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Technical Specifications for landfills and transfer stations in Tunisia

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CONTRACT ARTICLES
LANDFILL OPERATIONS

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5. Fuel Depot
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9. *Sanitary landfill* is a solid waste management facility used for the disposal of non-hazardous domestic waste and non-infectious medical waste, which employs compaction of wastes, covering of waste with soil cover material, and the management of leachate and gaseous materials produced by the organic decomposition of the landfilled waste, all in such a manner as not to harm human health and minimize negative impacts to the environment;

10. *Leachate* is the liquid byproduct of organic decomposition of landfilled waste or any liquid which comes in contact with solid waste in a sanitary landfill;

11. *Landfill gas* is the gaseous byproduct of organic decomposition of landfilled waste. Landfill gas contains significant concentrations of methane gas which is explosive at concentrations exceeding 5 percent.

12. *Recycling* is the sorting, processing, and transportation of solid waste materials, products or containers for the purpose of remanufacture or reuse;

13. *Sorting* is the authorized separation of solid waste materials for the purpose of recycling or disposal, either at the source of generation or at a solid waste management facility;

14. *Scavenging* is the unauthorized separation of solid waste for recyclable materials and food for human consumption;

15. *Surface water* is all waters in or coming from a water source which is found on the surface of the ground, excluding water under the surface of the ground and sea water;

16. *Perimeter drains* are open ditches surrounding the landfill installed to prevent surface water from entering the landfill.

17. *Groundwater* is all waters flowing or existing under the ground surface;

18. *Cell* is a volume of waste generally placed during one working day and covered on all horizontal surfaces by cover soil.

19. *Lift* is a series of one or more landfill cells forming a section of landfilled waste that extends horizontally across the landfill.

20. *Daily cover* is a daily application and compaction of approximately 15 centimeters of soil intended to control blowing litter, odors, flies, rats and fires, intended for an exposure of less than one week.

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21. *Intermediate cover* is an application and compaction of cover having the same functions as daily cover but applied at a thickness of 30 centimeters, intended to be exposed for a period of one week to one year.

22. *Final Cover* is an application and compaction of soil on the landfill after it has reached its designed elevation. The final cover soil shall be relatively impermeable and have a thickness of approximately 60 centimeters.

23. *Working area* is the area of the landfill where waste is unloaded, compacted and covered. It generally includes adequate space for several trucks to unload at the same time, for waste compaction and storage of cover soil.

24. *Vectors* are birds, insects, and rodents capable of carrying disease-causing bacteria, viruses or fungi from one host to another.

25. *Design Drawings* are drawings prepared by the landfill designer and include dimensions, specifications and other technical data regarding the construction of the landfill;

26. *Operating Plan* consists of drawings, descriptions and other documents regarding the operation of the landfill, placement of waste, building daily cells and lifts, leachate management, landfill gas management and all other functions related to the operation of the landfill.

27. *Operator* is the person or organization responsible for the operation of the landfill. The operator may be the owner, another public agency or private contractor.

28. *Owner* is the person or organization who owns the property and/or facilities that constitute the landfill.

GENERAL CONDITIONS

ARTICLE 2 - GENERAL

The Operator shall supply all labor, tools, supplies, utilities and supplemental equipment required to operate the landfill in accordance with the following contract articles and the operating plans. This shall include receipt and inspection of all waste, placement and compaction of waste, application of cover soil, control of surface water, operation of leachate collection and management systems, control of vectors, control of litter and record keeping.

All landfill operations shall conform to all laws and regulations of the Government of Tunisia (GOT).

ARTICLE 3 - CERTIFICATION OF SITE CONDITIONS

The operator shall review all landfill design drawings, operating plans and site conditions, and become familiar with all facilities and equipment, their capacities and their operational function. The owner shall provide access to all relative drawings, maps, documents and facilities as required by the operator to perform his evaluation of site conditions. By submission of his tender and signature on the tender documents, the operator certifies that he has inspected the site, equipment, designs and plans and finds them to be adequate to perform all landfill operations in conformance with the contract and for the contract prices included in his tender. If the operator finds any design, operating plan, equipment or site condition to be deficient, he shall list the deficiency in his tender.

ARTICLE 4 - LIGHTING

The owner has installed lighting for the receiving facilities and administrative area, which shall be maintained by the operator. The operator shall be responsible for installing additional permanent lighting along the permanent access road from the receiving facilities to the leachate holding pond. In addition to installing permanent lighting, the operator shall install temporary lighting along temporary access roads and in active working areas of the landfill. All lighting shall be suitable for 24-hour night time operation. The operator shall submit a lighting plan with his tender documents, showing the location of all permanent light poles and temporary light poles for the initial phase of operation. The cost for installing the permanent lighting shall be included as separate Item 3 of the Tender. The costs for providing temporary lighting shall be included in the general operating costs of the landfill.

ARTICLE 5 - ACCESS ROADS

The owner has constructed permanent access roads to the receiving facility, to all phases of the landfill and to the leachate holding pond. Permanent access roads are designed and constructed for rubber tired vehicles only and are not to be used by the landfill compactors or bulldozers. The operator shall construct a separate equipment access road on the site for use by landfill compactors and bulldozers, between the maintenance and repair depot and the active working areas of the landfill. The operator shall construct and maintain temporary access roads in the active areas of the landfill as required to provide truck access and dumping. Temporary access roads shall have a maximum slope of 15%. All access roads are to be maintained and repaired by the operator and be passable under all weather conditions.

ARTICLE 6 - OTHER FACILITIES

The owner has constructed receiving facilities, including a weighbridge, administrative offices and an equipment maintenance/repair depot for the exclusive use of the landfill operator. The operator shall be responsible for maintaining these facilities during the term of the operating contract. These facilities may not be used for any purpose other than landfill operation, without the written permission of the owner.

ARTICLE 7 - UTILITIES

The owner has installed electricity to the site. The operator shall be responsible for paying all electricity bills during the term of this contract. The operator shall be responsible for providing drinking water for all landfill workers.

ARTICLE 8 - INSURANCE

The operator shall maintain adequate insurance during the performance of the contract. As a minimum, the insurance shall include:

1. Equipment damage.
2. Personal Injury to operator's staff.
3. Third party property damage and personal injury.

All insurance policies shall name the owner as an additional insured and loss payee for all insurance on equipment of the owner. The operator shall submit proof of insurance as described above, within 30 days of notice of award.

EQUIPMENT

ARTICLE 9 - OWNER EQUIPMENT

The owner will provide to the operator the following equipment for operator's exclusive use under this contract:

1. Two landfill compactors
2. Three bulldozers
3. One rubber tired loader
4. Three dump trucks
5. One fuel depot
6. One weighbridge
7. One tractor with water tank
8. _____
9. _____

Detailed descriptions and specifications of each piece of equipment are included in Appendix A. The equipment is to be used only for this contract, and may not be removed from the site for any purpose without the written permission of the owner.

ARTICLE 10 - EQUIPMENT OPERATION, MAINTENANCE AND REPAIR

The operator shall be responsible for the operation, maintenance and repair of the equipment, listed under Article 9, in accordance with the manufacturer's recommendations. A preventive maintenance plan shall be prepared by the operator and submitted to the owner within 30 days of the operator's notice of tender award. As a minimum, the preventative maintenance plan shall meet manufacturers recommendations including fuel, oil, lubricants, filters, etc. The operator's monthly report shall include the hour meter reading for each piece of equipment plus a listing of all maintenance and repairs performed during that month in accordance with the preventative maintenance plan. The operator shall keep all receipts and invoices to document maintenance and repair, which may be reviewed by the owner at his request.

At the conclusion of the contract term the equipment shall be returned to the owner in good condition. Any damage to the equipment as a result of the operator's actions shall be repaired by the operator before the equipment is returned to the owner. If any equipment is damaged and not repaired, the owner shall make repairs and deduct the cost of repairs from the operator's final payment.

ARTICLE 11 - EQUIPMENT OPERATORS

All equipment operators shall have previous experience on similar equipment and shall have completed a training course on equipment operation. The operator shall submit the names and resumes of all equipment operators to the owner for his approval. The owner may reject any equipment operator who does not have adequate qualifications or who operates the equipment in a manner that my cause property damage or personal injury.

LANDFILL OPERATION

ARTICLE 12 - CAPACITIES

The landfill and related facilities have been designed and constructed for a daily capacity of 1,500 tonnes per day. The actual amount of waste received by the landfill will vary during the term of this contract, based on many variables, including the uncertain closure of the region's existing landfills, construction of transfer stations and upgrading of collection equipment. Since operating costs will vary with landfill capacity, this contract and tender prices included in Item 1 of the Tender will be based on three levels of operation as follows:

LEVEL 1	0 to 500 tpd	(0 to 15,208 tonnes per month)
LEVEL 2	500 to 1,000 tpd	(15,208 to 30,412 tonnes per month)
LEVEL 3	1,000 to 1,500 tpd	(30,412 to 45,624 tonnes per month)

ARTICLE 13 - HOURS OF OPERATION

The landfill shall be available for waste disposal, 24 hours per day, 7 days per week. Based on experience at the existing regional landfills, peak periods are 10:00 am to 3:00 pm and 1:00 am to 3:00 am. The operator shall adjust his staff and equipment needs to meet expected truck traffic.

ARTICLE 14 - RECEIPT OF WASTE

All waste received at the landfill shall be weighed at the weighbridge. The operator shall record the type of waste received, the origin of the waste, truck registration number and the truck's capacity in cubic meters. Initially, all trucks shall be weighed as they enter the landfill and when they leave. The difference in these weights is the weight of waste dumped in the landfill. After several trips, the empty or tare weight of each truck can be determined. Thereafter, it will only be necessary to weigh the truck as it enters the landfill. All waste entering the landfill shall be summarized in daily, weekly and monthly reports.

ARTICLE 15 - OPERATION & MAINTENANCE OF WEIGHBRIDGE

The owner reserves the right to oversee or operate the weighbridge to insure an accurate account of waste entering the landfill. The weighbridge shall be tested by the operator and its accuracy certified every 6 months. The cost of weighbridge testing and certification shall be included in the operator's general costs.

In the event that the weighbridge becomes inoperable, the operator shall immediately notify the owner, and arrange for repairs as soon as possible. When the weighbridge is not operational for any reason, the operator shall estimate the volume of waste in each truck and record it in the weighbridge log. The owner and operator shall determine a mutually agreeable method for estimating tonnage from volume estimates when the weighbridge is not functioning.

ARTICLE 16 - INSPECTION OF WASTE

The landfill operator shall accept only domestic waste and special wastes identified by the owner in Article 17. The operator shall perform periodic inspections of the waste as it is received, to confirm its type. Any waste that is not authorized for disposal shall be rejected by the operator. All waste that is rejected shall be recorded in the operator's log, including its type, reported origin and truck registration number.

ARTICLE 17 - ACCEPTABLE WASTE

The operator shall accept domestic solid waste plus the following special wastes:

1. Demolition and Construction waste
2. Brush and wood waste
3. Tires

4. Medical waste in approved containers
5. Incinerator ashes

The operator shall not accept the following wastes:

1. Hazardous (B_3) wastes
2. Liquid wastes
3. Industrial sludges
4. Olive processing wastes
5. Automotive oils

ARTICLE 18 - TRAFFIC FLOW AND UNLOADING

The operator shall be responsible for maintaining an orderly and controlled flow of traffic into and out of the landfill. Traffic shall not be permitted to by-pass the weighbridge unless it is inoperable. Barricades, fences, empty drums, and signs shall be used by the operator to direct the trucks to the appropriate dumping area. Dumping shall be approved only in approved active areas. The operator shall provide at least two attendants at each active area to direct traffic and insure that the waste is placed in the proper location.

The number of active areas and temporary access roads shall be established according the amount of waste and number of trucks using the landfill. In general, traffic ques of 5 trucks or more shall indicate inefficient traffic flow and additional areas and temporary access roads shall be added by the operator.

The operator may direct certain wastes to separate dumping areas. Construction and demolition wastes should be placed in a separate storage area for later use as cover, for stabilizing access roads and extinguishing fires.

ARTICLE 19 - OPERATING PLAN

The Operating Plan specific to this landfill is found in Appendix B. It consists of the following drawings:

Figure 1 - General Site Conditions: This drawing shows the major components of the site including surface (rainwater) drains, main leachate collection pipes, access roads, limits of the first 4 operation phases, and the leachate storage pond. Figure 1 shows the location of two power lines which are to be removed and relocated (see Article 20) This and other drawings in the operating plan are drawn to an approximate scale, and does not show all pipes or system components. They should be used as a general guide for operation and not for precise measurements. The operator should refer to the design drawings or field measurements for precise dimensions and locations of all system components.

Figure 2 - Initial Operations: This drawing shows the recommended initial operating procedures to begin filling in Phase 1.

Figure 3 - Landfill Phases: The landfill is to be constructed in 8 phases. Figure 3 shows the intermediate contours at the completion of the first four phases, prior to beginning Phase 5, which fills the valley created between Phases 1 and 2. This figure in addition to Figure 4, Cross Sections, provides the general dimensions and orientation of each of the 8 operating phases.

Figure 4 - Cross Sections: This drawing shows three cross sections of the landfill and vertical limits of the 8 operation phases. It is also used to estimate the volume of each operational phase. Maximum and minimum recommended slopes are shown on the cross section.

Figure 5 - Closure Plan: At the conclusion of Phase 8, the landfill will be full. Figure 5 presents the final contours of the landfill. The location of proposed methane vents is also shown on the Figure 5.

Compaction and Cell Construction: This one page schematic drawing presents the typical procedures for unloading, compacting and covering the waste.

Sequential Filling Plans (3 pages): This general series of schematic drawing shows the typical sequential filling of the first four phases of the landfill.

Final Cover & Methane Vent: This detail is a cross showing the installation of a typical landfill gas vent and application of the final cover soil.

ARTICLE 20 - POWER LINE RELOCATION

There are two power lines that cross the site, a large regional high voltage transmission line and a lower voltage local transmission line. The owner is responsible for removing these power lines from the landfill site in the near future. The operator shall operate the landfill in a manner that will not interfere with these power lines until they are moved. During the removal of the power lines, the operator shall cooperate with the enterprise performing the removal, including access to the site.

