OCD Exhibit 10
Case 13586
April 20, 2006

Rule 53.F
Landfills - Pollution Prevention & BMPs

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Rule 53.F
Specific requirements applicable to landfills

References:

EPA Crude Oil and Natural Gas Exploration and Production Wastes: Exemption from RCRA Subtitle C Regulation, 1995

EPA Guide to Technical Resources for the Design of Land Disposal Facilities

Xuede, Qian, Koerner, Robert M., and Gray, Donald H. 2001. Geotechnical Aspects of Landfill Design & Construction, Prentice Hall.

Koerner, Robert M., 1998. Designing with Geosynthetics. Fourth Edition, Prentice Hall

C.W. Fetter, "Contaminant Hydrogeology," Copyright 1993, Macmillan Publishing Company

What does crude oil consist of?

Crude oil consists of a mixture of hydrocarbons of varying molecular weight and on the average contains about 84.5% carbon, 13% hydrogen, 1.5% sulfur, 0.5% nitrogen, and 0.5% oxygen. A typical crude oil might consist of about 25% alkanes (paraffins), 50% cycloalkanes (naphthenes), 17% aromatics, including polycyclic aromatics, and 8% asphaltics, which are molecules of very high molecular weight with more than 40 carbon atoms. There have been more than 600 hydrocarbon compounds identified in petroleum (Hunt, 1979).

C.W. Fetter, "Contaminant Hydrogeology," Copyright 1993, Macmillan Publishing Company

Oilfield Exempt Wastes Disposed in Landfills

What types oilfield exempt wastes may be disposed in an OCD landfill?

The following simple rule of thumb can be used to determine if an exploration and production (E&P) waste is exempt or non-exempt from RCRA Subtitle C regulations: Has the waste come from down-hole, i.e., was it brought to the surface during oil and gas E&P operations? Has the waste otherwise been generated by contact with the oil and gas production stream during the removal of produced water or other contaminants from the product? If the answer to either question is yes, then the waste is most likely considered exempt from RCRA Subtitle C regulations. Wastes generated by activities other than E&P operations are not covered by the exemption.

Exempt oilfield wastes in OCD landfills may include:

- Drilling fluids*
- Drill cuttings
- Hydrogen sulfide abatement wastes from geothermal energy production
- Well completion, treatment, and stimulation fluids*
- Basic sediment, water*, and other tank bottoms from storage facilities that hold product and exempt waste
- Accumulated materials such as hydrocarbons, solids, sands, and emulsion from production separators, fluid treating vessels, and production impoundments
- Pit sludges and contaminated bottoms from storage or disposal of exempt wastes
- Gas plant dehydration wastes*, including glycol-based compounds, glycol filters, and filter media, backwash, and molecular sieves
- Workover wastes
- Gas plant sweetening wastes for sulfur removal, including amines, amine filters, amine filter media, backwash, precipitated amine sludge, iron sponge, and hydrogen sulfide scrubber liquid and sludge
- Spent filters, filter media, and backwash* (assuming the filter itself is not hazardous and the residue in it is from an exempt waste stream)
- Pipe scale, hydrocarbon solids, hydrates*, and other deposits removed from piping and equipment prior to transportation
- Produced sand
- Hydrocarbon-bearing soil
- Pigging wastes from gathering lines
- Wastes from subsurface storage and retrieval except for the non-exempt wastes
- Constituents removed from produced water before it is injected or otherwise disposed of
- Liquid* hydrocarbons removed from the production stream but not from oil refining
- Materials ejected from a producing well during blowdown
- Waste crude oil* from primary field operations
- Light organics* volatilized from exempt wastes in reserve pits, impoundments, or production equipment

* Solidified before disposal

Oilfield Non-Exempt Wastes Disposed in Landfills

What types oilfield non-exempt wastes may be disposed in an OCD landfill?

Non-exempt oilfield wastes in OCD landfills may include:

- Unused fracturing fluids[#] or acids[#]
- Gas plant cooling tower cleaning wastes[#]
- Painting wastes[#]
- Waste solvents[#]
- Oil and gas service company wastes such as drum rinsate[#], sandblast media, painting wastes[#], spent solvents[#], spilled chemicals[#], and waste acids[#]
- Vacuum truck and drum rinsate[#] from trucks and drums transporting or containing non-exempt waste[#]
- Refinery wastes[#]
- Liquid[#] and solid wastes generated by crude oil and tank bottom reclaimers[*]
- Used equipment lubricating oils[#]
- Waste compressor oil[#], filters, and blowdown[#]
- Used hydraulic fluids[#]
- Waste in transportation pipeline related pits[#]
- Caustic or acid cleaners[#]
- Boiler cleaning wastes[#]
- Boiler scrubber fluids[#], sludges[#], and ash
- Laboratory wastes[#]
- Insulation, and miscellaneous solids

[*] Although non-E&P wastes generated from crude oil and tank bottom reclamation operations (e.g., waste equipment cleaning solvent) are non-exempt, residuals derived from exempt wastes (e.g., produced water separated from tank bottoms) are exempt.

[#] Solidified before disposal

TABLE 5.15 LEACHATE CHARACTERISTICS FROM A HAZARDOUS SOLID WASTE LANDFILL

Parameter	Unit	Value
Alkalinity	mg/l as $CaCO_3$	11600
BOD_5	mg/l	19500
COD	mg/l	37200
Conductivity	μMhos	38575
Oil & Grease	mg/l	210
pH	St. units	9.1
Silica	mg/l as SiO_2	141
Total Dissolved Solids	mg/l	50100
Total Organic Carbon	mg/l	11500
Total Suspended Solids	mg/l	212
Turbidity	NTU	156
Calcium	mg/l	30
Iron	mg/l	19
Magnesium	mg/l	16
Nickel	mg/l	28
Potassium	mg/l	2715
Sodium	mg/l	13250
Chloride	mg/l	12100
Nitrate	mg/l as N	51
Phosphorus	mg/l as P	21
Sulfate	mg/l as SO_4	3850
Benzene	μg/l	6500
Chloroform	μg/l	1330
1,1-Dichlorethane	μg/l	2900
Ethyl Benzene	μg/l	35
Phenol	μg/l	14100
Styrene	μg/l	95
Toluene	μg/l	21100
m–Xylene	μg/l	284
o–Xylene	μg/l	93

Source: Dudzik and Tisinger [58]

RCRA Oil and Gas Exemption

The RCRA Subtitle C exemption, however, did not preclude these wastes from control under state regulations, under the less stringent RCRA Subtitle D solid waste regulations, or under other federal regulations. In addition,although they are relieved from regulation as hazardous wastes, the exemption does not mean these wastes could not present a hazard to human health and the environment if improperly managed.

In general, the exempt status of an E&P waste depends on how the material was used or generated as waste, not necessarily whether the material is hazardous or toxic. For example, some exempt E&P wastes might be harmful to human health and the environment, and many non-exempt wastes might not be as harmful.

Source: EPA

Rule 53.E(5): Siting and operational requirements applicable to all permitted facilities

- No free liquids
- Must use paint filter test (EPA SW- 846, Method 9095)

Paint Filter Liquids Test 9095A

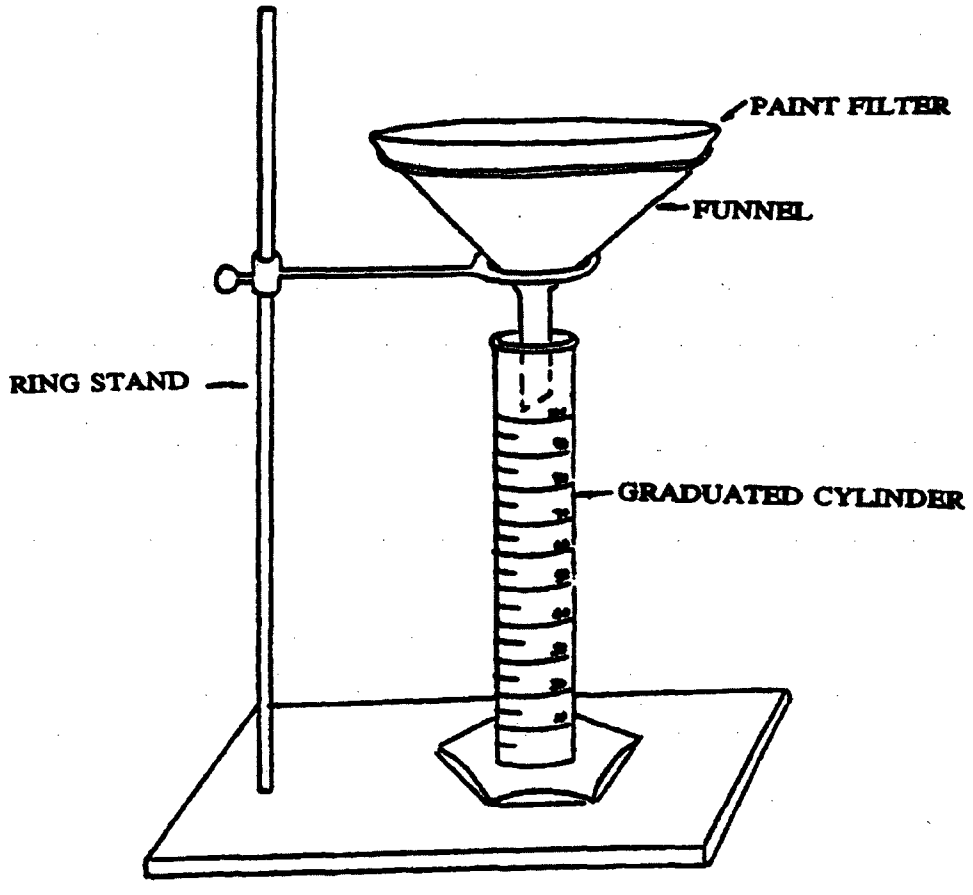
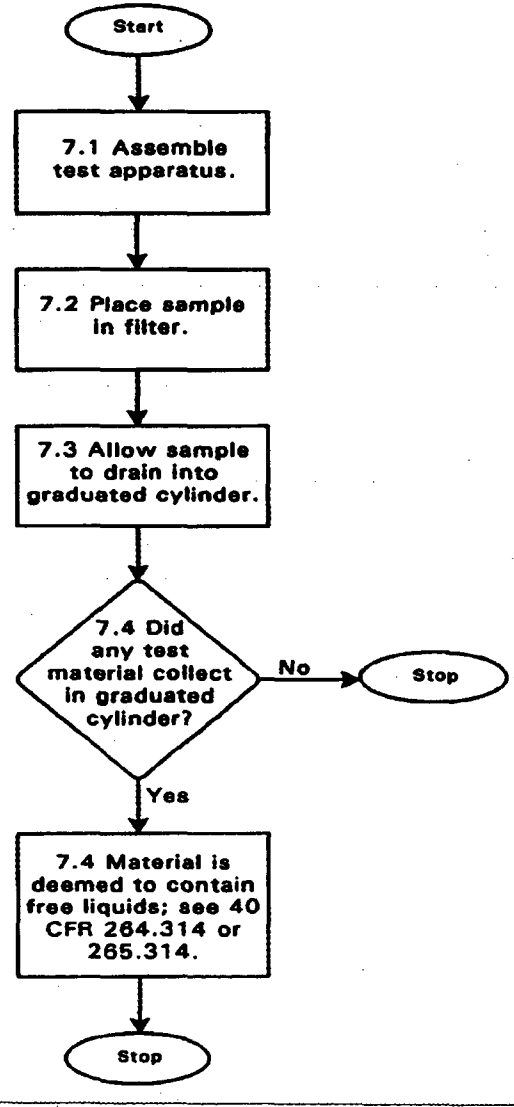


Figure 1. Paint filter test apparatus.

METHOD 9095A
PAINT FILTER LIQUIDS TEST



Liner Definitions:

•**"composite liner"** is a liner that may consist of multiple layers of geosynthetics and low permeability soils. The different layers of a composite liner may have different material properties and may be applied at different stages of landfill liner installation.

• **"geosynthetic"** is the generic classification of all synthetic materials used in geotechnical applications, including all of the definitions below.

•**"geocomposite"** is a manufactured material using geotextiles, geogrids, geomembranes, or combinations thereof, in a laminated or composite form.

•**"geogrid"** is a deformed or non-deformed netlike polymeric material used to provide reinforcement to soil slopes.

