Introduction to Lining Systems in Waste Containment Facilities

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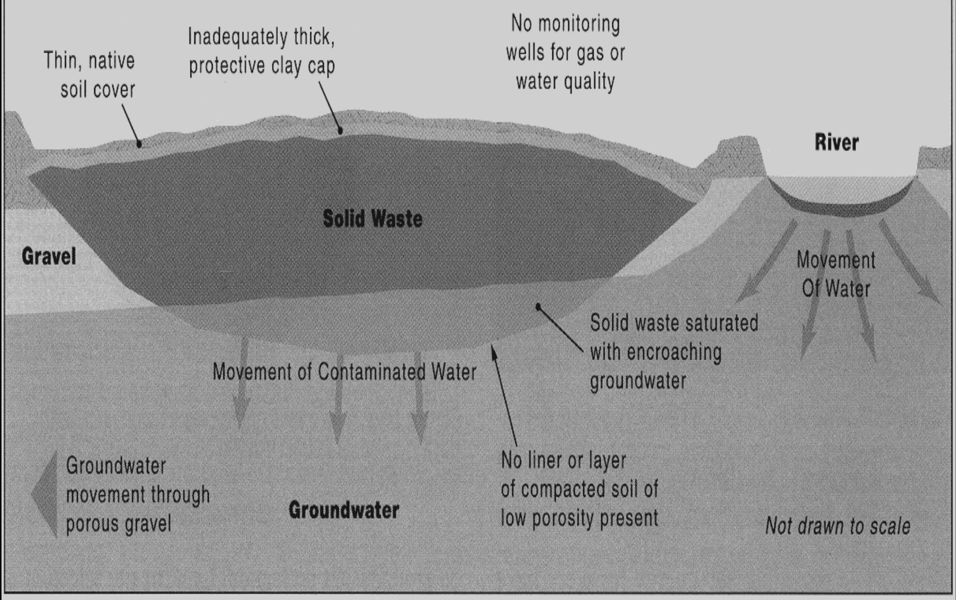