ARTICLE 21 - CELL AND LIFT DIMENSIONS

The landfill shall be constructed in cells and lifts as shown in the Sequential Filling Plan, found in Appendix B. The vertical depth of each landfill lift shall be 2 to 3 meters in depth. The horizontal width of each cell shall be determined by the operator to suit field conditions. Since the site is subject to strong winds and blowing debris, the width of the active cell should be minimized.

The operator shall begin landfill operations in Phase 1 as indicated in Figure 2. Subject to the estimated volume of daily waste, one or two active areas shall be formed as shown. Cell construction may progress in either direction after initial operations begin.

The operator shall establish elevation benchmarks around the site for the purpose of elevation control. An elevation survey shall be performed once per year, establishing the horizontal and vertical extent of the completed portions of the landfill. The survey map shall be submitted with the operator's annual report.

ARTICLE 22 - WASTE COMPACTION

All waste placed in the landfill shall be compacted with mechanical equipment before being covered. Compaction shall be performed by either a steel wheel landfill compactor or a tracked bulldozer. At least three passes of the compaction equipment will achieve sufficient compaction. Spreading and compaction of waste shall begin as soon as the waste is placed in the landfill. All waste shall be compacted and covered with soil within 6 hours of placement in the landfill. In areas that will serve as temporary access roads, additional compaction may be necessary. Compaction shall proceed as shown in the Compaction and Cell Construction Diagram, in the Operating Plan found in Appendix B.

During the placement of the first lift in each of Phases 1 thru 4, the operator shall compact the waste using only rubber tired equipment so that the leachate collection piping and gravel drainage blanket will not be disturbed. One rubber tired loader will be provided by the owner for this purpose. If one machine is not sufficient to perform this task, the operator shall be responsible for obtaining additional equipment during these initial operations of each phase of the landfill.

ARTICLE 23 - COVER

Daily Cover: The primary function of daily cover is to control litter, vectors and fire. Daily cover may be any type of soil having a compacted thickness of 15 centimeters. Since the landfill will operate 24 hours per day, the application of daily cover will be limited to the sides of each cell that will not be receiving waste during the next few days, up to one week. Daily cover may be removed before placing additional waste.

Intermediate Cover: Intermediate cover has the same general purpose as daily cover but it also must support the traffic flow of trucks and compaction equipment placing the next vertical lift. Therefore, intermediate cover shall be 30 centimeters thick and applied to all horizontal surfaces which will not receive additional waste for 7 days or more. Intermediate cover is also a method of controlling rainwater from entering the waste, by absorbing water during rainfall and evaporating water during dry periods. Intermediate cover may be any type of soil with suitable strength to support truck traffic.

Final Cover: When any portion of the landfill reaches its final contour elevation, the operator shall place final cover soil, having a minimum thickness 60 centimeters. Final cover soil shall be a low permeability soil material in order to promote drainage of rainwater off the site and the absorption/evaporation of water from the soil . Final cover soil shall have sufficient organic material to support plant growth.

Approximately 180,000 m^3 of on-site cover soil has been stockpiled for use as daily and intermediate cover. At the estimated capacity of 1,500 tpd, this supply of cover soil should last approximately 2.5 years. The operator shall not receive additional payment for using stockpiled cover soil.

After the on-site cover soil is used, the owner may designate a portion of the existing site where additional cover soil may be excavated. The operator will prepare an excavation plan of this area for the owner's approval. The operator will be paid for on-site excavation and hauling of cover soil for the tender price included as Item 2A of the Tender.

In the event that the excavation of additional on-site cover soil is not approved, the operator will be responsible for providing cover material from an off-site source. The operator will be paid for providing off-site cover soil in accordance with Item 2B of the Tender.

All cover soil, regardless of is origin shall be loaded onto trucks and weighed at the weighbridge before being used. A record shall be kept of all cover soil used. Daily and intermediate cover soil shall not exceed 15% of the waste, as measured by volume.

ARTICLE 24 - LEACHATE MANAGEMENT

The landfill has been designed and constructed with a leachate collection and storage system. The operator will be responsible for the operation and maintenance of this system for the duration of this contract. The amount of leachate to be produced by the landfill will vary based on many conditions, including rainfall, temperature and operating conditions. In general, the compaction and covering of the waste as specified herein will reduce or eliminate the amount of leachate produced.

Collection Pipes: Each of the first four phases of the landfill contains leachate collection pipes that connect to the leachate storage pond. Each phase contains a leachate control manhole. This control manhole permits access to the main leachate collector pipes for cleaning and also permits the leachate collection pipes to be by-passed to the rain water drainage system. The operator shall obtain copies of the leachate collection system from the owner and become familiar with its operation.

During the initial filling of Phase 1, (see Figure 2 of the Operating Plan) the leachate collection pipes shall be connected to the leachate storage pond. The leachate pipes in the other three, inactive, phases shall be bypassed to the rainwater collection system. As each

additional phase is activated, the leachate by-pass shall be removed and the leachate collection pipes connected to the leachate collection pond.

Leachate Storage Pond: The leachate collection pipes drain to the storage pond which has a capacity of 6,000 m^3. The purpose of the leachate storage pond it to capture the leachate and prevent it from entering the stream below the landfill. Leachate stored in the pond shall be permitted to evaporate naturally. In the event that the level of leachate reaches 1 meter below the top of the pond, the operator shall recirculate the leachate into the landfilled waste using temporary piping or the tractor and cistern provided by the owner. Leachate shall be recirculated into the landfill in areas having at least 10 meters of waste. The collected leachate may also be spread on access roads to control dust or to extinguish fires. All leachate withdrawn from the leachate pond, and its use, shall be recorded in the operator's log.

Cleaning: The leachate collection pipes may become blocked. The operator shall be responsible for maintaining the collection pipes and cleaning as required. Cleaning methods include removing material from the control manholes or pipe cleaning using high pressure water hoses. Access to the leachate control manholes shall be maintained during the filling of Phase 1 thru 4.

ARTICLE 25 - SURFACE WATER CONTROL

The landfill has been constructed with a surface and rainwater control system consisting of open drainage ditches around the landfill. This system of perimeter drains is designed to keep surface water from draining into the landfill. The operator is responsible for cleaning and maintaining these ditches. A separate 600 mm piped rainwater collection system is installed under the landfill to drain rainwater from inactive phases of the landfill. As each new phase of the landfill is started, the operator shall activate the leachate collection pipes and block and seal all inlets to the rainwater collection pipe.

ARTICLE 26 - LITTER CONTROL

The landfill site is subject to frequent high winds. The operator shall control wind blown litter using the following methods:

Portable Catch Fences: The operator shall use portable litter catch fences at each active area of the landfill to trap wind blown debris. Portable fences shall be 3 meters high and constructed of metal netting with maximum opening of 15 centimeters. The length of the portable fence shall suit the size of the working area but not less than 50 meters.

Litter Collection Crew: The operator shall maintain a litter collection crew of 5 persons, whose sole purpose will be to collect litter around the site. Litter shall be collected every

day on the site and at least one day per week along the public and private lands adjacent to the site.

ARTICLE 27 - SCAVENGING AND RECYCLING

The operator shall not permit unauthorized scavenging of food or other materials from the waste. Sorting and recycling of specific materials will be permitted, subject to a plan submitted by the operator for the owner's review and approval. Recycling of material shall be performed only by the operator's workers in an orderly manner. All recycled material must be removed from the site every 24 hours. Recycling of materials shall not interfere with compaction and covering procedures.

ARTICLE 28 - FIRES

The primary prevention of fires at the landfill will be the compaction and application of cover soil as specified in Articles 22 and 23. In the event that a fire starts at the landfill, the operator shall extinguish the fire within 24 hours, using cover soil, leachate from the leachate holding pond or water from an off-site source.

ARTICLE 29 - VECTOR AND DUST CONTROL

The operator shall be responsible for controlling vectors on the site, including flies, mosquitoes, rodents and other animals. The primary method for the control of vectors is the compaction and covering of the waste as specified herein. In the event that vectors become a major problem, the operator shall use insecticides or poison to eliminate the problem. The operator shall inform the owner of the application of all insecticides or poisons used for vector control.

The operator shall control dust by the proper construction and maintenance of access roads and wetting with water or leachate.

ARTICLE 30 - SECURITY

The operator shall provide guards, gates, fences, and any other means to control unauthorized access or dumping at the site. A Security Control Plan shall be prepared and submitted to the owner within 30 days of the notice of award. The plan shall describe the security measures to be employed by the operator and the number of security guards to be used.

ARTICLE 31 - OWNER ACCESS

The owner shall have access to the site and all facilities at all times for the purpose of administering this contract.

ARTICLE 32 - RECORD KEEPING AND REPORTING

The operator shall keep records of the following:

1. Tonnes of waste received in each category
2. Cover soil applied.
3. Leachate pumped from the storage pond.
4. Equipment maintenance.
5. Rejected waste.

In addition, the operator shall maintain an operators log, in which he will enter any other information regarding the operation of the landfill.

Landfill operations shall be summarized by day, month and year, with signed copies submitted to the owner.

