Assessing the risks from hydraulically contained landfill sites

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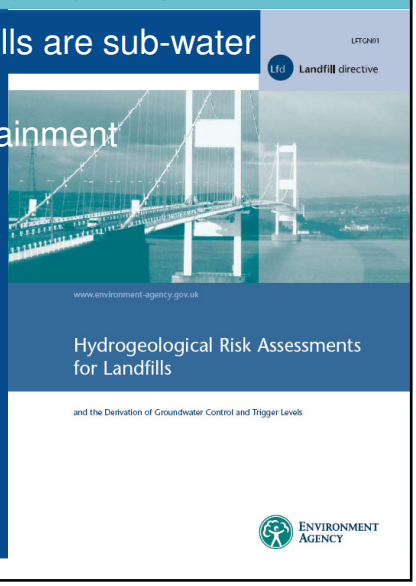
Hydraulic containment landfills

- ~200 non-hazardous waste landfills are sub-water table
- 40-50 of these are hydraulic containment
- Hydrogeological risk assessment guidance
  - no unacceptable risk to groundwater during full life-cycle of landfill
  - preferred model is LandSim 2.5
- Sub-water table landfills
  - no 'standard' model
- Literature review / spreadsheet
  - ESI (Steve Buss, Alan Herbert)

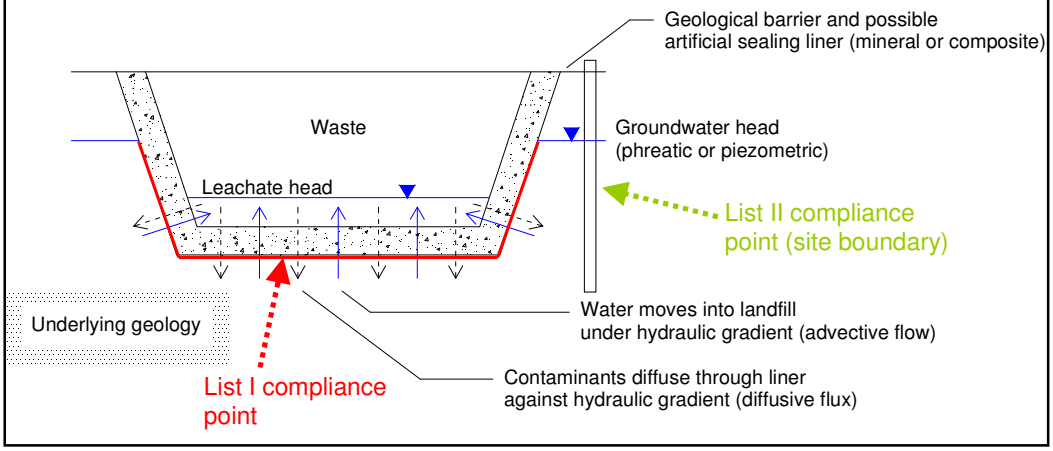


Hydraulic containment

- Advection is primary transport mechanism in most hydrogeological environments
- Molecular diffusion also occurs
- Diffusion dominant in low permeability media

Hydraulic containment

- Basic conceptual model
- Compliance points



Hydraulic containment report

- Literature review of:
  - hydraulic containment (theory and practice)
  - diffusion across liners
    - clay
    - geomembrane/composite
- Established that diffusion is an important contaminant transport mechanism under certain conditions

