.2	170.0

1/ exclusive of interest during construction (IDC)

b. Funding Needs within DGSU by Option– "Income Statement" Analysis

Further, an approach attempted to harness the quantitative analysis of the direct fiscal impact on DGSU is adopted, while taking the expedient borrowing from external finance source in view. In this case, the fund replenished and used for procurement will be categorized in "source of funds", thereby leading to no account of "use of funds" within DGSU. With this, the analysis will be geared sequentially to the estimation of project costs excluding loan proceeds.

In line with the method of cost estimation adopted thus far, the fund requirements directly harness the fiscal position of DGSU worked out P. 767.1 million (US$ 84.3 million), P. 776.2 million (US$ 85.3 million), P. 786.2 million (US$ 86.4 million), P. 795.3 million (US$ 87.4 million), P. 1,611.6 million (US$ 177.1 million), P. 1,612.5 million (US$ 177.2 million), P. 1,598.5 (US$ 175.6 million), P. 1,607.1 million (US$ 176.6 million), P. 2,043.9 million (224.6 million), P. 2,052.9 million (US$ 225.6 million), P. 2,062.9 million (US$ 226.7 million), and P. 2,067.5 (US$ 227.2 million) for the options (Options) 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, and 12, respectively. It would be reminded that each of the options, vis-à-vis, Options 1, 2, 3, 4, Options, 5, 6, 7, 8, and Options 9, 10, 11, 12, are associated with the funding categories of own

fund, international lending institution-type, and bi-lateral lending institution-type, For easy reference, a summary table providing the above work deliverables is given below as Table 8-48.

Table 8-48: Finance Needs within DGSU by Option

Institutional Framework	Own Fund (US$ million)	External Fund	
		World Bank-type (US$ million)	OECF-type (US$ million)
All Components internalized (Alternative 1)	Option 1 – 84.3	Option 5 – 177.1	Option 9 – 224.6
FDSs-Internalized, CP-Externalized (Alternative 2)	Option2 – 85.3	Option 6 – 177.2	Option 10 – 225.6
FDSs-Externalized, CP-Internalized (Alternative 3)	Option 3 – 86.4	Option 7 – 175.6	Option 11 – 226.7
All Components Externalized (Alternative 4)	Option 4 – 87.4	Option 8 – 176.6	Option 12 – 227.2
Average	85.9	176.6	226.0

As attached, a summary of "income statements" numerically elucidating the overall cash flow structure in a time slice of the project period and loan repayment period by Option is provided in Table 8-49.

Table 8-49: Summary "Income Statements" by Option

	Alternative 1:LF1CP1									Alternative 2: FL1CP2								
Options	OF	EF-WB				EF-OECF				OF	EF-WB				EF-OECF			
	1	5				9				2	6				10			
year	Investm ent	Investm ent Outlay	Amortiz ation	Disburs ement	Net Outlay	Investm ent Outlay	Amortiz ation	Disburs ement	Net Outlay	Investm ent	Investm ent Outlay	Amortiz ation	Disburs ement	Net Outlay	Investm ent Outlay	Amortiz ation	Disburs ement	Net Outlay
1999	0.2	0.2		0.3	-0.03	0.2	0.03	0.3	0.00	0.2	0.2		0.3	-0.04	0.2	0.03	0.3	-0.01
2000	13.7	13.7		14.3	-0.62	13.7	1.5	14.3	0.47	13.7	13.7		14.9	-1.22	13.7	1.5	14.9	0.32
2001	16.0	16.0		12.9	3.15	16.0	4.2	12.9	7.02	13.9	13.9		11.0	2.84	13.9	4.1	11.0	6.99
2002	9.8	9.8		1.7	8.10	9.8	5.7	1.7	13.80	10.3	10.3		2.1	8.14	10.3	5.5	2.1	13.60
2003	9.0	9.0		0.8	8.12	9.0	5.9	0.8	14.07	9.9	9.9		1.7	8.24	9.9	5.8	1.7	13.08
2004	7.8	7.8	12.3		19.76	7.8	5.9		13.87	8.3	8.3	12.2		20.51	8.3	6.0		14.33
2005	3.4	3.4	12.3		15.29	3.4	5.9		9.41	3.9	3.9	12.2		16.05	3.9	6.0		9.86
2006	3.5	3.5	12.3		15.41	3.5	5.9		9.52	4.0	4.0	12.2		16.16	4.0	6.0		9.98
2007	7.6	7.6	12.3		19.48	7.6	5.9		13.60	8.1	8.1	12.2		20.24	8.1	6.0		14.06
2008	6.3	6.3	12.3		18.20	6.3	5.9		12.31	5.5	5.5	12.2		17.65	5.5	6.0		11.47
2009	3.8	3.8	12.3		15.73	3.8	6.2		10.01	4.0	4.0	12.2		16.14	4.0	6.2		10.12
2010	3.2	3.2	12.3		15.13	3.2	6.2		9.41	3.7	3.7	12.2		15.88	3.7	6.2		9.86
2011-2014			36.8		21.90		24.6		24.79			36.6		36.56		24.7		24.66
2015-2029							86.2		85.36							86.3		85.30
Total	84.3	84.3	122.7	30.0	127.10	84.3	170.0	30.0	224.6	85.3	85.3	121.9	30.0	177.2	85.3	170.1	30.0	225.6

	Alternative 3: LF2CP1									Alternative 4 LF2CP2								
Options	OF	EF-WB				EF-OECF				OF	EF-WB				EF-OECF			
	3	7				11				4	8				12			
year	Investm ent	Investm ent Outlay	Amortiz ation	Disburs ement	Net Outlay	Investm ent Outlay	Amortiz ation	Disburs ement	Net Outlay	Investm ent	Investm ent Outlay	Amortiz ation	Disburs ement	Net Outlay	Investm ent Outlay	Amortiz ation	Disburs ement	Net Outlay
1999	0.2	0.2		0.0	0.20	0.2	0.02	0.0	0.22	0.2	0.2		0.3	-0.03	0.2	0.03	0.3	0.00
2000	10.6	10.6		10.6	0.03	10.6	1.1	10.6	1.13	10.5	10.5		10.9	-0.39	10.5	1.1	10.9	0.76
2001	18.7	18.7		16.9	1.80	18.7	3.8	16.9	5.65	16.5	16.5		15.2	1.37	16.5	3.8	15.2	5.12
2002	10.3	10.3		1.6	8.69	10.3	5.7	1.6	14.39	10.8	10.8		2.1	8.76	10.8	5.5	2.1	14.23
2003	9.6	9.6		0.9	8.74	9.6	5.9	0.9	14.69	10.5	10.5		1.6	8.94	10.5	5.8	1.6	14.78
2004	8.4	8.4	11.9		20.32	8.4	6.0		14.43	8.9	8.9	11.9		20.81	8.9	6.0		14.89
2005	3.8	3.8	11.9		15.73	3.8	6.0		9.85	4.3	4.3	11.9		16.22	4.3	6.0		10.30
2006	3.4	3.4	11.9		15.28	3.4	6.0		9.39	3.8	3.8	11.9		15.77	3.8	6.0		9.85
2007	5.9	5.9	11.9		17.78	5.9	6.0		11.90	6.4	6.4	11.9		18.27	6.4	6.0		12.35
2008	6.8	6.8	11.9		18.75	6.8	6.0		12.87	6.0	6.0	11.9		17.95	6.0	6.0		12.03
2009	4.7	4.7	11.9		16.59	4.7	6.2		10.87	4.8	4.8	11.9		16.74	4.8	6.2		11.02
2010	4.0	4.0	11.9		15.92	4.0	6.2		10.20	4.5	4.5	11.9		16.41	4.5	6.2		10.69
2011-2014			35.8		21.90		24.8		24.79			35.8		21.90		24.8		24.79
2015-2029							86.4		86.36							86.4		86.36
Total	86.4	86.4	119.2	30.0	175.60	86.4	170.2	30.0	226.2	87.4	87.4	119.2	30.0	176.6	87.4	170.1	30.0	227.2

c. Indicative Repayment Schedule

Provided that GDF would intake the external fund for capital investment of US$ 30.0 million prior to the commencement of the project, this small part of analysis provides herewith an indicative amortization plan. In association with the assumptive parameters as given in Data M in the Data Book, the study reveals that the annual amortization that DGSU is liable will reach respective of P. 111.9 million (US$ 12.3), P. 110.0 million (US$ 12.2), P. 108.3 million (US$ 11.9 million), and P. 108.3 million (US$ 11.9) for each of the Alternatives, when the World Bank-type borrowing is assumed. Alternatively, DGSU is liable to debt services corresponding to the OECF-type lending with P. 56.4 million (US$ 6.2 million) per annum. It would be noted that the amount of annual debt service varies where disbursement schedules and associated interest during construction are different among Alternatives thus by making the alternation of accumulated principals in the end of loan period. Indicative loan repayment schedules for the expedient loan of US$ 30.0 million with the prospective interest rate at 20 percent per annum is attached in Annex H. Year average interest rates on outstanding deposits is given in Data M in the Data Book.

8.5.3 "Totem Pole" Evaluation - Preferential Order Amongst Implementation Order

Affordability as well as ability to pay attached to GDF/DGSU are quantifiably investigated on a set of assumptions and provided herewith in a bid to offer a reference for taking further step in the long and arduous processing within the concerned administrative machine (s).

a. Ability to Pay: Aggregate Project Costs

a.1 Funding Sources

From what the analysis numerically exhibited in the accounting analysis of funding needs in Section II.7.5.2 in Annex II, it will be deduced that fiscal impact over the years of project duration is least when the project is financed by internal fund within GDF, followed by the cases of World Bank (WB)-type lending and Overseas Economic Cooperation Fund, Japan (OECF)-type lending. Cost ratios of the borrowing options reach 1.92 and 2.63 on average basis respectively, given the cost by own fund being set at unit (*i.e.*, 1.0). This is simply because the two sources of external borrowing carry amortization besides project cost, where the overall cost by OECF-type lending outnumbers that by WB-type due to the longer repayment period. The funds required in average during the project period are figured out at US$ 85.9 million, US$ 176.6 million, and US$ 226.0 million for respective of own fund, WB-type lending, and OECF-type lending (refer to Table 8-48). Consequently, this outcome places self-financing at the top of "Totem Pole" of preference, followed by WB-type and OECF-type loans in descending order. Once for all, the alternative cases will be lined up in descending order of Option 1, Option 2, Option 3, Option 4 (thus far Own Fund cohort), Option 5, Option 6, Option 7, Option 8 (so far WB-type funded), Option 9, Option 10, Option 11, and Option 12 (thus far OECF-type funded).

a.2 Institutional Framework

Amongst the institutional alternatives under the own finance, the case of all the three components being internalized (Alternative 1) is observed most favorable, followed

by the choices of final disposal sites (BP E-IV and V) under DGSU (Alternative 2), compost plant under DGSU (Alternative 3), and BP E-V and compost plant being all externalized (Alternative 4), in descending order. This line of preference evidently imparts a numerical proof of fiscal burden that DGSU would be liable to the prospective "contract out" treaty with the private firm(s) involved. It would be noted, notwithstanding, that it would be misleading if the analysis on preference order are confined to the categories of external borrowing simply because they do attach bias to the order with a large weights of debt service.

b. Affordability of DGSU – Annual Fund Needs within DGSU

In tandem with the total cost of project that has to be committed once for all prior to the project implementation, at issue in the alignment and placement of alternatives in the order of preference is the investment outlays that invariably draw a substantial part of public expenses allowed to GDF/DGSU every year. In search of the alternatives that are to be "friendly" to the fiscal position of DF government and DGSU, the accounting cash flows associated with each of the options have been investigated by categorically dividing the outlays into three parts in chronological order, notably, initial investment, operation and maintenance inclusive of intermittent investments for replacement, and amortization, with the ceilings of cash-outlay presumably benchmarked at US$ 10.0 million, US$ 13.0 million, and US$ 7.0 million per annum, in that order.

In so doing, annual finance needs within DGSU, that is the investment expenses exclusive of initial investments being covered by the loan, has been taken into consideration. Within this analytical framework, combined with the grades of 1 through 5 assigned in accordance with the annual cash-outlays estimated, the order in "Totem Pole of Preference" turned out to be almost in line with what had been seen in the analysis of the Ability to Pay except that amongst the WB-type and OECF-type lending. Grouped in cascading preference blankets, the Option 1 showed off its robustness in numerical line-ups, followed by the Options 4, 11, and 12 in the second tier, Options 3, 9, and 10 in the third tier, Options 8, 7, and 2 in the fourth, and eventually Options 5 and 6 in the end. It should be noted, however, that the outcome as demonstrated thus far is only indicative and might be subject to alteration depending on the variables and parameters adopted in evaluation.

A Totem Pole of preferential order with each of the options in the queue by size of aggregate fund needs is depicted as Figure 8-26.

