5.3 Collection Policy and Improvement Measures

5.3.1 Collection Policy

The following policy is recommended with respect to waste collection:

1. Use of Contractors
   The Municipality of Bucharest will use contractors for waste collection. The municipality should use at least 3 contractors to have sound competition among contractors.

2. Responsibility of Generators of Non-Municipal Waste
   The municipality will collect only municipal waste. Generators will collect non-municipal waste, i.e., industrial waste, demolition waste and large quantity waste of commercial companies.

3. Establishment of Monitoring System
   The municipality will establish a system for monitoring waste contractors' performance. It is proposed that Sector governments will monitor the performance and reports to the municipality. Monitoring plan is shown in Section 5.6.

4. Acquisition of Disposal Sites in the Western Part of Bucharest
   The municipality will acquire at least one more disposal site at western part of Bucharest. The location will be within 20 km from the city center. Transfer stations will not be necessary. Having 2 disposal sites, on the opposite sides of Bucharest will substantially contribute to the upgrading of service level (as more number of trips can be made by collection trucks in one day) and/or the saving of haulage costs if the same level of service is provided.
   Remark: It is roughly estimated that haulage cost difference between two collection areas; one near landfill site, the other in the opposite side of the city may be 20%.

5. Selection of Most Economical Collection Systems
   The municipality will select most economical and efficient collection system and truck types, which are recommended in Section 5.4. Number of truck types should be minimized.

6. Full Cost Recovery
The municipality should collect full collection and haulage costsfrom the citizens.

7. Supply of Bins
Use of the imported used plastic bins should be encouraged by the municipality as those bins are the most economical.

5.3.2 Summary of Improvement Measures

Improvement needs and measures are summarized in the following table:

Table 5.3-1 Improvement Measures for Collection and Haulage

Category	Improvement Item	Measures
1) Quantitative Improvement	a. Increase of collection capacity	1. Provision of new trucks with efficient loading equipment
	b. Increase of containers and bins	2. Provision of new containers and bins (imported used plastic bins)
	c. Sufficient parking space for trucks	3. Re-arrangement of garages in the aspect of location and area
2) Qualitative Improvement	d. Increase of easiness to handle container for discharge	4. Provision of plastic containers with casters as well as renewal of steel containers by plastic one
	e. Increase of collection speed	5. Renewal of old trucks and collection equipment with new efficient types
3) System and Management Improvement	f. Increase of collection efficiency and Decrease of maintenance costs	6. Simplification (Reduction) of types of truck and collection equipment
	g. Decrease of maintenance cost	7. Options include use of maintenance contractors and privatization of the existing workshops
	h. Increase of efficiency and simplification on management for collection and haulage	8. Introduction of a computerized operation-control system
4) Others	i. Proper control of contractor	9. Preparation of well designed contract, monitoring, and enforcement of contract conditions

5.3.3 Other Issues

1) Haulage distance

Current disposal site at Glina and 11 candidate future disposal sites are located within 15 km from the city center. Since Bucharest has a circular city area, the location of the candidate disposal sites has also a circular distribution.

According to the Study Team's time and motion study, distance of haulage from collection point to Glina disposal site is 21.5 Km in the longest case taking 58 minutes by an old and the lowest velocity truck (SRDAC).

In future more than one disposal site will be operated. Wherever the sites would be selected, the collection trucks only need to run about 40 km at maximum per round trip for haulage.

Thus, it is not necessary to construct any transfer stations for haulage as long as the future disposal sites are selected from the candidates.

2) Haulage routes

Now all the collection trucks haul waste only to Glina disposal site. Even in this case only collection trucks from Sector 1 and Sector 6 run through the city center, while other trucks do not run through the center.

Since the future disposal sites will be located along the outer ring road, almost all collection trucks will run radially to the sites from collection area, without passing through the city center.

No particular impediment for haulage routes will be estimated to appear.

3) Number of trips

Based on the following assumptions, it will be very possible for trucks to make 3 trips per day.

1. The future disposal sites are located within 20 km from the city center.

2. The average velocity of a truck in hauling is 30 km/hour or more.

3. Collection and loading time/one trip is less than 80 minutes.

5.4 Recommended Collection Systems and Truck Types

5.4.1 Desirable Truck Types

In Bucharest, bin system and container system are the 2 major systems applied for waste collection. At least 4 different types of trucks are used for bin system, and 2 types of trucks are used for container system.

The current deficiency in RASUB's collection service is partly attributable to the use of many different types of trucks, which causes maintenance problems and high collection costs. It is highly recommendable to select most appropriate types of trucks and reduce number of types of trucks.

Criteria used for selection of appropriate collection systems and truck types include the following:

1. Cost efficiency
2. Compatibleness with street conditions

Use of different types and sizes of trucks may be necessary in some cities that have narrow streets. However, in Bucharest, most bin storage areas are easily accessible by large trucks. Therefore, it is judged that use of different types of trucks is not necessary in Bucharest.

In Bucharest, collection efficiency can increase and collection costs can substantially decrease by choosing most economical types of trucks.

As shown in Table 5.1-6, RGR's collection system with Compactor RGR-16 and 240 litre plastic bins is the most economical. Its unit cost including truck and bins is US$ 10.1/ton. The second most economical system is the one with Container Compactor PELC-CON and 4 m^3 containers. Its unit cost is US$ 12.8/ton. Breakdown of the costs is shown in Table 5.1-5. Comparison of waste collection amounts of respective systems results in the same ranking as the that obtained from cost comparison.

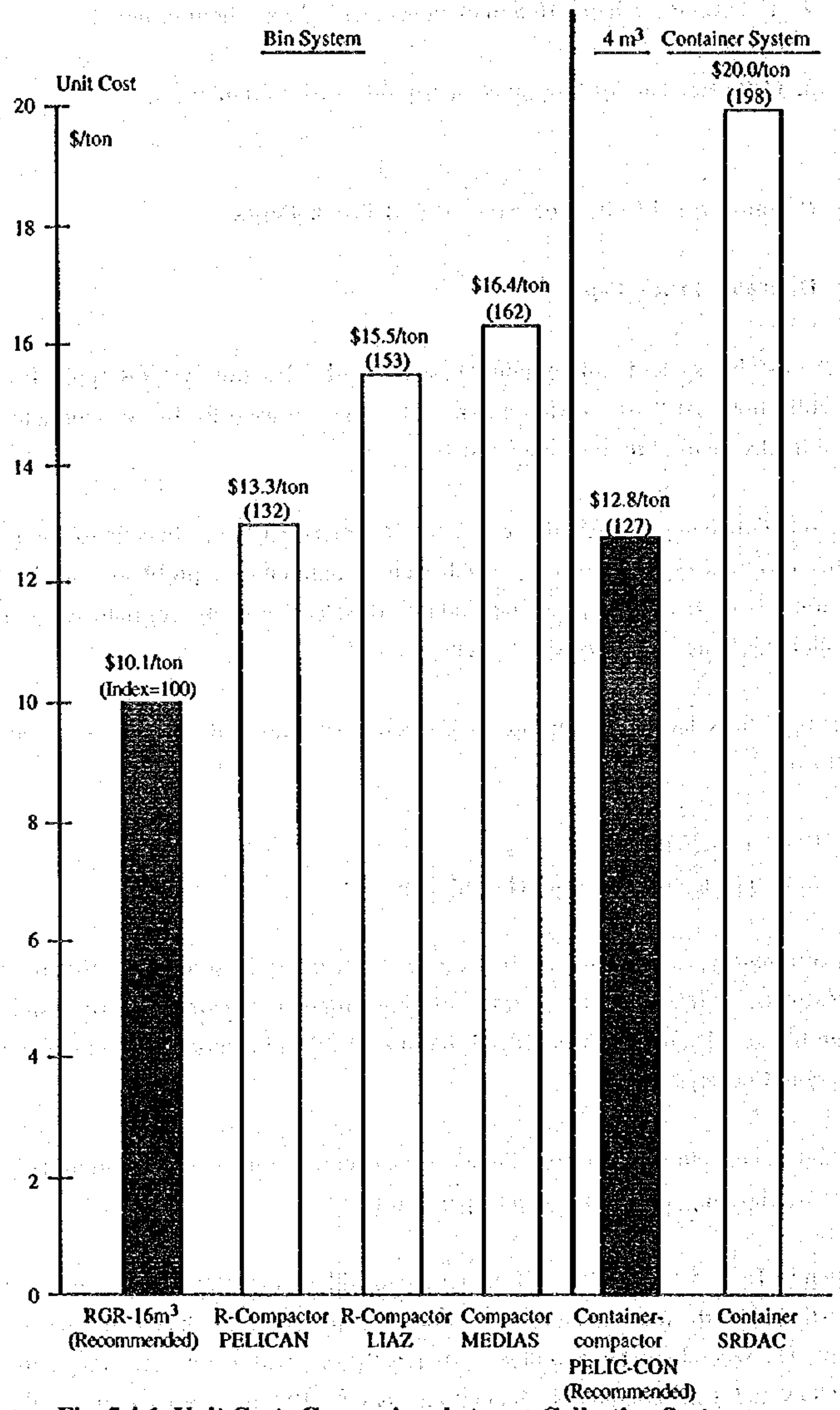


Fig. 5.4-1 Unit Costs Comparison between Collection Systems

Note: All the costs include costs of bins or containers.

Although the container compactor system is less economical than RGR-16, container system is necessary for factories and markets that generate large amount of waste. Therefore, both RGR-16 system and container-compactor system are recommended for future selection; the former as bin system, and the latter for container system. Some details of the recommended systems are shown in Table 5.4-1.

Table 5.4-1 Recommended Collection System for the Improvement

Collection System	Truck	Loading	Bin or Container used
1) Bin System	Compactor (16 m^3)	Two mechanical lifts	Plastic bin with casters (240 ℓ)
2) Container System	Compactor (12 m^3)	Mechanical arm-roll	Large container (4 m^3)

Table 5.4-2 Unit Cost by Collection System

System	Annual Depreciation Cost (US$) (1)	Maintenance Cost/Yr (US$) (2)	Fuel Cost/Yr (US$) (3)	Crew & Mechanic Salary/Yr (US$) (4)	Container Cost/Yr (US$) (5)	Total Cost/Yr * (US$) (6)
A. Bin System						
1) Compactor RGR-16	24,047	1,600	4,510	3,790	6,750 (240 ℓ) **	38,910
2) R-Compactor PELICAN	10,237	1,110	2,850	10,730	5,060 (110 ℓ)	31,486
3) R-Compactor LIAZ	14,437	1,110	2,700	9,430	4,660 (110 ℓ)	33,954
4) Compactor MEDIAS	9,489	2,110	3,040	9,430	3,800 (110 ℓ)	29,262
B. Container System						
5) Con. Compactor PELIC-CON.	10,786	1,220	4,930	8,140	4,220 ($4m^3$)	30,761
6) Container SRDAC	5,592	1,390	2,570	6,840	1,630 ($4m^3$)	18,923

Note : *: Overhead and indirect costs are included, refer to Appendix 5 for further cost details.

**: 240 ℓ plastic bin's cost is on a used bin.

5.4.2 Municipal Waste Collection

1) Precondition

In terms of the cost reduction, easiness to manage, and smooth operation, firstly the simplicity of the collection and haulage system should be considered.

In Bucharest, the existing collection and haulage is rather simply composed of discharge, collection, and haulage to one disposal site.

Collection and haulage system must consist of;

1. Container and bin
2. Truck with equipment for loading, compacting and tipping
3. Driver and collection worker(s)
4. Supplement tools

Each component should be compatible with street conditions, discharge methods, waste quantity and quality, distance to disposal site, and other conditions.

And the system should be managed as one of the public services taking the following concept into consideration.

1. Regularity
2. Appropriate frequency
3. Completeness
4. Quickness

Before discussing which system is the best for Bucharest, the following preconditions should be noted.

1. There are few narrow streets in Bucharest and a middle size truck (7.7 m × 2.5 m) can pass most streets in Bucharest.
2. Until 2010 the disposal sites for household waste will be located within 20 km from the city center.
3. Collection coverage should reach 100 %.

2) Framework

The following items are considered as a framework of municipal waste collection and haulage plan.

1. Waste amount to be collected:	As shown in Table 5.2-1
2. Collection coverage:	100% of people in Bucharest by 2000
3. Collection frequency:	Once/week at least by 2000, twice/week by 2010
4. Collection method:	Station collection and door to door collection
5. Collection system:	(1) Compactor with two-arms mechanical loader and load capacity of 5.0 ton, combined by 240 l plastic bins with casters. (2) Compactor with mechanical lift for container and load capacity of 4.4 ton, combined by 4m^3
6. Operation day:	Monday to Saturday; however, 20% of weekday's capacity is provided on Saturday
7. Number of trip, shift:	3 trips, 1 shift for operation day
8. Net utilization (working rate):	90% of full ability
9. Number of contractors:	It is not considered here, but it would be discussed in the feasibility study

5.4.3 Disposal Site and Transfer Station

1) Disposal Site

From collection efficiency view point, it is strongly recommended that;

1. Two or more disposal sites should be secured for economical haulage. In the case of two disposal sites, they must locate in west and east, or in north and south.

2. Each disposal site will be within 20 km (desirably 15 km) distance from the city center.

2) Transfer Station

It is concluded that transfer stations are not necessary in Bucharest until 2010 because, as discussed in 5.3.3, haulage distance and routes will not create serious impediment for haulage until 2010.

5.5 Vehicle Maintenance Plan

RASUB uses 4 workshops in Berzei, Serban Voda, Fintinica, and Timisoara. All the workshops provide some maintenance services. Generally, buildings, maintenance facilities and tools are old. Most of them are not workable.

In case that the municipality wishes to continue to use the workshops, rebuilding of workshops and renewal of maintenance facilities are necessary. Another alternative is to discontinue the use of the existing workshops, and use external private workshops for maintenance. These alternatives are discussed in Section 9.2.

In case that the municipality wishes to use the existing workshops without using external workshops, the following actions are necessary:

1) Rebuilding of workshops
2) Renewal of maintenance facilities and provision of maintenance equipment and tools including those for measurement
3) Provision of spare parts
4) Preparation of shop manual for overhauling and assembling

1) Rebuilding of workshops

The existing buildings of all the 4 workshops are very old and obsolete. Effective maintenance service cannot be provided in those buildings. The buildings do not have windows and, it is too dark to do maintenance job safely and effectively. Ceiling of the buildings are too low to install cranes which are necessary for maintenance. Poorly designed passage in the workshops premises prohibit smooth and easy movement of vehicles within the premises. Floors of the buildings are not smooth, which makes it difficult to move large equipment. Utilities such as power, water and drainage are inadequate.

In view of the above situation, rebuilding of the workshops is required.

2) Renewal of maintenance facilities and provision of maintenance equipment and tools including those for measurement

Most of the existing maintenance facilities of the workshops are old and not usable. Maintenance and repair require accuracy in measurement, adjustment and installation of parts. Accurate works cannot be done with the existing facilities. There are no cleaning equipment, no compressor, which are necessary for overhauling and assembling hydraulic components. There are also no hydraulic shop press or hydraulic removal equipment. Tools are inadequate in terms of both quality and quantity. Therefore, renewal of maintenance facilities and provision of maintenance equipment and tools are required.

3) Provision of spare parts

Most stock of spare parts in the workshops are of low frequent use. There is almost no stock of sand paper, vinyl tapes, liquid packing and other consumable. Due to the shortage of spare parts, it takes a few months to repair some trucks, which directly affect collection service level.

4) Preparation of shop manual for overhauling and assembling

There is no shop manual for overhaul and assembly, no measurement equipment. Without these, it is difficult to do repairs that requires accuracy. For example, degree of abrasion inside engines or other machine cannot be measured. As a result, repair is incomplete, and another repairs are necessitated.

<u>Immediate Improvements Needed</u>

It is recommendable for MB to do the following actions immediately:

1) Give higher maintenance priority to newer trucks in order to maintain the current high utilization rate. (Spare part of good quality should be quickly provided for new trucks.)
2) Use additive and mix it with oil or fuel to improve quality.
3) Price list of spare parts should be given to each workshop managers so that they can know cost of repair and judge whether or not it is worthwhile to repair damages. Cost of each repair should be recorded in history book of each truck (Fisa de Magazin).
4) Prepare check sheets for regular checking that is done for each truck every 250 hours of working time. This check sheet will enable mechanics to check trucks easily and record results of checking.
5) Provide paved on-site access roads in Glina landfill site to decrease damages to trucks.

5.6 Monitoring Plan

5.6.1 Objectives

The municipality plans to use contractors for collection, haulage and street sweeping services on municipal waste from 1995. It is necessary for the municipality to establish a well functioning monitoring system on contractor's operation. The purposes of monitoring are as follows.

1. To check degree of contractors' compliance with collection contracts.
2. To know current conditions and problems..
3. To check hazardous waste is not hauled to disposal sides.

