



# Extension FactSheet

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## Landfill Types and Liner Systems

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### Introduction

Modern landfills are highly engineered containment systems, designed to minimize the impact of solid waste (refuse, trash, and garbage) on the environment and human health. In modern landfills, the waste is contained by a liner system. The primary purpose of the liner system is to isolate the landfill contents from the environment and, therefore, to protect the soil and ground water from pollution originating in the landfill.

The greatest threat to ground water posed by modern landfills is leachate. Leachate consists of water and water-soluble compounds in the refuse that accumulate as water moves through the landfill. This water may be from rainfall or from the waste itself. Leachate may migrate from the landfill and contaminate soil and ground water, thus presenting a risk to human and environmental health.

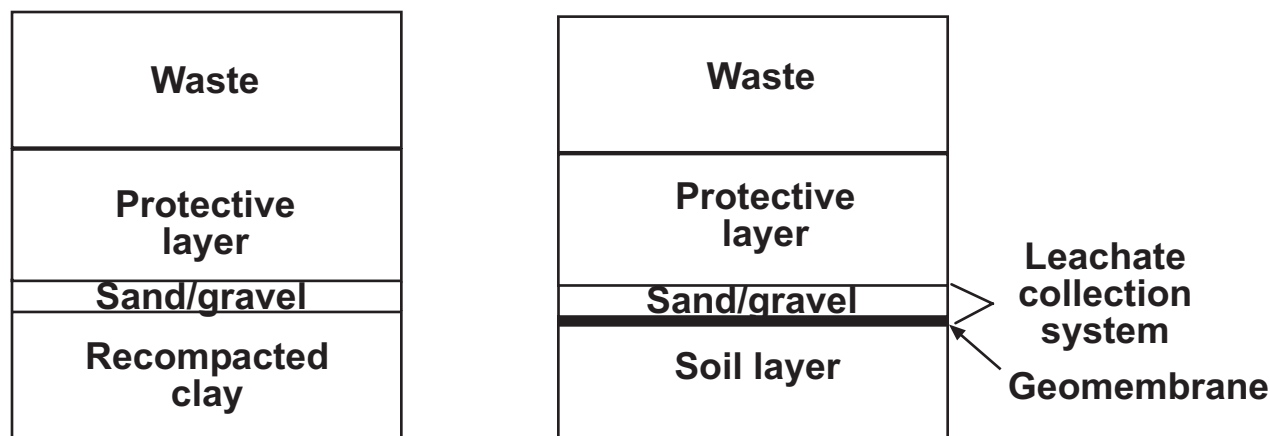
Landfill liners are designed and constructed to create a barrier between the waste and the environment and to drain the leachate to collection and treatment facilities. This is done to prevent the uncontrolled release of leachate into the environment.

Society produces many different solid wastes that pose different threats to the environment and to community health. Different disposal sites are available for these different types of waste. The potential threat posed by the waste determines the type of liner system required for each type of landfill. Liners may be described as single (also referred to as simple), composite, or double liners.

### Single-Liner Systems

Single liners (Box 1) consist of a clay liner, a geosynthetic clay liner, or a geomembrane (specialized plastic sheeting).

#### Box 1: Examples of Single liner systems



Single liners are sometimes used in landfills designed to hold construction and demolition debris (C&DD).

Construction and demolition debris results from building and demolition activities and includes concrete, asphalt, shingles, wood, bricks, and glass. The design and operation of C&DD landfills are regulated under the Ohio Administrative Code (OAC), Chapter 3745-400. Licensing requirements are addressed under OAC Chapter 3745-37. These landfills are not constructed to contain paint, liquid tar, municipal garbage, or treated lumber; consequently, single-liner systems are usually adequate to protect the environment. It is cheaper to dispose of construction materials in a C&DD landfill than in a municipal solid waste landfill because C&DD landfills use only a single liner and are therefore cheaper to build and maintain than other landfills.

### Composite-Liner Systems

A composite liner consists of a geomembrane in combination with a clay liner (Box 2). Composite-liner systems are more effective at limiting leachate migration into the subsoil than either a clay liner or a single geomembrane layer. Composite liners are required in municipal solid waste (MSW) landfills.

