CHAPTER 5 IMRPOVEMENT TARGETS

5.1 Collection and Transport

5.1.1 Target Collection Rate

Collection service rate is the most important indicator to measure the level of service of waste collection. At present, the estimated rate in terms of waste quantity for the whole city is 75%.

The proposed targets for service coverage are shown in Table 5.1-1. The whole population living within the three urban communes of Safi city will be covered by collection service by the year 2010. However for each respective urban commune the target rate of 100% service coverage is set based on the conditions there.

Table 5.1-1 Target Waste Collection Service Coverage

(unit: %)

Year	Safi city	Boudheb	Zaouia	Biada
1996	75	90	77	44
2000	90	97	95	71
2005	95	100	97	88
2010	100	100	100	100

Note: Collection service coverage rate is defined as the rate of waste collection quantity to generation quantity

The generated and collected waste amounts as targeted in waste collection and improvement plan are depicted in Fig. 5.1-1.

5.1.2 Operation Efficiency Targets

The above collection service rates should be achieved in a cost efficient manner in order to avoid creating a financial burden on each urban commune. Of course the actual costs will increase as the waste amount to be collected will rise, but if the work is done in an efficient manner the unit cost, i.e. Dirham/ton may be decreased.

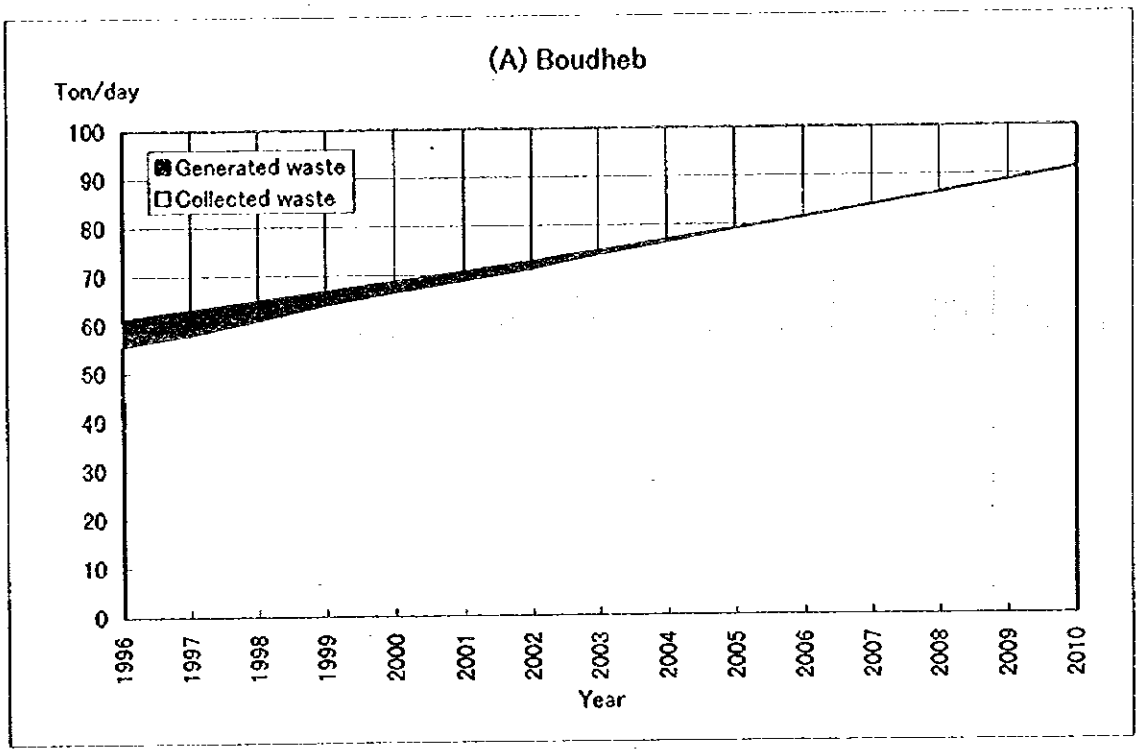
The selection of suitable trucks and their efficient operation will contribute towards reducing the unit costs. Table 5.1-2 sets services operation targets and Chapter 6 discusses ways to implement these targets.

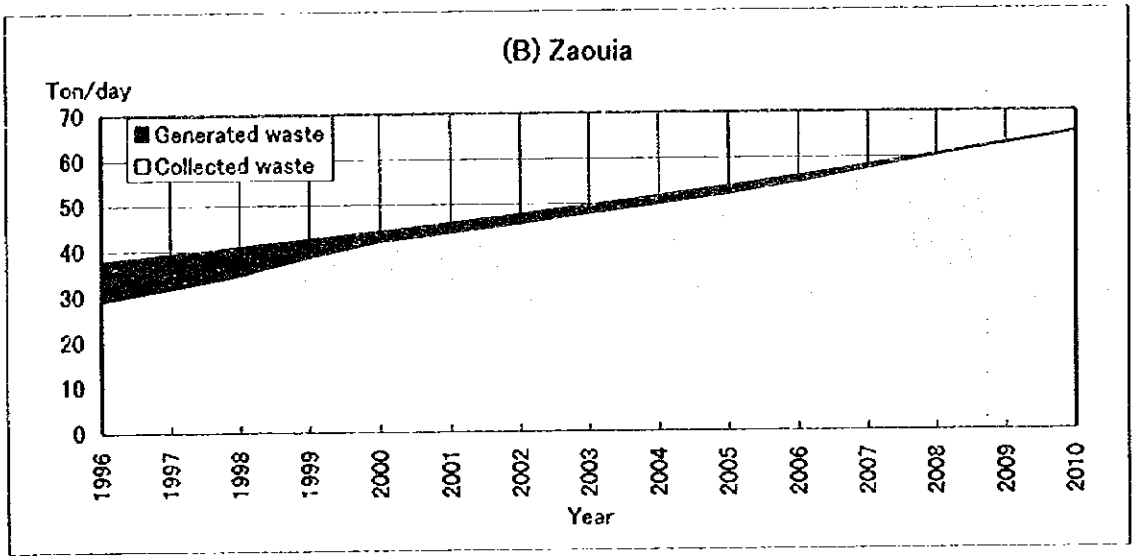
Targets are set taking into consideration present conditions of the trucks in each commune and the opening of the more distant disposal site in the year 2000 which will decrease the truck operation efficiency somewhat.

Table 5.1-2 Operation Service Targets

Operation Indices	1996	2000	2005	2010
A) Boudheb				
- Waste collected/collection crew (t/per)	1.3	1.4	1.5	1.7
- Waste collected/trip (t/trip)	2.3	2.4	2.5	2.5
- Waste collected/truck shift (t/truck shift)	5.3	6.0	7.0	7.0
- Unit cost (DH/ton)	254	200	205	210
B) Zaouia				
- Waste collected/collection crew (t/per)	0.8	1.0	1.2	1.5
- Waste collected/trip (t/trip)	2.9	2.4	2.5	2.5
- Waste collected/truck shift (t/truck shift)	3.4	5.0	6.0	6.0
- Unit cost (DH/ton)	336	300	280	260
C) Biada				
- Waste collected/collection crew (t/per)	0.7	1.0	1.2	1.5
- Waste collected/trip (t/trip)	2.3	2.4	2.4	2.5
- Waste collected/truck shift (t/truck shift)	3.1	5.0	6.0	6.0
- Unit cost (DH/ton)	377	310	280	260

Notes: 1996 figures based on truck scale survey results





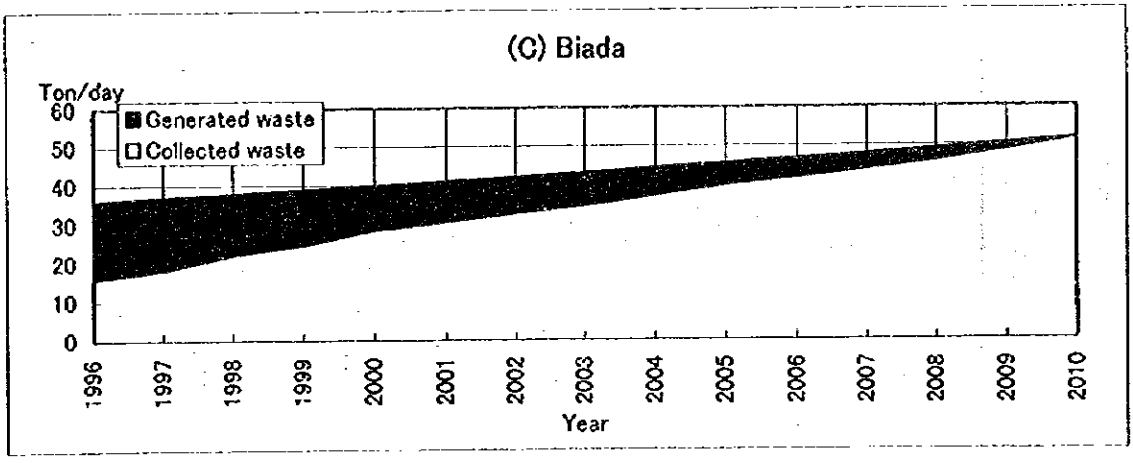


Figure 5.1-1 (a) Waste Generation and Collection Amounts - Urban Communes

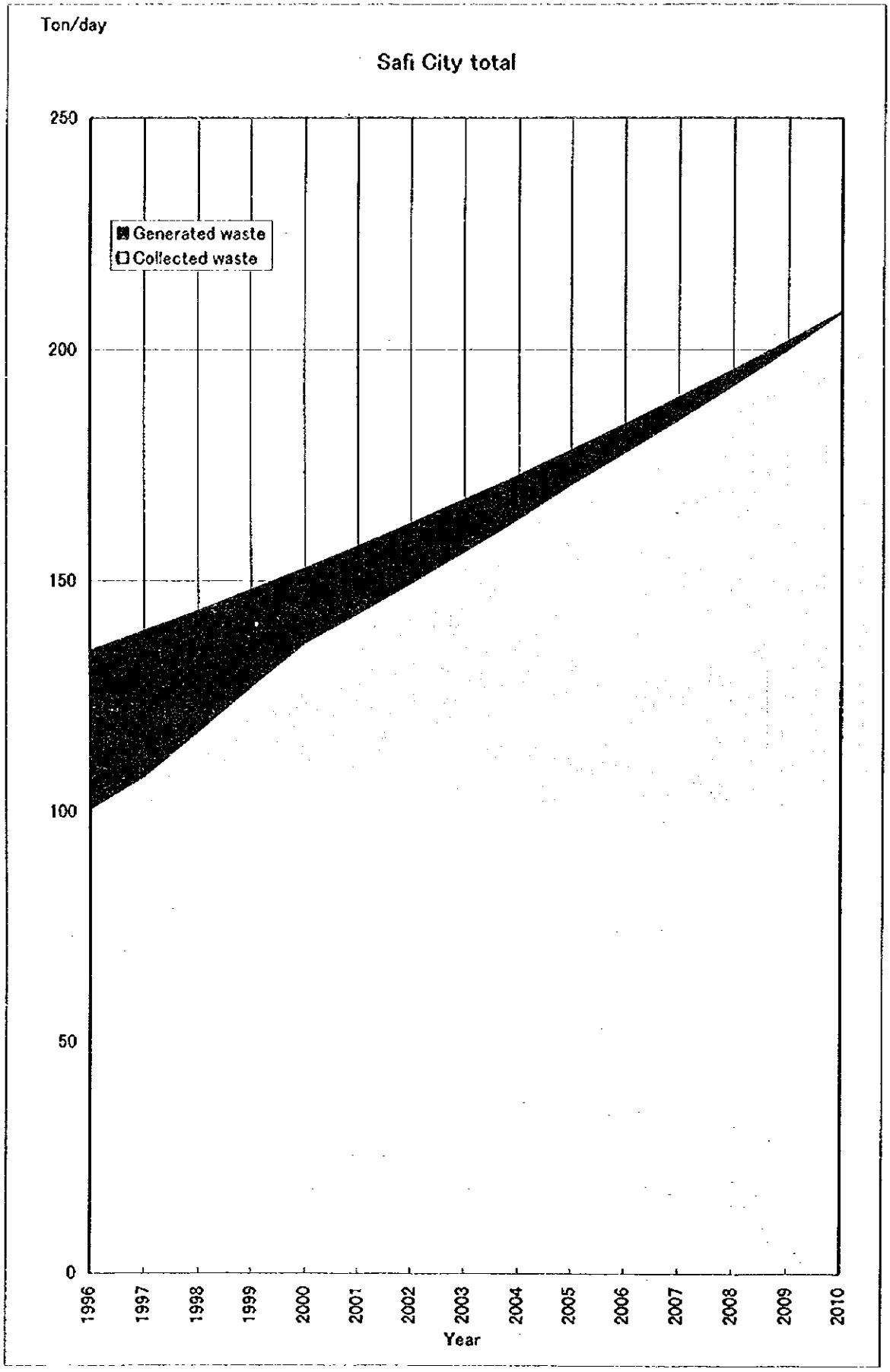


Figure 5.1-1 (b) Waste Generation and Collection Amounts - Safi City Total

5.2 Disposal

The final disposal site is the ultimate termination point of the collected and/or accumulated waste, and the site should be planned in consideration of environmental protection measures to prevent environmental impacts to the surroundings; such as scattering of waste, diffusion of offensive odor, breeding of harmful vectors, self-burning of waste, contamination to public water bodies and groundwater by leachate, fire and/or explosion hazard caused by produced gases, etc.

Based on the Guidelines prepared by the JICA Study Team, and in consideration of environmental impacts to the surroundings, meteorological, topographical and hydro-geological conditions of the Lahmidate site, financial capability of Safi Urban Community, etc., the improvement target for the Lahmidate disposal site should be determined as a Level-3 (Controlled Landfill-3) waste disposal system, its description being contained in Chapter 7, Section 7.1 of this report. Meanwhile, details of waste disposal systems, Level-1 to Level-4, are described in the Guidelines.

Accordingly, the targets adopted in the disposal improvement plan should be as follows,

- Immediate transformation of the existing municipal disposal site operation to controlled landfill operation.
- Implementation of the Urban Community plan to restore the private lands adjacent to the existing disposal site, where waste has been dumped in past years, by removing that waste to the improved disposal site, within the next 2 years.
- Commence operation of the new disposal site, Lahmidate, as a controlled landfill site, in the year 2000.

CHAPTER 6 COLLECTION AND TRANSPORT IMPROVEMENT PLAN

6.1 General

The issues identified based on survey of the existing conditions, and as explained in Chapter 4 of this report, will be covered in this improvement plan. The targets for collection service coverage are set as shown in Chapter 5.

The plan will cover the three urban communes only. Although the urban community is responsible for collection of slaughter house waste and waste from the general market it operates, it uses only one multi-loader truck (age 17 years) and has about 10 sweepers. During the survey in November the multi-loader was out of order and Boudheb trucks transported the urban community waste. It is strongly recommended that the limited responsibilities of the urban community be handled by the respective urban communes and the urban community should concentrate on the disposal site operation.

6.2 Objectives and Policy of the Improvement Plan

The objectives of the collection improvement plan for all three communes are twofold;

- Expansion of the collection service coverage both in terms of population and area
- Implementation of an efficient collection service

Targets have been set out to achieve these figures as outlined in Chapter 5. In order to achieve these objectives the basic policy of the improvement plan for each urban commune will be as follows.

1) Boudheb

- Intensify efforts in residents education and cleansing campaigns to eradicate illegal dumping and inform the residents of the proper waste discharge methods
- Extend collection service to village and fringe areas at least once a week
- Develop standards for management of the collection service
- Expand the compactor truck with communal container system

2) Zaouia

- Intensify efforts in residents education and cleansing campaigns to eradicate illegal dumping and inform the residents of the proper waste discharge methods
- Extend collection service to all the urban area, villages and fringe areas at least once a week
- Develop standards for management of the collection service
- Retire the old trucks and use the newer trucks more efficiently
- Introduce gradually the station system in place of the door-to-door system
- Procure compactor trucks at the time of replacement of the dump trucks recently purchased

3) Biada

- Procure compactor trucks and communal containers as soon as possible
- Introduce the station system instead of the door-to-door system to make most use of the available equipment
- Develop standards for management of the collection service

6.3 Alternative Collection Systems

6.3.1 Elements of the Collection Service

There are basically two types of collection services; hauled container system (HCS) and stationary collection system (SCS). In the HCS a large communal container (3 m^3 and above) is placed at a station. The waste is brought to the container by the generators. The collection truck therefore makes only one stop at the collection route, places an empty container and picks up the full container to take to the disposal site. In the SCS the collection truck makes a number of stops on the collection route collecting the waste from each. HCS is suitable for large generators and in densely populated areas, while SCS is more common for low and medium densely populated areas.

The improvement plan is based on the selection of the appropriate collection service type and most suitable collection system. The collection system is formulated by combining a number of elements. Suitability of the system is evaluated by the ease of operation in the collection area and the system's cost effectiveness. Elements from which the system is formed are described hereafter.

1) Equipment

The equipment include trucks and containers. The truck types that may be considered for Safi are;

- compactor
- dump truck
- pick-up
- multi-loader

Containers can be classified by type of material and by size. In Morocco metal containers are common in case of the larger containers (more than 2 m^3) while smaller containers are made of plastic. The larger size containers are generally more cost effective but require the cooperation of the residents to walk to the container. On the other hand, the smaller sized containers offer a more gradual transfer from the dominant door-to-door pick-up to the more cost effective station pick-up (as shall be discussed in the following section).

2) Pick-up points

The pick-up point is the point from where the collection truck collects the waste. In the door-to-door collection (also referred to as curbside) waste is collected from in front of each building or detached house. In the case of the station collection the waste of a number of buildings and houses is collected from one point.

While door-to-door collection is very comfortable for the residents it increases the time the truck spends on the collection route and decreases its utilization efficiency. Station collection is the opposite.

3) Others

Some other elements that effect the collection system are;

- **Collection frequency.** Two to 3 days/week collection when compared to daily collection is more cost efficient but requires the cooperation of the residents in storing two days' waste in their houses.
- **Separated waste discharge.** Separation of the waste by the residents into recyclable items (as plastic, paper and glass) is very important for the recycling activity.
- **Plastic bag discharge.** Plastic bag discharge facilitates the work for the collection workers and supports station collection. However it is increases the cost burden on the residents.

All these three elements are dependent on residents cooperation. To receive such cooperation it is necessary to increase the citizens awareness as a first step through effective education campaigns.

6.3.2 Formulation of Alternatives

The above elements of the collection system can be grouped up to form the alternatives shown in Table 6.3-1.

Table 6.3-1 Alternatives for the Collection System

Service type	Truck	Collection pick-up point	Communal container		Individual bin[1]
			Large	Med , small	
SCS	Compactor	Door-to-door	X	X	O
		Station	X	O	O
	Dump truck	Door-to-door	X	X	O
		Station	X	X	O
HCS	Multi-loader	Door-to-door	X[2]	X	X
		Station	O	X	X

Note: (1) Bins used by the residents including cans, plastic and paper bags
(2) Door-to-door in case of placing container at premises of large generator
(O) denotes applicable combination while (X) denotes opposite

Considering various truck and container capacity sizes, the following collection systems were identified for further study (Table 6.3-2);

Table 6.3-2 Collection Systems Studied

Code	Truck		Container		Remark
	Type	(m3)	Type	(m3)	
Cl (dd)	Compactor	12	individual	----	SCS; door-to-door, individual bin
Cs (dd)	Compactor	8	individual	----	SCS; door-to-door, individual bin
Cl (st)	Compactor	12	communal	0.8 & 0.4	SCS; station, communal container
Cs (st)	Compactor	8	communal	0.8 & 0.4	SCS; station, communal container
Cl (sti)	Compactor	12	individual	<0.1	SCS; station, individual bin
Cs (sti)	Compactor	8	individual	<0.1	SCS; station, individual bin
D (dd)	Dump truck	4	individual	<0.1	SCS; door-to-door, individual bin
P (dd)	Pick-up	2	individual	<0.1	SCS; door-to-door, individual bin
D (st)	Dump truck	4	individual	<0.1	SCS; station, individual bin
P (st)	Pick-up	2	individual	<0.1	SCS; station, individual bin
Ml (st)	Multi-loader	3	communal	3.0	HCS; station, communal container

6.3.3 Comparison of Collection Systems Costs

Soon Biada officials will have to decide what type of trucks to purchase. In 1996 the other two communes were in a similar position. Boudheb selected two compactors with communal containers (collection system Cl (st)) and Zaouia opted for dump trucks (D (dd)). At a first glance, dump truck at half the price of compactor may appear to be the less expensive choice, especially for financially weak communes. But taking into consideration overall cost efficiency, and ultimately translating cost into Dirhams for each ton of waste transported (DH/ton), compactor is obviously a better choice, as shown in Table 6.3-3 (and depicted in Figure 6.3-1).

The major two factors that affect amount of waste collected, and in turn cost efficiency (DH/ton) are truck capacities and number of trips operated per shift. Trip number can be increased only when wasted time at the collection route is reduced. The table shows that pick-ups with the smallest capacities are the least cost efficient trucks. Their use should be limited to difficult access areas only.

Compactors combined with communal containers are the most efficient system. This system provides largest haul capacity and shortest time spent on collection routes, with the exception of multi-loaders. Multi-loaders are also cost efficient, because thanks to the short distances to the disposal site they can make a large number of trips and loading time is very short.

There are fears in Morocco that reliance on compactors is not advisable because;

- waste moisture content is very high resulting in production of a large amount of leachate during compacting
- maintenance of the compactors is difficult

A number of urban communes using compactors were interviewed and responses in favor of using compactors were mainly positive. In two communes tanks were attached to collect the leachate, and when the amount became too large, while still on the collection route it was drained in the public sewer. One commune complained about maintenance problems in the hydraulic systems, but the other has adapted the workshop to deal with this matter. Obviously these are valid concerns, but not insurmountable ones.