Excellent

Good

Fair

Poor

Terrible

Preferential Order

Tctempole-Evaluation (Annual Finance Needs)

I	*Option 1*				
II	*Option 4*	*Option 11*	*Option 12*		
III	*Option 3*	*Option 9*	*Option 10*		
IV	*Option 8*	*Option 7*	*Option 2*		
V	*Option 5*	*Option 6*			

Preferential Order

Totempole-Evaluation (Aggregate Costs and Annual Finance Needs)

I	*Option 1*	*Option 4*			
II	*Option 2*	*Option 3*	*Option 12*		
III	*Option 5*	*Option 6*	*Option 7*	*Option 8*	*Option 9*
IV	*Option 10*	*Option 11*	*Option 12*		

	Evaluation Criteria				
		Annual Expenses			
Option	Project Cost	Initial 5years x<=US$10mil	Operation x<=US$13mil	Amortization x<=US$7mil	Consolidated Points
Option 1	1	2.5	5.0	4.8	2.8
Option 2	2	3.0	5.0	4.6	3.0
Option 3	3	3.5	5.0	4.8	3.3
Option 4	4	4.0	5.0	4.8	3.5
Option 5	5	4.3	2.0	2.6	2.8
Option 6	6	4.6	2.0	2.6	2.9
Option 7	7	4.8	2.0	3.0	3.0
Option 8	8	5.0	2.0	3.0	3.1
Option 9	9	4.0	4.0	3.5	3.2
Option 10	10	4.0	4.0	3.5	3.2
Option 11	11	4.2	4.0	3.5	3.3
Option 12	12	4.2	4.0	3.5	3.3

Figure 8-26: Totempole Evaluation - Preferential Order Amongst Options

c. Soundness of Public Finance in DGSU

Should the borrowing from external source be considered by GDF/DGSU, it would be appropriate to quantitatively measure the fiscal impact of amortization in DGSU. Debt Service Ratio (DSR), which is commonly used as a proxy index to represent soundness of public finance, with the whole revenue and own revenue as denominators worked out respective of 6.7 percent and 12.2 percent with P. 2,609.4 million (US$ 286.7 million equivalent with the quotation at P. 9.1/US$ in September 1998) of debt service authorized by Congress for the year 1998[4]. While considering the expedient loan of about US$ 30.0 million, an incremental portion of debt service as borne by DF government corresponds to 0.3 percent at maximum and 0.05 percent at minimum reaching respective of 12.5 percent and 12.25 percent on *Ceteris Paribus* condition[5], well below the generally accepted critical line of DSR 25 percent.

Budget allocation to DGSU for the year 1999 is allegedly P. 992.1 million with a little as 3.2 percent of increase in nominal term. Keeping this in view, the share of amortization associated with the presumptive loan amount of P. 273.0 million (US$ 30.0 million) out of the annual budget would range mostly between around 4 percent to 20 percent or 25 percent at maximum for the categories of own fund and WB-type lending, whereas mostly 5 percent to 15 percent at maximum for OECF-type lending.

d. Policy Implication

With due recognition of the rung of financial hardship that GDF/DGSU would have to endure annually in the forthcoming time-slice of 12-year-period of project implementation, it would be commendable that the project would be financed by own fund, IF and ONLY IF (i) the government in 1999 could decisively commit to the budget allocation of around US$ 30 million for initial investment during 1999 to 2003, and (ii) DGSU could deliberately carry the annual fiscal burden and recurrent costs accrued that accounts for around 10-17 percent of the total DGSU budget annually after the year 2004[6]. Should the occasion arise when DGSU has to consider funding sources embracing external borrowing, it would be recommended that DGSU borrow funds in line with the OECF-type loan conditions where no-capitalized interest to principal and longer repayment period are assumed. This type ensures the lower principal surmounted in the wake of full disbursement of loans, and smaller amortization in the following repayment years.

Nonetheless, it would be noteworthy that the World Bank-type loan be considered where DGSU is not liable to amortization during the initial construction period. While high obligation of debt service during the repayment period is assumed in this case, financial burden during the initial investment period is much lesser than the other two funding sources. This is a kind of trade-off issue between the amortization plans of "continuously so" and "First easy go and later very tough"[7].

---

[4] Source: HACIENDA, *Informes sobre la Situacion Economica, las Finanzas Publica y Deuda Publica, Acciones y Resultados del Primer Trimestre de 1998*, May 1998

[5] *DSR* herewith is being defined as debt service over own revenue of DF in 1998.

[6] In the case of all the sub-components being internalized.

[7] In favor of the World Bank type lending, inflation and possible increase in budget allocation to DGSU in conjunction with economic recovery and sound management of macroeconomic policy in Mexico would lessen the financial burden in the years to come.

In the meantime, the mission was advised that the approved line of credit accorded to DGSU for the year 1999 was around P. 356 million (equivalent to US$ 39.1 million as per P.9.1 per dollar).

Lastly, and not more than a reference for the comprehensive understanding on the ordering of preference, the evaluation outcomes are lined up in the Totem Pole by project cost and annual cash-outlays with the specific weights of 0.1 and 0.9 attached respectively. Option 1 came ahead of others with the followings in descending order, that is, Option 4, Option 3, Option 2, Option 6, Option 7, Option 8, Option 9, Option 5 in the second tier, and Option 10, Option 11, and eventually Option 12 came in the end.

8.6 Environmental Impact Assessment (EIA)

8.6.1 Scope of EIA Work

a. Background

As stated in Section A.5, Mexico has a legislative base for the realization of EIA for projects with potential environmental impact. The principal structure is given by the LGEEPA, which are in turn supplemented by several regulations on specific issues including EIA. While these are enforced at the federal level by the SEMARNAP, there are bylaws on general environmental matter and regulations on EIA which are issued by local governments (at state, municipality and DF levels) due to the progress of decentralization.

According to the LGEEPA, waste management projects for municipal waste is under the jurisdiction of state governments, and so is the EIA procedure for those projects[8]. The EIA for the proposed F/S projects were, however, considered to follow the EIA guidelines of general modality issued by the SEMARNAP for the following reasons.

- The proposed land is geographically within the State of Mexico but the land is owned and controlled by the CNA. Therefore, the EIA process would have to involve both organizations and the EIA reports should have to be satisfactory for both the SEMARNAP's EIA guideline and the EIA regulation of the State of Mexico.
- In spite of the above, the EIA regulations of the local states, including the State of Mexico, largely follow the SEMARNAP's EIA guideline and there is little disparity. In other words, EIA which is carried out based on the SEMARNAP's guideline should meet the EIA regulation of the State of Mexico.
- The Federation is responsible of protecting environment in the federal area.

b. Screening and Scope of the Work

Section 7.7 described the screening process where it was concluded that the EIA studies for the Etapa V project and the composting plant were to be undertaken by the team. For those two, scoping was attempted whose summary is as presented in Table 8-50 (see Tables in Section 7.7 of this report for detail).

[8] The EIA regulation of the State of Mexico defines projects subject to the EIA procedure of the state, which include installation and operation of a treatment plant and a final disposal site for municipal solid waste.

Table 8-50: Summary of Scoping

Evaluation Factors	BP V	Composting Plant
Social Environment		
Resettlement		
Economic Activities		
Transport		
Public Facilities		
Division of Community		
Historical Heritage/Cultural Properties		
Water Rights/Access Rights		
Public Health	B	B
Waste (from the project)		
Accidents/Risks	B	B
Natural Environment		
Topography and Geology		
Soil Erosion		
Groundwater	B	B
Hydrological Conditions		
Coastal Zone		
Fauna and Flora	C	
Meteorology		
Landscape/ Aesthetics	B	
Pollution		
Air Pollution	B	B
Water Pollution	B	B
Soil Contamination	B	B
Noise and Vibration		B
Land Subsidence		
Offensive Odor	B	B

In the table above, B refers to factors on which the project might have impacts if not well engineered or operated and C represents a lack of site information to determine whether adverse impacts are expected. Some factors with B also suffer a scarcity of base information.

For the EIA of the Etapa V project and composting plant project, Table 8-50 presents a scope of the EIA study: which factors should be paid careful attention (factors of white cells with letters B or C) and which are necessarily not (factors of shaded cells). It should be noted, however, that the scoping was attempted in the IEE process with limited resources at the initial stage of the study.

8.6.1.1 Present Environmental Setting

I Physical Aspects

a. Climate

Section A.1.3 of Annex A describes the climate of Mexico City. In considering waste management projects in ex-Lake Texcoco area, the following should be kept in mind.

- Annual rainfall is about 600 mm/year, while annual evaporation is 1,800 mm/year.

- Rainfall is concentrated in the rainy season, i.e. June, July, August and September. These months may have more than 150 mm/month of precipitation. On the other hand, the dry season may have rainfall no more than 5 mm/month.

b. Geomorphology and Geology

According to the previous study by Moro company (1992)[9], geology of the area of the ex-Lake Texcoco and its surrounding area consists of aluvial deposits, lacustrine deposits, lime-sand toba, volcanic brecha, andestine lava and "suelos tobáceos y pumíticos derivados de lluvia de ceniza", but within the ex-Lake Texcoco area, lacustrine deposit predominates, reflecting the history of its formation.

This lacustrine deposit is a plain comprising a number of sequential clay strata with some occurrence of volcanic sand, lime and glass. The total depth of this formation is assumed to be about 180m.

c. Soils

The soil studies were conducted by the JICA team. Although soil studies in the composting plant site was not carried out, oral communication with the counterpart and visual observation concluded that the soil type is fairly similar to that in Etapa IV, the closest landfill site.

Accordingly, it is understood that the soil type of the area is largely clay which is extended down to 50 m depth. This clay formation shows significantly high water content. Therefore it is considered that the stratum is soft and compressible.

d. Hydrology

d.1 Rivers and Canals

Several rivers flow into the ex-Lake Texcoco area. Although they are called rivers (Ríos), as a matter of fact, it should be more appropriate to call them canals. Their prime role is to serve as open sewerage receiving wastewater from residential areas of the DF and some of the municipalities of the State of Mexico. For this reason, they are found to be a nuisance for residents who are exposed to their unfavorable odor.

Those canals are, from northeast, the Río San Juan Teotihuacán, Río Papalotla, Río Xalapango and Río Coxcacoaco; from east, the Río Texcoco, Río Chanpingo, Río San Bernardino, Río Santa Mónica and Río Coatepec; and from south, the Río San Francisco, Río Churubusco and Río de la Compañía. In terms of the flow volume, Río Churubusco and Río de la Compañía are the main water ingress into the area, with flow volume of 10.0 and 4.2 m^3/sec on average[10], while the total flow volume of the others is merely 0.4 m^3/sec and it could be nearly zero in the dry season.

In general, water in the area finally find its way at canals *Canal de Desagüe* or *Canal de las Sales* both of which flow from south to north on the west edge of the ex-Lake Texcoco area. They join another large canal *Gran Canal* in the north of the Solar Evaporator (*Caracol*), and the Gran Canal runs towards a lake Lago Zumpango and further north.

---

[9] Estudios y Proyectos Moro, S.A. de C.V., *Estudio Geologico-Geohidrologico de Detalle en la Zona de Brodo Poniente, Estado de Mexico*, August 1992

[10] Data from Texcoco Project

d.2 Water Bodies

There are four major water bodies in the area; Lake Churubusco, Regulation Lake, Lake Xolapango and Lake Nabor Carrillo. All of those are the major accomplishment of the early 80s by the Texcoco Project to control the surface hydrology of the area. Total capacity of them is approximately 50 million m^3, of which Lake Nabor Carrillo has the capacity of 36 million m^3.

Apart from the hydrologic purpose, they are also important in serving as a host of migratory birds during winter.

d.3 Underground[11]

Interestingly, the surface clay stratum is peculiar to the ex-Lake Texcoco area. Once stepping out from the area, it becomes thin and eventually disappears. Within the area, the stratum has a depth of more than 50m according the JICA Team's field survey, and 40 to 90m according to Moro company (1992). Regarded as an aquitard, this stratum is mostly saturated with water, and the groundwater table is found at only 1.2m to 0.03m depth from the ground surface. It could be much shallower in rainy season.

The water (referred to be "shallow groundwater") in this geological clay formation is so saline that salt making was actively operated in the area. Alkalinity is also high. Rudolph, *et al.* (1989)[12] reported 80,500 ppm and Moro company (1992) reported 90,000 ppm. Because of the high salt content in this shallow groundwater, it is not used for human consumption.

Below this stratum is another aquifer which extends not only the ex-Lake Texcoco area but also wide part of the Mexico Valley. It is mostly made of sandy material with occasional occurrence of lime or clay horizontal layers. This is the aquifer from which water has been exploited for years to serve for public and industrial use particularly extensively in the south of Mexico City, although there is now restriction to extract this groundwater due to the land subsidence caused by over exploitation.