Key points - mineral liners

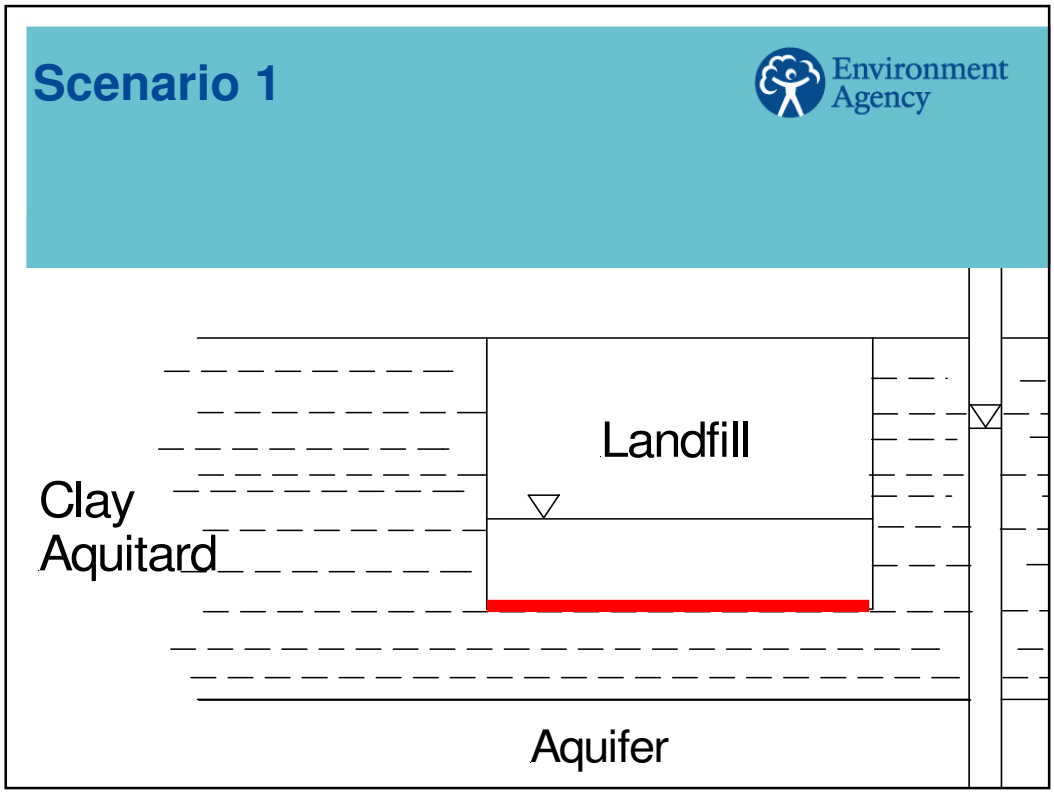
- Delicate balance between the water flow into the landfill and outward contaminant flux
- Outward diffusion effectively constant
- Lower hydraulic conductivity means decreased inward groundwater velocity and flow
- Therefore greater diffusive contaminant flux out of landfill as hydraulic conductivity decreases
- Higher hydraulic conductivity means more groundwater inflow (and therefore leachate) but less outward contaminant flux

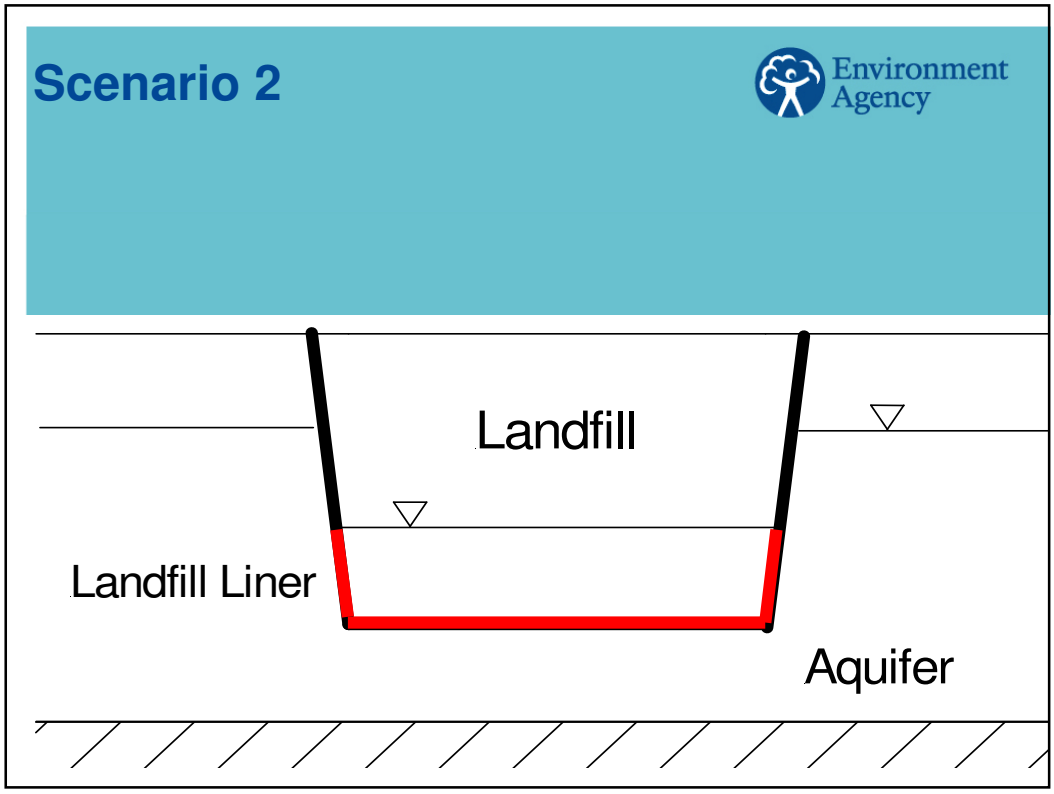
Key points - composite liners (HDPE)

