

# Engineering Standard

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SAES-S-007

29 December 2004

## Solid Waste Landfill Standard

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## Saudi Aramco DeskTop Standards

### Table of Contents

1	Scope.....	2
2	Conflicts and Deviations.....	2
3	References.....	2
4	Design.....	3
5	Definitions.....	8
	Figure 1 - Sanitary Landfill Methods.....	12
	Figure 2 - Area Method of Sanitary Landfilling...	13
	Figure 3 - Depression Method of Sanitary Landfilling.....	14
	Figure 4 - Progressive Slope Method of Sanitary Landfilling.....	15
	Figure 5 - Trench Method of Sanitary Landfilling.....	16

## 1 Scope

- 1.1 This standard prescribes the minimum requirements for the design, site selection, operation, maintenance, and closure of Class II and Class III solid waste landfill sites located in Saudi Aramco operating areas. This standard does not apply to Class I (hazardous waste) landfill sites.
- 1.2 This standard is applicable to all new facilities and projects. Existing facilities shall be brought into compliance.

## 2 Conflicts and Deviations

- 2.1 Any conflicts between this standard and other applicable Saudi Aramco Engineering Standards (SAESs), Materials System Specifications (SAMSSs), Standard Drawings (SASDs), or industry standards, codes, and forms shall be resolved in writing by the Company or Buyer Representative through the Manager, Environmental Protection Department, Dhahran.
- 2.2 Direct all requests to deviate from this standard in writing to the Company or Buyer Representative, who shall follow internal company procedure [SAEP-302](#) and forward such requests to the Manager, Environmental Protection Department of Saudi Aramco, Dhahran.

## 3 References

The selection of material and equipment, and the design, construction, maintenance, and repair of equipment and facilities covered by this standard shall comply with the latest edition of the references listed below unless otherwise noted.

### Saudi Aramco References

#### Saudi Aramco Engineering Procedure

[SAEP-302](#)

*Instructions for Obtaining a Waiver of a Mandatory Saudi Aramco Engineering Requirement*

#### Saudi Aramco Engineering Standards

[SAES-A-104](#)

*Wastewater Treatment, Reuse and Disposal*

[SAES-B-062](#)

*Onshore Wellsite Safety*

[SAES-B-064](#)

*Onshore and Nearshore Pipeline Safety*

[SAES-M-006](#)

*Saudi Aramco Security and General Purpose Fencing*

<a href="#"><u>SAES-M-100</u></a>	<i>Saudi Aramco Building Code</i>
<a href="#"><u>SAES-O-105</u></a>	<i>Gates in Perimeter Fences</i>
<a href="#"><u>SAES-Q-006</u></a>	<i>Asphalt Concrete Paving</i>

Saudi Aramco General Instructions

<i>GI-0150.001</i>	<i>Asbestos Hazard Management</i>
<i>GI-0430.001</i>	<i>Waste Management</i>

Saudi Aramco Material Instruction

<i>CU-22.03</i>	<i>Processing &amp; Handling Hazardous Material</i>
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Saudi Aramco Sanitary Code

<i>SASC-S-03</i>	<i>Solid Waste Management</i>
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## 4 Design

### 4.1 General Criteria

4.1.1 The proponent shall provide a landfill site operating plan as part of the design package. The operating plan shall address the following:

- Landfill cell construction
- Handling and compaction of waste
- Handling of wastewater treatment plant sludges
- Handling of special wastes
- Placement of cover material
- Litter control
- Fire control
- Final closure

The Saudi Aramco Sanitary Code (Section SASC-S-03) contains general landfill operating requirements. The Saudi Aramco Building Code ([SAES-M-100](#)) addresses excavation and backfilling. The Environmental Engineering Division of Environmental Protection Department (EED/EPD) and the Environmental Compliance Division of Environmental Protection Department (ECD/EPD) can offer guidance to the designer in the preparation of an operating plan. Both EED and ECD must approve the plan prior to operation of the landfill.