Table 6.3-3 Truck Cost Comparison per Shift

(unit: DH, exc. unit cost)

Truck type	Salaries	Fuel & oil	Maintenance	Depreciation	Indirect & misc.	Total cost	Unit cost (DH/t)
A) Boudheb							
Cl (dd)	600.0	182.0	175.7	439.3	279.4	1676.4	279.1
Cs (dd)	600.0	259.7	135.8	339.5	267.0	1601.9	280.4
Cl (sti)	600.0	221.8	175.7	439.3	287.4	1724.2	235.5
Cs (sti)	600.0	313.2	135.8	339.5	285.3	1711.8	245.3
Cl (st)	490.4	406.5	250.5	684.1	366.3	2197.8	163.8
Cs (st)	490.4	547.2	203.1	560.0	360.1	2160.8	179.5
D (dd)	600.0	549.9	86.3	215.7	290.4	1742.2	377.1
P (dd)	600.0	884.1	35.1	87.9	321.4	1928.6	574.0
D (st)	600.0	638.0	86.3	215.7	308.0	1847.9	344.8
P (st)	600.0	982.8	35.1	87.9	341.2	2047.0	548.1
Ml (st)	271.2	720.2	89.1	245.7	265.2	1591.3	193.8
B) Zaouia							
Cl (dd)	600.0	175.0	175.7	439.3	278.0	1668.0	288.9
Cs (dd)	600.0	245.6	135.8	339.5	264.2	1585.0	293.3
Cl (sti)	600.0	211.5	175.7	439.3	285.3	1711.8	245.3
Cs (sti)	600.0	292.5	135.8	339.5	273.6	1641.8	254.8
Cl (st)	490.4	373.1	243.7	661.9	353.8	2122.8	172.4
Cs (st)	490.4	488.2	195.1	533.7	341.5	2048.9	190.8
D (dd)	600.0	490.4	86.3	215.7	278.5	1670.8	405.6
P (dd)	600.0	739.4	35.1	87.9	292.6	1755.4	624.4
D (st)	600.0	559.3	86.3	215.7	292.2	1753.4	373.2
P (st)	600.0	807.6	35.1	87.9	306.1	1836.8	598.5
Ml (st)	271.2	546.5	86.8	234.2	227.7	1366.3	219.3
C) Biada							
Cl (dd)	600.0	176.7	175.7	439.3	278.3	1670.0	286.4
Cs (dd)	600.0	249.0	135.8	339.5	264.8	1589.1	290.1
Cl (sti)	600.0	214.0	175.7	439.3	285.8	1714.8	242.9
Cs (sti)	600.0	297.7	135.8	339.5	274.6	1647.6	251.5
Cl (st)	490.4	380.9	252.9	692.2	363.3	2179.7	173.4
Cs (st)	490.4	501.7	203.7	562.0	351.6	2109.5	191.1
D (dd)	600.0	504.1	86.3	215.7	215.7	1687.2	398.5
P (dd)	600.0	771.3	35.1	87.9	87.9	1793.1	611.8
D (st)	600.0	577.1	86.3	215.7	295.8	1774.8	366.1
P (st)	600.0	845.3	35.1	87.9	313.7	1882.0	585.9
Ml (st)	271.2	581.6	87.9	239.9	236.1	1416.7	213.2

Notes;

1. Equipment costs; Compactor (12m^3): DH 1,100,000; Compactor (8m^3): DH 850,000; Dump truck: DH 540,000; Pick-up (1.7m^3): DH 220,000; Multi-loader: DH 500,000; Container (3m^3): DH 9,000; Container (0.7m^3): DH 4,000; Container (0.4m^3): DH 1,800
2. Truck age 8 years, metal container 5 years, and 3 years for plastic containers
3. Waste densities; Compactor: 0.55 t/m^3; Dump truck: 0.42 t/m^3; Pick-up: 0.38 t/m^3; Multi-loader: 0.38 t/m^3
4. Collection crews (exc. driver); compactor 3, multi-loader 1, all other truck types 4
5. Loading time (min/ton); compactor 25, multi-loader 10, all other truck types 52
6. Running speed to disposal site 25 km/h, 45 min. breaks during 8 hour shift

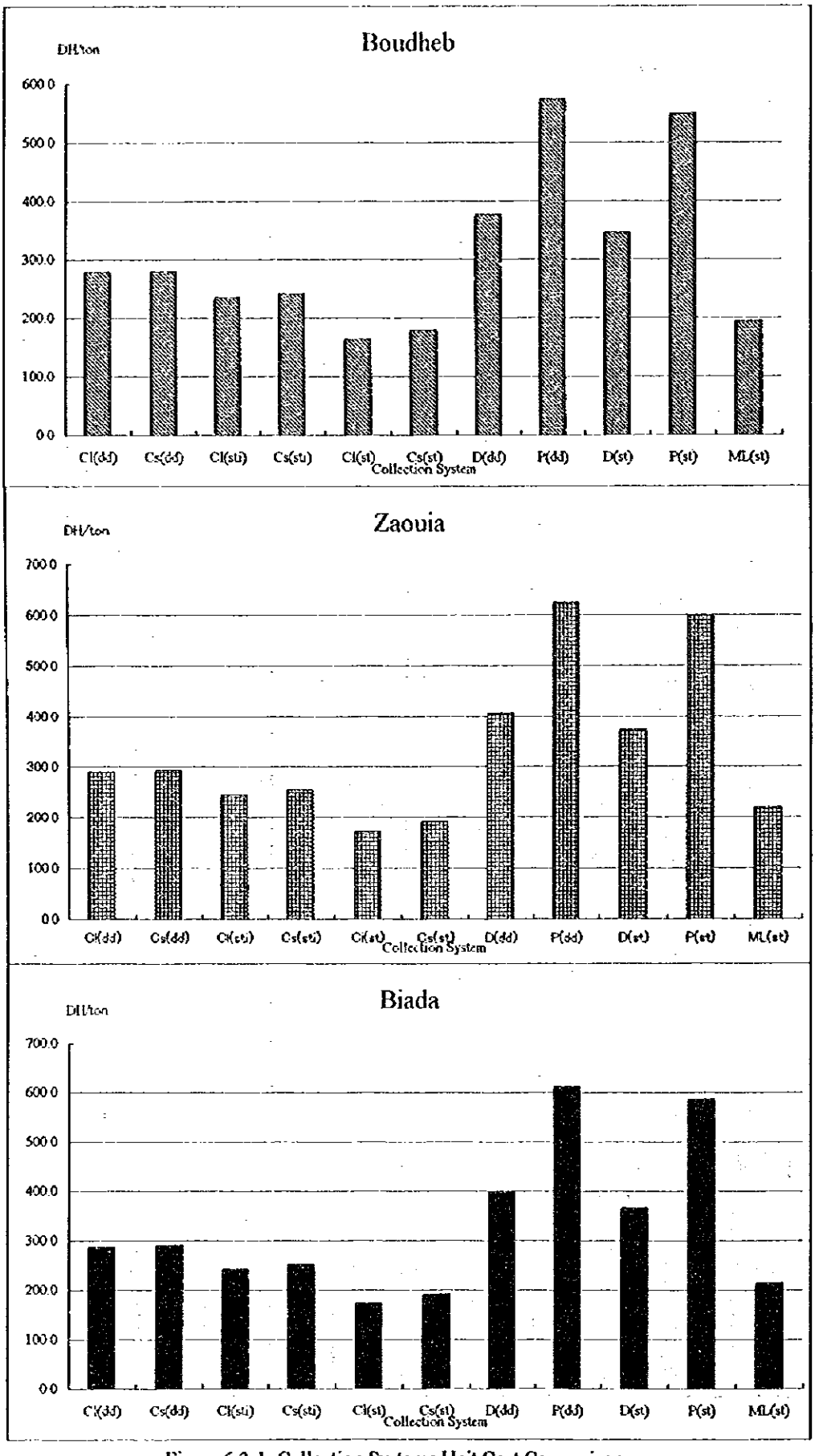


Figure 6.3-1 Collection Systems Unit Cost Comparison

6.4 Improvement Plan

6.4.1 Truck Fleet Condition

The first focus of the improvement plan will be to determine the available equipment in terms of capacity and efficient use. Where there is a deficit in equipment, the second focus of the plan will be to develop a more efficient collection system using suitable equipment.

The current truck fleet, by urban commune is shown in Table 6.4-1. Estimates of the existing fleet capacities in each urban commune are as follows (1997 figures);

Urban Commune	Ideal haul capacity (t)	Capacity/generated waste
A) Boudheb	65.3	104%
B) Zaouia	51.3	131%
C) Biada	20.6	56%

Zaouia is the only urban commune that can afford to retire its aged trucks anytime soon, provided they efficiently use their newer trucks. On the other hand, Biada is not in such a position as its fleet capacity is already well below the demand.

Therefore the improvement plan will consider retirement of old trucks in Zaouia to start in 1998 and replacement of such trucks in the other two communes to start at the same time.

6.4.2 Outlines of the Improvement Plan by Urban Community

The improvement plan for each urban commune is developed up to the year 2010, as a master plan. By that year the collection service in each urban commune shall be as described hereafter.

1) Boudheb Urban Commune

- Collection service coverage to reach 100% both in terms of population and area
- Collection by compactor trucks and communal containers to reach 60%
- Collection by dump trucks using station pick-up to cover villages, and for street sweeping
- Multi-loader collection using communal container to be expanded to about 20% of the waste for large generators and densely populated areas
- Collection by dumper with small transfer station to continue in Medina area with more station pick-up
- Implement recycling by source separation on a pilot project basis

Table 6.4-1 Existing Collection Truck Fleet

License	Type	Capacity m^3	Ideal haul/ trip (ton)	Ideal households served/day	Ideal trip/ day	Replacement year
A) Boudheb Urban Commune						
63955	Dump	3.2	2.4	840	1.0	1998
63957	Dump	3.5	3.1	1,080	1.0	1998
63958	Dump	3.0	2.4	840	1.0	1998
63959	Compactor	10.0	3.0	1,050	1.0	1998
73912	Dump	3.5	3.1	1,080	1.0	1998
90384	Dump	4.0	3.1	1,620	1.5	1999
97814	Pick-up	1.7	1.2	840	2.0	1999
117202	Compactor	12.0	6.5	4,540	2.0	2003
117203	Compactor	12.0	6.5	4,540	2.0	2003
117204	Multi-loader	3.0	2.3	NA	8.0	2003
B) Zaouia Urban Commune						
73911	Dump	3.0	2.4	1,250	1.0	1998
73914	Dump	3.0	2.4	1,250	1.0	1998
90381	Dump	4.0	3.5	1,820	1.0	1999
110233	Dump	3.0	2.9	2,500	2.0	2002
117050	Dump	4.0	3.1	2,500	2.0	2003
117051	Dump	4.0	3.1	2,500	2.0	2003
117052	Dump	4.0	3.1	2,500	2.0	2003
117053	Dump	4.0	3.1	2,500	2.0	2003
117054	Dump	4.0	3.1	2,500	2.0	2003
117055	Dump	4.0	3.1	2,500	2.0	2003
C) Biada Urban Commune						
49735	Dump	5.6	3.0	990	1.0	1998
51655	Compactor	10.0	3.6	1,190	1.0	1998
63956	Dump	3.0	3.0	990	1.0	1998
90380	Dump	4.0	3.0	990	1.0	1999
97815	Pick-up	1.7	1.0	990	3.0	1999
107430	Dump	6.0	2.5	1,650	2.0	2002

Notes;

1. Ideal haul and trip figures are based on the truck scale survey results and taking into consideration truck age
2. For older trucks replacement in 1998 and 1999 is considered but for newer trucks 8 years of service is applied
3. Boldly boxed in shaded areas denote the trucks that need to be retired as soon as possible

2) Zaouia Urban Commune

- Collection service coverage to reach 100% both in terms of population and area
- Presently dominant dump truck and door-to-door system to be gradually replaced by compactor (equal mix of small and large sizes) and communal container to cover about 55% of the waste
- Multi-loader with communal container collection will be gradually introduced to cover 25% of collection in order to accommodate large waste generators that are expected to increase based on the forecast economic growth in this urban commune
- Collection by dump trucks using station system to cover fringe areas, and for street sweeping
- Implement recycling by source separation on a pilot project basis

3) Biada Urban Commune

- Collection service coverage to reach 100% both in terms of population and area, with a frequency of at least once a week
- Collection by compactor trucks and communal containers to reach about 54%
- Multi-loader with communal container collection will be gradually introduced to cover 23% of collection in order to accommodate large waste generators that are expected to increase based on the forecast economic growth in this urban commune
- Collection by dump trucks using station system to cover fringe areas, pick-up for old city area and for street sweeping
- Implement recycling by source separation on a pilot project basis

6.4.3 Improvement Plan Implementation Phasing

The improvement plan for each urban commune is composed of;

- Improvement of existing equipment utilization efficiency
- Procurement of new equipment and preparation of their utilization plan
- Improvement of collection system
- Operation and monitoring using the truck scale

Table 6.4-2 shows the components and phasing of these items.

Table 6.4-2 Phasing of the Improvement Plan

Improvement plan year	1997 - '99	2000 - '01	2002 →
A. Preconditions			
A.1 - Procurement of new equipment			
• Boudheb	△	———	———
• Zaouia	△———	———	———
• Biada			△———
A 2 - Opening of new disposal site		△	
B. Improvement phasing			
B.1 - Improve existing equipment use	———		
B.2 - Shift to station system			
- partial shift to station system			
• Boudheb	———	———	
• Zaouia	△	———	
• Biada	△	———	
- Complete shift to station system			△———
B.3 - Utilize truck scale			
- Commencement of use		△	
- Operation evaluation/plan		———	
- Monitoring program		△———	———

Note: △ denotes commencement of the activity

6.4.4 Implementation of Plan

1) Improvement of existing equipment utilization

<u>Boudheb Urban Commune</u>

- Modify collection sectors and truck distribution based on data obtained in this study (and discussed in Chapter 4)
- Check, and as necessary modify route maps for dump trucks to avoid problems observed in the present operation, such as; excessive U-turns, rear movement, overlapping, avoiding dead end roads when possible, etc.
- Strict supervision to ensure that an 8 hour shift is implemented
- More control on rest period and time crew spends on scavenging the waste at the collection route
- Set standards of two trips per shift, based on the following simple calculation;

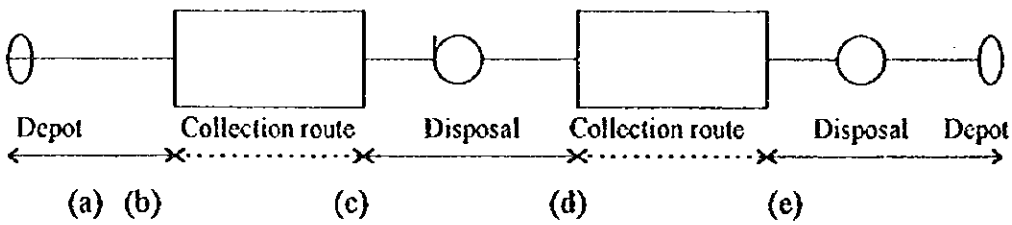


Figure 6.4-1 Collection and Transport System for Urban Commune of Boudheb

(a)	Depot to start of collection route	5 km / 30 kph = 10 min
(b)	in the collection route	2.5 ton x 75 min/ton = 188 min
(c)	Collection route to disposal to next collection route	(5 km/30 kph) x 2 + 20 min = 40 min
(d)	in the collection route	2.5 ton x 75 min/ton = 188 min
(e)	Collection route to disposal to depot	(5 km/30 kph) x 2 + 20 min = 40 min
	Lunch + 2 coffee breaks	30 min + (15 min x 2) = 60 min
	Total time	526 min
	Shift time	8 hours x 60 min = 480 min
	Time deficit	- 46 min

The above calculation is based on the present operation standards. It is therefore necessary to decrease the time spent on the collection route by about 25 minutes (i.e. reduce the collection time per ton to 65 min/ton) through application of the above improvement.

Zaouia Urban Commune

- Modify collection sectors and truck distribution based on data obtained in this study (and discussed in Chapter 4)
- Prepare maps for collection trucks showing present routing
- Identify routing problems observed in the present operation, such as; excessive U-turns, rear movement, overlapping, avoiding dead end roads when possible, etc.
- Readjust routes and show on the maps
- Strict supervision to ensure that an 8 hour shift is implemented
- More control on rest period and time crew spends on scavenging the waste at the collection route
- Set standards of two trips per shift, based on the following simple calculation;

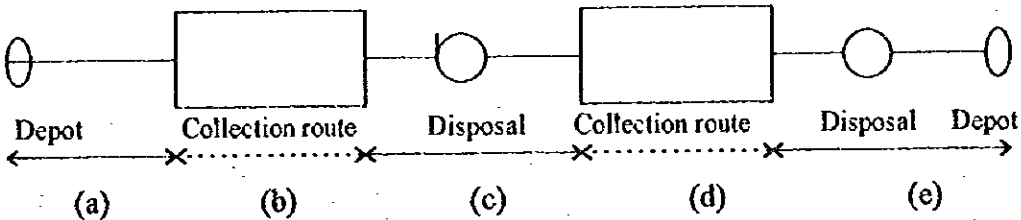


Figure 6.4-2 Collection and Transport System for Urban Commune of Zaouia

(a)	Depot to start of collection route	9 km / 30 kph = 18 min
(b)	in the collection route	2.5 ton x 63 min/ton = 158 min
(c)	Collection route to disposal to next collection route	(9 km/30 kph) x 2 + 20 min = 56 min
(d)	in the collection route	2.5 ton x 63 min/ton = 158 min
(e)	Collection route to disposal to depot	(9 km/30 kph) x 2 + 20 min = 56 min
	Lunch + 2 coffee breaks	30 min + (15 min x 2) = 60 min
	Total time	506 min
	Shift time	8 hours x 60 min = 480 min
	Time deficit	- 26 min

The above calculation is based on the present operation standards. It is therefore necessary to decrease the time spent on the collection route by about 15 minutes (i.e reduce the collection time per ton to 57 min/ton) through application of the above improvement.

Biada Urban Commune

It is not practical to anticipate a large improvement in operation of the existing trucks because of their old age. However some improvement is suggested as follows;

- Modify collection sectors and truck distribution based on data obtained in this study (and discussed in Chapter 4)
- Prepare maps for collection trucks showing present routing
- Identify areas not served and number of households involved
- Identify routing problems observed in the present operation, such as; excessive U-turns, rear movement, overlapping, avoiding dead end roads when possible, etc.
- Readjust present routes and show on the maps
- Strict supervision to ensure that an 8 hour shift is implemented
- More control on rest period and time crew spends on scavenging the waste at the collection route

2) Station System

a. Phased shift to station system

In principle under the SCS two truck types will be utilized; compactor and dump truck. The new compactors will be purchased with enough communal containers in order to fully implement station system. The compactors will not operate door-to-door. On the other hand, the shift from door-to-door to station pick-up system for the existing as well as new dump trucks will be gradual.

Table 6.4-2 shows two phases for the shift from door-to-door to station; partial and complete. In order to achieve a significant reduction in collection time and meet the targets set out in a) above about 40% of the households served should be shifted to station pick-up system in the partial shift stage. To achieve the final target of 25% reduction in collection time, compared to the present, a shift of 80% of the households in the complete shift stage should be realized.

Assuming that the dump truck collects 2.35 t/trip, an average building is 3 floors, with 2 households per floor, and to keep walking distances within 100 meters 5 buildings will be served by one station, the necessary open station number can be estimated as follows;

Number of persons served/trip	= 2.35 t/trip / 0.49 kg/person	=	4,800 persons
Number of households/trip	= 4,800 / 5.5	=	870 hh
Households/station (partial shift)	= 40% x 870 hh	=	350 hh
Households/station (complete shift)	= 80% x 870 hh	=	700 hh
Number of households/building	= 3 fl x 2 hh/fl	=	6 hh/bldg.
Households served per station	= 6 hh/bldg. x 5 bldg.	=	30 hh/station

Waste amount/station	= 30hh x 5.5per/hh x 0.49kg/per/d x 1/0.35t/m^3	=	0.24 m^3
Number of stations (partial shift)	= 350hh / 30hh	=	12 stations
Number of stations (complete shift)	= 700hh / 30hh	=	25 stations
Number of stops (partial shift)	= 12 + [(870hh - 350hh)/6 hh/bldg.]	=	100 stops
Number of stops (complete shift)	= 25 + [(870hh - 700hh)/6 hh/bldg.]	=	50 stops
Number of stops (door-to-door)	= 870 hh / (6hh/bldg.)	=	150 stops

Under the assumed conditions the above estimation shows the following;

- waste amount/station will not be large (volume less than one small communal container)
- with the completion of the shift to station pick-up the number of stops will be reduced by 2/3rds

b) Stations locations

The shift from door-to-door to station pick-up is easier in the case of compactor with communal containers. This has been done with large success in Boudheb and the procedure can be followed in the other two communes. The major obstacle is obtaining the residents agreement to put a communal container in front of their properties and selecting the correct container size for the service area. Two container sizes are proposed; 0.35 and 0.72 m^3. Assuming walking distances of 100 meters, selection can be as follows;

<u>0.35 m^3 communal container;</u>			
Waste amount/container	= 0.35 m^3 x 0.35t/ m^3	=	0.1225 t
Persons served/container	= 0.1225 t / 0.49 kg/person	=	250 persons
Coverage area	= 22/7 x (100 m)^2	=	310 m^2
Population density (not less than)	= 250 persons / 310 m^2	=	8,000 per/ha
<u>0.75 m^3 communal container;</u>			
Waste amount/container	= 0.72 m^3 x 0.35t/ m^3	=	0.252 t
Persons served/container	= 0.252 t / 0.49 kg/person	=	510 persons
Coverage area	= 22/7 x (100 m)^2	=	310 m^2
Population density (not less than)	= 510 persons / 310 m^2	=	16,400 per/ha

Therefore the selection of suitable container must take into consideration population densities; a combination of large density and small container size will result in short walking distances, and vice versa.

The stations system shall be introduced as follows;

- Select suitable locations based on walking distances and residents acceptance
- Select suitable container size based on population density
- Implement education campaigns to make residents aware of discharge times and station locations
- Place signs at locations stating collection times

- Strictly abide by collection time in order to allay fears of some residents that their individual bins, left for collection will not be stolen and prevent scattering of waste or placing for a long time

c) Residents cooperation

The residents can contribute to reducing time spent on the collection route by the truck through two ways. They can walk to a collection point, and they can discharge their waste once every 2 - 3 days a week. Both systems will allow the concentration of a large amount of waste at one point, thereby reducing time spent on the collection route.

The residents were asked about their willingness to assist in these two items during the interview survey (refer to the appendices), and their replies by urban commune are shown in the following table.

Table 6.4-3 Residents' willingness to assist in time reduction efforts

(unit: share of yes response)

Item	Boudheb	Zaouia	Biada
1. Walk to an open station 50 - 100 meters away	0%	2%	96%
2. Discharge waste in plastic bag (supports open station)	80%	49%	10%
3. Discharge waste once every 2 days	1%	21%	43%

The results discourage introduction of the 2 - 3 day/week collection system at present but encourage the use of open stations. Although the interviewed households in Boudheb were not too happy about walking long distances, the successful application of the communal container system in that commune recently suggest that they may be convinced. Willingness to purchase plastic bags by the residents of Zaouia and Biada may assist in the open station system. Obviously much effort will be required through campaigns to obtain the cooperation of Zaouia residents for the success of the open stations.

It is necessary to always remember that residents' acceptance and continuing use of open stations can be seriously damaged if the collection service does not remove the waste from these stations at the specified times. This can never be overemphasized.

3) Utilization of truck scale

a. Operation records

In the year 2000 the new disposal site, with an installed truck scale will come into operation. Daily records will be kept of the following;

- Each truck arrival and departure times
- Waste type and weight transported per truck trip
- Location where the truck is coming from
- Number of workers per truck

This information will be used by the disposal site officials to determine the daily incoming waste amount and implement the disposal plan. The information will also be used by the collection side officials to keep track of each truck's operation utilization;

- Number of trips implemented per day
- Number of workers comprising the collection crew
- Waste collected per trip and that per shift for each truck
- Daily, weekly and seasonal fluctuations of the waste amounts for each urban commune
- Extent of use of private companies
- Others

This information will assist the collection service operator in monitoring the operation of each collection truck and adjusting the sector served by each as necessary.

b. Operation standards

The truck scale will assist in monitoring the operation of each collection truck and modify the work as necessary. The standards upon which the operation shall be evaluated are set out in Table 6.4-1 for the existing trucks. Table 6.4-4 shows the standards for the new trucks in the year 2000. In this year the new disposal site will enter into operation and the distances from each urban commune will increase by 4 kilometers. Although this increased distance will lower the number of trips a truck can make there is no economic justification to construct a transfer station. Such a facility should be considered at distances larger than 25 kilometers.

