SPECIAL FEATURE: LANDFILL TECHNOLOGY
Landfill design and operation - saving money with risk assessment

by Dr Nick Rukin & Terry Walker of Entec UK Ltd

With the introduction of Landfill Risk Assessment under Regulation 15 of the Waste Management Licensing Regulations, the Environment Agency are now requiring landfill operators to defend their proposed cell designs or operation of leachate levels with a quantitative groundwater impact (risk) assessment. This applies to both proposed sites and existing operational sites.

"The prescriptive landfill design of 1m head on an engineered liner should be abandoned for a design based on risk assessment"

"This change of approach reflects a shift in philosophy from disposal of waste to the management of waste and its degradation products"

Historically, in order to accelerate the passage of a planning application for proposed sites, many landfills have been designed on a prescriptive approach of a 10^{-9} m/s liner with a 1m leachate head, based on guidance in Waste Management Paper 26 (1986), without fully examining the necessity for this level of control and the implications it has for capital costs, operating costs, control over conditions in the waste and long term environmental liabilities.

For existing sites with a Waste Management Licence and a history of developing best practice design and operation of leachate levels agreed with the former WRA, some landfill operators are now finding themselves faced with potentially costly delays in entering new cells as major changes to the sites cell design and leachate level operations are debated with the Environment Agency.

It is worth examining the background to these issues.

The background picture
The Environment Agency (EA) have the responsibility of implementing Waste Management Licensing Regulations (SI No 1056, 1994) which enacts the EC Groundwater Directive (80/68/EEC). The Directive states that steps should be taken

"*to prevent substances in List I entering groundwater; and to limit the introduction of List II substances into groundwater so as to avoid pollution.*"

Ammonia, present in high concentrations in most landfill leachates, is defined as a List II substance. Regulation 15 states that the EA must ensure that all activities which could lead to the direct or indirect discharge of List I and List II substances (i.e. virtually all landfills with the potential to produce leachate) are subject to "*prior investigation*". Guidance on the approach to this investigation is given in Waste Management Paper (WMP) 26B (Appendix E, 1995) and this includes undertaking a landfill risk assessment.

Design and operation
Landfill design and operation needs to address a large number of issues such as landscaping, odour, litter control, gas migration and impact on the water environment. The latter issue usually results in the installation of an engineered liner and design of a leachate level control strategy. It is this last issue which needs careful consideration to ensure that the principles of Best Available Technology Not Entailing Excessive Cost (BATNEEC) are not breached.

WMP 26B (1995) defines a policy of developing engineered barriers in landfill sites which are designed specifically for a certain hydrogeological environment, in preference "*to the prescription of a minimum overall standard with little or no regard to the valuable contribution that the natural geological formations can provide to the additional safeguarding of the environment*".

This is the reason why risk assessments should be carried out for each sites' design. Despite this policy, however, a common practice has developed for landfill design to comprise a minimum of an engineered mineral and/or geomembrane liner with a permeability of less than 10^{-9}m/s and operated

with a leachate head on the liner of less than 1m.

The requirement for a maximum leachate head of 1m above the base of a landfill was introduced in 1979 by the then North West Waste Regulation Authority. Whilst that design was appropriate at that time, before basal engineering was the norm, it has now outlived its usefulness and should be abandoned as a prescriptive approach. Its use could now slow waste stabilisation and the chosen control level should be dictated by the maximum value used in the landfill risk assessment which demonstrates no unacceptable risk to the water environment. This change of approach reflects a shift in philosophy from disposal of waste to the management of wastes and its degradation products.

For above water table landfill sites, leakage of leachate through the liner is reduced by lowering the head of leachate acting on the liner as per Darcy's Law. This normally requires a basal drainage system (spine drains or blanket) linked to a sump or the installation of numerous retro-fit leachate abstraction wells. However, for sub-water table sites, leakage of leachate out of the site can be avoided by maintaining leachate levels below the piezometric groundwater level in the adjacent strata. This is called 'hydraulic containment'.