Liner Definitions:

•"**geomembrane**" is an impermeable polymeric sheet material that is impervious to liquid and gas as long as it maintains its integrity and is used as an integral part of an engineered structure or system designed to limit the movement of liquid or gas in a system.

•"**geonet**" is a type of a geogrid that allows planar flow of liquids and serves as a drainage system.

•"**geosynthetic clay liner**" is a relatively thin layer of processed clay (typically bentonite) that is either bonded to a geomembrane or fixed between two sheets of geotextile.

•"**geotextile**" is any sheet material that is less impervious to liquid than a geomembrane, but more resistant to penetration damage and is used as an integral part of an engineered structure or system to serve as a filter to prevent the movement of soil fines into a drainage system, to provide planar flow for drainage, or to serve as a cushion to protect geomembranes, or to provide structural support..

Rule 53.F(1)(g): intermediate cover

- approved by the division
- stabilized with vegetation
- prevent erosion and manage infiltration or leachate

Rule 53.F(1)(h):

- landfill cell closure pursuant to Rule 53.J(4)(b)
  - top cover
  - soil contoured to promote drainage of precipitation
  - side slopes < 25 % grade
  - final cover gradient of 2 –5 %
  - prevent the ponding of water and erosion of cover
  - re-vegetate
- 3 working days notice to environmental bureau for top cover installations

Rule 53 F(2): Ground water monitoring program

- Ground water monitoring work plan
- Sampling and analysis plan (SAP)
- Ground water monitoring system
  - sufficient number of wells
  - yield ground water samples from uppermost aquifer
    - background quality
    - downgradient quality

Rule 53.F(3): Landfill design specifications

- base layer and a lower geomembrane liner (e.g., composite liner)
- leak detection system,
- upper geomembrane liner
- leachate collection and removal system
- leachate collection and removal system protective layer
- oil field waste zone
- top landfill cover

Rule 53.F(3): Landfill design specifications

Composite liner (base layer plus lower geomembrane liner)

Base layer

- Two feet of clay soil compacted to a minimum 90% Standard Proctor Density (ASTM D-698.)
- Hydraulic conductivity of 1 x 10-7 cm/sec or less.

In areas where depth to ground water is greater than 100 feet, or where no ground water is present, the operator may propose an alternative base layer design, subject to division approval.

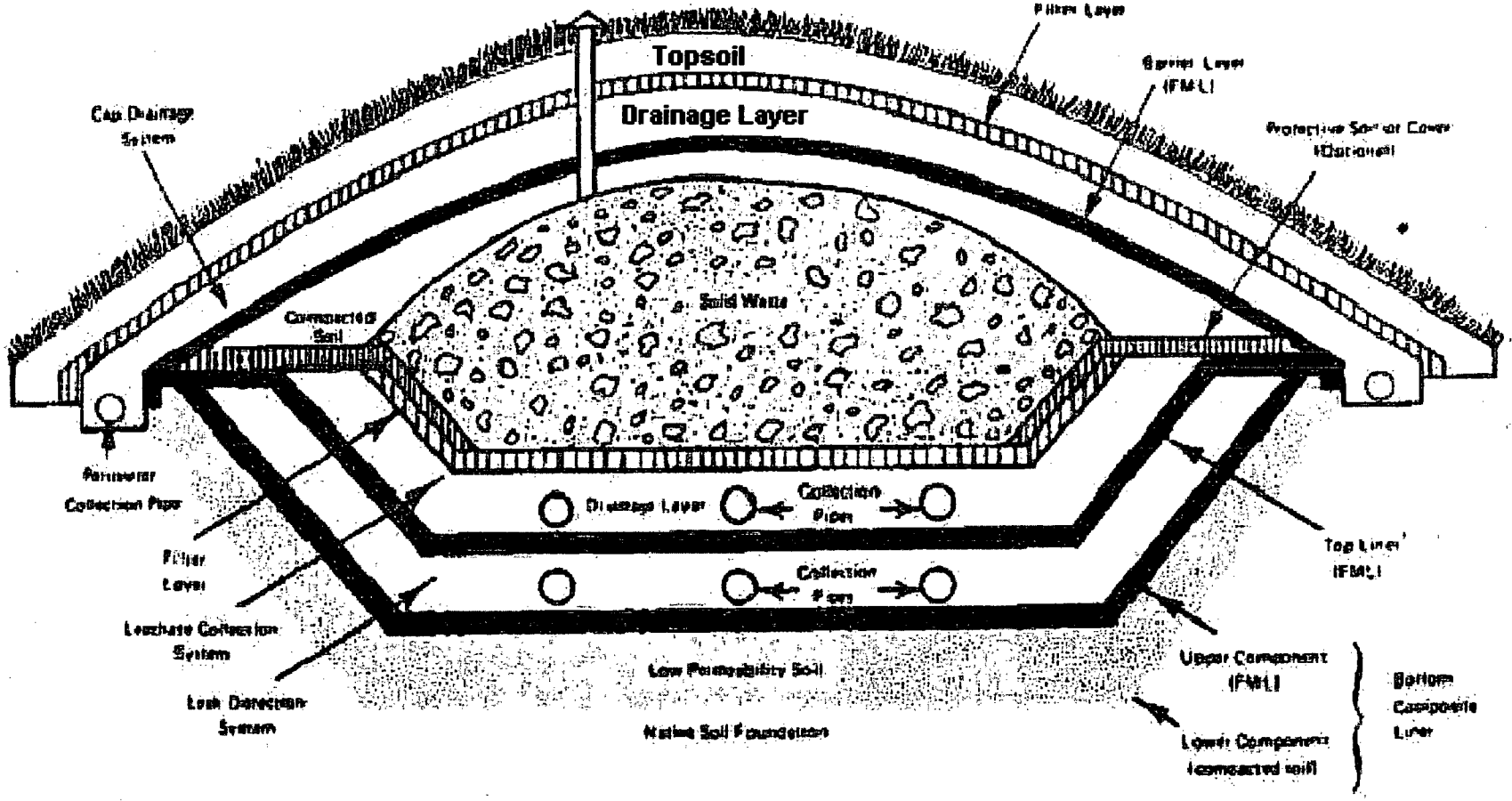
Lower geomembrane liner

- 30-mil flexible PVC or 60-mil HDPE liner
- equivalent liner approved by the division

Landfill Layer Comparison Table

Landfill Prescriptive Layers	RCRA Subtitle C	OCD	RCRA Subtitle D
Top Cover Zone	Topsoil: 6"	Topsoil: 6"	Topsoil: 6"
	Native soil: 18"	Protection layer (native soil): 12 - 30"	Barrier soil (10-5 cm/s): 18"
	Geotextile or sand: 12"	Drainage layer (≥ 10-2 cm/s): 12"	Drainage layer (≥ 10-2 cm/s): 12"
	Geomembrane: 40 mil	Geomembrane (30-mil PVC or or 60 mil HDPE) or equivalent liner	Geomembrane (20-mil liner) or equivalent liner
	Clay (≤ 10-7 cm/s): 24"		Barrier soil (≤ 10-7 cm/s): 18"
		Gas vent or foundation layer (sand or gravel): 12"	Gas vent or foundation layer (sand or gravel): 12"
Waste Zone	Hazardous Waste Zone	Oil Field Exempt & Non-Exempt Non-Hazardous Waste Zone	Solid Waste Zone
Bottom Layer Zone	Leachate collection & removal system protective layer (≥ 10-2 cm/s): 12"	Leachate collection & removal system protective layer (≥ 10-2 cm/s): 12"	Leachate collection & removal system protective layer (≥ 10-2 cm/s): 12 - 24"
	Leachate collection & removal system granular soil (≥ 10-2 cm/s): 24"	Leachate collection & removal system granular soil (≥ 10-2 cm/s): 24"	Leachate collection & removal system granular soil (≥ 10-2 cm/s): 24"
	Geomembrane (30-mil flexible or 60-mil HDPE liner)	Geomembrane (30-mil PVC or 60-mil HDPE) or equivalent liner	
	Leak detection system compacted clay soil (≤ 10-7 cm/s): 24"	Leak detection system granular soil (≥ 10-5 cm/s): 24"	
	Geomembrane (30-mil flexible or 60-mil HDPE liner)	Geomembrane (30-mil PVC or 60-mil HDPE) or equivalent liner	Geomembrane (30-mil flexible or 60-mil HDPE liner)
	Compacted clay liner (≤ 10-7 cm/s): 24"	Compacted Clay Liner (≤ 10-7 cm/s): 24"	Compacted Clay Liner (≤ 10-7 cm/s): 24"

OCD Landfill Design



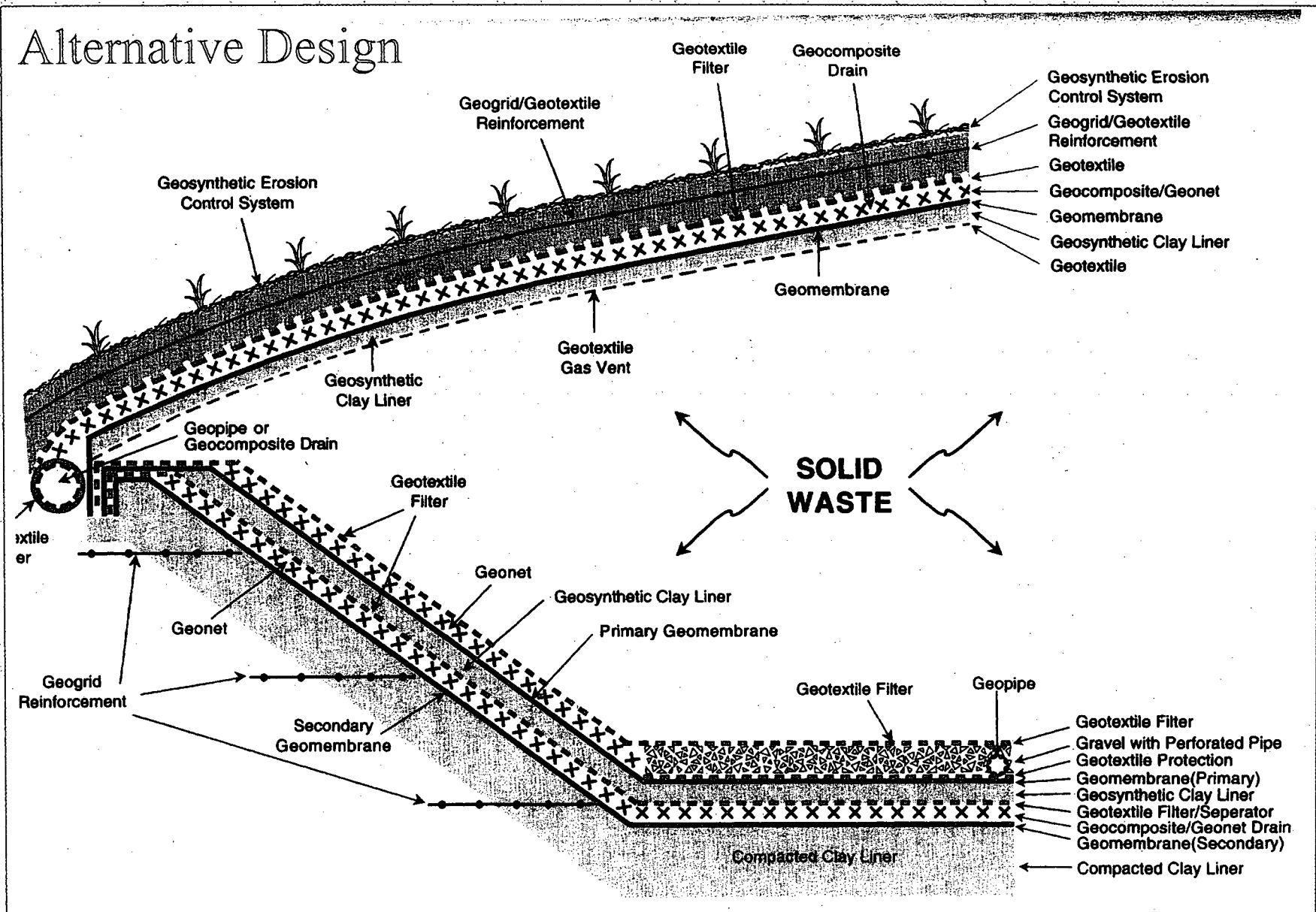
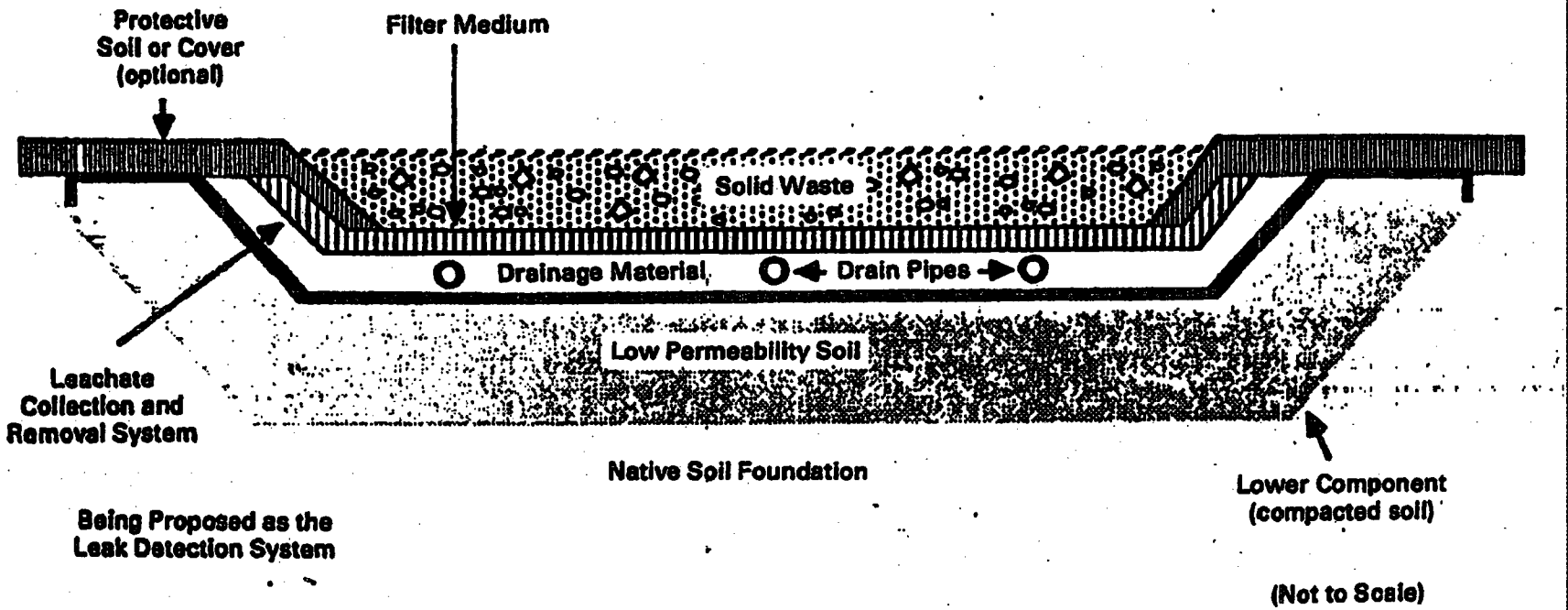


