ENVIRONMENTAL GEOLOGY
OVERVIEW OF LANDFILLS AND WASTE DISPOSAL

I. TYPES OF WASTE

A. Solid Waste
1. Municipal
a.Waste derived from residential/urban areas
(1) plastics, packaging, paper, cardboard
(2) food wastes
(3) Household Chemicals (paints, oil, cleaners, bathroom)
(4) Lawn wastes

2. Residual
a. Waste derived from industrial processing
(1) a "residuum" left after a particular product is processes

(2) Construction debris, shredded plastics, fly ash in some cases, ashes, industrial sludges, automobile parts

(3) difference between residual and hazardous is one of toxicity and risk to health

3. Hazardous
a. Heavy metals (chromium, lead, fluoride)
b. Organic chemicals/hydrocarbons
c. asbestos/particulates, ashes

B. Liquid Waste
1. Liquid Chemical By-products of Industrial Processing
a. Waste water/cleaners
(1) may be laden with organic chemicals, dissolved heavy metals, salts
b. Degreasers
c. Acids, pickle-liquors, alkali bases

II. WASTE DISPOSAL OPERATIONS
A. Landfilling- burial of wastes in earthen pits
1. Composting- of lawn and organic debris

B. Sludge Ponds, Impoundments, Lagoons- liquid wastes and waste water placed in open lagoons for storage and/or treatment

1. transformation of liquid wastes into solid sludges which are often then taken to landfilling operation

C. Deep Injection Wells- disposing of liquid wastes by pressure injection into disposal wells deep beneath earth's surface

D. Incinceration- burning of solid and liquid wastes

1. includes firing augmentation with other fuels (gas/coal)
2. fly-ash by-product must then be disposed of in landfill
    a. Up to 90% volume reduction of solid waste to fly ash

III. CONTAMINANT PATHWAYS

A. Ground Water Contamination

1. "Leachate" = chemical soup formed by chemical degradation of wastes via percolating water
    a. water source:
        (1) rain/precipitation
        (2) through-flowing ground water
        (3) de-watering of waste itself

2. Leachate leakage into porous/fractured subsurface aquifers
3. Direct seepage of liquid residual and hazardous wastes into ground water system
4. Potential contamination of residential/municipal well fields
    a. Potential contamination of surface waters via contaminated seeps and springs

    b. Toxic effects to plant and animal life, particularly in delicate wet-area ecosystems

    c. Toxic effects to humans via water consumption and direct contact with contaminants

B. Soils Contamination

1. Seepage of contaminants into vadose zone (unsaturated zone) of unconsolidated sediment and soils.
    a. eventual percolation into ground water system
    b. Toxic effects to plant and animal life
    c. Toxic effects to humans via direct contact

C. Direct Surface Water Contamination
1. Direct runoff of leachate/chemical contaminants into surface waters
    a. Toxic effects to plant and animal life
    b. Toxic effects to humans via contact and consumption

2. Sediment erosion= overloading waterways with high suspended sediment loads
    a. detrimental to aquatice life
    b. artificial in-filling of drainages

D. Other Considerations

1. Air Pollution: asthetically offensive fumes and odors emitted from waste areas
    a. Toxic chemical fumes, metals vapors (e.g. mercury), organic chemicals

2. "Fugitive dust" and/or particulates into atmosphere from landfill-excavation operations

a. Respiratory problems

b. Toxic metals and particles entering lungs

3. Methane Generation

a. Methane (CH_4): common gas derived from anerobic microbial decay of municipal waste

b. Methane = an highly explosive gas that is colorless and odorless

c. Methane may escape from landfill area via subsurface pathways (porous material/fractures) (Offsite migration)

(1) gases may travel into basements causing potentially dangerous situation.

IV. ENVIRONMENTAL DESIGN CONSIDERATIONS FOR LANDFILL FACILITIES

A. Permitting Considerations

1. "Environmental Impact Statements"

a. Potential impact to local geology, hydrologic systems, cultural systems

(1) Subsurface geologic conditions, bedrock, stratigraphy, aquifers, water-bearing horizons, aquitards, depth and flow of groundwater, etc.
(2) Pre-existing environental problems (e.g. subsurface mines)
(3) existing ground and surface water quality
(4) Site use history
(5) engineering characteristics of soils
(6) Wetlands/ecosystem delineation

b. Local aquifer delineation, water supply use, surface water uses

c. Climate, rainfall, precipitation

(1) Important for "Help" Modelling of anticipated leachate volumes (see below)
(2) Dictates design and engineering of water treatment facilities

d. Impact to significant archeological/cultural systems

(1) Economic impact
(2) Justification for construction in area
(3) cemetaries, archeological/historic sites, airports, cultural operations, local zoning considerations

B. Environmental Engineering and Design

1. Ground Water Monitoring System

a. Upgradient and Down-gradient Monitoring Well System
    (1) directions of ground water flow
    (2) ground water divides
    (3) ground water levels
    (4) ground water quality monitoring
        (a) organic chemicals
        (b) dissolved metals
        (c) chloride, iron, pH, sodium
    (5) contaminant detection system

b. Assessment and Remedial Action Plan
    (1) What will happen if leakage occurs?

2. Leachate Control and Treatment
    a. Liner System
        (1) Low permeability geosynthetics
        (2) drainage nets
        (3) double lined systems
        (4) clay liners
        (5) impermeable clay soils
        (6) drainage layers

    b. Leachate Catchment and Treatment
        (1) type of treatment system
        (2) sludge management
        (3) "evaporative" spray control

    c. Help Modelling, Leachate Volume Prediction

    d. Treatment Plant Design
        (1) storage ponds, conveyance systems, discharge points
        (2) method of treatment/chemical processing

3. Landfill Gas Control
    a. Methane Detection Probes
        (1) Monitoring Program to detect potential off-site migration
    b. Methane collection stations
        (1) Pumping/vacuum system
    c. Flaring station for burning off methane
        (1) cogeneration of electricity, heat

4. Fugitive Dust Control
    a. Facility plan for dust control

5. Air Pollution Monitoring
    a. sampling and monitoring plan

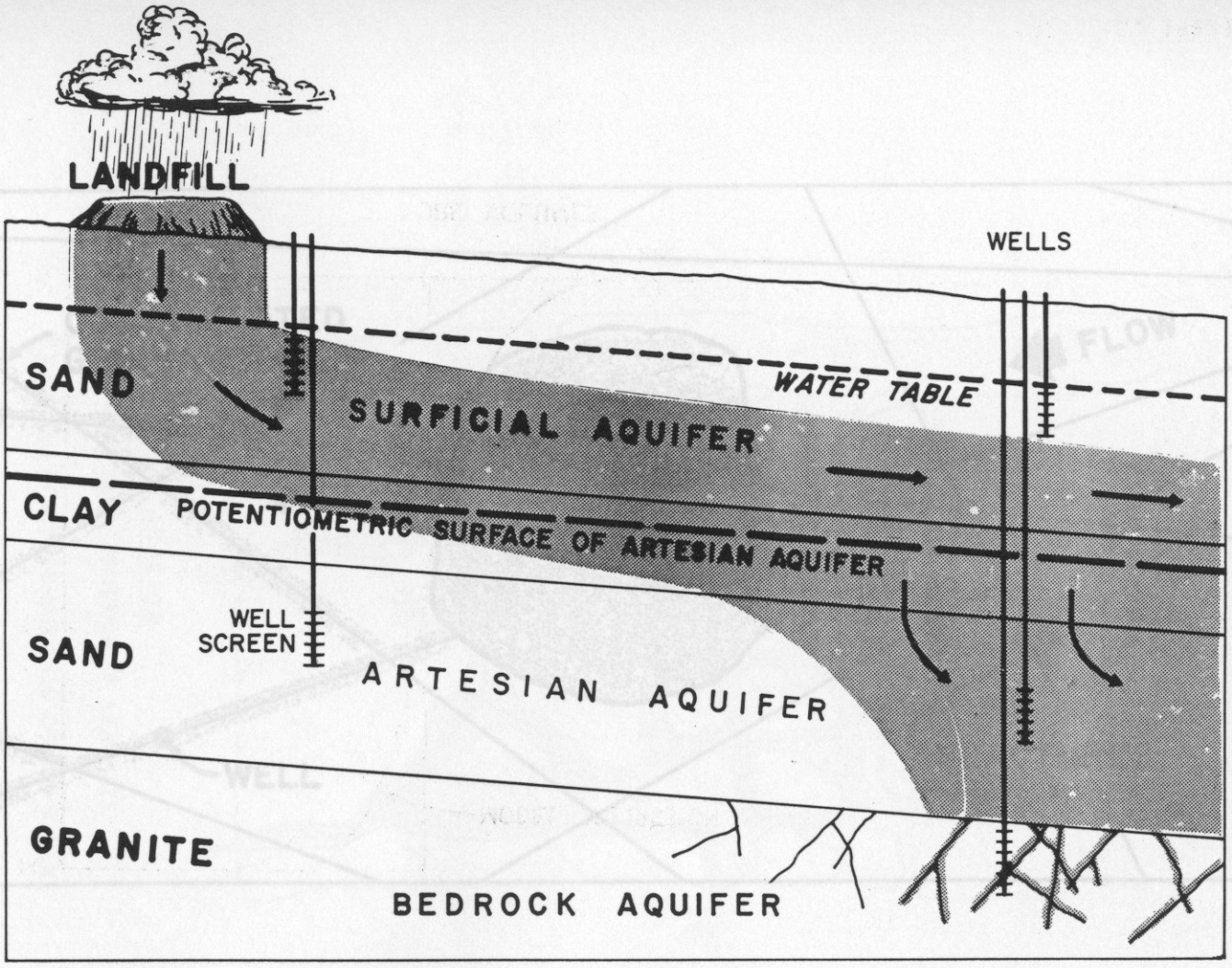
6. Erosion and sedimentation plan
    a. Preventing disturbed sediment from eroding into surface waters
    b. Sedimentation ponds or catch basins

