




Fail-Safe Engineering: towards sustainable landfill

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Project Outline

- A study to examine the role of engineering in assisting to render landfilling of residual wastes a sustainable waste management option.
- To extend the Equilibrium Study to examine different contaminants and different landfill geometries (and to understand the role of site geometry).
- To understand the hydraulics of a landfill upon abandonment given the need for chemical & hydraulic equilibrium.
- **Project funded by Defra as part of its Waste and Resources Research Programme. The research contract No. is WR0304/WRT279.**

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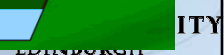
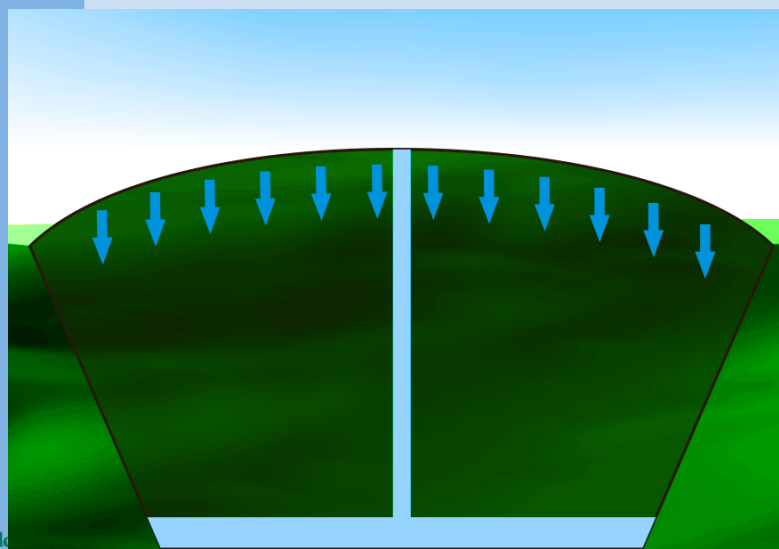
Flushing Landfills

- Flushing removes contaminant mass from landfill and is therefore an important part of the stabilisation process.
- The greater the amount of flushing the greater the removal of contaminants. (increasing the liquid/solid ratio)
- BUT.... What happens when the pumps get switched off?



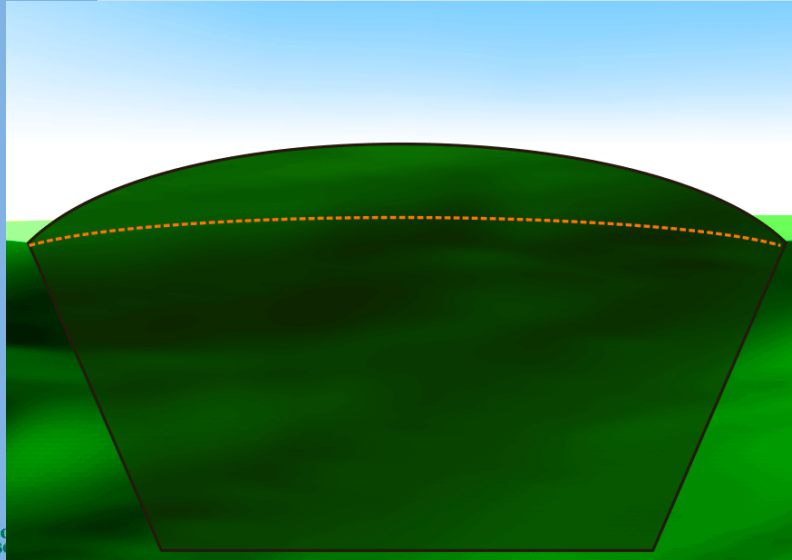
The waste is equally flushed during operations