Figure 5.52 Solid waste containment system with high geosynthetic utilization.

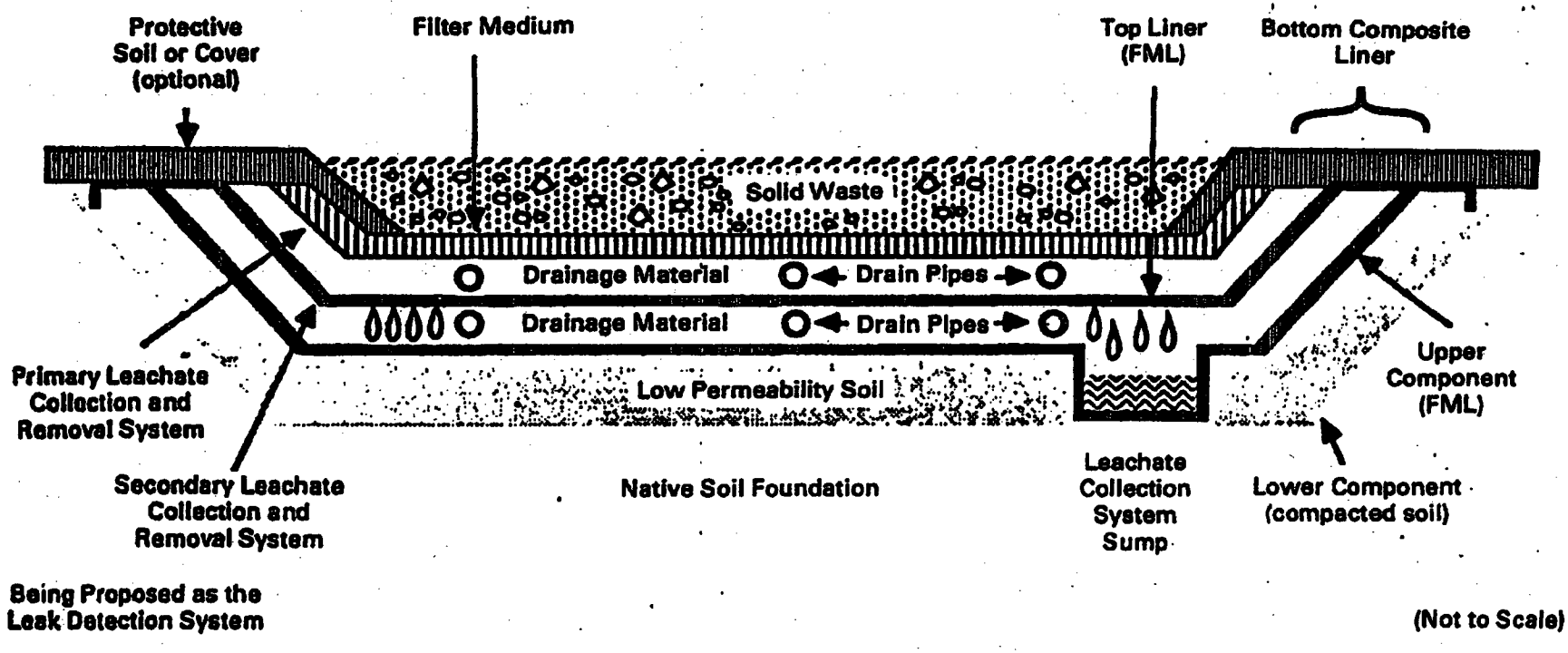
Typical Municipal Solid Waste Landfill Bottom Composite Liner

Exhibit 4.1. Schematic of a Single Clay Liner System for a Landfill



Typical RCRA Hazardous Waste Landfill Bottom Composite Liner

Exhibit 4-2. Schematic of a Double Liner and Leak Detection System for a Landfill



Rule 53.F(3)(I): Alternative designs

- Performance-based landfill design system using geosynthetics or geocomposites, including geogrids, geonets, geosynthetic clay liners, composite liner systems, etc.,

- Must use EPA's "Hydrologic Evaluation of Landfill Performance" (HELP) Model or other model approved by the division

- All designs must prevent the "bathtub effect"

EPA HELP Model - Hydrologic Evaluation of Landfill Performance

Quasi-two dimensional hydrologic model of water movement across, into, through, & out of landfills

Considers: climatologic, soil, and LF design data

Considers: surface storage, run-off, infiltration, percolation, evapotranspiration, soil moisture storage & lateral drainage

Estimates: run-off drainage and leachate expected from open, partially open & closed cells

Model estimates buildup & depth of leachate above bottom liner in landfill for designs, time averages & storm events

Can compare different designs and help design leachate drainage & collection systems

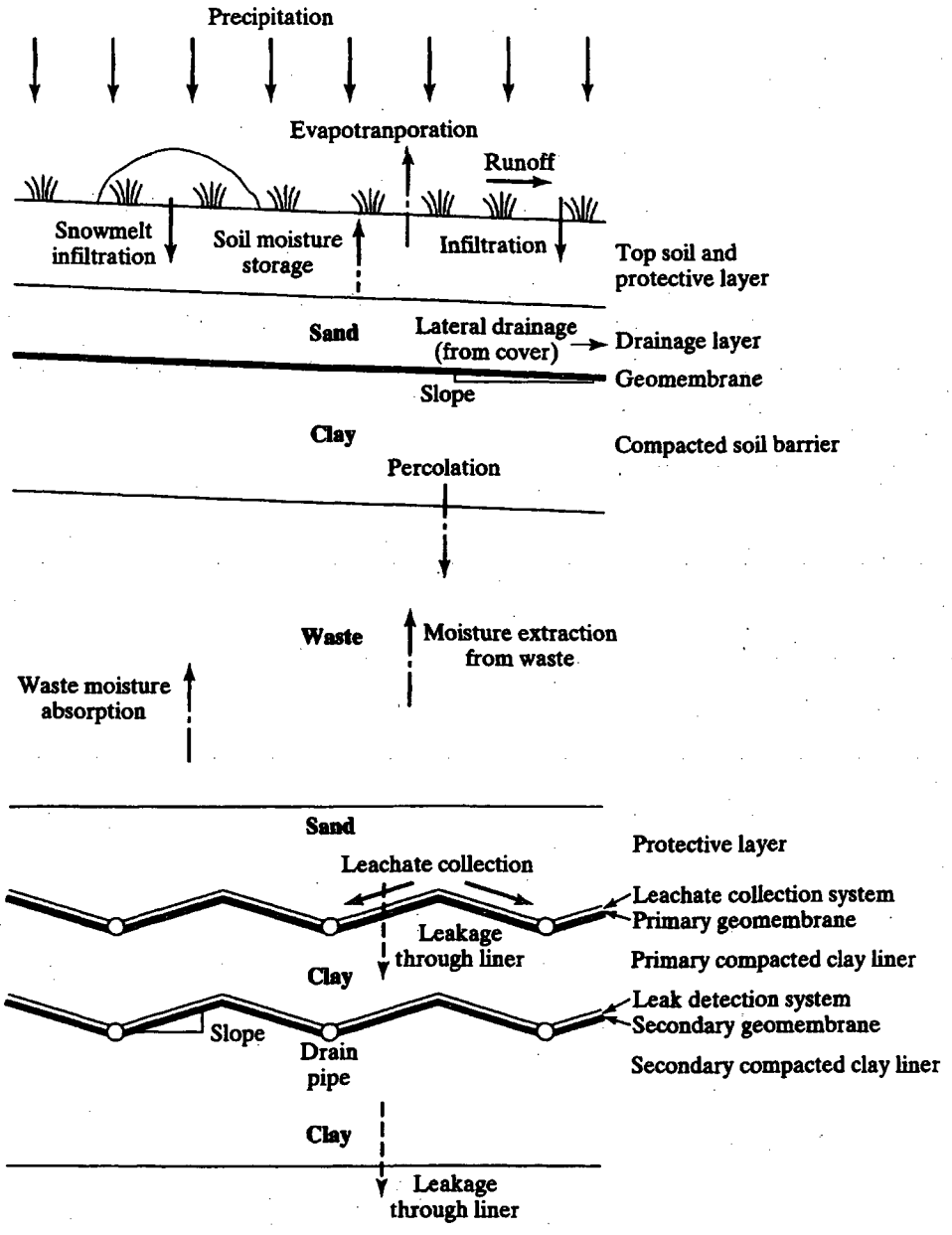


FIGURE 7.6 Leachate Generation or Water Movement in Postclosure Condition

Rule 53.F(4): Liner specifications and requirements

General requirements for geomembrane liners:

- 30-mil flexible PVC or 60-mil HDPE liner or equivalent
- Hydraulic conductivity < 1 x 10-9 cm/sec
- Impervious, geosynthetic material resistant to petroleum hydrocarbons, salts, and acidic and alkaline solutions
- UV resistant (depending on application)
- Liner compatibility as per EPA SW-846 Method 9090A
- Withstand projected loading stresses, settling and disturbances from overlying waste, waste cover materials and equipment operations
- Minimum two percent slope

Solid Waste Regulations:

Subtitle D regulations determine the thickness of geomembranes used in waste containment applications in the United States of America.