Table 6.4-4 Average Operation Standards for New Trucks

	ton/crew	ton/trip	ton/truck shift	household/day
(1) BOUDHEB				
- Cl (st)	3.4	6.6	13.4	4,680
- Cs (st)	3.0	4.4	12.0	4,200
- D (st)	1.1	1.7	5.4	1,870
- P (st)	0.7	0.8	3.7	1,300
- Ml (st)	4.1	1.1	8.2	NA
(2) ZAOUIA				
- Cl (st)	3.1	6.1	12.3	6,400
- Cs (st)	2.7	3.9	10.7	5,580
- D (st)	0.9	1.5	4.7	2,500
- Ml (st)	3.1	0.9	6.2	NA
(3) BIADA				
- Cl (st)	3.1	6.2	12.6	4,160
- Cs (st)	2.8	4.0	11.0	3,650
- D (st)	1.0	1.5	4.8	1,600
- P (st)	0.6	0.7	3.2	1,070
- Ml (st)	3.3	0.9	6.6	NA

Notes: - Standards differ by urban commune due to difference in distances to disposal site
- Household number estimated using unit generation rates and household sizes for 1996
- Multi-loader trucks to serve commercial and institutional areas

Estimates of overall collection and transport operation standards under this improvement plan are as follows;

Table 6.4-5 Improvement Plan Operation Standards

Operation standards	Present	2000	2005	2010
A) Boudheb				
- Waste collected/collection crew (ton/person)	1.3	1.6	1.6	1.6
- Waste collected/trip (ton/trip)	2.3	2.7	2.3	2.3
- Waste collected/truck shift (ton/truck shift)	5.3	8.4	7.5	7.5
- Unit cost (DH/ton)	254	202	213	213
B) Zaouia				
- Waste collected/collection crew (ton/person)	0.8	1.1	1.4	1.4
- Waste collected/trip (ton/trip)	2.9	2.3	2.1	2.2
- Waste collected/truck shift (ton/truck shift)	3.4	5.8	6.1	6.3
- Unit cost (DH/ton)	336	291	271	265
C) Biada				
- Waste collected/collection crew (ton/person)	0.7	1.1	1.3	1.3
- Waste collected/trip (ton/trip)	2.3	2.4	2.4	2.1
- Waste collected/truck shift (ton/truck shift)	3.1	6.1	6.5	6.3
- Unit cost (DH/ton)	377	303	279	278

Some of these standards meet the target figures set in Chapter 5, section 1, while others fall short. In Boudheb waste hauled per trip is slightly lower than the target because of more use of smaller multi-loader trucks to transport the increased commercial and market waste expected in that commune. The same applies for Zaouia.

In Biada both the smaller pick-ups and multi-loader trucks will continue to serve the old areas and commercial establishments and hence both indicators of waste collected per worker and per trip are below the set targets.

In Zaouia number of trips per shift by the dump truck will increase and older trucks will be retired earlier. Although this will result in a decrease in waste collected per trip, compared to the present, total waste collected per shift will increase and unit cost will decrease.

6.4.5 Required Equipment and Manpower

1) Considerations of each urban commune

Although cost is the most important consideration in selection of suitable collection systems, other items must also be considered. Some items must be considered independently for each commune and these are discussed in Table 6.4-6. Two common items however are safe working conditions and environmental conditions.

In Safi dump truck collection by door-to-door system is widely employed. This system is very tiring for workers who have to pick up the waste discharged from households in a wide variety of individual bins and empty them into the truck. One worker must stand in the truck box to arrange the waste. On the other hand residents are provided with service right up to their door steps. A compromise must be reached to improve working conditions and

request residents to be more helpful. The compactor with communal containers provides this alternative.

If the leachate problem is controlled, then operation of a compactor truck in the city is more environmentally friendly than open dump truck. However one problem with the compactor system is the use of communal containers. If such containers are not emptied regularly they will become a source of environmental problems.

For each of the three urban communes the plan elements are as shown in the table.

Table 6.4-6 Improvement Plan Framework for each Urban Commune

Urban commune	Compactor with containers	Dump truck, pick-up and multi-loader
A) Boudheb	• Large compactors can serve about 70% of the commune • Smaller compactors can be used in difficult access areas	• Dump trucks continue to serve villages (10% of waste) but with more collection points and less door-to-door service • Dump trucks used in street sweeping • Dumper system to continue in Medina • Multi-loader to serve large waste generators and Medina
B) Zaouia	• Compactors to be introduced in 2003 after residents become used to open station system	• Reliance on dump trucks up to 2003 but with reduced collection time and increased trip numbers through more use of open stations
C) Biada	• Both large and small compactors to be used from 1999 because of narrow streets • More reliance on larger compactors after 2004 as new development with wider streets and further away from the disposal site expands	• Reliance on dump trucks to decrease • Pick-up to continue to serve old part of town where streets are very narrow • Multi-loader to be mainly used for commercial wastes which after 2003

The term "open station" used in the table means a collection point where residents bring their individual containers and leave them for collection. Such a station is usually marked by a sign but no large communal container is placed there. Compared to the large number of stops in the door-to-door collection, collection of the concentrated waste at a fewer number of stops is expected to decrease collection time by about 80%.

Another important factor in reduction of time spent on the collection route is to control the time the workers spend on separation of waste during collection. Of course their need for additional revenue to supplement their salaries is understandable, but the wasted time sharply decreases truck use efficiency.

Figure 6.4-7 shows the share of each system as proposed in the improvement plan by urban commune.

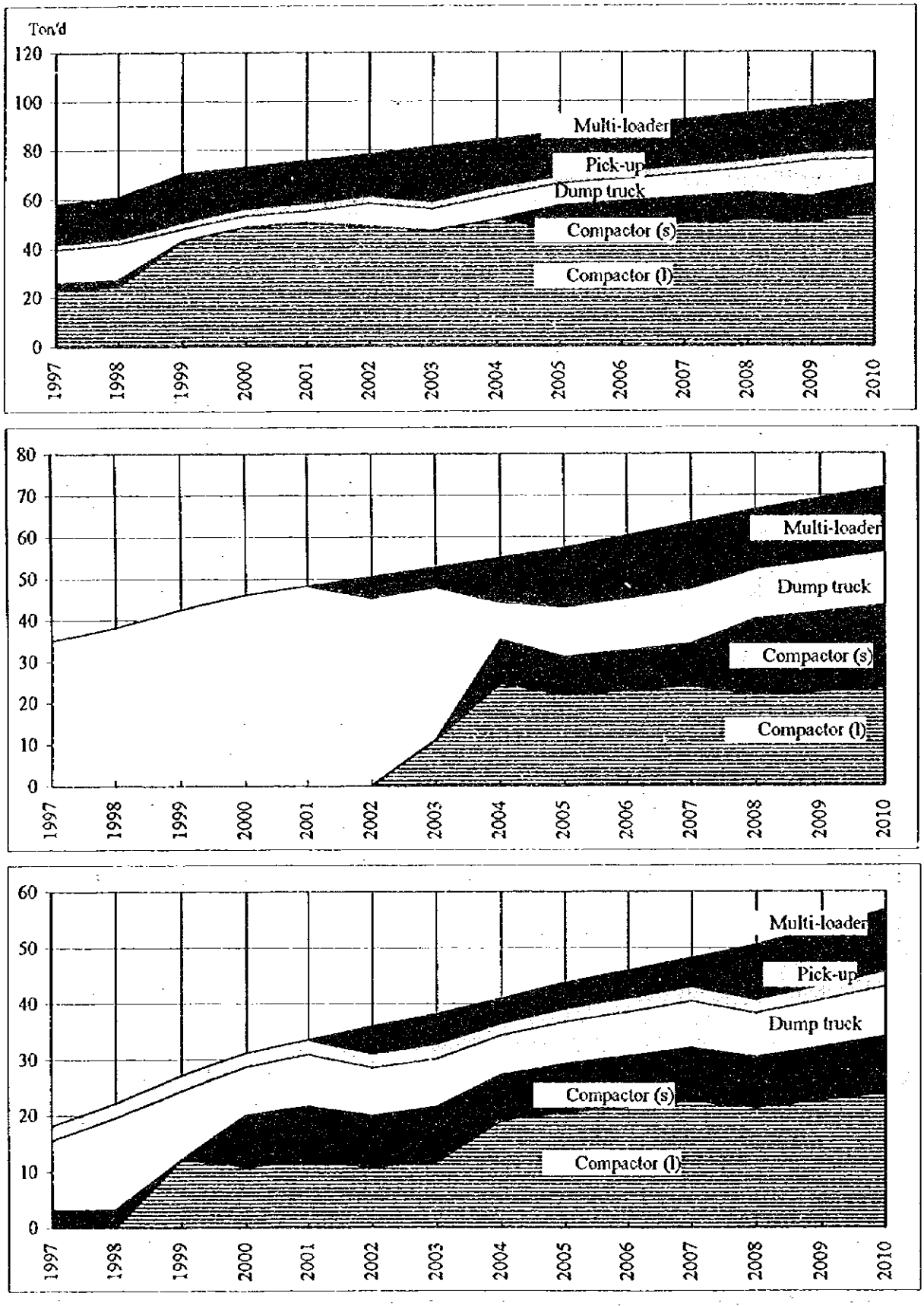


Figure 6.4-1 Collection Shares of each Truck Type

2) Equipment and Manpower

The improvement plan has been prepared taking into consideration the following;

- Trucks replacement/retirement will start by the year 1998
- Operation improvement through reduction of door-to-door system will start in 1999
- New disposal site will commence operation in 2000 (increasing trip distances for all three communes)

The estimated numbers of trucks and workers required are shown in Table 6.4-7.

Table 6.4-7 Estimated Equipment and Manpower Requirements

Urban Commune	Year	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
A. Boudheb Urban Commune															
(1) Waste collection amount	t/d	58	61	64	67	69	71	74	77	79	81	84	86	89	91
Share of generation amount	%	92%	94%	96%	97%	98%	98%	99%	100%	100%	100%	100%	100%	100%	100%
(2) Equipment number															
- Compactor	12m3	2	2	(1) 3	(1) 4	4	4	4	(2) 4	4	4	(1) 4	(1) 4	4	4
- Compactor	8m3	0	0	0	0	0	0	0	0	(1) 1	1	1	1	1	1
- Dump truck	4m3	6	6	1	(1) 1	1	(1) 2	2	2	2	2	2	(1) 2	(1) 2	2
- Pick-up	2m3	1	1	1	(1) 1	1	1	1	1	1	1	1	(1) 1	1	1
- Multi-loader	3m3	1	1	1	(1) 2	2	2	(1) 3	3	3	3	3	(1) 3	3	3
- Dumper	1m3	1	1	1	1	1	1	1	(1) 1	1	1	1	1	1	1
Boudheb tot. trucks		11	11	(1) 7	(4) 9	9	(1) 10	(1) 11	(3) 11	(1) 12	12	(1) 12	(4) 12	(1) 12	12
- Communal container	3m3	8	8	8	(12) 12	12	12	(16) 18	18	(12) 18	18	18	(6) 18	18	(18) 24
- Communal container	0.4m3	100	100	(180)180	(60)240	240	(180)240	(60)240	240	(230)290	(60)290	290	(230)290	(60)290	290
- Communal container	0.7m3	100	100	(90) 90	(30)120	120	(90)120	(30)120	120	(115)145	(30)145	145	(115)145	(30)145	145
Boudheb tot. containers	unit	208	208	(270)278	(90)372	372	(270)372	(90)378	378	(345)453	(90)453	453	(345)453	(90)453	(18)459
(3) Manpower		0	0	0	0	0	0	0	0	0	0	0	0	0	0
- Supervisor	person	2	2	2	2	2	2	2	2	3	3	3	3	3	3
- Driver	person	13	13	9	11	11	12	13	13	14	14	14	14	14	14
- Collection workers	person	37	37	25	29	29	32	33	33	36	36	36	36	35	36
Boudheb tot. manpower	person	52	52	36	42	42	46	48	48	53	53	53	53	53	53
B. Zeuia Urban Commune															
(1) Waste collection amount	t/d	32	35	39	42	44	46	48	50	52	55	57	60	63	65
Share of generation amount	%	81%	85%	91%	95%	96%	96%	97%	97%	97%	98%	99%	100%	100%	100%
(2) Equipment															
- Compactor	12m3	0	0	0	0	0	0	(1) 1	(1) 2	2	2	2	2	2	2
- Compactor	8m3	0	0	0	0	0	0	0	(1) 1	1	1	1	(1) 2	2	2
- Dump truck	4m3	10	10	8	7	7	7	6	(2) 2	(1) 3	3	3	3	3	3
- Pick-up	2m3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
- Multi-loader	3m3	0	0	0	0	0	(1) 1	1	(1) 2	(1) 3	3	3	3	3	(1) 3
- Dumper	1m3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Zaouia tot. trucks	unit	10	10	8	7	7	(1) 8	8	(5) 7	(2) 9	9	9	(1) 10	10	(1) 10
- Communal container	3m3	0	0	0	0	0	(5) 5	5	(5) 10	(5) 15	15	(5) 15	15	(5) 15	(5) 15
- Communal container	0.4m3	0	0	0	0	0	0	(55) 55	(100)155	155	(55)155	(100)155	(45)200	(55)200	(100)200
- Communal container	0.7m3	0	0	0	0	0	0	(28) 28	(51) 79	79	(28) 79	(51) 79	(23)102	(28)102	(51)102
Zaouia tot. containers	unit	0	0	0	0	0	(5) 5	(83) 88	(156)244	(5)249	(83)249	(156)249	(68)317	(88)317	(156)317
(3) Manpower															
- Supervisor	person	2	2	2	2	2	2	2	2	2	2	2	2	2	2
- Driver	person	12	12	10	9	9	10	10	9	11	11	11	12	12	12
- Collection workers	person	36	36	30	27	27	28	28	23	27	27	27	30	30	30
Zaouia tot. manpower	person	50	50	42	38	38	40	40	34	40	40	40	44	44	44
C. Biada Urban Commune															
(1) Waste collection amount	t/d	18	22	25	28	30	33	35	37	40	42	44	46	49	52
Share of generation amount	%	49%	58%	63%	71%	75%	78%	80%	84%	88%	90%	92%	94%	97%	100%
(2) Equipment															
- Compactor	12m3	0	0	(1) 1	1	1	1	1	(1) 2	2	2	(1) 2	2	2	2
- Compactor	8m3	1	1	0	(1) 1	1	1	1	1	1	1	1	(1) 1	1	1
- Dump truck	4m3	4	(1) 5	3	2	2	2	(1) 2	2	2	(1) 2	2	2	2	2
- Pick-up	2m3	1	1	1	(1) 1	1	1	1	1	1	1	1	(1) 1	1	1
- Multi-loader	3m3	0	0	0	0	0	(1) 1	1	1	1	1	1	(1) 2	2	(1) 2
- Dumper	1m3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Biada tot. trucks	unit	6	(1) 7	(1) 5	(2) 5	5	(1) 6	(1) 6	(1) 7	7	(1) 7	(1) 7	(3) 8	8	(1) 8
- Communal container	3m3	0	0	0	0	0	(6) 6	6	6	6	6	(6) 6	(6) 12	12	12
- Communal container	0.4m3	0	0	(60) 60	(50)110	110	(60)110	(50)110	(60)170	(60)170	(50)170	(60)170	(60)170	(50)170	(60)170
- Communal container	0.7m3	0	0	(30) 30	(25) 55	55	(30) 55	(25) 55	(30) 85	(30) 85	(25) 85	(30) 85	(30) 85	(25) 85	(30) 85
Biada tot. containers	unit	0	0	(90) 90	(75)165	165	(96)171	(75)171	(90)261	(90)261	(75)261	(96)261	(96)267	(75)267	(90)267
(3) Manpower															
- Supervisor	person	1	1	1	1	1	1	1	2	2	2	2	2	2	2
- Driver	person	8	9	7	7	7	8	8	9	9	9	9	10	10	10
- Collection workers	person	24	27	21	21	21	22	22	25	25	25	25	26	26	26
Biada tot. manpower	person	33	37	29	29	29	31	31	36	36	36	36	38	38	38

Note: Figures in parenthesis ( ) indicate equipment number purchased in that year

6.5 Related Improvement Plans

6.5.1 Street Sweeping Plan

The street network is usually classified into categories based on the street function and conditions. Class I streets (the main streets) are usually swept daily, while the lower categories of secondary and branch streets are swept with lesser frequencies. It is necessary to know this information in order to estimate the required length to be swept and calculate the manpower accordingly. This information was available for the urban communes of Boudheb and Biada, and assumptions were made for Zaouia. The street sweeping improvement plan was prepared, as shown in Table 6.5-1.

This plan does not include introduction of mechanical sweepers, which are expensive and difficult to maintain. Rather the plan is based on manual street sweeping with each sweeper using a hand cart. Sweeping waste is collected daily by dump trucks and taken to the disposal site. The required dump trucks have been included in the collection and transport plan.

6.5.2 Recycling Plan

In the year 2000 the new disposal site will come into operation. Under the plan to operate the site as a sanitary landfill, scavenging activity there should not be allowed. As explained in Chapter 4, about 1% of the waste is now recycled by the scavengers and the collection crew workers. The plan virtually eliminates this activity. An alternative must, therefore be considered.

Any new recycling plan will depend on the cooperation of the residents in separating the recyclable waste items, such as paper, newspapers, plastic bottles, and glass bottles, at the source. These items should be collected at suitable frequencies (at least once a week) in order to avoid creating space problems for the residents.

Collection can be done either by the urban commune or else by private firms. Surely the recycler presently buying the separated waste items from the scavengers at the disposal site and collection crews would like to maintain his source of supply, after the site closure. The urban communes may collect and transport the recyclable waste to the recyclers provided the recyclers cover the expenses.

Based on the waste composition analysis it is estimated that each household generates about 1.4 kg/week of recyclable plastic, paper and glass. A pilot study could be set up to cover 1,000 households using a pick-up of capacity 1.5 tons, with its box divided into three compartments. The problem is how to motivate the residents to assist in this project. It would be difficult to provide monetary motivation for each household as that would raise the cost very much. One possibility is to work through a social group, such as school, social club, religious society, etc. and provide some money or present to that group in return for their assistance in motivating the residents within their areas.

Table 6.5-1 Street Sweeping Improvement Plan

Year		1995	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
A) Boudheb																
(A.1) Tot. street length	km	120	120	121	122	124	125	126	127	129	130	131	133	134	135	137
(A.2) Street sweeping frequency	%															
- Daily	%	NA	60%	60%	60%	80%	80%	80%	80%	80%	100%	100%	100%	100%	100%	100%
- every 2 days	%	NA	30%	30%	30%	20%	20%	20%	20%	20%	0%	0%	0%	0%	0%	0%
- once per week	%	NA	5%	5%	5%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
- no sweeping	%	NA	5%	5%	5%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
(A.3) street sweeping length/person	km	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
(A.4) number of sweepers	per.	110	64	64	65	66	72	72	73	74	75	81	82	82	83	84
(A.5) number of hand carts	unit	NA	69	69	70	71	77	77	78	79	80	86	87	87	88	89
B) Zaouia																
(B.1) Tot. street length	km	120	120	121	123	124	126	127	129	130	132	133	135	136	138	140
(B.2) Street sweeping frequency	%															
- Daily	%	NA	20%	25%	25%	35%	35%	40%	40%	45%	55%	55%	60%	60%	65%	65%
- every 2 days	%	NA	10%	10%	10%	15%	15%	20%	20%	20%	30%	30%	30%	30%	30%	30%
- once per week	%	NA	30%	30%	30%	35%	35%	30%	30%	30%	15%	15%	10%	10%	5%	5%
- no sweeping	%	NA	40%	35%	35%	15%	15%	10%	10%	5%	0%	0%	0%	0%	0%	0%
(B.3) street sweeping length/person	km	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
(B.4) number of sweepers	per.	36	32	33	33	34	51	51	52	52	53	63	64	64	65	66
(B.5) number of hand carts	unit	NA	37	38	38	39	56	56	57	57	58	68	69	69	70	71
C) Biada																
(C.1) Tot. street length	km	46	46	47	48	49	50	50	51	52	53	54	55	56	57	59
(C.2) Street sweeping frequency	%															
- Daily	%	NA	20%	25%	30%	35%	40%	40%	40%	45%	55%	55%	60%	60%	65%	65%
- every 2 days	%	NA	10%	10%	15%	25%	30%	30%	35%	35%	40%	40%	40%	40%	35%	35%
- once per week	%	NA	30%	30%	30%	30%	20%	20%	20%	15%	5%	5%	0%	0%	0%	0%
- no sweeping	%	NA	40%	35%	25%	10%	10%	10%	5%	5%	0%	0%	0%	0%	0%	0%
(C.3) street sweeping length/person	km	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
(C.4) number of sweepers	per.	25	15	15	15	15	17	17	18	18	18	20	21	21	21	22
(C.5) number of hand carts	unit	NA	20	20	20	20	22	22	23	23	23	25	26	26	26	27

Therefore each urban commune is recommended to implement a pilot recycling project within its area, using the following steps;

- selecting an area of about 1,000 households of middle or high income in which there is a strong social fabric and social organizations exist
- securing the long-term commitment of a private recycler to buy the sorted waste items
- conducting a public education campaign for at least one month before implementation

6.5.3 Maintenance Improvement

Presently there are four workshops for each of the three urban communes and the urban community. Biada operates a temporary workshop and is expected to move into a larger facility once it is ready. Presently large repairs of Biada trucks are done at the urban community workshop. Each workshop has its own staff and facilities as explained in Chapter 4.

Maintenance records showing repair details (type of repair, parts used, manpower hours spent, costs involved, etc.) are kept. Daily operation sheets showing truck usage and fuel consumed are also maintained.

Issues that should be considered in improving operation at the workshops are as follows;

- Insufficient working space at the present workshops
- Lack of daily truck checking
- Lack of preventive maintenance

It is difficult to increase workshop floor area through purchase of new land in the case of Boudheb and the urban community workshops. It is more practical to remove irreparable equipment. Another proposal would be to construct new workshops for equipment other than that for cleansing.

Trucks should be checked daily before leaving the garage in the morning by the drivers, using daily check sheets. The sheets format should be prepared to provide a basic and speedy check. Check items should cover;

- Main clutch & transmission
- Instrument panel & steering
- Hydraulic oil (for compactor truck)
- Electrical system
- Tires
- Brake system
- Engine system
- Chassis and body

Daily checks will facilitate implementation of preventive maintenance. Washing of trucks is a minor but important item to prevent damage to the truck box.

CHAPTER 7 DISPOSAL PLAN

7.1 Disposal Options and Selection

7.1.1 Introduction

The following three major options shall be considered for waste disposal method in Safi city.