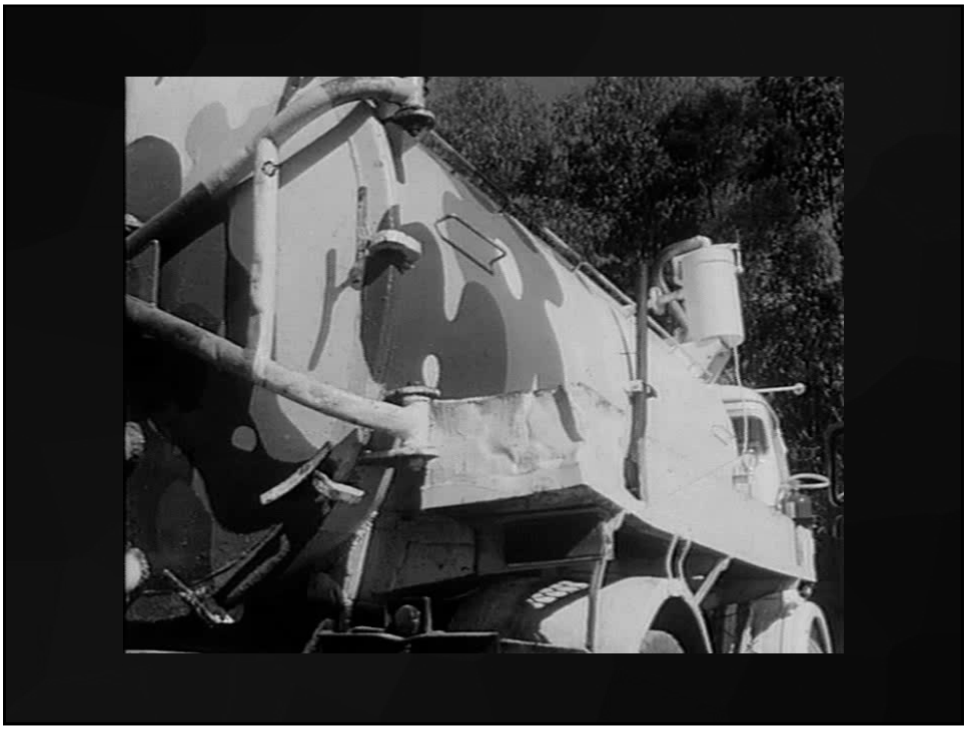
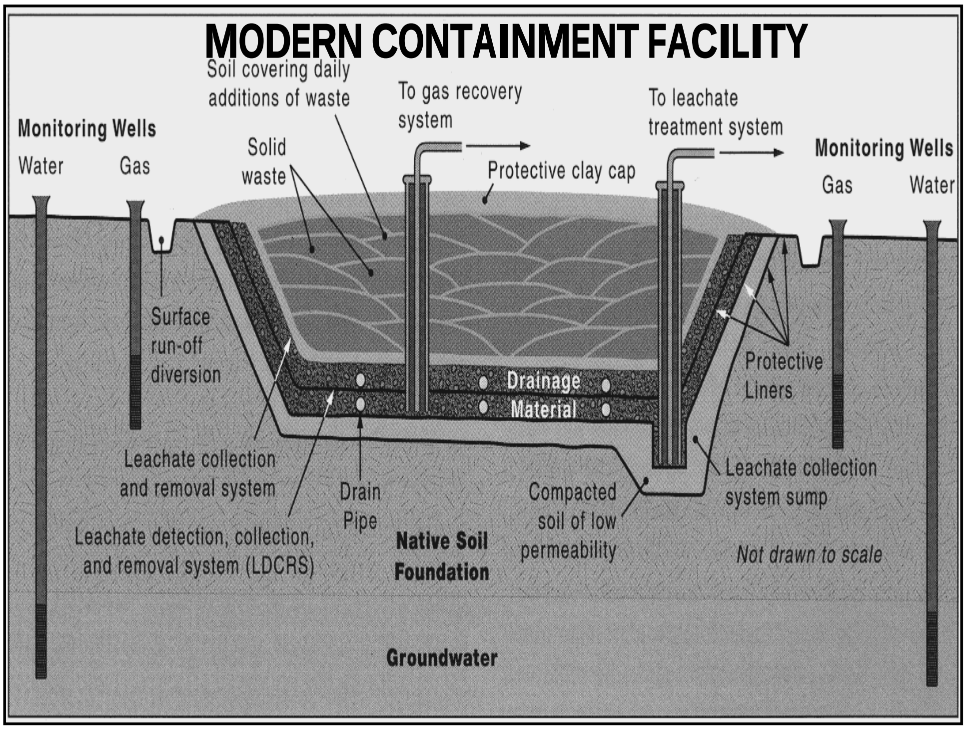
OLD STYLE CONTAINMENT FACILITY