The depth from the ground surface to this deeper aquifer is about 80m, and the thickness is thought to be 100 to 400m.

II. Biological Aspects

a. Flora and Fauna

a.1 Flora

Vegetation of the ex-Lake Texcoco area is poor because of the saline soil. Most part of the area is merely covered with pasture *Distichlis spicata* which is resistant to salinity. Land with lower salinity may allow other species to grow, but overall, species richness is substantially low. Trees or shrubs are rare.

---

[11] Data obtained from JICA team's field survey, Moro (1992) and ABC (1993)

[12] Rudolph, Herrera, Yates (1989), *Groundwater flow and solute transport in the industrial well fields of the Texcoco saline aquifer system near Mexico City,* Geofiscica International, vol.28-2 (adopted from ABC (1993))

a.2 Fauna

To the contrary, the area provides habitats to diverse species of animals. Among those, a wide range of birds can be found.

A Mexican official norm NOM-059-ECOL-1994 establishes a list of species which are categorized as rare (R), threatened (Th), endangered of extinction (Ex), or to be specially protected (Pr). Out of species found in the project site during the field investigation, the following ones fall into one of these categories.

In the Etapa V landfill site:

Reptiles: *Guerrhonotus liocephalus* (R), *Salvadora bairdii* (R), *Thamnophis eques* (Th), *Thamnophis scaliger* (Th), *Pituophis deppei* (Th)

Fowl: *Buteo jamaicensis* (Pr)

In the composting plant site and its surrounding:

Fowl: *Anas acuta* (Pr), *Anas discors* (Pr), and *Buteo jamaicencis* (Pr) (all are directly observed)

Reptiles: *Thamnophis Scaliger* (Th), *Pituophis deppei* (Th) and *Guerrhonotus liocephalus* (R) (all are only found in bibliography)

Mammal: *Peromiscus maniculatus* (Th) (only found in bibliography)

b. Ecosystem and Landscape

The land formation history of the ex-Lake Texcoco area suggests that the land was formerly under the lake and experienced a drastic change to become what it is. As a result, the ecosystem of the area was largely distorted.

Accordingly, the CNA has been taking care of the area and making efforts to restore the ecology.

The other characteristics of the area is that extensive hydraulic works take place. The control of water movement is managed exclusively by CNA. The major environmental interests are that most of water is in fact wastewater discharged from the metropolis and that the presence of large quantity of water, especially Lake Nabor Carrillo, receives migratory birds from north America during winter.

Under such conditions, the following is generally concluded.

- The ecology of the area has been deteriorated by human manipulation for centuries.
- Its severe environment with salinity has excluded most of wildlife, but because of its peculiarity, it also possesses unique species (see previous section).
- Because of the presence of the canals, water environment in the area may be giving a health hazard, but interestingly also serves for the avian ecology.

In regard to the tourism, the area is not and will not be supposed to be a tourist place. There is no historical heritage or archaeological asset in and around the area.

The area is fairly flat and arid, not giving an aesthetic landscape.

III. Socioeconomic Aspects

The ex-Lake Texcoco area is within the Mexico Valley Metropolitan area and lies next to Ecatepec and over the borders of other several municipalities in the state of Mexico, namely Nezahualcoyotl, Texcoco, Atenco and Chimalhuacan. Being adjacent to the DF where massive scale of productive activities concentrate, those municipalities have experienced rapid population growth.

As shown in Table 8-51, almost all households enjoy electricity supply. Except Chimalhuacan, the provision rate of public sewerage of the other four is higher than the average of the State of Mexico. Ecatepec, Nexahualcoyotl and Texcoco have higher provision rate of piped water in house.

Table 8-51: Public Service Provision Rate (1995)

(unit: % of households)

	Public Sewerage	Piped water in house	Electricity
State of Mexico	*84.9*	*49.1*	*97.6*
Atenco	86.3	37.0	99.1
Chimalhuacan	82.8	11.5	98.7
Ecatepec	93.5	57.6	99.4
Nezahualcoyotl	99.2	57.6	99.7
Texcoco	88.3	59.7	98.9

Source: INEGI

8.6.2 EIA for the Composting Plant

8.6.2.1 Description of the Composting Plant Project

Table 8-52 shows the summarized outline of the composting plant project.

Table 8-52: Description of the Composting Plant Project

Aspects	Description
Basic Features	
Project Location	The Federal Zone, ex-Lake Texcoco area.
Land Area	Around 36 ha occupied by the plant
Activity	Treating organic waste by a controlled aerobic decomposition to produce compost product which is used as soil conditioner and/or cover soil for waste landfill.
Type of waste accepted	Separated organic waste in the sub-system. Estimated composition is organic (dry) 13.6-23.6% and water 68.0-78.0%.
Structure of the plant	
Access	Entrance from Periferico (the Peripheral Ring Road).
Internal road	One outer road and one center road
Construction Procedure	
Construction stage	in 2001 750 ton/day capacity composting section 240 ton/day capacity curing section 300 ton/day capacity separation section in 2002 250 ton/day capacity composting section 80 ton/day capacity curing section in 2003 250 ton/day capacity composting section 80 ton/day capacity curing section

Aspects	Description
Land preparation in 1999 to 2000	Construction waste compacted up to 2m height, gravel of 0.5m thickness, then sandy soil of 0.5m thickness.
Operation	
Operation stages	Operation starts in 2002 with capacity of 750 ton/day composting section, 240 ton/day curing section and 300 ton/day separation section. Operation size rises to 1,000 ton/day in 2002, and 1,250 ton/day from 2003 onwards.
Operation sequence	Waste is shredded into pieces by a shredder and formed into windrows, undergoing aerobic decomposition for 28days. Young compost is transferred to curing to be decomposed by fungi. After 120days, impurities are removed from the mature compost and the product is shipped out. Rejected waste is disposed of at Etapa IV or V.
Rejected waste	96 ton/day to be disposed of (assuming 1,250 ton/day input).
Products amount	167.9 ton/day (assuming 1,250 ton/day input)
Sub-products amount	1.7 ton/day of metal to be recovered (assuming 1,250 ton/day input)

8.6.2.2 Analysis of the Environmental Impacts

Through the process of IEE shown earlier, it was concluded that the environmental impact would be identified in the following aspects.

- Public health.
- Accidents/Risks.
- Groundwater.
- Air Pollution.
- Water Pollution.
- Soil Contamination.
- Noise.
- Odor.

Examining the current site condition and the construction and operation process, IEE was reconsidered and concluded that the other environmental items, i.e. those which were ranked as D in the IEE, will not be affected by the project. The reasons for their exclusion are shown in a table in Section 7.7 of this report. The exception is about fauna because ecologically valuable species are found, hence this aspect is included in analysis.

a. Public Health

Public health can be adversely affected by the composting plant project for the following reasons.

1. Waste scattered from the waste trailers which deliver waste from its origins to the plant due to the mismanagement of waste delivery.
2. Offensive odor emitted from putrescible waste.
3. Proliferation of vector.
4. Loud noise emitted by the use of machinery.
5. Dust caused in the turning process and machinery.

Items 1 and 3 are examined below, and the others will appear in the later sections.

a.1 Mismanagement of Waste Delivery

Careless delivery of waste may allow waste to be scattered along the transportation routes and around the composting plant, resulting into the degradation of city beauty and public health.

Meanwhile, the DGSU has been using tarpaulin to cover waste on the trailers in order to avoid waste scattering. It is observed that the tarpaulin has been achieving a satisfactory result to overcome this problem.

Since **this practice is continued**, waste will not be significantly scattered to degrade the city cleanness or public health. **It is ensured by regular monitoring that the tarpaulin does not have large holes or tears though which waste might escape from the trailers.**

a.2 Vectors Proliferation

Organic waste attracts wide range of pathogens (i.e. disease-causing bacteria) and vermin (or disease vectors such as fly, mosquitoes, rats, etc. which transmit pathogens) and hence can potentially increase the incidence of diseases in surrounding population and the plant workers.

It is intended that waste is first subject to aerobic decomposition in the proposed composting plant. In the aerobic decomposition process, easily biodegradable organic matter, which is also the source attracting pathogens and vermin, is quickly decomposed. They are no longer readily available for those annoying fauna.

Aerobic decomposition will also raise the temperature of waste about 55 degrees centigrade. Since most pathogens are susceptible to heat, it is expected that the number of pathogens decreases significantly as aerobic decomposition proceeds, and vermin will not approach to such hot material.

Therefore, **aerobic decomposition, if successfully controlled**, will minimize the population of pathogens and disease vectors and limit the spread of diseases. Furthermore, residents live sufficiently far from the plant, thus they are unlikely to be affected by the annoying animals from the plant. Nevertheless, the newly delivered waste will attract pathogens and vermin, and there should be a certain amount of such young waste in the plant at any time. Therefore, **the plant workers working near the raw material are instructed to wear appropriate clothes and equipment** to prevent from being exposed to disease vectors and pathogens.

b. Accidents/Risks

Methane is explosive when it accounts for 5% of air. Methane associated with waste management, however, originates in methanogenic decomposition taking place in an anaerobic process. In the windrows which operate aerobic decomposition, it is unlikely to produce methane. If it should be produced, it will be easily dispersed into the air. During curing, anaerobic decomposition may take place in the deep section, but decomposition process is very slow. Thus gas generation will not significant.

Carbon dioxide is formed as a result of aerobic decomposition of organic matter and hence the plant will produce it. Human being will be asphyxiated if exposed to high concentration of carbon dioxide for hours. At the composting plant, however, carbon dioxide is produced at the windrows in open air and immediately diffused.

Therefore, the said risks or accidents should be unlikely to happen.

c. Groundwater

Groundwater contamination is anticipated to occur under a situation where leachate infiltrates into the soil and reaches to an aquifer.

Leachate intrusion into the aquifer, however, is only probable when there is enough leachate to fill all available pore space in the subsoil above the aquifer. In other words, leachate quantity matters. Although it is significantly difficult to numerically express the amount of leachate to be produced, the proposed composting plant will not yield much leachate for the following reasons[13].

- Meteorological data shows that precipitation is about 600 mm/year and evaporation is about 1,800 mm/year on average near the ex-Lake Texcoco area. The latter is by far greater than the former. Unlike a waste landfill which utilizes cover soil, waste in windrows is directly exposed to the air, hence waste is always prone to be dry.
- **Moisture content is strictly monitored and controlled to maintain the most favorable condition for decomposition, either by spraying water or encouraging evaporation using a turner.** It is noteworthy that turning was proved to be an exclusively effective countermeasure against flooded compost in the DGSU's existing composting plant during the rainy season of 1998, when abnormally much rainfall was recorded.

Nevertheless, taking the very high water table in the site into account, once leachate, even small amount, seeps into soil, it will readily meet with superficial groundwater. Althoughthe environmental impact given by this leachate may not be simply ignored, it is to be reminded that this groundwater is not used by people.

It is considered that leachate seepage into the soil will probably be a small amount; it does not contain toxic substances but high concentrations of organic matter; it will only very slowly flow with groundwater which is not used by humans; and groundwater in the deeper aquifer unlikely will be polluted.

d. Flora and Fauna

Field investigation revealed that flora of the area is not of particular interest, while its fauna includes important species to which special attention should be paid. Environmental impact on those species is anticipated.

Therefore, those environmentally valuable species are carefully transferred outside of the site, so that the reduction in their population is avoided.

e. Air Pollution

Air is anticipated to be polluted by traffic of waste trailers, dust raised from windrows when the shredder and the turner are used, and biogas generation. The latter was already discussed in Section b. Pollution due to the first two would increase the incidents of respiratory diseases and eyes irritation.

[13] It is empirically known that a windrow composting plant produces little leachate and it commonly operates without being provided with impermeabilization.

Regarding the traffic of waste trailers, the proposed project does not largely change the current traffic mode, thus the increase in pollutants emission attributable to the project should be minimum. At present, it is well known that the road traffic is the major cause of the air pollution in the DF, but the contribution of waste trailers traffic is negligible.

As for dust from windrows, the problem is highly local and the recipients are exclusively the plant workers. **To minimize the dust effect, the workers are urged to use appropriate clothes, masks and eye protectors and the site managers take care of their health condition.**

f. Water Pollution

Water pollution could be found in groundwater and surface water, and the groundwater issue has already been discussed.

The adjacent surface water is *Brazo Izquierdo Río Churubusco*. The effect on it by leachate is to be considered in terms of quantity and quality, as shown in the section of groundwater.

The migration of leachate to the canal will be through groundwater or via ground surface. Regarding the first route, groundwater contamination with leachate will not be significant as discussed earlier, therefore groundwater will not contaminate the canal.

On the other hand, surface runoff which might contain organic matter and probably surface soil and compost particles may flow into the River Churubusco when it rains hard. However, the problem will be insignificant since this will be an occasional event when the runoff exceeds the water absorption capacity of the platform. Moreover, the runoff is intercepted at the embankment along the river and eventually evaporated.

g. Soil Contamination

Soil contamination is a concern because it may cause groundwater pollution, degrade ecosystem within the soil, and restrict the future land use resulting in land devaluation.