- Landfill (Controlled landfill)
- Incineration
- Compost

Taking into consideration the environmental affects, budget allocation of Safi Urban Community, technical aspects, the introduction of controlled landfill is recommended for waste disposal. Details is described in the following Section 7.1.2.

7.1.2 Disposal Options

1) Final Disposal (Landfill)

a. Levels of Waste Disposal System

The existing municipal disposal site, which is an open dumping operation, should be improved as controlled landfill (Level-1), and the new Lahmidate disposal site should be constructed as controlled landfill (Level-3). Definition of both levels of waste disposal system are described in the following Section.

b. Level-1 : Controlled Landfill-1

The existing open dumping site should be transformed/improved into a controlled landfill site, based on the following concepts:

(1) Environmental impacts to be counter-measured

- Waste scattering
- Offensive odor, breeding of harmful insects, waste self-burning

(2) Facilities to be provided

- Establishment of proper access to the landfill site
- Establishment of operational roads to maintain good operating conditions and smooth waste dumping.
- Introduction of periodical soil covering in order to minimize adverse environmental effects on the surroundings. Frequency of soil covering should not be less than twice a week.
- Introduction of safety facilities, such as enclosing fences and gates.

- Introduction of landfill equipment for landfill work and soil covering, such as bulldozer, excavator, dump truck etc.

c. Level-3 : Controlled Landfill-3

The new Lahmidate disposal site should be constructed as controlled landfill, based on the following concepts:

(1) Environmental impacts to be counter-measured

- Waste scattering
- Offensive odor, breeding of harmful insects, waste self-burning
- Ground-water and runoff contamination

(2) Facilities to be provided

- Execution of daily soil covering, by adopting the cell method, in order to minimize adverse environmental effects on the surroundings, such as scattering of solid waste, diffusion of offensive odors, breeding of harmful insects, fire caused by spontaneous combustion, etc.
- Establishment of proper access to the disposal site
- Establishment of operational roads to maintain good operating conditions and smooth waste dumping.
- Procurement of landfill equipment for landfill work and soil covering, such as bulldozer, excavator, dump truck etc.
- Introduction of an inspection, control and operational recording system for incoming waste and trucks by using a truck scale.
- Establishment of an enclosing bund and/or on-site roads in order to distinguish the landfill site area and to maintain a proper landfill embankment.
- Set up litter control facilities and/or buffer zones.
- Set up safety facilities, such as enclosures, gates, site offices, lighting facilities, etc. in order to perform proper landfill operation and to control scavenging activity and animal grazing etc.
- Establishment of a drainage system in order to divert storm-water and seepage, in order to reduce leachate.
- Installation of clay soil, its thickness is approx. 0.5m, to keep proper leachate collection.
- Installation of leachate collection facilities, made of packed gravel, in order to keep smooth landfill operation by collecting leachate from landfill area.
- Introduction of leachate re-circulation facilities, in order to keep and reduce the leachate at inside the disposal site.
- Introduction of vertical gas removal facilities at several points of the site in order to monitor the gas production.

Regarding the Lahmidate disposal site, in consideration of the budgetary constraints faced by the Safi Urban Community, most facilities considered in this report should be prepared and/or constructed by using domestic materials which are extracted or produced in Morocco. However, each facility should fulfill the basic functions as required under controlled landfill Level-3.

2) Intermediate Treatment

In recent years, securing landfill sites has been getting rather difficult especially for large cities, not only in advanced countries but also in developing countries. On the other hand, more than 85% of solid waste generated worldwide is hauled to disposal sites. Under these conditions, several kinds of intermediate treatment systems have been developed and adopted by local governments of European countries and Japan for the purpose of volume reduction and resource recovery/recycling of solid waste. Incineration is the most common method, but other methods, such as composting, pyrolysis, RDF (refuse drive fuel), and methanization have been introduced on a very limited scale. In this article, the feasibility of introducing incineration and composting for Safi city will be discussed.

a. Incineration

The primary purpose of incineration is to render wastes inert, which also reduces volume and weight of the wastes, and may sometimes provide a source of energy.

The feasibility of incineration depends largely on the availability of land for a waste disposal site and its price, also, technically, on characteristics of waste and its amount. For the following reasons, incineration is not recommended at present for Safi. Instead, the introduction of sanitary landfill is recommended.

(1) Compared with European and Japanese cities, large vacant and/or not highly used lands exist in the surrounding area of Safi city. Therefore, it is not very difficult for the Safi Urban Community to acquire land for waste disposal.

(2) Investment and operating costs for incineration are very high compared with landfill. Unit cost of incineration, to handle/dispose one ton of waste, is about 11 times higher than that of sanitary landfill. Cost comparison of incineration and sanitary landfill is shown in the following Table 7.1-1.

Table 7.1-1 Comparison of Unit Costs of Incineration and Sanitary Landfill

(Unit : DH/ton)

No	Items	Sanitary Landfill	Incinerator
1.	Construction and Equipment	60	800
2.	Operation and Maintenance	17	140
3.	Land Acquisition	2	0
4.	Sub-Total (= 1 + 2 + 3)	79	940
5.	Value of Heat Recovery	--	50
6.	Net Cost (= 4 - 5)	79	890
7.	Disposal of Incineration Ash	--	10
8.	Total (= 6 + 7)	DH 79/ton	DH 900/ton

(3) For self sustaining combustion of wastes, the lowest calorific value of the waste should be approx. 1,200 Kcal/kg. The value of wastes in Safi is estimated at 900 - 950 Kcal/kg, because of its high moisture content (66.2 %) and high content of putrescible matters/kitchen waste (76.9 %). Therefore, for the proper operation of

an incineration plant, a large amount of supplementary fuel is required, which implies a higher operation cost.

(4) In general, a minimum furnace capacity of 200 ton/day may be required for incineration plant in order to perform energy recovery to generate electricity. However, the total amount of generated waste in Safi in 1996 was only 105 ton/day. Therefore, energy recovery by incinerator is not economically feasible at present.

b. Composting

Composting is the most commonly used biological process for the conversion of organic waste to a stable humus-like material called compost.

Waste generated in Safi is suitable for composting, because of its high content of putrescible matter/kitchen waste, even though its C/N ratio (Carbon-Nitrogen factor to determine the speed at which decomposition take place) is low. However, the following two aspects, which are major conditions affecting the feasibility of composting, should be carefully considered and examined for successful introduction of composting.

(1) Securing of compost market and sales routes

Market conditions are an extremely important factor which affect the feasibility of composting. Many compost plants in the world have failed due to insufficient demand for compost. For farmers, the costs of using compost depend on the price of compost products and transportation cost from the plant to its place of use. In general, if the transport distance is within 20 km, it may be feasible for farmers to use compost products. Meanwhile, compost demand is not constant, arising only in specific seasons of the year.

(2) Waste quality and composition

According to the result of the waste composition survey done by the JICA Study Team in November 1996 at Safi, the wet base content of organic matter, comprised of kitchen waste, paper, wood, leather and textiles, was 87.3% and kitchen waste itself was 76.9%. The result shows that the waste in Safi is suitable for composting, except under the following conditions.

- The moisture content of kitchen waste was 78.4%. If however the moisture content exceeds 55%, water begins to fill the interstices between the particles of wastes, reducing interstitial oxygen and causing anaerobic conditions; this results in a rapid fall in temperature and production of offensive odor. Therefore, it is necessary to reduce the amount of contained water before fermentation.
- The C/N ratio of waste of Safi was between 10-14 (reported by Solid Waste Collection Study in Safi in 1987). However, the ideal C/N ratio for waste composting is between 30 and 35. Therefore, some adjustment, such as adding papers etc., will be required for proper fermentation.
- The plastic bag content is rather high in Safi waste. Therefore, care must be taken to ensure that there is a proper waste separation system in the plant.

It should be noted that at the compost plant in Rabat, which is the only plant operating in Morocco at present, annual sales of compost products is estimated DH 562,000/year, which is about 38% of the operating cost of DH 1,462,000/year. The annual loss is equivalent to the sum of DH 900,000/year, in addition to the amortization of the initial investment plant construction.

7.2 Final Disposal Plan

7.2.1 Waste Type and Amount to be Accepted/Disposed

1) Type of Waste to be Accepted at Disposal Site

Waste types to be accepted at the Lahmidate new disposal site are domestic waste, commercial waste (which is comprised of market waste, store/shop waste and office waste), street/garden waste and demolition waste.

Regarding industrial waste, (which may include toxic substances), it should be treated and disposed of under the producer's own responsibility. In Europe and Japan, industrial enterprises are responsible for management of industrial waste according to law. Meanwhile, the Ministry of Environment in Morocco has a plan to draft a law which requires industrial enterprises to be responsible for management of industrial waste. From this point of view, it is recommended that industrial waste should not be disposed of at Lahmidate disposal site.

On the other hand, in consideration of existing conditions in Safi; that is, all types of waste are hauled in mixed form, it cannot help hauling the industrial waste at the municipal disposal site for the time being. Therefore, during the operation of improved municipal disposal site, designated blocks at landfill area for each type of wastes should be installed, to prevent dangerous contact with potential hazardous wastes by operators and scavengers.

2) Outline of Waste Disposal Plan and Waste Amount

Lahmidate new disposal site is comprised of two zones; that is, Zone-I and Zone-II. An outline of the disposal site plan, related to the waste amount to be disposed of at the sites, is shown in the following Table 7.2-1.

Table 7.2-1 Outline of Waste Disposal Site Plan

Items	Improved Municipal Disposal Site	Lahmidate New Disposal Site		Sub-total (Lahmidate site)
		Zone-I	Zone-II	
Site area (ha)	11.3	15	25	40
Landfill area (ha)	9.5	12	23	35
Waste amount disposed of (ton)	477,000	790,000	1,330,000	2,120,000
Operation period (year)	- 1999	2000 - 2011	2012 -	more than 20 years

A schedule of the improved municipal disposal site and Lahmidate disposal site, indicating the accumulated waste amount to be disposed of, is shown in Fig. 7.2-1.

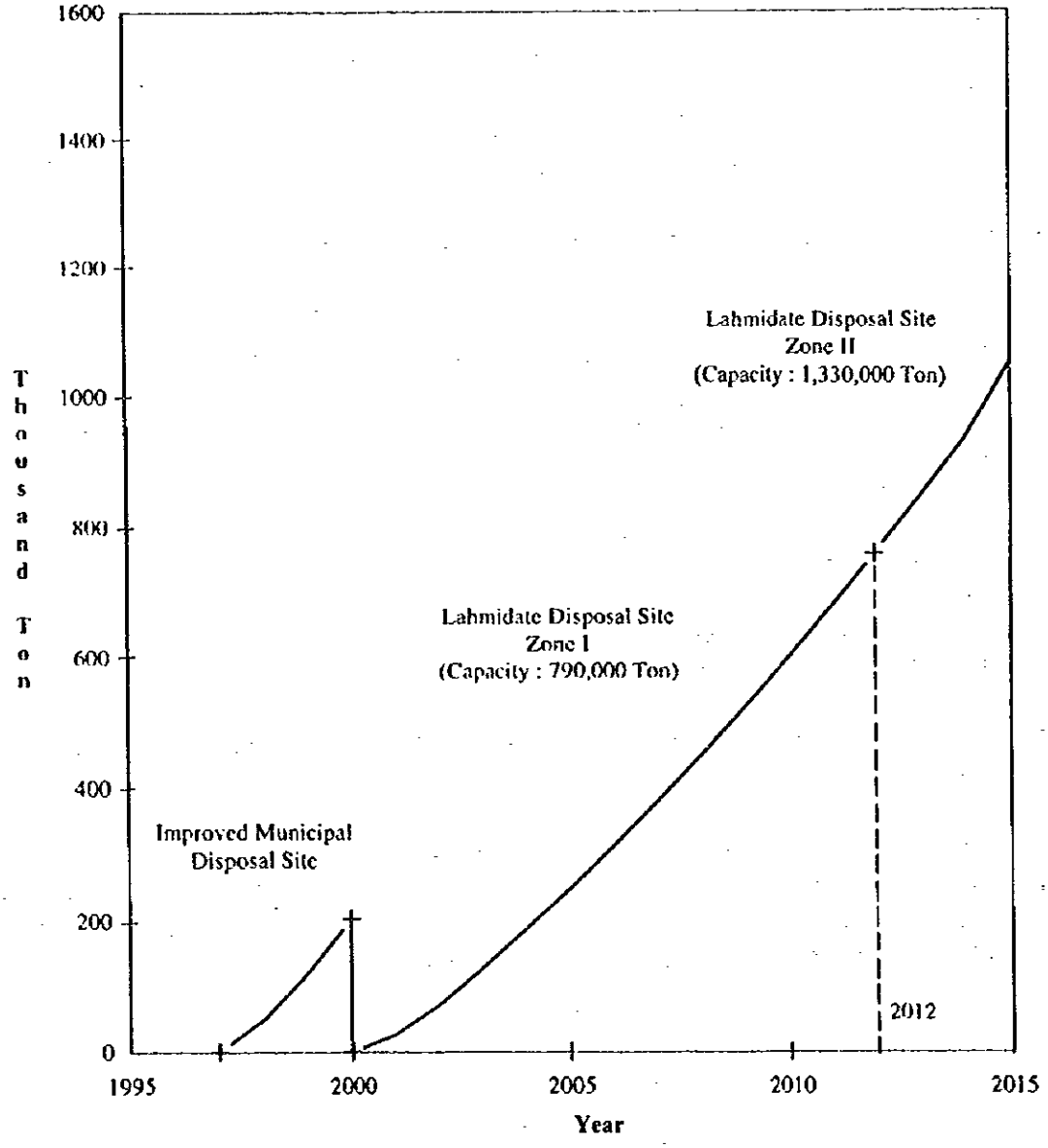


FIG. 7.2-1 Schedule of Final Disposal

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7.2.2 Selection of New Disposal Site

Location of the new disposal site of Safi, at Lahmidate in Khatte Azakane Rural Commune, has been selected by an official meeting which was organized by the Governor of Safi Province, President of Safi Urban Community, President of Khatte Azakane Rural Commune and Kaïdat (local authority from Ministry of Interior), in December 1996.

The JICA Study Team conducted site visits/inspections and data analysis for the Lahmidate site in order to evaluate its suitability as a waste disposal site, based on the Guidelines which have been prepared by the JICA Team. The JICA Team concluded that the Lahmidate site is suitable for the final disposal site of Safi. Major advantages and disadvantages of the Lahmidate site are described in the following Table 7.2-2.

Table 7.2-2 Description of Lahmidate Site (Advantages and Disadvantages)

No	Advantages	Disadvantages
1	Land area/capacity (40ha) is enough for more than 20years usage for disposal	Approx. 1.0km of access road should be improved
2	Residence area is far from the site (approx. 1.0km), therefore, environmental impacts are very low	No public water supply exists surrounding the site
3	The site is far from water sources	
4	Groundwater level is rather deep (approx. 50m)	
5	Distance from city center is 8.0km, which is suitable for waste collection	

Existing conditions of Lahmidate site correspond to the evaluation items and suitability criteria as shown in Table 7.2-3.

On the other hand, JICA Study Team visited at surrounding area of Safi city (5 to15 km radius from city center), in order to find potential sites for waste disposal, and resulted that several potential sites has found between Rond Marrakech and Sebt Gxoula, including Lahmidate site, 7 to 12 km east from city center.

Table 7.2-3 Evaluation for the Location of New Disposal Site

Evaluation Items	Lahmidate site	
	Description	Eval.
I Availability of Land		
1 Land ownership	Private	B
2 Land use restriction	No restriction	A
3 Administration boundary	Outside of Safi	B
4 Land capacity (life expectancy of new disposal sate)	40 hectare	A
- Other considerations		
II Acceptability to Neighboring Citizens and Related Authorities		
1 Proximity to the nearest residential area	Approx. 1.0 km	A
2 Achievement of consensus	(Provincial decision)	B
3 Proximity to strategic public facilities	School/small (350 m)	B
- Other considerations		
III Environmental Impacts and Disaster Prevention Measures		
1 Proximity to public water supply sources	1.0 km (private well)	A
2 Risk of dust, noise and odor hazard	Low risk	A
3 Ground water level	Approx. 50 m (Nov.1996)	A
4 Permeability of base soil of the site (marl-limestone/gypsum)	(unknown)	--
5 Impacts on ecological system	Little impact	A
6 Impacts on man-made assets of historical/religious value	Some impact	B
7 Impacts on natural landscapes	Partly visible from 2nd road	B
8 Impacts down-stream of prevailing wind	Every direction (little impact)	A
9 Impacts on disaster prevention measures	Little impact	A
- Other considerations		
IV Economic Factors		
1 Land acquisition price	70,000 DH/ha	B
2 Compensation requirements	Not necessary	A
3 Distance from waste generation areas (from El Jadida)	8.0 km (16 minutes)	A
4 Topographic conditions	Flat ground at foot of hills	B
5 Accessibility to the site (w/ access road condition)	1.0 km (poor condition)	C
6 Availability of covering material	Available at site	A
7 Availability of public utilities/services (water, electricity etc.)	Water shall be provided	B
8 Present land-use	Agriculture (partly)	A
- Other considerations		
Synthetic evaluation		B(A)

Note; A : Positive
B : Neutral
C : Negative

7.2.3 Disposal Policy of Lahmidate New Disposal Site

1) Basic Principles

Regarding the necessary functions of the Lahmidate disposal site, as a waste Level-3 (Controlled Landfill-3), basic principles for the execution of the preliminary design have been conceived of as follows.

i. The site plan and/or facility plan of Lahmidate disposal site should be appropriately tailored to its topographical and geological features, and the surrounding environment.

ii. Lahmidate disposal site should be constructed as a sanitary landfill to minimize adverse environmental effects on the surrounding areas.

iii. During and after completion of the landfill by waste, the Lahmidate disposal site should not to be a source of pollution, or threaten the safety of surrounding residential areas.

iv. The completed sites should be harmonious with the surrounding environment.

v. The layout of the facilities for the disposal site should take the need for smooth operation and maintenance into account.

vi. Administrative facilities should be located at the entrance area of the disposal site for the easy control and supervision of the waste collection vehicles and of the operation flow of the landfill.

vii. Leachate should always be kept inside the disposal site by adopting a leachate re-circulation system and eliminate the leachate by the function of evaporation, sedimentation and absorption. In other words, leachate should not be discharged outside of the disposal site, as a pollution prevention measure.

viii. Leachate re-circulation facilities should not necessarily be centralized. The location of this facility should be decided in light of the topographic features and re-circulation points of the leachate in the landfill area.

In addition, Lahmidate disposal site shall also be fulfilled the requirements for the disposal standard of "Basic Standard Type" which is under preparation by Ministry of Environment, at present.

Fig. 7.2-2 shows the location of the Lahmidate disposal site and surrounding areas.

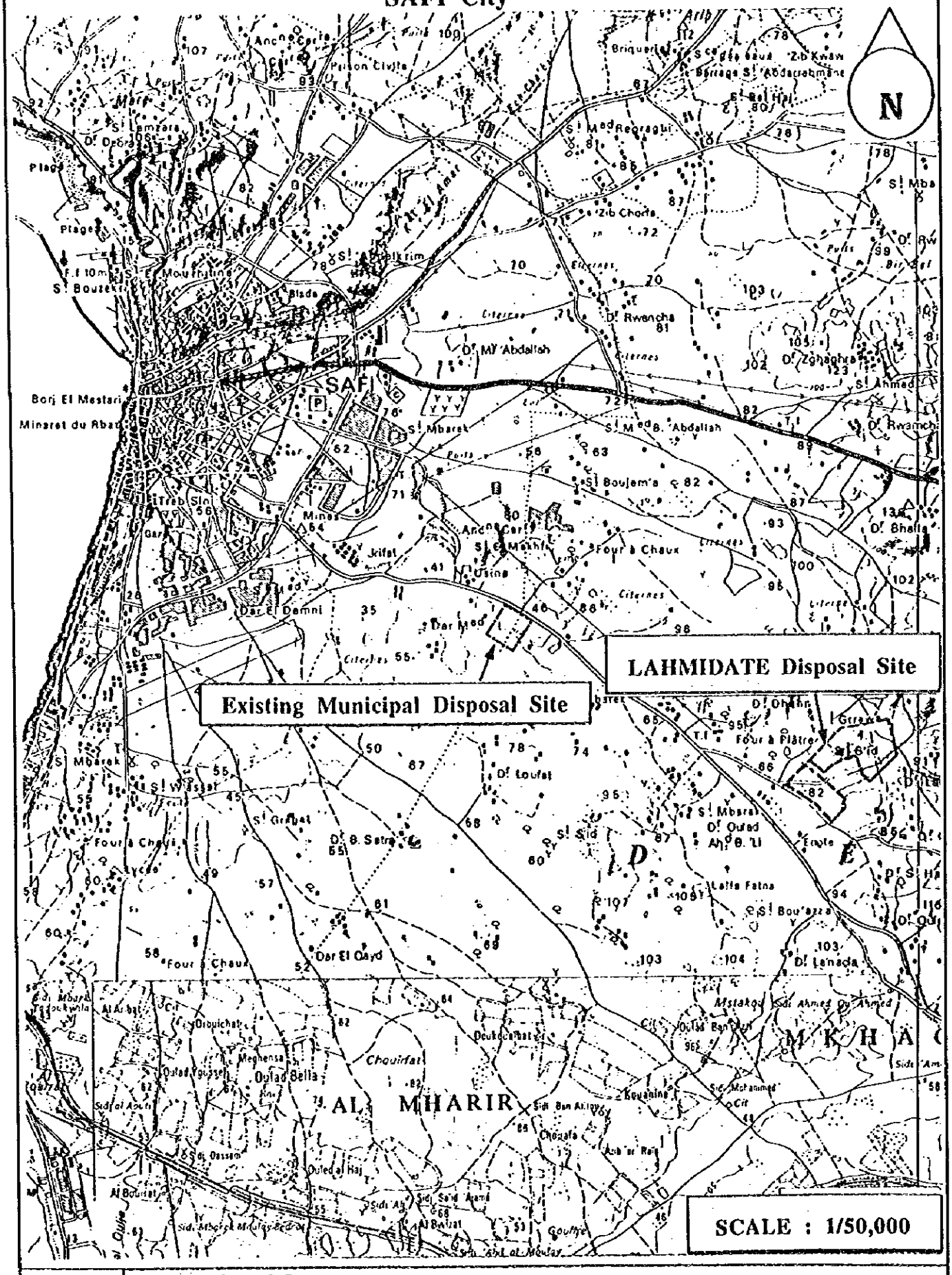

FIG. 7.2-2 Location Map

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2) Planning Conditions

It is proposed to construct the Lahmidate disposal site at the location of Village Lahmidate, Rue Sebt Gxoula, Rural Commune of Khatte Azakane. The total area of the Lahmidate disposal site is 40 hectares and it is expected to be used for more than 20 years.

The outline of the Lahmidate disposal site is described as follows and the layout plan is shown in Fig. 7.2-3.