MODERN CONTAINMENT FACILITY
Soil covering daily additions of waste
To gas recovery system
To leachate treatment system
Monitoring Wells
Water
Gas
Solid waste
Protective clay cap
Monitoring Wells
Gas
Water
Surface run-off diversion
Drainage Material
Protective Liners
Leachate collection and removal system
Drain Pipe
Compacted soil of low permeability
Leachate collection system sump
Leachate detection, collection, and removal system (LDCRS)
Native Soil Foundation
Not drawn to scale
Groundwater


LEONEL
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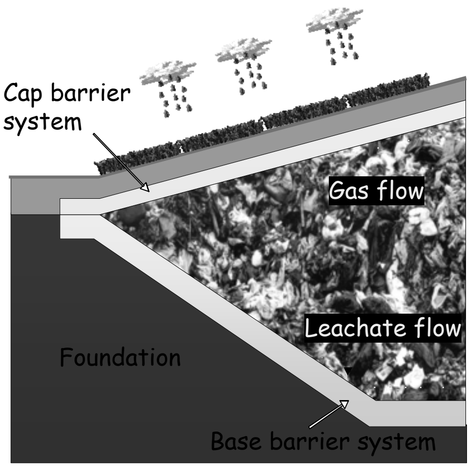
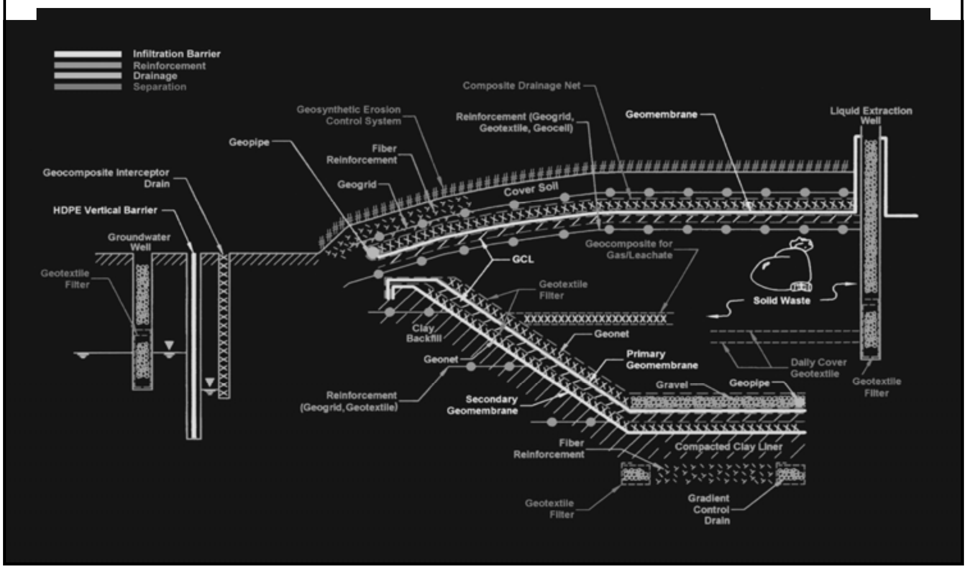
How do landfills perform?

- **Landfills perform by controlling and managing the movement of fluids (i.e. liquids and gasses) around, into and out of the contained waste volume**



1. ***Base barrier system functions:***
   - **To minimise the escape of leachate into the foundation**
   - **To prevent contamination of groundwater**
2. ***Cap barrier system functions:***
   - **To control moisture infiltration into the waste**
   - **To collect gas flows from the waste**
   - **To prevent odours, and sources of disease**
   - **To meet erosion, aesthetic and other functional criteria**