Operational Phase

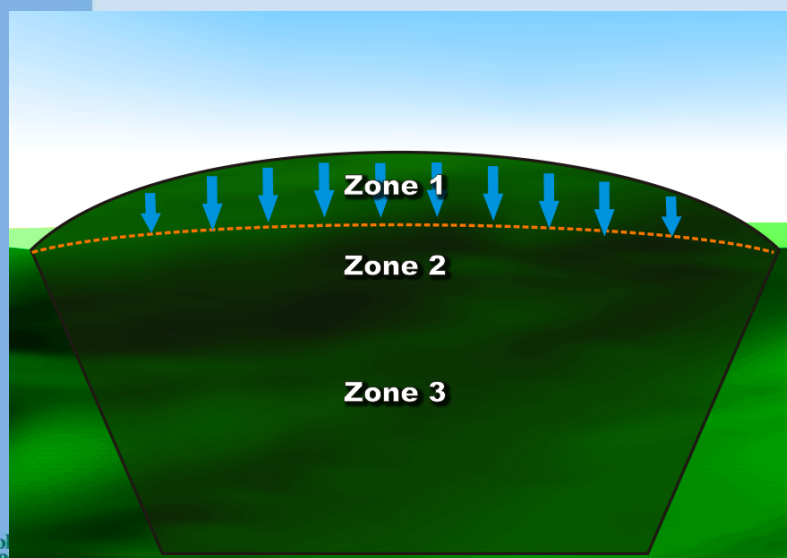


This would be the flow field if we were looking at isotropic and homogeneous conditions

Flooding and overtopping



Or this, if the system is not homogeneous & isotropic



Flow Zones

- Zone 1 = thin unsaturated zone dominated by vertical flow and high flushing rate (based on evolution of L/S ratio). Waste less compressed than that at depth and hence relatively permeable.
- Zone 2 = Horizontal flow based on saturated conditions below, in a high K zone in shallow waste.
- Zone 3 = deep area of waste disposal with high degree of compression leading to low K – nearly stagnant with very low flushing rates – driven by leakage only.
- Anisotropy taken as $K_h = K_v * 10$



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Modelling using Napier's HBM model