- Site location : 8 km from city center
- Total site area : 40 hectare (Zone I : 15 ha, Zone II : 25 ha)
- Landfill height : 15 m (including covering soil)
- Total landfill capacity : 2,120,000 ton
- Daily waste amount : 215 ton/day in year 2000
- Period of use : 2000 - 2020's (more than 20 years)

The Lahmidate disposal site will be developed in two (2) phases. The first project is called "Zone-I", which has an area of 15 hectares and can be used for 11 years. It will be operated from the year 2000, after closure of the existing municipal disposal site.

Planning conditions for the Lahmidate disposal site Zone-1 are the following;

- Site area : 15 hectare
- Landfill area : 12 hectare
- Landfill height : 15 m (6 waste layers including covering soil)
- Landfill capacity : 790,000 ton
- Period of use : 2000 - 2011 (eleven years)
- Landfill method : Controlled landfill
- Disposal standard : Basic standard type
- Daily waste amount : 177 ton/day in year 2005
- Operation method : Cell method with waste push-up
- Service area : Safi Urban Community and Khatta Azakane Rural Commune
- Waste to be disposed of : domestic waste, commercial waste, street/garden waste, demolition waste
- Ultimate land-use : Agricultural land

The issues discussed below refer mainly to Zone-I of the Lahmidate disposal site.

3) Topographic and Hydro-geological Features

Lahmidate site is located on flat ground at the foot of two hills which are located east and north of the site. The level of flat ground of the site is between EL+75.00m to EL+77.00m and the higher level of surrounding hills is approx. EL+115.00m. Flood water occasionally flows from the east hill side - its catchment area is approx. 2.4km^2, through the north end of the site to the west, in the rainy season. Traces of two quarries exist at the east and north ends of the site. Total area of the site is 40 hectares and, from

a topographical viewpoint, it could possibly be expanded another 20 to 25 hectares in a north-west direction.

A detailed geological profile of the Lahmidate site is not available at the moment because the specific data have not been obtained. However, it may be estimated, taking into consideration the neighboring soil conditions; that is, the site may be mainly composed of marl limestone/gypsum of superior Jurassic, and its top layer contains roots and leaves of crops. Groundwater level is assumed to be GL-50m, taking into consideration the conditions of surrounding dry wells and inspection of an existing well which is located 500m to the west of the site.

7.2.4 Facility Plan

Fig. 7.2-4 shows the facility plan for the Lahmidate disposal site Zone-I, and Fig. 7.2-5 shows its sectional elevation.

An outline of the facilities, that is, main facilities, environmental protection facilities and others, for construction of the Lahmidate disposal site is shown in Table 7.2-4. Fig. 7.2-6(1/2) & (2/2) show facilities of the Lahmidate disposal site.

Table 7.2-4 Facility Outline of Lahmidate Disposal Site (Zone-I)

Facility	Dimension	Unit	Quantity
I. Main Facilities			
1 a. Access road	Road width : 9.0 m (asphalt paved)	m	1,050
b. Onsite road	Road width : 5.0 m, h = 3.0 m (asphalt paved)		
- with Dike		m	530
- without Dike		m	1,020
c. Operational road	Road width : 8.0 m, h = 1.0 m (gravel paved)	m	1,080
d. Storm-water drainage	U-shaped gutter	m	1,550
	Open cut	m	2,160
II. Environmental Protection Facilities			
a. Site area	Site levelling/compaction	ha	15
	Earth cut	m^3	804,000
b. Liner	Clay soil (t=0.5 m)	m^2	126,500
c. Leachate collection facilities	Packed gravel : 300 mm square (sub/branch)	m	1,700
	Packed gravel : 400 mm square (main)	m	980
d Gas removal facilities	Packed gravel (w/ steel net and timber frame)	m	50
e. Leachate re-circulation facility	8.1 m^3/ha/day (leachate amount) Re-circulation pump, etc.	LS	1
f. Litter prevention facility /Buffer zone	Fence and trees	m	650
	Fence (only)	m	1,020
III. Other facilties			
a. Site office		m2	60
b. Truck-scale	Load cell type, 30 ton capacity	unit	1
c. Washing facilities	High pressure spray, pump etc.	LS	1
d. Lighting facilities		LS	1
e. Water supply		LS	1
f. Surrounding works	Gate, parking, etc.	LS	1
g. Rain-water channel	Open cut	m	500

1) Main Facilities

- Access road

A local path, the length of which is 1,050 m, should be improved in order to become the access road for the Lahmidate disposal site. The function of this road should not only be for access to the site but for the use of the surrounding inhabitants. In light of this matter, design conditions of the access road should be as follows.

i. The road should be wide enough for two-way traffic and shoulder (or side-walk).
ii. The road should be asphalt paved.
iii. The road level should be 0.5 m higher than surrounding ground level.
iv. The width of the road is 9.0 m.
v. Stopping/waiting lane/area should be included along the access road for the collection vehicles near the entrance of the site.

- Onsite road (with dike)

The major functions of the onsite road (with dike) are as follows.

i. To confine the waste which will accumulate to a height of 15 m.
ii. Access for collection vehicles.
iii. To confine the flood water to prevent water penetrating inside the site.

The onsite road should also be used for operation of the landfill work and site inspection. The design conditions of the onsite road are as follows.

i. The road width should be 5.0 m at its crest, and 4.0 m should be asphalt paved.
ii. The height of the road should be 3.0 m.
iii. Stormwater drainage should be located on outside of the onsite road.

- Operational road

To maintain good operating conditions and smooth waste dumping, an operational road should be constructed in the landfill area.

The design conditions for the operational road should be as follows.

i. The road width should be 8.0 m at crest of the road, and 6.0 m of it should be gravel paved.
ii. The height of the road should be 1.0 m from ground level.
iii. The slope on both sides of the road should be 1:4, for easy access of landfill equipment and collection vehicles.

- Storm-water drainage

Especially during the rainy season, a stream of water occasionally originates in the eastern hill-side region and flows into west through the northern part of the site, its catchment area being approx. 2.1 km^2. To eliminate the rainwater which flows into the landfill site from the outside, and to prevent disasters such as landslides caused by dike erosion, storm-water drainage should be constructed along the outside of northern onsite road.

In general, storm-water drainage can be divided into three types, based upon its location, that is, surrounding drainage, onsite drainage and drainage of the reclaimed area. The surrounding drainage should be installed along the outside of the onsite road. Rainwater collected by this facility should be discharged to the existing drain. Onsite drainage should be installed inside the landfill site, that is, along inside of the onsite road. The rainwater collected from the non-landfill area should be discharged outside of the enclosing bund by using these facilities. Drainage for the reclaimed area should be established after completion of the final soil covering. The rainwater collected from this facility should be discharged outside the enclosing bund. Therefore, storm-water drainage should be constructed in several ways.

2) Environmental Protection Facilities

- Liner

In order to keep proper leachate collection for smooth landfill operation, a liner should be installed at the bottom of the whole landfill area. Based on the "Basic Standard Type" concept, clay soil liner shall be selected and its thickness is 0.5 m or more.

Clay soil liner is more economical than artificial liner such as rubber, polymer sheet etc., and enough efficiency for leachate interception. It should also prevent much of the decontamination caused by pollutants contained in leachate. At the construction stage of the clay soil liner, it is important that proper material should be selected and proper soil compaction should be carried out.

- Leachate collection system

Gravity leachate collection facilities should be installed in the landfill area, for the purpose of collecting leachate and directing it to the leachate re-circulation facilities which are located at the west end of the disposal site. Given the topographical feature of Lahmidate disposal site, the flow of leachate is basically from east to west, so the leachate re-circulation facilities should be located at the west end of the site.

Based on the "Basic Standard Type" concept, leachate collection facility should be made of packed gravel, which consists of steel net. timber frame and gravel, dimensions of which are 400 mm square for main lines and 300 mm for square sub/branch lines. This facility should be arranged at the bottom of the landfill area; installation pitch of packed gravel is approx. 50 m.

- Gas removal facilities

Generally, several kinds of gas will be produced by organic substances contained in the reclaimed waste during the process of putrefaction and decomposition; these are caused by microorganisms etc. which exist in the reclaimed waste layer. Main components of the gas produced in the landfill area are methane gas, carbonic acid gas and nitrogen, which are colorless and odorless. In addition, although in small amounts, ammonia, hydrogen sulfide, methyl mercaptane, methyl sulfide etc. which are malodorous gases, are also produced. These gases cause fire and/or explosion hazards, the destruction of ecological systems, and offensive odors to surrounding areas.

For proper environmental countermeasures, gas removal facilities should thus be installed in the landfill area. Planning criteria for gas removal facilities are as follows.

Taking into consideration the following conditions, and also, based on the "Basic Standard Type" concept, gas removal facility shall be installed at several points of the site for the monitoring purpose of produced gases only.

i. No housing exists surround the site.
ii. Lower level landuse (agricultural land) is planned at the site.

A gas prevention facility should consist of steel net, timber frame and gravel, or PVC perforated pipe rounded by gravel. It should be installed in parallel with the reclamation operation.

- Leachate re-circulation facility

Since the leachate, or polluted water produced in the landfill area may be the cause of contamination to the surrounding bodies of water, it is necessary to prepare facilities to treat the leachate, as a pollution prevention measure. In the Lahmidate disposal site, based on "Basic Standard Type" concept, a leachate re-circulation system should be adopted in order to keep or eliminate the leachate inside the disposal site.

a. Amount of Leachate

No reliable data regarding the amount of leachate are available in Morocco. The leachate amount should therefore be estimated based on the monthly rainfall data shown in the following Table 7.2-5, and calculated as follows:

Table 7.2-5 Monthly Rainfall

(unit : mm)

Year/Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1993	37	31	59	19	9	0	0	0	0	121	106	7	389
1994	49	69	17	1	11	2	0	0	1	32	15	20	217
1995	0	34	42	20	0	0	0	0	3	13	32	155	299
Average	29	45	39	13	7	1	0	0	1	55	51	61	302

(Source : Department of National Meteorology, Ministry of Public Works)

$Q = 10 \times C (I - E) A$

where, Q : Leachate amount (m^3/day)
C : Seepage coefficient (set to 0.7)
I : Average rainfall (mm/day)
E : Average evaporation (mm/day)
A : Landfill operation area (12 ha)

Results of the leachate amount estimation/calculation are shown in the following Table 7.2-6.

Table 7.2-6 Leachate Amount

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ave
Rainfall (mm)	29	45	39	13	7	1	0	0	1	55	51	61	
Leachate amount (m^3/day)	65	101	87	29	16	2	0	0	2	123	114	137	56

b. Leachate re-circulation facilities

The facilities of the leachate re-circulation system are comprised of the following:

i. Leachate intake pipe
ii. Leachate storage pond
iii. Re-circulation pump

The capacity of the storage pond should be decided taking in light of seasonal variation in of rainfall amount. To be on the safe side, rainfall data for the rainy season, from November to January, should be used to design the capacity of the lagoon which should be sufficient to hold the amount of leachate produced in five days during this period.

$(114+137+65)/3$ m^3/day x 5 days = 530 m^3

- Litter Prevention Facility/Buffer Zone

The wind tends to blow from the northeast in the summer/dry season and from the southwest in the winter/rainy season, as shown in the following Table 7.2-7. A litter prevention facility should therefore be installed all around the disposal site. In order to shelter traffic on the Road Sebt Gxoula from the site, it is also recommended to install buffer trees along the southern onsite road.

Table 7.2-7 Wind Velocity and Direction in Safi

Year/Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1993	20	15	19	18	18	19	16	16	17	23	26	14
	SW	N	W	NNE	SSW	NNE	NNE	NNE	NNE	SW	SSW	NE
1994	26	23	15	19	16	35	30	18	18	15	-	-
	SW	SSW	N	NNE	NNE	NNE	ENE	NE	NNE	NNE	-	-
1995	15	20	26	18	17	15	16	17	17	22	22	26
	NNE	NNW	SW	S	NNE	N	NE	NNE	NNE	SSW	SW	SW

Remarks, Upper row : Maximum wind velocity (m/sec)
Lower row: Average wind direction
(Source : Department of National Meteorology, Ministry of Public Works)

- Rain-water channel

As described above, in Section 7.2.3, 3), a rain-water stream originates in the eastern hillside region and flows into the west through the northern part of the disposal site. Therefore, it is recommended to construct a canal for rain-water along the northern part of the onsite road in order to control and direct the stream.

By using Francou & Rodier formula, dimension of the channel is calculated that; height is 1.5 m, bottom width is 3.0 m and side wall slope is 2:3.

3) Other Facilities

The following facilities should be constructed for the proper, smooth and safe operation of the Lahmidate disposal site. The principal functions and planning conditions for each facility are as follows.

- Site office

A site office should be constructed for the administrative work of the disposal site. It is recommended that the floor area of the site office should be 50-100 m^2 and the structure RC (reinforced concrete).

- Truck-scale

Installation of a truck-scale is the first and basic requirement for Solid Waste Management (SWM). This facility is to ensure that the landfill waste meets the requirement stipulated. The amount of hauled-in waste is also measured and recorded by this facility.

All hauled-in waste should be weighed by using a truck-scale so as to obtain several important data for SWM. The truck scale should be installed in a strategic position in the disposal site where the collection vehicles will pass through whenever entering and leaving the site. The entrance point of the site is recommended for the location of the truck-scale. Meanwhile, to secure access for other vehicles; such as site construction, site patrol, visitors vehicle, etc., an access road should also be built next to the truck-scale.

Waste type and quality should also be checked periodically. By understanding the type/quality of landfill waste, the type of gas production, leachate quality, and subsidence of waste, etc. can be predicted, so these data are very important for ultimate land-use planning of the site as well as for future disposal site planning. Meanwhile, if toxic substances are contained in landfill waste, they will cause environmental pollution. Therefore, hauled-in waste should be checked periodically. A waste sampling facility should thus be installed.

Data which should be collected and analyzed regularly by using a truck-scale are shown in the following Table 7.2-8. Analyzed data should be reported on daily, weekly, monthly and yearly, as required. These data are essential for the following control items of SWM:

i. Understanding the amount of waste disposed of should be the basic factor for future disposal site planning
ii. Understanding the type and quality of waste provides basic data for the ultimate land-use plan for the site
iii. Understanding the working time and the waste collected by each vehicle/truck, are necessary for planning effective collection routes and methods
iv. Checking hauled-in waste amounts are the basic data for collection of tipping fees

Table 7.2-8 Input Data of Truck Scale (example)

	Outgoing Vehicle		Incoming Vehicle
(1)	Date	(1)	Contractor's Name
(2)	Contractor's Name	(2)	Vehicle Registration Number
(3)	Vehicle Registration Number	(3)	Driver's Name
(4)	Driver's Name	(4)	Waste Type
(5)	Waste Type	(5)	Entry Time
(6)	Collection Route	(6)	Gross Load (kg)
(7)	Departure Time	(7)	Unloaded Weight (kg)
(8)	Gross Load (kg)	(8)	Net Load (kg)
(9)	Unloaded Weight (kg)		
(10)	Net Load (kg)		

The landfilled waste volume, waste type/quality, hauled-in place and time for each type of waste, etc. should be reported with above mentioned monthly report. These data are recommended to be prepared by using a plan and section drawing of disposal site.

The specifications of the truck-scale are as follows.

i. Weighing capacity : 30 ton / unit
ii. Load-cell type and four-point support system
iii. Automatic digital counter
iv. Control post with card reader
v. Connected with computer and printer to input and analyze the data

- Washing facility

For the purpose of washing and cleaning landfill equipment and/or collection vehicles periodically, a washing facility should be installed at the administration area of the site. The facilities should contain a high pressure spray, pump etc.

- Fences and gates

To prevent the scattering of waste and free access by scavengers, suspicious persons and animals, an enclosing fence should be installed surrounding the disposal site.

- Lighting facilities

For safe night-time operation, lighting facilities should be installed at appropriate places in the landfill area.

- Water supply

Water supply should be provided at the site, in order to maintain sanitary and healthy working conditions for personnel stationed at the site, as well as for landfill equipment maintenance and washing.

7.2.5 Operation Plan

1) Landfill Operation Plan

Solid waste should be sufficiently spread and compacted when landfilling, so as to stabilize the landfill area and to prolong the lifetime of the disposal site. On the other hand, cover soil should be placed systematically and periodicaily after landfilling of each waste cell and/or waste layer, in order to prevent/minimize environmental impacts on the surrounding areas and living environment.

a. Basic Concept of Landfill Operation

The basic concepts of landfill operation are as follows.

i. Solid waste should be spread and compacted sufficiently
ii. Scattering of solid waste should be minimized
iii. Diffusion of offensive odor should be minimized
iv. Breeding of vectors and insects should be minimized
v. Self-burning of the waste should be minimized
vi. Waste stabilization should be achieved as early as possible

b) Landfill Method

In order to achieve sufficient spreading and compaction of the waste, the "cell method" by adopting "waste push up method" should be adopted for landfill operation.

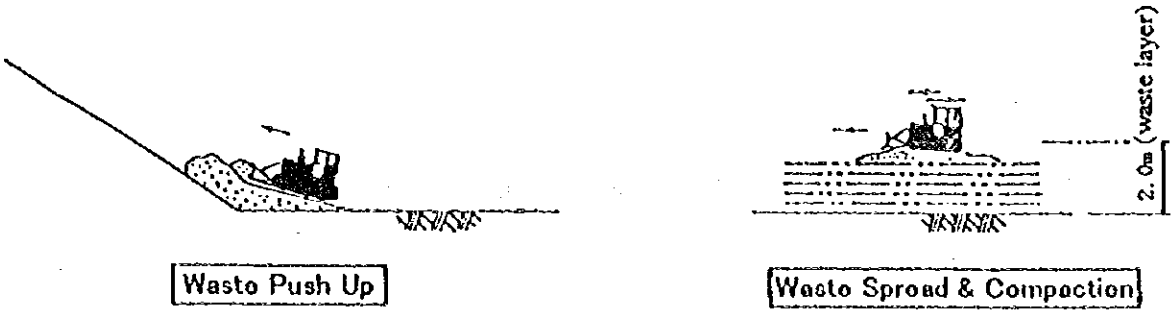
The cell method requires that waste cells topped with a layer of cover soil should be created, where the size of each cell basically consists of one day's amount of waste. Since each cell is implemented independently the applied cover soil can prevent scattering of solid waste, emission of bad odor, breeding of harmful vectors, and self burning of the waste.

The push up method requires that when creating the waste cell, hauled waste should be pushed up from low to high areas and spread/compacted by using landfill equipment such as a bulldozer or wheel-loader. As a result, sufficient compacted waste cell/layer can be created and landfill stabilization will be accomplished quickly.

The following items should be taken into consideration for waste spreading and compaction work;

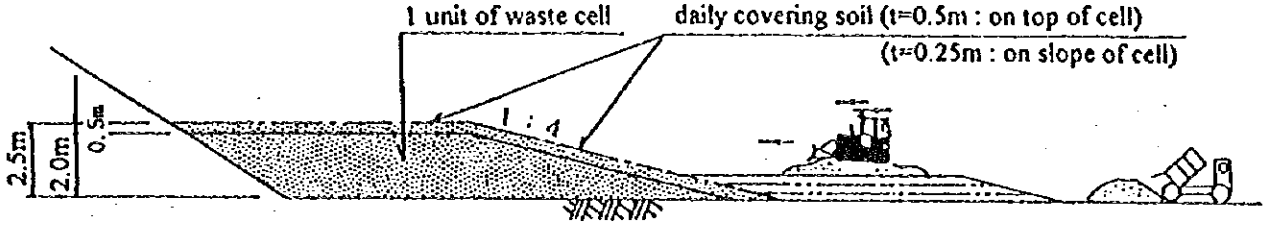
i. Waste spreading should not be too thick. Normal waste thickness of one time spreading is about 30 to 50 cm.
ii. Landfill cells and/or layers should be made as uniform as possible by the push up method. Gradient of the waste slope should be 4:1 or less, to ensure effectiveness of landfill equipment.
iii. The height of each waste cell and/or layer should be approximately 2 m. When the site is planned to be used as early as possible after completion of landfilling, or when technically advanced usage of the completed landfill site is considered, the waste cell/layer should be less than 2 m in height.

A conceptual drawing of landfill operation is shown in Fig. 7.2-7, and detailed operating procedures for landfilling are shown in Fig. 7.2-8(1/3), (2/3) & (3/3).

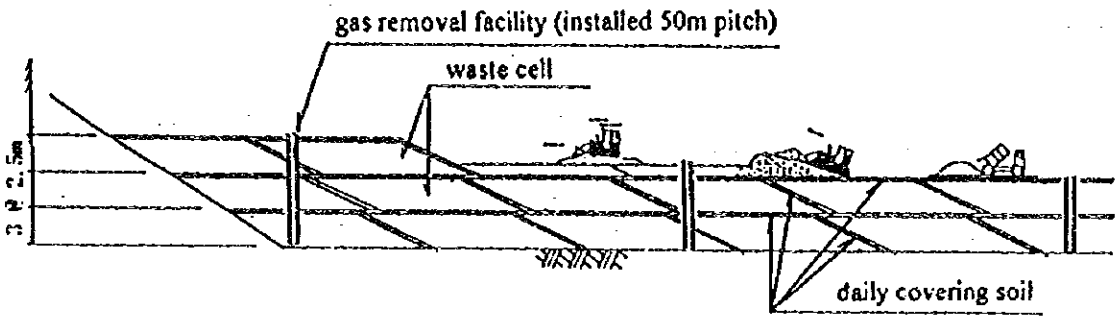


Waste Push Up

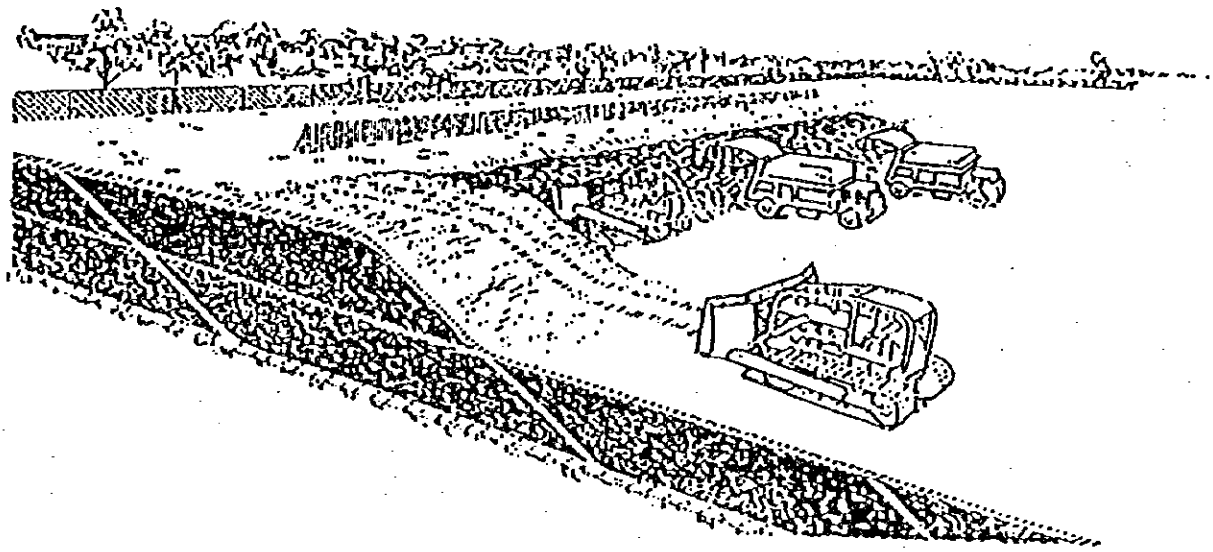
Waste Spread & Compaction



Cell & Cover Soil



Cell Method Operation - (1/2)



Cell Method Operation - (2/2)

FIG. 7.2-7 Conceptual Drawing of Landfill Operation (Cell Method)

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c. Cover Soil

Together with the landfill operation by the push up method and cell method, cover soil, which consists of daily covering and final covering, should be carried out at proper times. The main purposes and thickness of each type of cover soil are shown in the following Table 7.2-9.