7. "Vector" control
    a. animals, rodents, birds
    b. daily cover of waste

8. Construction/Soils Engineering
    a. Design of loads, sizing of containment structure
    b. Grading design, slope stability design
    c. soils properties
    d. designation of "borrow areas", storage areas
    e. Blasting Permits/considerations

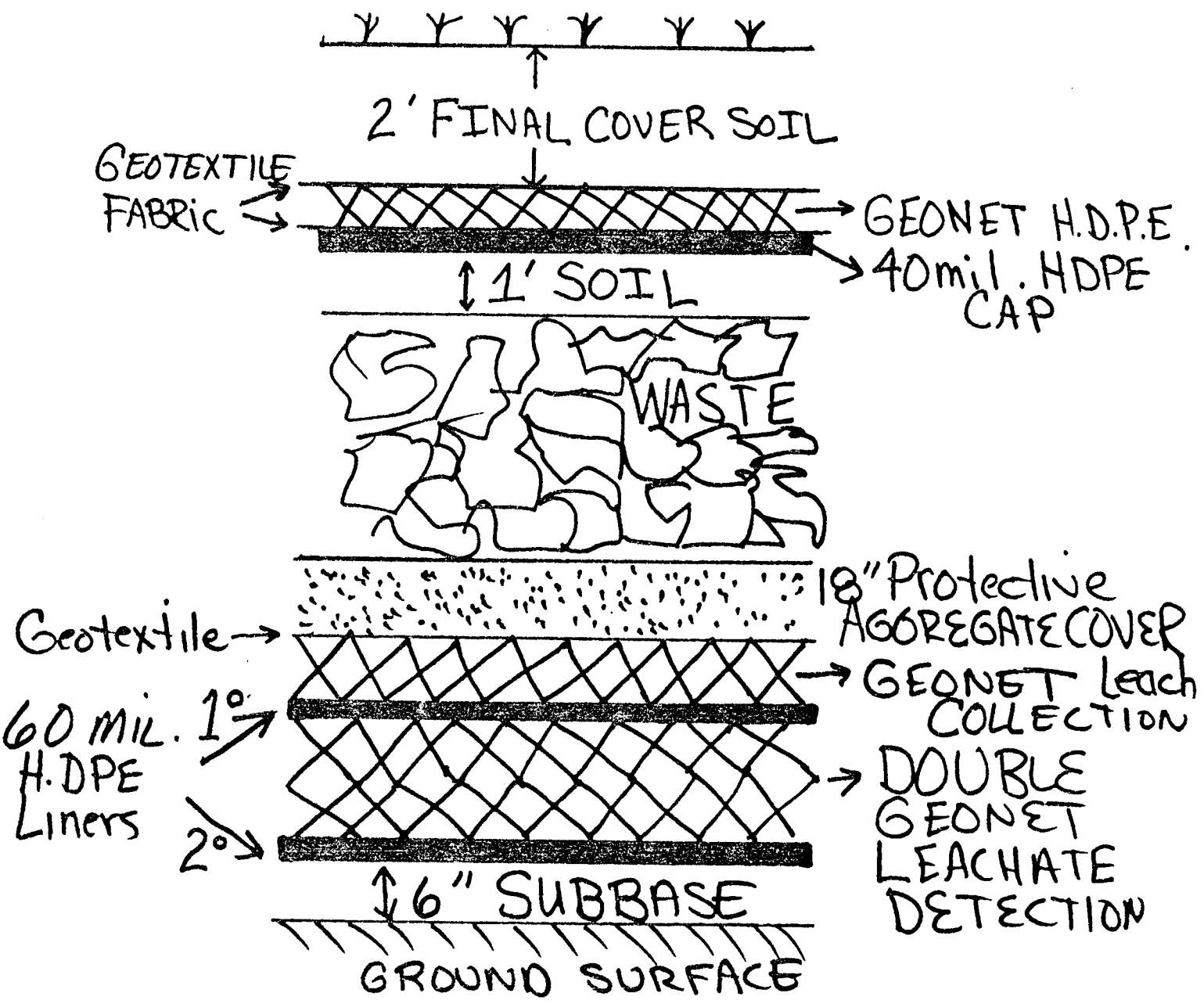
9. Landfill construction and management plan
    a. bonding, daily operations, waste stream allowances
    b. access roads, transportation considerations
    c. Construction plan, "cell life" projections
    d. Daily cover/mitigation procedures
    e. Waste-fill sequence

10. Landfill Closure and Reclamation Plan
    a. What will happen to land when landfill is completed?
    b. Post-closure monitoring
        (1) gas
        (2) ground water quality
        (3) remedial action plan
        (4) revegetation
        (5) geosynthetic caps/capping procedure
            (a) prevent water percolation, reduce leachate potential