Municipal solid waste landfills contain waste collected from residential, commercial, and industrial sources. These landfills may also accept C&DD debris, but not hazardous waste. Municipal solid waste landfill design, construction,

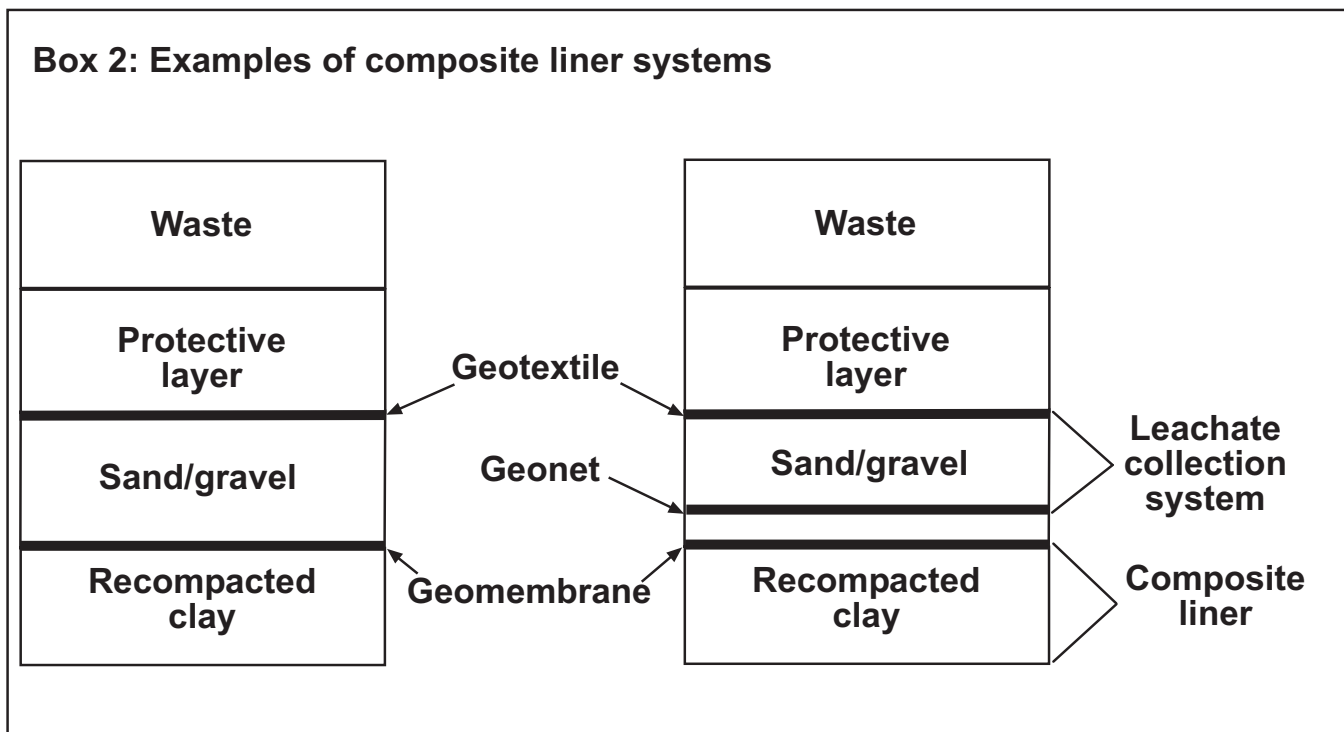
and operation are regulated by Subtitle D of the federal Resource Conservation and Recovery Act (1976) under Title 40 of the Code of Federal Regulations, Part 258 (40CFR258).