Table 7.2-9 Cover Soil Classification

Type of cover soil	Main purposes	Thickness
Daily covering	Prevent scattering of waste Prevent diffusion of offensive odor Prevent breeding of harmful vectors Prevent self-burning of waste Reduction of leachate amount Secure trafficability of landfill equipment & collection vehicles	50 cm (top of waste cell) 25 cm (slope of waste cell)
Final covering	Ultimate land use Landscaping Minimize the leachate amount Environmental prevention measures	50 cm (total 100 cm)

The volume of cover soil required for landfill operation of the Lahmidate disposal site (Zone I) is 339,000 m³. During the construction stage of this site, 804,000 m^3 of surplus soil will be generated, and approx. 20,000 m^3 of it will be used as material for site construction, such as the onsite road, operation road, etc. Therefore, all of the cover soil required for the landfill operation will be obtained from surplus soil generated during the site construction work.

2) Landfill Equipment Plan

The landfill equipment listed in the following Table 7.2-10 should be prepared for the purpose of waste landfilling, soil covering, and maintenance of site facilities such as the enclosing dike, operational road, etc.

Table 7.2-10 Landfill Equipment

No	Equipment	Specification	Landfilling works etc.	Number
1	Bulldozer	200HP, blade (w/trash rack):10m^3	waste push-up, spread & compaction	1
2	Excavator	130HP, bucket:0.8m^3	excavation of covering soil	1
3	Wheel loader	150HP, bucket:2.0m^3	loading cover soil on to dump trucks	1
4	Dump truck	10m^3	covering soil transport	1
5	Tank truck	6,000litre	sprinkle with water	1
6	Pick up	2,500cc	site inspection, worker transport	2

3) Personnel Plan

The disposal site should be managed and/or operated by the administrative, technical and operational personnel, as shown in the following Table 7.2-11. Total manpower of Lahmidate disposal site will be 15 persons in the year 2005.

Table 7.2-11 Personnel Plan

	Personnel	Number of personnel
1	Site manager	1
2	Civil engineer/supervisor	1
3	Administrative staff	1
4	Truck-scale operator	1
4	Landfill equipment operator/driver	5
5	Worker/watchman	3
	Total	12

4) Scavenging Activities

In principal, scavenging activity shall not be allowed at Lahmidate disposal site, because of its sanitary conditions. However, in consideration of present social/economical conditions of Safi, it cannot help accepting scavengers at the site for the next certain period as recycling purpose. The following manner is recommended for temporary scavenging activity at the site controlled by Safi Urban Community.

i. Waste hauling area and scavenging activity area shall be divided daily and cover soil shall be carried out after completion of scavenging activity.
ii. Scavenging activity shall be contractig-out to contractors. Each scavenger shall be registered.
iii. Introduction of measurement system of valuable materials collected by scavangers, at the site.

7.2.6 Ultimate Land-use Plan

1) Basic Conditions for Ultimate Land-use

Generally, at the landfill site, the following phenomena will be observed continuously for a long period even after completion of reclamation.

i. Land subsidence (approx. 5 years after landfill completion)
ii. Production of gas (over 15 years after landfill completion)
iii. Production of leachate

The above phenomena can sometimes be a hindrance to ultimate land-use. Therefore, the following facilities should be installed and operated in the landfill area from the beginning of the landfill. Also, these facilities can help to accelerate stabilization of the site conditions. Monitoring of the stability of the ground, the generated amount of gas and water, and quality of the leachate should be carried out continuously until the site conditions are properly stabilized for the planned ultimate land-use. The facilities are:

i. Drainage facilities for rainwater
ii. Gas removal facilities
iii. Leachate re-circulation facilities

2) Ultimate land-use plan

Generally, in the early period after completion of the landfill, the land occupied by the disposal site is suitable as farmland, or as a park, athletic field, play ground, golf links, car parking, and so on. After a longer period, the site can be used for a school, office, housing complex and so on.

In consideration of its value to the surrounding residents, harmony with the existing landscape and financial aspect of Safi city, it is recommended that the ultimate land-use for the Lahmidate disposal site should be as farmland for several kinds of crops.

7.3 Improvement Plan for Existing Municipal Disposal Site

7.3.1 Basic Principles

The basic principles for improvement of existing municipal disposal sites have been developed as follows.

i. The existing disposal site should be improved in light of the general need to improve current poor environmental conditions.

ii. Existing wastes, accumulated outside the municipal disposal site boundary, should be conveyed to the newly improved existing disposal site.

7.3.2 Planning Conditions

Key aspects of the improvement plan for the existing municipal disposal site are as follows;

- Site area : 11.34 hectare
- Landfill height : 11m (3 waste layers including cover soil)
- Landfill capacity : 477,100 ton of waste (= 632,000 m^3)
- Daily waste amount : 141 ton/day in year 2000
- Period of use : 1998 - 2000 (two years)
- Landfill method : Controlled landfill

The site plan and sectional elevation are shown in Fig. 7.3-1 and Fig. 7.3-2, respectively.

Necessary measures for improving the existing municipal disposal site are described in the following Sections.

1) Environmental Protection Measures

- Cover soil

Covering soil should be carried out periodically, at least twice a week, in order to prevent the scattering of waste, diffusion of offensive odor, breeding of vectors & insects and self-burning of waste.

- Enclosing fence and buffer zone

To prevent the scattering of waste and free access by scavengers, suspicious persons and animals, an enclosing fence should be installed all around the disposal site. Meanwhile, it is recommended to install buffer trees along the northern onsite road, in order to prevent the site from being seen from the Sebt Gxoula Road. Fig. 7.3-3 shows conceptual section of buffer zone.

- Stripping top layer and earth compaction

The groundwater level is very deep, at approx. 50 m. Accordingly, it is estimated that leachate will be adequately decontaminated during its infiltration process. In general, the leachate produced from the waste which has been deposited a long time ago has not indicated much BOD, COD, etc. (Approx. 60% of the waste expected to be hauled to the improved municipal disposal site is old waste which has accumulated outside the existing site.) Therefore, the contamination of underground water by the leachate is expected to be very low.

However, to be on the safe side, it is recommended to strip the top layer of the site, and compact it, in order to achieve lower permeability of the surface of the disposal site.

- Designated blocks for each type of waste

Designated blocks for each type of waste should be installed at landfill area. Basically, industrial waste (which may include toxic substances) should be treated and disposed of under the producer's own responsibility. But, in light of existing conditions in Safi, this is not realistic at the moment. Therefore, it is necessary to dispose of industrial waste at the municipal disposal site for the time being. Regarding hospital waste, the same issue can be defined. From this point of view, and taking into consideration environmental protection measures, such as dangerous contact with potential hazardous wastes by operators and scavengers, industrial waste, hospital waste and municipal waste must be disposed of separately at designated blocks in the landfill area.

2) Site Facility

- Access road, on-site roads and operational roads

The access road and on-site roads should be wide enough and asphalt paved for easy access of collection vehicles. Meanwhile, operational roads should be constructed in consideration of efficient operation of the landfill, and it is recommended that it should be paved by gravel. Clouds of sand dust can be reduced by road paving.

- Storm-water drainage

To prevent rainwater flowing into the landfill area, and thus to reduce the amount of leachate, storm-water drainage should be constructed along the access road and on-site roads.

3) Others

- Conveying the existing accumulated waste

Wastes which have been accumulated outside the existing disposal site, the total volume of which had been estimated at approx. 390,000 m^3, must be conveyed to the improved municipal disposal site, in order not to disturb private land surrounding the site.

Existing conditions of accumulated waste at the disposal site are shown in Fig. 7.3-4.

The period for required conveying existing accumulated waste to improved municipal disposal site, assuming the use of four units of 10 m^3 dump trucks, is estimated at about 2.0 years, as shown in the following:

4 units x 10 m^3 x 16 trips/unit/8hours x 1 shift/day x 300 days = 192,000 m^3
390,000 m^3 / 192,000 m^3 = approx. 2.0 year

Required heavy equipment for the above described waste-conveying work is shown in the following Table 7.3-1.

Table 7.3-1 Required Heavy Equipment

No	Equipment	Specification	Works	Units
1	Wheel loader	150HP, bucket:2.0m^3 (work cap. 87m^3/hr)	loading accumulated waste to dump trucks	1
2	Dump truck	10m^3	waste transport to improved site	4
3	Bulldozer	200HP	waste push-up and compaction	1

7.4 Estimated Cost

Estimated costs of construction, procurement and operation and maintenance costs for the existing municipal disposal site improvement and Lahmidate new disposal site are as follows, and details are described in Table 7.4-1 and Table 7.4-2, respectively.

i. Improvement of existing municipal disposal site

a. Site construction : DH 4.9 millions
b. Unit disposal cost : DH 18.4 /ton

ii. Lahmidate new disposal site

a) Construction and procurement

a. Site construction :	DH 33.9 millions
b. Procurement of equipment :	DH 8.5 millions
c. Total (a+b) :	DH 42.4 millions

b) Land purchase : DH 1.5 millions

c) Annual operation and maintenance

a. Salary of personnel :	DH 409 thousand/year
b. Fuels :	DH 281 thousand/year
c. Maintenance of equipment :	DH 351 thousand/year
d. Indirect and miscellaneous costs :	DH 104 thousand/year
e. Total (a+b+c+d) :	DH 1,145 thousand/year

d) Annualized costs including depreciation

a. Annual depreciation of construction :	DH 2.9 million/year
b. Annual depreciation of equipment purchase :	DH 1.2 million/year
c. Annual operation & maintenance :	DH 1.1 million/year
d. Total (a+b+c) :	DH 5.2 million/year

e) Unit disposal cost

a. Construction :	DH 42.9/ton
b. Procurement :	DH 17.3/ton
c. Operation & maintenance :	DH 17.0/ton
d. Land purchase :	DH 1.8/ton
e. Total (a+b+c+d) :	DH 79.0/ton

Investment, operation and maintenance costs are estimated based on the following assumptions:

1) Investment cost

i. Price level is that of November 1996.
ii. Annualized capital cost is the construction cost divided by the life-time of the disposal site which is 3.0 years for the improved municipal disposal site and 11.7 years for the Lahmidate disposal site Zone-I.
iii. Land acquisition cost is based on counterpart/site hearing information
iv. Depreciation cost: 7 years for bulldozers, excavators and wheel loaders, and 8 years for dump trucks, tank trucks and pick ups were used.
v. Cost per ton is calculated as total cost divided by waste capacity of the disposal sites, which is 760,500ton for the improved municipal disposal site and 790,000ton for the Lahmidate disposal site Zone-I.

2) Operation and maintenance cost

i. Annual equipment maintenance cost is 30% of depreciation cost.
ii. Indirect cost is 10% of {personnel salary + fuel cost + equipment maintenance cost}
iii. Cost per ton is calculated in the same manner as that for investment cost.
iv. Site operation consists of one shift per day and 313 days per year.

Table 7.4-1 Investment and O/M Cost of Improved Municipal Disposal Site

(Unit : DH)

Items	Unit	Quantity	Unit Price	Cost
1 Construction Cost				
1-1 Main Facilities				
a. Access/Onsite road :with dike	m	630	1,200	756,000
- ditto - :without dike	m	545	500	272,500
b. Operational road	m	605	500	302,500
c. Storm water drainage :U-gutter	m	850	400	340,000
- ditto - :open cut	m	325	80	26,000
1-2 Environmental Protection Facilities				
a. Site area : stripping/compaction	ha	9.5	80,000	760,000
: earth cut	m^3	137,000	14	1,918,000
b. Litter prev. facilities/Buffer zone	m	460	450	207,000
: fence (only)	m	800	200	160,000
1-3 Other Related Facilities				
a. Site office	m^2	30	2,000	60,000
f. Surrounding works	LS	1	50,000	50,000
Sub-Total				4,852,000
Annualized Capital Cost (1)				1,617,333
Cost per Ton (DH/ton)				6.4
2 Equipment Procurement Cost				
- Bull dozer	nos	1	2,300,000	2,300,000
- Excavator	nos	1	1,700,000	1,700,000
- Wheel loader	nos	0	2,000,000	0
- Dump truck	nos	1	700,000	700,000
Sub-Total		3		4,700,000
Depreciation (2)				658,929
Cost per Ton (DH/ton)				2.6
3 Operation and Maintenance Cost				
3-1 Operation				
a. Personnel				
- Site manager/Civil engineer	psn	1	54,000	54,000
- Administrative staff	psn	1	36,000	36,000
- Landfill equipment operator/driver	psn	8	26,400	211,200
- Worker/watchman	psn	4	22,800	91,200
3-2 Utilities				
a. Fuel				
- Bull dozer	nos	2	100,160	200,320
- Excavator	nos	1	100,160	100,160
- Wheel loader	nos	1	100,160	100,160
- Dump truck	nos	4	30,048	120,192
3-3 Equipment rental cost				
- Bull dozer	nos	1	394,286	394,286
- Excavator	nos	0	291,429	0
- Wheel loader	nos	1	342,857	342,857
- Dump truck	nos	3	105,000	315,000
Sub-Total (3)				1,965,375
Annual Equip. Maintenance Cost (4)=(2)x30%				196,138
Indirect Cost (5)=(3+4)x10%				216,151
Sub-Total (6)=(3+4+5)				2,377,665
Cost per Ton (DH/ton)				9.4
Total / Annual Cost (1+2+6)				4,653,926
Cost per Ton (DH/ton)				18.4

Table 7.4-2 Investment and O/M Cost of Lahmidate Disposal Site (Zone-I)

(Unit : DH)

Items	Unit	Quantity	Unit Price	Cost
1 Construction Cost				
1-1 Main Facilities				
a. Access road	m	1,050	3,400	3,570,000
b. Onsite road :with dike	m	530	2,400	1,272,000
- ditto - :without dike	m	1,020	1,800	1,836,000
c. Operational road	m	1,080	800	864,000
d. Storm water drainage :U-gutter	m	1,550	600	930,000
- ditto - :open cut	m	2,160	100	216,000
1-2 Environmental Protection Facilities				
a. Site area : site levelling/compaction	ha	15	100,000	1,500,000
: earth cut	m^3	804,000	14	11,256,000
b. Liner : clay soil (t=0.5m)	m^2	126,500	70	8,855,000
c. Leachate collection facilities :300 sq.	m	1,700	100	170,000
- ditto - :400 sq. packed gravel	m	980	150	147,000
d. Gas removal facilities	m	750	250	187,500
e. Leachate re-circulation facilities	LS	1	550,000	550,000
f. Litter prev. facilities/Buffer zone	m	650	500	325,000
: fence (only)	m	1,020	300	306,000
1-3 Other Related Facilities				
a. Site office	m^2	60	5,000	300,000
b. Truck scale	unit	1	850,000	850,000
c. Washing facilities	LS	1	100,000	100,000
d. Lighting facilities	nos	14	7,000	98,000
e. Water supply	LS	1	250,000	250,000
f. Surrounding works	LS	1	200,000	200,000
g. Rain-water channel	m	500	150	75,000
Sub-Total				33,857,500
Annualized Capital Cost (1)				2,893,803
Cost per Ton (DH/ton)				42.9
2 Equipment Procurement Cost				
- Bull dozer	nos	1	2,300,000	2,300,000
- Excavator	nos	1	1,700,000	1,700,000
- Wheel loader	nos	1	2,000,000	2,000,000
- Dump truck	nos	1	700,000	700,000
- Tank truck	nos	1	800,000	800,000
- Pick up	nos	2	500,000	1,000,000
Sub-Total		7		8,500,000
Depreciation (2)				1,169,643
Cost per Ton (DH/ton)				17.3
3 Operation and Maintenance Cost				
3-1 Operation				
a. Personnel				
- Site manager	psn	1	60,000	60,000
- Civil engineer	psn	1	54,000	54,000
- Administrative staff	psn	1	36,000	36,000
- Truck scale operator	psn	1	36,000	36,000
- Landfill equipment operator/driver	psn	5	26,400	132,000
- Worker/watchman	psn	4	22,800	91,200
3-2 Utilities				
a. Fuel				
- Bull dozer	nos	1	100,160	100,160
- Excavator	nos	1	62,600	62,600
- Wheel loader	nos	1	62,600	62,600
- Dump truck	nos	1	18,780	18,780
- Tank truck	nos	1	14,085	14,085
- Pick up	nos	2	11,268	22,536
Sub-Total (3)				689,961
Annual Equip. Maintenance Cost (4)=(2)x30%				350,893
Indirect Cost (5)=(3+4)x10%				104,085
Sub-Total (6)=(3+4+5)				1,144,939
Cost per Ton (DH/ton)				17.0
Total / Annual Cost (1+2+6)				5,208,386
Cost per Ton (DH/ton)				77.1
4 Land Aquisition Cost (annual)	ha	15	100,000	128,205
G. Total / Annual Cost				5,336,591
Cost per Ton (DH/ton)				79.0

7.5 Implementation Schedule

Implementation schedule for the disposal sites is comprised of the following two components.

i. Improved municipal disposal site
   - Construction of improved municipal disposal site
   - Procurement of landfill equipment

ii. Lahmidate disposal site
   - Construction of Lahmidate disposal site
   - Procurement of landfill equipment

Implementation schedules for disposal site construction and equipment procurement are shown in Table 7.5-1.

Table 7.5-1 Implementation Schedule of Disposal Site

		1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
1. Site Construction and Operation															
- Operation of Existing Municipal Disposal Site															
a. Construction of Improved Municipal Disposal Site															
- Operation of Improved Municipal Disposal Site															
b. Construction of Lahmidate Disposal Site (Zone-I)															
- Detailed Design and Tendering															
- Site Construction															
- Operation of Lahmidate Disposal Site (Zone-I)															
2. Procurement of Equipment															
a. Bull dozer	200 HP, blade:10m^3 w/trush rack	1							1						
b. Excavator	130 HP, bucket: 0.8m^3	1							1						
c. Wheel loader	150 HP, bucket: 2.0 m3	1							1						
d. Dump truck	10 m^3	4								1					
e. Tank truck	6,000 litter			1								1			
f. Pick up	2,500 cc			2								2			