APPENDIX A

EQUIPMENT SPECIFICATIONS

APPENDIX B

OPERATING PLANS

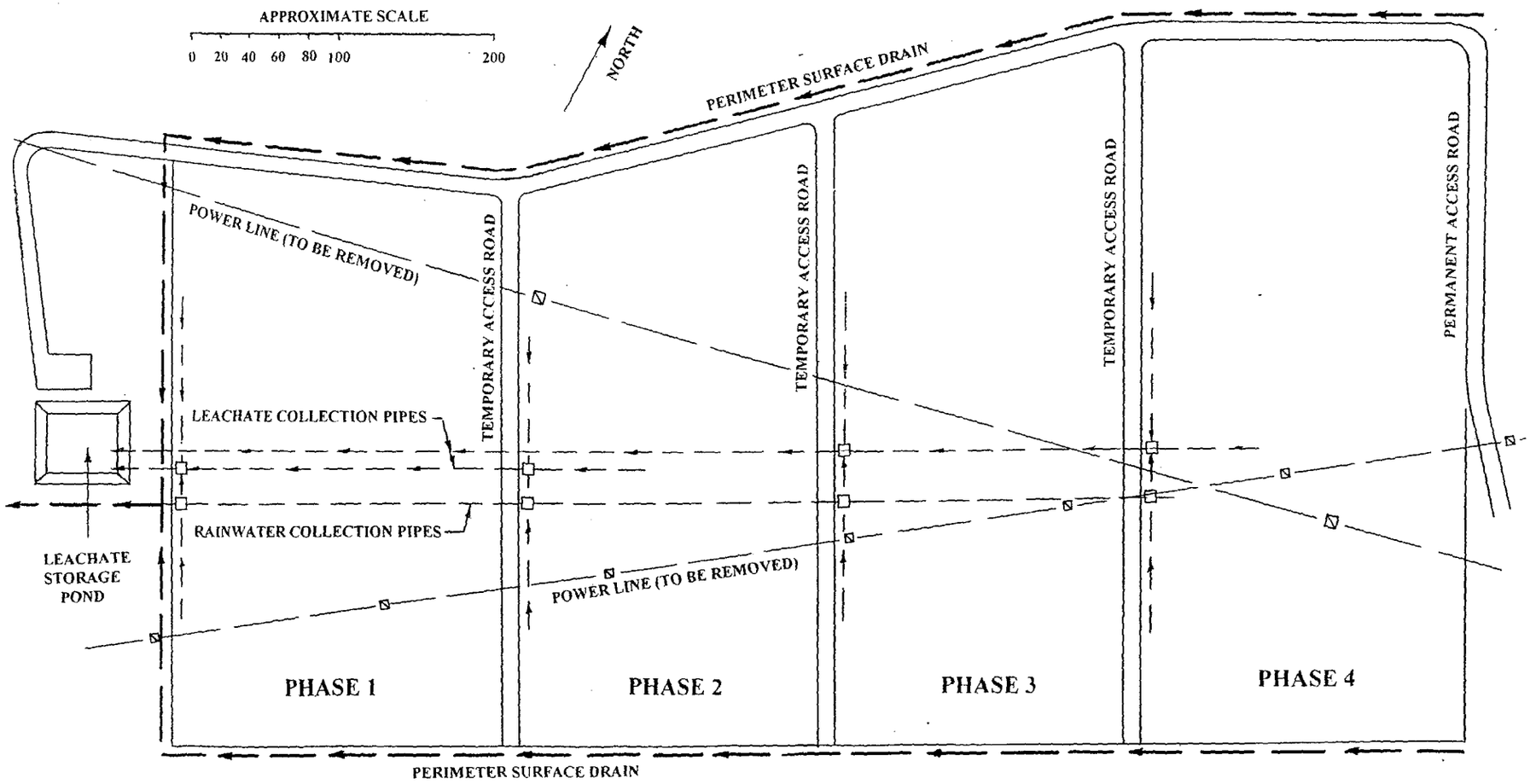

FIGURE 1
GENERAL SITE CONDITIONS

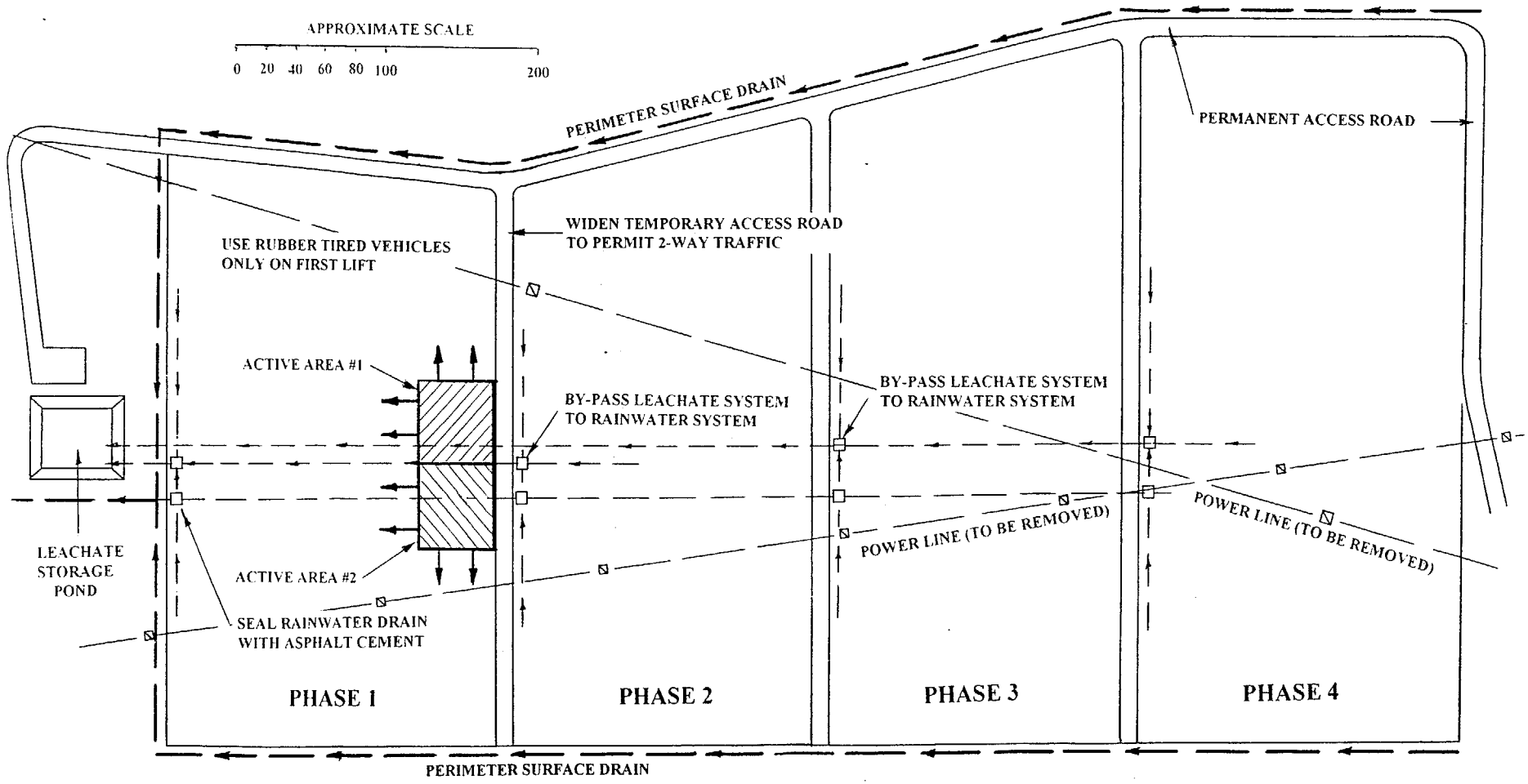

FIGURE 2
INITIAL OPERATIONS - PHASE 1

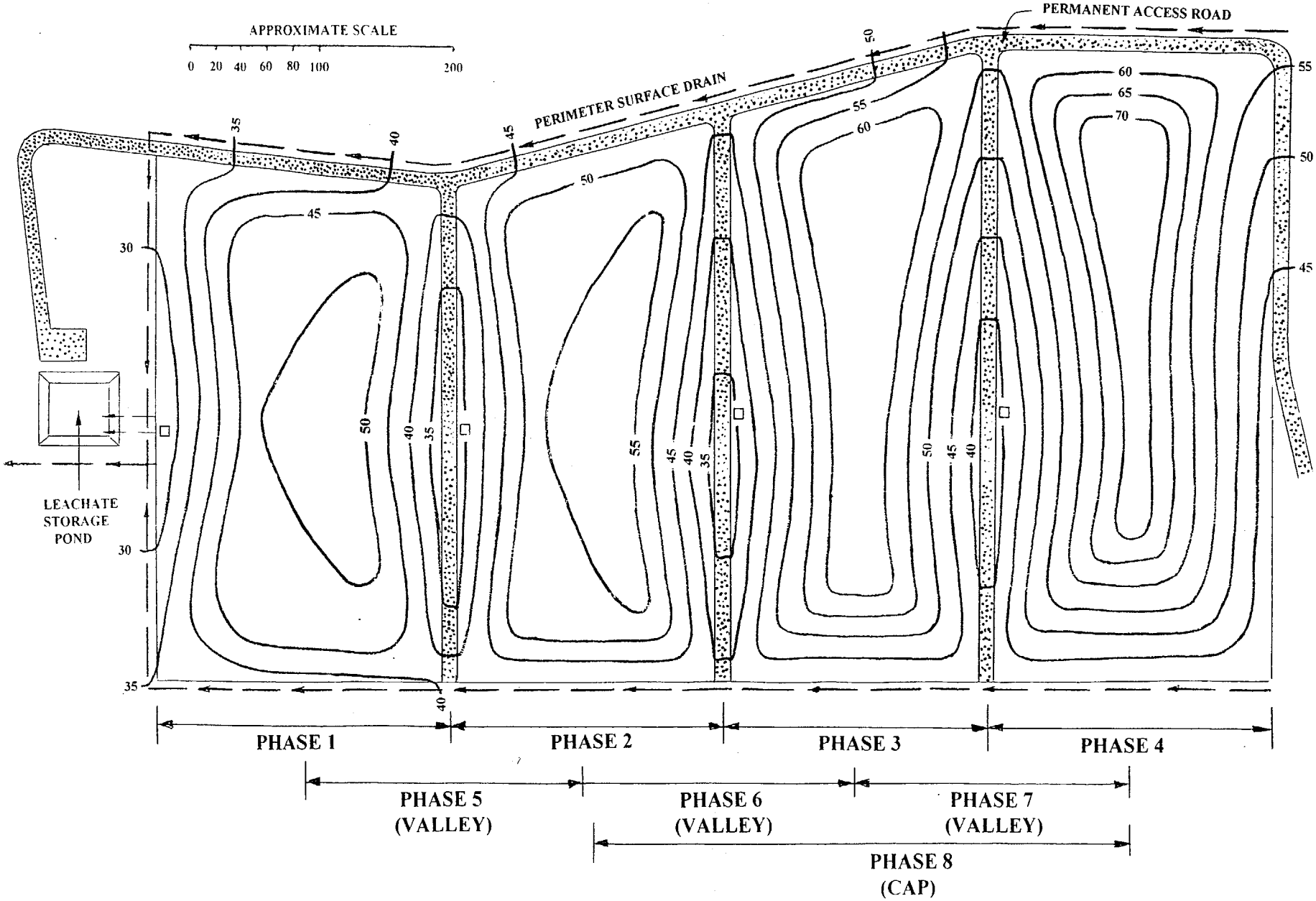

FIGURE 3

INTERMEDIATE CONTOURS PHASES 1-4

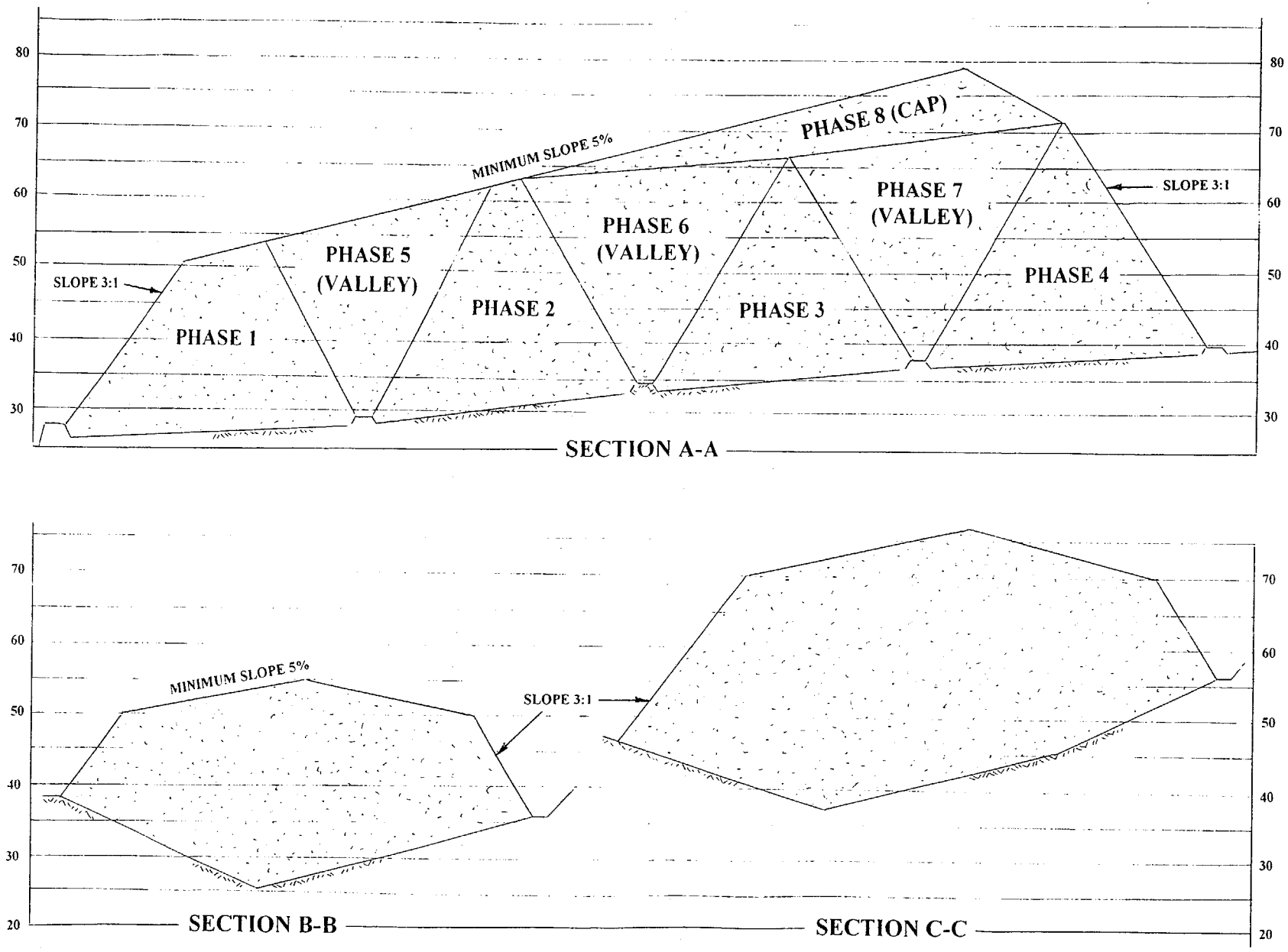

FIGURE 4
CROSS SECTIONS

22