WRT279 Deep8 FLeak DepV Anls

Run ID = 4010

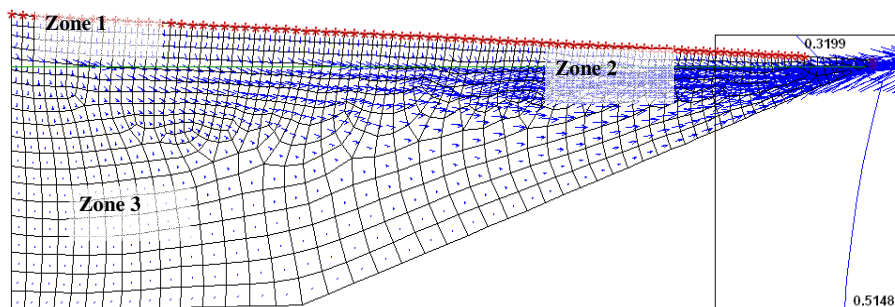
02/11/2006

* = Dirichlet boundary cond
 * = Neumann boundary cond

Time step = 400000
Time elapsed [days] = 4000.0

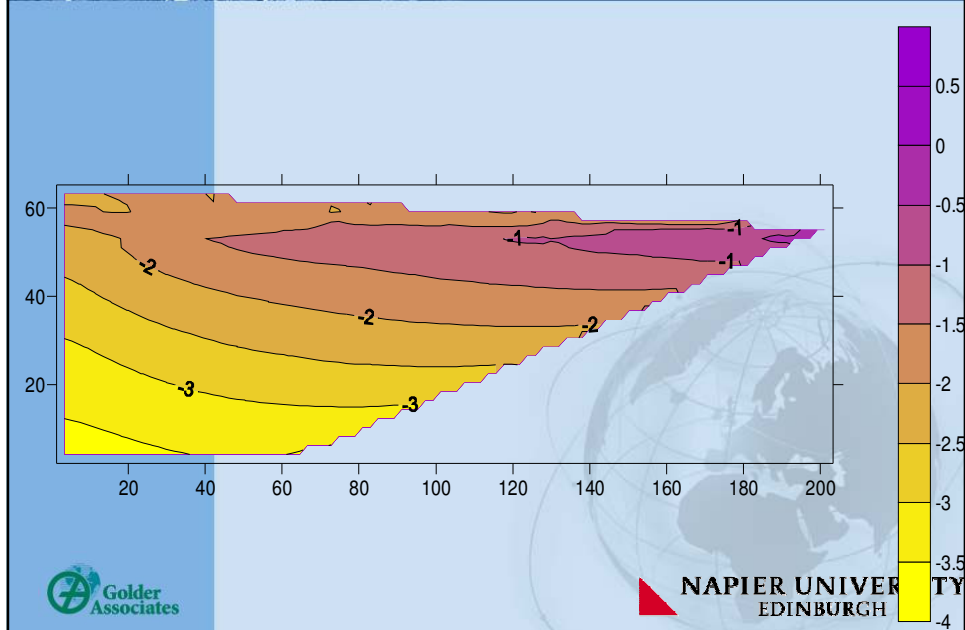
Vector scaling
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 maximum = 1.640E+00
 scalar = 5.000E+02

kappa = 0.000E+00
lamda = 0.000E+00



moisture profile

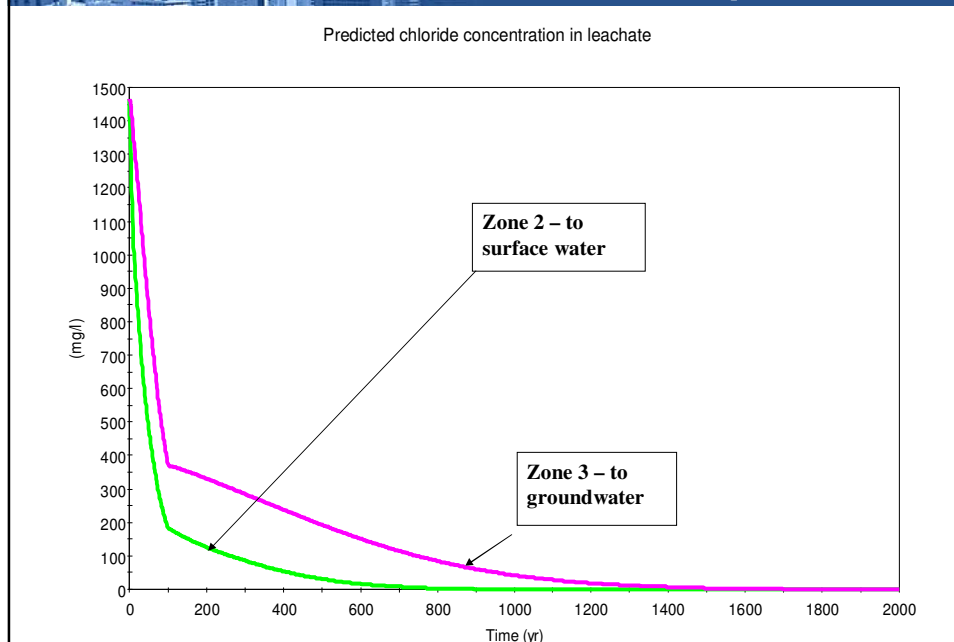
Order of magnitude of fluid flux in flooded landfill



What does this mean?

- It means that the evolution of leachate quality with time can be markedly different in different parts of the landfill.
- Surface areas will flush more readily and quickly than deep areas within the landfill.
- Lower concentrations discharged to surface water while higher concentrations leak to groundwater.

Evolution of different leachate qualities



Geometry Matters

- We examined three different landfill geometries (all with the same volume) – shallow, medium and deep.
- We examined two land-raise geometries - medium and deep
- We looked at raw (untreated) MSW, MBT residues and IBA.
- We modelled three fail-safe scenarios.....