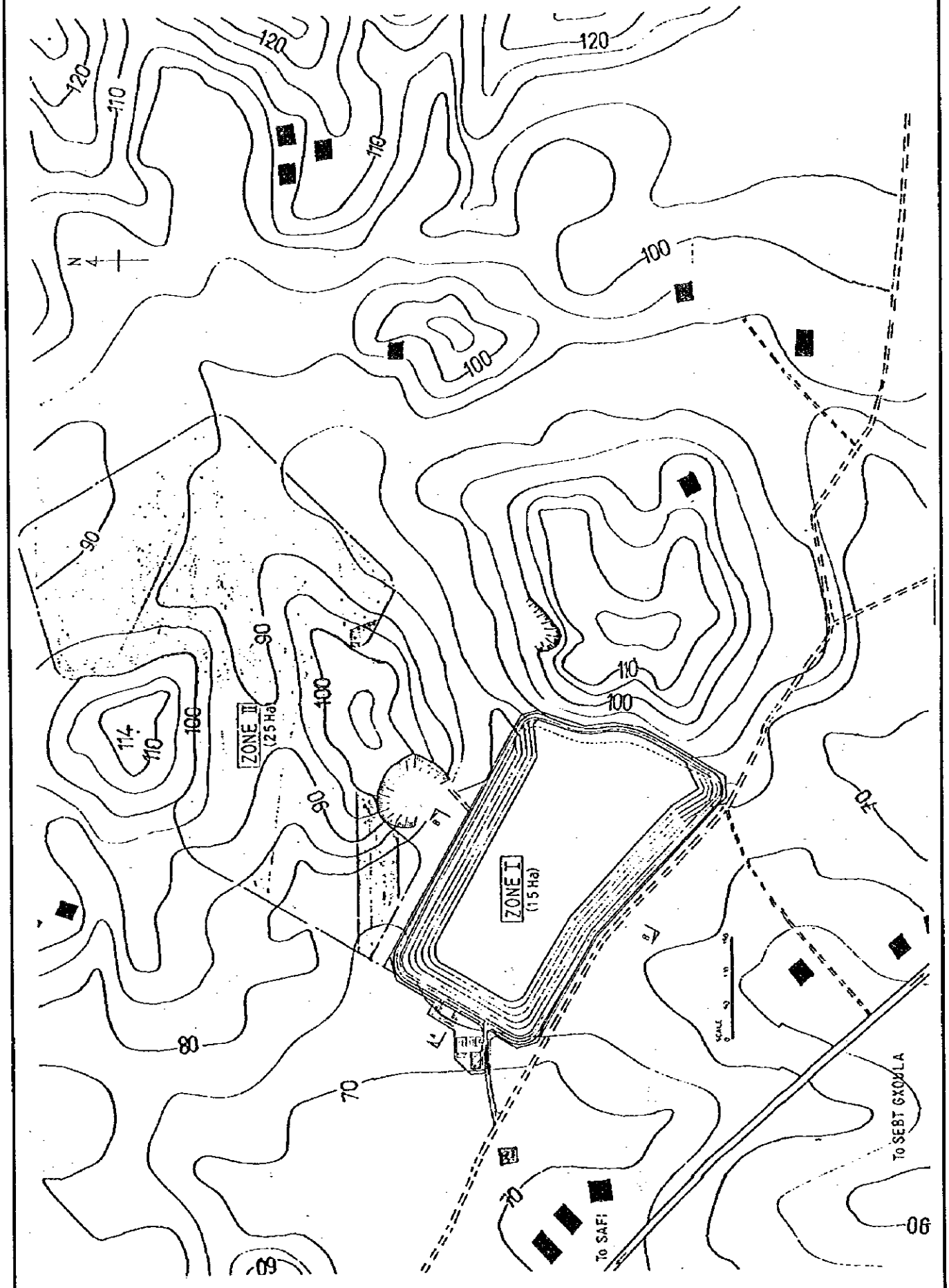


FIG. 7.2-3 **Layout Plan of Lahmidate Disposal Site**

THE STUDY ON THE NATIONAL GUIDELINES FOR SOLID WASTE MANAGEMENT
FOR THE KINGDOM OF MOROCCO

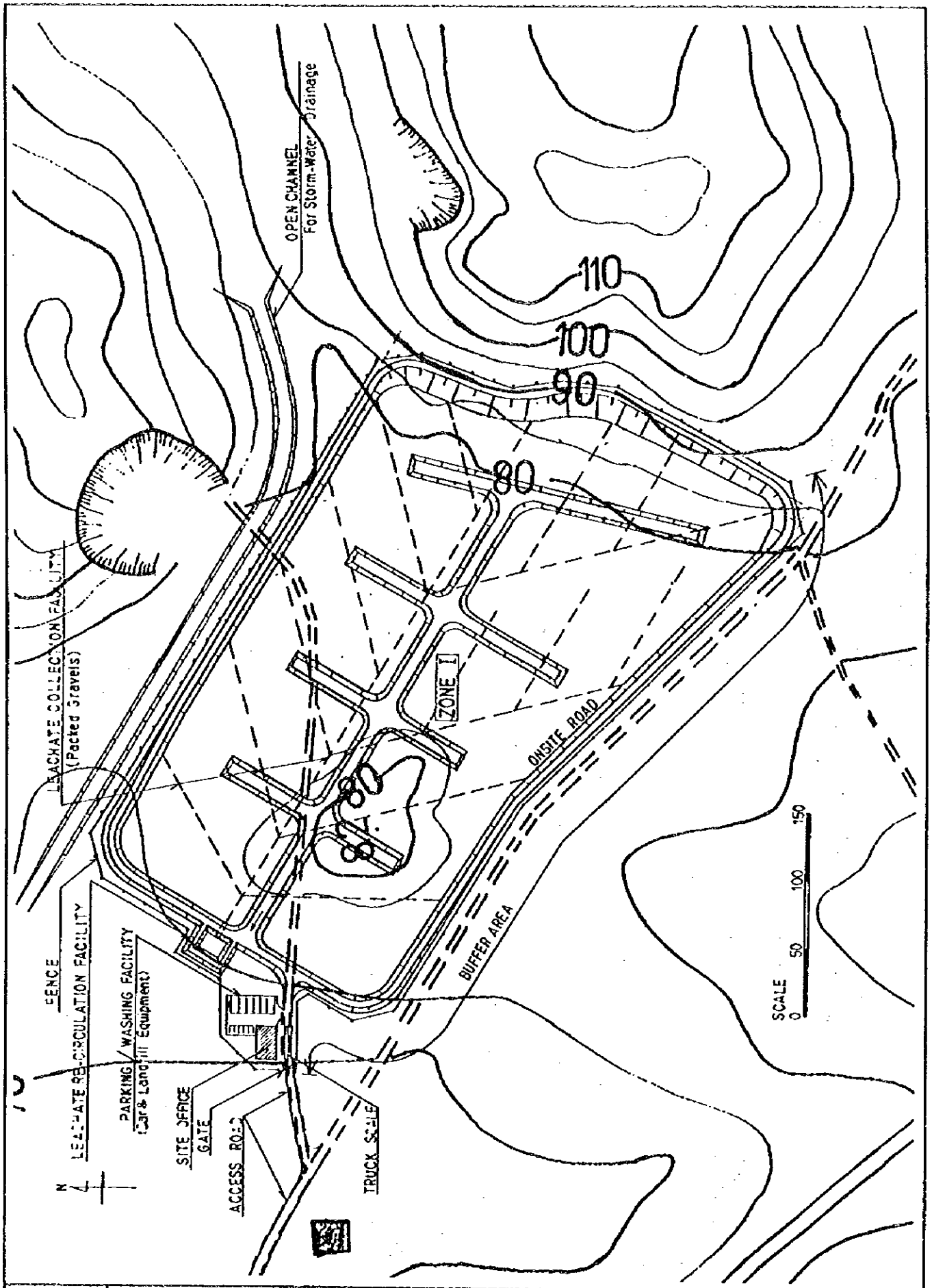
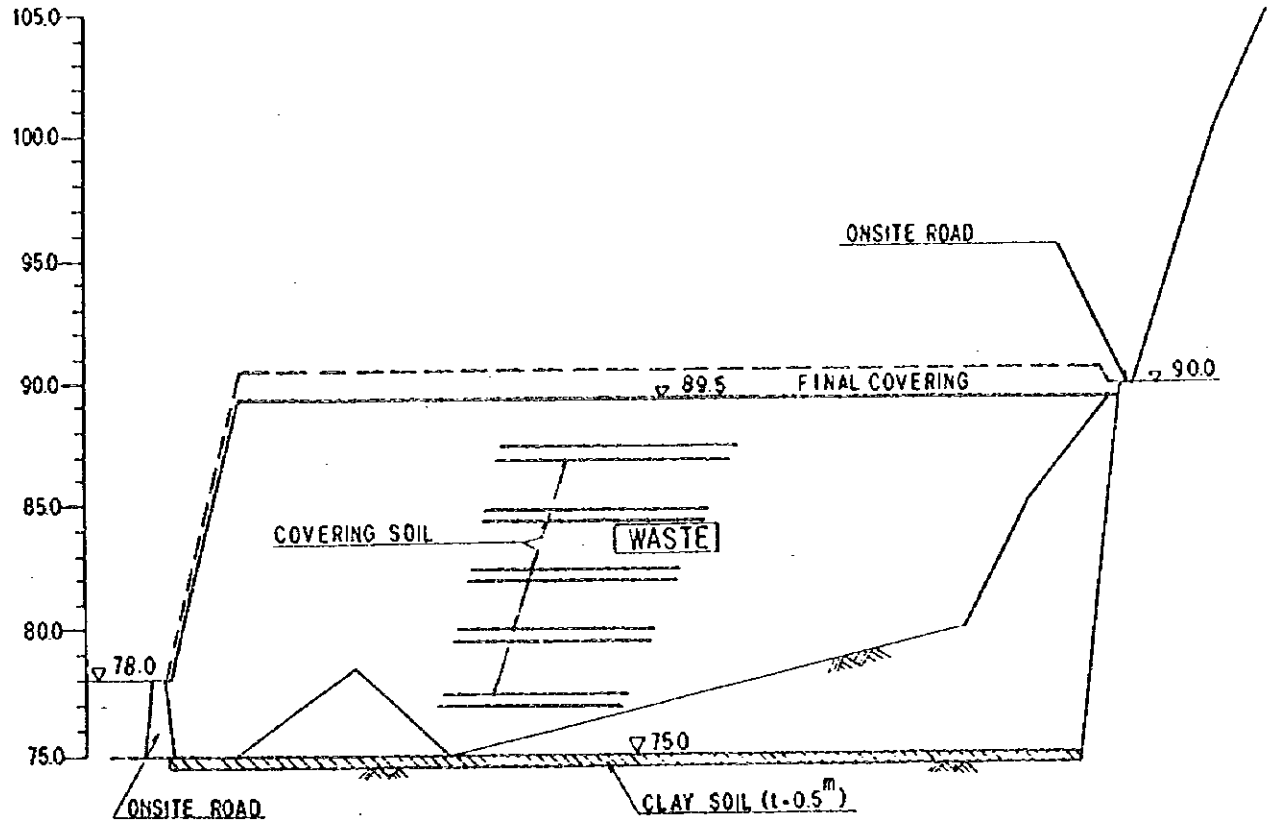
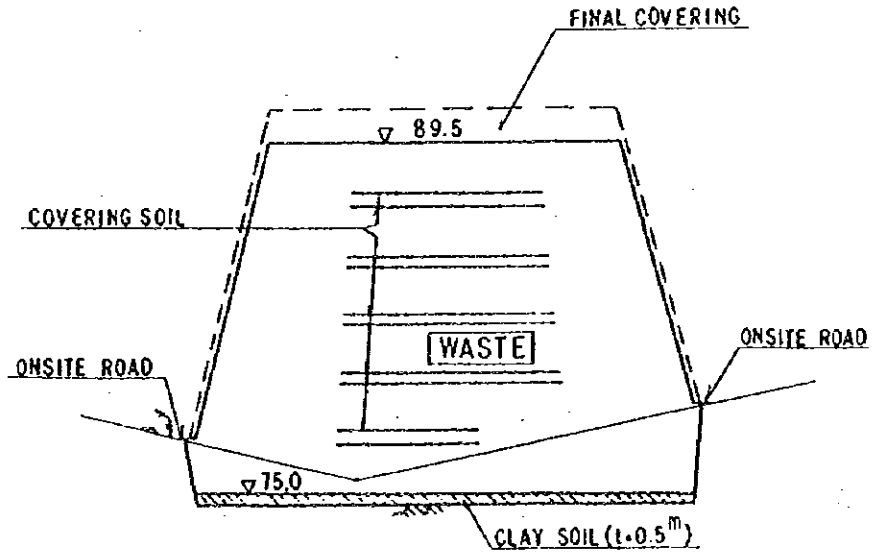


FIG. 7.2-4 Facility Plan of Lahmidate Disposal Site (Zone I)

THE STUDY ON THE NATIONAL GUIDELINES FOR SOLID WASTE MANAGEMENT FOR THE KINGDOM OF MOROCCO



SECTION A - A



SECTION B - B

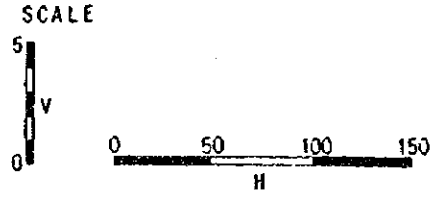
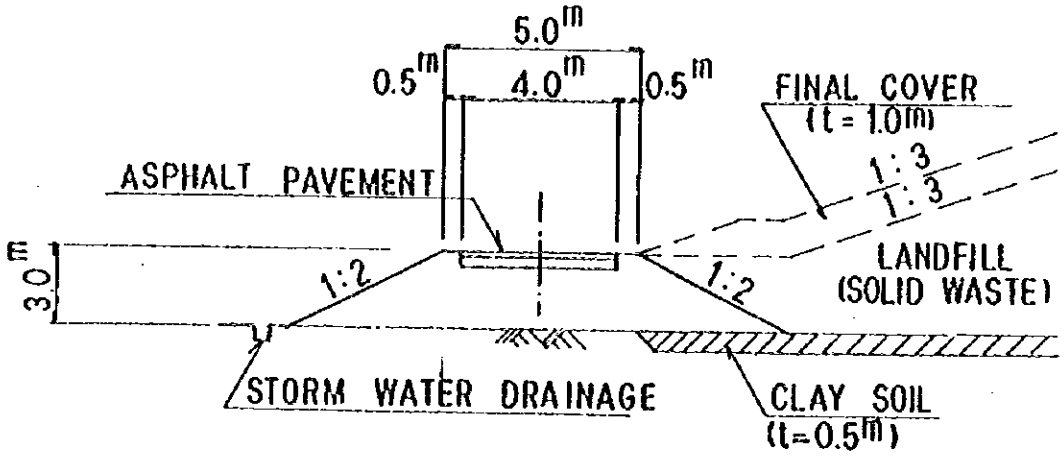
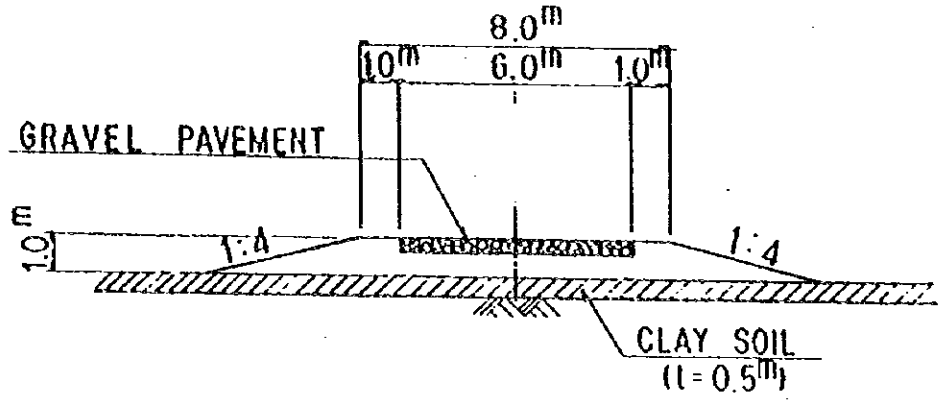


FIG. 7.2-5 Sectional Elevation of Lahmidate Disposal Site (Zone I)

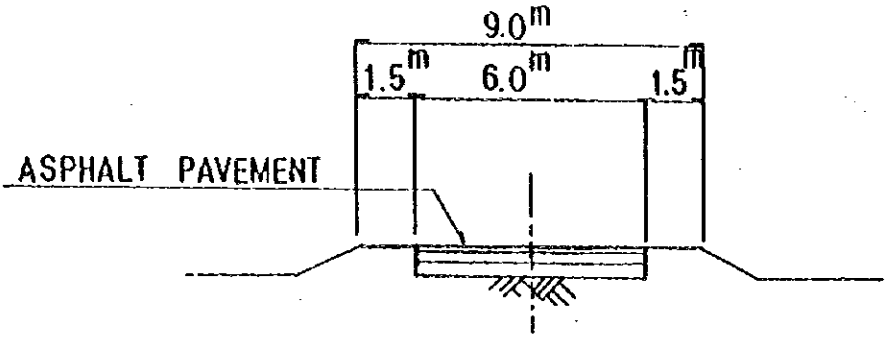
THE STUDY ON THE NATIONAL GUIDELINES FOR SOLID WASTE MANAGEMENT FOR THE KINGDOM OF MOROCCO



ONSITE ROAD



OPERATION ROAD



ACCESS ROAD

FIG. 7.2-6 Typical Facilities of Lahmidate Disposal Site (1/2)

THE STUDY ON THE NATIONAL GUIDELINES FOR SOLID WASTE MANAGEMENT FOR THE KINGDOM OF MOROCCO

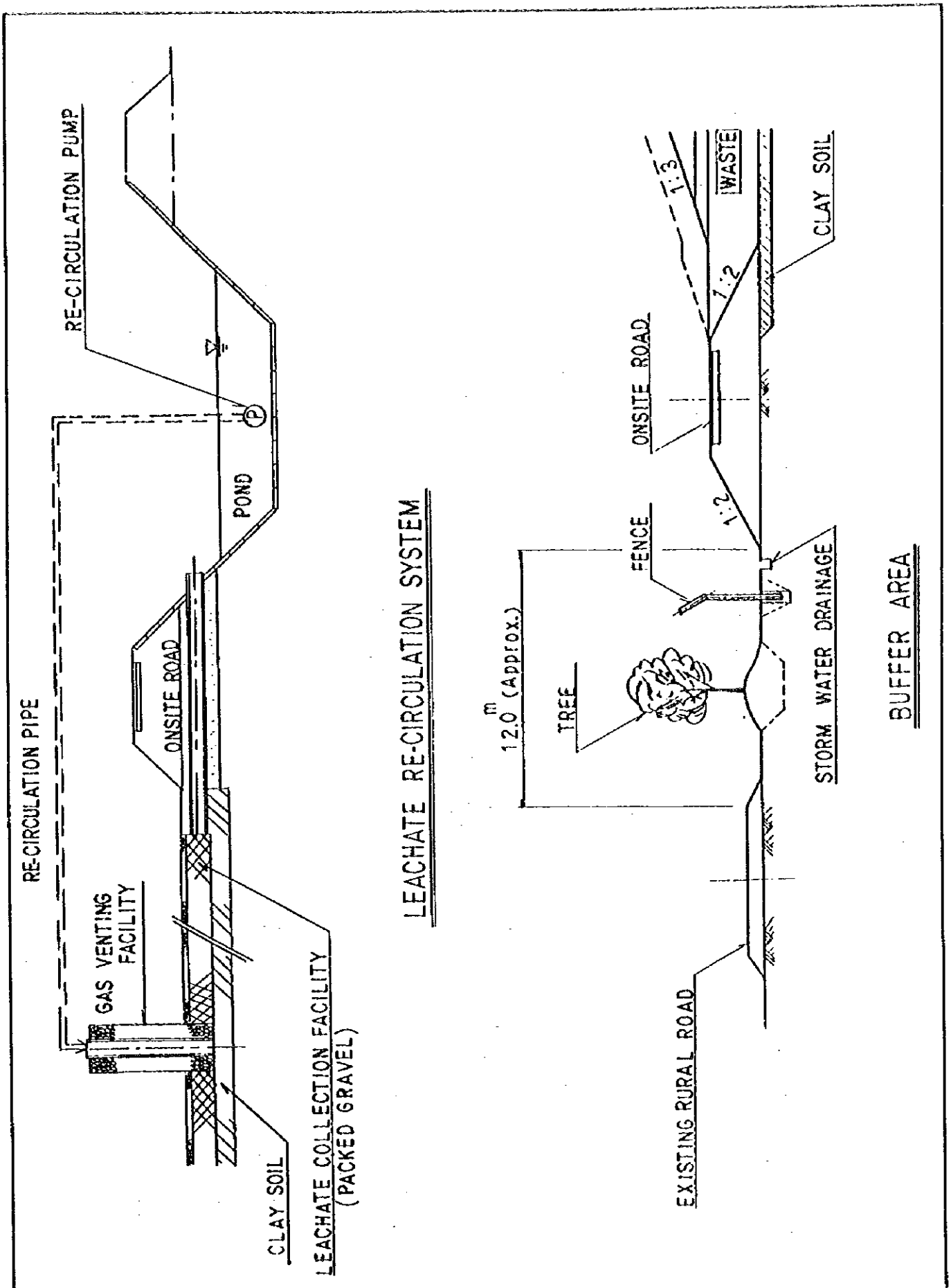
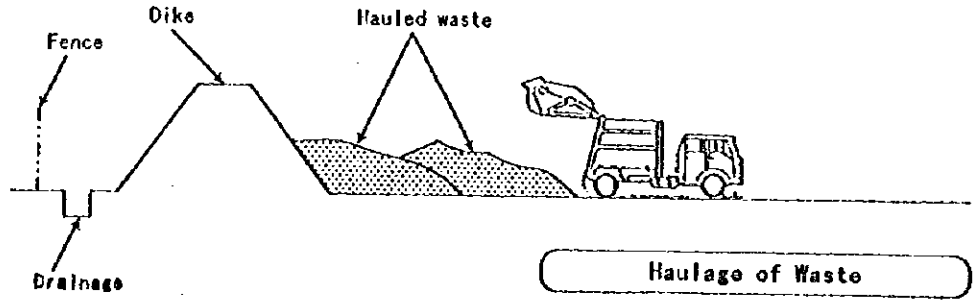
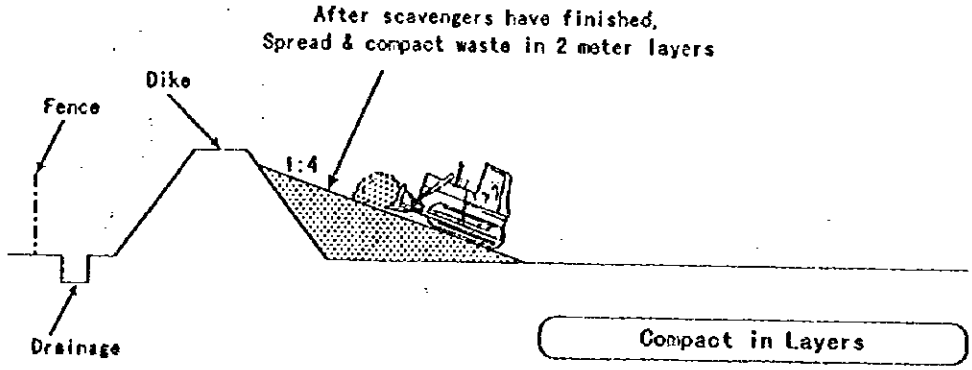
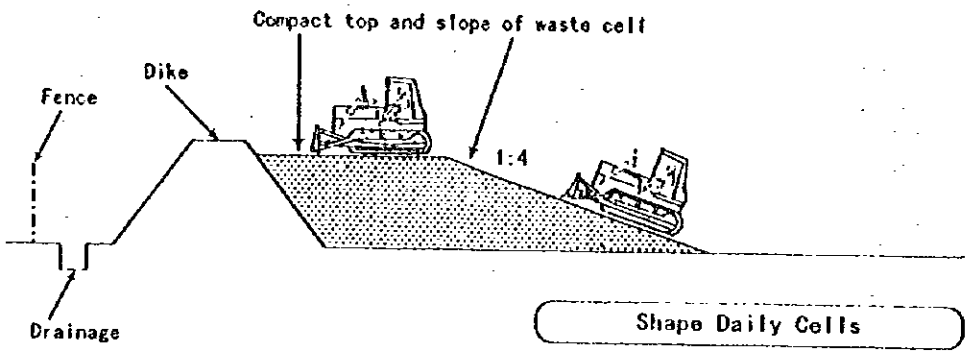


FIG. 7.2-6 Typical Facilities of Lahmidate Disposal Site (2/2)

THE STUDY ON THE NATIONAL GUIDELINES FOR SOLID WASTE MANAGEMENT FOR THE KINGDOM OF MOROCCO







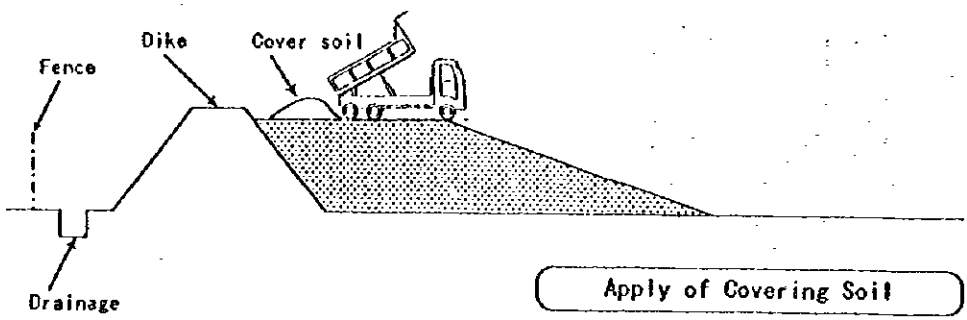
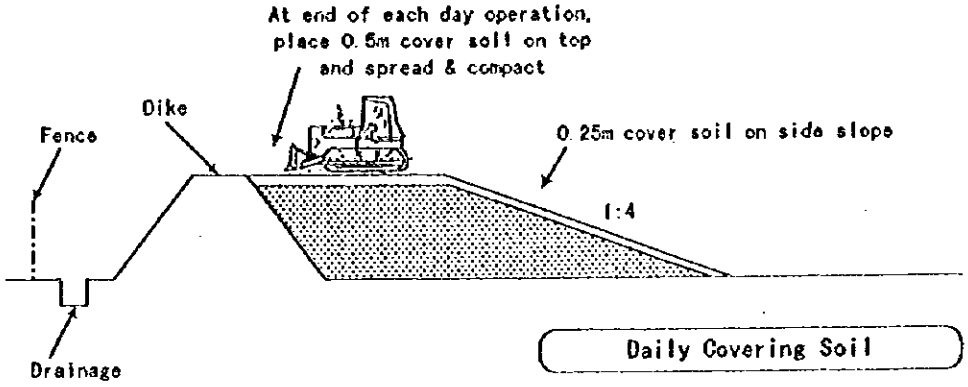
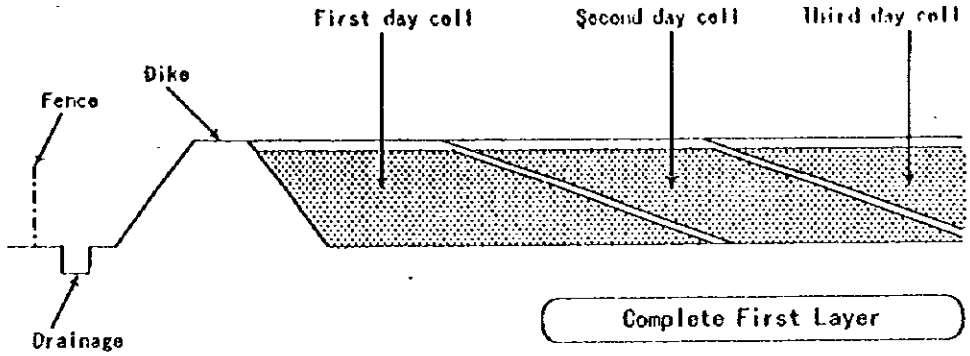
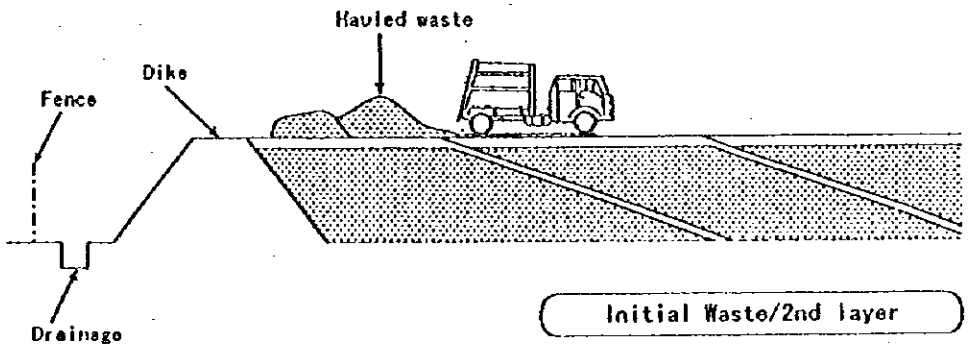