Geosynthetics in Modern Landfills

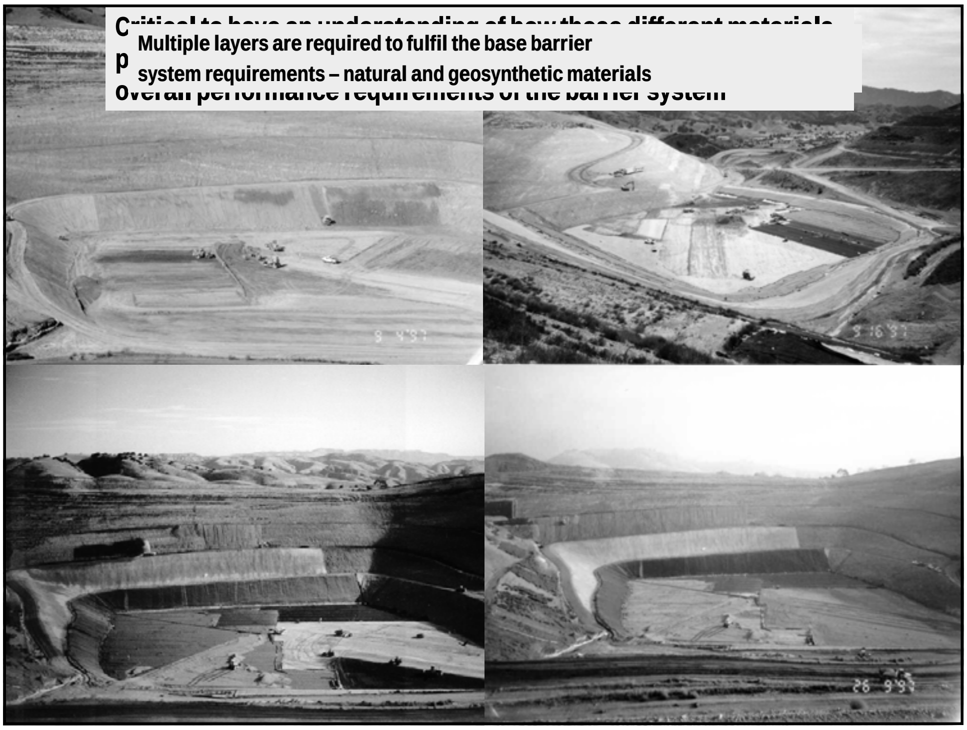


Nature of Waste Problem

1. Moisture within and flowing on the waste generates leachate
2. Leachate takes characteristics of the waste
3. Thus leachate is very variable and is site specific-there is no "typical" leachate
4. Flows gravitationally downward into the leachate collection system
5. Enters groundwater unless a suitable barrier layer or system is provided.

Genesis of Liner Systems

- Single CCL
- Single GM
- Double GM
- Single GM/composite GM/CCL
- Composite GM-GCL/composite GM-CCL
- Composite GM-GCL/composite GM-GCL-CCL


Multiple layers are required to fulfil the base barrier
system requirements – natural and geosynthetic materials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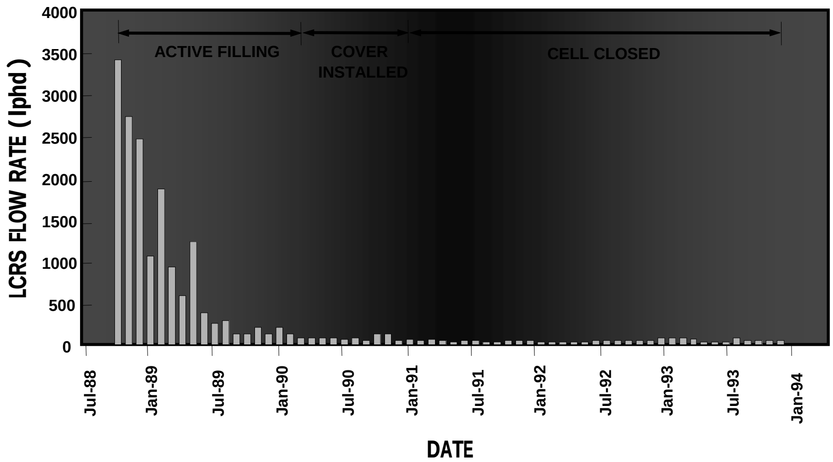
(Areal View of 70 ha Site)

LEACHATE GENERATION RATES AT A MODERN LANDFILL (Bonaparte, 1995)



Design

Passive:

To provide cover system as impermeable as possible and as soon as possible after landfill has ceased operation.

Advantages

Minimisation of amount of leachate to be collected and treated and mounding of leachate.

Disadvantages

Extend contaminating lifespan.

Design (Cont'd)

Active:

Allow as much infiltration as would practically occur

Advantages

Landfill brought to field capacity very quickly.