- Organic contaminants transported by advection through defects, and by diffusion through intact HDPE liners
- Beneath defects, inward advective flow limits contaminant discharge
- Beneath ***intact*** geomembrane, pore water is immobile so organic contaminants diffuse outwards through the underlying mineral liner
- Organic compounds can diffuse through a defect-free geomembrane more readily than if have many defects
- Intact HDPE liners may increase outward diffusive flux
- Delamination - during construction and/or operation

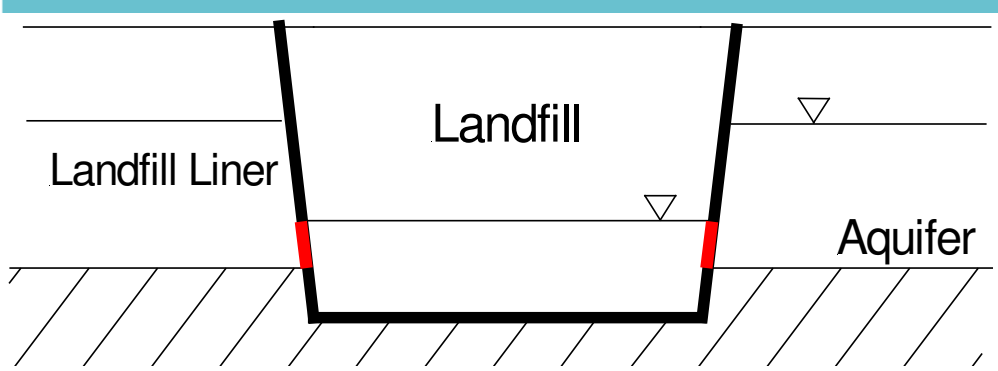
Hydraulic containment spreadsheet

- Simple scoping tool
- Three conceptual models (scenarios)
  - existing and new sites
  - not necessarily Landfill Directive compliant
- Computes:
  - contaminant mass flux out of landfill over time
  - water flow into landfill
  - concentrations in groundwater at compliance point
    - List I = base of liner (no dilution in groundwater)
    - List II = specified receptor (dilution allowed)
- Includes attenuation processes
- Constant leachate source concentration


Scenario 1
Environment Agency
Landfill
Clay
Aquitard
Aquifer


Scenario 2
Environment Agency
Landfill
Landfill Liner
Aquifer

Scenario 3

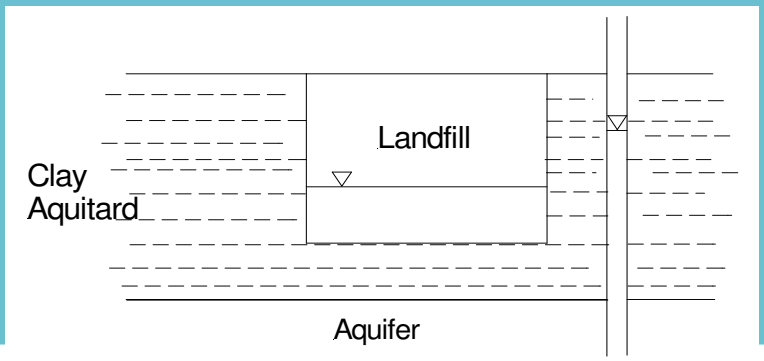


Scenario 1 - cadmium

Clay permeability = 1 x 10^{-10} m/s
Head difference = 1 m
Leachate conc = 1 x 10^{-2} mg/l
Compliance point = base of clay
Target conc = 1 x 10^{-4} mg/l

Max conc = 1.7 x 10^{-6} mg/l
Max conc time = 50,000 years
Groundwater inflow = 3800 m^3/yr

ACCEPTABLE RISK



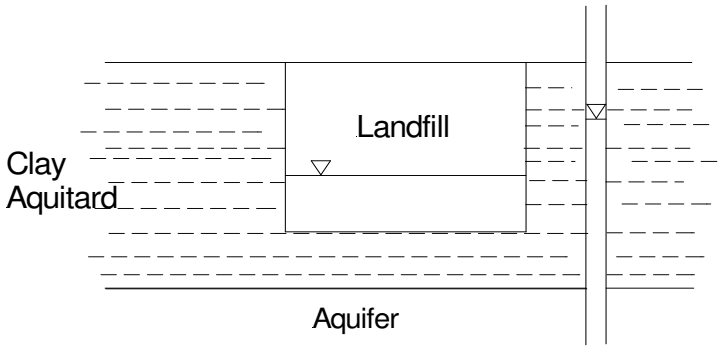
Scenario 1 - cadmium

Environment Agency

Clay permeability = 1 x 10^{-8} m/s
Head difference = 1 m
Leachate conc = 1 x 10^{-2} mg/l
Compliance point = base of clay
Target conc = 1 x 10^{-4} mg/l