The US Government Subtitle D regulations and all state regulations, which use Subtitle D as their guide, require a minimum 30-mil thick flexible membrane liner. This 30-mil liner is used in conjunction with a compacted clay base or some other form of composite liner system. Subtitle D and many State Regulations require that if the liner used is HDPE, then the HDPE cannot be 30 mil, but is required by regulation to be a minimum of 60 mils thick.

40 CFR Ch. I (7–§ 258.29 1–02 Edition)

Subpart D—Design Criteria

§ 258.40 Design criteria.

(b) For purposes of this section, composite liner means a system consisting of two components; the upper component must consist of a minimum 30-mil flexible membrane liner (FML), and the lower component must consist of at least a two-foot layer of compacted soil with a hydraulic conductivity of no more than 1x10-7 cm/sec. FML components consisting of high density polyethylene (HDPE) shall be at least 60-mil thick. The FML component must be installed in direct and uniform contact with the compacted soil component.

Liner Comparison

ATTRIBUTE	HDPE	LLDPE	CSPE-R	PVC	EPDM	EIA	FPP	GCL
General Chemical Exposure	Excellent	Good	Excellent (when cured)	Fair	Good	Excellent	Excellent	Fair
Hydrocarbon Exposure	Good	Good	Good (when cured)	Fair	Good	Excellent	Good	Poor
Weathering (UV Exposure)	Excellent	Fair	Excellent (when cured)	Poor	Excellent	Excellent	Excellent	Poor
Thermal Stability	Poor	Poor	Excellent	Good	Excellent	Good	Good - Excellent when reinforced	Good
Tensile Performance	Good	Good	Excellent	Good	Good	Excellent	Good - Excellent when reinforced	Good
Uni-Axial Elongation Performance	Excellent	Excellent	Good	Good	Good	Fair	Excellent	Fair
Multi-Axial Elongation Performance	Poor	Excellent	Good	Excellent	Good	Fair	Excellent	Fair
Puncture Performance	Fair	Excellent	Good	Excellent	Good	Excellent	Good	Good
Installation Damage Resistance	Fair	Fair	Good	Excellent	Excellent	Good	Excellent	Good
Seaming Methods	Thermal/ Excellent	Thermal/ Excellent	Thermal or solvent bonding/ Good	Thermal or solvent bonding/ Good	Tape seams/ Good	Thermal/ Excellent	Thermal/ Excellent	Overlap
Repair in Service	Good	Good	Poor/ requires adhesives	Good	Good	Good	Excellent	NA
Stress Cracking	Fair	Good	Does not occur	Does not occur	Does not occur	Does not occur	Does not occur	Does not occur
Flexibility in Detailing	Fair	Excellent	Good	Good	Good	Good	Excellent	NA

Source: www.geosynthetica.net/tech_docs/LinerComparisor.asp

Descriptions:

HDPE: High Density Polyethylene
CSPE-R: Chlorosulfonated Polyethylene- Reinforced
PVC: Poly Vinyl Chloride
EIA: Ethylene Interpolymer Alloy
LLDPE: Linear Low-Density Polyethylene
GCL: Geosynthetic Clay Liner
EPDM: Ethylene Propylene Diene Monomer
FPP: Flexible Polypropylene

TABLE 5.5a TENSILE BEHAVIOR PROPERTIES OF HDPE, VLDPE, PVC, AND CSPE-R

Test Property	Unit	Index Tension Tests (Figure 5.2) HDPE	VLDPE	PVC	CSPE-R
Maximum stress and	(kPa)	18,600	8,300	21,000	54,500
corresponding strain	(%)	17	500+	480	19
Modulus	(MPa)	330	76	31	330
Ultimate stress and	(kPa)	13,800	8,300	20,700	5,700
corresponding strain	(%)	500+	500+	480	110

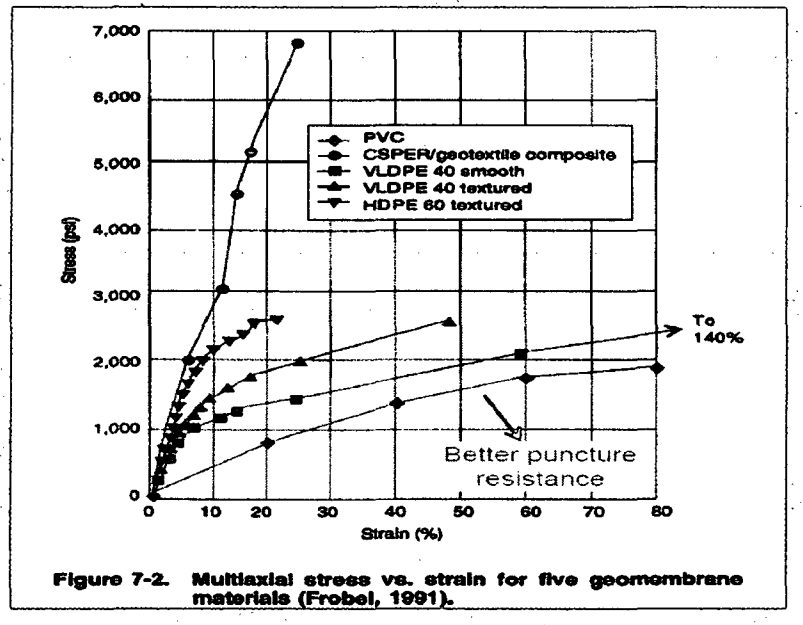


Figure 7-2. Multiaxial stress vs. strain for five geomembrane materials (Frobel, 1991).

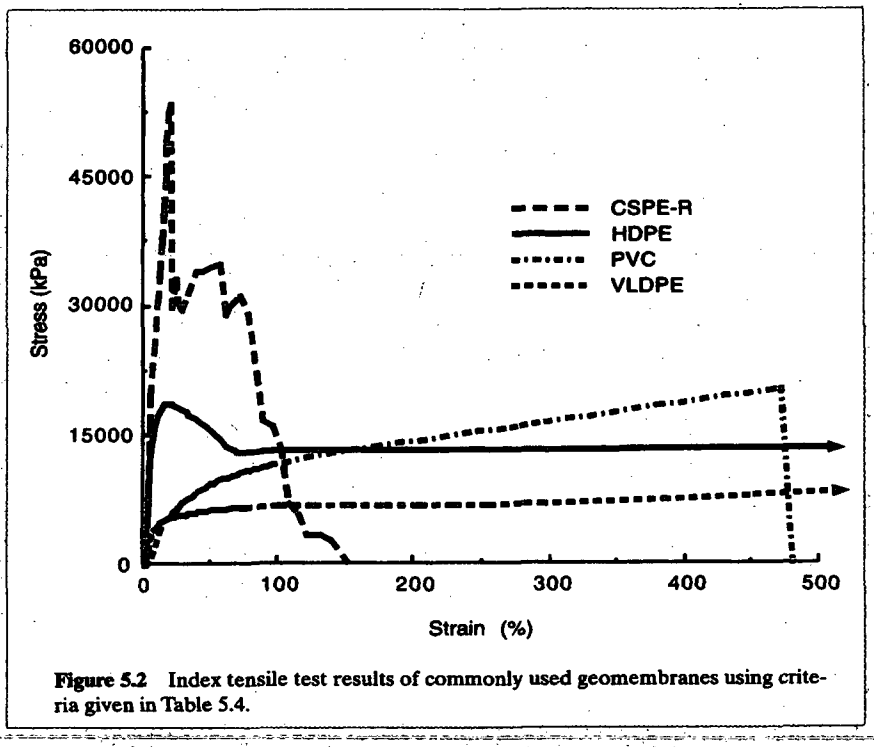


Figure 5.2 Index tensile test results of commonly used geomembranes using criteria given in Table 5.4.

Source: U.S. EPA, 1994. Seminar Publication: Design, Operation, and Closure of Municipal Solid Waste Landfills. Report Number EPA/625/R-94/008. Center for Environmental Research Information, U.S. EnvironmentalProtection Agency, Cincinnati, Ohio. September1994. (http://www.epa.gov/ORD/NRMRL/Pubs/1994/6 25R94008.pdf)

Rule 53.F(4): Liner specifications and requirements

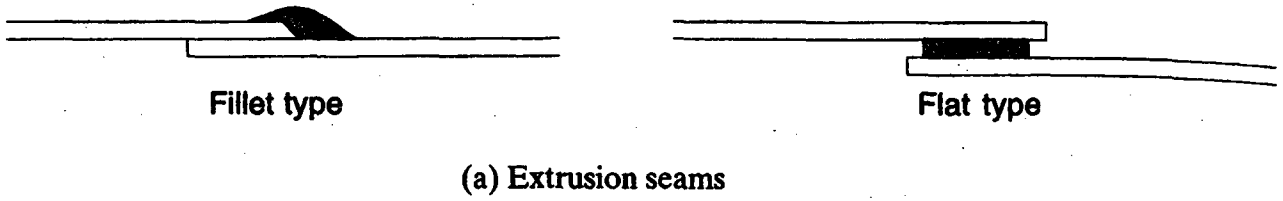
Additional requirements for geomembranes

- Must be compatible with waste
- Must be resistant to chemical attack (demonstrate using test reports, laboratory analyses or other division-approved method)
- Must withstand the calculated tensile forces

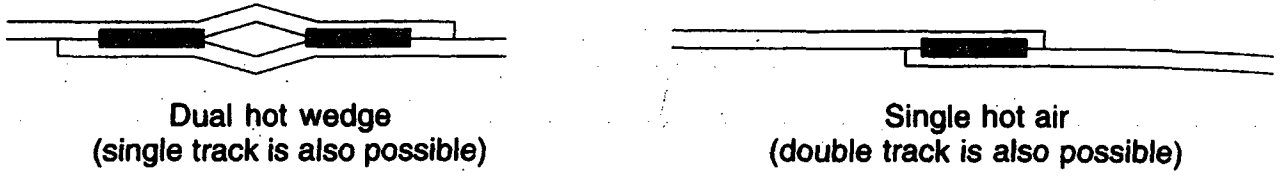
Rule 53.F(4): Liner specifications and requirements

Additional requirements for geomembranes (Field Seams)

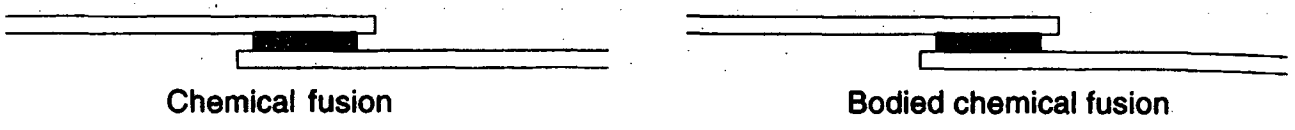
- Field seams must be thermally seamed (hot wedge) with a double track weld to create an air pocket for non-destructive air channel testing or other approved thermal seam method when double track is not possible
- Must be overlapped 4 to 6 inches before seaming
- Seams must be oriented parallel to the slope
- Minimize number of field seams in corners and irregularly shaped areas
- Factory seams must be used where possible.
- No horizontal seams within 5 feet of the toe of the slope
- Only qualified personnel may perform field seaming



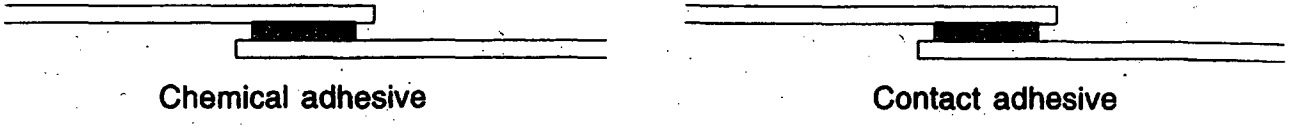
(a) Extrusion seams



(b) Thermal fusion seams



(c) Chemical seams



(d) Adhesive seams

Figure 5.63 Various methods available to fabricate geomembrane seams.