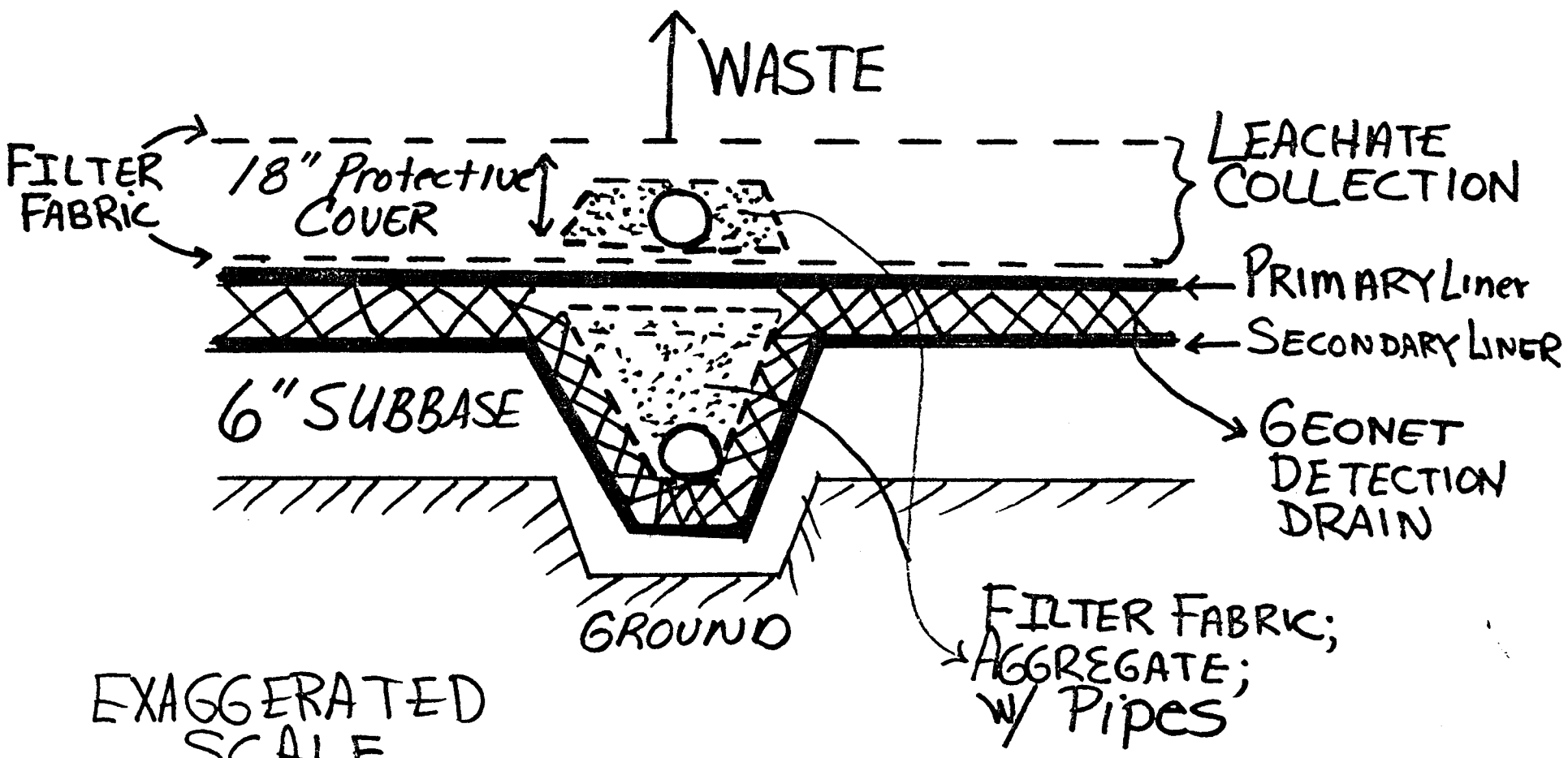


Contamination in a three-aquifer system.