5.6.2 Monitoring Responsibility

Sector Salubrity Administration (SSA) should be responsible for collection of monitoring information with respect to all the parameters shown in Table 5.6-1, while the Public Service Department (PSD) of Bucharest Municipality will be responsible for analysis, and use of the monitoring information in addition to application of sanctions to providers who are in breach of their contracts.

PSD should also be responsible for preparing monitoring plan and monitoring report form that will be used by SSA.

A more detailed responsibility issue is discussed in Section 9.2.

5.6.3 Monitoring Parameters

It is proposed that the following monitoring parameters will be used.

Table 5.6-1 Monitoring Parameters and Information Obtained

Monitoring Parameters	Information to be Collected
1. Population covered by the collection service by zone and by contractor	- Truck scale information - Tariff billed
2. Quantity of waste collected	- Truck scale information (monthly base information will be useful.)
3. Collection service frequency	- Contractors' report - Occasional hearing from the citizens
4. Citizens' complaints	- Number and kinds of complaints
5. Operational information including: - Number of trucks used - Number of trips made	- Trucks scale information - Contractors' report
6. Incoming of hazardous waste to landfill sites	- Occasional spot checking of waste types brought in by contractors and by generators

It is advised that SSA will prepare monthly monitoring reports and provide PSD with them.

5.7 Preliminary Cost Estimation

5.7.1 Methods and Assumptions

Major assumptions and methods used for the cost estimation are as follows:

1. Future collection costs are estimated based on estimated unit costs and estimated waste quantity to be collected under the responsibility of the municipality.
2. Generators will collect and haul all non-municipal waste (demolition waste, industrial waste and large quantity business waste) by themselves.
3. Costs shown in the table are costs of using collection contractors to be paid by the municipality.
4. Costs comprises of the following items;
   A. Direct cost
      (1) Equipment cost (depreciation of trucks, containers, and used bins)
      (2) Operation cost (salary of drivers and collection workers, and fuel)
      (3) Maintenance cost (parts and salary of mechanics)
      (4) Interest on equipment loan (Interest is 8% per year)
         Note: Useful periods of equipment are assumed as follows;
         – Trucks : 8 years
         – Containers and used bins : 4 years
   B. Indirect cost (overhead and profit)
      (1) Indirect cost is 5% of the direct cost.
5. The existing trucks and bins (non-recommended types) will be replaced with recommended types according to the following schedule:

Table 5.7-1 Renewal Schedule for the Existing Equipment of Non-Recommended types

Year	Existing Equipment	Newly Purchased Recommended Trucks
1995	100%	0%
1996	75%	25%
1997	50%	50%
1998	25%	75%
1999-2010	0%	100%

6. Vehicle utilization rate (ratio of average daily vehicle number relative to total vehicle available) is 90%.

   Note) Factors of reduction includes; (1) regular check (2) repair (3) driver's absence

7. Costs are indicated in 1995 prices.
8. Estimated current unit waste management cost is US$15.3 per ton. (See Appendix 5)

5.7.2 Cost Projection

Estimated Cost based on the above assumptions is as follows.

Table 5.7-2 Estimated Annual Costs of Collection and Haulage 1996 - 2010

Year	Unit Collection & Haulage Cost including Costs of Waste Containers ($/ton) (a)	Annual Municipal Waste Collection Quantity excluding Street wast (ton/year) (b)	Collection & Haulage Cost to the Citizens a x b = (c)	Collection Cost to the Municipality (excluding cost of containers to be paid by the citizens) (83 % of c) (d)
1996	14.1	383,225	5,403,473	4,484,882
1997	12.9	397,055	5,122,010	4,251,268
1998	11.7	418,812	4,900,100	4,067,083
1999	10.5	444,899	4,671,440	3,877,295
2000	10.5	471,924	4,955,202	4,112,818
2001	10.5	484,675	5,089,088	4,223,943
2002	10.5	498,245	5,231,573	4,342,205
2003	10.5	512,196	5,378,058	4,463,788
2004	10.5	526,538	5,528,649	4,588,779
2005	10.5	541,281	5,683,451	4,717,264
2006	10.5	556,437	5,842,589	4,849,348
2007	10.5	572,017	6,006,179	4,985,128
2008	10.5	588,033	6,174,347	5,124,708
2009	10.5	604,498	6,347,229	5,268,200
2010	10.5	621,424	6,524,952	5,415,710
Total		7,621,259	82,858,336	68,772,419

Note:

It is assumed that the citizens will purchase containers from the waste contractors. Therefore, the future waste tax will not include costs of containers. It is assumed that the cost of waste containers is 17 % of the total collection/haulage costs.

Chapter 6
Street Sweeping

CHAPTER 6 STREET SWEEPING

6.1 Current Condition

6.1.1 Costs and Equipment Used

In Bucharest, ADP of each sector is responsible for street sweeping.

ADP in each Sector has budget at around 3 billion lei /year for its activities. Among them 20 % to 28 % are used for street sweeping. Costs and equipment used for street sweeping by sector are shown in Table 6.1-1.

Table 6.1-1 Costs and Equipment Used by ADP for Street Sweeping

Sector	No. of Worker	Total Annual Cost (a)+(b) (million Lei)	Salary (a)	Other O/M cost (b)	No. of Truck 1)	No. of Mechanical Sweepers Requested by ADP 2)
1	350	611	297	314	4 (8 m^3 open truck)	10
2	436	633	358	275	12 (open truck & container)	5
3	454	860	603	257	10 (compactor & container)	6
4	278	743	520	223	6 (compactor)	9
5	340	617	335	282	8 (open truck & container)	7
6	226	604	200	404	6 (open truck & container)	11
Total	2,084	4,068	2,313	1,755	46 trucks	48

Note) 1): Each ADP has tractors for multi-purposes use including waste collection and haulage. Number of tractors belonging to each ADP is 15 to 20 on average.

2): Mechanical Sweepers belong to RASUB. ADP rents them from RASUB.

6.1.2 Service System

Generally ADP provides 24 hours-sweeping service for main streets served by public transport in Bucharest. Each ADP applies 3 shifts per day and also has special shifts for Saturday and Sunday.

A sweeping team consists of 20 to 30 workers. A worker sweeps 0.6 to 0.7 km per day. ADP uses mechanical sweepers for trunk roads everyday. RASUB rents mechanical sweepers to ADP upon the request.

Collected waste by street sweeping are put into 4m^3 -containers, plastic bags, or just left on side walks. ADP's trucks haul them to the final disposal site.

6.1.3 Service Performance

ADP's street sweeping services differ by sector as shown in the table below:

Table 6.1-2 Service Performance by Sector (1994)

Sector	Total length of served street (km)				Total collected waste/ month 2) (m^3)	Average collected waste/ week-day (m^3/day)	Coverage ratio of everyday sweeping (%)
		Coverage ratio 1) (%)	Mechanical (km/day)	Manual (km)			
1	110.0	37.3	18.0	92.0	570	24.8	51.0
2	155.7	51.7	12.0	143.7	1,200	52.1	100.0
3	68.5	43.9	10.0	58.5	500	21.7	92.0
4	76.2	37.5	34.0	42.2	480	20.8	44.0
5	143.0	62.0	12.0	131.0	870	37.8	62.0
6	116.0	89.6	60.0	56.0	750	32.6	65.5
Total	669.4	51.0	146.0	523.4	4,370	189.8	70.7

Note) 1): Coverage ratio = Served street length/Paved street length

2): Estimated based on interview data

Source: ADPs, Road Administration MB

6.1.4. Major Problems

1) Workers

Judging from some simple indicators, quantitatively the workers for street sweeping meet the requirements. If all the workers sweep all the length of served streets in a day, the indicators are;

1. Length of the streets swept per worker per day:
   669.4 km/2,084 = 0.32 km/worker/day
2. Distance of sweeping per worker per day:
   0.32 km × 2 sides = 0.64 km/worker/day
3. Distance of sweeping per team per day:
   669.4 km × 2/2,084/20 = 12.8 km/team/day
4. Collected waste amount per worker per weekday:
   189.8 m^3/2,084 =0.09 m^3/worker/day

Note 1) 669.4 km is the total length of streets served with street sweeping.
2) "day" means weekday.

Meanwhile according to ADP's answer to the study team, qualitatively the workers don't meet the requirements because they are lack of basic skill to sweep, likely to be absent from duty (absence ratio is almost 30%), which leads to inadequate service performance.

2) Equipment

RASUB has 40 workable mechanical sweepers which cover 146 km of the streets, which means a sweeper must cover 7.3 km of distance of sweeping. As long as this figure shows, there is no lack of mechanical sweepers. But 17 sweepers out of 40 are older than 8 years.

In addition, ADPs have 46 trucks for hauling waste from streets, parks, and other places. It is not clearly decided so far whether or not all the trucks will be transferred from ADPs to RASUB. If not, RASUB will have to procure trucks enough to collect street waste of 190 m^3 (58.5 ton)/week-day to be hauled.

3) Cost

ADPs expended 4.07 billion lei for street sweeping in 1994. Unit cost of the street sweeping is estimated to be US$121/ton.

6.2 Target Service Level

6.2.1 Principle

Street waste is expected to decrease with the improvement of public manners of the citizens and with improvement of waste collection service to waste generators. In future, street sweeping should be minimized only to cleanse streets of dust caused by natural phenomenon.

The expenses for street sweeping cannot get cash return at all. If the municipality of Bucharest (MB) intends to avoid waste money, must be so, MB has to establish a principle like the following.

1. To decrease and prevent littering up the streets through providing sufficient collection service and propagating public manner to neighborhood

2. To decrease periodical street sweeping and change to one in response to necessity for long term

3. To decrease expenses for street sweeping gradually through realizing the above items

6.2.2 Street to be served

The total length of roads/streets (hereinafter streets) in Bucharest except Buftea and rural area is 1,821 km. The streets are categorized to five by surface, namely asphalt paving (622 km), fine stone paving (193 km), rough stone paving (496 km), ballast (344 km), and soil (166 km).
MB has responsibility to maintain all the streets, and to keep them clean and safe as those are domain of MB. However there should be priority and criteria for execution of the duty, which also should be stipulated in a form of ordinance/legislation. There is no ordinance on street sweeping in MB so far. Thus, ADP selects streets to be swept based on public transport network (394 km) and each ADP's staff view point at present.

Streets to be served cover all the streets in Bucharest for the Draft Master Plan.

6.2.3 Target Service Level

For planning of street sweeping, the master plan period is divided into 2 phases, i.e., phase 1 1996 – 2001, and phase 2 2002 – 2010. Targets are set for each phase as shown in Tables 6.2-1 and 6.2-2.

Table 6.2-1 Target Service Level (1996--2001, Phase 1)

	Central District		Suburban District	
	Trunk road	Street	Trunk road	Street
1. Asphalt & Fine Stone (815 km)	-Mechanical & Manual Every day (50 km)	-Manual -Periodical (120 km)	-Mechanical & Manual -Every day (150 km)	-Manual -Patrol 1) (495 km)
2. Rough Stone (496 km)	-NA-	-Manual -Patrol (50 km)	-NA-	-Manual ** -Upon Request 2) (446 km)
3. Ballast & Soil (510 km)	-NA-	-Manual -Upon Request (25 km)	-NA-	-Manual -Upon Request (485 km)

Note) 1) Patrol: Patrol cars observe street condition and dispatch a sweeping team if necessary.

2) Upon request: To dispatch a sweeping team upon citizen's request.

3) Definition

Trunk road: To have 3 lanes or more.

Street: To have 2 lanes or less.

Central District: District situated inside the inner beltway.

Suburban District: District situated outside the inner beltway.

Street length by each break-down into trunk and street is estimated.

Table 6.2-2 Target Service Level (2002--2010, Phase 2)

	Central District		Suburban District	
	Trunk road	Street	Trunk Road	Street
1. Asphalt & Fine Stone (815 km)	-Mechanical & Manual -Every day (50 km)	-Manual -Periodical (120 km)	-Mechanical & Manual -Patrol (150 km)	-Manual -Patrol (495 km)
2. Rough Stone (496 km)	-NA-	-Manual -Upon Request (50 km)	-NA-	-Manual -Upon Request (446 km)
3. Ballast & Soil (510 km)	-NA-	-Manual -Upon Request (25 km)	-NA-	-Manual -Upon Request (485 km)

Note) Parts different from Phase 1 are underlined.

6.3 Improvement Plan on Street Sweeping

6.3.1 Recommended Sweeping System

Based on the comparison of the existing mechanical sweeping systems, the following systems are recommended as suitable and economical sweeping measures.

1) Mechanical Sweeping

Among the existing mechanical sweepers, FAWN (made by Mercedes) shows the best cost performance, that is, $210/ton, which is $74 more efficient than a sweeper made by Ford if its loading capacity is fully utilized. (But the cost data related to import duty, value added tax and precise depreciation are still needed for further analysis.)
Note: See Appendices for further detail.

Therefore, in this study FAWN or other mechanical sweepers of better cost performance is recommended.

2) Manual Sweeping

Cost performance of manual sweeping is $48/ton and is higher than mechanical sweeping. Furthermore, sweeping for sidewalks and for rough paved street can only be done manually.

So the priority of improvement should be put on selecting light containers, efficient collection trucks and small trash box for passengers to reduce waste littering on streets.

3) Introduction of Patrol Cars

The regular sweeping will substantially decrease in the plan as mentioned in 6.2. Basic idea is to decrease substantially, but to increase containers and trash boxes in order to decrease the Municipality's expenses for street sweeping because the Municipality needs a large fund to invest in new disposal sites, and other municipal projects.

Thus, small type compactor trucks (2 ton or 3 ton) should be used for as both patrol and collection purposes.

6.3.2 Basic Assumptions

The improvement plan for street sweeping is made based on the following assumptions.

1) Street Condition

Since the Municipality has not prepared a comprehensive master plan for city development yet so far, the following assumptions are used.

1. Until 2010, total length of streets in Bucharest by category will not change.
2. Cars parked or abandoned on side walks and on sides of streets will decrease at certain rate by year due to enforcement of "The ordinance of Parking, 1994" enacted in August of the year. The number of abandoned cars are assumed to decrease to 25% of 1995 level by 2010. This will be quite helpful for speedy work of street sweeping.

2) Waste Generation

Future waste generation in the streets will increase as population will increase and per capita generation will increase, but also will possibly decrease by realization of appropriate waste collection service and improvement of the citizens manner. Despite the anticipation, any factors that could make the street waste decrease are not assumed here.

3) Sweeping Equipment

a. Mechanical Sweeper (per 1 sweeper)

(1)	Length of sweeping	24 km/shift
(2)	Collection at maximum loading	4.4 ton/shift
(3)	Velocity during sweeping	5.4 km/shift
(4)	Number of trip	once/shift
(5)	Utilization of sweeper	90%
(6)	Cost/ton at 100% utilization	$15.6/ton
(7)	Shift	1.5 shift/working day

b. Manual Sweeping Team (per 1 team = 20 workers, per 1 shift)

(1)	Length of sweeping	12.8 km/shift
(2)	Collection	2.4 ton/shift
(3)	Velocity during sweeping	1.6 km/shift
(4)	Number of trip	-------------
(5)	Number of Container truck	0.55 unit/shift
(6)	Plastic Container (240 litre)	5 unit/shift
(7)	Utilization of team	100%
(8)	Utilization of truck	90%
(9)	Cost/ton at 100% utilization	$20.5/ton
(10)	Shift	2.5 shift/working day

c. Other Equipment

(1)	Street Container (2 m^3)	3 unit/km
(2)	Town Trash Box (120 litre, for passengers)	8 unit/km

4) Unit Street Waste Generation

(1)	In regularly swept streets	0.185 ton/km (as of 1996)
(2)	In streets served by "Patrol"	0.093 ton/km (as of 1996)

5) **Operation Day**

(1) Weekday and Saturday:
Regular/Patrol Sweeping, 303 days/year.

(2) Sunday and Holiday:
Patrol Sweeping only with mobility ratio at 10% – 20% of one weekday's capacity.

6.3.3 Planned Street Length to be Swept and Waste to be Collected

1) Street Length and Waste Projection

The following table shows street length to be swept and estimated street waste to be collected.

Table 6.3-1 Street to be Swept and Waste Projection

Year	Length of served street (km)				Total street waste to be collected (ton/weekday)			
		Daily	Every 2 days	Patrol		Daily	Every 2 days	Patrol
1996	703	429	184	90	58.5	38.2	16.4	3.9
1997	737	384	172	181	60.8	36.0	16.2	8.6
1998	770	339	159	272	63.1	34.0	15.6	13.5
1999	802	293	146	363	66.6	31.3	15.6	19.7
2000	834	247	133	454	68.9	28.0	15.2	25.7
2001	865	200	120	545	72.3	24.3	14.5	33.5
2002	860	180	120	560	74.6	23.0	15.3	36.3
2003	855	160	120	575	76.9	22.0	16.1	38.8
2004	850	140	120	590	79.2	20.0	16.9	42.3
2005	845	120	120	605	81.5	18.0	17.9	45.6
2006	840	100	120	620	83.8	16.1	18.6	49.1
2007	835	80	120	635	86.1	13.5	19.7	52.9
2008	825	60	120	645	88.4	10.5	20.9	57.0
2009	815	50	120	645	90.7	9.0	21.9	59.8
2010	815	50	120	645	93.0	9.2	22.5	61.3

2) Needed Equipment and Workers

Estimated capacity needed for street sweeping are shown as Table 6.3-2.