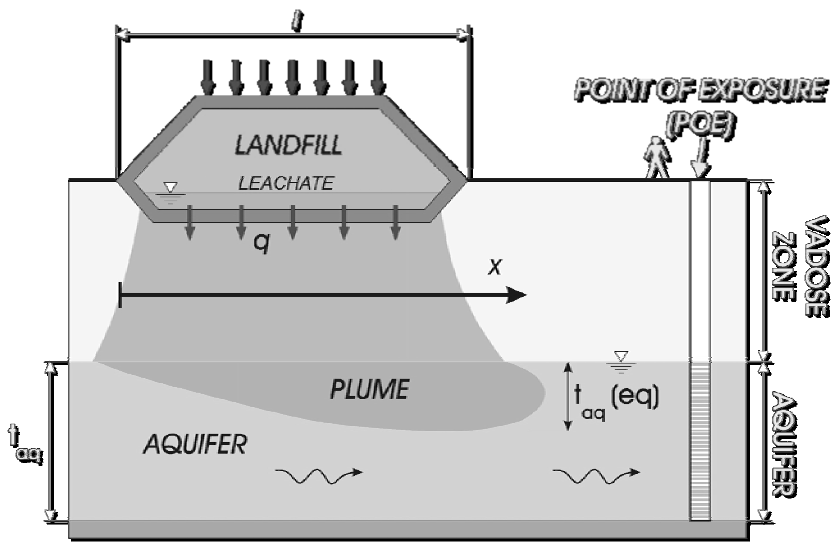
Allow removal of large proportion of contaminants.

Disadvantages

Large volume of leachate must be treated.

If leachate collection system fails, significant leachate mounding will occur.

Conceptual scheme for contaminant impact evaluation and risk analysis



Prescriptive Based Design

Advantages

1. Approval of the proposal is simply based on a check list.
2. A minimum environmental protection is assured

Disadvantages

1. Unsafe and Overconservative design can occur

Performance Based Design

Advantages

1. Updated Design
2. Need of a detailed evaluation of the proposed solution
3. Solution tailored to the specific features of the considered site