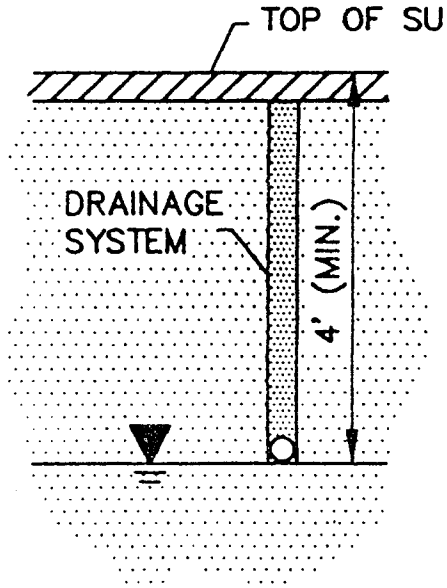
M.S.W. DOUBLE LINER



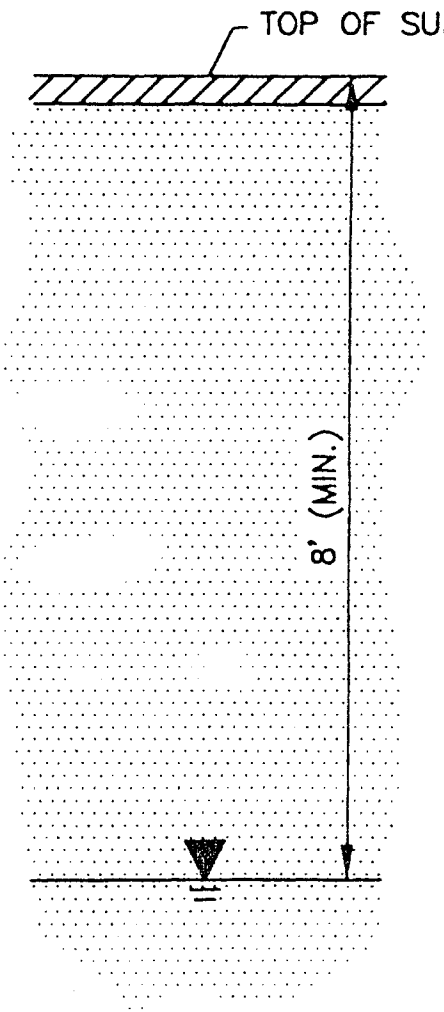
M.S.W. LINER SYSTEM



A. SEASONAL HIGH GROUNDWATER

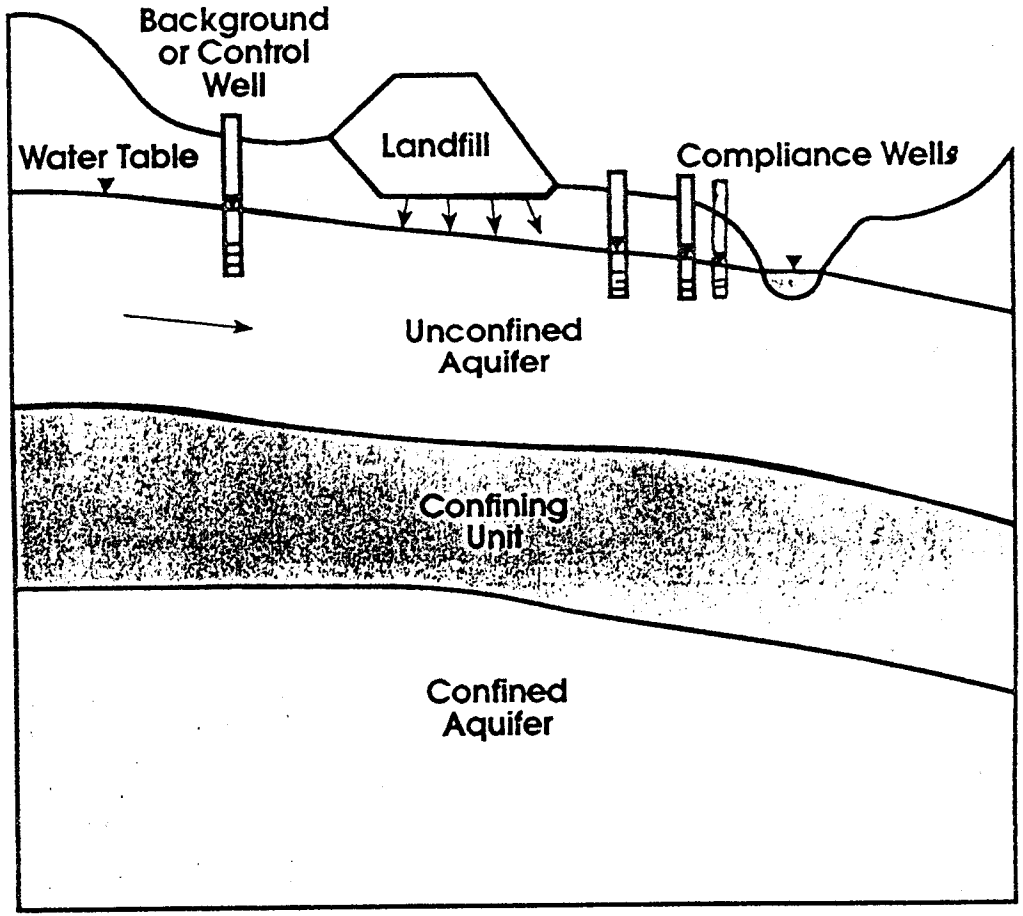


B. REGIONAL GROUNDWATER TABLE

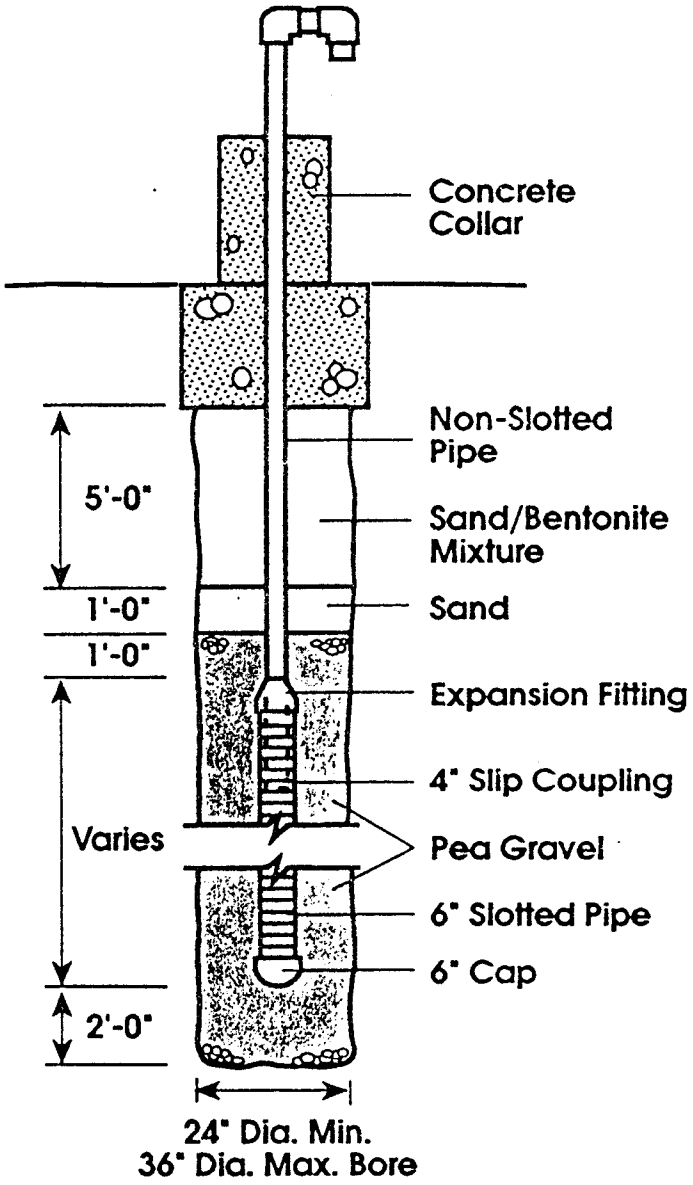


REQUIRED ISOLATION DISTANCE BETWEEN LINER SYSTEM AND GROUNDWATER TABLE

Groundwater Monitoring



Landfill Gas Vent



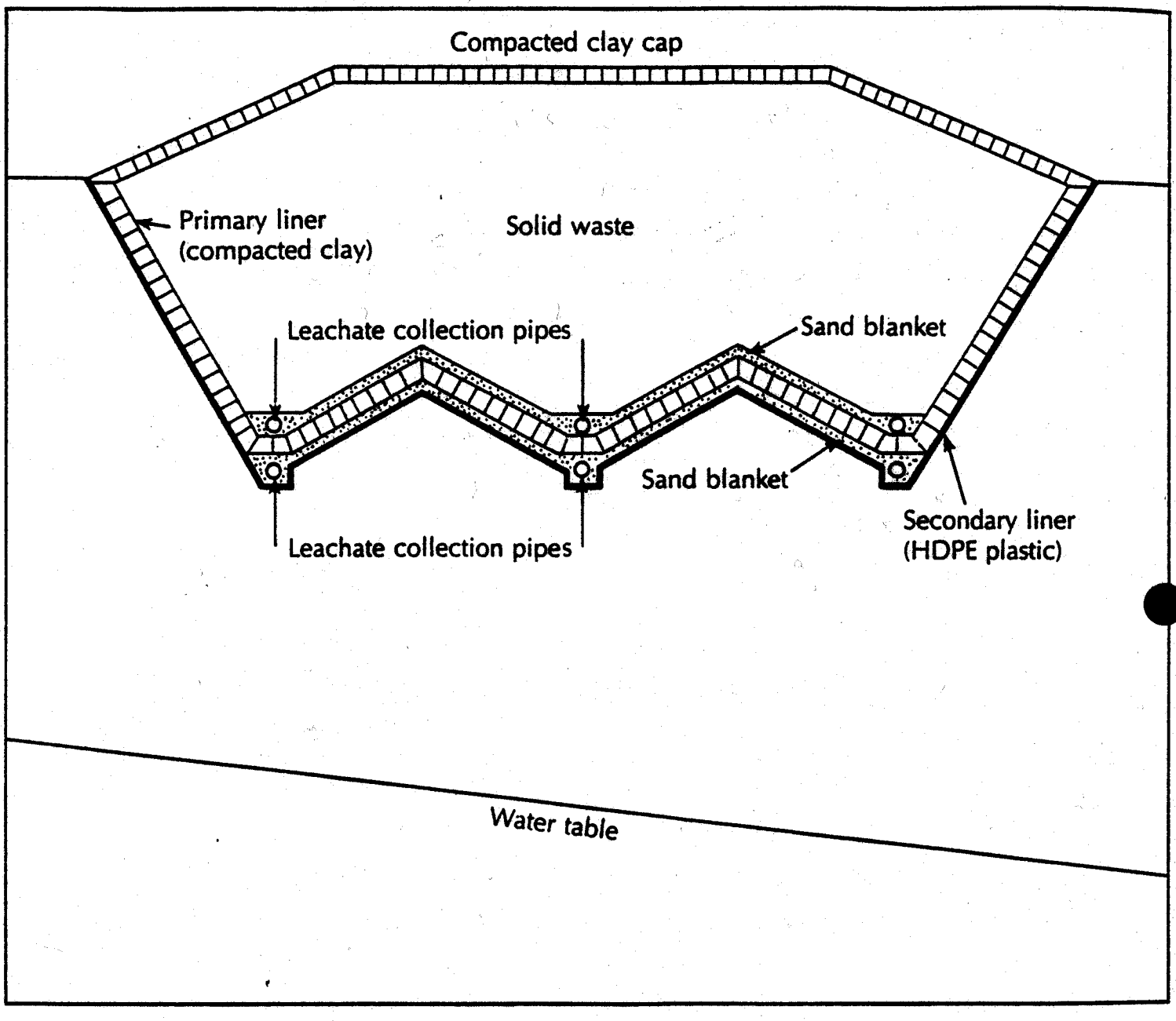


FIGURE 10.17 Double-lined landfill with leachate collection system. Primary liner consists of five feet of compacted clay soil with hydraulic conductivity of no more than 1×10^{-7} cm/sec. Secondary liner is flexible membrane such as 40 mil HDPE plastic. Leachate collection system consists of one-foot-thick sand layers with perforated pipes, which drain to a leachate collection tank.