- 4.1.2 Class II solid wastes shall be disposed in either a Class II or a Class I landfill. Class III solid wastes shall be disposed in either a Class III or a Class II landfill. Refer to GI-0430.001, Waste Management.
- 4.1.3 The design shall prohibit open burning and/or open dumping of waste. This prohibition includes offshore activities.
- 4.1.4 The procedure for solid waste disposal at small remote sites shall be determined on a case-by-case basis by ECD/EPD.
- 4.1.5 Clearly visible, legible signs, written in Arabic and English identifying the site as an approved landfill and stating the site rules shall be erected at the site entrance and wherever necessary to ensure adequate compliance with the approved operating plan. At a minimum, signs shall contain the following information:
- Name of the facility and proponent
  - Emergency phone number of attendant
  - Permitted materials
  - Hours of operation during which wastes will be received for disposal
- 4.1.6 Landfill space requirements shall be based on the waste generation rates shown in Table 1 and the waste density values shown in Table 2.

**Table 1 - Solid Waste Generation Rates**

Class	Generation Rates
II	6.0 kgcd
III	2.5 kgcd

**Note:** kgcd kilograms per capita per day

**Table 2 - Solid Waste Density Value**

Class	Generation Rates
II Uncompacted	136 kgm <sup>3</sup>
II Compacted	492 kgm <sup>3</sup>
III	504 kgm <sup>3</sup>

**Note:** kgm<sup>3</sup> kilograms per cubic meter

## 4.2 Class II Landfill Design Principles

- 4.2.1 Class II landfills shall be designed to prevent direct contact of the waste with surface water or groundwater. The ground around the landfill shall
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be sloped or protected so that drainage will be diverted around the operational areas of the landfill.

4.2.2 The design shall employ one or a combination of the following methods (Refer to Figure 1):

- Area Method (Refer to Figure 2)
- Depression Method (Refer to Figure 3)
- Progressive Slope Method (Refer to Figure 4)
- Trench Method (Refer to Figure 5)

#### 4.3 Class III Landfill Design Principles

Class III landfill design may allow surface water adjacent to the disposal site to contact the waste. Only Class III waste shall be placed in this landfill.

#### 4.4 Site Selection

4.4.1 The landfill Proponent shall prepare a Site Study and present it to the General Supervisor, Environmental Engineering Division for approval prior to constructing either a Class II or Class III landfill. The following items shall be included in the Site Study:

4.4.1.1 A detailed discussion of the following parameters:

- Hydrology
- Topography
- Geology

4.4.1.2 A map showing the location and existing features of the proposed site. The following features shall be plotted:

- Airport runways
  - Residences or other facilities
  - Oases
  - Roads
  - Water wells
  - Oil wells (Ref. [SAES-B-062](#))
  - Communication and power lines
  - Pipelines and pipeline corridors (Ref. [SAES-B-064](#))
  - Topography
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- Direction and flow of groundwater
- Downgradient groundwater uses
- Seasonal surface water flows
- Proposed surface water diversion structures
- Current and projected land use of proposed site
- Prevailing and seasonal wind characteristics

4.4.2 Landfills may not be located within 3.3 kilometers of any airport runway.

4.4.3 Landfills may not be located within 400 meters of residential or other facilities.

4.4.4 A Class II landfill may not be located in an area where the vertical distance between the bottom of the landfill and the maximum water table elevation may allow leachate to mix with the groundwater.

#### 4.5 Design Requirements

The design of either a Class II or Class III landfill shall be approved by the General Supervisor, EED/EPD. The design shall incorporate the following:

##### 4.5.1 Groundwater Contaminant Monitoring Wells

Provisions for groundwater contaminant monitoring wells shall be included in the landfill design package for Class II landfills. The number, location and design shall be approved by EED/EPD. Class III landfills do not require groundwater contaminant monitoring wells.

##### 4.5.2 Liner Requirements

Provisions for a liner shall be included in the design package for a Class II landfill if groundwater resources are threatened by the proposed use. The liner permeability shall not exceed  $10^{-7}$  cm/s. Other liner specifications; e.g., material and thickness shall be determined on a case-by-case basis by EED/EPD.