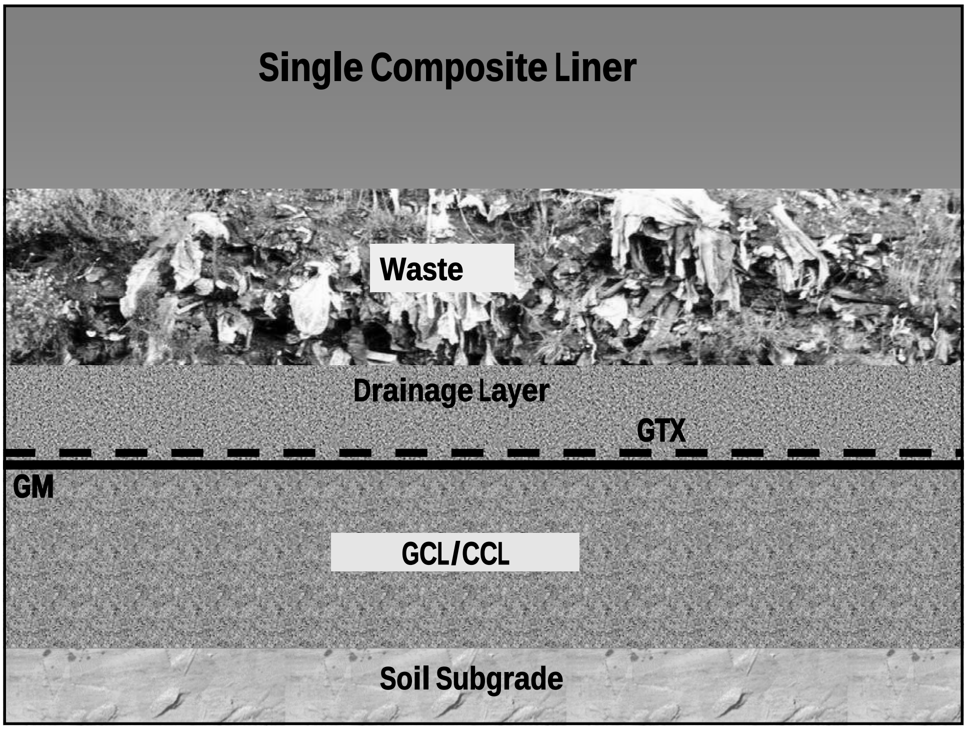
Performance Based Design

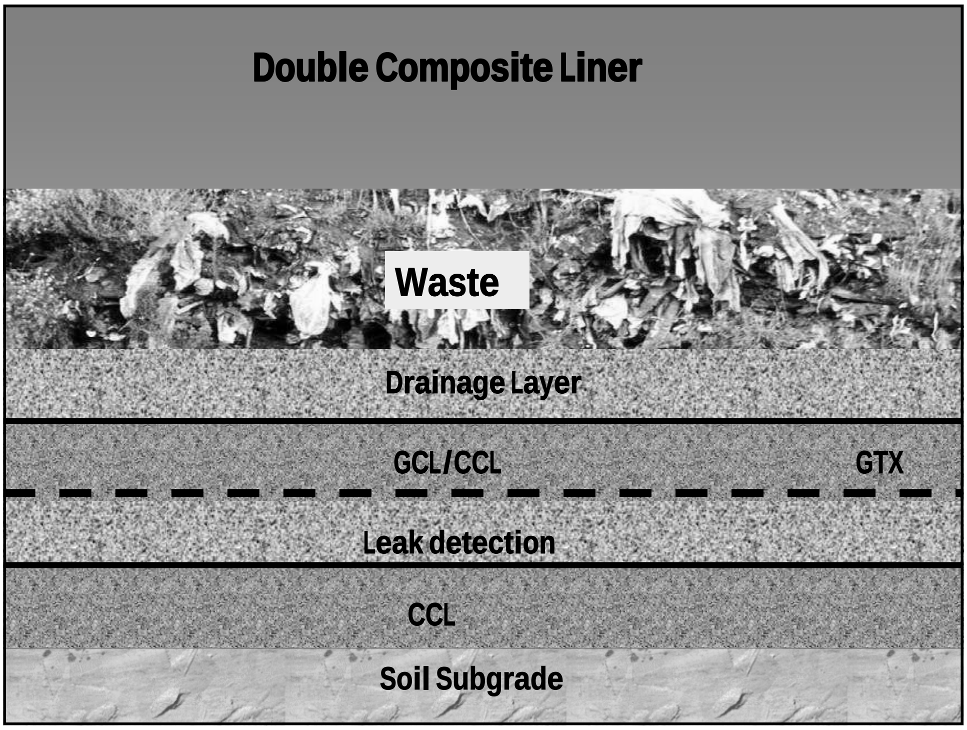
Disadvantages

1. **Reliability of the design model must be validated.**
2. **Reliability of some input parameters must be checked (Lab + Field Tests).**
3. **Evaluation of some projects can be very difficult.**