Table 6.3-2　　Equipment and Workers Required 1995 – 2010

Year	Street Length to be Swept (km)					Waste to be collected (ton/operation day)				Capacity (per operation day)				
	Mech-anical Sweeper	Manual			Total	Mech-anical Sweeper	Manual		Sub-total	Mech-anical Sweeper	Worker			Com-pactor
		With Mech-anical Sweeper	Manual				With Mech-anical Sweeper	Manual only			Regular	Patrol	Total	
			Regular	Patrol										
1995	146	146	524	-	670	6.0	8.9	43.6	58.5	40	2080			31
1996	150	150	553	90	703	6.3	9.4	42.8	58.5	22	909	78	987	14
1997	160	160	396	181	737	7.0	10.5	43.3	60.8	22	727	132	859	12
1998	170	170	328	272	770	7.9	11.8	43.4	63.1	22	655	186	841	12
1999	180	180	259	363	802	8.9	13.4	44.3	66.6	22	583	240	823	12
2000	190	190	190	454	834	9.9	14.8	44.2	68.9	15	510	294	804	12
2001	200	200	120	545	865	11.2	16.8	44.3	72.3	13	436	348	784	12
2002	200	200	100	560	860	11.9	17.8	44.9	74.6	13	411	357	768	11
2003	200	200	80	575	855	12.4	18.8	45.7	76.9	13	386	365	751	11
2004	200	200	60	590	850	13.0	19.7	46.5	79.2	13	362	375	737	11
2005	200	200	40	605	845	13.7	20.5	47.3	81.5	13	337	383	720	10
2006	200	200	20	620	840	14.2	21.4	48.2	83.8	13	312	393	705	10
2007	200	200	0	635	835	15.1	22.6	48.4	86.1	13	267	401	668	10
2008	180	180	0	645	825	15.9	23.9	48.6	88.4	13	243	407	650	10
2009	170	170	0	645	815	16.7	25.0	49.0	90.7	13	230	407	637	10
2010	170	170	0	645	815	17.1	25.5	50.4	93.0	13	230	407	637	10

Note) 1) Mechanical Sweepter: 1.5 shift × 4.4 ton × 90% utilization = 5.94 ton/day/sweepter
1.5 shift × 12 km × 90% utilization = 16.2 km/day/sweeper
2) Manual Sweeping: 2.5 shift × 6.4 km net length/ shift = 16.2 km/day/team (20 pr)
3) Compactor truck: 4.4 ton/trip × 2 trip/day × 90% utilization = 7.9 ton/day
4) 40% of Patrol streets areserved by manual every day = (P)
5) Upon request streets areserved by manual every day at 20% of (P)
6) *: including 12 small compactors for patrol.
7) Operation day per week is 6.1 days.

6.4 Monitoring Plan

6.4.1 Objectives

The municipality plans to use contractors for street sweeping services as well as collection and haulage of municipal waste from 1995.

It is also needed for the municipality to establish a well functioning system for monitoring contractor's operation. The purposes of monitoring of street sweeping service are:

1. To check degree of contractors' compliance with collection contracts.
2. To know current conditions and problems.

6.4.2 Monitoring Responsibility

The municipality should be responsible for planning of monitoring, analysis and use of monitoring data, and application of sanctions to service providers who did not comply with the service contract.

Sector office (Salub rity Administration) should be responsible for the field monitoring, and obtaining data.

6.4.3 Monitoring Items

Monitoring should be done in accordance with a clear monitoring plan based on the municipality's municipal waste management plan and contents of the contract on street sweeping services between the municipality and contractor(s).

It is proposed that the municipality will obtain the following monitoring information.

Table 6.4-1 Monitoring Information to be Obtained on Street Sweeping

Monitoring Item	Monitoring Method
1. Operational situation	– To do both regular and spot inspection in order to check compliance with the contract
2. Quantity of collected waste	– To measure weight at truck scale
3. Citizen's Compliants	– To receive complaints through telephone etc.

6.5 Preliminary Cost Estimation

6.5.1 Methods and Assumptions

Basic assumptions metioned in 6.3.2 and Table 6.3.2 are used for the cost estimation. In addition, the following conditions are used.

1. Durability of mechanical sweeper: 8 years

2. Durability of container and other equipments: 4 years

3. Eighteen mechanical sweepers, IFA shall be out of service in 1996 due to beyond durability.

4. Fifteen mechanical sweepers, Ford shall be out of service in 2000 due to durability and low cost efficiency.

5. Seven mechanical sweepers, FAWN shall be out of service in 1999 due to durability. And contractor(s) shall purchase thirteen new mechanical sweepers in 1999.

6. The municipality shall rent sweepers at rate with deduction of depreciation cost to contractor(s).

7. Compactors including small compactors, street containers, town trash boxes and plastic containers shall be purchased by the municipality in 1996.

8. Street containers ($2m^3$) are distributed to all the streets to be swept.

9. Town trash boxes (120 ℓ) are distributed to all the trunk streets.

6.5.2 Preliminary Cost Projection

Estimated cost based on the above assumptions is as follows.

Table 6.5-1 Preliminary Cost Projection for Street Sweeping

Year	Nos. Mechanical sweeper		Mechanical sweeper cost* a (10^3US$)		Nos. Manual team (shift)	Manual team cost	Other equipment cost*	Total cost
	Existing sweeper	New sweeper	Existing sweeper	New sweeper		b (10^3US$)	c (10^3US$)	(a+b+c) (10^3US$)
1996	22	0	540.1	-	50	737.4	36.9	1,314.4
1997	22	0	540.1	-	43	639.2	36.9	1,216.2
1998	22	0	540.1	-	43	645.8	36.9	1,222.8
1999	15	(13)	381.8		42	638.9	36.9	1,057.6
2000	0	13	-	295.0	41	629.8	36.9	961.7
2001	0	13	-	295.0	40	623.5	36.9	955.4
2002	0	13	-	295.0	39	615.4	36.9	947.3
2003	0	13	-	295.0	38	606.1	36.9	938.0
2004	0	13	-	295.0	37	596.7	34.6	928.6
2005	0	(13)	-	295.0	36	588.6	34.6	920.5
2006	0	13	-	295.0	36	593.9	34.6	925.8
2007	0	13	-	295.0	34	569.3	34.6	901.2
2008	0	13	-	295.0	33	561.0	34.6	892.9
2009	0	13	-	295.0	32	551.2	34.6	883.1
2010	0	13	-	295.0	32	555.1	34.6	887.0

Note) 1) (13):newly purchased.
2) *: including interest, salary, O/M cost as well as depreciation.

Chapter 7
Treatment and Disposal

CHAPTER 7 TREATMENT AND DISPOSAL

7.1 Current Situation

7.1.1 Treatment

1) Incineration

In Romania, there are several incinerators constructed by National Council for Science and Technology in early 1980'. Of which, there are 2 incinerators in Bucharest that now belong to RADET (Heat energy supply company); one in Militari, the other in Pantelimon. The latter stopped operation last year.

The primary purpose of construction of the incinerators in Romania was to utilize heat generated from waste incineration.

From both technical and economic view points, it is considered that the existing Militari incinerator is not feasible. The incinerator is not feasible from view points of either 1) solid waste management or 2) utilization of incinieration heat. In other words, the purpose of the construction of the Incinerator has not been fulfilled.

Technical Conditions of the Militari Incinerator

There is a design problem in the Militari incinerator. Design low calorific value of the Militari incinerator is 600 kcal/kg. However, the incinerator dose not well incinerate waste of this caloric in reality. Currently, the RADET uses waste of higher caloric, but still dose not incinerate waste well. Use of waste having caloric higher than the design caloric implies that waste incineration capacity in terms of incineration quantity will be lower than the design incineration capacity, and also will damage the incinerator leading to a shorter useful period.

Economic Conditions

According to the RADET's information, the operation and maintenance costs of Militari incinerator have been higher than the revenues. In 1993, total operation and maintenance cost was 151,763,000 lei, which is 31,387,000 lei higher than the revenue of 122,882,000 lei. The loss will be higher if depreciation of the facilities is added to the cost, and if real economic costs of electricity is taken into account instead of subsidy-supported nominal price. (It is reported that electricity charge rates for companies are less than 30% of real price, while those for households are about 12%.) The RADET's information also shows that Militari incinerator incinerated 8,720 tons (24 ton/day average) of waste in 1993 by using 21,197 kg of fuel and 721,304 kwh of electricity. Average unit consumption for incinerating one ton of waste is estimated to be:

- Fuel: 2.43 kg/ton and
- Electricity: 82.7 kwh/ton

The electricity consumption rate is very high. It seems that this is because the electrical equipment does not function efficiently.

2) Composting

There was a pilot composting facility in Bucharest. It was abandoned 8 years ago because the produced compost product contained heavy metals. It was vertical fermentation tank type.

In general, technically fasible composting requires that waste should contain nitrogen/carbon (C/N) ratio ranging between 25:1 - 50:1. The most appropriate rations ranges between 30:1 - 35:1. However, it is generally very difficult for composting plants to be economically feasible even if benefits of waste volume reduction and resultant disposal cost saving are considered.

7.1.2 Disposal

1) Former Dump Sites

The Bucharest Municipality used 9 landfill sites since 1968 for disposal of solid waste. The locations and outline of sites are shown in Appendix 7.1. Of the 9 landfill sites, 2 sites are located on borrow pit of brick factory, the other sites are located on swampy land formed by river erosive action. One of the sites is located in Sector 2, the others are located around the ring road. Haulage distance to those sites is not long, which contributed to economical waste haulage.

All the former sites were selected from geographical and topographical viewpoints. Little consideration was given to the natural conditions in the selection of the former

sites. There are some local residents who complained about contamination of ground water near one of the sites.
There is no post landfill closure management and supervion for these sites. And, illegal waste dumping has been continuing.

2) Glina Disposal Site

a. Environmental Condition

In Bucharest, there is, at present, only one landfill site, which is located in Glina. It is 13 Km to southeast of the center of Bucharest. The site is outside the boundary of the Bucharest city. The current detailed conditions are described in Appendix 7.2.

The Glina site lies on low land and has an area of about 110 ha, which is adequately large as municipal landfill site. The site is ideally located from waste haulage efficiency view point as it is near the ring road.

Adjacent to Glina site are Glina-village and Popesti-Leordeni-village. However, no facilities are provided to prevent secondary pollution. There is a high risk of environmental pollution which may affect to health of residents in the following ways:

1. Smoke, odor and rodents are generated, which may affect health of the people living near the site and site workers. The problem may become more serious since the dumping operation area is moving towards the housing areas;

2. There is a considerably high risk that leachate generated from the waste deposits will contaminate surface and ground water on Glina village side; and

3. The results of the leachate analysis and a map showing sampling points are attached in Appendix 7.5. The leachate includes material of low density is poor because there is a contact flow of water from the terrace into the site. Forturately, there is no heavy metal contamination. However, the results of the analysis suggest that agricultural drainage water near the site is being significantly polluted by the leachate.

b Management Condition

1. There is no strict control to prevent toxic and hazardous waste from being brought into the site.

2. Landfill is not operated in systematic and planned manner. Tipping method and area are decided by operators of heavy machines.
3. There are large number of waste trucks in queue in entrance area of the site. According to RASUB, daily total trips made by waste trucks ranges about 1,000 including those of industrial waste generators. This congestion is attributable to the facts that 1) Glina landfill is the only landfill used at present, and 2) there is only one entrance to the site.

4. Partly because there are too many trucks coming to the site, site controllers cannot give appropriate instructions to truck drivers as to waste dumping place.

7.2 Disposal Policy

The following disposal policy is proposed:

1. <u>The Bucharest municipality should be responsible for disposal</u>

It takes a few decades for waste to decompose and become stable. It is difficult for private companies to take this responsibility for such a long time. Therefore, the public body representing the city, i.e., the Bucharest municipality should be responsible for disposal of waste.

2. <u>Introduction of sanitary landfill</u>

Though open dumping as currently practiced by RASUB is the cheapest method of disposal, it causes environmental pollution and can potentially affect the health of local residents living near disposal sites. A disposal site with open dumping will be increasingly difficult to be accepted by local residents. Therefore, it is necessary for Bucharest to introduce sanitary landfill. Sanitary landfill of the highest environmental standard is still much more economical than incineration.

3. <u>Staged improvement of disposal standard</u>

It is proposed that initially the municipality introduces an economical sanitary landfill, and subsequently upgrades the disposal standard by providing lining of improved quality and leachate leakage monitaring system.

4. <u>Systematic acquisition of landfill sites of large area</u>

It is advisable for the municipality to plan the acquisition of future landfill sites as the acquisition is increasingly difficult and takes time. The difficulty in site acquisition is partly due to the increasing public awareness of environmental problems and demand to avoid such problems. In order to make construction of landfill sits more acceptable to local residents, it is necessary for the municipality to prove that the disposal by sanitary landfill, does not cause serious problems to them, and to show future landuse plans such as the conversion of a completed site into a green park. Failure to acquire landfill sites of reasonably large size, will mean that waste incineration will have to be employed which is very costly.

5. <u>Acquisition of at least 2 landfill sites</u>

The municipality should have at least 2 landfill sites, prefetably, one in the east and the other in the west to reduce waste haulage costs. A substantial reduction of haulage costs can be expected if the municipality obtains a landfill site in the west.

6. <u>Use of appropriate guidelines for the selection of landfill sites</u>
It seems that former dumpsite locations were selected on the basis of geographical view criteria only. Other conditions such as geological and environmental conditions should also be taken into consideration in selection of sites. Refer to Attachment 1, Technical Guidelines for Selection and Acquisition of Landfill Sites.

7. <u>Improvement of the existing Glina landfill site</u>
Glina landfill site has caused environmental pollution that has affected the life of local residents living in neighboring villages. This pollution problem may become a political issue in the near future. It is necessary for the municipality to take measures to control the pollution. To take appropriate measures, as explained in Section 7.5, will enable the municipality to use the site for the next few years without the risk of complaints from the local residents. Taking appropriate measures will also make the landfill operation more efficient.

8. <u>Management and monitoring of former dumpsites</u>
The dumping of waste, particularly demolition and industrial waste is still occurring at some former dumpsites. If there is no waste dumping at those sites, they may be used for developing residential, commercial or industrial properties. It is advisable for the municipality to manage the sites by periodic monitoring of site conditions including the impact of leachate on water.

9. <u>Recovery of methane gas</u>
Recovery of mathane gas from landfill sites will not be considered because it is not feasible. Mathane gas recovery may be technically feasible if waste deposit at landfill sites is 15m or deeper. However, the depth of waste deposit of planned landfill sites for Bucharest is about, 10m due to geographic conditions of the planned locations. Another important conditions for the methane gas recovery to be feasible is that there must be demand for methane gas at places reasonable near to the sites.

7.3 Methods of Solid Waste Management

1) Alternative Methods

It is considered that the following two alternative methods are worth studying their applicability as a major means of waste disposal in Bucharest:

Alternative 1 Sanitary landfill
Alternative 2 Incineration

Theoretically, composting is another disposal alternative. However, the composting is not considered feasible as a major means of waste disposal in Bucharest judging from the fact that the composting was carried out in Bucharest but several years ago stopped because compost product contained heavy metals and there was not sufficient demand for the product.

2) Criteria for Evaluation

Cost and environmental soundness are two major criteria used in evaluation of disposal alternatives.

3) Evaluation

a. Specifications of Facilities Assumed for Evaluation

Cost of sanitary landfill and incinerator vary greatly depending on level (specifications) of respective facilities. For the purpose of meaningful comparison, environmentally-sound facilities of minimum cost were assumed. Outlines of assumed landfill facility and incinerator are shown below.

Table 7.3-1 Outline of Landfill Facilities Assumed for Evaluation

Facilities	Functions	Specifications
1. Embankment	to prevent garbage from flowing out of the site and to also prevent rainfall from flowing in.	Soil bank of 7 m height around site.
2. Lining	to avoid seepage of leachate and contamination of ground water	Artificial liner Thickness = 2.0 mm
3. Leachate Collection Facility	to collect leachate quickly	Crushed stone
4. Rain Water Drain Facility	to prevent water from flowing into the site	Concrete drain ditch (Width= depth=300mm) are constructed around the site
5. Leachate Treatment Facility	to treat leachate and improve quality of water to be discharged outside the site	Generated leachate will be transported to Glina sewage treatment facilities through leachate transmission pipes.
6. Gas Exhaust Facility	to collect and release the gas generated from decomposed waste	PVC porous pipe with crush stone

Table 7.3-2 Outline of Incinerator Assumed for Evaluation

	Description
Type	24 hours operation stoker type
Facilities included	1. Refuse receiving and feeding system 2. Combustion system 3. Ash treatment system 4. Waste waster treatment system 5. Air supply system 6. Flue gas draft system 7. Dust collection system 8. Surplus heat utilization system 9. Instrumentation - Automatic control system 10. Stack 11. Building

b. Cost Comparison

Both sanitary landfill and incineration assumed for comparison are considered environmentally sound and acceptable. Therefore a meaningful evaluation of the two alternatives can be made in terms of unit cost. The unit cost is defined as follows:

Unit cost = a ÷ b where,

a: Sum of investments and all costs of operation and maintenance needed during entire operation period

b. Total quantity of waste to be disposed of during entire operation period

Estimated net unit costs of the sanitary landfill and incinerator are \$ 5.17/ton and \$ 42.05/ton respectively as shown in Table 7.3-1 and Fig. 7.3-1. The unit incinerator cost of \$42.05 is a net cost obtained by deducting heat sales (\$ 7.83/ton) from the gross cost {(\$ 48.88/ton). (\$ 48.88/ton - \$ 7.83/ton = \$ 42.05/ton}

The unit cost of the sanitary landfill was estimated based on estimated costs of the planned landfill sites in Balaceanca and Cretuleasca.