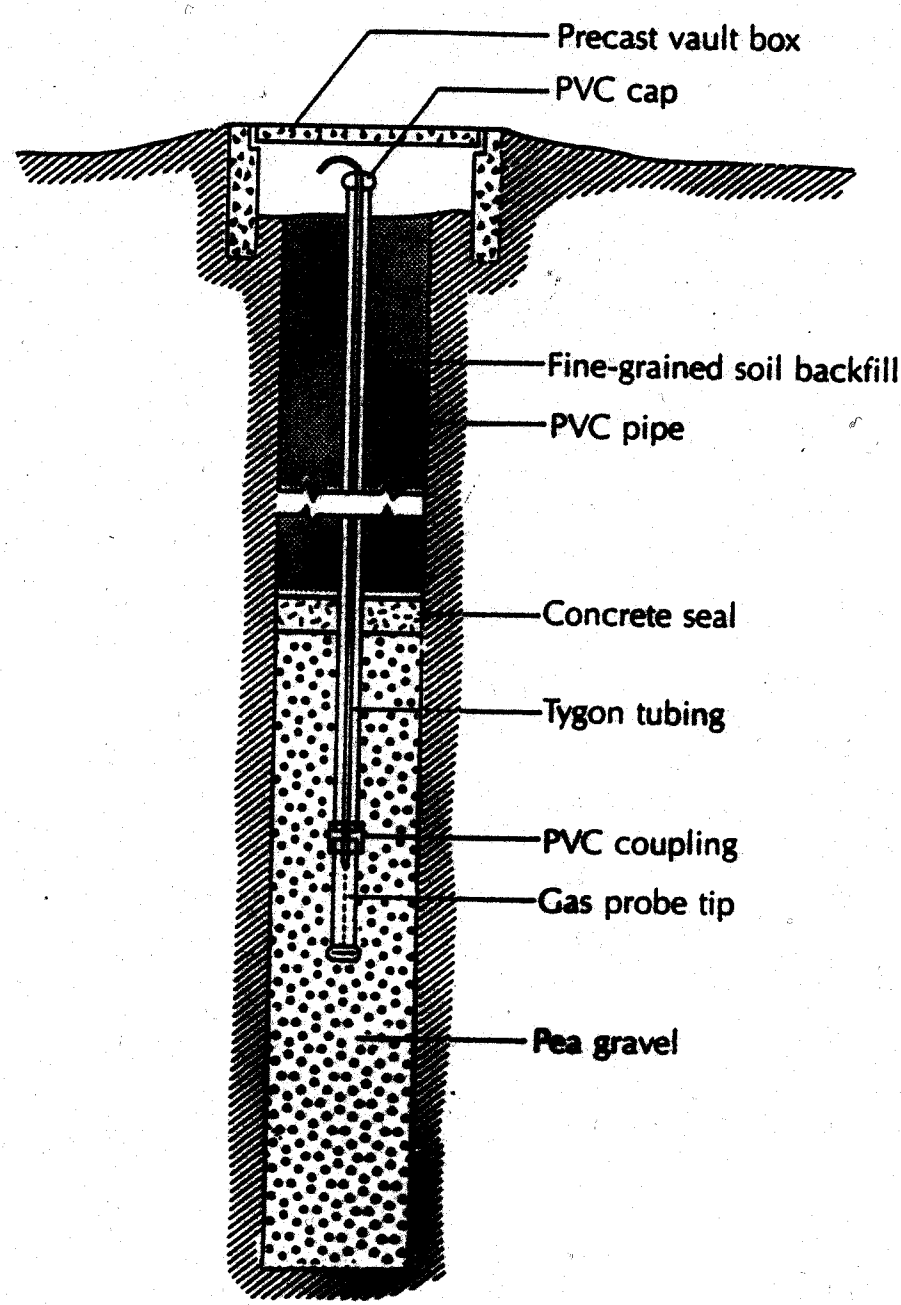


FIGURE 10.6 Gas monitoring well in vadose zone. Source: L. S. Wilson, *Ground Water Monitoring Review*, 3, no. 1 (1983):155–66.

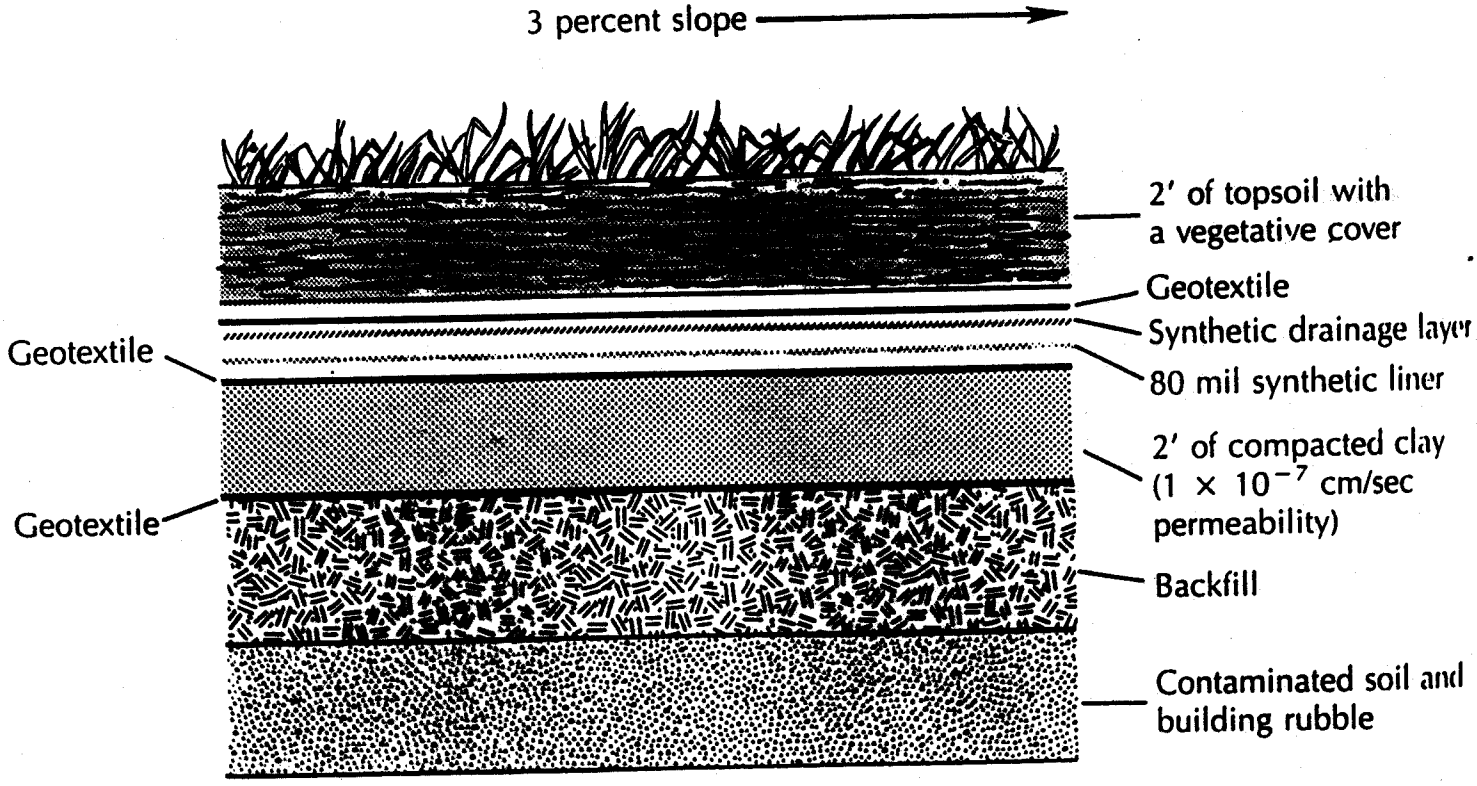
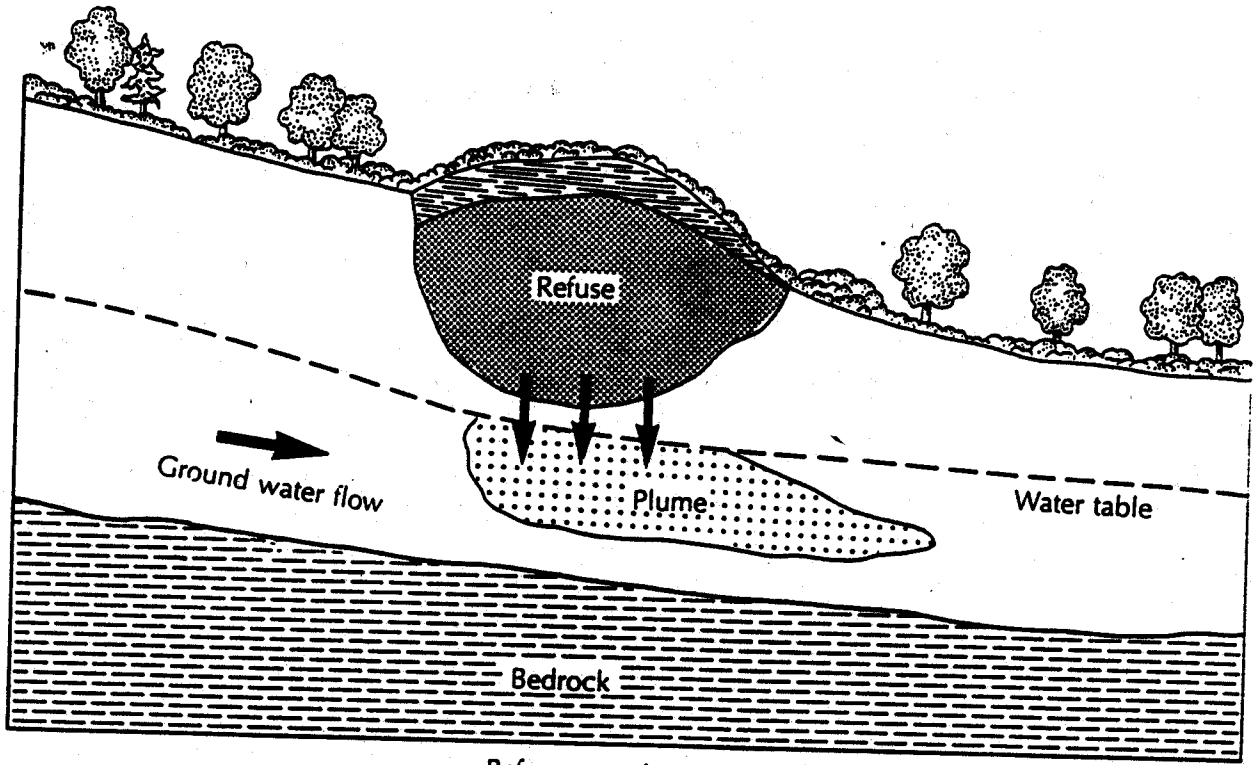
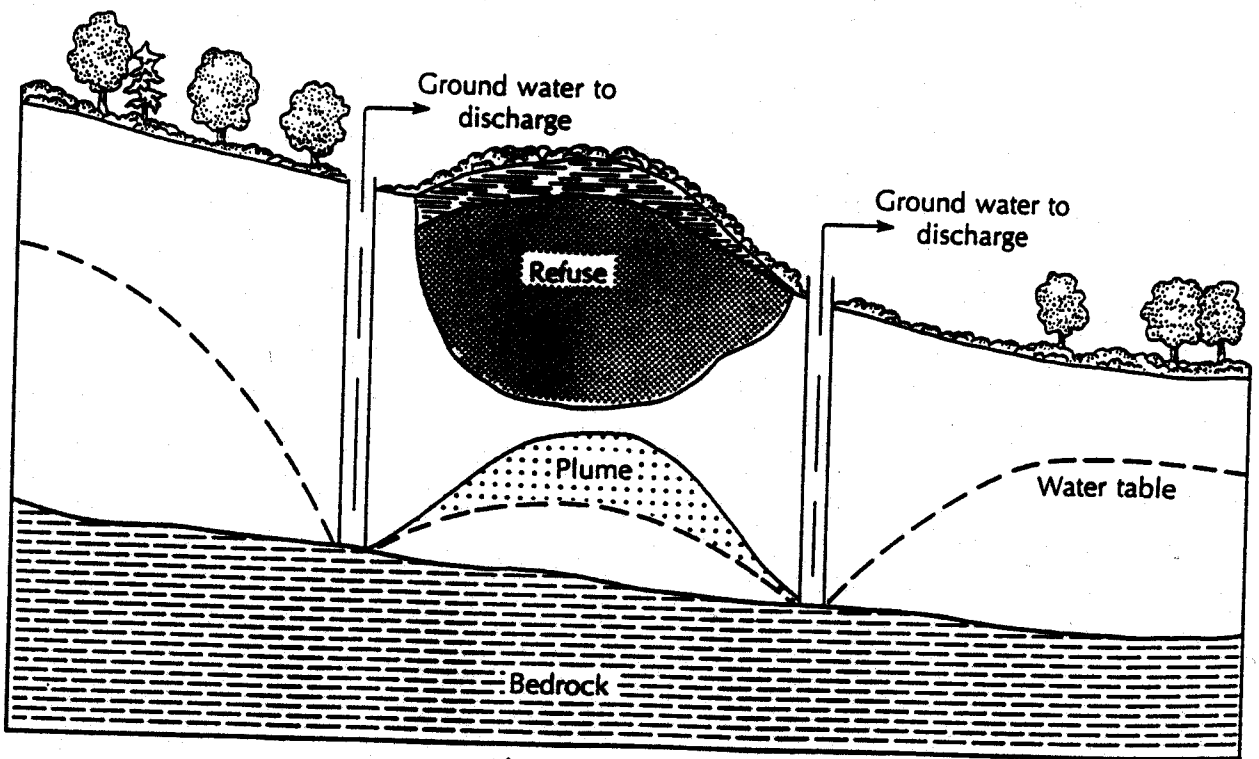