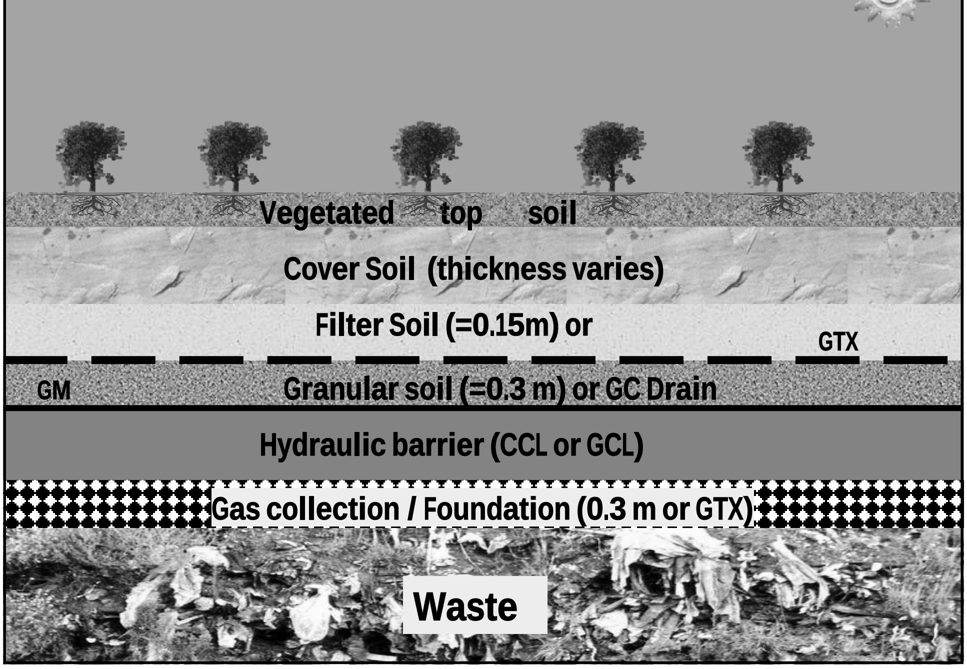
REGULATORY REQUIREMENTS FOR LINER DESIGN

1. **Nature of liner design varies, both within and between countries, depending on waste management strategies and practices, public concern and political will.**
2. **Consensus reached among institutions is to have a waste disposal facility protective to the environment**


Single Composite Liner
Waste
Drainage Layer
GTX
GM
GCL/CCL
Soil Subgrade


Double Composite Liner
Waste
Drainage Layer
GCL/CCL
GTX
Leak detection
CCL
Soil Subgrade

Typical closure system



Mineral Liners Vs Geomembranes

Liner Performance

Clay

- Thick
- Permeable
- Predictable leakage
- Attenuation
- May desiccate

Geomembrane

- Thin
- "Impermeable"
- Unpredictable leakage
- No attenuation
- No desiccation

Flow through a single clay liner

- $q = k\,i\,A$

  Q= flow rate (m^3/s)

  K = hydraulic conductivity of soil (m/s)

  I = hydraulic gradient

  A = area (m^3)

  Example:

h, head = 1 m	$q = k\,i\,A$
T, thickness = 1 m	$q = (1 \times 10^{-9})\,(2)\,(10{,}000)$
$i = (h+T)/T = 2$	$q = 2 \times 10^{-5}$ m^3/s per ha
$k = 1 \times 10^{-9}$ m/s	$q = 1.7$ m^3/ha/day
$A = 1$ ha $= 10{,}000$ m^2	

Flow through a geomembrane liner

- From Giroud & Bonaparte (1989)

$$q = C_B\,a\,(2\,gh)^{0.5}$$

Q= flow rate (m^3/s)

C_B = 0.6 (flow coefficient)

a = area of hole

g = acceleration due to gravity (m/s^2)

h = head

Example:

$a = 100\ mm^2 = 1 \times 10^{-4}\ m^2$

h, head = 1 m

For one hole/ha:

$q = (0.6)\,(1 \times 10^{-4})\,(2 \times 9.81 \times 1)^{0.5} = 2.66 \times 10^{-4}\ m^3/s$

$= 23\ m^3$/ha/day

Comparison of leakage

Single clay liner

Hydraulic conductivity (m/s)	Flow rate (m^3/ha/day)
1×10^{-8}	17
1×10^{-9}	1.7
1×10^{-10}	0.17
1×10^{-11}	0.017

Single geomembrane liner

Size of hole (mm^2)	No. per ha	Flow rate (m^3/ha/day)
1	1	2.3
10	30	70
100	1	23
100	30	700

Equivalency Issues

- Most (all) regulations allow for replacement if alternate is "technically equivalent".
- Regulations rarely (never?) illustrate how technical equivalency is to be justified.