Incineration is of continuous operation stoker type with systems of heat recovery. Its construction cost is assumed to be around US \$ 185,000/ton, which is considered a minimum level as a modern incinerator.

Table 7.3-3 Estimated Unit Costs of Sanitary Landfill and Incineration

Unit: US \$/ton in 1995 price

Cost Items	Sanitary Landfill	Incineration
1. Depreciation of Investment Cost	4.58	36.97
2. Operation & maintenance	0.59	12.91
3. Total cost (1 +2)	5.17	48.88
4. Sales of heat	-	7.83
5. Net cost (3 - 4)	**5.17**	**42.05**
6. Index of net cost	100	813

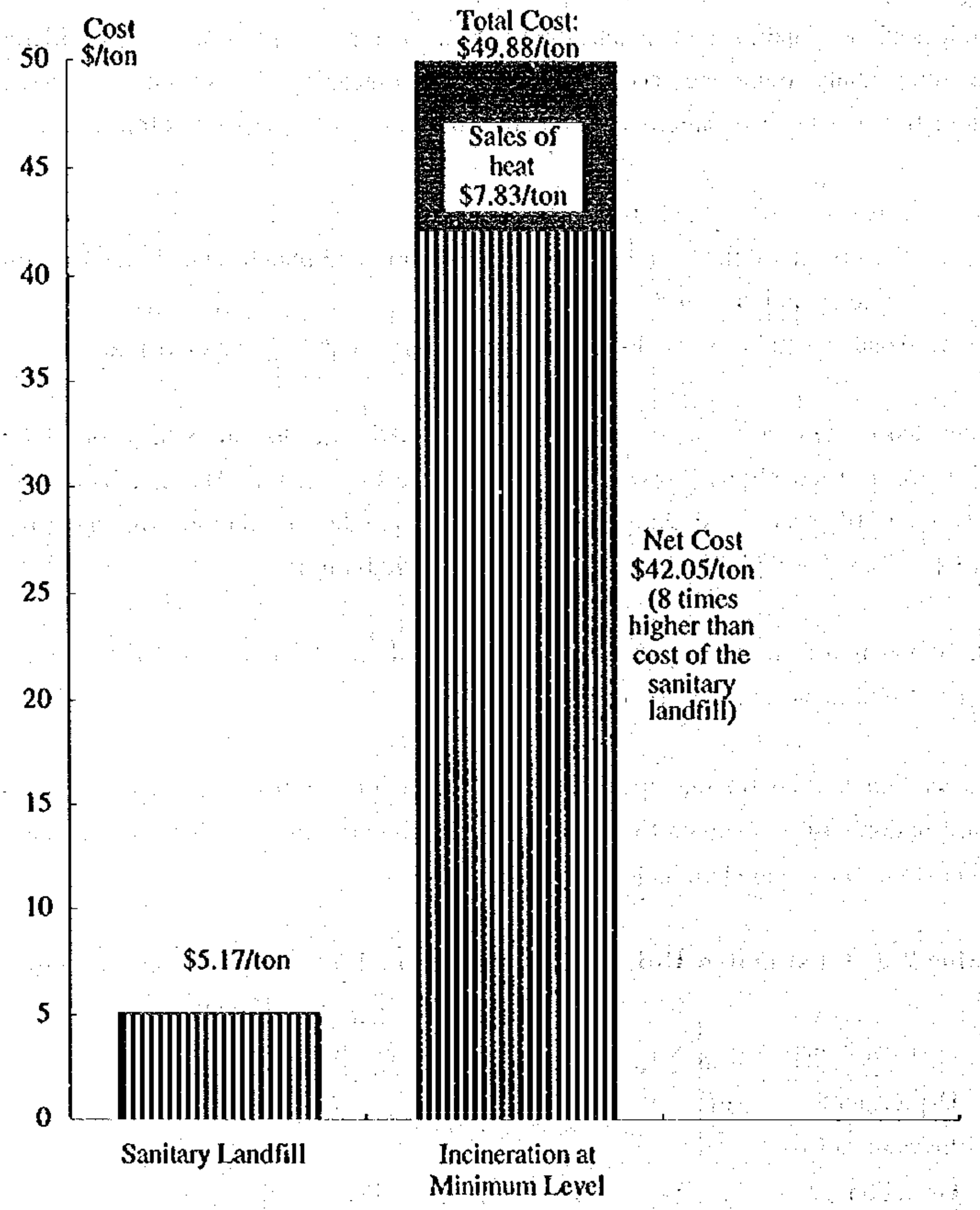


Fig. 7.3-1 Comparison of Unit Costs of Sanitary Landfill and Incinerator

c. Major Assumptions Used for the Estimation of Sanitary Landfill Cost and Incineration Costs

A. Assumptions Used for Estimation of Sanitary Landfill Cost

A1 Unit Construction Cost: $ 4.58/ton

Calculation:
a ÷ b = $ 45,706,551 ÷ 9,995,000 ton = $ 4.58/ton
where,
a: Estimated total cost of construction of the Glina & 5 sanitary landfill sites in Balaceanca, Cretuleasca, Afumati and Berceni: $ 45,706,551
b: Estimated total waste quantity to be disposed of at the Glina & 5 sanitary landfill sites in Balaceanca, Cretuleasca, Afumati and Berceni: 9,995,000 ton

A2 Unit operation and maintenance cost: $ 0.59/ton

Calculation:
a ÷ b = $ 5,918,915 ÷ 9,995,000 ton = $ 0.59/ton
where,
a: Estimated total cost of operation and maintenance of the Glina & 5 sanitary landfill sites in Balaceanca, Cretuleasca, Afumati and Berceni: $ 5,918,915
b: Estimated total waste quantity to be disposed of at the Glina & 5 sanitary landfill sites in Balaceanca, Cretuleasca, Afumati and Berceni: 9,995,000 ton

A3 Unit total cost of sanitary landfill: $ 5.17/ton

Calculation:
$ 4.58/ton (Unit construction cost) + $ 0.59/ton (Unit operation & maintenance costs) = $ 5.17/ton

See Appendix for further details.

B. Unit Incineration Cost

B1 Unit Construction Cost

B1.1 Construction cost per capacity: US $ 185,236/ton/day capacity

This costs was estimated based on an Austrian incinerator manufacturer's price quotation which is US $ 185,236/ton/day capacity. Further assumptions used are as follows: 1) building work shares 30 % of the original Austrian price. 2) building work in Romanian is one third of the Austrian price. 3) imported equipment cost in Romania is subject to 5 % import duty, 4) total incinerator price is subject to 18 % value added tax.

<u>Calculation:</u>

- Equipment cost before value added tax (a) = US $ 188,000/ton/day capacity x 70 % (equipment portion) x 1.05 (import tax: 5%) = $ 138,180/ton/day capacity
- Building work cost before valued added tax (b) : $ 188,000/t/d capacity x 30 % (building work portion) x 1/3 (ratio of Romanian building cost to Austrian cost) = $ 18,800/t/d capacity
- Total incinerator cost = (a + b) x 1.18 (value added tax: 18%)
= ($ 138,180 t/d + $ 18,800 t/d) x 1.18 = $ 156,980 t/d capacity x 1.18
= $ 185,236 t/d capacity

B1.2 Quantity of waste to be incinerated per capacity through life period: 5,010 ton

<u>Calculation:</u>

a x b x c = 1 t/d x 334 days/year x 15 years = 5,010 ton where
a: Waste incineration quantity per one t/d capacity: 1 t/24 hours (by definition)
b: Operation day: 334 day/year (11 months/year)
c: Useful period: 15 years

B1.3 Unit construction cost = $ 36.97/ton

<u>Calculation:</u>

$ 185,236 (unit construction cost per ton capacity) ÷ 5,010 ton (total waste quantity to be incinerated per ton capacity through life period) = $ 36.97/ton

B2. Unit Operation & maintenance costs: $ 12.91/ton

<u>Calculation:</u>

(a x b) + (c x d) = ($ 18.5/ton x 25 %) + ($ 25.1/ton x 33 %)
= $ 4.63/ton + $ 8.28/ton = $ 12.91/ton
where,
a: Typical Japanese operation cost of a 300 ton/day capacity incinerator:
$ 18.5/ton
b: Ratio of Romanian operation cost to Japanese operation cost: 0.25
c: Typical Japanese maintenance cost of a 300 ton/day capacity incinerator:
$ 25.1/ton
d: Ratio of Romanian maintenance cost to Japanese maintenance cost: 0.33

B3. Unit heat sales: $ 7.83/ton

Calculation: a ÷ b = $ 68,268/year ÷ 8,720 ton/year = $ 7.83/ton
where
a: Total heat sales of Militari incinerator (owned by RADET in Bucharest) in 1993: 122,882,000 lei/year = $ 68,268/year (at exchange rate: 1,800 lei/$)
b: Total waste quantity incinerated by the Militari incinerator in 1993:
8,720 ton/year

B4. Net incineration cost: $ 42.05/ton

Calculation: a + b - c = ($ 36.97/ton + $ 12.91/ton) - $ 7.83/ton =
$ 49.88 - $ 7.83 = $ 42.05
where,
a: Unit construction cost
b: Unit operation maintenace cost
c: Unit heat sales

4) Conclusion

1. Incineration is 8 times costlier than Sanitary landfill.

2. Feasibility of sanitary landfill crucially depends on land availability. Judging from the land use condition of Bucharest, it is likely that the Bucharest municipality can obtain, in the agriculture sector, land of area required for landfill up to the year 2010 (200 ha in total).

3. Therefore, it is judged that sanitary landfill is more economical, suitable and recommendable for Bucharest than incineration.

4. Appropriate level and specifications of sanitary landfill depend on such conditions as 1) geographical and geological conditions of sites, 2) distance from site to the nearest human settlement area, and 3) national environmental standards and regulation.

5. Although the incineration is not feasible at present, it may become feasible for Romania some time in the future as there will be changes in the Romanian socio economic conditions which will affect waste composition and land availability. Therefore, the incineration should not be excluded from a future option.

It may be an appropriate strategy for Bucharest to have a pilot incinerator to develop incineration technology suitable for conditions of the Romanian waste. It took about 10 years for the Japanese local governments to develop incineration technology suitable to Japanese waste conditions after they first imported modern incinerators from European countries.

It is generally said that if a local government wishes to apply incineration as major means of waste disposal without causing a serious economic load on the citizens, GDP per capita of $ 4,000 or more would be needed.

It would be beyond the financial capability of the Municipality of Bucharest to entirely finance even a pilot incinerator with the capacity of 200 ton/day within 10 years time. (Minimum construction cost would be $ 40 million.). In view of the possibility of diffusion of the incineration technology to other local governments, it makes a sence that the central government should finance a major portion of the cost of construction of such pilot incinerator. Timing of the construction of such pilot incenerator depends mainly on availability of funds and speed of changes in socio econimic conditions. The appropriate timing would not be before the year 2000.

Part D of Report 8 Other Studies (Report 13 in Romanian version) shows technical information on incinerators.

Comments on Incineration and Energy Recovery from Incineration

In Romania, primary purpose of incineration was to obtain heat from waste incineration. However, the Romanian experience did not show that this was feasible.

It is important to consider and establish a clear objective of municipal waste incineration. In Japan and in other countries, primary purpose of waste incineration is the waste treatment (to reduce waste volume that has to be disposed of at landfill, and to make waste harmless). Energy recovery is only the secondary purpose. No waste incinerators in Japan and other countries would be economically feasible if the incinerators aimed at generation of energy alone. The value of energy recovered is always much lower than the aggregate cost of waste incineration and energy recovery costs. In Japan, a typical cost and benefit condition can be expressed as follows:

$A + B > C$ but considered that $A + B < C + x$

where

A: Cost (Investment and operation/maintenance) of waste incineration facilities

B: Cost (investment and operation/maintenance) of energy recovery facilities (boilers and power generators) attached to incinerators

C: Value of energy recovered and used

x: Expected benefit of waste treatment

In cases of typycal incinerator in Japan, value of energy recovered (C) is smaller than (B) (i.e.,$C < B$) A reason that still some Japanese municipalities construct incinerators with power generation facilities in spite of the above cost situation ($C < B$) is, the power generation through waste incineration is expected to bring about another benefit, i.e., contribution to global environmental protection (prevention of global warming) by consuming less quantity of aggregate fuel, which leads to resultant less emission of global warming gas. This situation may be expressed in the following equation:

$C < B$ but $C + y > B$

where, y is expected value of the environmental contribution.

Remark:

Some Romanian scientists have been attempting to develop technology for incinerating waste of low caloric. " Incinerator of fluidized bed " which has been already applied in Japan and some other countries are capable of incinerating waste of very low caloric such as sewage sludge and night soil sludge. However, this type of incinerator would not be economically feasible in Romania though technically feasible.

7.4 Future Disposal Plan

7.4.1 Disposal Site Area Requirement

1) Site Area

An attempt was made to estimate area of land needed for future landfill from 1995 till 2010 based on the assumption on the future waste collection volume which is shown in Chapter 11 in addition to the following assumptions:

1. Average waste bulk density is 350 kg/m^3 at waste collection trucks, and 700 kg/m^3 at landfill sites a few years after landfilling and compacting of waste. Therefore compacting ration is 2 (700/350).
2. Disregarding include edges of landfill sites, typical depth of waste deposit is 10 m . However, when inclined edges are considered, average depth recalculates at 8.5 m.
3. Quantity of cover soil to be applied will be 20 % of waste quantity.
4. Glina site has a remaining capacity of 6.12 million m^3.
5. Total cumulative volume of waste to be disposed of at landfill site for 16 years from 1995 till 2010 will be 10.48 million ton. (See Chapter 2)
6. The required relation facilities area is equivalent to about 20% of landfill area.