FIGURE 10.24 Design of a low-permeability multimedia cap to cover waste. Fill material is used above waste to create a 3 percent slope if the waste material or land surface over the waste material is not sloped.



Before pumping



After pumping

FIGURE 10.27 Use of extraction wells to remove contaminated ground water. Source: U.S. Environmental Protection Agency.

1. Definitions

"**200 Year Floodplain**" means land where the chance of a flood occurring in any given year is at least one in two hundred.

"**access road**" means a road that leads from a public road to a waste disposal site.

"**active life**" means the period of operation beginning with the initial receipt of municipal solid waste and ending at completion of closure activities.

"**action plan**" means a document describing an organized, planned, technically coordinated and financially feasible course of action to be followed in identifying nonconforming landfills and to upgrade the landfill(s) to meet these criteria or to justify exemptions.

"**aerobic**" means in the presence of oxygen.

"**approved**" means authorized in writing or specified in writing with or without conditions or requirements, by the Minister of Environment, Lands and Parks, his designate, or a Manager.

"**aquifer**" includes any soil or rock formation that has sufficient porosity and water yielding ability to permit the extraction or injection of water at reasonably useful rates.

"**biomedical waste**" means a substance that is defined as biomedical waste in the *Waste Management Act*.

"**black water**" means toilet waste

"**buffer zone**" means land used to separate a facility from other land.

"**cell**" means a compartment within a landfill isolated from other compartments by appropriate cover material and of such size so as to be considered manageable in the context of total volume and the day-to- day operating concerns including garbage placement and compaction, stability of working surfaces and slopes and the operation of landfill equipment.

"**composting**" is the aerobic biological decomposition of organic municipal solid waste under controlled circumstances to a condition sufficiently stable for nuisance-free storage and for safe use in land application.

"**contingency plan**" means a document describing an organized, planned, technically coordinated and financially feasible course of action to be followed in case of emergency or other special conditions, including, but not limited to, equipment breakdowns, fires, odours, vectors, explosions, spills, accidents, receipt or release of hazardous or toxic materials or substances, contamination of ground water, surface water or the air attributable to a solid waste management facility and other incidents that could threaten human health or safety or impair the usefulness of the environment.

"**cover material**" means soil or other material approved for use in sealing cells in landfills.

"**daily cover**" means a compacted layer of at least 0.15 metre of soil or functionally equivalent depth of other cover material that is placed on all exposed solid waste at the end of each day that municipal solid waste is discharged at the landfill.

"**design volume**" means the maximum volume of solid waste, including cover material, to be discharged at the solid waste management facility during its active life.

"**designated flood**" means a flood, which may occur in any given year, of such magnitude as to equal a flood having a 200 year recurrence interval, based on a frequency analysis of unregulated historic flood records or by regional analysis where there is inadequate stream flow data available. Where the flow of a large watercourse is controlled by a major dam, the designated flood shall be set on a site-specific basis.

"**disposal**" means the introduction of waste into the environment for the purpose of final burial, destruction or placement for future recovery.

"**fault**" means a geological fracture or zone of fractures in any material along which strata on one side have been displaced with respect to that on the other side.

"**final cover**" means a layer consisting of soil and, in some cases, other natural or synthetic materials that is placed on any surface of a landfill where no additional solid waste will be deposited and serves to restrict the infiltration of precipitation, to support vegetation, to control landfill gas, to restrict access by wildlife, and to promote surface drainage.

"**flood plain**" means a lowland area, whether dyked, floodproofed or not, which, by reasons of land elevation, is susceptible to flooding from an adjoining watercourse, ocean, lake or other body of water and for administration purposes is taken to be that area submerged by the designated flood plus freeboard.

"**floodway**" means the channel of the watercourse and those portions of the floodplains which are reasonably required to discharge the flood flow of a designated flood. A minimum required floodway shall be equal to the width of the channel within the natural boundary plus a minimum setback of thirty metres from the natural boundary on each side of the channel or channels unless otherwise approved.

"**freeboard**" means a vertical distance added to the designated flood level and is used to establish the flood construction level.

"**free liquid**" means any quantity of a liquid which is separated from a solid when subjected to the Free Liquid Test Procedure described in Part 3 of Schedule 4 of B.C. Reg. 63/88 (*Special Waste Regulation*).

"**groundwater**" means water below the ground surface in a zone of saturation

" **infiltration**" is the entry into the soil or solid waste of water at the soil or solid waste surface.

"**intermediate cover**" means a compacted layer of at least 0.30 metre of soil or functionally equivalent depth of other cover material placed where no additional solid waste has been deposited or will be deposited within a period of 30 days.

"**lateral expansion**" means a horizontal expansion of the footprint of the area of landfilling beyond that

which is currently authorized for waste discharge by an approved permit or operational certificate. The footprint area must not be greater than the area within the property boundaries less the areas set aside for other land uses such as buffer zones, access roads, recyclable storage areas and any other areas designated for uses other than waste discharge.

"**leachate**" means any liquid and suspended materials which it contains, which has percolated through or drained from a municipal solid waste disposal facility.

"**liner**" means a continuous layer of synthetic material or natural clay or earth materials, placed beneath and at the sides of a landfill and intended to restrict the downward or lateral escape of waste or leachate or in some cases to restrict the upward movement of ground water into the landfill.

"**lower explosive limit**" means the minimum percent concentration (by volume) of a substance in air that will explode or produce a flash of fire when an ignition source is present, measured at 25 degrees Celsius and atmospheric pressure.

"**manager**" means the "manager" as defined in the *Waste Management Act*.

"**municipal solid waste**" means "municipal solid waste" as defined in the *Waste Management Act*.