Rule 53.F(4)(c) Requirements for the soil component of composite liners

- Base layer shall be placed on a prepared subgrade
- Compacted to 90% Standard Proctor Density (SPD)
- Soil surface must be properly prepared to prevent damage the geosynthetic
- Clay soil component of any composite liner below waste must be compacted to a minimum of 90% SPD
  - Plasticity index (Atterberg Limit) > 10%
  - Liquid limit between 25% and 50%
  - No. 200 sieve > 40% by weight
  - Clay content > 18% by weight

Exhibit 4-4. Methods for Testing Low-Permeability Soil Liners (Reference 9)

Parameter to be Analyzed	Methods	Test Method Reference
Soil type	Visual-manual procedure	ASTM D2488
	Particle size analysis	ASTM D422
	Atterberg limits	ASTM D4318
	Soil classification	ASTM D2487
Moisture content	Oven-dry method	ASTM D2216
	Nuclear method	ASTM D3017
	Calcium carbide (speedy)	AASHTO T217
In-place density	Nuclear methods	ASTM D2922
	Sand cone	ASTM D1556
	Rubber balloon	ASTM D2167
	Drive cylinder	ASTM D2937
Moisture-density relations	Standard effort	ASTM D698
	Modified effort	ASTM D1557
Strength	Unconfined compressive strength	ASTM D2166
	Triaxial compression	ASTM D2850
Cohesive soil consistency (field)	Penetration tests	ASTM D3441
	Field vane shear test	ASTM D2573
	Hand penetrometer	Horslev, 1943
Hydraulic conductivity (laboratory)	Fixed-wall double ring permeameter	EPA, 1983 SW-870 Anderson et. al., 1984
	Flexible wall permeameter	Daniel et al., 1985 SW-846 Method 9100 (EPA, 1984)
Hydraulic Conductivity (field)	Sealed Double-Ring Infiltrometer	Day and Daniel, 1985
	Sai-Anderson-Gill double-ring Infiltrometer	Anderson et al., 1984

Rule 53.F(3)(h): Top landfill cover design (top to bottom)

- 6 in. re-vegetated soil erosion layer
- 12 to 30 in. of protection/frost protection layer
- 12 in. drainage layer (sand or gravel) with a saturated hydraulic conductivity of 1 x 10-2 cm/sec
- hydraulic barrier-layer: geomembrane (30-mil flexible PVC or 60-mil HDPE liner) minimum slope of 4%

Note: Equivalent liners may be approved by OCD

- 12 in gas vent/foundation layer (sand or gravel) with 80% SPD
- Top landfill cover must be installed within one year of achieving the final landfill cell waste elevation
- Timely completion of working face required

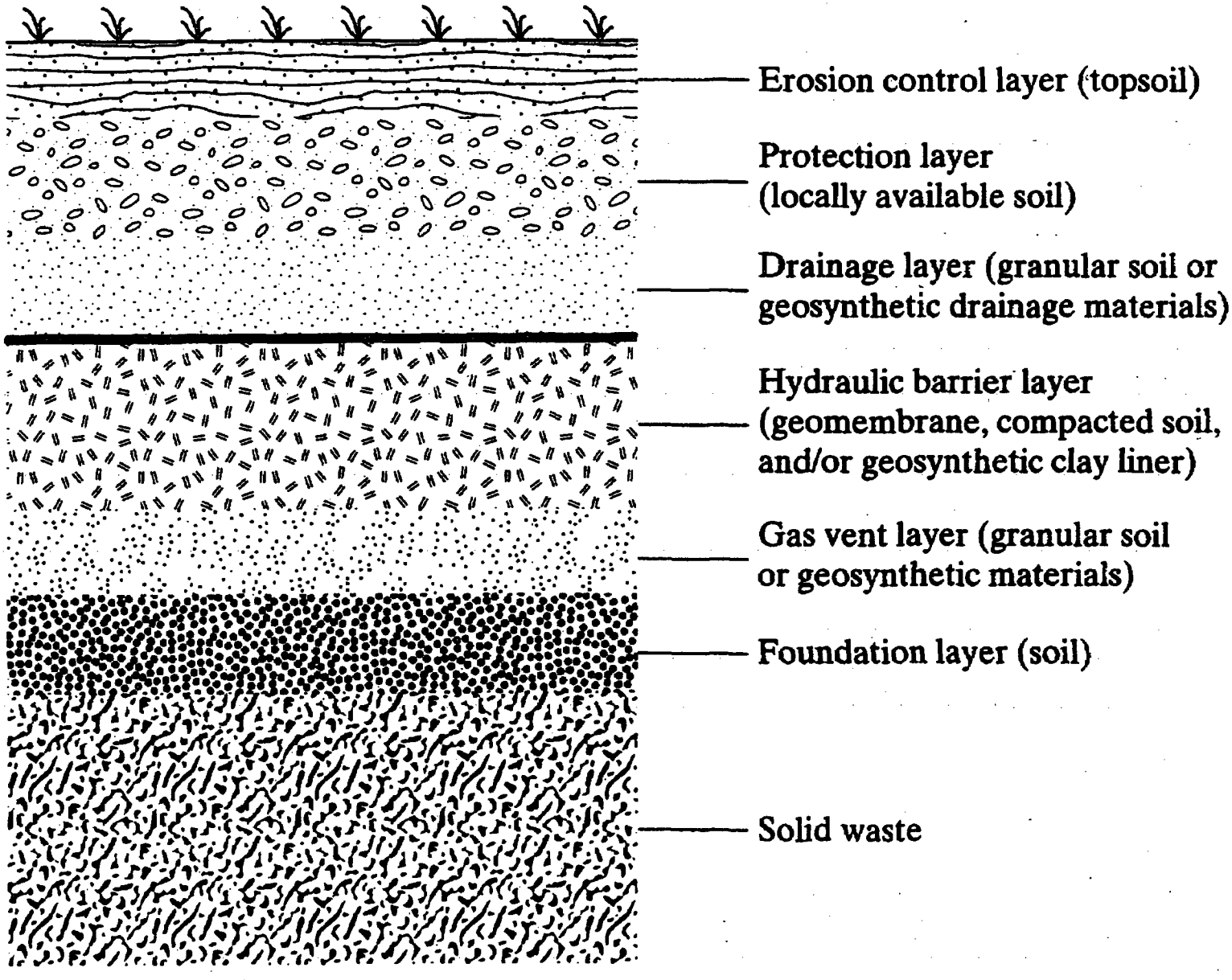


FIGURE 11.1 Typical Layers of Final Cover System for Municipal Solid Waste

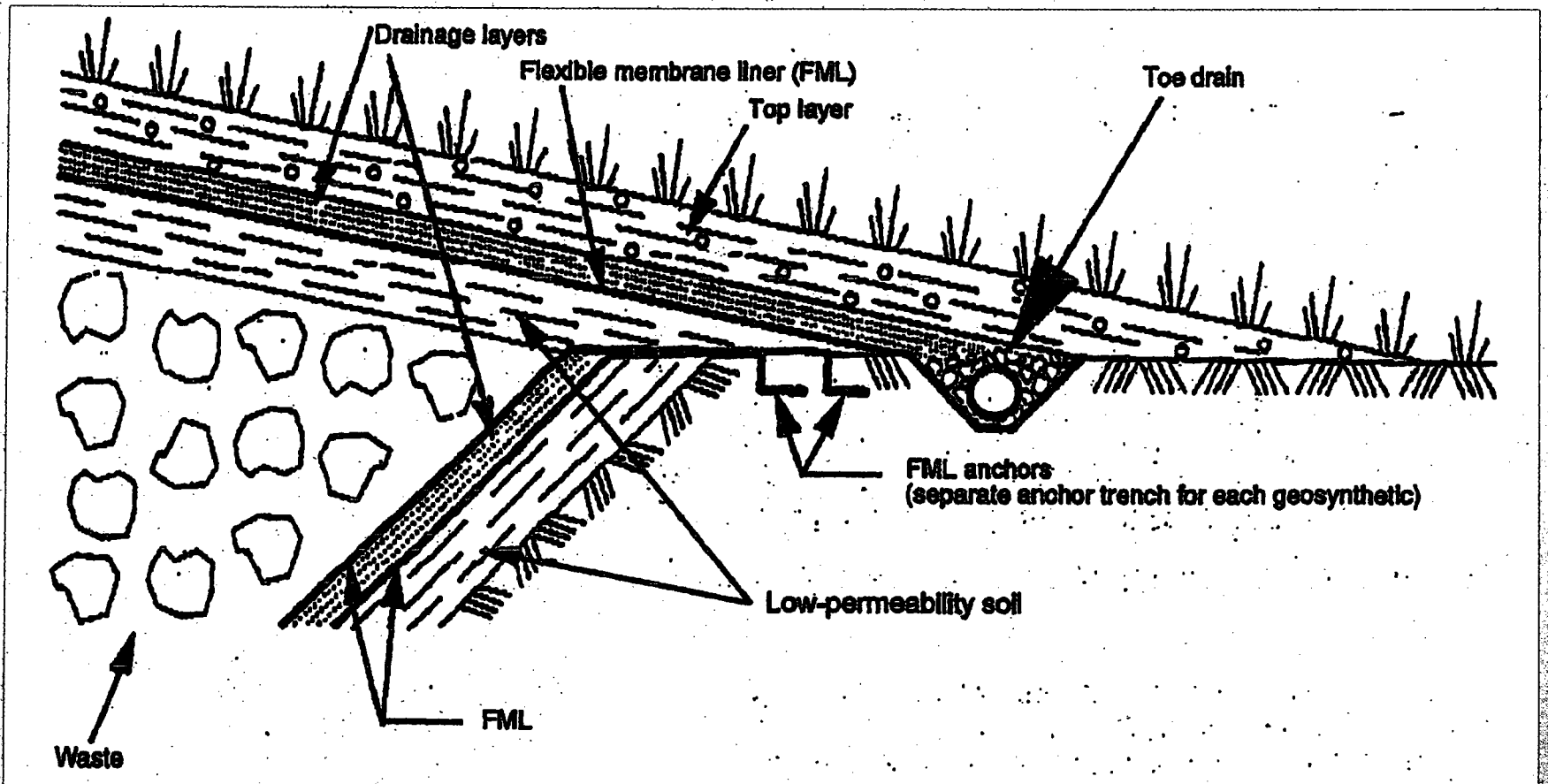


Figure 7-3. Schematic of a sideslope drainage layer (U.S. EPA, 1989c).

Rule 53.C: Permitting requirements, application, public notice and financial assurance

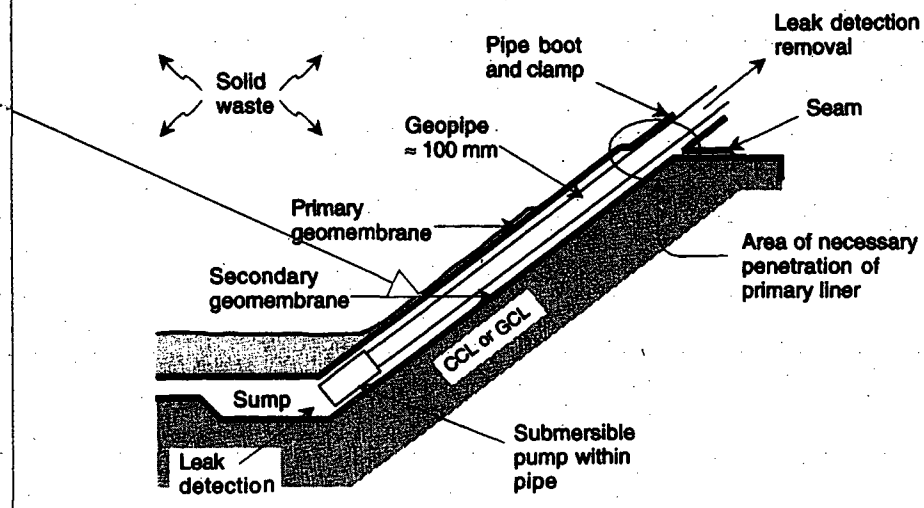
For applications for a new or expanded landfill permit application, the operator must submit a leachate management plan that describes the anticipated amount of leachate that will be generated and the handling, storage, treatment and disposal of the leachate, including final post closure options

Note: Pre-existing landfills are exempt from siting requirements, but not operation and closure requirements of the new rule. Except siting may be an issue where expansion is outside of the permitted acreage

Rule 53.F(3)(j): External piping

- External piping (*e.g.*, leachate collection, leak detection, and sump removal systems) must have side-wall riser pipe design
- Pipes must not penetrate the liner with the exception of gas vent or collection wells
- Flexible clamped pipe riser through the top landfill cover liner must be used to accommodate waste settling and to prevent tearing of top cover liner leading to leakage, off-gassing, etc.