It is estimated that 167 ha of land will be required to satisfy landfill demand arising from 1995 till 2010. See the calculation below:

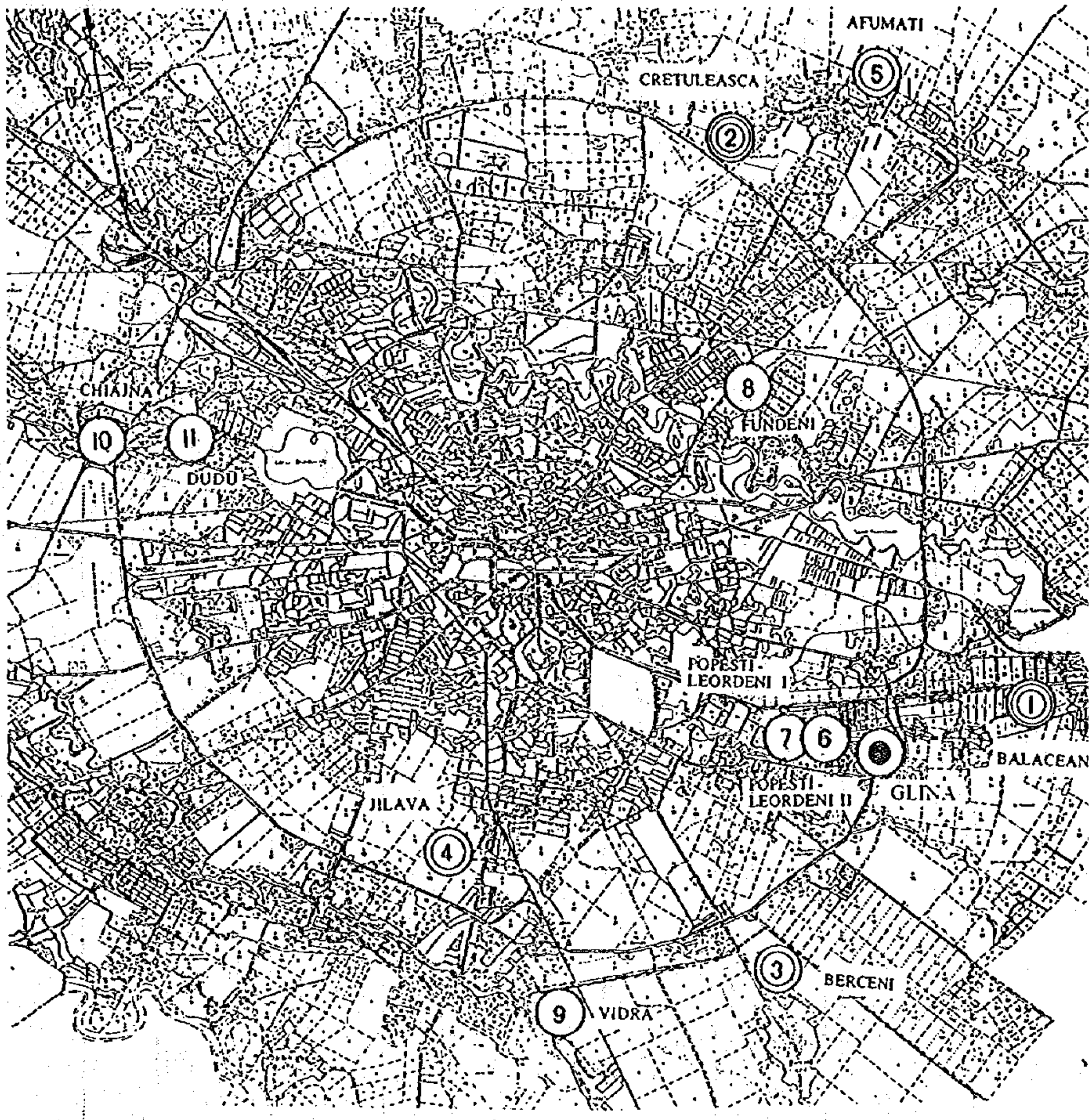
10.48 million tons $\div$ 0.35 $\div$ 2 X1.2 = 17.97 million m^3
17.97 million m^3 - 6.12 million m^3 = 11.85 million m^3
11.85 million m^3 $\div$ 8.5 m = 139 ha
139 ha $\times$ 1.2 = 167 ha

2) Number of the Site

The final disposal site should be located near by collection area, because collection and transportation costs share a major portion of solid waste management costs. Therefore, it is desirous that the municipality should have a few landfill sites from economic point of view. If there are a few landfill sites, number of incoming trucks will reduce, and landfill operation in each site will be more sound in terms of dumping area alolocation

to each truck and cover soil applicaiton.
Considering the future landfill area requirement arising by 2010, it is proposed that the Bucharest municipality should acquire 5 new landfill sites (Balaceanca, Cleturcasca, Berceni, Afumati and Jilava) as shown in Fig. 7.4.1. Total area of these 5 sites will be 167 ha and have capacity of desposing 12.39 million m^3 of waste.

The sites are selected by the condition of distance frpm collection areas to landfill sites should be less than about 20 km to avoid high haulage costs.



(Triple circles indicate the first 3 sites to be obtained now. Double circles indicate the other 3 sites to be constructed later.)

Fig. 7.4-1 Location of Candidate Sites

3) Construction Schedule

A proposed construction schedule is shown in Table 7.4-1. Of the 5 sites, the municipality should start arrangements for acquiring the first 2 sites (Balaceaca and Cretuleasca) as soon as possible. The municipality should acquire the site early 1996 when the municipality apply for a soft loan for the construction.

Table 7.4-1 Final Disposal Sites Development Schedule

NAME \ YEAR	95'	96'	97'	98'	99'	00'	01'	02'	03'	04'	05'	06'	07'	08'	09'	10'
GLINA			Design													
				Construction												
	Continue										Closed					
BALACEACA			Design													
				Construction												
					Start							Closed				
CRETULEASCA			Design													
				Construction												
					Start							Closed				
BERCENI										Design						
											Construction					
												Start				Closed
AFUMATI										Design						
											Construction					
												Start				Closed
JILAVA											Design					
												Construction				
													Start			Closed
Construction				○	○					○	○	○				
Design			△							△	△					

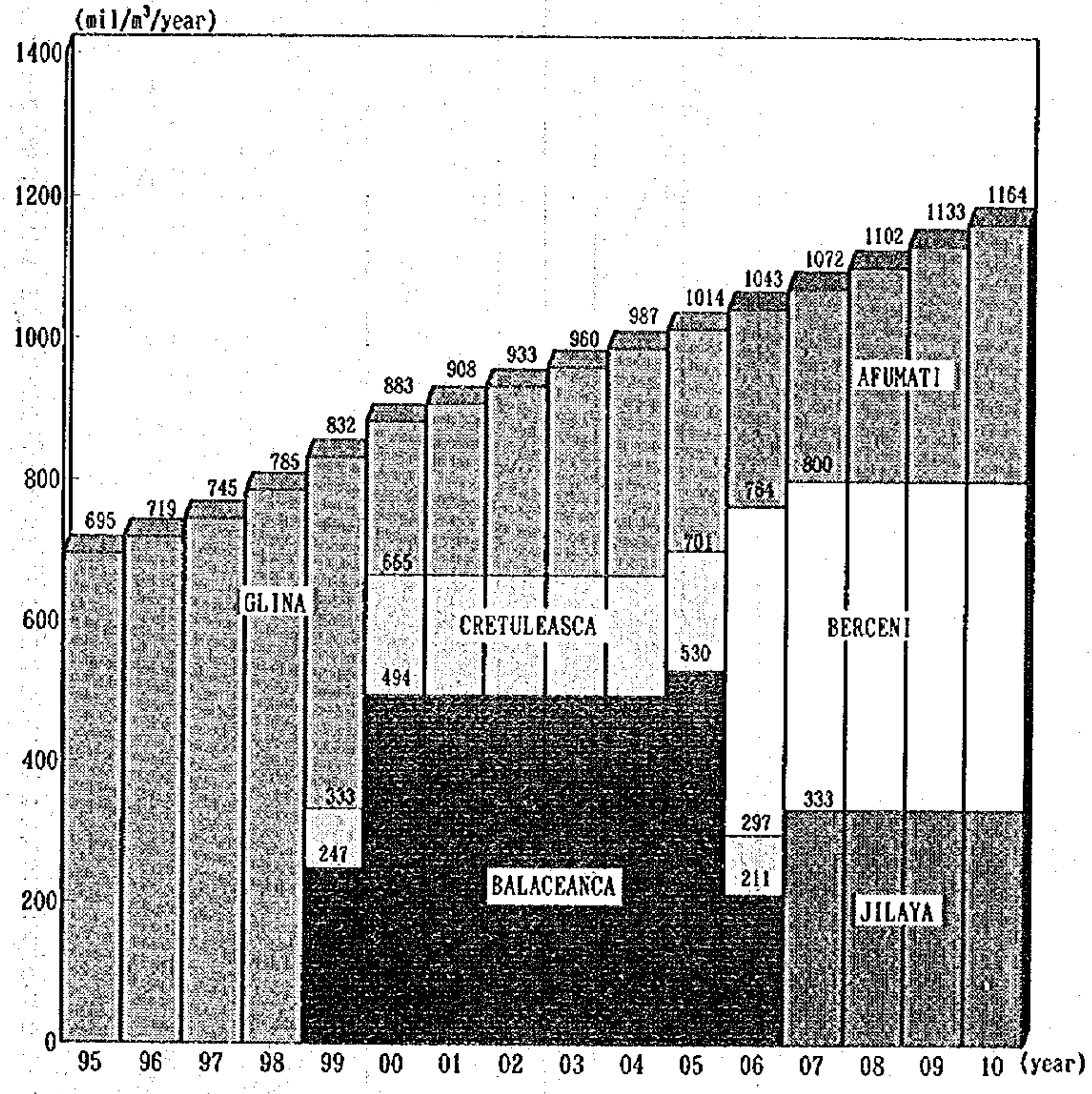


Fig. 7.4-2 **Annual Disposal Volume and Allocation Plan**

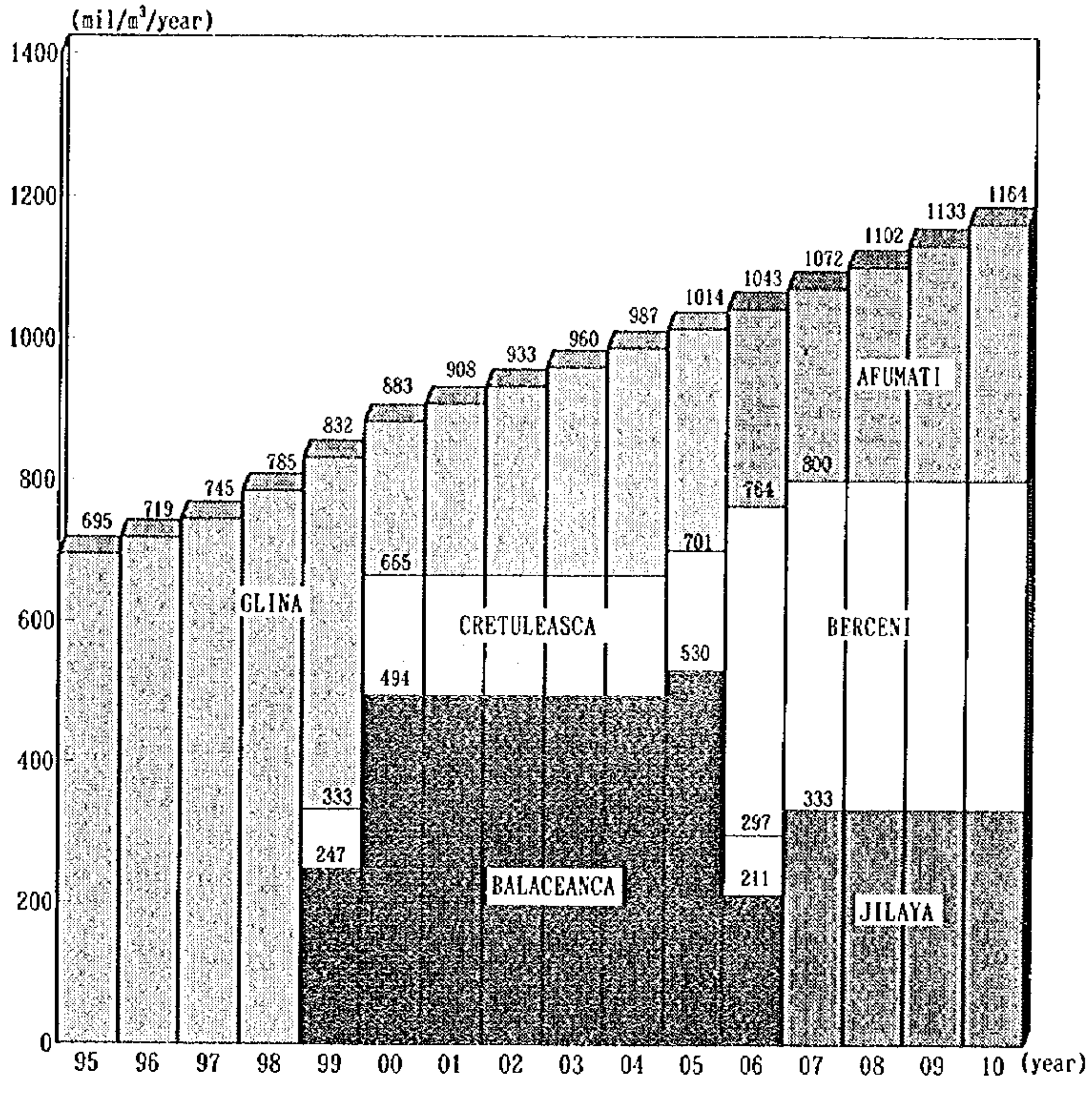


Fig. 7.4-2 **Annual Disposal Volume and Allocation Plan**

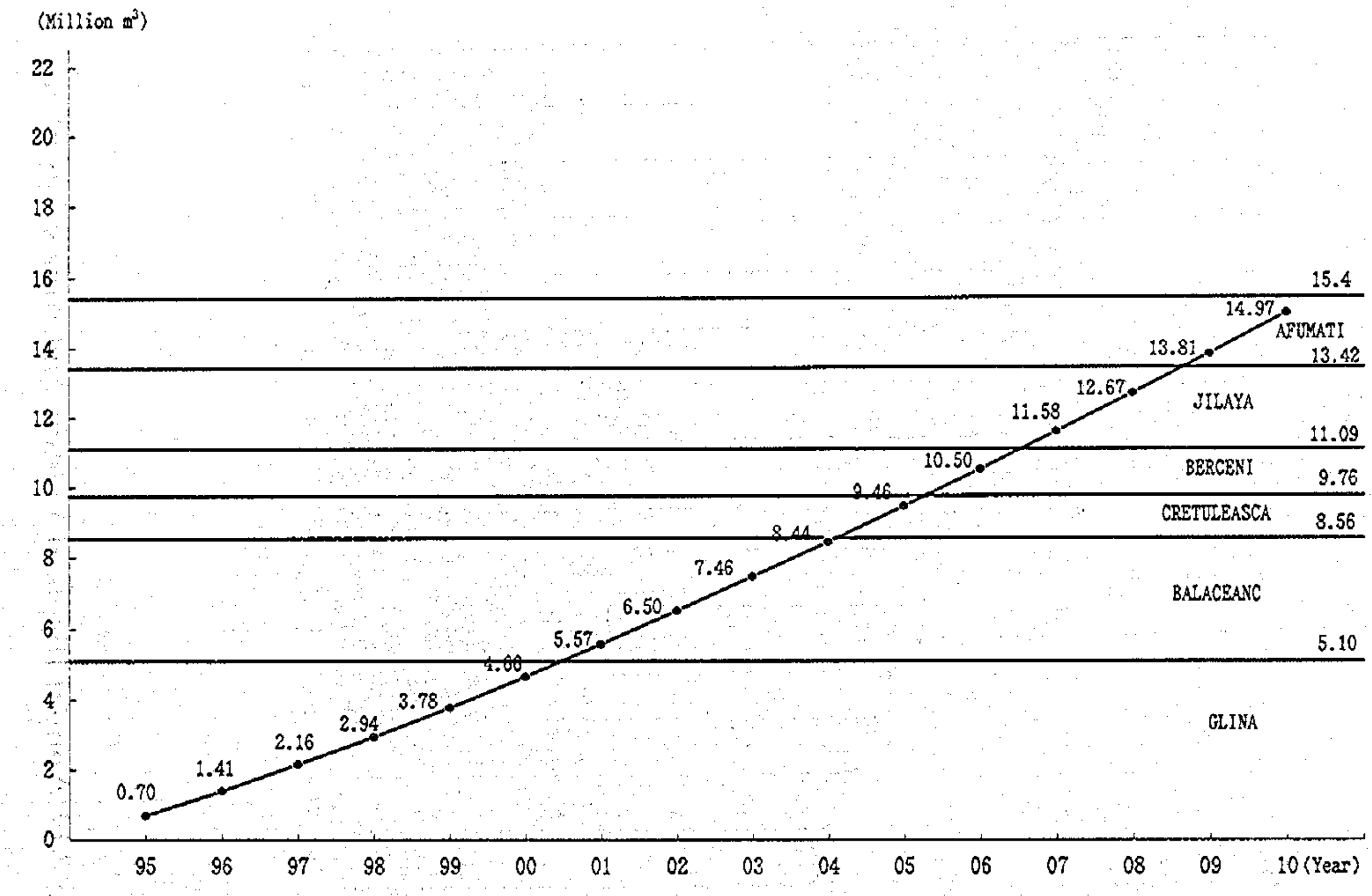


Fig. 7.4-3 Relationship between Cumulative Waste Disposal Quantity and Site Capacity

7.5 Improvement Plan for Glina Disposal site

7.5.1 Improvement Policy

Improvement policy of Glina landfill site is as follows:

1. Number of incoming trucks should be reduced to improve landfill operation. Reduction in number of incoming trucks will be made possible by having other landfill sites.
   Remark :
   At present, control of incoming of unsuitable types of waste and area designation for waste unloading have not been done properly because too many trucks are coming to the site.
2. Glina site should be divided in two parts. Each part should have a gate. This will reduce number of incoming truck in each part, and contribute to the improvement of landfill operation.
3. Daily soil should be applied to minimize adverse impacts on surbounding residential areas.
4. Landfill operation efficiency should increase.
5. Work conditions should improve through provision of basic facilities.
6. It is proposed that the municipality should provide water supply to the local residents living near the Glina site.

7.5.2 Improvement Plan

1) Outline of Improvement Plan

The proposed improvement plan include the following components:

1. Regular application of cover material in order to prevent fire, reducing surface movement of waste and odor
2. Provision of access road
3. Provision of site boundary (embankment)
4. Provision of drainage system in order to divert storm water
5. Control of hazardous waste, and recording of incoming waste through truck scale.
6. Provision of gas exhaust facility

An improvement plan map is shown in Fig. 7.5-2. The proposed improvements are the minimum requirement for the protection of health of residents living nearby the site, to improve landfill operation efficiency and quality. It should be noted that the Glina site, even after implementation of those improvement plan, will not meet the proposed standards of EC (Amended proposal for a Council Directive on the Landfill of Waste, presented by the Commission pursuant to Article 149 (3) of EEC - Treaty in June 1993).