##### 4.5.3 Leachate and Landfill Gas Collection and Monitoring

Provisions for a leachate collection system shall be included in the design of a Class II landfill if groundwater resources are threatened by the proposed use. Provisions for landfill gas collection and monitoring shall be included in the design of a Class II landfill. The number, location and design of landfill gas monitoring points shall be approved

by EED/EPD, and shall be determined on a case-by-case basis. Ensure that the final landfill design considers effective vent points as part of the gas gathering system to remove expected methane gas buildup. Leachate control and landfill gas management are addressed in SASC-S-03.

#### 4.5.4 Fencing and Gates

Landfill sites shall be provided with a perimeter fence (Type V, Ref. [SAES-M-006](#)) with locking gates (Ref. [SAES-O-105](#)).

#### 4.5.5 Access and Site Roads

Access and site roads shall be designed to support regular heavy truck traffic. Refer to [SAES-M-100](#) for excavation, compaction, and backfilling. Refer to [SAES-Q-006](#) for asphalt paving.

#### 4.5.6 Cell Construction

Waste shall be spread on a slope no steeper than 3 horizontal to 1 vertical and compacted in layers not to exceed 60 centimeters in depth up to maximum cell height. Each layer shall be covered with not less than 15 centimeters of compacted daily cover material.

#### 4.5.7 Final Cover Material

A layer of not less than 60 centimeters of compacted cover material shall be placed over the completed fill following the final placement of waste. The final cover shall be graded to prevent cracking, erosion and the ponding of water.

#### 4.5.8 Site Utilities

Provisions for water, electrical, and sanitary services shall be made.

#### 4.5.9 Fire Protection

Fire protection equipment design and locations shall be provided in accordance with design and operating plans approved by the Chief Fire Prevention Engineer.

#### 4.5.10 Cleaning Facilities

If equipment is to be cleaned at the landfill, the following minimum facilities shall be provided: a) steam or hot water; and b) a concrete area that slopes to a holding basin or disposal system that meets [SAES-A-104](#) design requirements.

#### 4.6 Closure Requirements

- 4.6.1 Before a landfill may be closed or abandoned to further use, all waste at the disposal site shall be covered, compacted and graded according to the requirements outlined in section 4.5.7.
- 4.6.2 A maintenance program for continued control of erosion, repair and stabilization of the compacted final cover material shall be provided for a minimum of ten years to assure that the completed fill has stabilized to a point where maintenance is no longer required. At the end of the tenth year, EED/EPD will evaluate the site to determine if further maintenance is needed.
- 4.7 The Environmental Engineering Division of Environmental Protection Department (EED/EPD) and the Environmental Compliance Division of Environmental Protection Department (ECD/EPD) shall review and approve all maps, drawings, and plans for the design of solid waste landfills.
- 4.8 The Environmental Compliance Division of Environmental Protection Department (ECD/EPD) shall review and approve all site investigations and all operational plans and methods before beginning construction, modification, or operation of a landfill disposal site.
- 4.9 Untreated medical wastes and potentially infectious biological or laboratory wastes shall not be disposed in Saudi Aramco landfill facilities.
- 4.10 There are special requirements for handling and disposing of asbestos-containing wastes. These requirements are defined in GI-0150.001, Asbestos Hazard Management.

## 5 Definitions

**Area Method:** In this method of landfilling the waste is spread on the natural ground surface in a series of layers. Each layer is compacted as filling progresses. A layer of cover is placed over the completed fill and compacted. This method is used when the terrain is unsuitable for the excavation of trenches. (Refer to Figure 2).

**Class I Landfill:** Isolates solid wastes from surface water or groundwater. The site must have a stable foundation and two impermeable liners with leachate collection and removal systems. Precipitation runoff from surrounding areas must be diverted away from the site. A Class I Landfill Disposal Site must be used for the disposal of Class I hazardous wastes and may be used for the disposal of Class II biodegradable and chemically decomposable wastes and Class III inert wastes.



**Class II Landfill:** Must be above the highest groundwater elevation to prevent direct contact of the wastes with surface water or groundwater. The landfill site should have a stable foundation and provisions should be made for diversion of runoff. A Class II Landfill Disposal Site must be used for Class II wastes and may be used for Class III wastes.

**Class III Landfill:** Provides little or no protection for underlying groundwater. Surface water adjacent to the disposal site may contact the waste material. A Class III Landfill Disposal Site is for the disposal of Class III inert wastes only.