"**natural boundary**" means the visible high watermark of any lake, river, stream or other body of water where the presence and action of the water are so common and usual and so long continued in all ordinary years as to mark upon the soil of the bed of the lake, river, stream or other body of water a character distinct from that of the banks thereof, in respect to vegetation, as well as in respect to the nature of the soil itself (Land Act, Section 1). In addition, the natural boundary includes the best estimate of the edge of dormant or old side channels and marsh areas.

"**open burning**" means the combustion of any material or solid waste in the absence of containment and control of the combustion reaction with respect to residence time, temperature and mixing.

"**person**" includes an individual, a corporation, partnership or party, and the personal or other legal representatives of a person to whom the context can apply according to law.

"**public nuisance**" refers to an activity or action or result of such activity or action, which in the opinion of the Manager:

(a) interferes with the reasonable use and enjoyment of property surrounding the landfill;

(b) is a source of irritation to the public; or

(c) is annoying, unpleasant or obnoxious to the public.

"**putrescible**" refers to organic matter which has the potential to decompose with the formation of malodorous byproducts.

"**recovery**" means reclaiming of recyclable components and/or energy from the post-collection solid waste stream by various methods including incineration, pyrolysis, distillation, gasification or biological conversion (including composting) and includes the collection and subsequent management of methane gas generated in the landfill.

"**recyclable material**" means "recyclable material" as defined in the *Waste Management Act.*

"**recycling**" means the collection, transportation and processing of products separated from the municipal solid waste stream which are no longer useful in their present form and the use (including composting) of their material content in the manufacture and sale of new products. Recycling refers to source-separated wastes only, when used in the context of the 3 **R** s (**R**educe, **R**euse, and **R**ecycle).

"**reduction**" means decreasing the volume, weight, and/or toxicity of discarded material and includes activities which result in greater ease or efficiency of reuse of a product or recycling of materials.

"**regional district**" means a jurisdiction created under Section 767 of the Municipal Act.

"**remediation**" means actions taken to remove, eliminate, limit, correct, counteract or mitigate the negative effects on human health or the environment of a release or threatened release of one or more contaminants into the environment.

"**reuse**" means the repeated use of a product in the same form but not necessarily for the same purpose.

"**salvaging**" means the removal of material from a solid waste facility under the control of the facility owner or operator.

"**scavenging**" means the uncontrolled removal of material from a solid waste facility.

"**seismic impact zone**" means an area with a ten percent or greater probability that the maximum horizontal acceleration in lithified earth material, expressed as a percentage of the earth's gravitational pull, will exceed 0.10 g in 250 years.

"**septage**" means the pumped contents of a septic tank

"**sewage**" means effluent from a municipal sewerage system.

"**solid waste facility**" refers to a facility designed, constructed and operated for the collection, processing, transferring or disposal of the solid waste stream or components thereof, including but not limited to, transfer stations, material recycling facilities, composting facilities and disposal facilities.

"**solid waste stream**" means the aggregate of all solid waste components, and also the process through which they move from point of generation to ultimate disposal.

"**special waste**" means "special waste" as defined in the B.C. *Special Waste Regulation.*

"**surface water**" means lakes, bays, sounds, ponds, impounding reservoirs, perennial or ephemeral streams and springs, rivers, creeks, estuaries, marshes, inlets, canals, the Pacific Ocean within the territorial limits of British Columbia, and all other perennial or ephemeral bodies of water, natural or artificial, inland or coastal, fresh or salt, public or private, but excludes groundwater or leachate collection channels or works.

"**unstable area**" means a location that is susceptible to natural or human-induced events or forces capable of impairing the integrity of some or all of the landfill structural components responsible for

environmental works

Constructing the landfill

The basic element of a sanitary landfill is the refuse cell. This is a confined portion of the site in which refuse is spread and compacted in thin layers; several layers may be compacted on top of one another to a maximum depth of about 10 feet. The compacted refuse occupies about one-quarter of its original loose volume. At the end of each day's operation, the refuse is covered with a layer of soil to eliminate windblown litter, odours, and insect or rodent problems. One refuse cell thus contains the daily volume of compacted refuse and soil cover. Several adjacent refuse cells make up a lift, and eventually a landfill may comprise two or more lifts stacked one on top of the other. The final cap for a completed landfill may also be covered with a layer of topsoil that can support vegetative growth.

Daily cover soil may be available on-site, or it may be hauled in and stockpiled from off-site sources. Various types of heavy machinery, such as crawler tractors or rubber-tired dozers, are used to spread and compact the refuse and soil. Heavy steel-wheeled compactors may also be employed to achieve high-density compaction of the refuse.

The area and depth of a new landfill is carefully staked out, and the base is prepared for construction of any required liner and leachate collection system. Where a plastic liner is used, at least 12 inches of sand is carefully spread over it to provide protection from landfill vehicles. At sites where excavations can be made below grade, the trench method of construction may be followed. Where this is not feasible because of topography or groundwater conditions, the area method may be practiced, resulting in a mound or hill rising above the original ground. Since no ground is excavated in the area method, soil usually must be hauled to the site from some other location. Variations of the area method may be employed where a landfill site is located on sloping ground, in a valley, or in a ravine; the completed landfill eventually blends in with the landscape.

Controlling by-products

Organic material buried in a landfill decomposes by anaerobic microbial action. Complete decomposition usually takes more than 20 years. One of the by-products of this decomposition is methane gas. Methane is poisonous and explosive when diluted in the air, and it can flow long distances through porous layers of soil. If it is allowed to collect in basements or other confined areas, dangerous conditions may arise. In modern landfills, methane movement is controlled by impermeable barriers and by gas venting systems. In some landfills, the methane gas is collected and recovered for use as a fuel.

Tools

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Summary

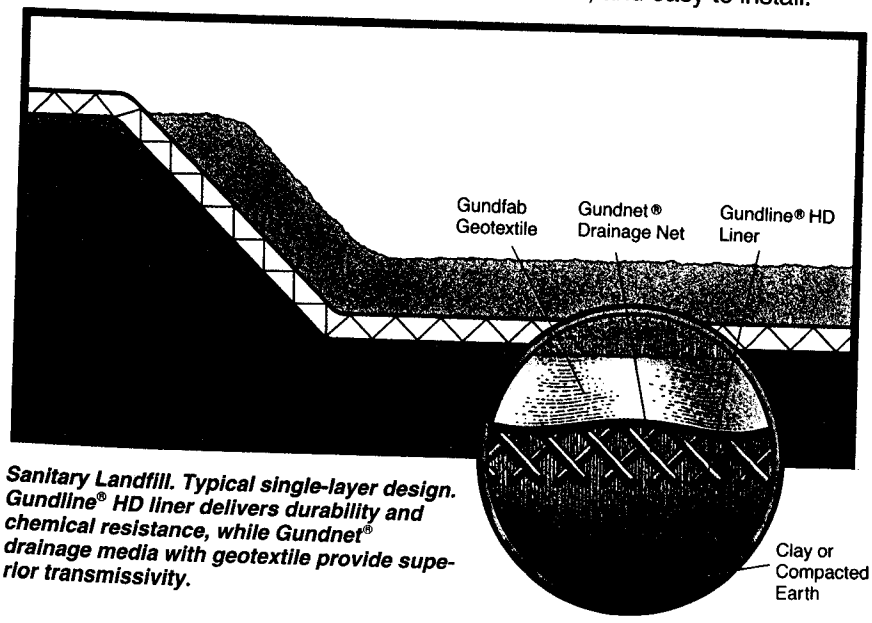
Gundle Lining Systems Inc

Gundle®

Sanitary Landfills

Modern household wastes deposited in sanitary landfills contain many of the same hazardous chemicals that require special treatment at hazardous waste facilities. Toxic pollutants in household garbage come from chemicals in cleaning products, paints, oils, insecticides, and solvents in addition to other products. The primary problem with these wastes is their high potential for mobility from the disposal site to the surrounding soil and ground water.

Numerous countries around the world including the USA are facing the problem and now require the use of synthetic lining systems for solid waste containment. High Density Polyethylene (HDPE) lining materials offer many advantages over conventional soil liners. And Gundle has multiplied these advantages through manufacturing and installing over 1 billion square feet of polyethylene liner systems worldwide. Gundle liners are inherently flexible to allow for differential settlement; suitable for all types of soils; resistant to decay, rodents, microorganisms and chemicals; and easy to install.



Sanitary Landfill. Typical single-layer design. Gundline® HD liner delivers durability and chemical resistance, while Gundnet® drainage media with geotextile provide superior transmissivity.