FIG. 7.2-8 Landfill Operation Procedures (1/3)

THE STUDY ON THE NATIONAL GUIDELINES FOR SOLID WASTE MANAGEMENT FOR THE KINGDOM OF MOROCCO







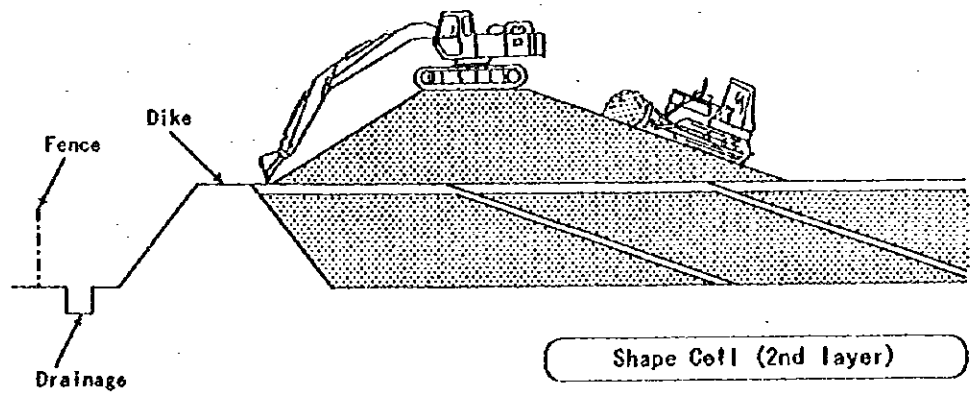
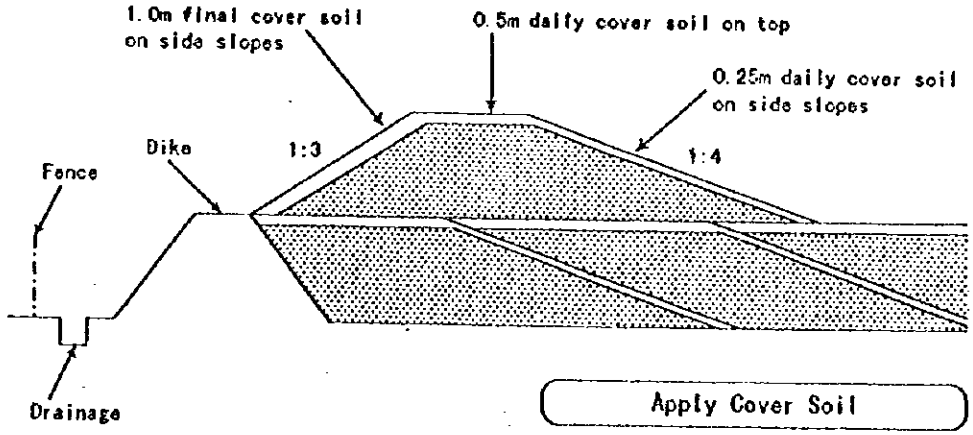
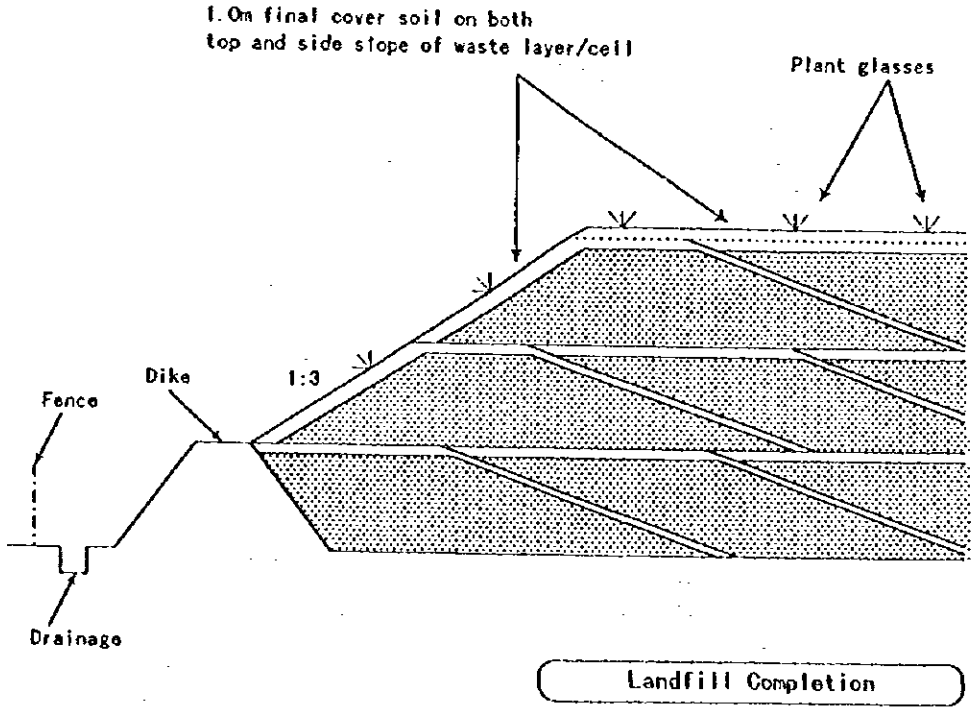


FIG. 7.2-8	**Landfill Operation Procedures (2/3)**

THE STUDY ON THE NATIONAL GUIDELINES FOR SOLID WASTE MANAGEMENT FOR THE KINGDOM OF MOROCCO





Source:
"Landfill Management Plan" by
International City Managers Association
(Washington D.C.) in 1992

FIG. 7.2-8 Landfill Operation Procedures (3/3)

THE STUDY ON THE NATIONAL GUIDELINES FOR SOLID WASTE MANAGEMENT FOR THE KINGDOM OF MOROCCO

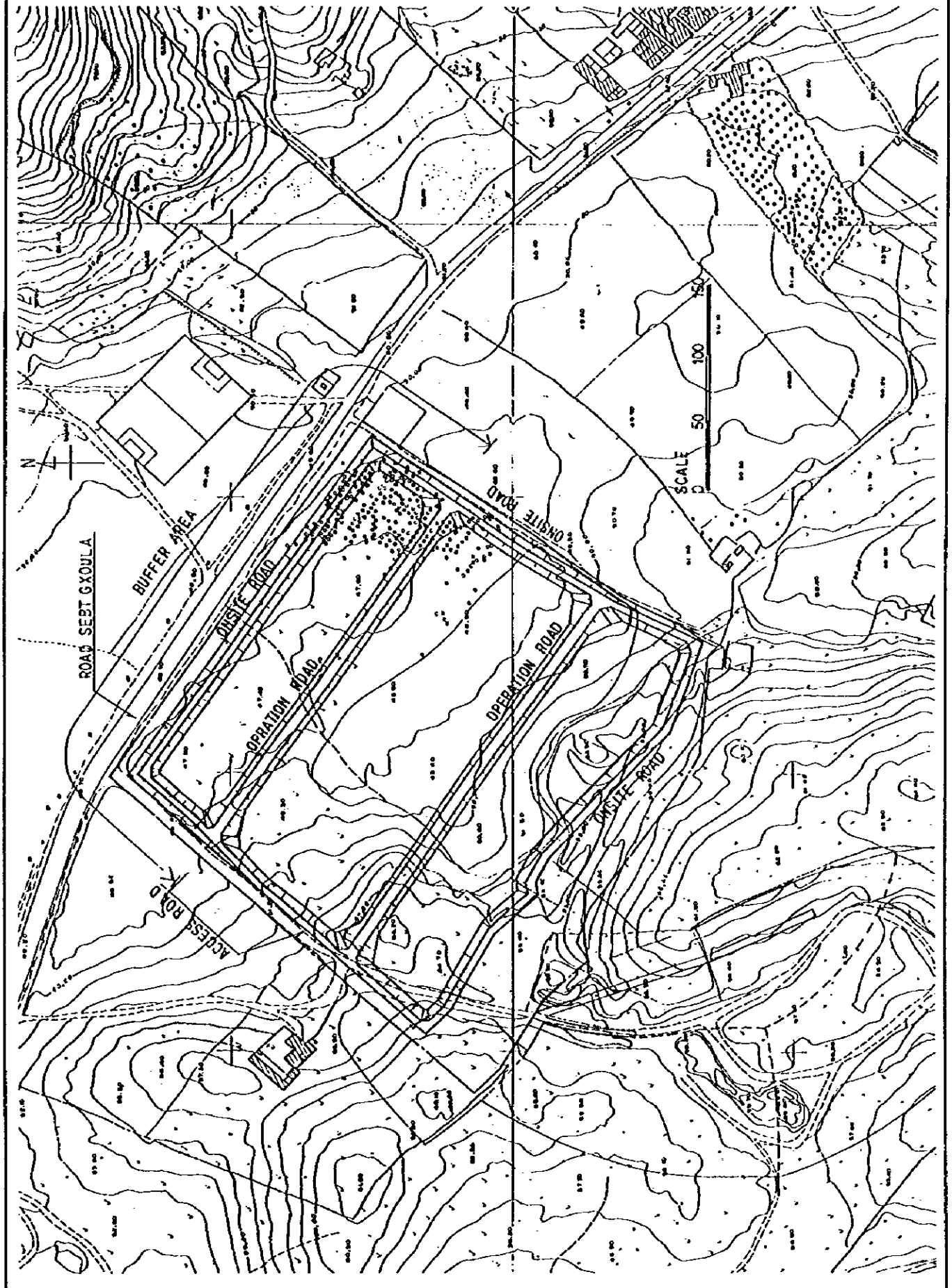


FIG. 7.3-1 Improvement Plan of Existing Municipal Disposal Site

THE STUDY ON THE NATIONAL GUIDELINES FOR SOLID WASTE MANAGEMENT FOR THE KINGDOM OF MOROCCO

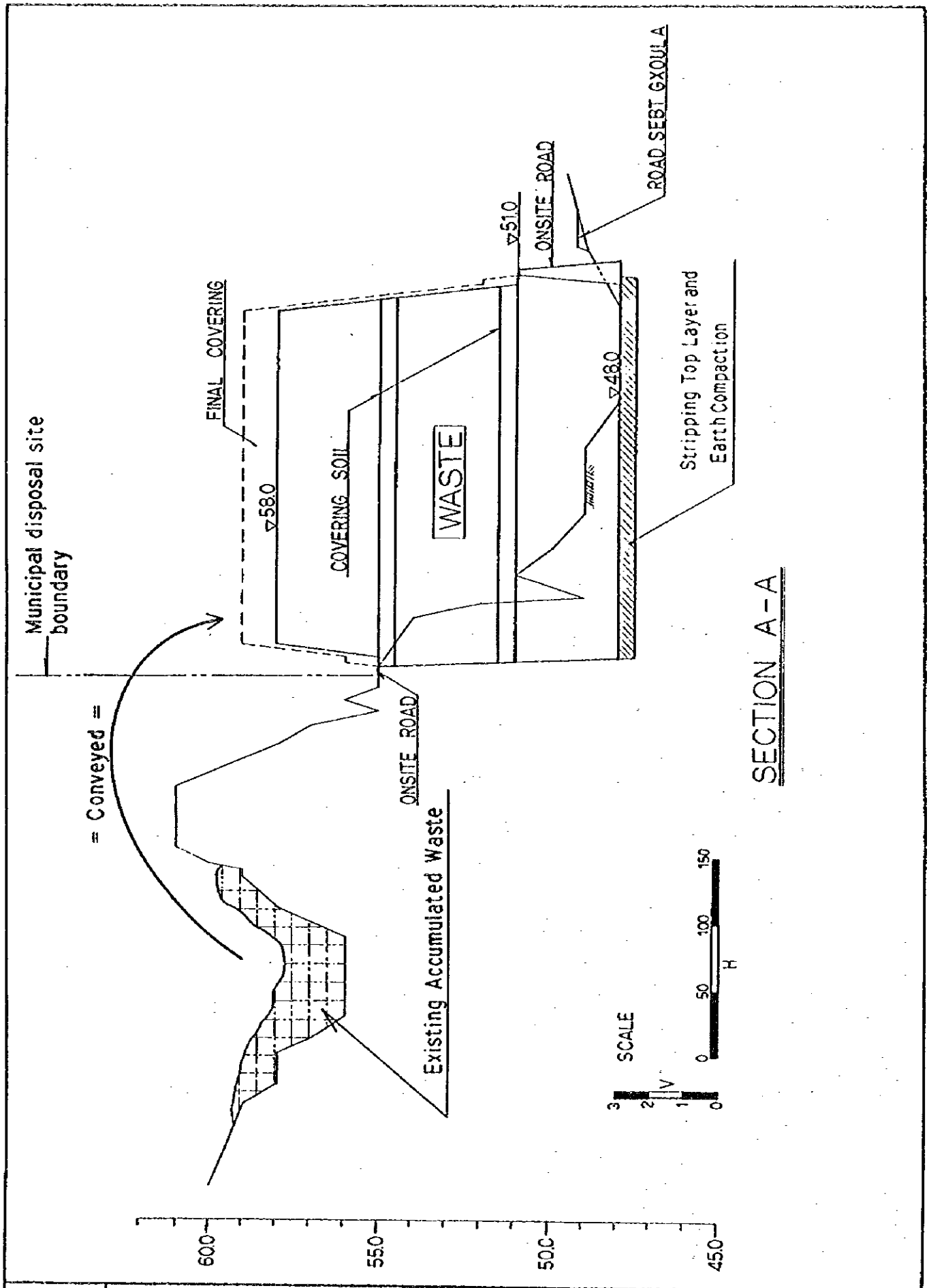


FIG. 7.3-2 **Sectional Elevation of Improved Municipal Disposal Site**

THE STUDY ON THE NATIONAL GUIDELINES FOR SOLID WASTE MANAGEMENT FOR THE KINGDOM OF MOROCCO

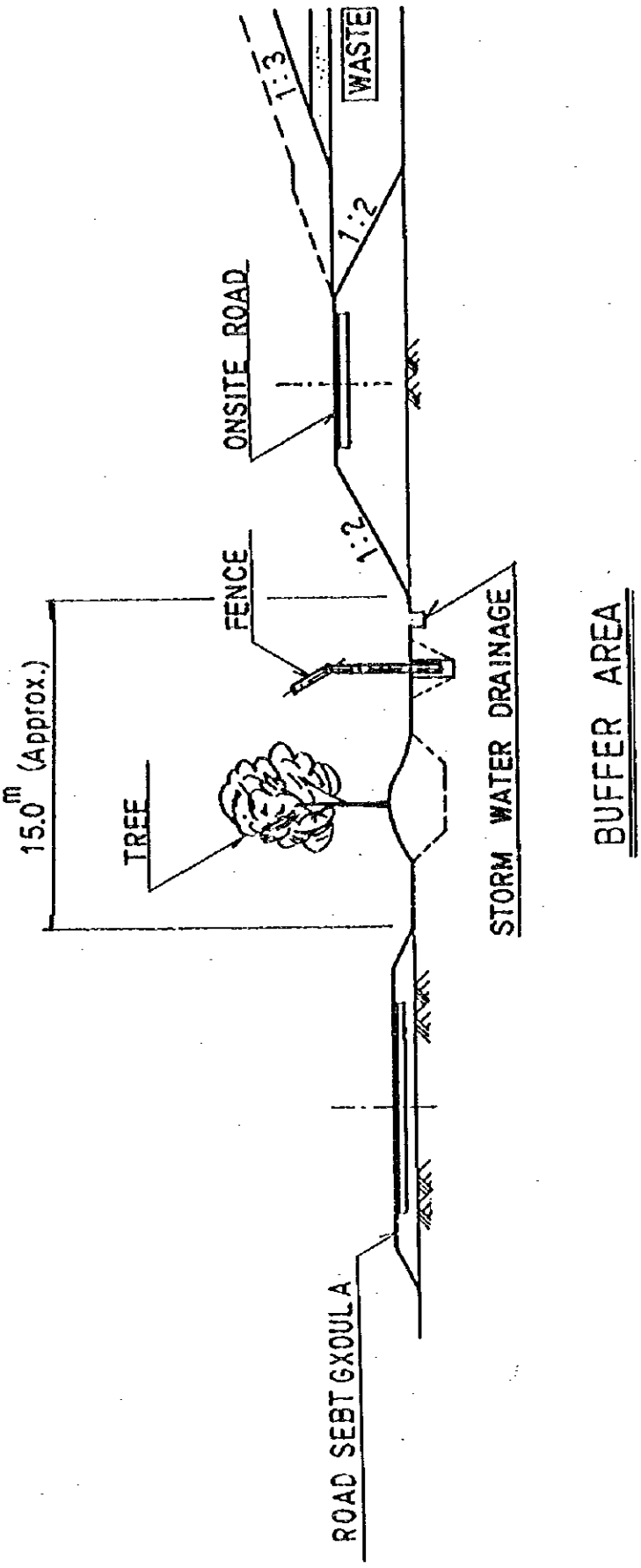


FIG. 7.3-3 Typical Facilities of Improved Municipal Disposal Site

THE STUDY ON THE NATIONAL GUIDELINES FOR SOLID WASTE MANAGEMENT FOR THE KINGDOM OF MOROCCO

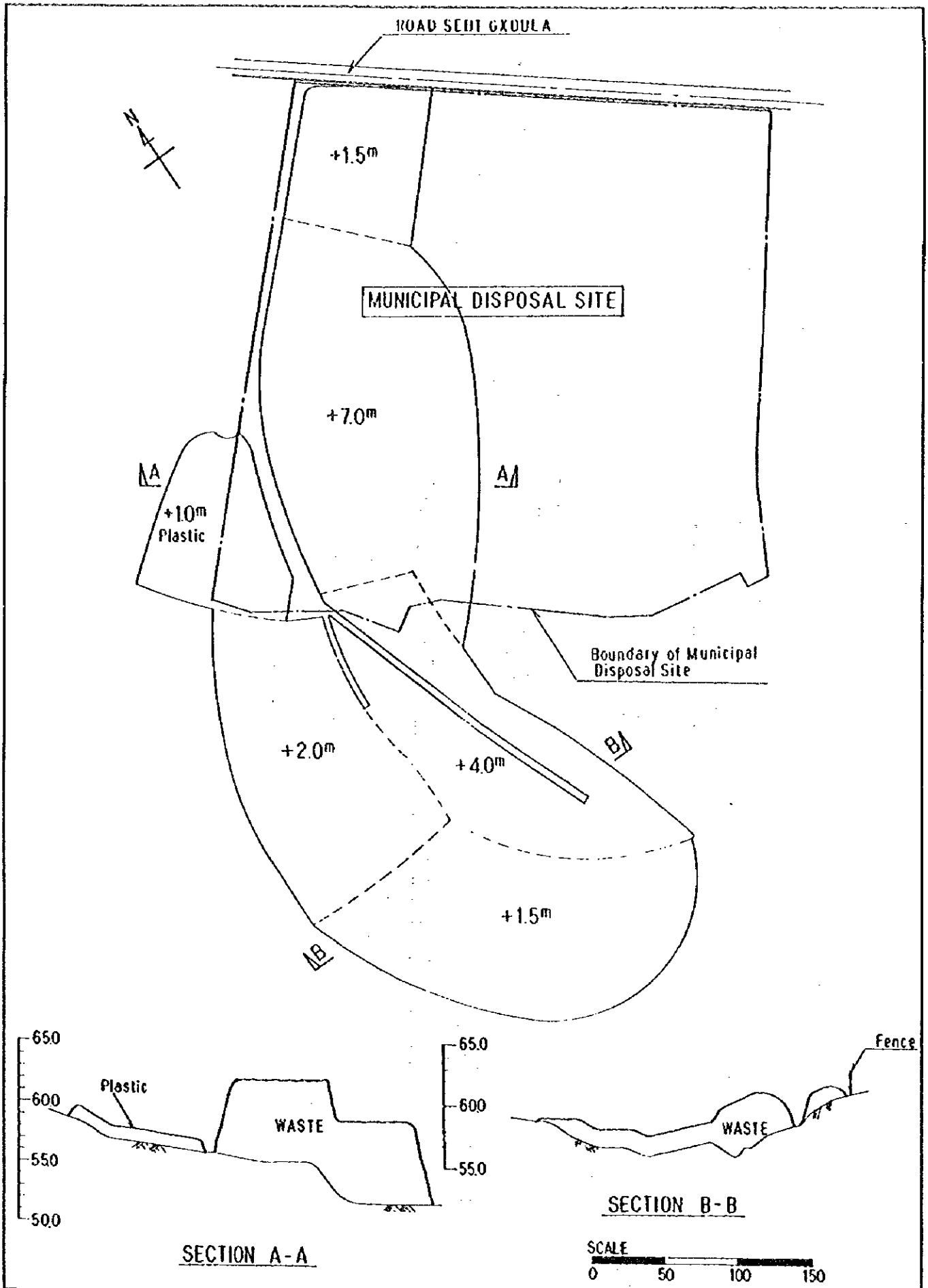


FIG. 7.3-4 Current Waste Conditions in Existing Municipal Disposal Site

THE STUDY ON THE NATIONAL GUIDELINES FOR SOLID WASTE MANAGEMENT FOR THE KINGDOM OF MOROCCO