**Class I Waste (Hazardous Waste):** Wastes, which constitute a high degree of hazard to the public health and the environment. These include materials, which are flammable, corrosive, reactive, toxic, radioactive, infectious, carcinogenic, mutagenic or teratogenic. Refer to CU-22.03, Processing & Handling Hazardous Material.

**Class II Waste:** Non-hazardous solid wastes and dewatered sludges which are biologically or chemically decomposable in the natural environment. Examples include paper, dewatered digested sewage sludge, animal wastes, garbage and other putrescible wastes.

**Class III Wastes:** Non water-soluble wastes which are not biologically or chemically active in the natural environment. Examples include glass, wood, inert plastics, rubber products, brick, concrete and clay.

**Commercial Waste:** Waste material produced from commercial facilities; e.g., restaurants, stores, markets, office buildings, hotels, motels, print shops, auto repair shops and other services operations. May include food wastes, rubbish, ashes, demolition and construction wastes, and occasionally hazardous wastes.

**Construction Wastes:** Building material wastes and rubble resulting from the construction, remodeling, repair or demolition of houses, commercial buildings, pavements (e.g., roads) and other structures.

**Cover Material Soil:** (e.g., marl, clay) is used to cover compacted solid wastes in a Class II landfill. It should be free of large objects that would hinder compaction and free of organic content that would be conducive to vector harborage, feeding and/or breeding.

**Depression Method:** This landfilling method is used where natural or artificial depressions exist. Ravines, canyons, dry borrow pits and quarries are used for this purpose. Waste placement techniques vary with the geometry, geology, hydrology of the site, characteristics of the cover material and site access. (Refer to Figure 3).

**Groundwater:** Subsurface water that is in the zone of saturation. Includes confined, unconfined, and perched groundwater systems.

**Industrial Waste:** Waste from industrial processes and manufacturing operations; e. g., construction, fabrication, light and heavy manufacturing, refineries, chemical plants, mining, power plants and demolition. May include demolition and construction wastes, food wastes, rubbish, ashes and sometimes hazardous wastes.

**Institutional Waste:** Waste material originating in schools, hospitals, public buildings and research institutions. May include food wastes, paper, cardboard and certain hazardous wastes.

**Large Remote Site:** A site that services the daily disposal requirements of more than fifty (50) people and is located more than sixty (60) kilometers from a major Saudi Aramco community.

**Leachate:** Water that has percolated through solid waste or other medium, which contains dissolved or suspended materials from the medium.

**Liner:** A natural or synthetic membrane material used to line the base and sides of a landfill site to prevent leachate from seeping into underlying geological strata.

**Medical Waste:** Solid wastes that are, or potentially are, contaminated with biological fluids, including blood, fecal, tissue, and laboratory-derived wastes. Treated medical wastes that have been degraded by incineration, thermal treatment, or autoclave technologies are no longer considered medical wastes.

**Municipal Solid Waste:** Solid waste resulting from a municipality including garbage, rubbish, ashes, street cleanings, animal carcasses, abandoned automobiles, and other solid wastes other than industrial or institutional solid waste.

**Progressive Slope Method:** This landfilling method is a variation of the Area and Trench methods and is used when limited usable cover material is available on site. Cover material is excavated ahead of the working face and placed on waste, which has been spread and compacted on an existing or prepared slope. (Refer to Figure 4).

**Recreational Solid Waste:** Solid waste generated in recreational facilities such as parks, beaches, picnic areas, swimming pools, and golf courses.

**Residential Waste:** Solid waste generated in houses and apartments including paper, cardboard, beverage and food cans, plastics, food waste, glass containers and garden wastes.

**Small Remote Site:** A site that services the daily disposal requirements of fifty (50) or less people and is located more than sixty (60) kilometers from a major Saudi Aramco community.

**Solid Waste:** Solid or semi-solid discarded material, which is characterized as either municipal, residential, commercial, institutional, industrial or recreational, except sewage.