Fail-Safe Scenarios

- Manage landfill so that there is limited leakage – all excess leachate overtops and is diluted in a moat where dilution from cap run-off reduces the concentration of the contaminants.
- Ditto, but with the addition of an unmanaged wetland providing some (limited) treatment capacity.
- Use of a low-grade sidewall liner.

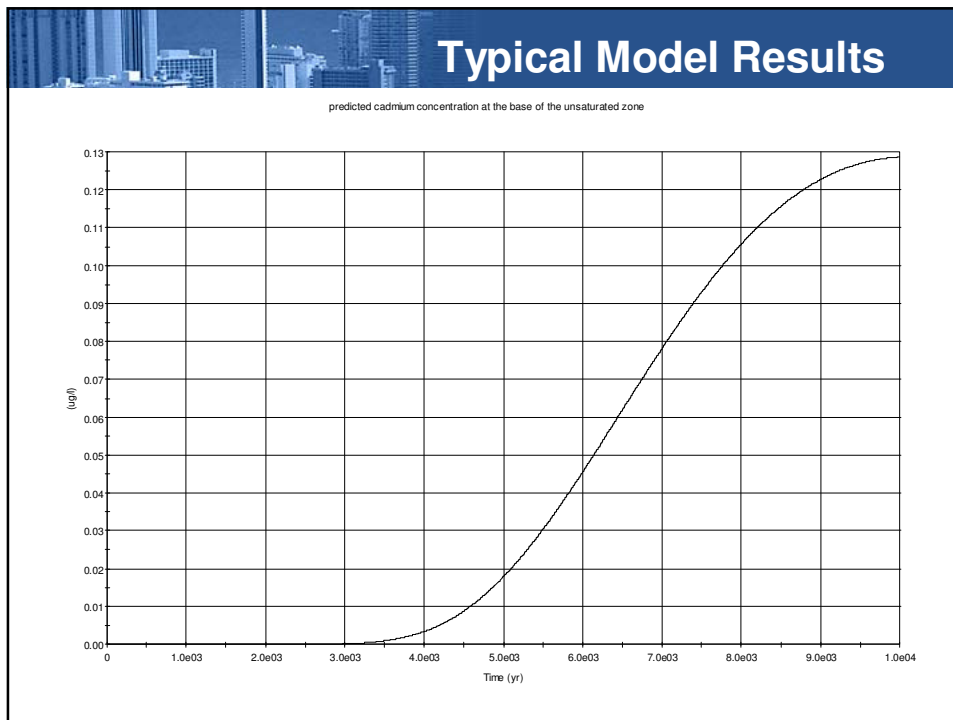


Assessment Method

- Run the performance assessment with the management time as a stochastic variable (25 iterations).
- Compare ultimate (maximum) groundwater contamination conc. with the management time. (see example on the next slide).
- Compare with water quality standards.
- Use the amount of time required to manage the site to avoid a breach as a measure of the sustainability of the system.



Typical Model Results



Waste Types and their limiting contaminants

- MSW (untreated) constant problem with mecoprop to groundwater and ammoniacal N to groundwater and surface water.
- MBT problem with ammoniacal N to groundwater and surface water.
- IBA problem with copper to surface water.

Findings

- Shallow landfills and all Land-Raise sites achieve equilibrium status sooner – but more risk to surface water (less to groundwater as heads acting on the base cannot build up very high values).
 - Low groundwater leakage rates
 - Comparatively high L/S ratios
- Deep sites are protective of surface water (they rarely overflow and when they do the flux of water will be less as the leakage will be much greater) due to high heads acting on the basal liner system.
 - High groundwater leakage rates
 - Comparatively low L/S ratios



Conclusions

- Unlikely to be able to rely solely on engineering methods to meet sustainability targets (to stabilise waste in landfill in decades rather than centuries).
- Additional technologies need to be used to speed up the process of waste stabilisation (higher rates of flushing, or air injection to create aerobic landfill).
- Perhaps financial incentives for operators to undertake additional works to stabilise waste.
- Remember, it is society's waste, and it's society's desire to see sustainable waste management – so society should pay the price!



Acknowledgements

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Thank you for your attention.

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