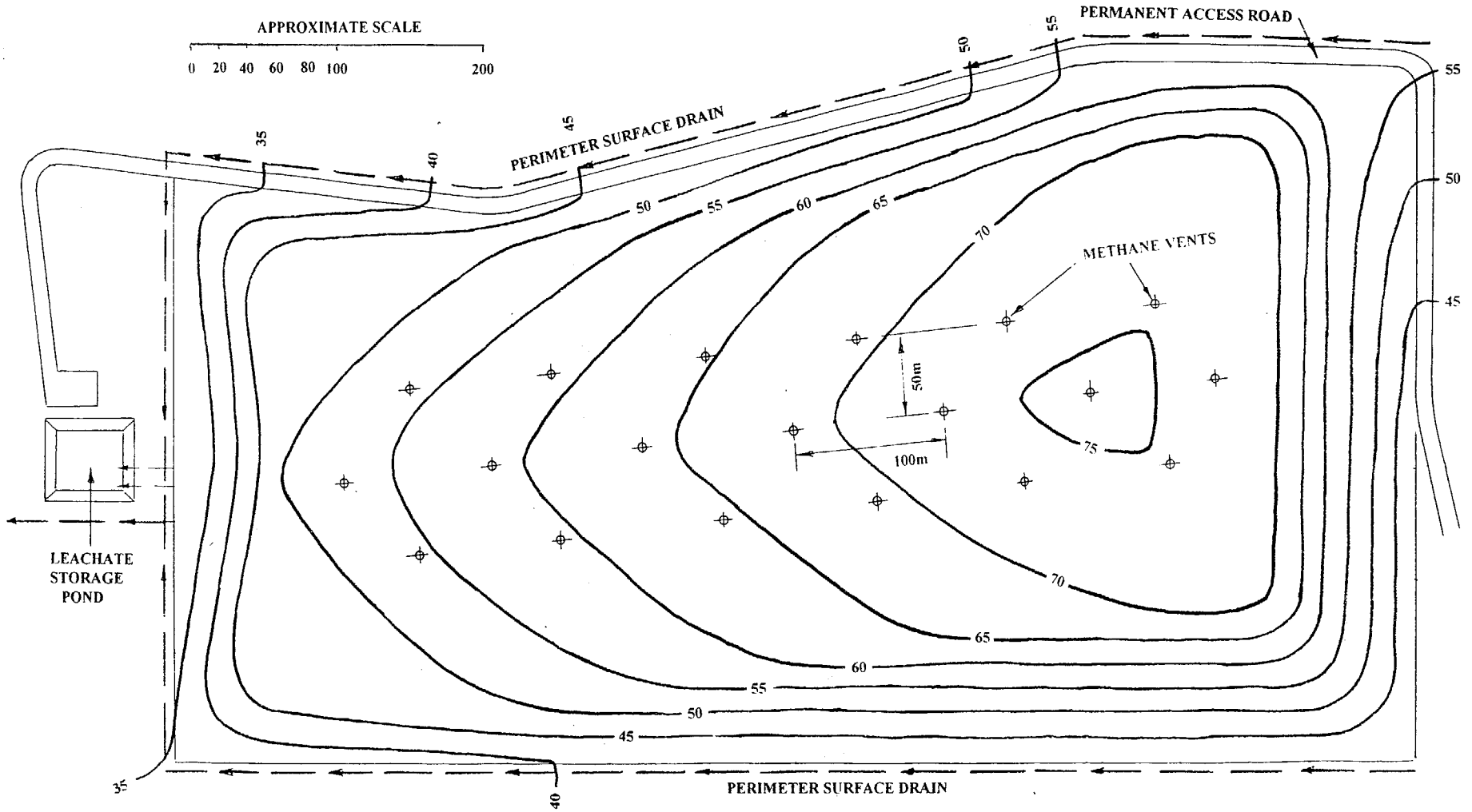

FIGURE 5
CLOSURE PLAN

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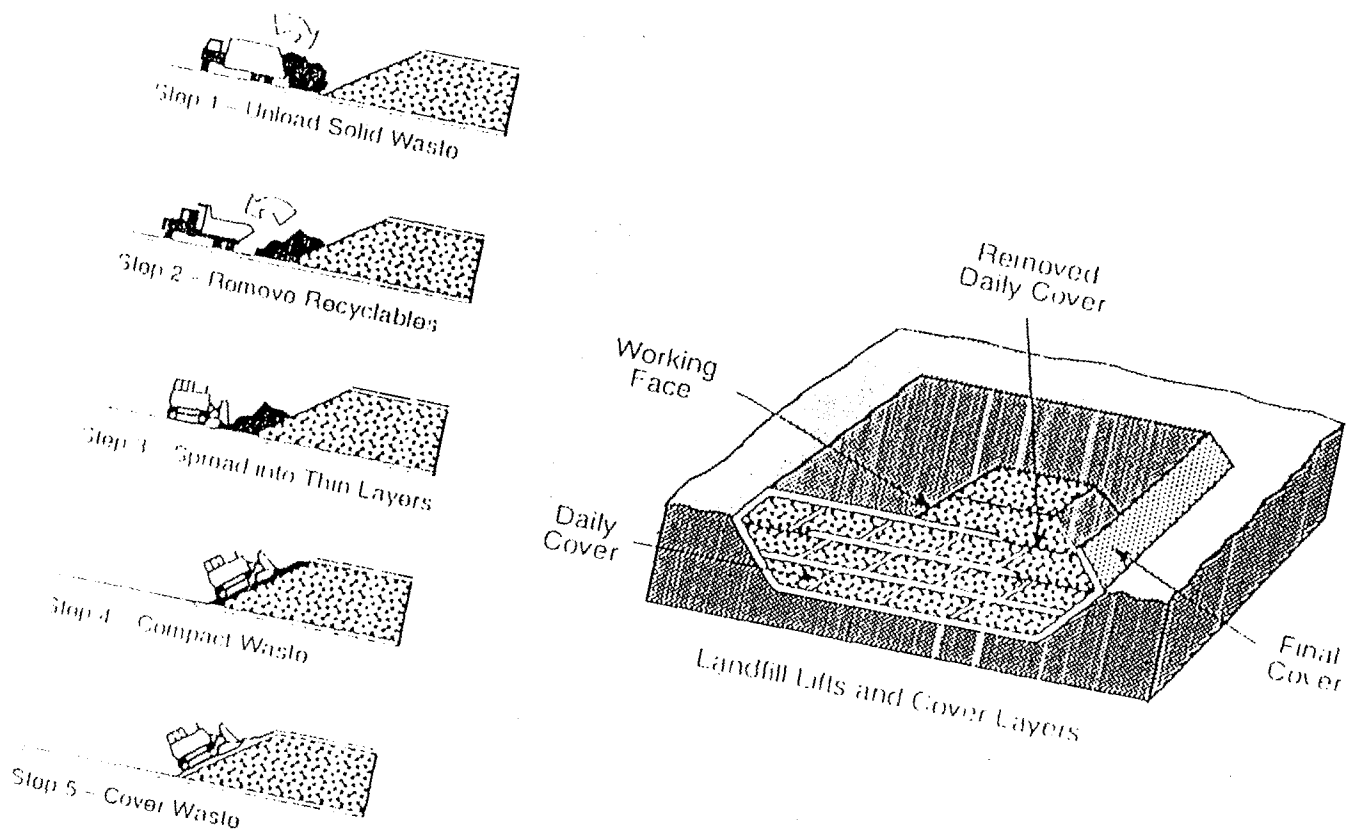

Figure 1. Daily Landfilling Operations

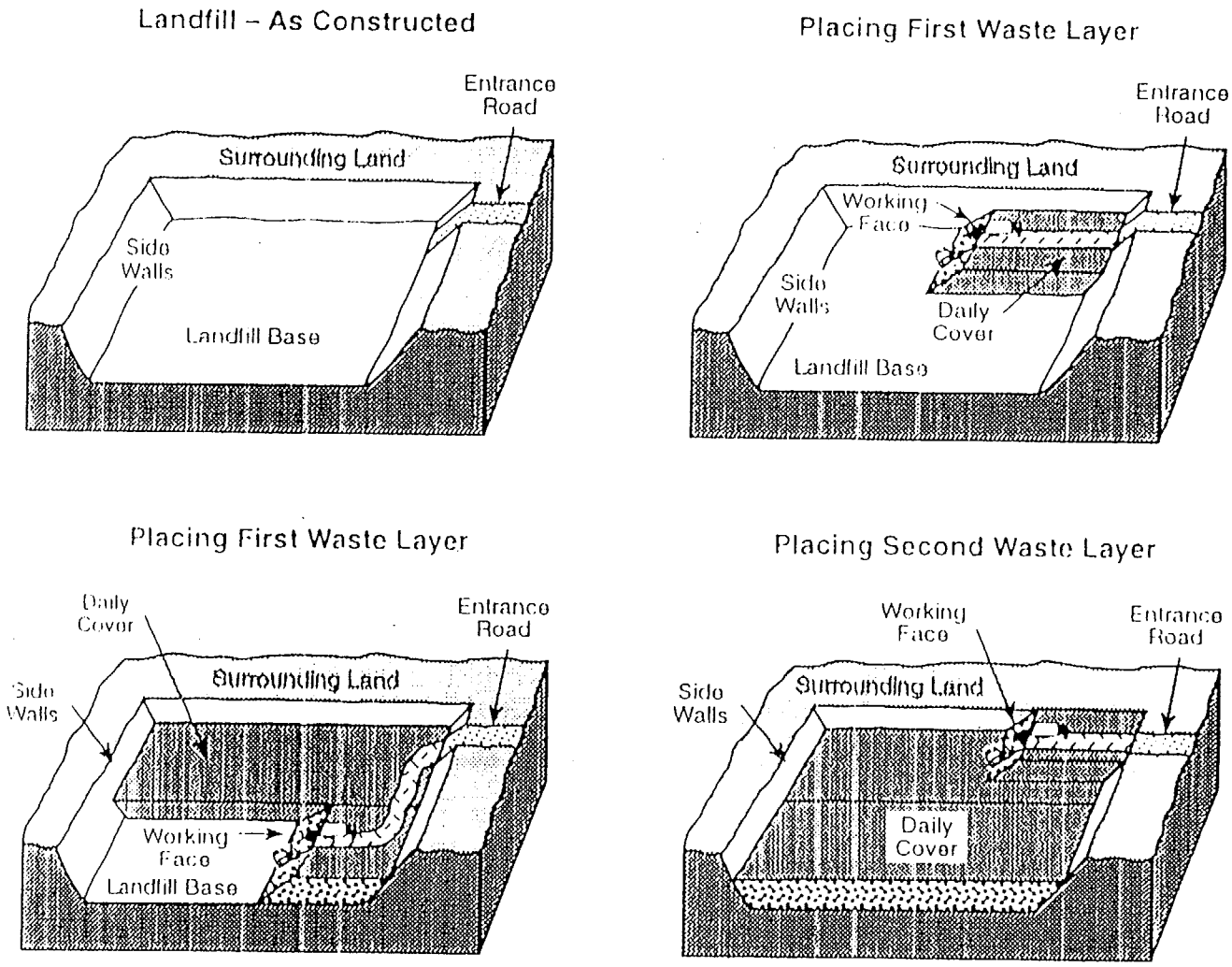

Figure 4. Sequential Filling Plans

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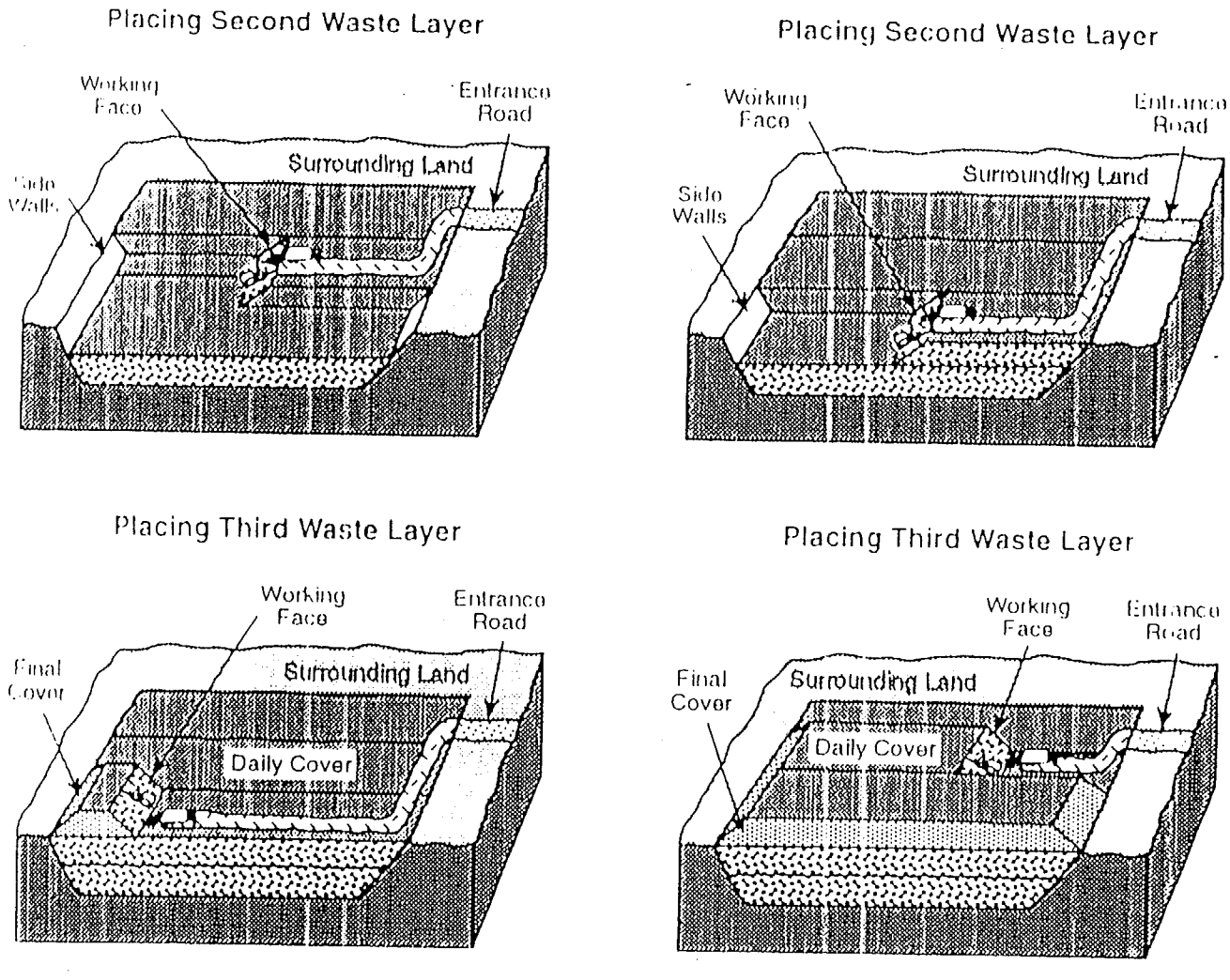


Figure 4. Sequential Filling Plans (continued)