Maintenance of the lowest head of leachate may mean minimum leakage of leachate from the site, but with respect to WMP 26 B, the design has failed to consider "*the valuable contribution that the natural geological formations can provide to the additional safeguarding of the environment*".

If the prescriptive minimum head is enforced by the local EA office or accepted blindly by the landfill operator to gain planning consent, regardless of the hydrogeological setting of the site, then the landfill operator could be unnecessarily accepting:

- increased capital costs associated with construction of drainage blankets or spine drains;
- increased operational costs from maintenance of the leachate abstraction system and from abstraction of larger quantities of leachate for treatment and disposal.

From a holistic, environmental point of view, there are two disadvantages arising from unnecessarily severe leachate head constraints:

- less control on the moisture content of the waste, potentially larger volumes of dry entombed waste with slower degradation rates for putrescibles, and consequently longer times for the waste to stabilise. This ultimately means liabilities associated with aftercare of the site will increase and a site could he left as a 'time bomb', ready to reactivate if the cap degrades in future years.
- the leachate abstracted has to be disposed of somewhere and may do more environmental damage (including transport costs etc.) if abstracted rather than being left in place.

Landfill operators should clearly be interested in reducing all of the above, and the Environment Agency at least in the latter two, if the prescribed leachate levels are unnecessarily low and do not affect liabilities associated with possible pollution. This is why landfill risk assessments can be a valuable investment. But they need to be done properly.

Liaison with the EA

Landfill risk assessments are no different from any other aspects of environmental assessment. They are most cost effectively carried out and more likely to be accepted if undertaken in full consultation with the relevant bodies, in this case the Environment Agency.

There are currently a number of difficulties facing landfill operators in this matter. The first is that the EA's own guidance on reviewing landfill design through a landfill risk assessment approach is still in preparation and is not due for release until later this year. This means that there is a lack of policy consistency and different approaches are being experienced with different EA offices across the country.

This sometimes relates to their WRA or NRA background or experience in risk assessment review. The second difficulty is that there may not be full and open communication between the landfill operator and the EA and delays can be expected in the review of the risk assessment report. Both difficulties mean that a landfill cell's design and operation which has been agreed in haste may not be the most cost effective environmentally acceptable option.

Groundwater Impact Assessments
Guidance on groundwater impact assessments is given in WMP 26B (Appendix E) and in a document produced by North West Waste Regulation Officers Group in 1995. This guidance requires a thorough desk study review of the hydrogeological setting of the site (including site investigation) and the impacts on the groundwater environment. These impacts should be assessed quantitatively, if this is at all possible.

The assessment must be based on adequate information and understanding of the site and the quantification of any impact must be based on well documented and approved methods or calculations.

To help carry out and perhaps standardise these calculations, the Environment Agency has released a new software package called LandSim, which puts a user friendly front end onto the standard calculations. However, like all tools, the output from LandSim is only as reliable as the input parameters, which depend on the understanding of the hydrogeology of the site. The danger is that, if used by inexperienced hydrogeologists, LandSim can quickly become a black box suffering from the GIGO principle (Garbage In Garbage Out !).

It is also worth bearing in mind that LandSim can not be used to assess sub-water table sites, it does not allow dilution by streams receiving groundwater to be assessed, and it doesn't allow for attenuation (aeration, biodegradation, cation exchange below the liner and unsaturated zone) to be considered fully.

For existing sites, the travel times and dilutions from a risk assessment (or LandSim run) must always be consistent with the landfill's groundwater monitoring data.

Conclusion
A good risk assessment of your landfill design could help you reduce unnecessary capital and operational costs and your future aftercare liabilities. It is worth doing properly and not just going through the motions, cranking a handle on a black box, and agreeing with the EA to what may be unnecessary design and operational constraints.

For example, by carrying out a comprehensive risk assessment and liaising with the EA, Entec have recently demonstrated that under certain circumstances, it was not necessary to construct a full drainage blanket in order to minirnise the risk to the groundwater environment. This ultimately provided the landfill operator with potential cost savings of the order of £100K.

Wastes Management March 1998
Pages 43-44