Sidewall Riser



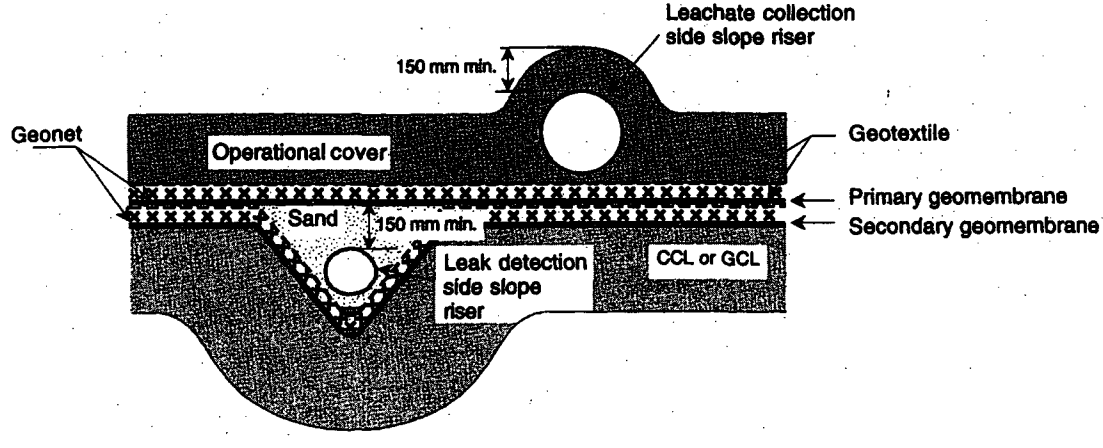


Figure 5.45 Leak detection and removal system (upper) and side wall details when using a geonet (lower).

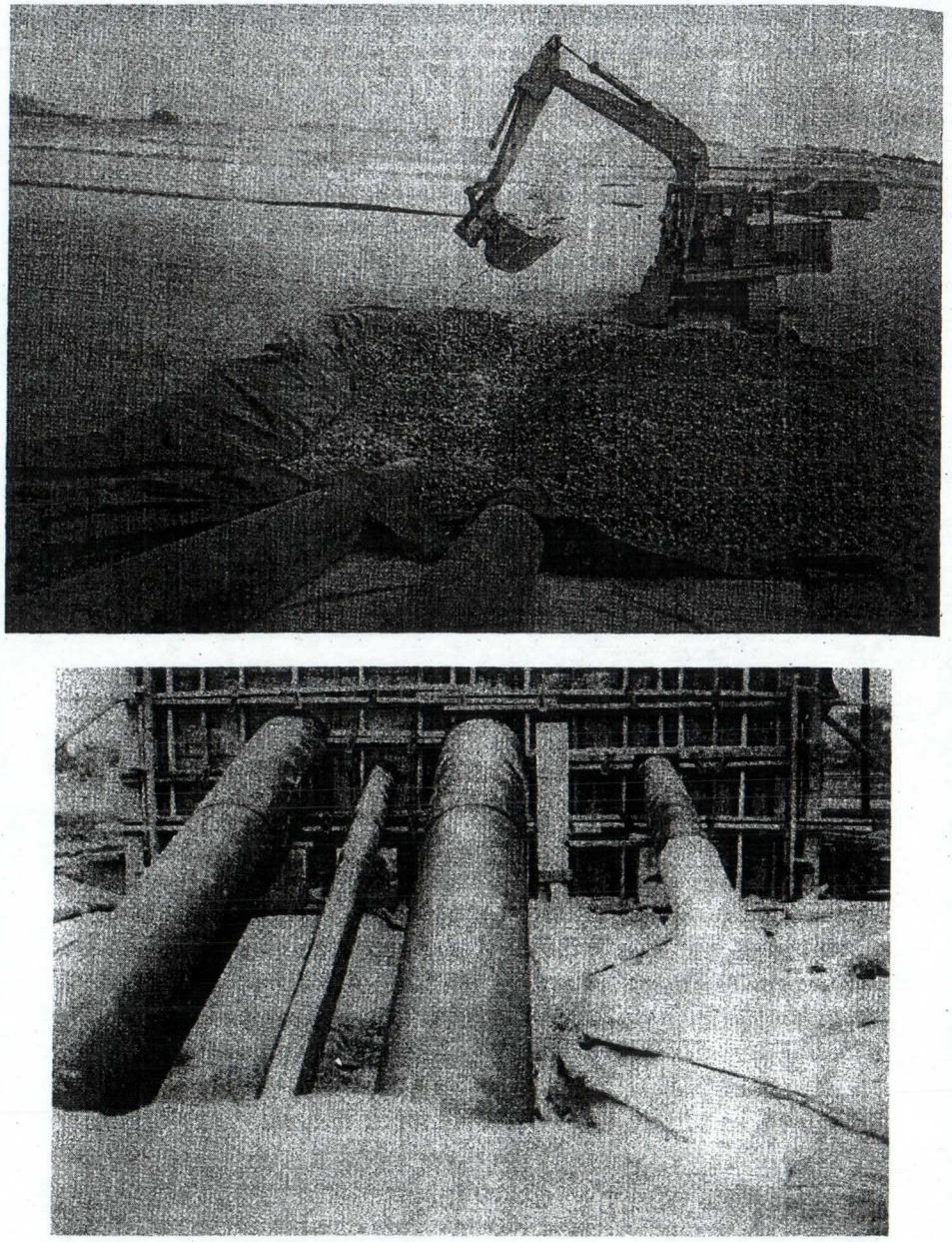


Figure 5.44 Primary leachate collection sump side-wall riser pipes leading from sump into a collection and monitoring shed.

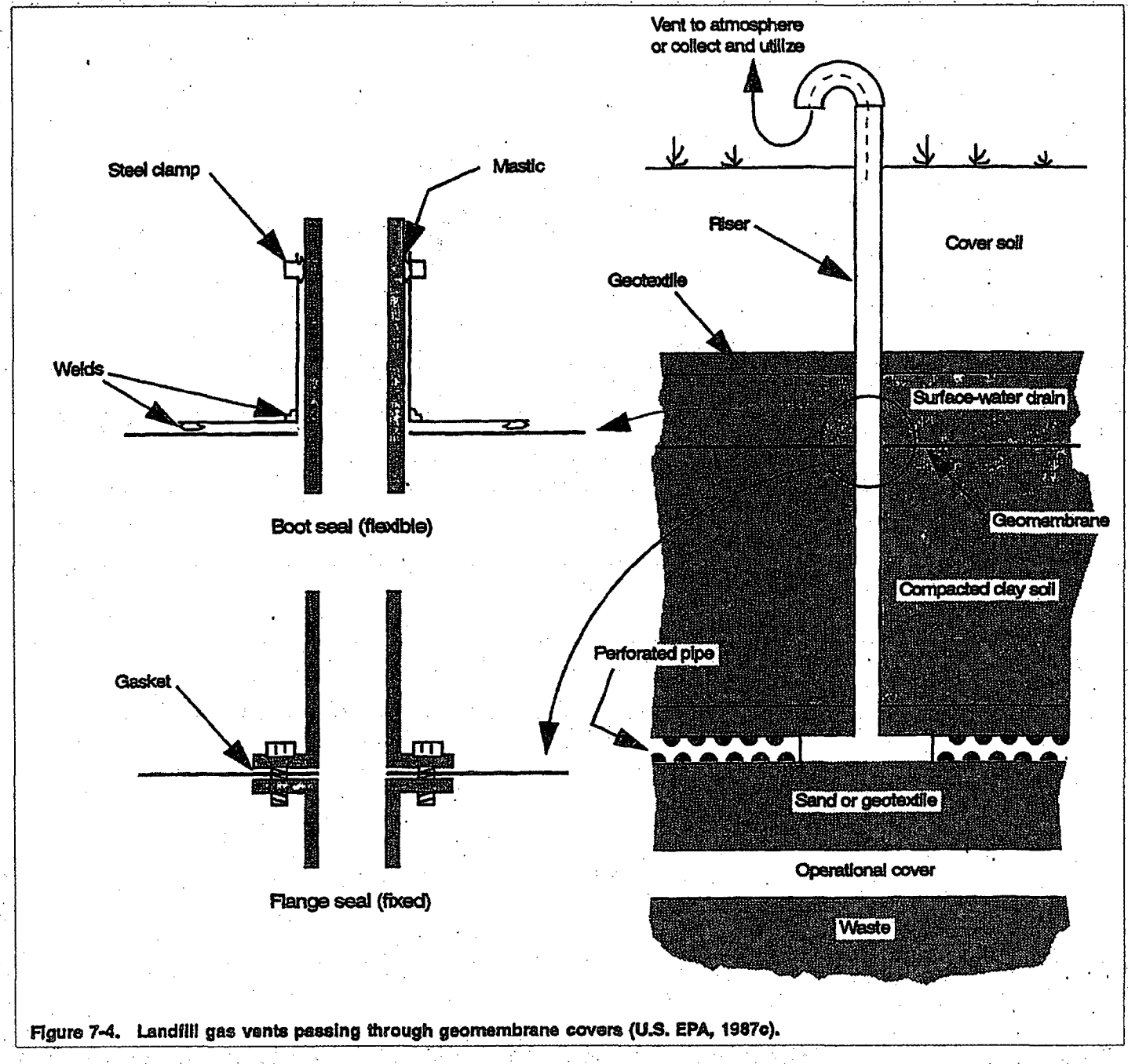


Figure 7-4. Landfill gas vents passing through geomembrane covers (U.S. EPA, 1987c).

Rule 53.I(2)(I): Leak detection system

- between lower and upper geomembrane liners
- two feet of compacted soil w/ saturated hydraulic conductivity of >= 1 x 10-5 cm/sec
- properly designed drainage, collection and removal system
- placed above the lower geomembrane liner in depressions
  - sloped to facilitate earliest possible leak detection
  - piping must withstand chemical attack, structural loading, expansion or contraction

Rule 53.I(2)(I): Leak detection system

- facilitate clean-out maintenance.
- material between the pipes and laterals must be permeable
- slope must be at least a two percent grade
- 4 in. Schedule 80 solid and perforated pipe
- solid drainage pipe must be sealed to convey fluids to sump within perimeter of the landfill, for observation
- alternative designs may be considered

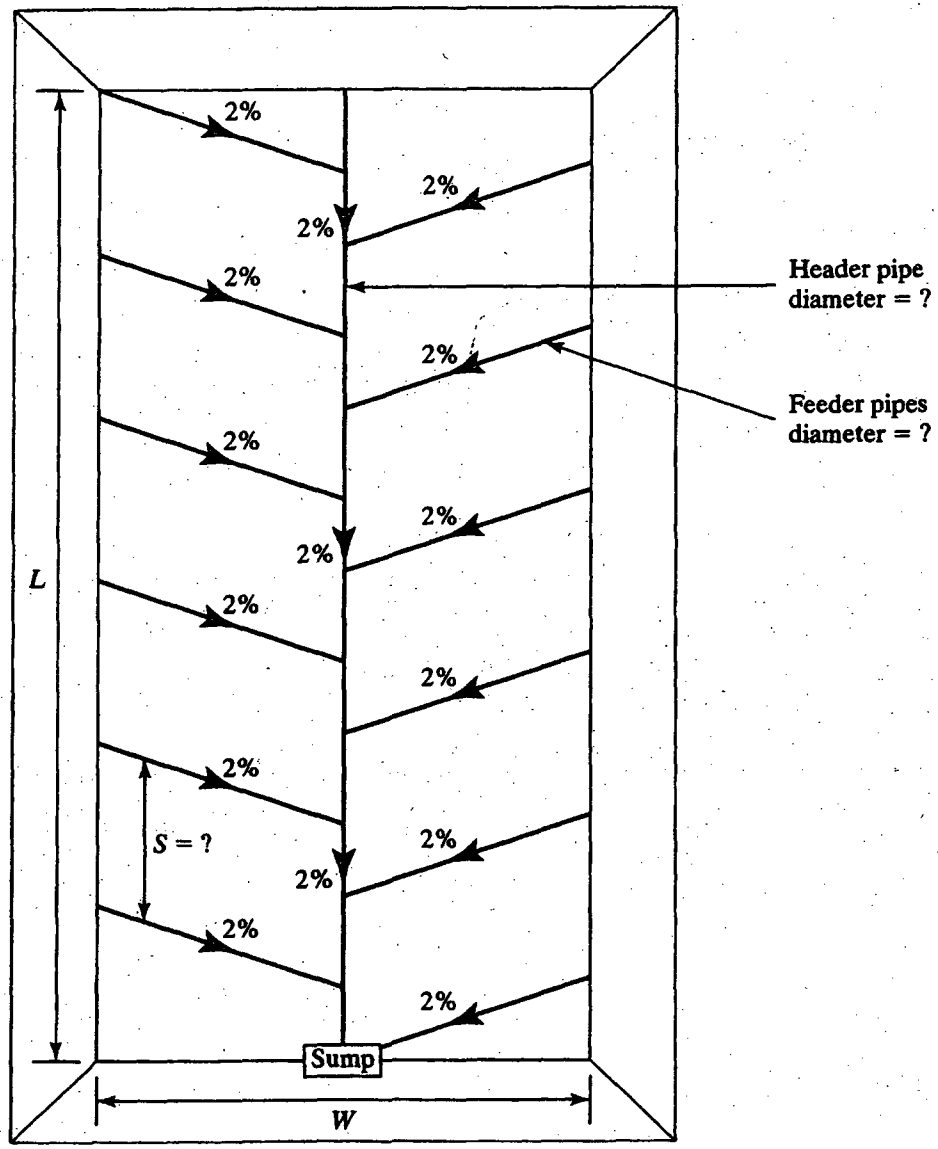


Figure 7.13 Typical plan view of the perforated pipe network of the leachate collection system for a landfill.