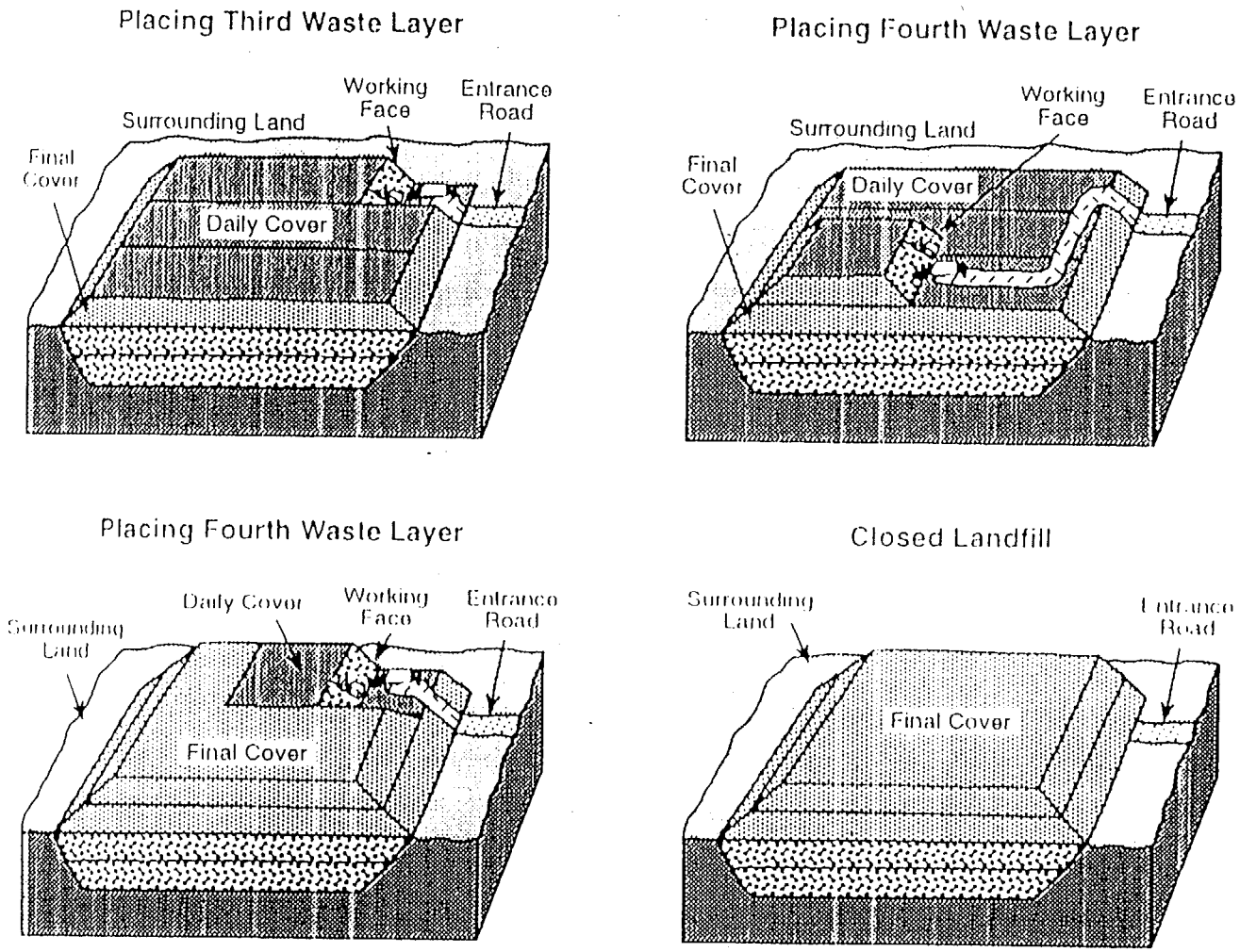
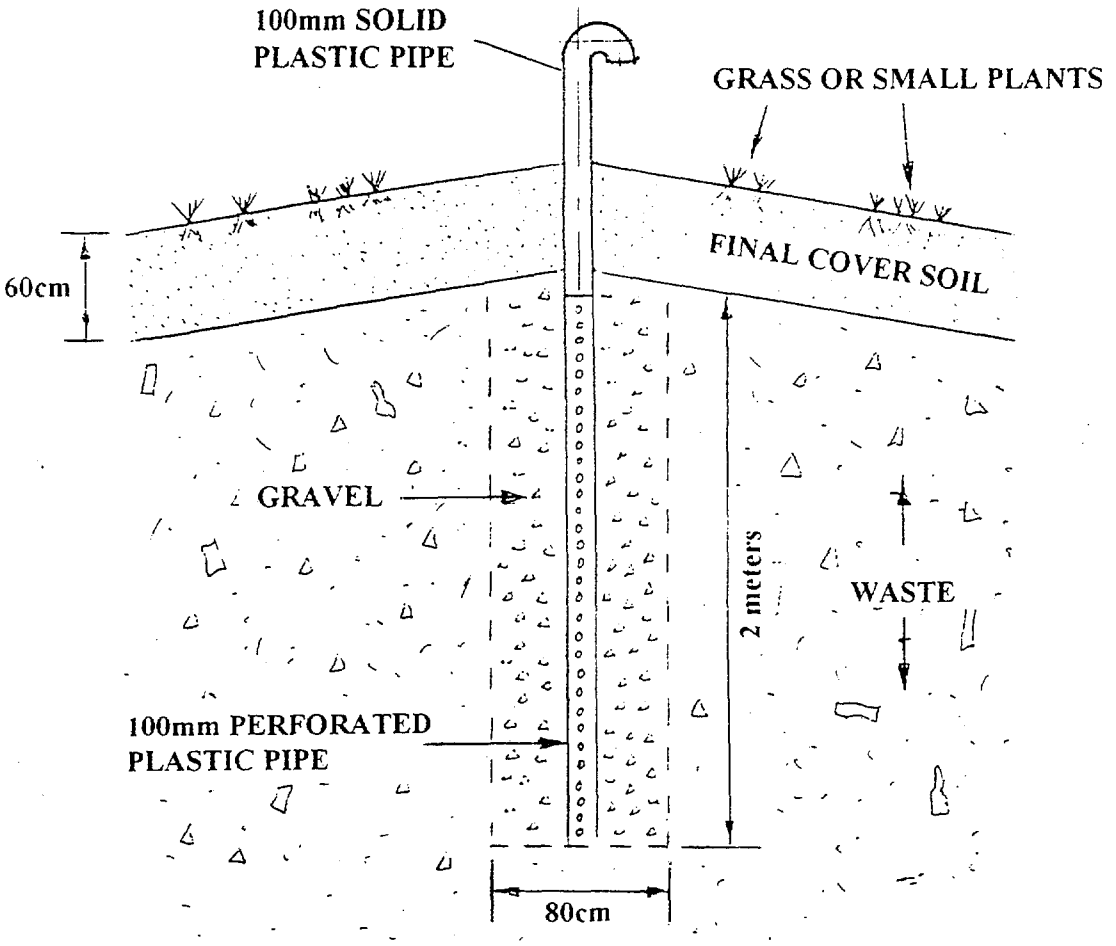


Figure 4. Sequential Filling Plans (continued)



FINAL CLOSURE AND GAS VENT

APPENDIX C

DRAFT TENDER

DRAFT
TENDER PRICES

The contractor shall supply all materials, tools, supplies, and related items to perform the landfill operations as described in Articles 1 through 32, Appendix A, Appendix B, and the design drawings for the following costs:

ITEM 1 LANDFILL OPERATION

ITEM 1A For Level One operation of the landfill at a capacity of 0 to 500 tonnes per day as computed as a monthly average, 0 to 15,208 tonnes per month for a unit cost of:

_____Dinars per Tonne (_____DT/tonne)

ITEM 1B For Level Two operation of the landfill at a capacity of 500 to 1,000 tonnes per day as computed as a monthly average, 15,208 to 30,412 tonnes per month for a unit cost of:

_____Dinars per Tonne (_____)DT/tonne)

For level Three operation of the landfill at a capacity above 1,000 tonnes per day as computed as a monthly average 30,412 tonns per month and higher for a unit cost of:

_____Dinars per Tonne (_____)DT/tonne)

ITEM 2 ADDITIONAL COVER SOIL

ITEM 2A For excavation and transportation of on-site cover soil in accordance with Article 23 of the contract, a unit price of:

_____Dinars per Tonne (_____)DT/tonne

ITEM 2B For excavation and transportation of off-site cover soil in accordance with Article 23 of the contract, a unit price of:

_____Dinars per Tonne (_____)DT/tonne

ITEM 3 For furnishing and installation of permanent access road lighting, a lump sum of:

_____Dinars (_____DT)

Transfer Station Discussion

Greater Tunis Region

TRANSFER STATION DISCUSSION
GREATER TUNIS REGION

Background

The Ministry of the Environment under the PROGNADES program, has constructed a new landfill at Borj Chakir that has been planned to serve the gouvernorats of Tunis, Ariana and Ben Arous, for a 10 to 15 year period. These municipalities are estimated to produce 569,890 tonnes per year (tpy) in 1997, increasing to 814,010 tpy in 2007. Although the landfill construction will be completed by mid-1997, other infrastructure systems have not been constructed to allow the entire region to access the site. Preliminary planning studies have indicated that outlying areas will require transfer stations to efficiently access the site. Some of these areas such as LaMarsa and Sidi Bou Said are over 25 kilometers from the site. A study has been commissioned by the Ministry to assess potential transfer options in the region. This study will begin in May 1997. In addition to the transfer infrastructure, the institutional arrangements for operation, administration and financing have not been established.

The following report has been prepared as part of the USAID Private Provision of Environmental Services (PPES) program. It is intended to be a reference document to assist the ministry and its consultants in completing the planning for the Borj Chakir landfill. It presents information that the PPES program has assembled in its various activities in Tunisia and other similar countries.

Waste Characteristics

Before beginning a discussion of specific transfer options it is important to review the waste characteristics of the region and how they may differ from typical waste in other parts of the world. ***This is particularly important since much of the reference materials available on waste transfer technology and efficiencies are based on waste from more developed countries in Europe and the United States which is significantly different than waste from developing countries.***

In considering transfer options, the most important difference to consider is density and compactability. Typical waste from more developed countries has a significantly higher paper and plastic content and a much lower organic content. Waste density from developed countries varies from 100 to 170 kilograms per cubic meter (kg/m^3) with 150 kg/m^3 considered as the norm. This is compared to 250 to 500 kg/m^3 for developing countries such as Tunisia, with 350 kg/m^3 considered as the norm. These densities represent loose, as-generated densities.

Compaction Ratios

Waste collection methods vary from country to country but most collection is performed using rearloading compaction trucks with capacities up to 20 m^3. Some long haul transfer trucks use stationary compactors and compactor trailers holding 50 to 60 m^3. These compaction trucks

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typically compact the 150 kg/m^3 waste to 400 to 500 kg/m^3. This equate to a compaction ratio of approximately 3:1. In other words, the volume of waste has been reduced by a factor of three (3).

The three-fold reduction in volume is the biggest efficiency that is achieved through compaction, especially in transfer applications.

In Tunisia, typical compaction equipment can increase waste density to 500 to 600 kg/m^3. But since the initial density was 350 kg/m^3 , the compaction ratio is only 1.5:1. ***Therefore compaction in Tunisia will only result in a volume reduction of 1.5 as compared to a reduction of 3 in more developed countries. This lower compaction ratio for Tunisian waste is an important factor to consider when evaluating transfer options.***

Collection Equipment

The municipalities within the planning region that will use the new landfill, are collecting waste primarily with rear loading compactor trucks, servicing containers of 750 and 1,100 liter capacities. Truck capacities vary from 12 to 18 m^3, depending on the size of the area served and street patterns. Many of the municipalities still use tractors and trailers to service high density areas with narrow streets. Hand carts are still used for waste collection in the medinas and old sections of the city, and for street sweeping. Where tractors and hand carts are used, small local transfer stations load the waste into compactor trucks or dump trucks for the trip to the landfill.

The trend in collection trucks is clearly toward larger truck capacities, where street patterns will permit. In the municipality of Tunis, 16 m^3 and 18 m^3 collection trucks are now standard. As smaller outlying municipalities continue to develop, it is anticipated that they also will use larger collection trucks.

Road Capacities

The condition of roadways between the potential transfer facilities and the landfill is also an important issue to consider in designing a transfer system. Tunisia is fortunate to have an excellent highway system but many secondary and local roads are in fair to poor condition and may not be suitable for heavy transfer vehicles. Tunisia has generally adopted the same highway weight limits that exist in France. These limits include a maximum weight of 13 tonnes per axle. This is similar to weight limits in the United States. Although the major highways are designed and constructed to support these loads, many of the local and secondary roads are not. Several secondary and local roads must be used to access the Borj Chakir landfill. These will have to be upgraded to handle the increased truck traffic to the landfill.

Actual axle loading will depend on the truck or trailer design, number of axles, its capacity and empty weight. Considering the higher density of Tunisia's waste, it is probable that axle loading will be the determining factor in establishing the maximum capacity of transfer trailers.

Privatization

Another very important issue to consider is the current trend toward privatization of collection services. One of the most important advantages of privatization is the increased efficiency provided by the private sector. Part of that efficiency is the ability to find the lowest cost method of collecting and transporting waste. This efficiency is usually gained through maximizing the use of equipment and manpower. A transfer station may not be the most efficient method of getting waste to the landfill. We should not impose this method on the private sector but rather give them the flexibility in the collection contracting process to select the transportation method. If transfer stations are more efficient, then the private sector should be the ones to construct and operate these systems.

Current Tunis Transfer System

The Municipality of Tunis currently operates 10 local transfer stations. These stations generally only handle waste and street sweepings that are collected by handcarts and farm-type tractors. Eight stations use standardized 30 m^3 dump trailers. Four stations use two trailers each and four stations use one trailer each. All trailers are taken to the landfill once per day, using four highway tractors. The 30 m^3 trailers take between 8 and 12 tonnes of waste per load, based on weigh records at Borj Chakir. This equates to densities of 300 to 400 kg per m^3, assuming full trailers.

One of the Tunis transfer stations has recently been converted from open top dump trailers to enclosed compactor trailers (2) also having a capacity of 30 m^3. After 6 months of operation the compactor trailers deliver between 14 to 17 tonnes to the landfill, or densities of 470 to 570 kg per m^3. These actual field measurement confirm a relatively low compaction ration of only 1.4:1. In addition to the compaction, the automatic loading is a distinct advantage over the open trailers which must be loaded manually.

Planning Region

The Borj Chakir landfill has been designed for the Gouvernorats of Tunis, Ariana and Ben Arous. This region currently uses the two AMTVD landfills in Henchir Lihoudia and Raoued. The new landfill and the two existing landfill are shown on the attached map of greater Tunis. The new Borj Chakir landfill is approximately 10 km (6.25 miles) from Henchir Lihoudia and approximately 30 km (18.75 miles) from Raoued. The municipality of LaMarsa, in the Governorat of Tunis is the furthest major municipality at approximately 35 km (21.88 miles). These are not large distances for collection trucks to travel. The largest change will be for those municipalities who are currently using the Raoued landfill, such as LaMarsa.

A transfer station at the Raoued landfill would help the outlying municipalities of LaMarsa, Gammarth, Sid Bou Said, and Carthage to access the new landfill at Borj Chakir. The remaining areas appear to be close enough for collection trucks to access the landfill directly.

Transfer Technology

In general, there are two types of transfer technology that would apply to the greater Tunis region, open top loading and compaction. An open top transfer station is a two level facility where waste in collection trucks, hand carts or tractor/trailers is dumped into "open top trailers" located on a lower level. One or two trailers are generally provided. Waste can also be dumped and stored on a tipping floor and pushed into the trailers with a front end loader or backhoe. Laborers or a backhoe can be used to distribute the load within the trailer. Due to the high density of the waste, and existing highway conditions transfer trailers may be limited to a maximum of 40 m^3, with a tandem axle.

This type of system has many advantages. Trailers of different designs and capacities can be used. The tractor used to haul the trailers to the landfill is a typical semi tractor used throughout Tunisia. If the hauling is privatized, there are many companies in the Tunis region who would compete for the tender. Construction and operating costs are considerably lower than for a comparable compaction station.

Compaction stations also use a two level facility but instead of dumping into an open trailer, the waste is dumped into a hopper, where a stationary compactor, forces the waste into an enclosed specially built trailer. These types of stations are generally used where compaction ratios are high and haul distances are relatively far. The efficiency is obtained through reducing the number of truck trips to the landfill. Due to the high costs of the stationary compaction units and special trailers, back-up units are expensive and sometimes not provided.

Due to the high initial density, low compaction ratio, and relatively short transfer distances, a compaction transfer station is not appropriate for the greater Tunis region and open top transfer trailers should be the only technology considered for the regional transfer stations.

Conclusions and Recommendations

The following recommendations are made based on the above discussions and our experience with similar projects in developing countries:

General:

Based on limited data from the local Tunis transfer stations, compaction ratios for Tunisian waste are relatively low in the 1.5:1 range compared to western waste ratios of 3:1..