Max conc = 0 mg/l
Max conc time = never
Groundwater inflow= 380,000 m^3/yr

ACCEPTABLE RISK



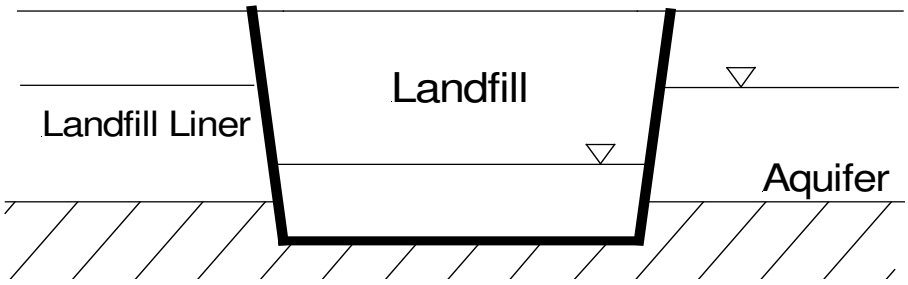
Scenario 3 - TCE

Environment Agency

Clay = 1 x 10^{-9} m/s + HDPE
Head difference = 1 m
Leachate conc = 5.6 x 10^{-3} mg/l
Compliance point = base of liner
Target conc = 1 x 10^{-4} mg/l

Max conc = 5.6 x 10^{-3} mg/l
Max conc time = 40 years
Groundwater inflow = 0.1 m^3/yr

UNACCEPTABLE RISK



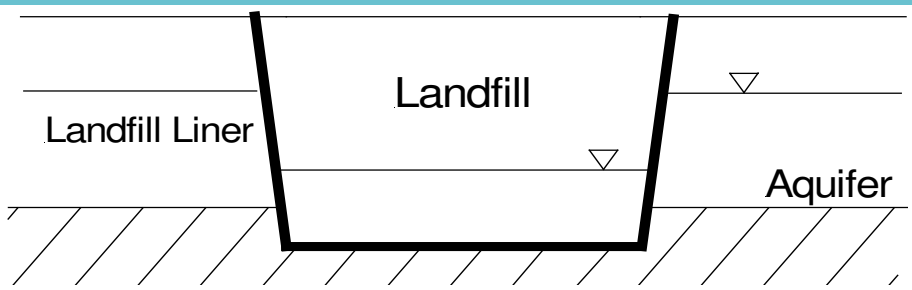
Scenario 3 - TCE

Environment Agency

Clay = 1 x 10^{-9} m/s + HDPE
with biodegradation of TCE
Leachate conc = 5.6 x 10^{-3} mg/l
Compliance point = base of liner
Target conc = 1 x 10^{-4} mg/l

Max conc = 1.3 x 10^{-7} mg/l
Max conc time = 48 years
Groundwater inflow = 0.1 m^3/yr

ACCEPTABLE RISK



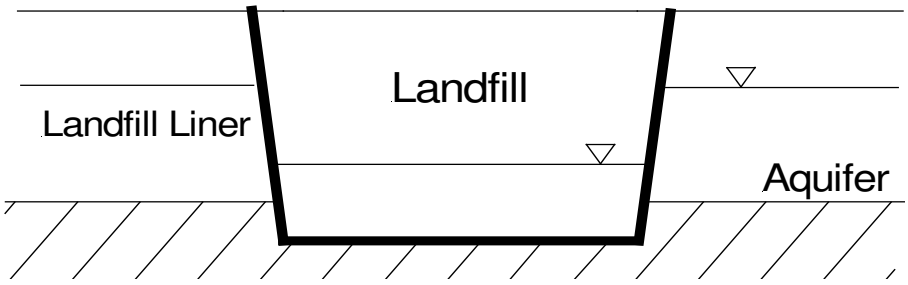
Scenario 3 – TCE

Environment Agency

Clay = 1 x 10^{-9} m/s ***No HDPE***
NO biodegradation of TCE
Leachate conc = 5.6 x 10^{-3} mg/l
Compliance point = base of liner
Target conc = 1 x 10^{-4} mg/l

Max conc = 9.6 x 10^{-42} mg/l
Max conc time = 9 years
Groundwater inflow = 130 m^3/yr

ACCEPTABLE RISK



Conclusions

- Hydrogeological risk assessment guidance sets out framework for landfill risk assessment
  - LandSim is preferred tool if conceptual model applicable
- Diffusion can cause pollution from hydraulic containment landfills
- Simple spreadsheet provides scoping tool to estimate impacts for three conceptual scenarios
- ***Use model outputs to inform decisions, not make them***
- Report peer reviewed by Golder Associates and public consultation

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