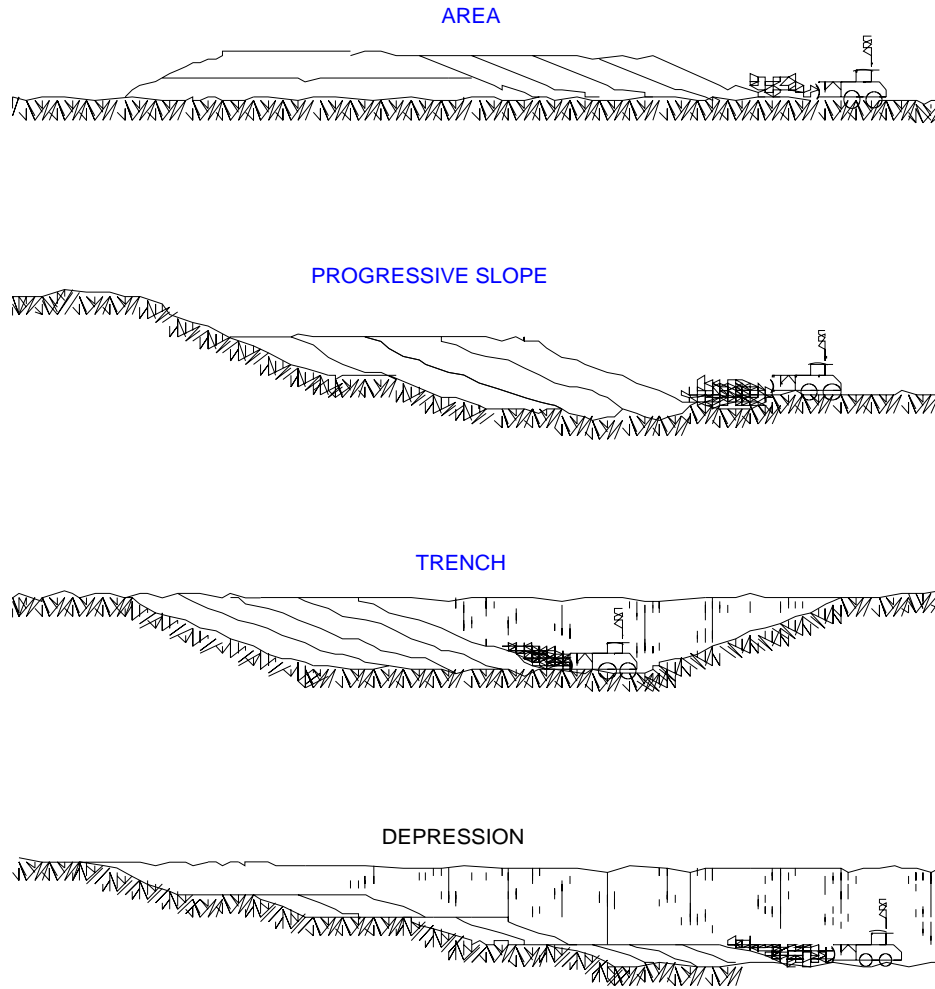
**Special Wastes:** Wastes which include dead animals, abandoned vehicles, catch basin debris, street sweepings, roadside litter, and litter from municipal containers. Because it is impossible to predict where dead animals and abandoned automobiles will be found the wastes are often identified as originating from non-specific diffuse sources.

**Trench Method:** This method involves excavating a long trench and stockpiling the earth alongside. Waste is deposited in the trench, spread and compacted in thin layers against one end of the trench and covered with a layer of earth. (Refer to Figure 5).