The first issue has already been discussed under the title of groundwater.

As for the ecosystem, there are three items to be considered. One is that the **leachate infiltration occurs only when the control of moisture content is not successful.** Another is an effect by toxic material. Leachate produced at the proposed composting plant should not contain toxic substances that may impact the ecosystem, since waste **handled at the plant should contain few sources of toxicity.** The other is an effect by organic matter. Leachate containing high concentrations of organic matter may change the living environment for microorganisms in the subsoil and, in turn, change the structure of ecosystem. This change, if any, should not be negative.

In regard to the restriction of future land use, there are two key issues to be taken into account. Firstly, the land use in the project site is already restricted by its high salt content. Secondly, soil will be contaminated not by hazardous substances but by organics, which will be decomposed slowly but partly accumulated in soil for years little by little.

Generally speaking, soil containing excessive organic matter may fall in short of oxygen, then produce gases such as methane and hydrogen sulfide. Thus, excavation before construction works could be risky. But it is only the case where exist commonly expected biological activities. In the present case of the composting plant site, however, **leachate seepage is limited in volume, and organic matter will be degraded only in a slow manner.** Therefore, soil contamination with organic leachate would not restrict the land use options. Even if it should do so, the extent of restriction should be by far smaller than that due to salinity.

h. Noise

The plant will use a shredder to shred waste and a turner to turn waste in windrows to supply oxygen. These equipment can be a source of loud noise which might disturb the daily life of adjacent residents and/or have an adverse health effect on the plant workers.

Regulations in Mexico in regard to noise stipulate the following.

- Noise in the environment should not be louder than 68dB giving care to the surrounding residents and fauna (NOM-081-ECOL-1994).
- Noise in the working areas to protect the health of workers is defined by NOM-011-STPS-1994 which establishes the permissible maximum time of exposure to noise expressed by Continuous Sound Level Equivalent (NSCE)[14] as follows.

Table 8-53: Permissible Maximum Time of Exposure to NSCE

Time (Hours)	NSCE (dB)
8	90
4	93
2	96
1	99
0.5	102
0.25	105

Both the shredder and the turner produce noise of 85dB from 1m away at the 1.5m height according to the technical specification. Background noise level is assumed to be at 50dB.

If the shredder and the turner are working very closely, the noise level from the two will be 88.01 dB by using equation (ii). Since **the buffer area has 100m width**, the noise level at the periphery of the plant will be 50 dB using equation (i). Combining this and background noise, the resulted noise level is 53dB.[15] It is sufficiently below the permissible limit of 68dB.

As regards the second standard, the noise level of machinery, i.e. 85dB, combined with the background noise level, can be assumed to be the NSCE for the machine

[14] NOM-011-STPS-1994 gives a guide to obtain Continuos Sound Level Equivalent (NSCE: Nivel Sonoro Continuo Equivalente) in case where the workers are exposed to noises with different intensity for different period in their work day.

[15] Letting two noise levels A(dB) and B(dB) (A>=B), and when the disparity A-B is given, the value d=B-A is empirically known, where C(dB) is the compound noise level of A and B. In this case, A-B=0(dB) and d=3(dB).

operators who work near the turner or shredder for eight hours. The synthetic noise still remains 85dB[16] and exposure to 85dB noise for eight hours is within the permissible limit set by the norm, thus no health hazard is anticipated. Even when the shredder and the turner come close each other, the combined noise level will be 88dB, which should not be a serious problem.

Nevertheless, some plant workers may be vulnerable to noise less louder than the permissible level. **Putting appropriate clothes and protectors and regular health consultation are recommended.**

i. Offensive Odor Emission

Offensive odor is nearly unavoidable in solid waste management. It will be a minor issue for the majority, but can be extremely serious for limited population.

Culprits of offensive odor emitted from waste are gases such as ammonia (NH_4), hydrogen sulfide (H_2S) and methyl mercaptan (CH_3SH) which are mostly generated as the end products the anaerobic decomposition of readily decomposable organic matter.

On the other hand, the plant is planned to operate a windrow system of aerobic decomposition. Waste will be mixed with air by periodical turning to maintain oxygen in waste. Therefore, **well managed aerobic decomposition minimizes the production of malodorous gases.**

In conclusion, odor produced in the early stage of composting is the most significant. Since the plant design shows that a curing area with much less odor is laid out in a portion closest to the residential area, odor will not affect the adjacent residents. **The plant workers are instructed to wear appropriate clothes and masks.**

8.6.2.3 Conclusion

The previous section described the possible causes and effects on the environment given by the composting plant and the extent of the problems. Figure 8-27 is a diagram to show the discussion schematically.

[16] Following the above, A-B=3.5(dB) and d=0(dB)

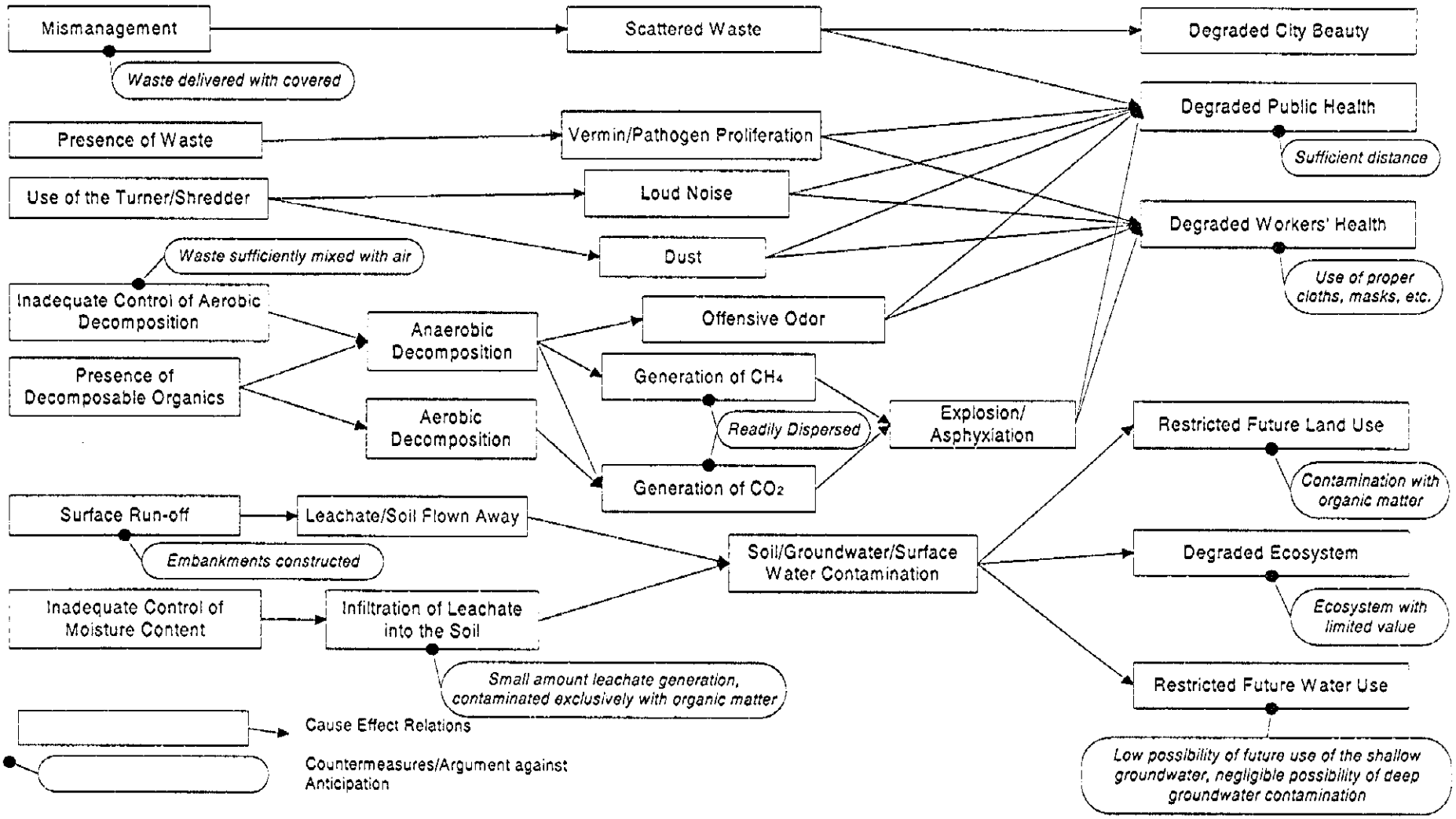


Figure 8-27: Cause Effect Relations (Composting Plant Project)

In conclusion, any major environmental adverse effect is not anticipated. This is, however, based on the several preconditions which were indicated with bold letters. The failure to meet them may result in serious environmental impacts. Compliance with those preconditions and recommendations has to be ensured by controlled operation. These are shown in Table 8-54.

Table 8-54: Preconditions to Prevent Environmental Impacts

Preconditions	Consequence of Failure	Method of Control
A. During the waste transportation, waste is covered with a sheet over the trailer.	Waste is allowed to fall and city beauty and public health will be degraded.	Periodical check of sheets. Use of the sheets to be acknowledged to all workers.
B. Aerobic decomposition in the windrow is securely controlled.	Explosive methane and trace gases with offensive odor will be generated and endanger the adjacent residents and plant workers.	Aerobic decomposition is monitored by measuring temperature and moisture content within the windrows.
C. Water content is carefully controlled.	Leachate infiltrates into the subsoil and reach the high groundwater table when it rains hard.	Regular measurement of water content. Frequent turning may necessary in the rainy season.
D. Organic waste is satisfactorily sorted at its source in the sub-system.	Leachate may contain toxic substances which should not be allowed to be seeped into the subsoil.	Education of waste generators. Compost product quality to be controlled periodically.
E. Embankments is constructed.	Runoff water may bring leachate, soil and compost particles to the surface water.	Plant to be carefully designed. Embankments to be well maintained.
F. The plant workers are provided with proper clothes and protection.	Gases, waste-borne diseases, noise and dust will degrade the workers' health.	Code of plant operation to be prepared. Workers' health to be regularly checked.

Note: Problem D. is to be raised only when problem C. is present.

8.6.3 EIA for the Etapa V Project

8.6.3.1 Description of the Etapa V Project

The description of the Etapa V new landfill project is summarized in Table 8-55 below. Detailed descriptions are presented in Section H.2.2.2 of Annex H.

Table 8-55: Description of the Final Disposal Site Project at Etapa V

Aspects	Description
Basic features	
Location	The Federal zone of ex-Lake Texcoco area
Land Area	About 250 ha in total
Activity	Final disposal of municipal waste collected in the DF and part of State of Mexico
Type of waste accepted	Waste from household and institutions, disinfected medical waste.
Structure	
Access	Accessed from the toll road (*Autopista*) connecting the DF and Texcoco.
Outer ring road	Asphalt paved: width 20.0m, length app. 6km
Inner roads	Width 10.0m, length app. 20km in total for the first lift.
Landfill area	First lift: 194ha, Second lift: 130ha, Third lift: 74ha
Landfill bottom liner	HDPE 1mm thick liner
Leachate collection	Submerged pumps are installed in leachate extraction wells.
Leachate handling	Pumped leachate sprayed over the landfill.
Gas removal	Passive control through ventilation wells.
Construction Procedure	
Construction stage	In 2001 Roads and cells for the first lift In 2006 Roads and cells for the second lift In 2010 Roads and cells for the third lift
Operation	
Operation stage	From 2002 to 2004 Up to 8m From 2007 to 2008 Up to 16m From 2011 to 2012 Up to 24m
Waste disposal amount	3,609,000 ton/year in 2002 and 3,278,000 ton/year in 2010 assuming the implementation of the M/P.
Waste trailers traffic	About 700 trailers per day.
Method of landfilling	Waste is unloaded from the trailers, compacted, piled up to 8m height, and covered with soil. After the first lift of 8m, the second lift is made 100m inner from the edge of the first lift and up to 16m height. The third is similarly made up to 24m.

8.6.3.2 Analysis of the Environmental Impacts

The following environmental items were deemed to be negatively affected through the IEE process.

- Public health.
- Accidents/Risks.
- Groundwater.
- Flora and Fauna.
- Landscape.
- Air Pollution.
- Water Pollution.
- Soil Contamination.
- Odor.

IEE was attempted again with taking into account of the design features of the landfill and environmental condition of the site, and it was confirmed that the other items ranked "D" will not be affected adversely. The reasons for their exclusion from the EIA are described in a table in Section 7.7 of this report. Only one exception is traffic.

Initially, the project was not thought to bring any change in traffic to the current situation. Since the Autopista is to be used by waste trailers, however, the issue would require examination in terms of accident and risk. Consequently, it will be discussed under the item of accidents/risks.

a. Public Health

Public health might be affected by the project for the following reasons.