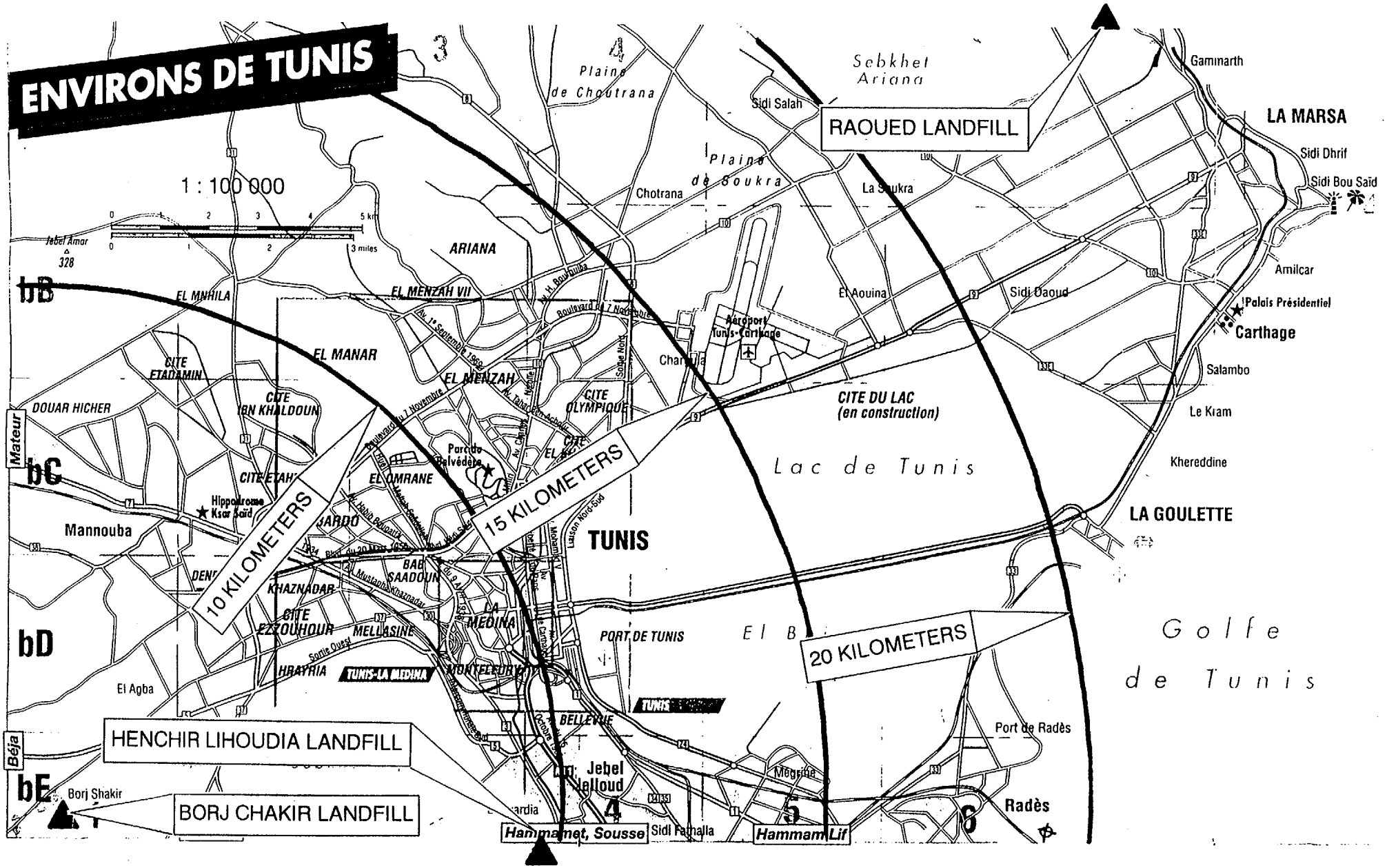
The high density of Tunisia waste and truck axle loadings may limit the size of transfer trailers used in Tunisia.

All municipalities should be encouraged to upgrade their collection trucks to rear loading compactors of 16 and 18 m^3. These larger trucks will be more efficient at transporting waste over longer distances and can drive direct to the landfill.

All municipalities using hand carts or small tractor/trailer should develop local transfer stations similar to those used in Tunis, using 30 m^3 open trailers, or compactor trailers.

One regional transfer station is recommended for the existing Raoued landfill, 400 to 600 tpd. All other municipalities should be required to drive directly to the new landfill.

The Raoued transfer station should be of the open top trailer design using maximum 40 m^3 trailers. If larger trailer are considered they should have three axles and be constructed of lightweight materials.


ENVIRONS DE TUNIS
1 : 100 000
0 1 2 3 4 5 km
0 1 2 3 miles
Jebel Amar
328
Plaine de Choutrana
Sebkhet Ariana
Sidi Salah
RAOUED LANDFILL
Plaine de Soukra
Chotrana
La Soukra
Gaminarth
LA MARSA
Sidi Dhrif
Sidi Bou Saïd
ARIANA
EL MNHILA
EL MENZAH VII
Av. 1er Septembre 1956
Av. H. Bourguiba
Boulevard du 7 Novembre
Aéroport Tunis-Carthage
El Aouina
Sidi Daoud
Amilcar
Palais Présidentiel
Carthage
EL MANAR
CITE ETADAMIN
EL MENZAH
CITE OLYMPIQUE
Charguia
CITE DU LAC (en construction)
Salambo
DOUAR HICHER
CITE IBN KHALDOUN
Av. Taieb Mehiri
Av. Cartage
Sortie Nord
Le Kram
Mateur
bC
Parc du Belvédère
CITE ETAH
EL OMRANE
Lac de Tunis
Khereddine
Hippodrome Ksar Said
Mannouba
10 KILOMETERS
15 KILOMETERS
TUNIS
LA GOULETTE
Av. Habib Bourguiba
Av. Mohamed V
Liaison Nord-Sud
Av. de la Liberté
Av. de Carthage
Av. Mustapha Khaznadar
BAB SAADOUN
KHAZNADAR
CITE EZZOUHOUR
MELLASINE
LA MEDINA
PORT DE TUNIS
El B
20 KILOMETERS
Golfe de Tunis
bD
Sortie Ouest
HRAYRIA
TUNIS-LA MEDINA
MONTFLEURY
TUNIS
El Agba
BELLEVUE
Port de Radès
HENCHIR LIHOUDIA LANDFILL
Béja
bE
Borj Shakir
BORJ CHAKIR LANDFILL
Jebel Jelloud
Megrine
Radès
Hammamet, Sousse
Sidi Fathalla
Hammam Lif
4
5
6

Landfill Closure and Post-Closure

Technical Specifications

TECHNICAL SPECIFICATIONS
LANDFILL CLOSURE AND POST-CLOSURE

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1.0 INTRODUCTION

1.1 General

Solid Waste generated in Tunisia's 257 municipalities is placed in open dumps and landfills of various sizes and configurations. These dumping areas and landfills are generally uncontrolled and the potential sources of pollution,,visual impairment or both. The government of Tunisia (GOT) has committed to a long range program of upgrading solid waste disposal sites by closing or rehabilitating existing dump sites, and by the construction of 27 regional controlled landfills. Both the existing dump sites and the new proposed landfills will require proper closure and post closure monitoring to insure that they will not be the source of pollution or visual impairment in the future. This report will present the Technical Specifications and related issues for closure and post-closure of these sites.

1.2 Goals for Closure and Post-Closure

The general goal for proper closure of waste disposal sites is to reduce or eliminate the visual impacts of the site, and to reduce potential environmental contamination to air, surface water and groundwater resources. The primary means of meeting these goals is the placement of final cover soil over the completed landfill. Secondary closure procedures are also required to insure that these goals continue to be met in the future. Since site characteristics and weather patterns will vary throughout Tunisia, the design and placement of the final cover soil and post-closure procedure will also vary.

1.3 Pollution Factors

After a dumping site or landfill has stopped accepting waste for disposal, the primary pollution factor will be the control of rainwater or surface water entering the landfilled waste. It is this external source of water, added to the organic waste which causes the waste to decompose forming both methane gas and leachate. Organic waste decomposition begins when moisture content rises above 40% and is at its maximum as the moisture content approaches saturation (100%). At moisture contents below 20%, organic decomposition essentially stops. Since typical waste in Tunisia contains 50% moisture, all dumping areas and landfills will produce some leachate and methane initially. In most open dumping areas, without significant cover, the waste will quickly dry to below the 20% moisture and decomposition stops.

The primary goal of any closure plan is to reduce the amount of water that reaches the landfilled waste to below 20%. The major function of the cover soil is to absorb and evaporate rainwater to prevent it from entering the waste. In areas with higher rainfall, the cover soil should have a low permeability which causes a portion of the rainwater to run off, while the water that is absorbed can evaporate during non-rain periods. Grasses or other small shallow rooted plans are beneficial in removing water from the cover soil.

1.4 Tunisian Weather Patterns

Tunisia's is generally regarded as a semi-arid country with relatively low amounts of rainfall. Rainfall will vary significantly, with higher amounts in the north and along the coastal zones. Rainfall, in general, is significantly lower in the southern and inland areas. Most of Tunisia's population and waste generation is located in the major cities along the coastal zones. As an example of the wide variation in rainfall, the following table summarizes rainfall amounts in 1995 and 1996 for several Tunisian cities. 1995 was considered a very dry year, while 1996 was slightly wetter than the average.

CITY	1995		1996	
	mm/year	inches/year	mm/year	inches/year
Tunis	264	10.4	577	22.7
Bizerte	516	20.3	763	30.1
Gafsa	84	3.3	158	6.2
Tozeur	132	5.2	94	3.7
Gabes	216	8.5	159	6.3
Sfax	144	5.7	233	9.2
Monastir	156	6.1	319	12.6
Nabuel	348	13.7	608	24.0

In addition to low rainfall, average daily temperatures are high and relative humidity is low during non-rain period. These two factors combined form a high evapotranspiration index, which is a measure of the soil's ability to release moisture through evaporation or plant growth. Although specific calculations have not been performed, it is estimated that the evapotranspiration index in most areas of Tunisia is well above 800 mm per year. Therefore a 50 to 60 cm layer of soil placed over the completed waste should be adequate to prevent rainwater from entering the waste, through evapotranspiration.

2.0 SITE CHARACTERISTICS

2.1 General

Before considering the closure of a dumping or landfill site, its characteristics should be defined. The closure and post-closure specifications are then determined based on these characteristics.

2.2 Waste Type

The types of wastes received will effect the extent of the closure and post-closure specifications. If the site has received only demolition and construction waste or other non-organic waste, an extensive closure is not required. However, if the site has received industrial or other hazardous

4'

waste in a addition to common domestic waste, a more detailed plan should be implemented to ensure that leachate formation is reduced and does not migrate to surface or ground water.

2.3 Slope

A properly designed and operated landfill should have slopes which are no less than 5% nor greater than 33% (3:1). Finished slopes which are less than 5% may result in low areas or pockets, allowing rainwater to pond, which may cause it to infiltrate the landfill. Ponded water also creates breeding areas for mosquitos or other insects. The final slope must also consider the fact the waste will subside as it decomposes, as much as 20%. With the limited moisture available to promote this decomposition, the subsidence will be very slow.

A slope which it greater than 33% may result in excessive erosion during rainfall. If the completed landfill contains slopes which are outside of the above limits. It should be re-graded before the cover soil is applied.

2.4 Intermediate Cover

A properly constructed landfill will have intermediate cover of about 30 cm. If this has been placed, the quality of the intermediate cover should be assessed. If it is of good quality, such as fine grained sand, silt or clay, it can serve as a portion of the final 60 cm cover, thus reducing the final cover requirements. If, however, the intermediate cover is of poor quality such as demolition material or coarse gravel, it should not be considered as part of the final cover soil.

Unfortunately, most of the existing dumping sites have received only minimal cover, or no cover at all, and must receive the full 60 cm of final cover soil.

2.5 Surface Water Control

Surface water from rainfall runoff or drainage ditches should not be allowed to run onto or into the completed landfill. This will promote leachate and gas formation in the landfill. If surface water is not controlled on the site, diversion ditches should be incorporated into the final closure design to divert all surface water away from the landfill. Many former landfills have been placed in ravines or valleys. Care should be taken during the closure to divert water around the landfilled areas.

2.6 Soil Types

The soil type under the landfill and the soil available for covering the landfill are important aspects for the closure plan. If there is a great depth of soil (10 plus meters) of good quality soil (silt or sandy clay) between the bottom of the landfill and groundwater, then any leachate formed from a domestic waste landfill should be of little concern since the soil will have a low permeability and will filter any leachate that may be produced. If, however the base soil under the landfill is dense

clay with a very low permeability, leachate may run out of the landfill over the surface rather than seep into the soil. This is a potential pollution source for nearby streams or ponds. This is the current situation with the Henchir Lihoudia and Raoued landfills in Tunis

The soil used for final cover should be a fine grained soil with enough organic content to support vegetative growth. Permeability should be less than 1×10^{-5} cm/sec. This will promote much of the rainwater to run off while absorbing the remaining water for later evaporation. If this soil does not exist on the site, other sources of final cover soil should be investigated. The quality of the final cover soil is more important in the northern landfills with higher rainfall amounts than for the southern landfills with low annual rainfall.

Some dumping sites in Tunisia have been located in rock quarries, where there is no soil under the waste. Leachate produced in the waste will enter cracks in the bedrock and travel long distances which may contaminate groundwater. These sites should be covered with a high quality soil to eliminate or reduce leachate generation to the lowest amount possible. New landfills should not be permitted in quarries or other areas on bedrock.

2.7 Erosion Potential

Each completed landfill should be evaluated for its erosion potential from both water and wind. A closed landfill will continue to decompose for up to 30 years or longer. The final cover soil must remain intact and functional during that period and should not be susceptible to wind or water erosion. Topography, wind direction, surface water control, soil types will all have an impact on the site's erosion potential. In order to reduce the erosion potential of the site, the closure plan should consider tree plantings as wind breakers, vegetative plantings on the final cover and lining of drainage ditches.

Given Tunisia's topography, soils and weather conditions it will not be possible to eliminate all potential erosion. Therefore, post-closure specifications should include periodic inspections and maintenance of the covered landfill. The frequency of a post-closure inspections will depend on the site's erosion potential.

2.8 Groundwater Quality

Much of the groundwater in Tunisia is salt water of little or no value for domestic or agricultural use. In general, the major population centers in Tunisia obtain their drinking water from surface reservoirs located in the mountains. If possible, the quality of the groundwater under the landfill, and its depth below the surface should be determined. If the groundwater is greater than 10 meters below the surface and is saline, there should be little concern with groundwater contamination during the closure. New landfills should be located in areas of saline groundwater, if possible.

2.9 Other Environmental Issues

Each site to be closed should be evaluated for other potential environmental impacts. These may include adjacent wetlands, a nearby school or village or an historical site. Regardless of other site characteristics, these potential impacts may require a higher quality of closure.