2) Site Capacity

Glina site has a land area of 109 ha. As shown in Table 9.4-1, a total waste receiving capacity is 16.64 million m^3, of which the remaining capacity os 7.89 million^3.

Table 7.5-1 The Outline of Renewal of Glina Landfill site

	Item	Quantity
1	Area	109.2 ha
2	Landfill Area	82.0 ha
3	Capacity (4+5)	14.87 Mil m^3
4	Existing Disposed Quantity	8.75 Mil m^3
5	Future Capacity	6.12 Mil m^3

3) Structure of Main Facilities

a. Embankment

There are two main purposes to construct the embankment. One is to safely store the designed quantity of waste, another is to provide a site boundary.

An embankment itself should be stable, as the site will be filled up to a height of 20 m from ground level. The proposed structure of embankment is shown in Fig. 7.5.1 below.

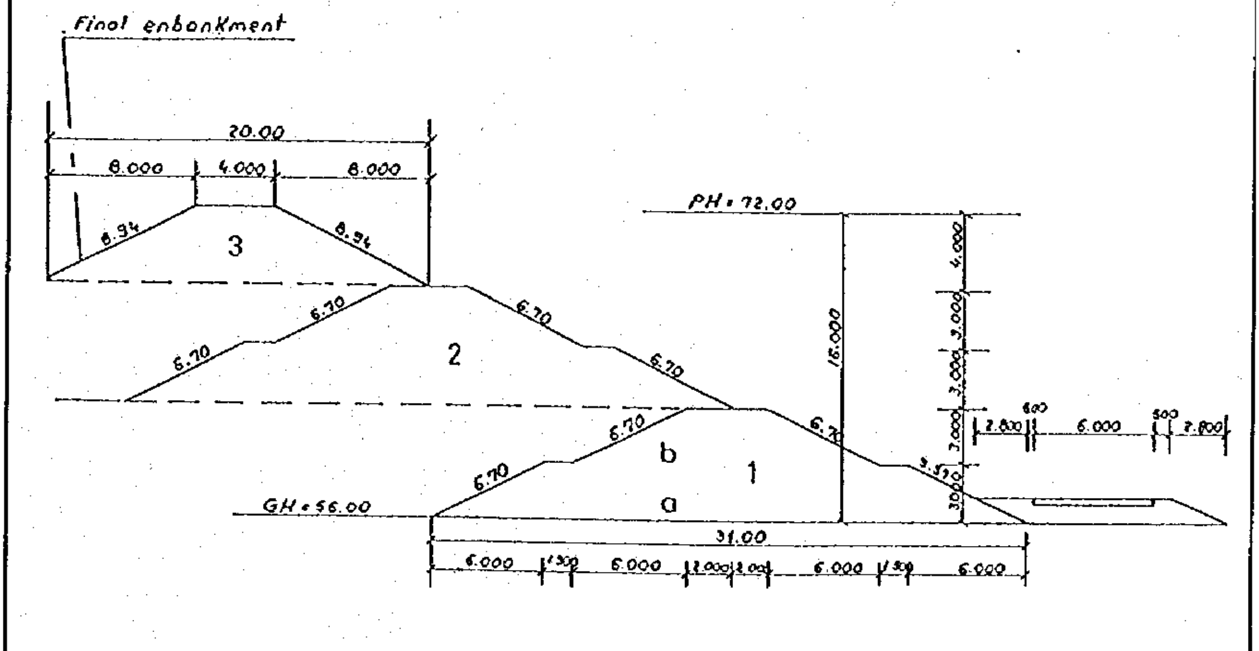


Fig. 7.5-1 Structure of Embankment

b. Road

The repair of the access road should comply to the structural standard of the city road pavement. And, in the case of new construction of the access road, the foundation should be flat and sufficiently paved to the same class of standard city road. The management road around the embankment should also comply with the standard structure of local road pavement. However if the construction cost is too great for the municipality, a crushed stone pavement can be used insted of concrete pavement. The insite road can also be constructed in the same way as the manegement road.

c. Drainage

A drainage ditch for rainfall water shoud be constructed around the site. The structure and scale is designed according to the surrounding conditions and the catchment area. The drainage ditch for leachate consists of a ditch filled with crushed stones. The size of the ditch is detemined by the site area.

d. Leachate storage pond

A leachate storage pond should be constructed to prevent the flow of leachate from going directly to agriculture drainage ditch. And, in future the pond can be used as an aerobic pond. The capacity of pond needs to be about 1,000 m³ / ha. The detailed calculation is given in Appendix. 7.4.