Private Industry, Owners and Municipal Landfills

Many of the nearly 2,000 U.S. Superfund Priority Sites are municipal landfills. These and many other owners and operators of both public and private sanitary landfill sites are becoming acutely aware of the consequences that await improper waste containment.

Many chemicals contained in the waste materials at landifll sites cannot be properly impounded using traditional clay liners alone. Research has shown that these chemicals interact with clay particles causing structural changes which allow migration of toxic substances outside of the site.

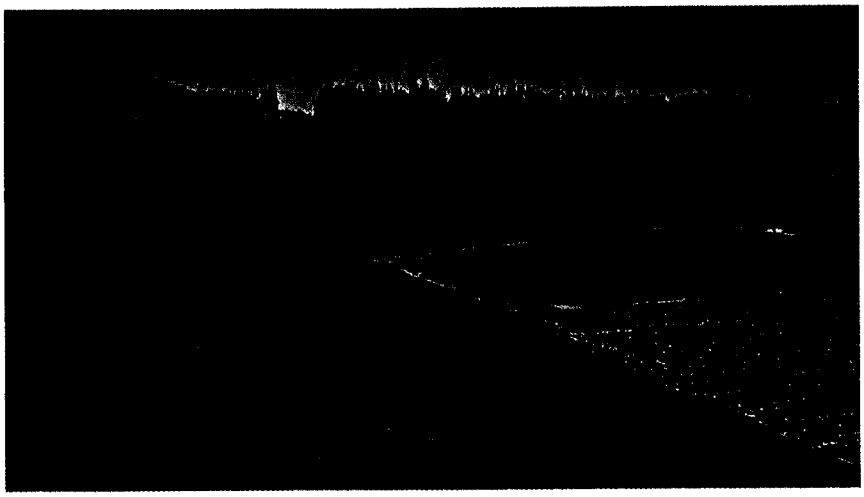
Case History

Calabassas County Landfill. A new HDPE lined landfill was opened on a 23 acre site to accept solid waste from both refuse firms and individuals.

The site also processes leachate that is removed by a collection sump for final disposal at a waste water treatment facility.

The most critical element of the new composite system is its 80 mil Gundline® HD liner, manufactured and installed by Gundle. The liner was delivered in 22.5 ft. seamless widths using Gundle's wedge welding system for field seaming. A leachate collection system was then placed above the liner installation.

Waste-to-Energy



Waste-to energy companies and municipal incineration facilities can produce an end product ash that is a more concentrated source of hazardous materials than the incoming solid waste. Heavy metals such as lead and cadmium, in addition to harmful organic chemicals precipitated in flu stacks, frequently cause the ash to fail EPA toxicity tests. To impound this material safely, the ash residue is landfilled in approved lined facilities.

Gundle can provide a system that includes Gundline® HD as the bottom liner, Gundnet® drainage media as the leachate collection zone with Geotextile placed over the Gundnet. A protective soil cover is then placed over the collection system. Some states are now requiring double liner systems such as those mandated for hazardous waste by the Resource Conservation and Recovery Act (RCRA). Gundle also offers a liner system that meets these requirements.

Case History

Shrewsbury, Massachusetts. Approximately 375 tons of incinerator ash are trucked daily from a nearby waste-to-energy plant and deposited at an ash monofill site located on 13 acres. The process begins each day with the burning of up to 1,500 tons of solid waste collected from the central part of the state.

The ash landfill incorporates a single composite liner, comprising a sheet of 60-mil Gundline HD manufactured and installed by Gundle on top of two feet of compacted clay. During and after installation, complete quality-control measures were carried out including both destructive and nondestructive testing of the heat welded seams.

Gundle Lining Systems Inc

Gundle®

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Landfill Closures

Once a sanitary landfill site has been filled to capacity, a barrier cap of Gundline HD or Gundline® VL is installed over the landfill. An effective closure eliminates the spread of contaminating pollutants to the surrounding surface and ground water because it eliminates leachate generated by precipitation.

HDPE and VLDPE liner materials are well-suited for landfill closures. Unlike clay caps, which can become highly permeable in a short time when exposed to the weather and vegetative growth, Gundline HD is highly resistant to weathering and chemical attack, not penetrated by root growth, flexible, and can therefore handle differential settlement. Gundline VL has superior elongation properties, flexibility, and puncture resistance in certain kinds of puncture tests.

Case History

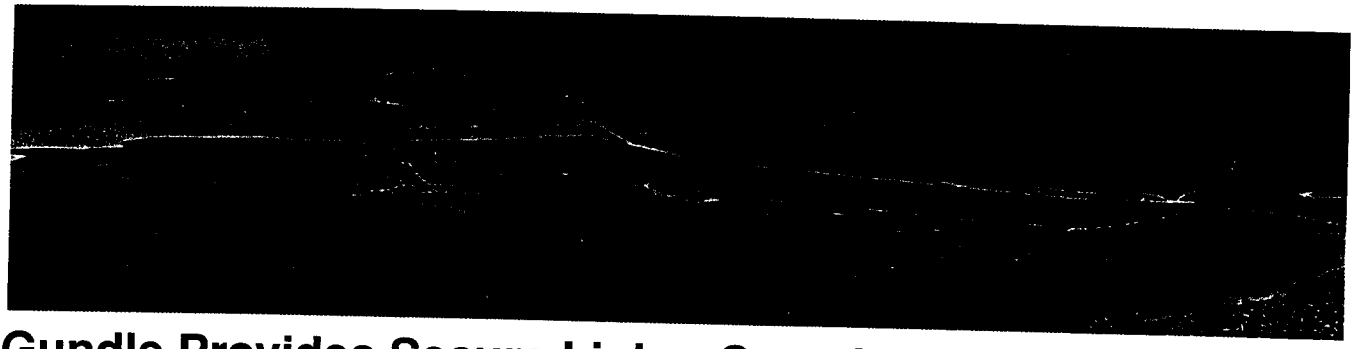
Western Pennsylvania. A third-party consultant recommended to the operator of this landfill that a 650,000 sq. ft. closure system be employed to cover two of the cells in the fill. Gundline HD, in a 50-mil thickness, was chosen as the primary closure material because this membrane would not only produce an impermeable closure, but also because its flexibility would protect the already installed leachate detection system. Gundnet drainage media and geotextile were installed over the HDPE membrane to drain off surface precipitation.

When installation and all quality checks were complete, 18 inches of cover soil was applied and seeded.

Gundle Lining Systems Inc

Gundle®

Mining Applications



Gundle Provides Secure Lining Containment For Leach Pads and Tailings Dams

Today's mining industry demands optimal performance from a lining containment system. Such specialized applications as heap leach pads and tailing dams rely upon an effective lining system in order to securely retain valuable ores and process chemicals as well as protect the groundwater from chemical contamination. Gundle Lining Systems Inc meets the demands of the mining industry by providing a combination of high performance lining materials, dependable installation technology, and a level of experience unapproached by any other lining company.

Gundle's credentials in servicing the mining industry are underscored by the fact that the company has successfully manufactured and installed over one billion square feet of lining material, including systems for major mining projects throughout the world. The knowledge derived from this wealth of experience plays a key role in each new project produced by Gundle.

Leach Options for Heap Leaching and Other Mining Needs

The growth in popularity of heap leaching as an economically viable process has created a need to securely contain all process areas of the heap leaching operation. Gundle has met this need, successfully lining many of the world's largest heap leaching operations, including a leach pad requiring over 6 million square feet of installed liner.

In order to securely contain this heap leaching process, Gundle lines all process areas including leach pad, leachate drainage system, and holding pond with its proven Gundline® HD High Density Polyethylene material. Depending upon the application, 30 - 140 mil Gundline HD is used. Impervious to the effects of the acids and cyanide used in the leaching process, Gundline HD creates a secure barrier between the process and the soil. In addition, Gundle offers Gundline® VL, Very Low Density Polyethylene in various thicknesses for mining applications where increased flexibility and elongation are desired. Gundle's capability to co-extrude provides other options for improved ponds, pads, and impoundments including textured surfaced liner, Gundline HDT for excellent liner friction and slope stability; reflecting white surfaced liner, Gundline HDW for improved installation efficiency and installation damage detection; and electrically conductive spark testable liner for leak testing over 100% of the lined area after installation.

Gundseal, the premier Geosynthetic Clay Liner (GCL) is also available for mining operations. The only GCL supported by geomembrane, Gundseal can replace or supplement clay layers, or even become a geomembrane/clay composite liner in one product.