3.0 LEACHATE CONTROL

Every landfill that has received organic waste has the potential of producing leachate which can contaminate surface or groundwater. Since most of Tunisia's existing dumps and landfills have been built without controls, the moisture content of the waste will most likely be above 20% and some leachate is being produced. In southern sites with relatively low annual rainfall and high evapotranspiration, the leachate generation will be minimal and of little concern. In northern coastal sites with higher rainfalls, significantly more leachate will be produced. Although a well designed and installed closure will effectively eliminate the addition of more water to the landfill, the landfill will continue to produce leachate for many years after closure. As water and leachate in the landfill drains to the bottom of the landfill, the leachate production should decrease.

Several of Tunisia's larger landfills produce significant quantities of leachate which may be collected or controlled in some manner. These landfills will continue to produce leachate after closure for many years and the leachate controls must be maintained as part of the post-closure care. The closure of an existing site also presents the opportunity to install leachate controls where none have existed previously. This would be the case where the landfill is located in dense clay and leachate is flowing horizontally out of the landfill and entering surface waters. In this case the closure plan should include collection trenches to collect the leachate and divert it to an evaporation/holding pond. After placing the final cover, the leachate flow should gradually decrease over a period of several years. When the leachate flow has stopped, the trenches and holding pond could be filled in.

4.0 LANDFILL GAS CONTROL

Landfill gas is also a by-product of the decomposition of organic waste material and is affected by the same variables, namely moisture content. Landfill gas is a concern during closure because it contains methane which is produced during the decomposition of the waste. Methane gas is explosive at concentrations greater than 5%.

During the active life of a landfill, landfill gas which is formed, escapes through the uncovered waste into the atmosphere. If the final soil cover on the landfill is a low permeability silt or clay, the gas can no longer escape to the atmosphere and may collect under the clay cover soil. This build-up of gas under the clay cover can cause the gas to migrate off-site. In some instances, gas can flow along geologic formations or utility trenches for several hundred meters from the landfill. This gas can kill vegetation and can cause explosions in building foundations near the landfill resulting in personal injury or loss of life.

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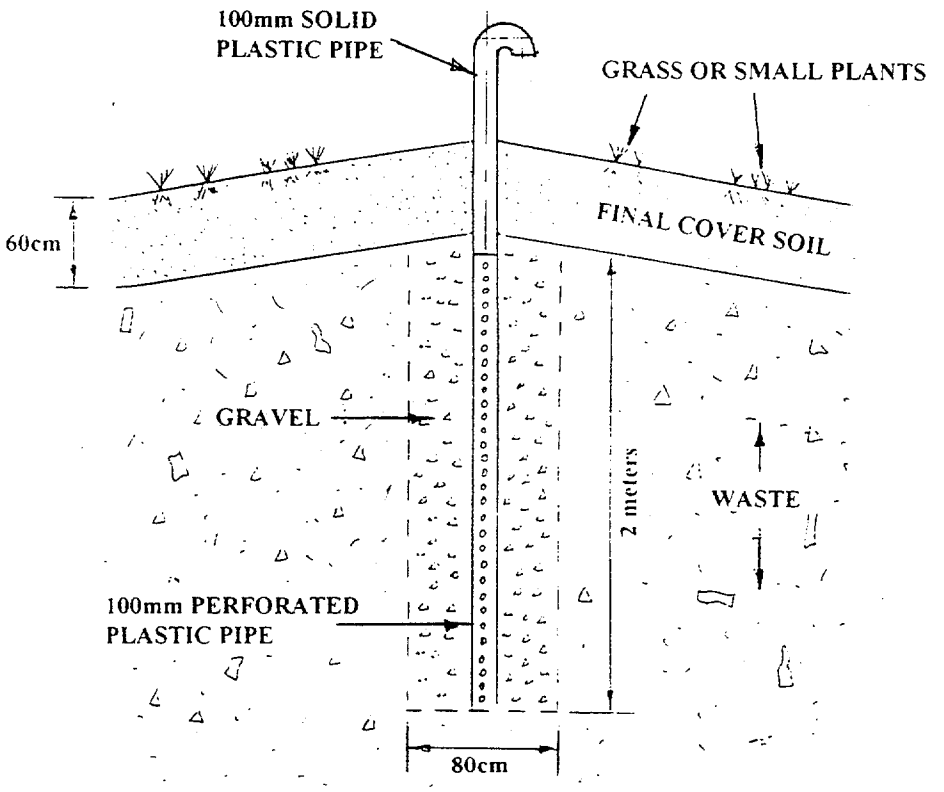
The closer plan must evaluate the potential of landfill gas generation, its release from the landfill and any potential buildings or homes which may be impacted by the gas.

In general, closed landfill sites in the south, with annual rainfall below 300 mm per year, and who use a sandy permeable final cover soil should not have a problem with landfill gas. Landfills in the north and along the coast, with higher rainfalls and less permeable final cover soil should consider installing vents in the final cover soil to allow the gas to escape to the atmosphere. As with leachate, the volume of gas produced will decrease over time, as water drains from the landfill and moisture levels decrease below 20%.

A typical gas vent includes a horizontal perforated collector pipe located in the waste just under the final soil cover. A vertical riser pipe is connected to the collector pipe extending through the cover soil to the atmosphere. In practice, any opening left in the final cover soil will allow gas to escape to the atmosphere. Since landfill gas is lighter than air, gas will migrate to the top of the covered landfill, gas vents should be located at the high points of the closed landfill. A typical gas vent is shown in Figure 1.



FINAL CLOSURE AND GAS VENT

The requirement for gas venting should be evaluated during the closure planning and should consider the volume of waste in the landfill, the estimated moisture content of the waste at closure, annual rainfall, quality of the cover material, and land use adjacent to the landfill that might be impacted by migrating landfill gas.

5.0 PROCEDURES FOR LANDFILL CLOSURE

5.1 Closure Plan

Prior to closing any landfill or open dump, a closure plan should be prepared. As a minimum, the plan should include a site inspection, definition of the site characteristics discussed in Section 2.0, an estimate of the area to be covered, and a determination whether gas venting will be necessary. If final cover soil is not available on-site, the plan should locate a suitable source of this soil within a reasonable distance of the landfill. Larger landfills should perform a topographic survey, complete a topographic map and cover designs to insure that all closure objectives are met.

5.2 Topographic Mapping

A topographic map should be prepared to determine the extent of the area to be covered, existing grades and slopes, location of all facilities, location of surface waters and site access for post closure inspection and maintenance.

5.3 Closure Design

The closure design is based on the topographic map and should include the following:

- Areas requiring regrading or fill
- Limits of area to be covered
- Surface drainage
- Erosion control
- Gas control
- Leachate control
- Access control
- Estimate of cover soil volume (m^3)

5.4 Cover Placement

Cover soil placement begins with re-grading the site, if required, to meet minimum slope conditions. If methane vents are required they can be installed prior to placing the final cover soil, or after. In general, the cover soil should be applied in two layers, each being 30 cm in thickness. Each layer should be spread and compacted with a track mounted bulldozer. To obtain maximum compaction and low permeability, water should be added to the soil during spreading and

compaction. If the soil is spread and compacted without sufficient moisture it will remain loose and highly erodible.

The final aspect of cover placement is planting of grass or other shallow rooted plants. This may be a difficult task considering Tunisia's weather and rainfall patterns. Planting and establishing growth in the southern regions may be particularly difficult. If plant growth cannot be maintained, the site will be more susceptible to erosion and must be inspected and maintained on a more frequent basis.

6.0 ENVIRONMENTAL MONITORING

Many of Tunisia's existing and future landfills will have a potential for environmental impacts. The closure plan should address these issues and propose a program for monitoring these impacts during the post-closure period. The most common environmental monitoring is quality of groundwater or surface water. Samples from groundwater test wells and surface water should be collected at least annually and tested for typical leachate parameters (Fe, Mn, BOD, COD, Specific Conductance, Ph). This should be continued for several years until a base line is established, after which the frequency could be decreased. If the landfill is equipped with gas vents, they also should be tested periodically for methane concentration. The closure plan should include a program of periodic monitoring and reporting to the appropriate regulatory agency. If these tests determine that the situation has deteriorated, then the closure should be re-evaluated and corrections made.

7.0 POST CLOSURE USES

Former landfills are very limited in their post-closure uses. Since the waste will continue to decompose and settle for 30 years or more after closure, the sites are not suitable for building construction. Typical uses include green space areas, golf courses, or non-tillable farming. Since the soil cover and plant growth are important aspects of controlling the water entering the landfill, they should not be disturbed and therefore closed landfills are not suitable for most agricultural applications.

It is possible to grow trees on the landfill but only with special procedures. The landfilled waste under the final soil cover will contain landfill gas consisting primarily of methane and carbon dioxide, and generally void in oxygen. Methane gas is toxic to most plant varieties and will kill plants whose roots extend beyond the 60 cm of the cover soil. Therefore if trees are to be planted on a closed landfill, the depth of cover soil must be increased to accept the longer tree roots. The fact that landfill gas kills trees is an indicator for off-site migration of gas. If trees or other plants adjacent to the landfill are dying, it is a sign that gas is leaving the site.

8.0 POST-CLOSURE MAINTENANCE

As mentioned above, a closed landfill may continue to be a potential source of pollution for 30

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years or more, until all of the organic matter has decomposed. Therefore, the final closure soil and related items should be maintained during that period. In addition to continuing the environmental monitoring program, the post-closure maintenance should include periodic inspections, at least once per year, and maintenance and repair of any erosion to the final soil cover. If the site is more susceptible to erosion it should be inspected more frequently, especially after heavy rainfalls.

9.0 SUMMARY

All waste dumps and landfills in Tunisia have a potential of producing contamination from leachate and methane gas. This potential will vary, based on many factors including weather patterns and site characteristics. In general, sites in the south and inland with annual rainfall below 200 to 300 mm per year should have a very low potential for leachate and gas generation and closure should concentrate on covering the waste with soil and eliminating visual impacts. Due to the limited rainfall and difficulty in establishing plant growth, these sites will be subject to wind and water erosion and require frequent inspection and repair.

Northern and coastal sites, with annual rainfall above 500 mm per year will require a higher level of closure including low permeability cover soils and gas vents. Potential environmental impacts to surface and ground water resources should be defined and included in the closure plan.

Borj Chakir Landfill

Technical Observations

BORJ CHAKIR LANDFILL
TECHNICAL OBSERVATIONS

Capacities

The capacity of the new landfill has been estimated at approximately 8,000,000 cubic meters, using the final contours presented in the April 1997 operating plan prepared by USAID consultants. Total waste generation estimates for the Grand Tunis region were estimated in the PROGNADES feasibility reports. These estimates included an estimated 570,000 tonnes per year in 1997 (1,561tpd), increasing by approximately 4% per year thereafter. Due to many variables, it is not certain when the new landfill will begin receiving waste or how much of the region will actually use the new landfill. In order to plan for the future, it would be helpful to know the lifespan of the new landfill under various scenarios.. For this purpose we have prepared a computer spreadsheet estimating the landfill capacities at various capture rates of 100, 75 and 50 percent. Individual spreadsheets are included at the rear of this report and are summarized as follows:

Capture Rate	Life Span
100%	8 years
75%	10.5 years
50%	14.2 years

The individual spread sheets assume an in-place landfill waste density of .75 tonnes per cubic meter and a cover volume of 15% of total volume.

Leachate Management

The new landfill has a standard leachate collection system composed of a network of perforated plastic collection pipes. The pipe perforations are slots, cut in the pipe around part of the circumference. These slots are very narrow and may be subject to plugging. Leachate from this landfill will be minimal, but will be concentrated due to the low rainfall and high organic content of the waste. The strong leachate will likely promote biological activity within the leachate and surfaces which contact the leachate. Early experience in the United States has indicated that this leachate biological activity can clog fine sand soil and filter fabric that was used to encase early leachate collection systems. Collection systems are now designed so that the main pipes can be cleaned with a high pressure jet cleaner in the event that they become clogged. Based on the Borj Chakir design, only the main collector pipes can be cleaned between the storage pond and the control manholes. Consideration should be given to extending some of the secondary collection pipes to outside the landfill so they can be cleaned. Access to the leachate collection control manholes should be maintained as long as possible between phases 1 through 4 so that cleaning can be performed if required.

The amount of leachate produced by the landfill may be minimal. This is the result of the relatively low annual rainfall and high evapotranspiration index. If the landfill is properly operated,

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especially the placement of cover soil, the leachate generation should be low. Waste placed in the landfill will have an initial moisture content of 50%, but will not produce significant leachate until the waste nears saturation. If no additional water reaches the waste, very little leachate will be produced over the long term life of the landfill. Several computer models are available to predict leachate generation based on waste type, cover soil, rainfall and average daily temperature.

Rainwater Drainage System

In addition to the leachate collection system, there is also a separate system to drain rainwater from the unused phases of the landfill. As each new phase is activated, it is disconnected from the rainwater system and connected to the leachate system. The 600 mm concrete pipe is located at the low point of the landfill, about 1 meter below the main leachate collection pipes. The specifications call for the rainwater drain to be backfilled and sealed with clay to isolate it from any leachate that may form in the landfill. This construction method will be an effective seal only if the clay is moist when backfilled around the concrete pipe and it is compacted in place. If the concrete rainwater drain was backfilled with dry clay soil, a water tight seal will be difficult to obtain. There is a significant potential that leachate will leak into the rainwater drain at some point during the life of the landfill. The rainwater drain should be monitored frequently for signs of leachate.

Wind Blown Debris

The landfill is subject to frequent high winds and wind blown debris. The site is open, without trees or topographic features to reduce wind and catch debris. The owner should consider planting trees around the landfill as a wind break and debris collector, or installing permanent fencing around the site.

Equipment

The major mobile equipment to be supplied to operate the landfill includes 2 landfill compactors, 3 bulldozers, one rbber tire loader and three dump trucks. We would recommend that one of the bulldozers be changed to a tracked excavator to assist in excavation of additional on-site cover soil. This soil is dry, hard packed clay, and a rubber tire loader may not have the ability to excavate this soil.

During our field visit, we were informed that the bulldozers would be equivalent to a Catapillar D9 but our review of the specifications (November 1996) indicates that an equivalent D7 is actually specified. The D7 is the appropriate selection for this application. A D9 would be too heavy and too slow to operate on solid waste. If possible, the bulldozers should be equipped with a high driver to avoid fouling with waste.