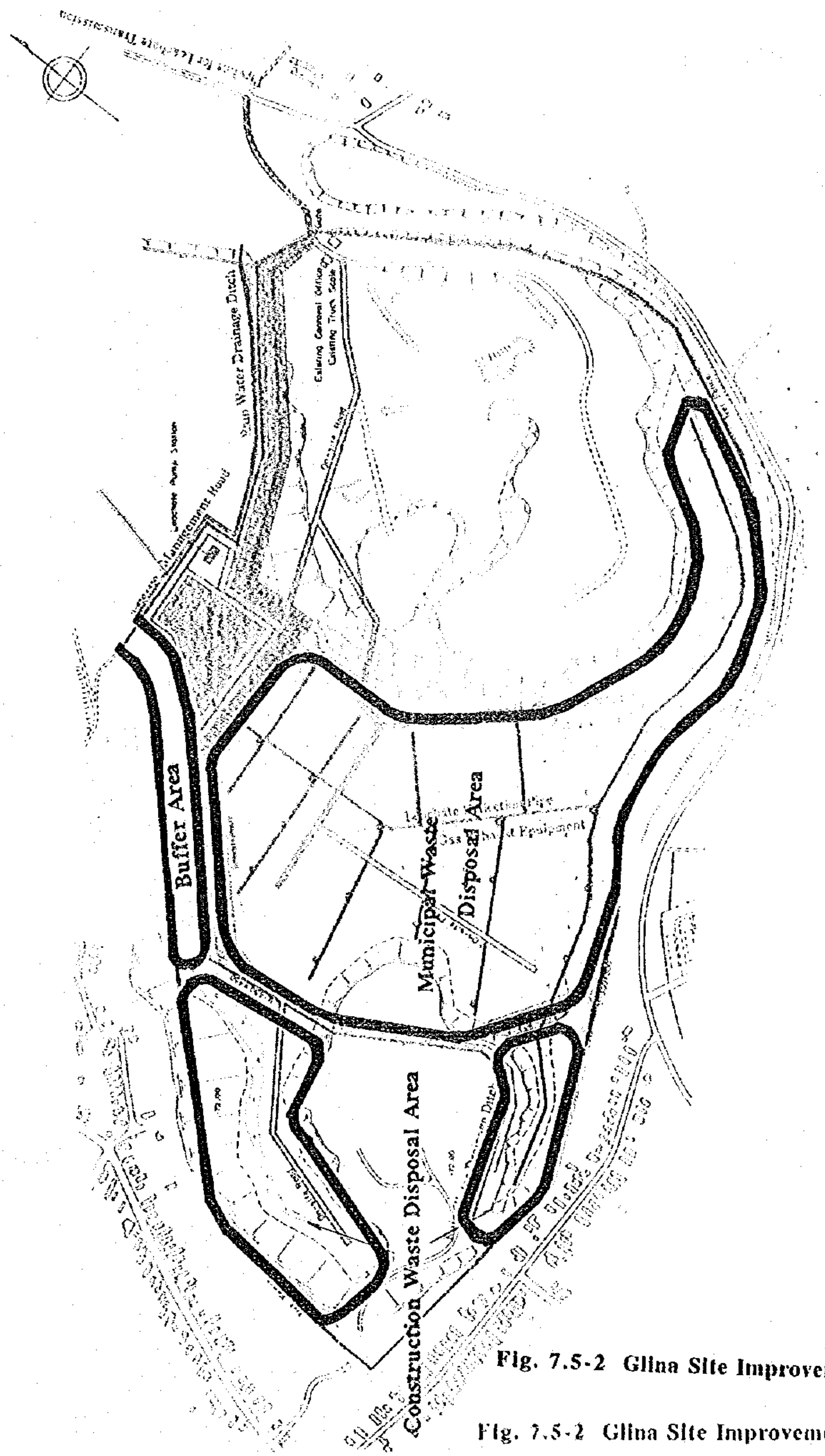


Fig. 7.5-2 Glina Site Improvement P

Fig. 7.5-2 Glina Site Improvement Pla

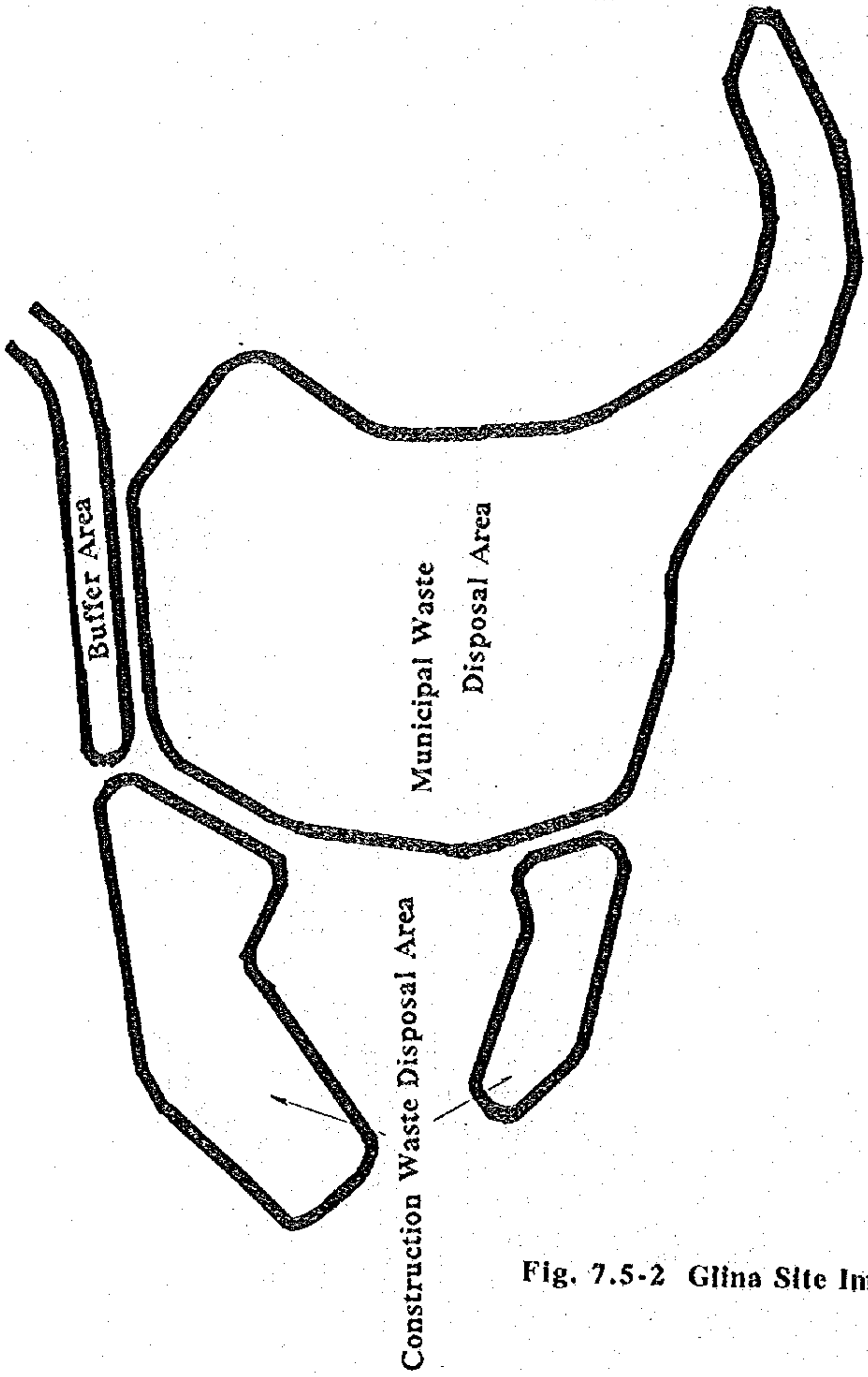


Fig. 7.5-2 Glina Site Improvement Pla

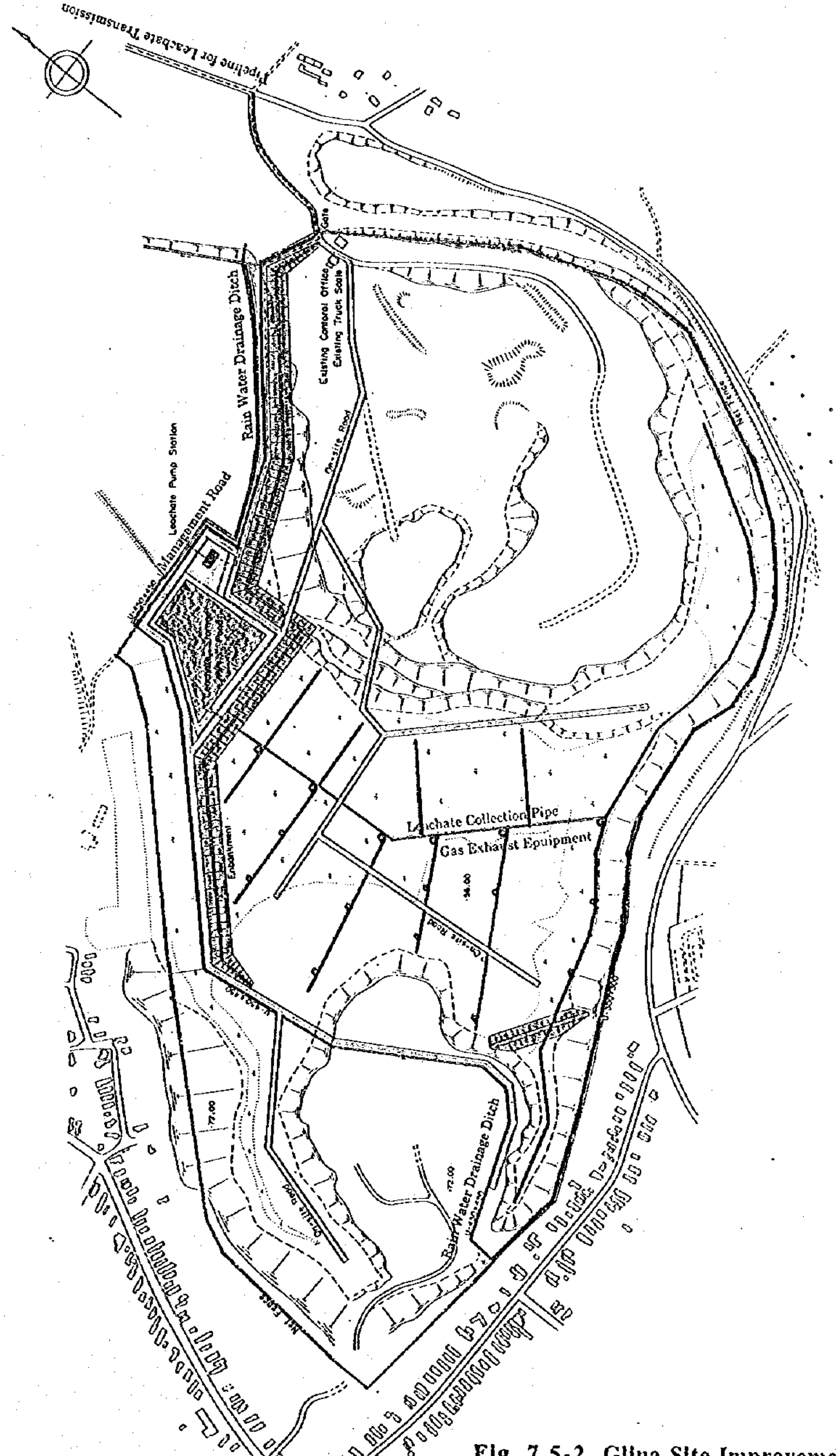


Fig. 7.5-2 Glina Site Improvement Plan

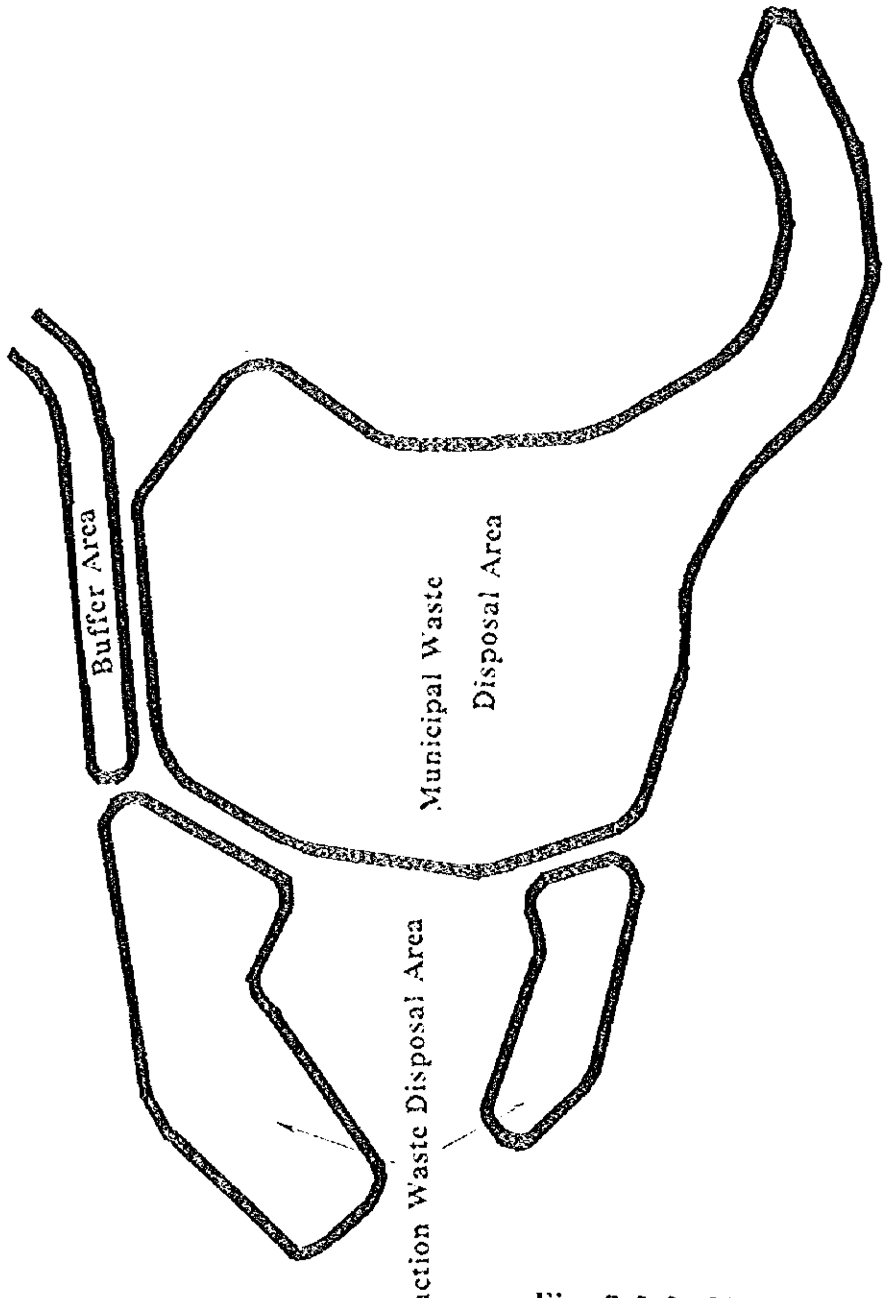


Fig. 7.5-2 Glina Site Improvement Pla

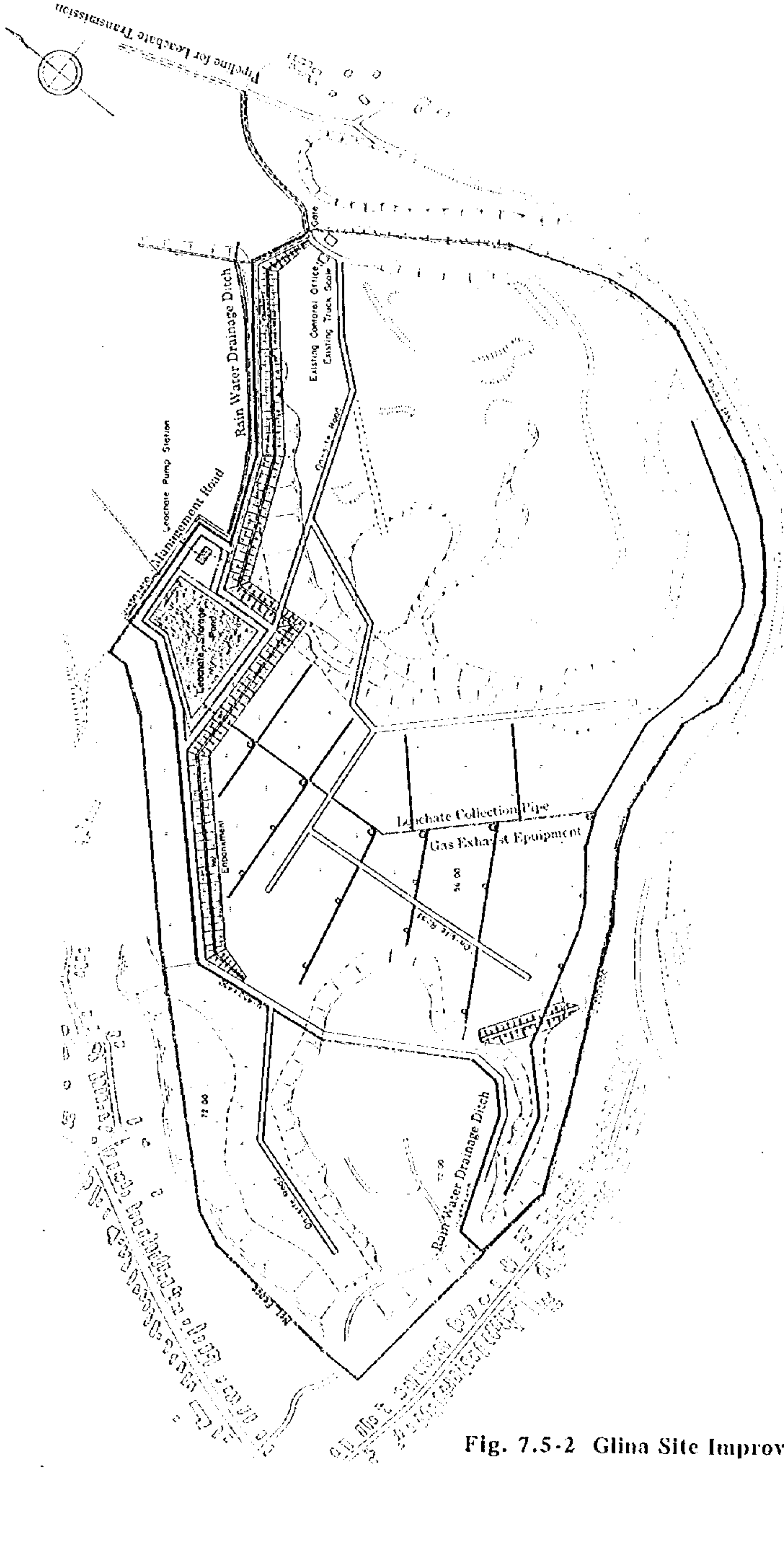


Fig. 7.5-2 Glina Site Improvement Pla

4) Landfill Operation Methods

The solid wastes must be sufficiently compacted so as to stabilise the landfill foundation and to prolong the life span of the landfill. A layer of cover soil must be systematically placed after landfilling each layer of solid waste.

The wastes are unloaded at the toe of the earth dyke and spread and compacted on the slope of the dyke in a series of layers that vary in depth from 30 to 60 cm. The recommended slope of these layers is 1 to 3.

At the end of each days operation, a 15 cm to 30 cm layer of cover soil is placed over that day's completed fill. This one day's completed fill including the cover soil is called a cell. Recommended landfill method is shown as Fig. 7.5-3.

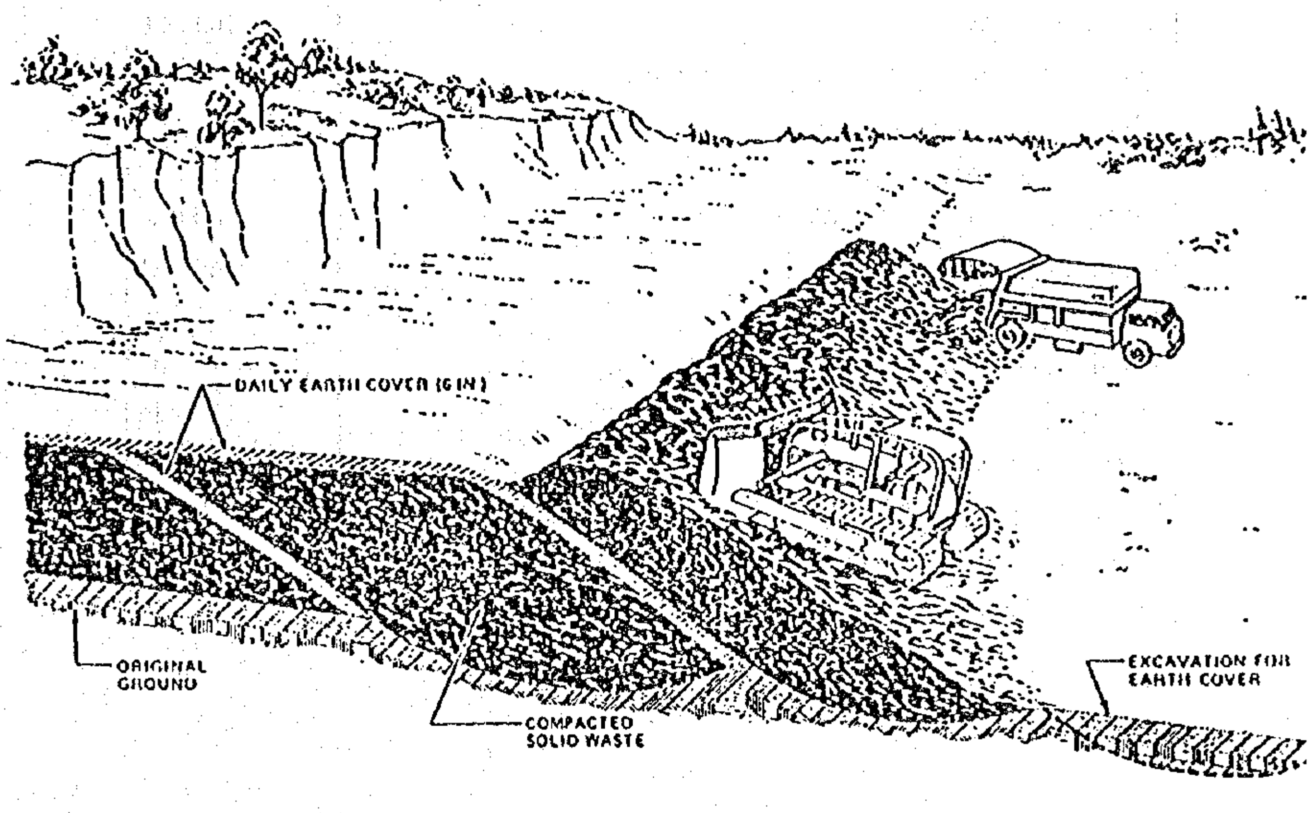


Fig. 7.5-3 Landfill Methods

5) Rough Cost Estimation

As shown in Table 7.5-1, It is estimated that US$ 2.3 million will be needed to implement the improvement plan.

Table 7.5-1 Rough Cost Estimation

Item	Cost ($)
1) Embankment Work	718,099
2) Leachate Collection and Drainage System Construction Work	110,133
3) Rainwater Drainage System Construction Work	156,706
4) Gate and Fence Construction Work	136,816
5) Gas Exhaust Equipment Construction Work	2,584
6) Road Construction Work	731,880
7) Existing Drainage Ditch Improvement Work	234,710
8) Temporary Work	104,680
9) Leachate Storage Pond Construction Work	113,686
10) Leachate Pump Station	73,809
11) Electricity Work	18,500
12) Building Construction Work	60,060
13) Pipeline	60,551
14) Transportation	5,200
15) Site Plant Work	7,600
16) 2nd Embankment Work	727,936
Total Direct Cost	3,262,950
Include Overhead (20%) Cost	3,910,000
Include Price (10%) & Physical (5%) Contingency	4,496,000
Include TVA (18%)	5,305,280

7.6 Identification of Candidate Landfill Site

7.6.1 Proposed Sites

1) Selection Criteria

There are not suitable sites found in Bucharest city area considering the land use conditions and city development plan. Therefore, candidate sites are selected in the agriculture sector area of the city. The existing Glina disposal site is located also in the agriculture sector.

Important criteria for selection of landfill sites include the following:

- Efficiency of collection and transport (locations should be within about 20 km from the center of Bucharest.)
- Compliance with related urban planning regulations
- Area of sufficient size (one site area should be larger than 10 ha.)
- Suitable topographical conditions to ensure landfill capacity efficiency
- Sites should be located more than 200 m away from the property lines of premises such as residences and stores.
- The landfill site should be located at least 200 m away from rivers or lakes
- Approach road and access road should be available.
- In addition, Attachment 1 Technical Guidelines fo Selection of Landfill Sites was used by he Study Team for the identification of candidate landfill sites.

2) Candidate Landfill Sites

The locations of selected candidate sites are shown in Fig. 7.6-1. Outline of the sites is presented in Table 7.6-1.

Fig. 7.6-1

The Location of Condidate Sitc

Table 7.6-1 Description of the Candidate Final Disposal Site

No.	NAME	LOCATION & Distance from the city center	AREA (Landfill area)	CAPACITY (Mil. m^3)	LAND USE	NOTE
1	BALACEANCA	SOUTH - EAST 10.0 km	35 ha (40 ha)	4.15	Swampy land	• New access road 1.5 km should be constructed • Excavation work is needed
2	CRETULEASCA	NORTH - EAST 12.0 km	23 ha (28 ha)	1.44	Field	• The site is located nearby Balta river (150 m) • Excavation work is needed • New access road 0.8 km should be constructed • There is an institute nearby the site
3	BERCENI	SOUTH 9.0 km	20 ha (16 ha)	0.8 (4m Height = 1.6)	Field	Same as above
4	JILAVA	SOUTH 9.0 km	43 ha (35 ha)	1.4 (4m Height = 2.8)	Field	• New access road 0.6 km should be constructed • Excavation work is needed
5	aFUMATI	NORTH EAST 12.0 km	36 ha (30 ha)	1.2 (4m Height= 2.4)	Field	• New access road 1.0 km should be constructed • Excavation work is needed
6	POPESTI - LEORDENI II	SOUTH - EAST 10.0 km	58 ha (50 ha)	7.2	Field	• The site is located nearby Glina existing site and residential area • New access road 1.6 km should be constructed • There is not cover soil material
7	POPESTI - LEORDENI I	SOUTH - EAST 7.0 km	25 ha (21 ha)	3.0	Field	• The site is located nearby Glina existing site and residential area • New access road 1.2 km should be constructed • There is not cover soil material
8	FUNDENI	NORTH - EAST 15.0 km	41 ha (30 ha)	1.2 (4m Height = 2.4)	Field	• New access road 0.3 km should be constructed • Excavation work is needed
9.	VIDORA	SOUTH 11.0 KM	90 ha (57 ha)	5.1	Field	New access road 0.6km should be constructed Excavation work is needed
10.	CHIAJNA	WEST 11.5 km	50 ha (42 ha)	3.0	Reed plain	• New access road 0.8 km should be constructed • The site located nearby the residential area (100 m) and Dimbovita river (200 m) • There is not cover soil material
11.	DUDU	WEST 9.0 km	25 ha (21 ha)	1.5	Open Pit	• New access road 2.0 km should be constructed • The site is located near by Dimbovita river (150 m) • There is not cover soil material

From an economic view point it is preferable to choose a site with good geological conditions.

It is preferable to build the landfill system on a unpermeable ground, and to avoid building on soft ground or places where subsidence may occur. This avoids the cost of improving the site. However, if this is unavoidable it is necessary to take countermeasures to prevent unequal land subsidence.

3) Evaluation

The results of the evaluation of the candidate landfill sites are given in Table 7.6-2. The evaluation is based on a consideration of location, landuse and construction cost. Construction costs of each candidate site were estimated for the following 2 cases:

Case 1 : Off-site Leachate Treatment (Leachate will be collected and transmitted through pipelines to the nearest public sewer line, and treated at the existing Glina Sewage Treatment Plant.)
Case 2 : On-site Leachate Treatment (Leachate will be collected and treated both biological and chemical by an independent treatment facility to be provided at each site.)

The detail information of construction costs is attached in Appendix. 7.3. Based upon the result of the evaluation, it is planned that new landfill sites are constructed in Balaceanca and Cleturcasca so that they can open in 1999. A feasibility study has been carried for construction of these 2 sites as well as for improvement of the existing Glina site. To meet the future disposal demand, 3 more landfill sites should be developed in Berceni, Afumati and Jilava.