1. Waste scattered from the waste trailers which deliver waste from its origins to the plant due to the mismanagement of waste delivery.
2. Offensive odor emitted from putrescible waste.
3. Proliferation of vermin and/or pathogens attracted to food waste.
4. Dust caused by waste tipping, trailers movement on site, or from cover soil.

Items 1 and 3 are examined below, and the others will appear in the later sections.

a.1 Mismanagement of Waste Delivery

Careless delivery of waste may allow waste to be scattered along the transportation routes and around the landfill site, resulting into the degradation of city beauty and public health.

Meanwhile, the DGSU has been using the tarpaulin to cover waste on the trailers in order to avoid waste scattering. It is observed that the tarpaulin has been achieving satisfactory result to overcome this problem.

Since **this practice is continued,** waste will not be significantly scattered to degrade the city cleanness or public health. **It is ensured by regular monitoring that the tarpaulin does not have large holes or tears though which waste might escape from the trailers.**

a.2 Vermin/Pathogen Proliferation

Organic waste attracts wide range of pathogens (i.e. disease-causing bacteria) and vermin (or disease vectors such as fly, mosquitoes, rats, etc. which transmit pathogens) and hence can potentially increase the incidence of diseases in surrounding population and the site workers.

Waste is continuously landfilled (i.e. 24 hours a day) and covered with soil within 24 hours. Cover soil is widely practiced to prevent the population increase of noxious fauna.

Therefore, vermin/pathogens proliferation should be minimum, without posing health hazards to the public. The workers working at the landfill front **are instructed to put appropriate clothes and equipment to avoid any exposure to health hazards.**

b. Accidents/Risks

Landfill operation can lead to an unexpected incident due to (i) problematic site management and waste collection management, (ii) problematic traffic, (iii) waste load pressure (such as landfill slope slides and lateral movement of soil) and (iv) gas generation.

b.1 Problems of Management

Incidents caused by careless site management can be expected during both the construction and operation phases.

During construction, the operation of construction equipment and machine such as dump trucks, bulldozers and loaders may be a danger to the site workers. **Instructing good site operation to the workers, control of their movement and appropriate site supervision by experienced personnel minimize the potential risk.**

During the operation, waste itself can pose serious risk. Hazardous, chemically active, and/or radioactive wastes are particularly dangerous for the workers and could bring long term risks open to the general public. Since the BP V is not supposed to accept those waste, **proper waste disposal manner will be thoroughly instructed to the generators of such waste.** At the site, **waste is inspected periodically on arrival, and visually monitored by the site workers at the tipping front.**

Even household waste can be hazardous. The site workers may be injured with sharp material and broken glass. Containers with spray cans with remaining gas is explosive. **The site workers are equipped with adequate clothes and protectors such as gloves and boots in case of such event.**

Glass material is also dangerous setting spontaneous fire to waste under the sunlight. **Soil cover** should minimize this risk.

The general public is prohibited from entering the site as practiced in Etapa IV, thus danger to them will be also minimized.

b.2 Problems of Traffic

Change in traffic mode near the site is expected during the construction and operation along the Autopista México-Texcoco and a peripheral ring road called *Periferico.*.

The Periferico and Avenue Peñon-Texcoco are currently used for waste delivery to the BP IV. Therefore traffic load along them will remain the same with slight increase brought by traffic for construction. The increase in traffic load on the Periferico should be negligible.

The Autopista is not used for waste transport at present and should have an increased traffic during the construction and operation. The current traffic load of the Autopista is presumed to be moderately high considering the fact that this Autopista is one of the major roads connecting the DF and the state of Mexico, although reliable data is absent. Therefore, traffic increase in terms of proportion will be small. Furthermore, the Autopista can be considered to have a capacity to absorb the traffic increase brought by the project. What should be stressed is that the impact by the project is not permanent but restricted in the construction and operation period, and that economic development and population growth particularly in the state of Mexico sill bring a much larger impact on the traffic load than the landfill project.

Caution should be exercised to the junction of the Autopista and the Periferico, and the junction of the Autopista and the newly built access road. Since vehicles run the Autopista relatively high speed, any actions which interrupt the traffic flow such as altering lanes and turning of long vehicles should be carefully controlled. **Expansion of roads at the junctions and other traffic control measures such as providing clear signs to call for drivers' attention to the movement of waste trailers are carried out.** In considering those, examination on the fluctuation of traffic loads of normal vehicles and that of waste trailers in a day is taken into account with particular attention.

b.3 Waste Load Impact

As waste is accumulated, its gravitational force turns to be a significant stress to the land. The EIA study[17] previously carried out prior to the construction of BP IV stressed a possible risk of land subsidence by the waste landfill and impact on the canals running in and around the ex-Lake Texcoco area.

On the other hand, the impact which may be caused by waste load at vertically expanded Etapa IV has been already discussed in Section II.2.2.2. Considering the similarity of the projects and soil character at Etapa IV and Etapa V, the conclusion derived from the said discussion will hold in the case of Etapa V.

The other possible concerns in regard to the compression effect are derived from the presence of wells within the site, which were previously used to extract salty groundwater. Without properly dealing with those wells, the following is anticipated.

- The impermeable liner at the bottom of the landfill is pressed down, scratched with the sealed wells, and damaged. It may have a fault, or may become susceptible to a fault.
- Change in subsoil structure by weight pressure may result in cracks or fissures of the wells. If leachate should be leaked into groundwater, such cracks or fissures would act as a migration pathway towards underlying strata.

The landfill plan states that **the well casings are totally removed and the boreholes are filled with bentonite.** If the work is successfully done, the worry mentioned above can be ignored.

b.4 Gas Generation

The biological process taking place in a landfill with municipal solid waste results in the generation of so-called "landfill gas" or "biogas" which contains CH_4, CO_2, and small quantities of CO, N_2, O_2, ammonia, sulfide and other trace gases. Primary concern regarding the biogas is CH_4 and CO_2. The proportion of these varies with the composition of waste and the age of the landfill, but in general, CO_2 becomes the principal gas (about 60% on dry volume bases) in the earlier stage of anaerobic decomposition. After this, CH_4 exceeds CO_2, remaining about 60% for a fairly long period.

[17] ABC Estudios y Proyectos, S.A. de C.V., *Estudio de Impacto Ambiental del Sistema Integral de Manejo de Desechos Solidos Bordo Poniente*, Contract N. SU-2-31-1-800, March 1993

The proposed landfill design incorporates passive ventilation facilities in order to prevent unexpected gas migration. As far as the ventilation is exercised in a controlled manner, landfill gas will be trapped and dispersed before migrating and risks due to the landfill gas will be minimal.

Besides, due to the presence of the geomembrane liner on the bottom of the landfill, the chance of biogas migration through underground pathways is also minimal. Further, as for CO_2, there is a sufficient distance between its source and the residential area, which is an anticipated target of CO_2 impact.

It should be stressed that landfill gas formation generally lasts for nearly 15 years or more after the site closure, depending on the decomposition speed of waste. Therefore, **ventilation facilities are kept maintained and regular monitoring of gas composition is carried out.**

c. Groundwater

When water passes through waste which is under biological decomposition, a wide variety of substances present in waste, of which heavy metals are of particular concern, will be dissolved into water. As the decomposition of relatively young waste produces carbon dioxide and organic acids, pH of water drops and toxic constituents, particularly heavy metals, become readily soluble. The impact of leachate on underlying groundwater should be considered in terms of quantity and quality of leaked leachate.

In general, origins of water (or leachate) can be waste itself, rain, surface water body, or groundwater, but the first one is usually negligible. In the present case of BP V, neither surface water nor groundwater will be the source of leachate as there is no major surface water body around, and groundwater infiltration into the landfill is to be cut off by an impermeable liner laid at the landfill bottom. The remaining possible origin of leachate is rainfall, but its percolation into the waste is considered to be small. This is because cover soil and intermediate cover soil will act as waterproofing. Therefore, leachate generation amount is controlled in first place.

Generated leachate will gradually travel downwards through waste, reaching a inpermeabilization system. The system consists of a synthetic liner (1 mm thickness), and the original clay formation of with about 0.5 m thickness, below which exists the shallow groundwater. **As far as the liner functions in a normal manner**, the system should be enough to prevent leachate from leaking, hence preventing groundwater contamination.

Abnormal function of the liner can be anticipated in case where the liner gets damaged by hard objects or pressure given by waste. The proposed design attempts to protect the liner from physical damage by providing a 0.5 m thick tepetate layer over the liner, and to control the water head of leachate by extracting it. Waste load will not cause land subsidence large enough to make a fault to the liner (see above). Therefore, the possibility of leachate leakage is substantially small.

In conclusion, the possibility of contaminated groundwater will be negligibly low.

ABC study (1993) pointed out that the abandoned wells existing in the surrounding area might act as a migration pathway for leachate. It would be problematic only if a

certain amount of leachate with significant contaminants reached one of the wells. However, because of what has considered above, such event is implausible.

d. Flora and Fauna

Field investigation revealed that flora of the area is not of particular interest, while its fauna includes important species to which special attention should be paid. Environmental impact on those species is anticipated.

Therefore, those environmentally valuable species are carefully transferred outside of the site, so that the reduction in their population is avoided.

e. Landscape

As the project site is almost flat, the presence of 24m high landfill must be a significant change in the appearance of the area.

In considering an issue of landscape, however, not only the simple appearance but also, or with higher attention, how the appearance appeals to peoples' perception should be taken into account.

Although the latter is highly subjective and difficult to be discussed in general terms, a good attempt will be to employ a photomontage technique to compare the landscape before and after the project. The results are found in the EIA report prepared by the JICA team. It can be deemed that since the ex-Lago Texcoco area is vast, the elevation of 24m is not significant. Further, vegetation developed on the landfill is expected to improve the aesthetics of the area.

As the landfill is 2.2km away from the nearest residential area, it is not be well seen by the residents. It will be most visible from the Autopista, hence the car drivers and passengers will be those who perceive the landscape. Since the site is not regarded as a scenic spot, it is considered that any impact to the drivers and passengers given by the change in landscape will be relatively small.

f. Air Pollution

Air pollution may be caused by two factors: traffic and site operation.

f.1 Air Pollution by Traffic

Etapa V is to be used as an alternative to Etapa IV, waste trailers will be simply diverted from the present access road to the Autopista and a new access road. Although the travel distance will increase by about 10km for one round trip, the increase of pollutants emission in populous areas due to the project will be only slight.

f.2 Air Pollution by Operation

Air pollution caused by landfill operation is attributed to the generation of noxious gases and dust.

Regarding the former, the concern is twofold. One is major biogas components, namely methane and carbon dioxide, and already discussed earlier. The other is about trace gases with offensive odor, which will be independently considered later.

In respect of dust problem at the site, it is anticipated that dust will be raised at the tipping front, from the soil cover, and/or from the inner roads when a vehicle passes (the outer road, paved with asphalt, will not be a dust source). For the first issue, it will be more or less inevitable due to the nature of the operation, but the problem is very local and **the impact can be minimized by workers' using appropriate masks.** Dust from the soil cover will be insignificant since the proposed project **sprays leachate and/or water over the landfill.** Spraying leachate and **the control of vehicle movement within the site** will limit the dust form the inner roads.

g. Water Pollution

Water pollution could be found in groundwater and surface water, and the former was already discussed.

There are three canals along the west, east and south sides of Etapa V. Possible effect on surface water will be caused by the following.

- Overflowed leachate migrates over the land surface to reach the canals.
- Infiltrated leachate migrates via unsaturated pore spaces toward the canals.
- Infiltrated leachate migrates to the shallow groundwater and contaminated groundwater reaches the canal.

On the other hand, the design of the Etapa V landfill includes **the soil cover over the waste and an impermeable HDPE liner at the bottom of the landfill.** Therefore, leachate generation within the landfill and migration out of the landfill should be well controlled. It is unlikely for leachate to cause surface water contamination.

However, surface water pollution might be also occurred by the ingress of runoff. It is unlikely that runoff water becomes contaminated with leachate or particles of the soil cover. This is because firstly runoff water does not have a contact with leachate doe to the presence of the soil cover, and secondly the final cover is firmly compacted not to be eroded. Further, since rainfall in the region is few, the problem will be only occasional. Therefore, the impact of surface runoff on the surrounding canals is insignificant.

h. Soil Contamination

Soil contamination matters because if it occurs, groundwater will be degraded, soil ecosystems will be affected and the future land use will be restricted.

Soil contamination is probable only if substances present in the leachate from the tipped waste intrude into the soil. However, **there is an HDPE liner** to confine leachate within the landfill, hence it is very unlikely that leachate finds a way to the soil.