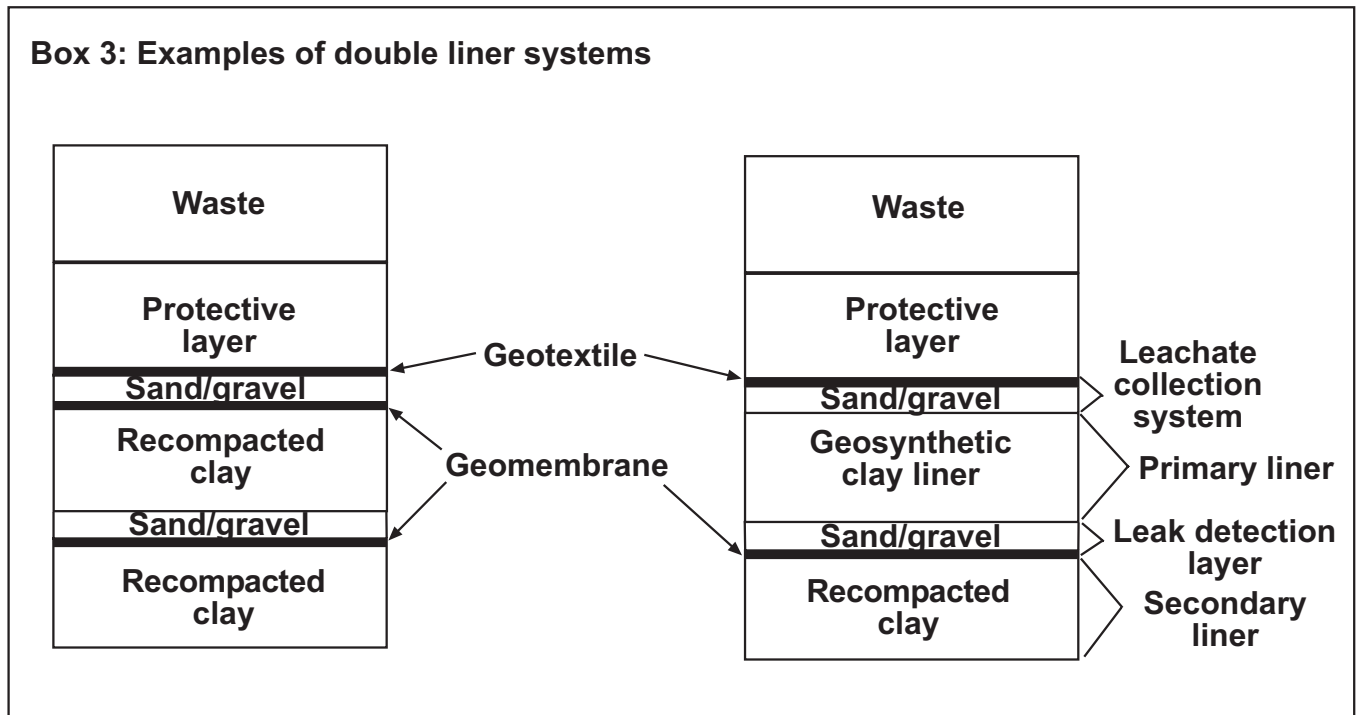
Further regulations are specified by the Ohio Administrative Code, Chapter 3745-27. The minimum requirement for MSW landfills is a composite liner. Frequently, landfill designers and operators will install a double liner system in MSW landfills to provide additional monitoring capabilities for the environment and the community.

### Double-Liner Systems

A double liner consists of either two single liners, two composite liners, or a single and a composite liner (Box 3). The upper (primary) liner usually functions to collect the leachate, while the lower (secondary) liner acts as a leak-detection system and backup to the primary liner. Double-liner systems are used in some municipal solid waste landfills and in all hazardous waste landfills.

Hazardous waste landfills (also referred to as secure landfills) are constructed for the disposal of wastes that once were ignitable, corrosive, reactive, toxic, or are designated as hazardous by the U.S. Environmental Protection Agency (U.S. EPA). These wastes can have an adverse effect on human health and the environment, if improperly managed. Hazardous wastes are produced by industrial, commercial, and agricultural activities. Subtitle C of the federal Resource Conservation and Recovery Act, 1976, under Title 40 of





the Code of Federal Regulations, Part 264 (40CFR264), provides minimum standards for the disposal and management of hazardous waste.

Further regulations are specified by the Ohio Administrative Code, Chapter 3745-57-02 through 3745-57-18. Hazardous wastes must be disposed of in hazardous waste landfills. Hazardous waste landfills must have a double liner system with a leachate collection system above the primary composite liner and a leak detection system above the secondary composite liner.

### Leachate Collection Systems

Integrated into all liner systems is a leachate collection system. This collection system is composed of sand and gravel or a *geonet*. A *geonet* is a plastic net-like drainage blanket. In this layer is a series of leachate collection pipes to drain the leachate from the landfill to holding tanks for storage and eventual treatment. In double-liner systems, the upper drainage layer is the leachate collection system, and the lower drainage layer is the leak detection system. The leak detection layer contains a second set of drainage pipes. The presence of leachate in these pipes serves to alert landfill management if the primary liner has a leak.