Table 7.6-2 Evaluation of the Candidate Landfill Sites

NO.	Location (Distance from residential area)	Land use	*Remark	Construction Cost		Priority
				Case 1 (US$ / m^3)	Case 2 (US$ / m^3)	
1	BALACEANCA about 800m A	Swanpy Land A	***	2.30	4.12	1
2	CRETULEASCA More than 1000m A	Agriculture Area B	***	3.50	5.68	2
3	BERCENI More than 1,000m A	Agriculture Area B	**	2.26	3.80	3
4	JILAVA about 500m A	Agriculture Area B	**	2.21	3.78	4
5	AFUMATI about 400m A	Agriculture Area B	**	2.34	4.38	5
6	POPESTI - LEORDENI II about 200m B	Agriculture Area B		1.03	2.20	6
7	POPESTI - LEORDENI I about 200m B	Agriculture Area B		1.44	2.54	7
8	FUNDENI about 200m B	Agriculture Area B		2.37	4.41	8
9	VIDORA about 1000m A	Agriculture Area B		3.10	4.99	9
10	CHIAJNA about 500m *Water Resourse Area B	Reed Plain and Agriculture Land B		2.08	4.41	10
11	DUDU About 400m *Water Resourse Area B	Borrow Pit and Fish Pond B		3.11	5.31	11

Note : Grading
A : Good
B : Acceptable
Remark : *** : The 1st priority sites studied in the current feasibility study.
** : The 2nd priority sites tobe chosen

7.6.2 Facilities Plan

1) Major Facilities Plan

Table 7.6-3 shows major facilities required for sanitary landfill, their function, and specifications for Cases 1 and 2.

Table 7.6-3 Outline of Major Facilities for Cases 1 and 2 for New Landfill site

MAJOR FACILITY	FUNCTION	SPECIFICATION	
		CASE 1	CASE 2
Embankment	To prevent garbage from flowing out of the site and rainfall water from flowing in	Soil band of 7 m height around the site	Same as Case 1
Lining	To avoid seepage of leachate and contamination of ground water	Artificial liner Thickness = 2.0 mm	Same as Case 1
Leachate Collection Facility	To collect leachate quickly	Crushed stone & PVC pipe	Same as Case 1
Rain Water Drain Facility	To prevent water from flowing into the site	Concrete drain ditch (Width= depth=300mm) are constructed around the site	Same as Case 1
Leachate Treatment Facility	To treat leachate and improve quality of water to be discharged outside the site	Off-site treatment	On-site treatment (both biological & chemical)
Gas Exhaust Facility	To collect and release the gas generated from decomposed waste	Crushed stone & PVC pipe	Same as Case 1

Note:

It is assumed that waste soil excavated from Cretuarcsca landfill site construction will be used for construction of embankment and on-site and access roads.

2) Leachate Treatment Facility Plan

As a result of cost comparison of Case 1 : off-site treatment (Connection to public sewer line for leachate treatment at the Glina Treatment Plant) and Case 2 : on-site treatment, Case 1 provided to be much more economical than Case 2. Therefore, the off-site treatment (Case 1) is recomended.

3) Plan for Operation Control Facility and Monitoring

Major operation control facilitis consist of the follwing facilities;

1. Site Office
2. Weigh-bridge
3. Ground water quality monitoring facility (Well)

4) Plan for Other Facilities

Other facilities required on the site are outlined in Table 7.6-4. Those facilities are common for Cases 1 and 2.

Table 7.6.4 Other Facility

FACILITY	FUNCTION	OUTLINE
Access road	Access to the site from the public road	8 m wide, two way road. Paved Part is 6 m wide, and covered with 0.5 m crushed stone and concrete pavement.
On-site road	Access to the working face	6 m wide, two way road. Pavement is 6 m, covered with 0.5 m crushed stone.
Fence	To prevent waste from flowing out To maintain security and avoid waste flowing out	Net fence height = 1.8 m
Gate	To manitain security	Main gate is 6 m wide. Small gate for leachate treatment facility is 3 m wide.
Fire fighting facility	To extinguish fire on the site	Handy fire extinguishers and cover soil to be placed on the site.

5) Heavy Equipment Plan

Some heavy equipment is required for bedding and compaction of waste and cover material. It is estimated that 21 bulldozers with wide caterpillars, 3 excavators, 6 trucks and 3 jeeps will be required for the planned 3 landfill in Balaceanca, Cretuleasca and Glina judging from the amount of waste and cover material to be handled. See Table 7.6-5.

Table 7.6-5 Heavy Equipment Required for landfill site

Item	Balaceanca	Cletuleasca	Glina	Berceni	Afumati	Jilava	Total
Bulldozer 15t class	10	5	6	8	6	6	41
Excavator 1m3 class	1	1	1	1	1	1	6
Truck 10t class	3	1	2	2	2	2	12
Jeep	1	1	1	1	1	1	6

Note: The following assumptions are used for calculating required number of units;

- Bulldozer, Class 15t/unit, Capability 45 m3/hour (Spread & Compaction)
- Excavator, Class 1m3, Capability 60 m3/hour (Exavation & Loading)
- Dump truck, Class 10t, Capability 25m3/hour (L= 1km)

7.6.3 Operation and Maintenance Plan

1) Landfill Operation Plan

a. Application of Cover Soil

Dumped wast should be covered with soil every day. Daily application of cover soil is required to:

- reduce smoke and odor.
- reduce the number of insects and rodents.
- accelerate waste decomposition.

b Bedding and Compaction

Bedding and compaction are two important activities required for sanitary landfill operation. There are two methods for the bedding and compaction: down-fill method and up-fill method. The former is not recommended as it is difficult to keep the waste layer at the same thickness with this method. (Waste layers get too thick with this method.) The up-fill method is preferred and is illustrated in Figs. 7.6-2, 7.6-3 and 7.6-4.

c. Landfill Method

The cell method is recommended for the sanitary landfill in view of the large area of the landfill. Waste layers will be made as shown in Fig. 7.6-5. For example in Balaceanca site, thickness and area of the layer are shown bellow:

	THICKNESS	AREA REQUIRED
1. Each waste layer:	2.7 m	702 m^2 / day
2. Cover material layer:	0.3 m	702 m^2 / day
3. Total	3.0 m	702 m^2 / day

Note: The required area is calculated as follows:

Incoming waste volume 1,896 m3 ÷ Layer thickness 2.7m = 702 m2

Fig.7.6-2 Method of Bedding and Compaction

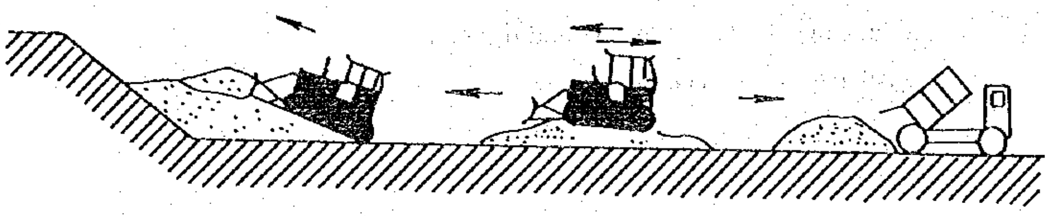


Fig.7.6-3 Preparation of A Unit of Cell with the Up-fill Method

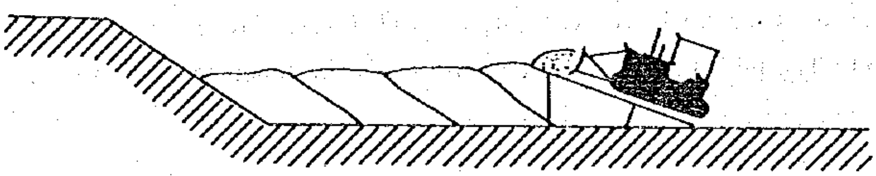


Fig.7.6-4 Preparation of Cells with the Up-fill Method

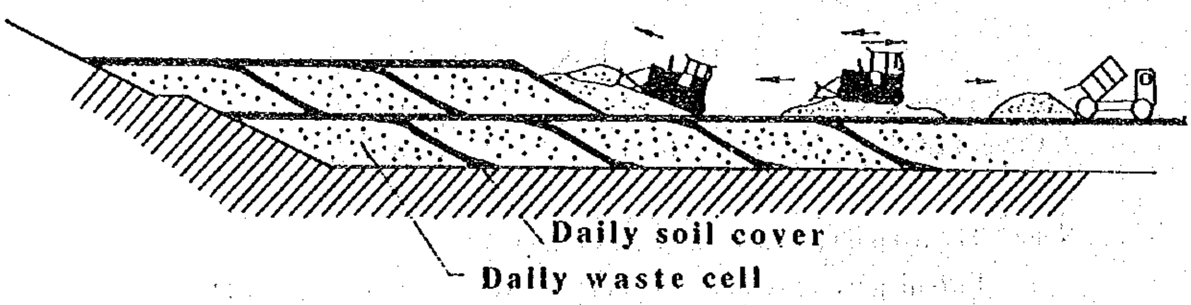


Fig. 7.6-5 Typical Landfill by Cell Method

2) Periodical Monitoring Plan

Table 7.6-9 Shows an outline of proposed monitoring.

Table 7.6-9 Outline of Proposed Monitoring

MONITORING ITEMS	MONITORING FACILITY	INSPECTION ITEMS	MINIMUM FREQUENCY
Ground water	Ground water monitoring well	pH, CN, Pb, T-Hg, Cd, BOD COD, SS, MPN, Color, NH3-N, Temperature	1 /month
Gas	Gas exhaust pipe	Temperature and humidity of original air, Temperature and volume of gas, component analysis (CH_4, CO_2)	1 /month
Settlement	Ground surface settlement	Settlement of ground level	1 /month
Odor	-	Item should be selected by surround conditions	2 /year
Leachate	Leachate reservoir pond	pH, CN, Pb, T-Hg, Cd, BOD COD, SS, MPN, Color, NH3-N, Temperature	1 /month
Effluent water from leachate treatment facility	-	pH, CN, Pb, T-Hg, Cd, BOD COD, SS, MPN, Color, NH3-N, Temperature	1 /month
		pH, CN, Pb, Cr (VI), As, T-Hg, Cd, PCB, TCE PCE MC, R-Hg, BOD COD, SS, MPN, Cl⁻ n- C_6H_{14} (plant oil, Ph, Cu, Zn, S-Fe, S-Mn, T-Cr, F, $CaCo_3$, NO_3-N, NO_2-N, $KMnO_4$-C, color, Muddiness, NH3-N, Temperture	1 /year

7.7 Cost Estimation

As shown in Table 7.7-1, it's estimated that total expenditures needed for waste disposal from 1996 to 2010 will be $ 47.8 million, of which about 38 million will be used for development and operation of 3 landfill sites in Balaceanca, Cretuleasca and Glina (herein after called " the project "); $ 22 million will be required for development and operation of another 3 sites in Berceni, Afumati and Jilava; $ 1 million will be needed before the Project for Immediate improvement of the Glina site and other purposes. Annual expenditure are shown in Table 7.7-2.

Table 7.7-1 Estimated Disposal Expenditures 1996 - 2000 (Including Contingency and Value Added Tax)

Unit : US$ in 1995 price

Items	Price
A. Pre Project Expenditures	
A1. Immediate improvement of the Glina site	52,081
A2. Purchase of bulldozers of Glina site	105,000
A3. Operation and maintenance of the Glina site 1996 - 1998 before the three sites open	662,129
Total of Item A	**819,210**
B. Project Expenditures	
B1. Engineering Services for B3 & B4	1,807,170
B2. Technical assistance	86,140
B3. Construction work	19,919,580
B4. Equipment procurement	1,270,860
B5. Total of Project Investment (B1+B2+B3+B4)	23,083,750
B6. Operation & maintenance of landfill sites (1999 - Mid 2007)	3,003,555
Total of Item B	**26,087,305**
C. Post Project Expenditures	
C1. Additional civil works for the 3 sites (Construction of embankment)	1,939,920
C2. Construction of other landfill sites in Afumati, Berceni & Jilava (2004 - 2006) including engineering cost	16,702,600
C3. Operation and maintenance of Afumati, Berceni & Jilava sites (Mid 2006 - 2010)	2,253,231
Total of Item C	20,895,751
Ground Total (A + B + C)	**47,802,266**

Table 7.7-2 **Annual Disposal Expenditures**
(Investment include value added tax)

Unit : US dollar in 1995 price

Year	Project Costs (a)	Pre Project & Post Project Expenditure (b)	Total (a + b) = (c)
1996	7,080	302,804	309,884
1997	1,081,456	254,804	1,336,452
1998	16,343,635	261,410	16,605,045
1999	6,317,126	0	6,317,126
2000	409,260	716,260	1,125,520
2001	414,700	607,700	1,022,400
2002	420,295	0	420,295
2003	426,044	0	426,044
2004	431,956	4,422,310	4,854,266
2005	438,033	8,753,506	9,191,539
2006	137,546	4,464,810	4,602,356
2007	0	462,980	462,980
2008	0	475,944	475,944
2009	0	489,271	489,271
2010	0	502,970	502,970
Total	26,087,305	21,714,961	47,802,266

Chapter 8

Industrial, Demolition and Hospital Waste Management

CHAPTER 8 INDUSTRIAL, DEMOLITION AND HOSPITAL WASTE MANAGEMENT

8.1 Current Conditions

8.1.1 Industrial Waste

In Romania, generators of technological process waste is responsible for disposal of their waste at generators' factories. Generators are obliged to obtain permission for construction of disposal facilities for their waste.

At present there is little information on generation quantity of this type of waste and how the waste is disposed of.

Remarks:
There are 3 ways for disposal of industrial waste in Bucharest, i.e., 1) disposal of waste at sources (factories), 2) generators transport waste to Glina landfill site, and 3) generators request RASUB to transport waste to Glina site. RASUB checks factory waste brought to Glina site. Names of factory, quantity of waste and vehicles used for transportation are recorded.

Monitoring and control systems for industrial waste have not been established yet in Bucharest. Industrial waste management system at factory is weak. Problems with control of industrial waste are as follows:

1. Bucharest Municipality does not have regulations or guidelines which specify types of waste to be accepted or rejected at disposal sites.
2. Types and quantity of industrial waste brought into disposal sites are not checked.
3. There is no data management system which records generators (factory), persons in charge of managing industrial waste in each factory, types and quantity of waste.

8.1.2 Demolition Waste

Demolition waste is generally of stable condition, and harmless to health. However, demolition waste may affect residential conditions if it is dumped on streets or public spaces.

In Bucharest, there are many abandoned or suspended building construction sites where demolition waste is dumped. In many occasions, demolition waste is illegally dumped on public places.

An important problem is that it is not clearly specified who is responsible for collection of demolition waste dumped on sites or on public places. More clear definition of the responsibility in the regulations and their enforcement are necessary.

Remarks:
In EU countries, land owners are responsible for collection and disposal of their demolition waste. Municipal governments have power to order land owners to remove and dispose of it. Municipal governments also have power to remove and dispose of demolition waste, and require land owners to pay costs spent for removal and disposal.

8.1.3 Hospital Waste

According to the guidelines of Ministry of the Health, hospital waste is defined as waste generated in relation with medical activities. The guidelines state that each hospital should have an incinerator to incinerate hospital waste.

The Study Team visited incinerators of 2 hospitals, and found that their incinerators are not capable of completely burning waste. Inside of some waste remained unincinerated. Incompletely burned hospital waste is hauled to Glina landfill site, and causes health risks. Problems with hospital waste management are summarized as follows:

1. Hospitals do not have adequate management system for hospital waste.
2. Incinerators of hospitals are not capable of rendering (making) hospital waste completely harmless, and there are no operators responsible for operation of the incinerators.
3. Inspection and control of hospital waste at Glina site are inadequate.

8.2 Recommendations for Improvement

In order to reduce environmental and public health risks associated with industrial, demolition and hospital waste, it is proposed that the municipality should take following actions:

1. The municipality should clearly specify types of waste to be collected under the responsibility of the municipality and those to be collected by waste generators. The municipality should make and enforce regulations which prohibit waste generators to mix former type waste with the latter. The regulation should also include an article stipulating penalty to be applied to those who violate the regulations.

2. The municipality should specify types of waste to be accepted or rejected at the municipality's disposal site.

3. The municipality should make and enforce regulations that require industrial factories 1) to report on disposal of their waste, and 2) to obtain a permission from the municipality for the use of the municipality's disposal site.

4. The municipality should strengthen inspection of industrial waste at the municipality's disposal sites, ans should not accept hazrdous waste.

5. The municipality should establish data management system for industrial waste brought into the municipality's disposal sites. Installation of adequate number of truck scale will be necessary.

6. The municipality should make and enforce regulations to specify who is responsible for management of demolition waste. The regulations should also empower the municipality to remove demolition waste and recover the necessary costs from bodies responsible for management of the demolition waste in case they did not do it by themselves.

7. The municipality should make and enforce regulations that empower the municipality to monitor hospital waste management and give guidance to hospitals so that they will properly manage their waste.

8. The municipality should organize a section responsible for monitoring, inspection and data management in connection with hospital and industrial waste management. This section should provide industries and hospitals with guidance and information useful for improvement of management of their waste.

9. There should be a law that requires industrial factories and hospitals to have a person responsible for management of their waste within their organization. Training programs as well as license system should be established for persons to be assigned with this responsibility.

10. Ministry of Health should prepare technical guidelines for management of hospital waste.