In regard to the land use, the site is currently already restricted due to the high salinity. The landfill development may even improve the land condition since vegetation will be introduced on closure.

i. Odor

Although organic waste generated in the sub-system is to be separately collected and delivered to the composting plant, organic waste will still be a large proportion of

waste to be disposed of at Etapa V. Therefore, production of offensive odor is anticipated.

However, it is observed that the dry climate of the Mexico City helps decrease odor. Further, once tipped at the landfill, waste is compacted and covered with soil at fairly short interval. These practices should minimize odor problems.

Offensive odor may also result from the production of landfill gas. However, landfill gas should not cause a significant odor problem as they will be ventilated in a controlled manner and will be adequately treated.

8.6.3.3 Conclusion

The previous section described the possible causes and effects on the environment given by the landfill development at Etapa V and the extent of the problems. Figure 8-28 is a diagram to show the discussion schematically.

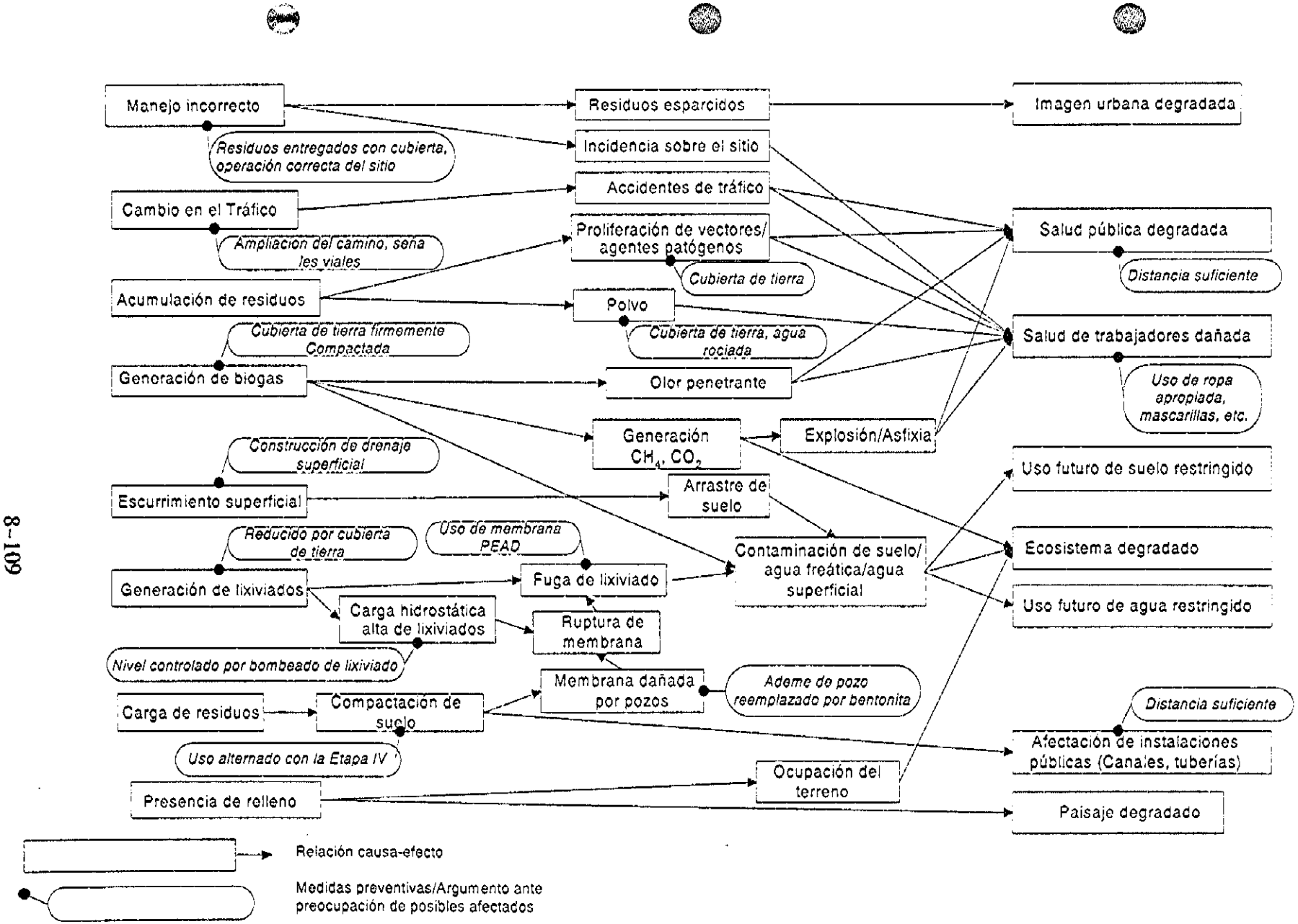


Figura 8-28: Relación de Causa - Efecto (Proyecto de Relleno Etapa V)

Although the further study is to be done, major adverse effect on the environment has not been identified, except the impact on fauna which require careful attention. However, the conclusion so far relies on several preconditions which are to be implemented on the project commencement. In other words, if some of those preconditions are not realized in the actual project, the conclusion of EIA presented here can not be guaranteed. Table 8-56 presents such preconditions, consequence of their failure, and method to ensure the preconditions.

Table 8-56: Preconditions to Prevent Environmental Impacts

Preconditions	Consequence of Failure	Method of Control
A. During the waste transportation, waste is covered with a sheet over the trailer.	Waste is allowed to fall and city beauty and public health will be degraded.	Periodical inspection of sheets / Use of the sheets to be acknowledged to all workers.
B. Tipped waste is covered with soil with fairly small interval.	Vermin/pathogens will be proliferated. Offensive odor will be generated. Much leachate will be generated. Waste will catch a fire.	Soil covering practice to be acknowledged to the site workers.
C. Project site is well managed during the construction.	There will be accidents/risks.	Site management is to be checked by experience personnel.
D. Hazardous industrial or medical waste is not disposed of.	Water and soil contamination with toxic substances.	Thorough instruction in regard to the waste disposal method is to be given to people in industry and medicine.
E. Waste is inspected on arrival at the landfill.	Hazardous waste can be disposed of without detected.	Regular waste inspection is to be encouraged.
F. Workers are equipped with proper clothes, masks and protectors (i.e. boots, gloves, ear protectors, etc.)	Sharp material, dust, odor and noise will degrade the workers' health.	Equipping with proper clothes and protectors is to be encouraged.
G. Traffic is controlled at the junctions.	Risk of traffic accident will increase.	Change of traffic is well studied and countermeasures such as road expansion and provision of traffic signs should be implemented if necessary.
H. Well casings are totally removed.	The impermeable liner will be damaged.	Wells to be inspected after the casings removed.
I. Landfill gas is ventilated even for sufficient period.	Landfill gas will migrate and cause problems of methane explosion, asphyxiation, and odor.	Landfill gas is to be monitored and the function of gas ventilation facility is to be inspected.
J. An impermeable liner is laid at the bottom of landfill.	Groundwater will migrate and to generate leachate. Leachate will migrate and contaminate groundwater and soil.	Appropriate site work is to be encouraged in order to securely lay, anchor and protect the liner.
K. Vehicles move within the site in a controlled manner.	There will be accidents/risks and dust problem will be raised.	Vehicle movement is controlled by proper personnel.

8.7 Project Evaluation

Project evaluation was carried out from the technical, institutional, social, environmental, financial and economical perspectives.

8.7.1 Technical Evaluation

Technical systems of the priority projects comprise:

- **Composting plant to treat organic wastes separately discharged from the sub-system;**
- **Vertical expansion of the Bordo Poniente Etapa IV; and**
- **Construction of New Final Disposal Site (Bordo Poniente Etapa V)**

Technical evaluation herewith gives an assessment whether or not these priority projects are enforceable, with reference to the present technical capabilities reserved by the DGSU.

a. Composting Treatment

The delegation Gustavo A. Madero had owned a municipal solid waste composting plant operated until 1993. The facility was shut down and dismantled mainly because mixed municipal waste fed to the facility deteriorated compost quality. Although the project ended in failure, it gave an experience of constructing and operating the facility to the DGSU, which learned that, in order to prevent this failure, a composting facility should be fed with selected organic wastes.

On the other hand, the DGSU is currently operating a small windrow composting plant for processing the garden wastes (e.g., pruned tree branches and grasses), and the compost products are of satisfactory quality.

Therefore, it is judged that the DGSU reserves technical capability to construct and operate the composting plant. In other words, technical problems in constructing and operating the plant are not foreseen.

Major factors to decide success or not of a composting plant are:

- quality.
- market demand.

of compost product.

The compost plant owned by the delegation Gustavo A. Madero was fed with mixed municipal waste, consequently the compost product from the plant was of inferior quality as it contained high impurities, where market demand for such low quality compost was so small that the plant was finally shut down.

Since the compost plant in the study is planned to treat organic waste separately discharged and collected, it is expected that compost products of good quality are to be produced.

Although the market demand of compost products in the DF is not well known, if the compost products are of high quality, it is very possible to be used as soil conditioner for:

- gardening in place of natural fertile soil presently exploited from forest areas;
- greening of ex-lake Texcoco area where high salinity in the original ground impinges the growth of vegetation; and
- greening the Bordo Poniente final disposal sites.

Therefore, the mistake experienced by the Gustavo A. Madero compost plant will not be repeated by this composting plant project.

On the other hand, it is anticipated that the market demand of compost product might sometimes become smaller with seasonal factors. Therefore, it will sometimes be necessary to consume the compost products with lesser costs, rather than over-stockpiling. In targeting cost reduced compost consumption, it can be an alternative to utilize mature compost before separation for such as cover soil for landfills (as cost of separation process could be saved). In this light, it will be necessary to investigate and develop a market of:

- low quality compost.

b. Vertical Expansion of the Bordo Poniente Etapa IV

This project is in line with the current technical practices of landfill operation by the DGSU, and only an additional technical requirement of the leachate collection and spraying is included. Therefore, it is judged that the DGSU could easily comply with the technical requirements of this project.

c. Construction of New Final Disposal Site (Bordo Poniente Etapa V)

The Bordo Poniente Etapa V is proposed to be constructed with the same technical components as what are employed in the present landfill (Etapa IV), and only an additional technical requirement of the leachate collection and spraying is included. Therefore, it is obviously judged that no technical problems are foreseen.

8.7.2 Institutional Evaluation

Alternatives of institutional settings for priority projects can be: "DGSU", "parastatal entity" or "private entity". However, an alternative that a "private entity" be an owner of any of the three priority projects seems to be very difficult to be realized. This is because all the priority projects are located on the federal territory managed by the CNA, where the guarantee of long term environmental protection by an eligible project proponent (such as GDF) is necessary. In other words, two-parties (CNA and a private entity) negotiation regarding a SWM project in which the DGSU being absent will unlikely be accepted by the CNA.

Meanwhile, in any case, responsibilities of the project should always be placed on the DGSU where three parties intervene in the project (i.e., the land owner CNA, a project proponent, and DGSU who assumes the responsibility against CNA).

Furthermore, the priority projects are selected as they have an urgency in implementation. Therefore, an appropriate alternative in practice should be that at first instance the DGSU becomes in charge of project investments and that the project operation for the initial time being should be: directly by DGSU; or by contract-out.

This institutional setting recommended above is in line with the present institutional framework practiced by the DGSU. All existing human and technical resources of the DGSU can continuously be utilized. Therefore it is judged that institutional alternative is reasonable and workable.

However, in view of the medium and long term target to improve efficiency in SWM by the GDF, whether "maintaining the original institutional setting" or "altering it to other institutional alternatives" should be carefully examined at an appropriate time interval.

8.7.3 Social Evaluation of Priority Projects

The following components are remarkable in the social evaluation of the three priority projects, whose feasibility studies were carried out.

a. Public Health

The construction and operation of the composting plant will carry the following public health results:

- Separation and processing of the organic material will be beneficial, as it will considerably reduce the proliferation of disease-carrying vectors (flies, cockroaches, mosquitoes, rodents).
- Likewise, a decrease in a number of illegal dumping sites, yet significantly less.
- There will be no adverse impacts -represented by noise or offensive odors- for the surrounding population due to the location of the plant, as long as it will be operated efficiently.

Regarding the operation of Etapa IV and the construction of Etapa V, the effects on public health will be the following:

- Significant reduction in the proliferation of harmful, disease-carrying fauna (vectors).
- Less illegal dumping sites.
- No negative impact caused by noise and offensive odors.
- Possible adverse effects by dust, noise and accident, due to the intense truck traffic; this fact would lead to the adoption of mitigation measures, though the supervision and control of transportation and public education.

b. Employment

Composting Plant:

- It is estimated that 250 jobs will be created during the construction of the plant in year 2001.

- It is considered that 280 new jobs will also be created for the years 2002-2003, amount that will rise to 420 jobs for the period of 2004 to 2010.