Equipment Access Road

The existing access road is built for rubber tired trucks delivering waste to the landfill. The bulldozers and landfill compactors should not use this road to travel between the maintenance and

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repair depot and the active face of the landfill. They would quickly destroy this road, especially the compactors with their steel wheels. A separate equipment road should be constructed for this purpose.

Cover Material

It has been estimated that approximately 180,000 m^3 of cover soil has been stockpiled on the site as the result of the initial construction. A review of the landfill capacity spreadsheets indicates that approximately 1,200,000 m^3 will be needed over the life of the landfill, assuming a 15% cover ratio. The existing stockpile should last only between 1 and 3 years. The owner should begin designing the next section of the landfill so that the operator has a plan for excavation of on-site cover soil, when the current stockpile is depleted.

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LANDFILL CAPACITIES @100 % CAPTURE

Year	Tonnes per year	Landfill 100%	Tonnes per day	Cu.meters per year	Cover (15%)	Total LF Volume	Cumulative LF Volume	Cumulative Cover
1997	569,890	569,890	1,561	759,853	113,978	873,831	873,831	113,978
1998	584,707	584,707	1,602	779,610	116,941	896,551	1,770,382	230,919
1999	607,788	607,788	1,665	810,383	121,558	931,941	2,702,323	352,477
2000	631,779	631,779	1,731	842,372	126,356	968,728	3,671,051	478,833
2001	656,718	656,718	1,799	875,623	131,344	1,006,967	4,678,018	610,176
2002	682,641	682,641	1,870	910,187	136,528	1,046,716	5,724,734	746,704
2003	709,587	709,587	1,944	946,116	141,917	1,088,033	6,812,767	888,622
2004	737,597	737,597	2,021	983,462	147,519	1,130,982	7,943,748	1,036,141
2005	766,712	766,712	2,101	1,022,283	153,342	1,175,625	9,119,374	1,189,484
2006	796,977	796,977	2,183	1,062,636	159,395	1,222,031	10,341,405	1,348,879
2007	828,436	828,436	2,270	1,104,582	165,687	1,270,269	11,611,674	1,514,566
2008	861,138	861,138	2,359	1,148,184	172,228	1,320,411	12,932,085	1,686,794
2009	895,130	895,130	2,452	1,193,506	179,026	1,372,532	14,304,618	1,865,820
2010	930,464	930,464	2,549	1,240,618	186,093	1,426,711	15,731,329	2,051,912
2011	967,192	967,192	2,650	1,289,590	193,438	1,483,028	17,214,357	2,245,351
2012	1,005,371	1,005,371	2,754	1,340,495	201,074	1,541,569	18,755,926	2,446,425
2013	1,045,056	1,045,056	2,863	1,393,409	209,011	1,602,420	20,358,346	2,655,436

LANDFILL CAPACITIES @ 75 % CAPTURE

Year	Tonnes per year	Landfill 75%	Tonnes per day	Cu.meters per year	Cover (15%)	Total LF Volume	Cumulative LF Volume	Cumulative Cover
1997	569,890	427,418	1,171	569,890	85,484	655,374	655,374	85,484
1998	584,707	438,530	1,201	584,707	87,706	672,413	1,327,787	173,190
1999	607,788	455,841	1,249	607,788	91,168	698,956	2,026,742	264,358
2000	631,779	473,834	1,298	631,779	94,767	726,546	2,753,288	359,125
2001	656,718	492,538	1,349	656,718	98,508	755,225	3,508,514	457,632
2002	682,641	511,980	1,403	682,641	102,396	785,037	4,293,550	560,028
2003	709,587	532,190	1,458	709,587	106,438	816,025	5,109,575	666,466
2004	737,597	553,197	1,516	737,597	110,639	848,236	5,957,811	777,106
2005	766,712	575,034	1,575	766,712	115,007	881,719	6,839,530	892,113
2006	796,977	597,733	1,638	796,977	119,547	916,524	7,756,054	1,011,659
2007	828,436	621,327	1,702	828,436	124,265	952,702	8,708,756	1,135,925
2008	861,138	645,853	1,769	861,138	129,171	990,308	9,699,064	1,265,095
2009	895,130	671,347	1,839	895,130	134,269	1,029,399	10,728,463	1,399,365
2010	930,464	697,848	1,912	930,464	139,570	1,070,033	11,798,497	1,538,934
2011	967,192	725,394	1,987	967,192	145,079	1,112,271	12,910,768	1,684,013
2012	1,005,371	754,028	2,066	1,005,371	150,806	1,156,177	14,066,944	1,834,819

LANDFILL CAPACITIES @ 50 % CAPTURE

Year	Tonnes per year	Landfill 50%	Tonnes per day	Cu.meters per year	Cover (15%)	Total LF Volume	Cumulative LF Volume	Cumulative Cover
1997	569,890	284,945	781	379,927	56,989	436,916	436,916	56,989
1998	584,707	292,354	801	389,805	58,471	448,275	885,191	115,460
1999	607,788	303,894	833	405,192	60,779	465,970	1,351,162	176,238
2000	631,779	315,890	865	421,186	63,178	484,364	1,835,526	239,416
2001	656,718	328,359	900	437,812	65,672	503,484	2,339,009	305,088
2002	682,641	341,320	935	455,094	68,264	523,358	2,862,367	373,352
2003	709,587	354,793	972	473,058	70,959	544,017	3,406,383	444,311
2004	737,597	368,798	1,010	491,731	73,760	565,491	3,971,874	518,071
2005	766,712	383,356	1,050	511,141	76,671	587,813	4,559,687	594,742
2006	796,977	398,488	1,092	531,318	79,698	611,016	5,170,702	674,439
2007	828,436	414,218	1,135	552,291	82,844	635,135	5,805,837	757,283
2008	861,138	430,569	1,180	574,092	86,114	660,206	6,466,043	843,397
2009	895,130	447,565	1,226	596,753	89,513	686,266	7,152,309	932,910
2010	930,464	465,232	1,275	620,309	93,046	713,356	7,865,664	1,025,956
2011	967,192	483,596	1,325	644,795	96,719	741,514	8,607,179	1,122,675
2012	1,005,371	502,685	1,377	670,247	100,537	770,784	9,377,963	1,223,213

Terms of Reference

PIO/T No. 664-0356-3-70003

Attachment B: STATEMENT OF WORK

ARTICLE I: TITRE: SOLID WASTE PROGRAM DEVELOPMENT IV

ARTICLE II: BACKGROUND AND OBJECTIVES

In August 1993, the Government of Tunisia (GOT) and USAID signed the Capital and Grant assistance agreements for the Private Participation in Environmental Services (PPES) Program. The PPES is a joint program of the GOT and USAID to improve the coverage and efficiency of urban environmental services (eg-solid waste collection and treatment, liquid waste collection and treatment, storm sewerage and low-income land development) through increased participation of the private sector and community groups in the provision and financing of these services.

The PPES Program has $40 million of Housing Guaranty capital support to GOT programs that provide improved HG-eligible environmental infrastructure in poor neighborhoods, as a bridging mechanism until this greater private sector role begins to take effect.

The PPES Program also contains a $3.65 million Policy Component of policy analyses, institutional strengthening and pilot projects to create an enabling environment to facilitate a greater private sector role. The Policy Component consists of some ninety-five actions, set forth in the "Policy Action and Cooperation Timetable (PACT)".

The population of Tunisia's 257 cities, totalling nearly 5.4 million inhabitants, produces approximately 1.2 million tons of solid waste per year.

At present, with the exception of two semi-controlled dumpsites in Greater Tunis, all solid waste is discharged in dumps that do not meet requirements with respect to either environmental protection or control. There is no interim and daily cover, no controlled access, no compacting, and no control of water pollution.

The Tunisian authorities have now begun to attach special importance to setting up sanitary landfills and transfer stations, the latter being indispensable when the actual landfill lies some distance from the cities served.

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In this context, the National Solid Waste Management Program (PRONAGDES) has planned to create some 27 controlled landfills in Tunisia. The program envisages closing the uncontrolled dumpsites that the municipalities are currently using.

However, moving from the current system of uncontrolled dumpsites to a system of controlled regional landfills will require resources beyond the financial and technical capacities of the central and local institutions responsible for solid waste. For this reason, the GOT has decided to enlist the participation of the private sector, where there is potential for financial and technical resources for landfills.

By establishing the technical specifications for sanitary landfills, the present activity will make a definite contribution to fostering greater private-sector participation, and to improving the environment through better landfill management.

Within the context of the PPES Technical Assistance, the purpose of this Delivery Order is to furnish necessary expertise for the development of technical specifications for landfills and transfer stations.

ARTICLE III. WORK TO BE PERFORMED

The following tasks A, B, C, and D make up this delivery order:

- Task A: Technical specifications for operating sanitary landfills;
- Task B: Technical specifications for operating transfer stations;
- Task C: Technical specifications for the closure of uncontrolled dumps; and,
- Task D: Calculation of the cost of operating the Borj Chakir controlled landfill and the transfer stations that depend on it.

A. Specifications for operating a sanitary landfill

The contractor will develop technical specifications operating for a controlled landfill.

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To do so, he/she will meet with executives from the Municipal Waste Treatment and Use Agency (AMTVD), the Ministry of the Interior, the Ministry of Environment and Land Use Planning, and the other ministry departments concerned, as well as with certain private firms, to collect information regarding current methods of landfill operation.

The contractor will also review the legislation in force, and decrees or draft decrees related to the enforcement of Law No. 96.41 of June 10, 1996 concerning waste management and disposal.

Based on this information, and after diagnosing the main constraints to rational landfill operation, the contractor will prepare draft technical specifications for the operation of a controlled landfill which will include, but need not be limited, to the following elements:

- General definitions: sanitary landfill, operator, customer, etc.;
- Control of admittance: waste origin, nature, weight, etc.;
- Organization of the landfill site: boundaries, access, signs, traffic, lighting, etc.;
- Cell planning:
  - choice of burying method depending upon site topography, soil texture, groundwater table, etc.:
  - technical specifications for the cells: length, width, height, cover material, biogas exhaust, etc.;
- Conduct of the operation:
  - operating plan: identification of machinery, vehicles and equipment required to operate the landfill; required staff qualifications; working hours; etc.;
  - inspection and weighing of waste;
  - treatment of special wastes;
  - dumping, spreading, compacting, covering, etc.;
  - controlling insects;
  - maintenance of access roads and approaches, installations, machinery and vehicles;
  - safety problems;
  - keeping an operating register.
- Inspections:
  - failures and penalties;
  - handling of complaints, etc...
- Environmental controls:

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- respect for standards;
- sanitary regulations;
- respect for the surroundings;
- control of water pollution (leachates, etc.);
- control of atmospheric pollution;
- noise prevention;
- fire and explosion dangers.

- Technical specifications for final closure of the site: soil cover, retimbering, etc...

In addition, certain key points should be made clear, such as the lifetime of the operation and the respective roles and responsibilities of the operator and of the landfill's potential "clients" (municipalities or other).

The specifications should also refer to the standards proposed in the study "Sectoral Standards and Performances for Solid Waste Collection and Treatment" done by RTI/SMART in October 1995 as a technical assistance component of the PPES program.

B. Specifications for operating transfer stations

It may prove necessary to create one or more transfer stations if a landfill is located more than 20 km from a city. In general, transfer stations have a close, functional relation to the landfills. The location, nature, capacity, and general technical characteristics of a transfer station often depend on those of the landfills for which they act as a relay.

For this reason, the contractor will prepare draft specifications for the operating of a transfer station, following the same approach and methodology as those used in drafting the specifications for the operation of a controlled landfill.

The contractor will also address issues related to certain technical decisions that might be proposed, such as the transfer of uncompacted refuse, or of refuse that has been compacted and thus requires the use of a hydraulic system.

C. Specifications for closure of uncontrolled dumps

The contractor will develop technical specifications for the closure of uncontrolled dumps, and these specifications should be applicable to the various types of uncontrolled dumps that exist in Tunisia. For this the contractor should refer in particular to the study "Inventory of Uncontrolled Dumps" done by SCET-Tunisie in 1995.

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The contractor will attach prime importance to meeting with the AMTVD, which successfully rehabilitated the Henchir Lihoudia and Raoued dumps.

He will also contact any municipalities that have already begun closing uncontrolled dumps, to discuss the related constraints. The Municipality of Sousse, for example, is currently rehabilitating its dump, with assistance from ONAS.

The contractor will also meet with the concerned authorities of the Ministry of the Interior and the Ministry of Environment and Land Use Planning. Based on the information gathered from these contacts, the contractor will prepare technical specifications for the closure of uncontrolled dumps. These should, in particular, address the following issues:

- Procedures for closure, including the different technical phases to be implemented;
- Organization of the information to be given to users and to the public to prohibit access, building fences, etc...;
- Technical options to be proposed, such as whether an active or a passive gas ventilation system should be installed;
- Environmental controls;
- Definition of the service to be assured, including the documents that must be provided (topographical plans, reports);
- Post-closure plan and, if appropriate, plan for the conversion of the landfill to some other use;
- Respective roles and responsibilities of the government office involved and of the private business.

D. Operating costs of the Borj Chakir controlled landfill and of the transfer stations that depend upon it

The GOT recently undertook to build a controlled landfill at Borj Chakir. This landfill is to serve the 29 municipalities of Greater Tunis, which includes the governorates of Ariana, Ben Arous and Tunis. Borj Chakir will be relayed from three transfer stations to be set up in Raoued, Nahli and Ben Arous.

To select the most appropriate institutional framework for managing the Borj Chakir landfill and the transfer stations, the Tunisian authorities would, among other things, like to have a cost estimate for landfill and transfer station operation, and an

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estimate of the impact these costs would have on the budgets of the concerned municipalities of Greater Tunis.

To provide this, the contractor will carry out the following tasks:

- Estimate the costs of operating the Borj Chakir controlled landfill based on existing data and studies;
- Estimate the costs of operating the three transfer stations based on existing data and studies;
- Evaluate the financial impact of these operating costs on the budgets of the concerned municipalities of Greater Tunis.

Based on the above estimates, the contractor will make a certain number of recommendations that may help the authorities select the most appropriate agency for managing the Borj Chakir landfill and the related transfer stations.

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