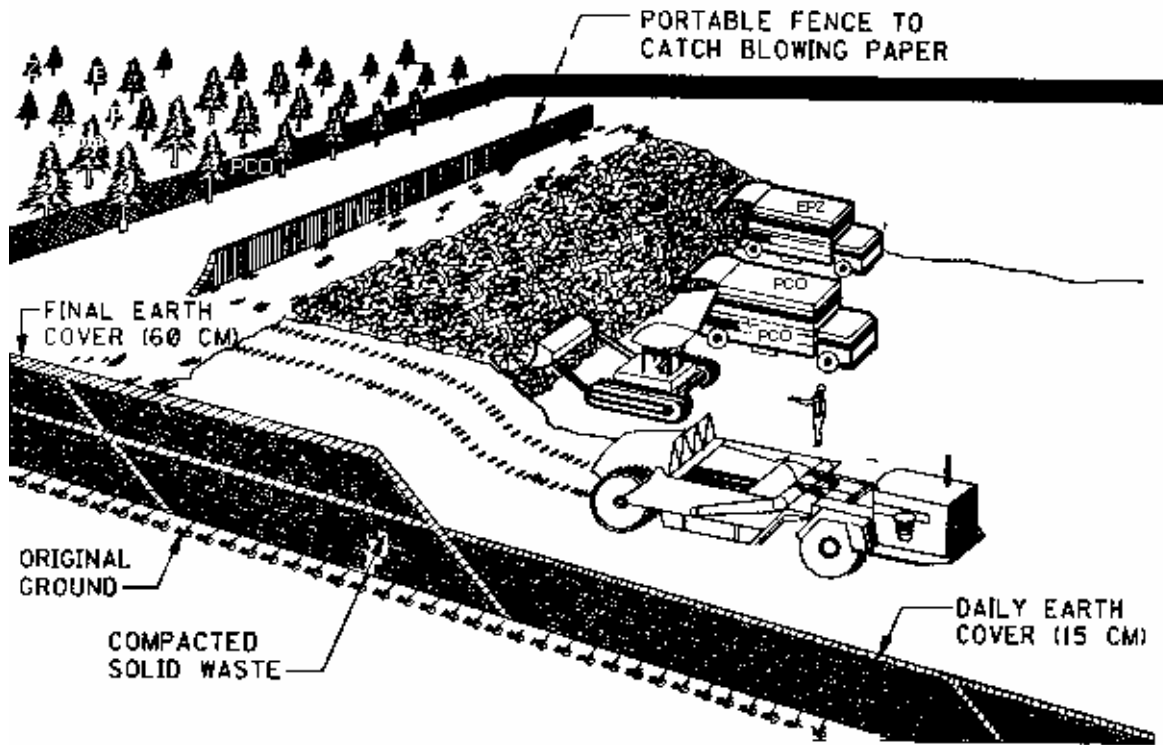
#### Revision Summary

29 December 2004

Revised the "Next Planned Update". Reaffirmed the contents of the documents, and reissued with editorial changes.



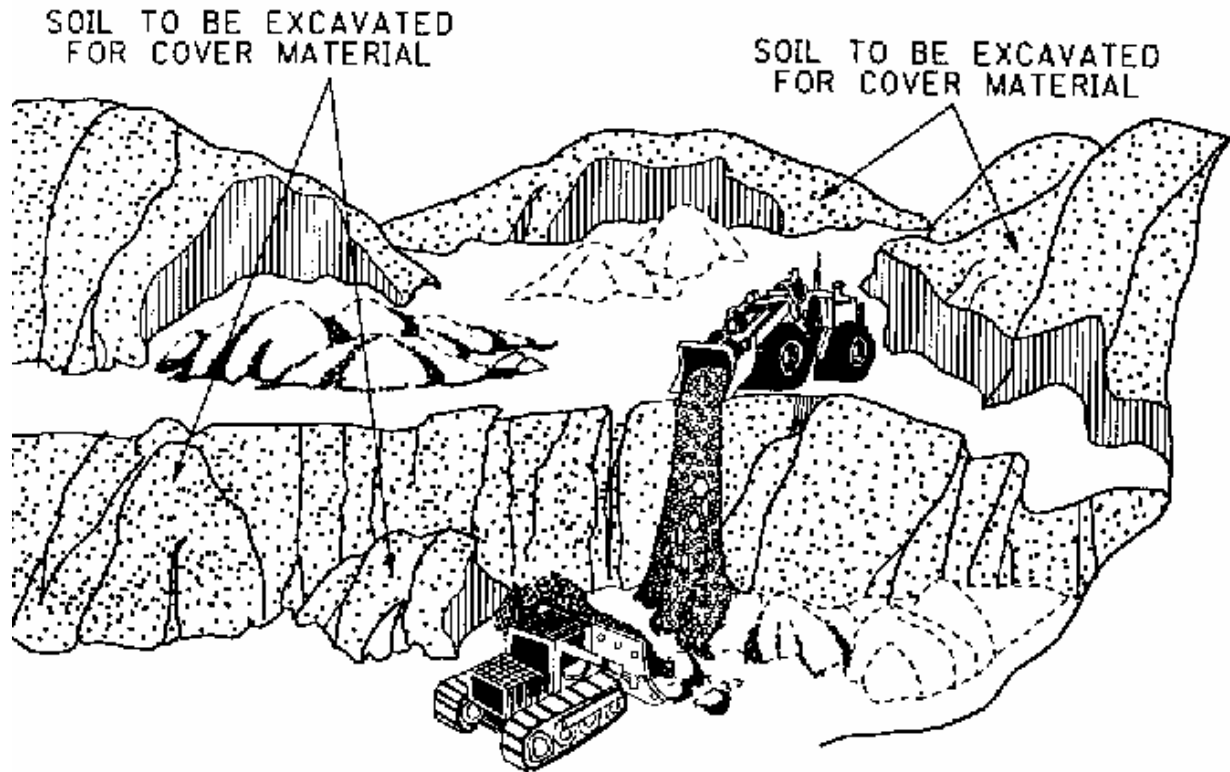
**Figure 1 – Sanitary Landfill Methods**