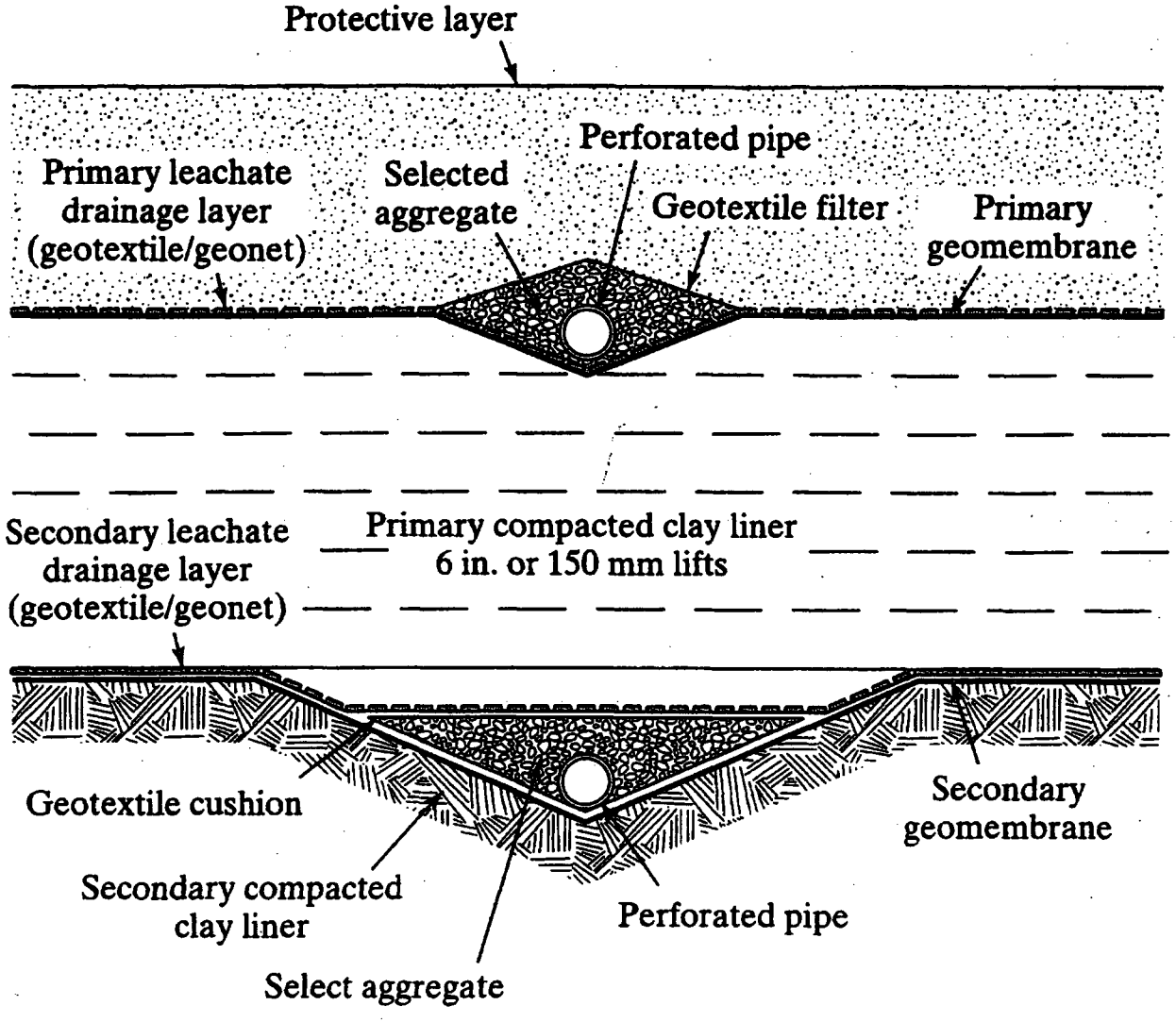
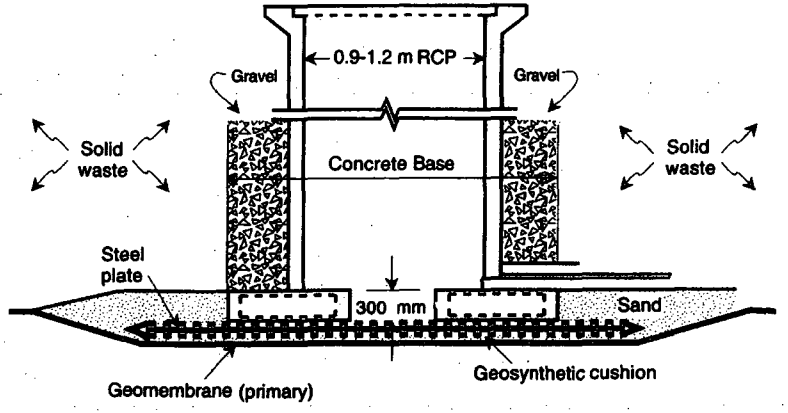
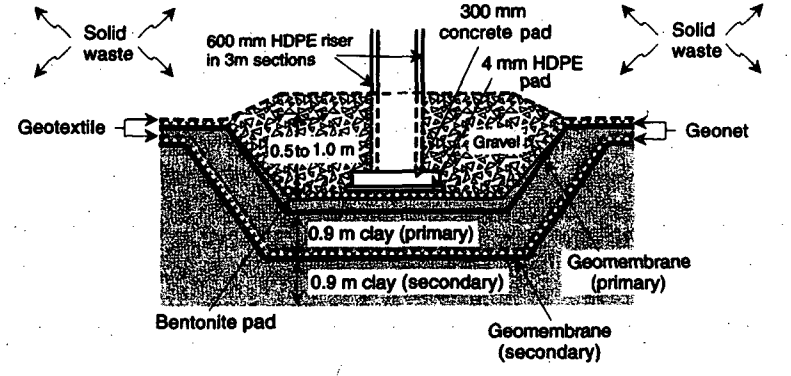


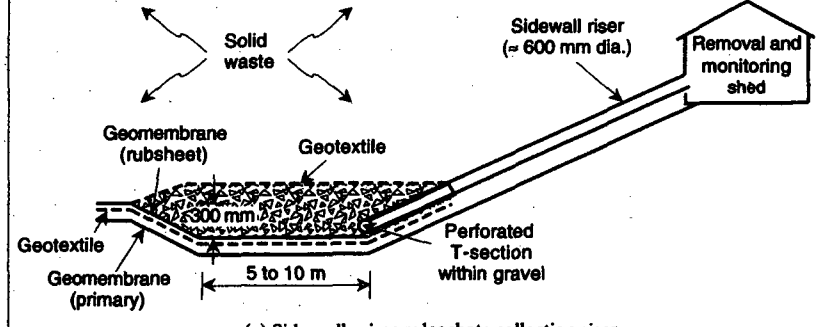
FIGURE 9.2 Example of Leachate Collection Pipe and Trench for Double Geomembrane/Compacted Clay Composite Liner System



(a) Low-volume primary leachate collection



(b) High-volume primary leachate collection manhole
(after Chemical Waste Management, Inc.)



(c) Side wall primary leachate collection riser

Rule 53.A(1)(m): Gas safety management plan

Rule 53.E(15): Gas safety management plan

- Describe in detail how Operator will prevent landfill-generated gases
- Must address anticipated amounts and types of gases that may be generated,
- Must include air monitoring plan for vadose zone
- Must also address final post closure monitoring and control options

All landfills containing organic, decomposable materials will generate gas. The total volume of landfill gas generated over its life is a direct function of the total quantity of organic material contained therein. In a mature landfill, which approaches fully anaerobic, steady-state conditions (8 to 40 yrs), empirical evidence suggests that the gas generation rate at most landfills may actually be at or below 0.10 ft^3 (LFG)/lb (waste)/yr [6.24 m^3 (LFG)/Mg (waste)/yr] (EMCON, 1998).

TABLE 10.1 Summary of MSW Landfill Gas Generation Phases (EMCON, 1998)

Phase	Name	Primary Activity Signaling the End of Phase
I	Aerobic	No oxygen in the landfill gas (several hours to 1 week)
II	Aerobic/Acid Generation	Formation of free fatty acids is at its peak and methane generation begins (1 to 6 months)
III	Transition to Anaerobic	Methane and carbon dioxide concentrations stabilize and no nitrogen in the landfill gas (3 months to 3 years)
IV	Anaerobic	Methane and carbon dioxide concentrations begin to reduce and some nitrogen (air) returns to the system (8 to 40 years)
V	Transition to Stabilization	Gas is primary air and all anaerobic decomposition is

Rule 53.F(5): Landfill Gas Control Systems:

(a) System design: location and design of vents, barriers, collection piping and manifolds and other control measures that will be installed (gas vent or collection wells must have clamped and seamed pipe riser through top cover liner)

(b) Gas recovery system

(c) Gas processing plan

(d) Gas disposal plan:

(f) Means to prevent the generation and lateral migration of gas

(g) Quarterly gas monitoring program

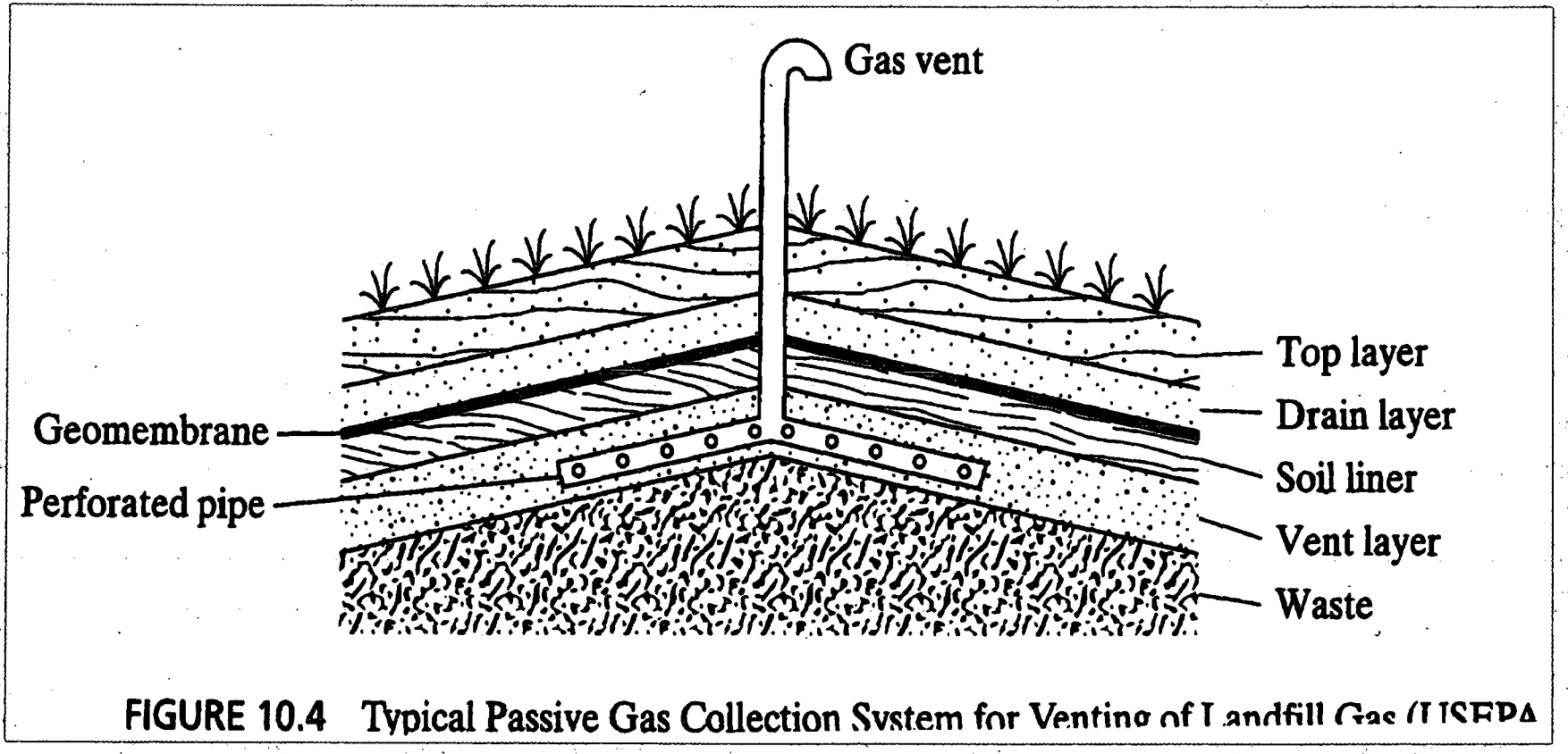


FIGURE 10.4 Typical Passive Gas Collection System for Venting of Landfill Gas (USEPA