Sanitary Landfill (Etapa IV and V)

- It is estimated that 50 jobs would be created during Etapa V planning, designing and construction phase in years 2000 and 2001.
- Creation of new jobs during the operation stage of landfills IV and V from year 2001 to 2010. Since the works in Etapa IV and V will be held alternatively, it is estimated that the same staff will be used, with slight increments of around 100 new jobs.

Separated Collection:

- For the subsystem collection, which is to be contracted out or operated by concessionaire, it is estimated that 530 jobs would be created as of 1999.
- The separated collection to be contracted out and/or operated by concessionaire granted in the areas in which such service is currently rendered by the delegations is estimated to begin gradually in the year 2002. With the possible participation of worker associations currently linked with this service, a balance between the number of jobs is expected without dismissal, since the staff will be rotated to more advanced phases of collection, processing, haulage and recycling tasks of the separated material. All the aforementioned process would generate around 11,000 new jobs by the year 2010, which in turn would cover the possible displacements of voluntary and informal personnel (see Table 8-57).

However, it should be noticed that such estimation of staff dedicating to recycling tasks is theoretical and subject to several factors, which may reduce the aforementioned figure.

c. Occupational Health

- The adverse effects of dust and odors on the composting plant workers will be prevented and controlled through the compliance of standards and laws on occupational and security environment, established by the corresponding labor and health legislation bodies.
- Regarding the adverse effects of dust, noise and exposure to hazardous factors due to harmful agents contained in the solid wastes of Etapa IV and V, they are to be controlled or mitigated through the supervision and monitoring by the GDF on the landfill operators, by the reinforcement of the existing laws on workers' protection.
- Likewise, supervision and control must be exercised with respect to the safety of workers at the unloading zones and the internal landfill roads, so as to avoid accidents due to the operation of the equipment and heavy trucks. These methods will prevent negative impacts that the uncontrolled operation of heavy machinery might cause.

- In addition, all the adverse impacts previously mentioned will be mitigated through training courses on occupational health and safety at work for the GDF staff and contractors.

d. Continuity of the Service

The operation of a sanitary landfill is continuous. This fact is even more critical for the DF, whose only final disposal site is represented at Bordo Poniente sanitary landfill. Without any other available alternative, this site must run permanently; this means that the operators (contractors, concessionaires or parastatal entity) must ensure its proper functioning throughout the year. For this purpose, clear contracts will be helpful, stating the punitive clauses in case of a breach, the measures to be followed should a interruption of the service occur, and even insurance policies to guarantee the continuous operation of the landfill.

Other items related to the social evaluation of the three projects are shown in Table 8-58. In summary, the social evaluation of such projects does not show significant problems, and hence certain benefits -such as more jobs- will be present. In addition, it should be pointed out that the most important health and environmental problems for the urban population of Ecatepec and Nezahualcoyotl municipalities arise from the open wastewater canal (Canal de Sales), which is adjacent to the urban concentration along a distance of 7 km and are not related to the three priority projects.

Table 8-57: Estimation of Jobs Required for Processing Recyclable Material (1999-2010)

(From delivery of selected material to the final presentation of the product for its consumption)

Items	% from Total	Man/day per processed ton[19]	Recyclable Material (1000 ton/year)				Number of Jobs[18]			
			Current 1998	Phase 1 1999-2001	Phase 2 2002-2004	Phase 3 2005-2010	Current 1998	Phase 1 1999-2001	Phase 2 2002-2004	Phase 3 2005-2010
Paper/Cardboard	46.0	3.0	83	83-103	127-175	188-272	800	800-1,000	1,300-1,800	1,900-2,700
Plastics	21.0	3.0	38	38-47	58-80	86-124	2,000	2,000-2,500	3,100-4,300	4,600-6,600
Ferrous Metal	9.5	16.0	17	17-21	26-36	39-56	900	900-1,100	1,300-1,900	2,000-3,000
Aluminum	1.5	10.0[20]	3	3-3	4-6	6-9	100	100-100	200-300	300-300
Glass	19.0	11.0	34	34-43	53-72	78-112	1,300	1,300-1,600	1,900-2,600	2,900-4,100
Others	3.0	9.0	6	6-7	9-11	12-18	200	200-200	300-300	400-500
Total	100.0		181	181-224	277-380	409-591	5,300	5,300-6,500	8,100-11,200	12,100-17,200

Source: Prepared by the Study Team, based on researches conducted.

[18] 300 working days/ year are considered
[19] Preliminary estimations
[20] Material exported for its recycling overseas

Table 8-58: Social Evaluation of Priority Projects

Social Items	Composting Plant	Sanitary Landfill (Etapa V)
Location	Texcoco and Nezahualcoyotl Municipalities (State of Mexico).	Texcoco and Atenco Municipalities (State of Mexico).
Closest Urban Concentration	1 Km away (Ciudad Lago *Colonias* of Nezahualcoyotl Municipality), State of Mexico.	2.1 Km away (La Glorieta y Mexico Colonial *colonias* of Ecatepec Municipality), State of Mexico.
Production Activity of the Land	None.	None.
Land Ownership	Federal Property.	Federal Property.
Features of the Surrounding Housing	Houses made of bricks and concrete with water supply, sewerage, electricity, etc.	Houses made of bricks and concrete with water supply, sewerage, electricity, etc.
Underground Water Use	It is believed (yet it has not been confirmed) that there is water supplying wells at the urban concentration -more than 2 km away from the composting facility.	It is believed (yet it has not been confirmed) that there is water supplying wells at the urban concentration of Ecatepec Municipality.
Canal de las Sales	Wastewater canal next to the houses, thus representing a health and environmental problem.	Wastewater canal next to the houses, thus representing a health and environmental problem. Canal is 2 km away from Etapa V.
Employment	Additional 250 jobs will be created during construction phase in the year 2001, 280 new jobs during the operation stage in the years 2002 and 2003, and 420 jobs more from 2004 to 2010.	50 new jobs are estimated during the construction stage of Etapa V in 2001, and 100 additional jobs in the operation of Etapa IV and V from 2001 to 2010.
Population Health in General Terms	• Reduction in the proliferation of vectors through the separation and processing of organic material. • Less illegal dumping sites. • No adverse impacts by noise and furious odors on surrounding populations.	• Reduction of harmful disease-carrying fauna. • Less illegal dumping sites. • No adverse impacts by noise and offensive odors. • Adverse effect by dust, noise and accidents due to the intense traffic of trucks; it must be mitigated through supervision and public education.

8.7.4 Environmental Evaluation

Environmental adverse impacts envisaged to be induced, when and where the priority projects are implemented, are all estimated to be mitigable and/or preventable by some countermeasures to be incorporated in project design or operation manner or others. It is judged that the all priority projects are environmentally sound.

8.7.5 Financial Evaluation

a. Introductory Remarks

In quantitative analysis to address the major issues of financial sustainability and viability of SWM was attempted by applying FIRR index. In so doing, four kinds of "benefits"[21] would be estimated by the measurement of proxies, vis-à-vis, (i) money transaction actually taken place from beneficiaries to collectors, (ii) willingness to pay (WTP) currently revealed by people in DF, (iii) empirical WTP, and (iv) long-run marginal cost (LRMC) of service. Thus by using FIRR, the analysis will numerically elucidate the rung of financial vulnerability associated with, and amongst each of the "benefits" as numerated above. In preparation of FIRR analysis, current household income and entity revenues in DF have duly been investigated to provide a baseline conditions in estimation of WTP in pecuniary term.

Details of income distribution of households and revenues of entities, its estimation in Mexico City, as well as the work outcomes of the Public Opinion Survey (POS) that was carried out in 1998 level are provided in Data M in the Data Book. Further, the theoretical background and the *state-of-the-art* estimation of long-run marginal cost (LRMC) are instructed as reflected in Data M to provide a briefing on the underlying economics concept in search of financial viability, and economic feasibility as well, as borne out by FIRR and Economic Internal Rate of Return (EIRR).

b. Household Income and Entity's Revenue

In preparing the measurement of project benefits in terms of willingness to pay (WTP) of people to pay for the public service in concern, current households income and entity's revenue in DF are estimated while utilizing the Public Opinion Survey (POS) and macroeconomic data, as appropriate.

The results figured out thus far are summarized in Table 8-59 and Table 8-60 below.

[21] Meanwhile, to date, cost recovery scheme to finance the concerned urban sanitation service is yet to come, as such the detailed investigation of financial viability in terms of benefit-cost analysis with costs (of the prospective investment plan) and benefits (profits emanating from tariff on public service) encounters difficulties at this moment in time. In the light of this, it should be noted that the term "benefits" used in the following parts does not presume, except for the tariff system for large-scale consumers in DF, the pecuniary concept of "revenues" from tariff levied on direct beneficiaries.

Table 8-59: Gross and Disposable Income by Beneficiary

	Gross Income	Disposable Income
Average Household (US$/year)	6,194 (or 516.2/month)	5,347 (or 445.6/month)
Entities in Aggregate (US$ mil/year)	34,920	22,698
Entities per Unit (US$ million/year)	0.105	0.068

Table 8-60: WTP and Actual Money Transactions by Beneficiary

	Willingness to Pay (WTP)		Actual Transactions	
	Amounts	Share in Disposable Income (%)	Amounts	Share in Disposable Income (%)
Household per Unit (US$/year)	65.3	1.22	36.9	0.69
Household in Total (US$ mil/year) 1/	123.2	1.22	69.7	0.69
Entities in Total (US$ mil/year) 2/	7.6	0.03	5.0	0.02
Entities' Bid Price (US$/ton)	3.4	0.014	2.2	0.009

1/ 1.9 million households are assumed in DF, with the total population of 8.6 million and 4.7 household members in average.

2/ Weighed Average. 2,243,000 tons of wastes generated from entities per annum is assumed.

With the foregoing in view, the weighed averages of *tips* and *fincas* revealed as WTP and actually paid in DF worked out respective of US$ 61.5 million and US$ 34.9 million per annum in gross term, while applying the waste amounts generated by each of the beneficiaries.

c.2 Empirical WTP – An Intuition of Mark-Up Expenses

It would be useful to make some accepted measures of people's ability to pay available for reference herewith. In this connection, international lending institutions presumably assume, as a kind of mark-up expenditures, that the percentage share of household disposable income for the service of solid waste management remain around 2 percent, in line with other major services, notably, water, sanitation (drainage, street cleaning), urban transport being set at 4 percent, 1 percent, and 3-8 percent, respectively[22].

With this, the mark-up expenses for the households and entities currently in DF are estimated at US$ 211.6 million and US$ 499.4 million per annum in gross term, and US$ 111.4 and US$ 1,496 per annum per unit for the households and entities currently in DF, respectively. Once weighed by wastes generated by each of the beneficiary category, the average (weighed average) WTP is figured out at US$ 366.4 million in gross and US$ 856.2 per year per unit. Aggregates of revealed WTP, actual money transfer, and empirical WTP estimated from the sample statistics in DF in 1998 are summarized in Table 8-61 below.

Table 8-61: Aggregates of Revealed WTP, Actual Money Transfer, and Empirical WTP in DF, 1998

All Beneficiaries in DF, 1998	Revealed WTP	Transfer	Empirical WTP
Weighed Average (US$ million)	61.5	34.9	366.4

[22] Source: World Bank, *Institutionalization of Integrated Urban Development*, 1994, p.9

d. Benefits Measured by Long-Run Marginal Cost (LRMC) Pricing

In order that the analysis provide financial sustainability directly corresponding to the efficient allocation of scarce resources in the society, the project benefits are measured by way of estimating the Long-Run Marginal Cost pricing. Against the financial back data conveying the project costs of each of the project components, the marginal costs (levelized annuity costs of construction and maintenance) of an incremental and new units and facilities are estimated.

In summary, marginal costs associated with each of the project components by institutional framework are shown in the following Table 8-62.

Table 8-62: LRMCs by Project Component and Institutional Framework

	Landfill	Compost	BP E-IV		BP E-V		Compost		Total	
			CRF	LRMC	CRF	LRMC	CRF	LRMC	CRF	LRMC
Alternative 1	Case 1	Case 1	0.33	7.4	0.33	7.6	0.28	4.6	0.24	17.4
Alternative 2	Case 1	Case 2	0.33	7.4	0.33	7.6	0.28	4.6	0.24	17.7
Alternative 3	Case 2	Case 1	0.33	6.2	0.33	7.6	0.28	4.6	0.24	17.7
Alternative 4	Case 2	Case 2	0.33	6.2	0.33	7.6	0.28	4.6	0.24	18.0

Note: Case 1: Internalized DGSU
Case 2: Constructed by DGSU and O/M on contract-out basis by the private sector
duration: 12 years, social discount rate: 20%
CRF: Capital Recovery Factor
LRMC: Long-Run Marginal Costs (US$ million/year)

e. Financial Internal Rate of Return (FIRR) Analysis and Financial Evaluation

Initiated by the outline view of the analytical framework and presumptions as reflected above, the numerical results are given with the variation of "*benefits*" considered. Subsequently, the sensitivity analysis will be carried out in a bid to simulate the financial viability with changes in the major variables of the model.