In the area method of sanitary landfilling the waste is spread and compacted by a bulldozer on the natural surface of the ground. A scraper is used to haul the cover material at the end of each day's operation.

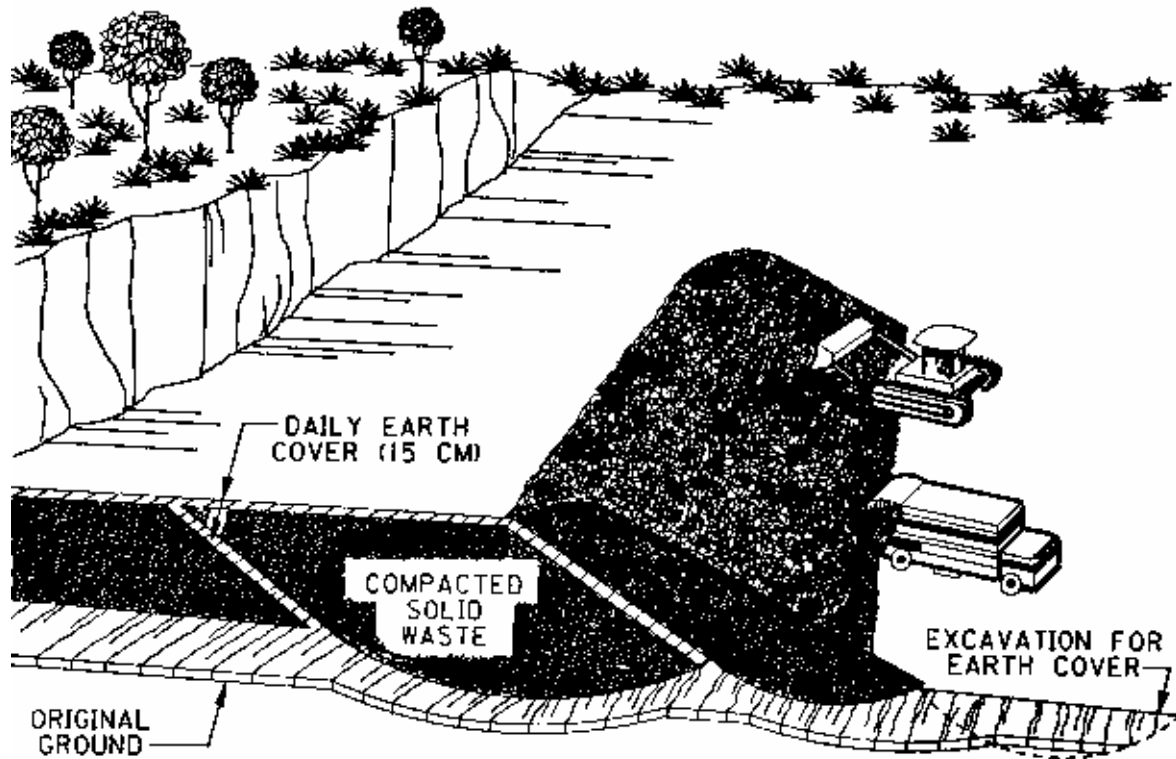
Extracted from U.S. EPA report SW-287, Sanitary Landfill Design and Operation.