Components of the liner system are protected by a layer that minimizes the potential for materials in the landfill to puncture the liner. This protective layer was traditionally composed of soil, sand, and gravel, but many landfills

now use a layer of *soft refuse* instead of soil. Soft refuse consists of paper, organic refuse, shredded tires, and rubber. Individual components of the liner systems are described on the next page.

### Liner Components

**Clay:** To protect the ground water from landfill contaminants, clay liners are constructed as a simple liner that is two- to five-feet thick. In composite and double liners, the compacted clay layers are usually between two- and five-feet thick, depending on the characteristics of the underlying geology and the type of liner to be installed. Regulations specify that the clay used can only allow water to penetrate at a rate of less than 1.2 inches per year. The effectiveness of clay liners can be reduced by fractures induced by freeze-thaw cycles, drying out, and the presence of some chemicals.

In theory, one foot of clay is enough to contain the leachate. The reason for the additional clay is to safeguard the environment in the event of some loss of effectiveness in part of the clay layer. The efficiency of clay liners can be maximized by laying the clay down in four- to six-inch layers and then compacting each layer with a heavy roller.

The efficiency of clay liners is impaired if they are allowed to dry out during placement. Desiccation of the clay during construction results in cracks that reduce the liner efficiency. In addition, clays compacted at low moisture

contents are less effective barriers to contaminants than clays compacted at higher moisture contents. Liners that are made of a single type of clay perform better than liners constructed using several different types.

**Geomembranes:** Geomembranes are also called flexible membrane liners (FML). These liners are constructed from various plastic materials, including polyvinyl chloride (PVC) and high-density polyethylene (HDPE). The preferred material for use in MSW and secure landfills is HDPE. This material is strong, resistant to most chemicals, and is considered to be impermeable to water. Therefore, HDPE minimizes the transfer of leachate from the landfill to the environment. The thickness of geomembranes used in landfill liner construction is regulated by federal and state laws. In Ohio, HDPE geomembranes must have a minimum thickness of 0.060 inches for use in MSW landfills (OAC 3745-27-08).

**Geotextiles:** In landfill liners, geotextiles are used to prevent the movement of small soil and refuse particles into the leachate collection layers and to protect geomembranes from punctures. These materials allow the movement of water but trap particles to reduce clogging in the leachate collection system.

**Geosynthetic Clay Liner (GCL):** Geosynthetic clay liners are becoming more common in landfill liner designs. These liners consist of a thin clay layer (four to six millimeters) between two layers of a geotextile. These liners can be installed more quickly than traditional compacted clay liners, and the efficiency of these liners is impacted less by freeze-thaw cycles.

**Geonet:** A geonet is a plastic net-like drainage blanket which may be used in landfill liners in place of sand or gravel for the leachate collection layer. Sand and gravel

are usually used due to cost considerations, and because geonets are more susceptible to clogging by small particles. This clogging would impair the performance of the leachate collection system. Geonets do, however, convey liquid more rapidly than sand and gravel.

## For More Information

These sources provide additional information on landfills and landfill liners:

Shah, K. L. 2000. *Basics of Solid and Hazardous Waste Management Technology*. Prentice Hall, Upper Saddle River, N.J.

Tchobanoglous, G., Theisen, H., and Vigil, S. 1993. *Integrated Solid Waste Management: Engineering Principles and Management Issues*. McGraw-Hill, Boston, Mass.

Vesilind, P. A., Worrell, W., and Reinhart, D. R. 2002. *Solid Waste Engineering*. Brooks/Cole, Pacific Grove, Calif.

Ohio Administrative Code, Chapter 3745-400. Construction and Demolition Debris.

Ohio Administrative Code, Chapter 3745-27. Solid and Infectious Waste Regulations.

Ohio Administrative Code, Chapter 3745-37. Solid Waste, Infectious Waste Treatment, and Construction and Demolition Debris Facility Licenses.

U.S. Environmental Protection Agency, Code of Federal Regulations, Title 40, Part 258 Subtitle D, Criteria for Municipal Solid Waste Landfills.

U.S. Environmental Protection Agency, Code of Federal Regulations, Title 40, Part 264 Subtitle C, Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities.

## Other Related OSU Extension Fact Sheets in this series:

OSU Extension Fact Sheet CDFS-106-05, *Integrated Solid Waste Management*.

OSU Extension Fact Sheet CDFS-137-05, *Landfills: Science and Engineering Aspects*.

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