Do more detailed Hydrogeological Risk Assessment tools support better regulation of landfill?

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Introduction

Need to show

- No pollution
- No discernable discharge of List 1 substances
- Compliance over lifecycle of the landfill

The real world…

…is very detailed!

- Complex
- Uncertain

But…

- Computer power is still increasing in accordance with Moore's law
- More detailed data is available due to improved monitoring requirements and research

Kiss Me!!!

Two philosophies of modelling…

- Keep It Simple, Stupid!
- Model Everything!!!

Where have we come from?

- Nothing!
- LandSim 1.0
- RAM
- Hydraulic containment
- Landsim 2.5
- RAM 2

At each stage models are 'validated'

- Introduce more detail with effects that cancel
- Introduce insignificant detail
- Additional detail reduces uncertainty

So what is the problem? Complex setting

- Site geometry
- Hydrogeology and heterogeneity of barriers
- Detailed engineering
- Heterogeneous source term

Complex processes

- Transport by advection dispersion retardation and degradation
- Water balance
- Giroud's relations
- Leachate chemistry
- Organic retardation and degradation in low permeability materials and at extreme concentrations
- Unsaturated zone and flow beneath defects in saturated low permeability clays
- …

Uncertain parameterisation

Orders of magnitude uncertainty for key parameters

- Permeability
- Partition coefficients
- Half lives
- Source concentration!

Timescales

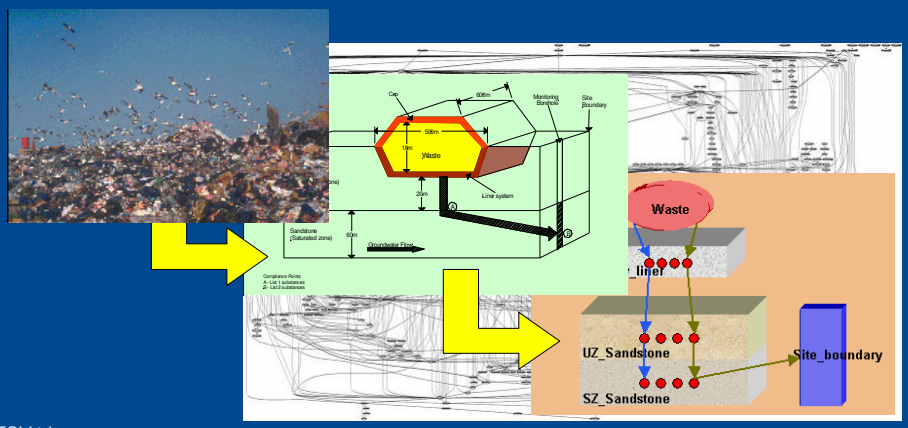
Improving containment leads to extending timescales of potential risk

- Very long timescales

- Degradation of engineered and natural barrier system
- Non-steady conditions

Risk Assessment Modelling

- **A skill to be learned**



Need to understand HRA models

- All model results can be reproduced on a piece of paper with simple calculations!
- HRAs can be done in half an hour!

But…

- Sometimes takes a few months to figure out how to spend that half hour
- The more complex the model, the harder it is to figure out what it's telling us

Benefits of Landsim 2.5

Time evolution

- Degradation of barriers
- 20000 year predictions

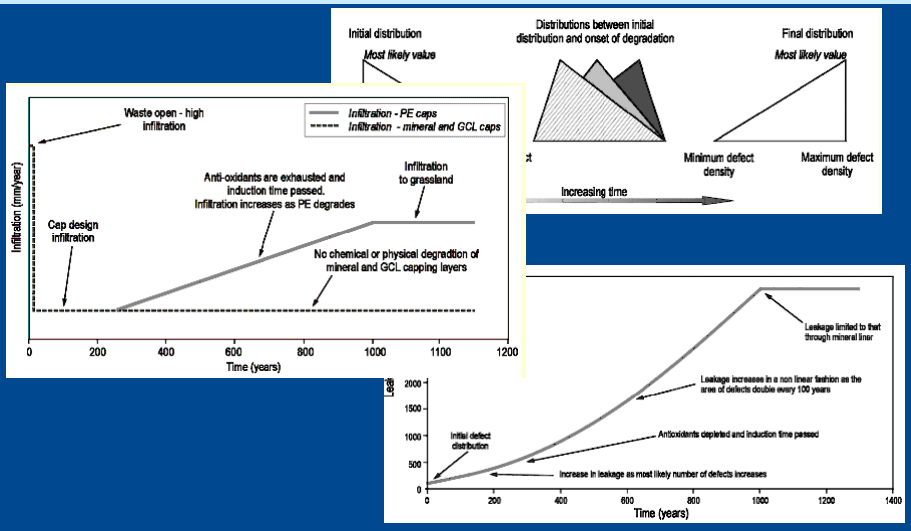
Modified source term

- Kappa model
- revised estimation of source concentration

New model features reflect real processes

- But not *all* real processes!
- Still very simplified conceptual model
- Processes very simplified compared to real systems

Degradation of barriers and the water balance



Transient flow and the unsaturated zone

- Specification of moisture content of unsaturated zone?
- Very dependent upon Q
- Difficult and important if flow is small

Mathematical model

- HRA models are probabilistic and need to be very fast!
- Laplace transform approach is very efficient
- Requires linear steady state transport problem

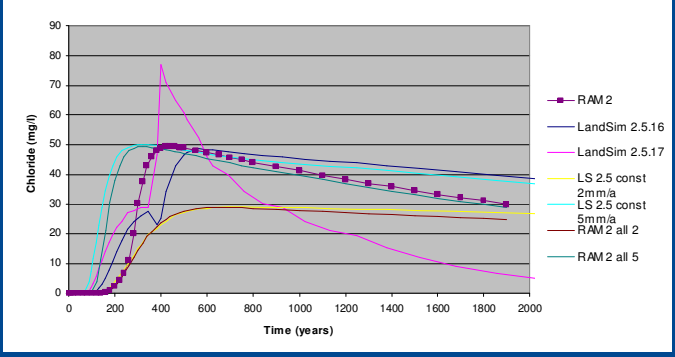
Benefits of Landsim 2.5?

- Improved realism… of some processes
- New parameters for modeller!
- New uncertainties!
- Better predictions?
- Harder to appraise!!

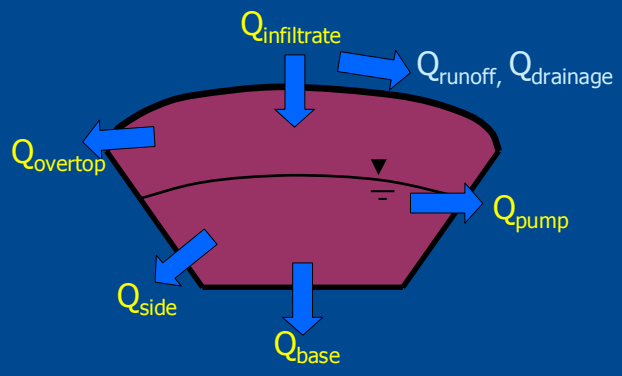
Difficulties

- Key simplifications – 'weakest link' limits benefits of additional detail
- Complexity of model leads to complexity of interpretation
  - Model transparency
  - Understanding model performance
  - Identifying what processes are relied upon
- Uncertainty
  - Conceptual
  - Mathematical
  - Parameter

Verification and validation



Summary



Summary

- Key features can be understood with relatively simple tools
- Much of risk arises during quasi steady conditions
- Complex models only help if they bring new insight