**Figure 2 – Area Method of Sanitary Landfilling**



In the depression method of sanitary landfilling, solid waste is deposited in an existing natural or artificial depression such as a ravine, quarry or borrow pit. Deposited waste is bulldozed initially against the side of the depression for efficient consolidation and spread and compacted to form a slope not exceeding 1 in 3. Cover material is either hauled in or excavated from the side or floor of the depression. Filling proceeds in multiple lifts.

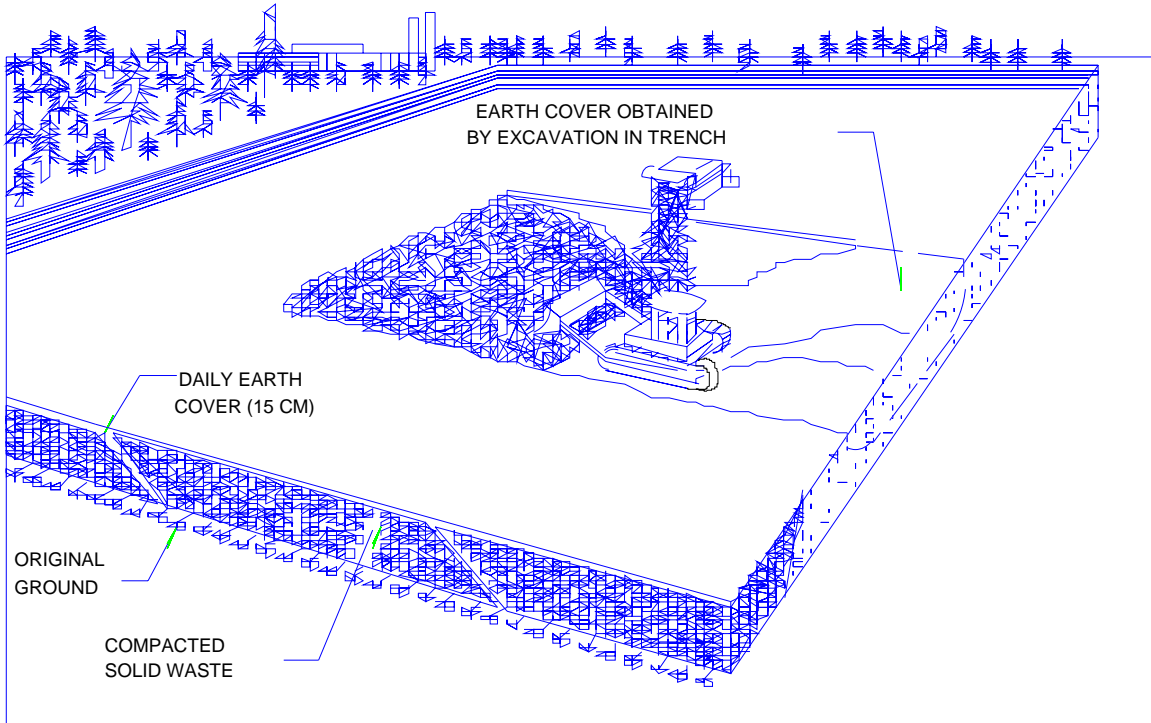
**Figure 3 – Depression Method of Sanitary Landfilling**



In the progressive slope method of sanitary landfilling, solid waste is spread and compacted on a slope. Cover material is obtained directly in front of the working face and compacted on the waste.

Extracted from U.S. EPA Report SW-287, Sanitary Landfill Design and Operation.

**Figure 4 – Progressive Slope Method of Sanitary Landfilling**



In the trench method of sanitary landfilling, collection trucks deposit their loads into a trench where a bulldozer spreads and compacts the waste. At the end of each day, the trench is extended and the excavated soil is used for cover material.

Extracted from U.S. EPA Report SW-287, Sanitary Landfill Design and Operation.

**Figure 5 – Trench Method of Sanitary Landfilling**