Against the background of model configuration and parameters as reflected in Data M in the Data Book, FIRR estimation was only possible when the benefits are counted by empirical WTP, marginal cost pricing, and market price for composting. The outcomes are summarized in the Table 8-63 down below.

Table 8-63: FIRRs by Benefit Variation and Project Component – Alternative 1

unit: %

	BP E-IV	BP E-V	Composting	Overall
WTP – Paid (i)	Immeasurable 1/	Immeasurable	NA 2/	Immeasurable
WTP – Revealed (ii)	Immeasurable	Immeasurable	NA	Immeasurable
WTP – Empirical (iii)	47.5	82.0	NA	67.5 3/
MC Pricing (iv)	15.5	19.7	37.4	23.3
Market Price (v)	NA	NA	17.5	NA

Table 8-64: FIRRs by Benefit Variation and Project Component – Alternative 2

unit: %

	BP E-IV	BP E-V	Composting	Overall
WTP – Paid (i)	Immeasurable 1/	Immeasurable	NA 2/	Immeasurable
WTP – Revealed (ii)	Immeasurable	Immeasurable	NA	Immeasurable
WTP – Empirical (iii)	47.5	82.0	NA	67.5 3/
MC Pricing (iv)	15.5	19.7	42.4	23.8
Market Price (v)	NA	NA	19.3	NA

Table 8-65: FIRRs by Benefit Variation and Project Component – Alternative 3

unit: %

	BP E-IV	BP E-V	Composting	Overall
WTP – Paid (i)	Immeasurable 1/	Immeasurable	NA 2/	Immeasurable
WTP – Revealed (ii)	Immeasurable	Immeasurable	NA	Immeasurable
WTP – Empirical (iii)	58.2	71.7	NA	72.2 3/
MC Pricing (iv)	19.5	22.4	42.4	26.4
Market Price (v)	NA	NA	30.8	NA

Table 8-66: FIRRs by Benefit Variation and Project Component – Alternative 4

unit: %

	BP E-IV	BP E-V	Composting	Overall
WTP – Paid (i)	Immeasurable 1/	Immeasurable	NA 2/	Immeasurable
WTP – Revealed (ii)	Immeasurable	Immeasurable	NA	Immeasurable
WTP – Empirical (iii)	58.2	71.7	NA	72.2 3/
MC Pricing (iv)	19.5	22.4	37.3	27.2
Market Price (v)	NA	NA	19.3	NA

1/ Immeasurable – FIRR is not mathematically calculated due to extraordinary low positive figures in the net cash-flow stream.

2/ NA – By nature of the attributes to the sub-components, FIRRs are not appropriate in estimation of financial sustainability.

3/ Excluding the composting sub-component

(i) Considering money transaction actually taken place from beneficiary to collectors as benefit.
(ii) Considering willingness to pay (WTP) currently revealed by people in the DF as benefit.
(iii) Considering empirical WTP as benefit.
(iv) Considering long-run marginal cost of service as benefit
(v) Obtaining benefit from the sale of compost at 700 pesos/ton.

As compared to a mark-up price level to pay for the service, both alternatives with actual money transaction and revealed WTP as project benefits sequentially showed off people's affordability as well as financial sustainability with all the cost shares rest far below the bottom-line. FIRRs could not be calculated due to extraordinary low profiles of benefits-"revenue" attributable to the cases. With this, coupled with the ever-increasing cost of waste disposal, DGSU would encounter difficulties in the face of financial vulnerability and fragility in sound management of the concerned public service in the days to come. The entire financial burden is, and will be into the future, on the shoulder of the DGSU's public unless any policy alternative is initiated.

8.7.6 Economic Evaluation

8.7.6.1 Proposition

Economic analysis of the prospective SWM investment project was undertaken while using benefits and costs as measured in terms of scarcity of resources and allocative efficiency in the national economy as a whole. As regards the index in appraisal of economic feasibility, Economic Net Present Value (ENPV) analysis has duly been carried out in a bid to compare with the breakeven point of zero to reveal its numerical superiority. In measurement of economic benefits, the cost that would have otherwise accrued unless the proposed investment plan did take place (*cost saved*) was used as proxy. In practice, the cost of the prospective investment plan for the new final disposal site that needs to be established as soonest. Economic cost was revalued from the financial costs while excluding the incorporated imperfections due to non-competitive pricing, externality of the economy, and fiscal distortions such as taxes and duties levied on goods and services in the markets. Specifically, Standard Conversion Factor (SCF) in use for the analysis was 0.95, while considering the low tariff rates on the imports and subsidies on the exports, as well as those recently applied in the investment projects in Mexico under the auspices of the World Bank. Should the quantification of costs and benefits accrued be undertaken in terms of the local currency, shadow exchange rate would be considered to stray at around 1.05[23].

The baseline concepts, guidelines considered and the parameters applied in due course of the analysis are extensively elucidated in Data M in the Data Book.

8.7.6.2 Findings

Economic feasibility of the proposed investment plan as borne out by ENPV has been estimated in line with the foregoing guiding principles and the operational parameters as given below. To be noted that economic evaluation for ENPV has only been carried out for the project component of final disposal sites (FDSs), notably, Etapa IV and V, because final disposal site(s) is certainly necessary whether intermediate processing exists or not.

a. Economic Benefit

The benefit as replaced by the cost saved is assumed to be the unpaid cost otherwise accrued to the construction of the new final disposal site that is to be located in a far distance than the existing ones. Although indicative, the prospective investment cost is envisaged to reach US$ 70 million[24], with the scheduled disbursement of capital investment consecutively taking place at 28.6 percent, 42.8 percent, and again 28.6 percent over the three years commencing in 1999. In the currency term, direct

[23] As easily understood, shadow exchange rate (SXR) is numerically expressed as an inverse of SCF.

[24] It is estimated that US$70 million of initial investment is needed for construction of a new landfill at Ixtapaluca that was evaluated as a secondary prospective candidate site following BP-V in "Annex D Comparative Evaluation of Candidate Sites for Final Disposal of Solid Waste." About 35million tons of waste are needed to be disposed of by 2010. The site at Ixtapaluca is located at a hillside and the aquifer under the site has good quality of groundwater. Therefore, a bank to protect the waste from flowing out to the downstream and leachate collection/treatment system to protect the groundwater from being contaminated are surely necessary when the new landfill is constructed. The study team assumed the initial cost of such a landfill to be US$2 per ton of waste, i.e., 35 million tons of waste multiplied US$2 equals to US$70 million.

benefits, therefore, is assumed to be US$ 20.0 million, US$ 30 million, and US$ 20.0 million in the said initial investment period.

b. Economic Cost

The aggregate economic costs of initial investment accrued to supply one additional tonnage solid waste management and disposal in the forthcoming years till 2010 have been figured out to be US$ US$ 21.9 million, US$ 21.0 million, US$ 22.2 million, and US$ 20.8 million for the Alternatives 1,2,3,and 4, respectively. Of this, the economic costs of FDSs in use for the estimation of economic feasibility are respective of 14.4 million and US$ 14.1 million for the Alternatives 1,2 (Case 1) and the Alternatives 3,4 (Case 2), while accounting for around 65 percent for both of the cases. The economic costs of operation and maintenance are also converted from the financial to the economic cost, reflecting the true value of goods and services employed in the project. These recurrent economic costs turned out to be US$ 52.1 million, US$ 53.7 million, US$ 52.6 million, and US$ 54.2 million for Alternatives 1, 2, 3, and 4, respectively.

In aggregate, the economic costs accrued to the project as a whole worked out US$ 74.0 million, US$ 74.7 million, US$ 75.2 million, and US$ 76.6 million for the Alternatives 1, 2, 3, and 4, respectively. Of this, the economic costs in concern for economic feasibility study, vis-à-vis, Etapa IV and Etapa V, reached respective of US$ 56.3 million and US$ 57.5 million for Case 1 and Case 2, while accounting for around three quarters of the total for both of the cases.

c. Economic Net Present Value (ENPV)

Economic Net Present Value (ENPV) was calculated on the basis of the new and the incremental cost and benefit streams associated with the proposed investment outlays over the period of maximum 3 years with the commencement in 1999. All the costs are shadow priced, being adjusted to convert market prices to shadow prices expressed in terms of border currency unit (US dollar).

With the methodology and the numerical assumptions as noted immediately above, ENPV on the FDS component was readily estimated at respective of US$ 26.2 million and US$ 26.5 million as per 1998 price level for the Alternatives 1,2 (Case 1) and Alternatives 3,4 (Case 2), with the social discount rate of 20 percent over the 12 years of project duration. With this, the overall performance of the project in terms of allocative efficiency in the economy proved to be preferable, and substantially feasible.

The work outcomes as readily estimated above are summarized in Table 8-68 below. Further, summary net cash-flow tables for FDSs in aggregate and by component are shown in Table 8-67.

Table 8-67: Summary Net Cash-Flow for ENPV

unit: US$ million

Alternative 1 & 2 (Case 1)
Overall Cash Flow for the Project (Initial-BC+PhyC, O.M-Base)

	BP-ETAPA IV			BP-ETAPA V			Aggregate				Net
	Foreign	Local	Total	Foreign	Local	Total	Foreign	Local	Total	Benefit	Cash-Flow
1999	0.04	0.05	0.09	0.004	0.03	0.04	0.04	0.08	0.13	20.00	19.87
2000	4.35	5.58	9.93	0.02	0.17	0.19	4.37	5.75	10.12	30.00	19.88
2001	0.09	2.52	2.61	0.33	3.80	4.13	0.41	6.32	6.73	20.00	13.27
2002	0.07	0.42	0.49	1.60	4.91	6.51	1.67	5.33	7.00		-7.00
2003	0.00	0.42	0.42	1.55	4.78	6.32	1.55	5.20	6.74		-6.74
2004	0.07	0.42	0.49	1.58	4.65	6.23	1.65	5.07	6.72		-6.72
2005	0.09	2.30	2.39	0.00	0.01	0.01	0.09	2.31	2.40		-2.40
2006	0.16	2.30	2.46	0.05	0.01	0.06	0.21	2.31	2.51		-2.51
2007	0.00	0.42	0.42	2.96	3.15	6.10	2.96	3.57	6.52		-6.52
2008	0.07	0.42	0.49	0.13	2.22	2.35	0.20	2.64	2.84		-2.84
2009	0.09	2.22	2.31	0.00	0.01	0.01	0.09	2.23	2.32		-2.32
2010	0.16	2.03	2.19	0.05	0.01	0.06	0.21	2.04	2.25		-2.25
Total	5.2	19.1	24.3	8.2	23.7	32.0	13.4	42.8	56.3	70.0	
	ENPV=	26.2 US$ million									

Alternative 3 & 4 (Case 2)
Overall Cash Flow for the Project (Initial-BC+PhyC, O.M-Base)

	BP-ETAPA IV			BP-ETAPA V			Aggregate				Net
	Foreign	Local	Total	Foreign	Local	Total	Foreign	Local	Total	Benefit	Cash-Flow
1999	0.01	0.02	0.03	0.016	0.05	0.07	0.03	0.07	0.10	20.00	19.90
2000	1.69	5.62	7.30	0.08	0.26	0.33	1.76	5.87	7.64	30.00	22.36
2001	0.00	0.87	0.87	1.61	5.33	6.94	1.61	6.20	7.81	20.00	12.19
2002	0.07	0.42	0.49	1.51	5.60	7.10	1.58	6.02	7.60		-7.60
2003	0.00	0.42	0.42	1.46	5.46	6.92	1.46	5.88	7.34		-7.34
2004	0.07	0.42	0.49	1.49	5.33	6.82	1.56	5.75	7.31		-7.31
2005	0.00	2.58	2.58	0.00	0.23	0.23	0.00	2.81	2.81		-2.81
2006	0.07	2.11	2.18	0.05	0.23	0.27	0.12	2.34	2.46		-2.46
2007	0.00	0.42	0.42	0.54	3.83	4.37	0.54	4.25	4.79		-4.79
2008	0.07	0.42	0.49	0.05	2.90	2.95	0.12	3.32	3.44		-3.44
2009	0.00	2.91	2.91	0.00	0.23	0.23	0.00	3.13	3.13		-3.13
2010	0.07	2.72	2.79	0.05	0.23	0.27	0.12	2.95	3.07		-3.07
Total	2.1	18.9	20.6	6.8	29.7	36.5	8.9	48.6	57.5	70.0	
	ENPV=	26.5 US$ million									

Table 8-68: Summary of Economic Feasibility by Components and Measurement Indices

	FDSs	
	Case 1	Case 2
ENPV (US$ million)	26.2	26.5

8.7.7 Total Evaluation

As a total evaluation, it was concluded that the implementation of the priority projects were feasible in technical, institutional, social, environmental, financial and economical aspects.