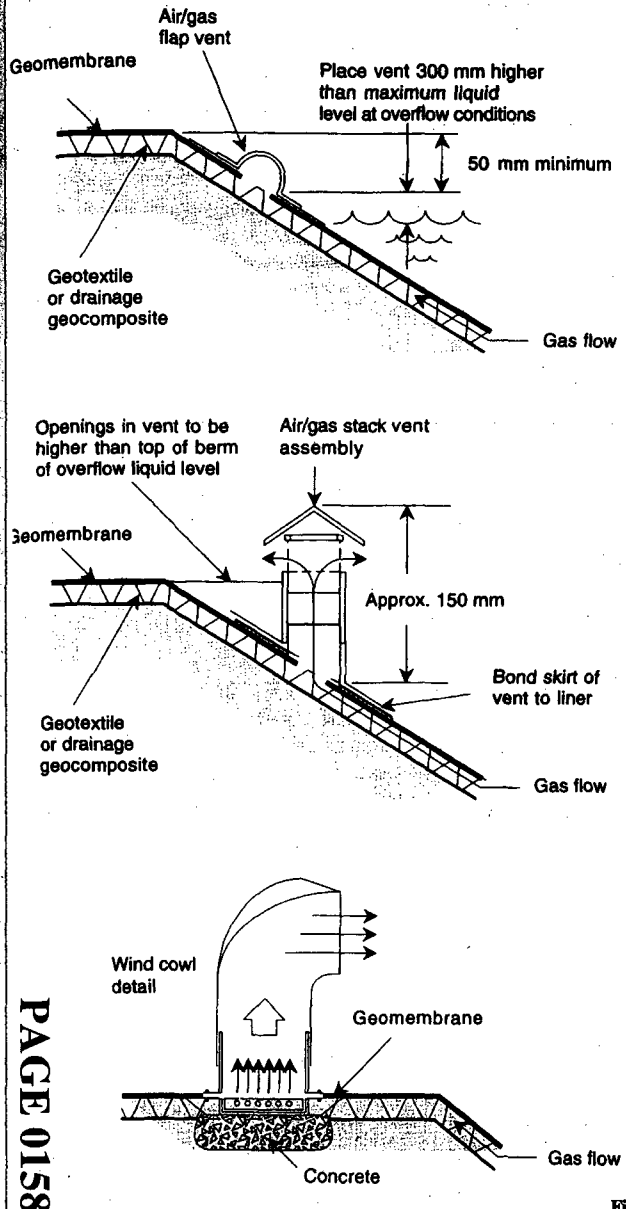


Figure 5.72 Typical gas vent details. (After Richardson and Koerner [67])

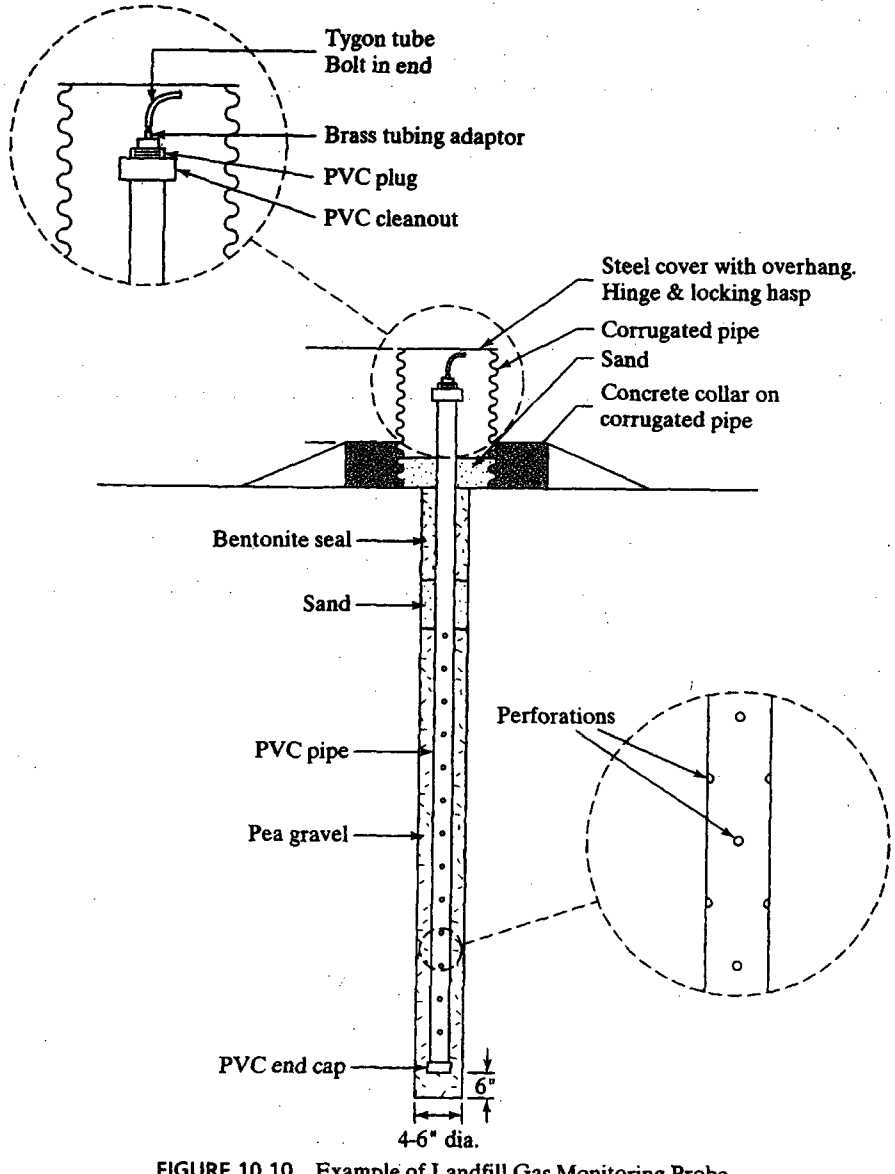


FIGURE 10.10 Example of Landfill Gas Monitoring Probe

Rule 53.F(6): Landfill gas response. If gas levels exceed the specified limits, the operator shall:

(a) immediately take steps to ensure protection of fresh water, public health, safety and the environment and notify the division

(b) within 7 days, record gas levels and a description of the steps taken

(c) within 30 days, submit remediation plan for gas releases

(d) within 60 days of OCD approval, implement the remediation plan and notify OCD

Rule 53.J(4)(c)(i): Post-closure care and monitoring plan: maintenance of cover integrity, maintenance and operation of the leak detection system and leachate collection and removal system and operation of gas and ground water monitoring systems.

Rule 53.J(4)(c)(ii): Sample ground water monitoring wells annually and submit reports

Rule 53.J(4)(c): Landfill post closure: post-closure period shall be 30 years.

Rule 53.F(1)(d): The operator shall control litter and odors.

Rule 53.F(1)(f): The operator shall provide adequate cover for the landfill's active face as needed to control dust, debris, odors and other nuisances, or as otherwise required by the division.

Notes: 1) soils reeking of odor will not be allowed as daily cover (i.e.; mercaptan)

2) leachate collection & removal systems with minimal leachate volume may serve a dual purpose of leachate and gas collection to control gas vapors/odors

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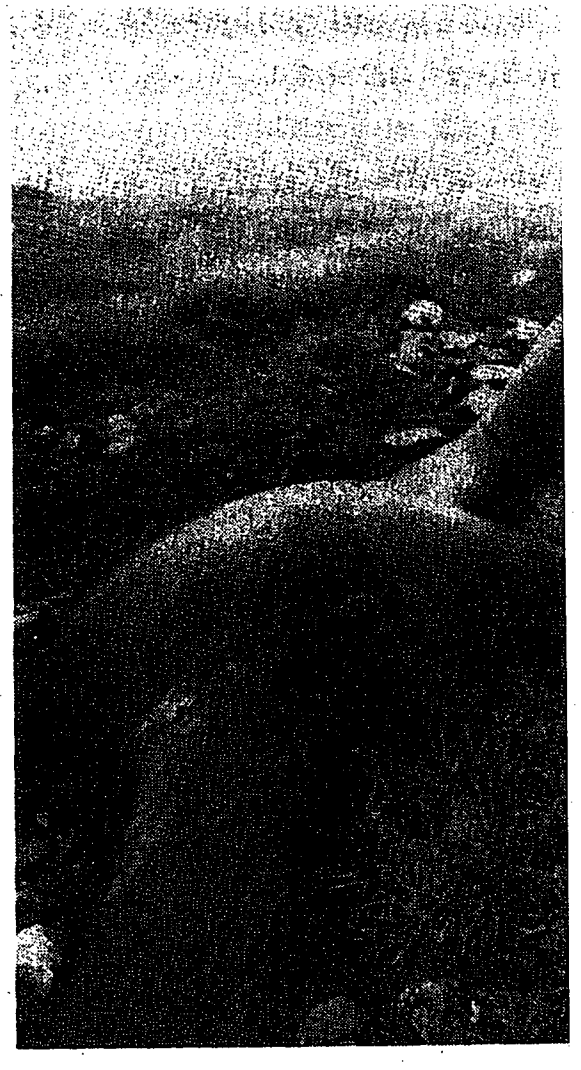

Figure 5.54 Geomembran
ing aside ≈1.5 m of cover sc

Rule 53.J(4)(c)(i): Post-closure care and monitoring plan: maintenance of cover integrity, maintenance and operation of the leak detection system and leachate collection and removal system and operation of gas and ground water monitoring systems.

Rule 53.J(4)(c)(ii): Sample ground water monitoring wells annually and submit reports

Rule 53.J(4)(c): Landfill post closure: post-closure period shall be 30 years.

Exhibit 5-3. Typical Elements of Maintenance Program

PREVENTATIVE MAINTENANCE (2 to 3 years)

Cover System Component	Frequency	Task
Vegetation	twice per year annual	mowing (weed and brush) fertilization
Topsoil	as needed	soil reconditioning (supplemental fertilization, aeration)

PROBLEM IDENTIFICATION/CORRECTION

Cover System Component	Problem	Repair
Cover System	gully development	backfill to original grade with stone of narrow size range regrade cover replant vegetation
	subsidence	backfill with additional cover soil (care should be taken to maintain continuity of low permeable soil layer, geomembrane and drainage layer)
	slope instability	reconstruct cover flatten slopes add toe berm along base of slope
	gas migration that causes cracking	upgrade or install gas venting system install perimeter vents
Run-off Control System	erosion, siltation	placement of stone riprap or concrete modify channel alignment and/or gradients