Land and Resource Management

Interim Guidance on Landfill Closure: Capping and Restoration

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Contents

1. Introduction and Scope

This note provides interim guidance for EHS staff and operators on capping of landfill sites. The procedures may be applied to both existing and new landfill sites.

This guidance document sets out a brief overview of the main aspects to be considered when establishing the capping standards at landfill sites. Reference should also be made to the Environment Agency's Technical Guidance on capping and restoration of landfills November 2004.

The advice provided is applicable to landfill sites closing or closed under the Waste Management Licensing regime and landfill sites regulated under the PPC regime. Regardless of the regulatory regime, the standard of cap required is risk-based and developed through site specific assessment. Operators will be required to establish site specific requirements for each landfill site based on the waste accepted at the site, the overall design and setting of the landfill and the history of the site.

This guidance is our understanding of the law at the date of this document and is no substitute for obtaining your own legal advice. The law may change and the user should ensure they refer to the latest version of this document which will always be available on the EHS website www.ehsni.gov.uk .

2. Regulatory Requirements

This note covers landfill sites closing or closed under the Waste Management Licensing regime and landfill sites under the Pollution Prevention and Control (PPC) regime. The implementation of the Landfill Directive leads to several scenarios, these are:

- Non Landfill Directive Compliant Sites

  Scenario A: Closed before July 2001 under WML and hence not subject to Landfill Directive.

  Scenario B : Closed after July 2001 and before July 2004 under WML and are subject to Landfill Directive closure procedures only.

  Scenario C : Closed after July 2001 and before March 2007 under WML and are subject to Landfill Directive closure procedures only.

- Landfill Directive Compliant Sites

  Scenario D : Existing sites transferred from WML to PPC permit and operating after 2007

  Scenario E : New Sites issued with WML or PPC permit after July 2004

Below outlines the minimum requirements which must be fulfilled for the above scenarios

1. Sites that fall into Scenario A are to be capped and closed in accordance with the requirements of their licence and are not affected by the Landfill Directive
2. Sites that fall into Scenarios B and C are also to be closed in accordance with their licence and the Waste Management Licensing Regulations and in addition will be required to follow the closure procedures of the Landfill Directive. However it is only the closure and aftercare procedures that apply to such sites as set out in article 13 of the Landfill Directive. This includes monitoring requirements and the setting of ‘trigger levels’ of contaminants in groundwater. The capping recommendations given in the Landfill Directive should be used as a guide to the options available for capping.
3. Sites falling into scenario D and E must be full Landfill Directive Compliant both for operational and closed phases. This means that old closed phases of existing landfill sites that transfer to the PPC regime must comply with the capping requirements of the Landfill Directive. The standards of capping for closed phases can be established on a site

specific risk based approach. Operators will be required to justify retaining existing caps and consider any additional works that may be necessary to improve existing cap performance.

Nevertheless, regardless of the regulatory regime, the standard of cap required is to be based on site specific risk assessment. The Directive requires that soil, groundwater and surface water are protected by the geological barrier and a top liner following closure. The Directive then goes on to provide recommendations for capping of non-hazardous and hazardous landfills but these can be established on a site specific basis by risk assessment. The need for and specification of a cap is also related to the gas management system and also potential need to physically separate waste from the environment, even if there is no leachate risk (e.g. for asbestos waste). However, as a minimum, the capping system should contain a low permeability/sealing layer (i.e. clay, LDPE,GCL), a surface drainage system and cover soils. All hazardous and non-hazardous landfills will require a cap and operators should provide site specific justification for their proposals and any deviations from the Landfill Directive recommendations.

The Landfill Directive recommendations for capping are:

Capping Layer	**Non-Hazardous Landfill Site**	**Hazardous Landfill Site**
Gas drainage layer	Required	Not Required
Artificial sealing liner	Not Required	Required
Impermeable mineral layer	Required	Required
Drainage layer > 0.5m	Required	Required
Top soil cover >1m	Required	Required

The Landfill Directive makes it clear that theses are ‘guideline’ standards. They also stress that these apparently prescriptive engineering requirements for containment should be validated by Risk Assessment and can be reduced if appropriate.

The appropriate engineering requirements should be determined based on a site specific assessment of the nature of the hazard that the landfill poses and the risks that it presents to the environment in both the short and the long term. This may demonstrate that more or, on occasions, less stringent standards are appropriate to provide adequate environmental protection over the period during which the landfill will present a hazard.

The fact that there are no guidelines for the capping of inert landfills does not mean that they do not need capping. Some inert landfill sites have been licensed to dispose of Categories A & B these materials may result in the production of leachate and gas. In such cases, some form of capping will be important. In addition inert waste landfills require restoration and, as a minimum, a layer of soil or soil forming material must be placed over the wastes to allow restoration to take place. Operators of inert landfills must provide a site closure report outlining the closure and restoration programme for approval.

3. Design of Landfill Caps

General principles

The primary functions of the cap should be considered during the risk assessment process that informs its design. These functions are subject to the nature of the waste that is to be deposited in the landfill and can be to:

- Reduce the infiltration of precipitation into the landfill to control leachate generation;
- Minimise fugitive emissions of landfill gas through the surface of the cap (in combination with an active gas abstraction system);
- Separate the waste in the landfill from its surrounding environment.

The landfill design process, of which the cap design is an important element, should start by identifying the potential hazards that the landfill poses to the environment. Once this screening has been carried out, an appropriate risk assessment should be completed to allow identification of the mitigation measures (essential and technical precautions) that need to be adopted to ensure satisfactory environmental protection.

Where the risk assessment indicates that a cap is necessary to provide environmental protection, this aspect of the landfill design should not be compromised by other considerations such as restoration after-uses. While restoration is an important element in the overall planning of the landfill development, it should only be considered once the pollution control requirements of the design have been determined.

For instance, where risk assessments have demonstrated the need for a capping system to reduce infiltration to a certain level, any restoration (and after-use) scheme should be designed to incorporate a cap with the necessary specification. This may mean that steep restoration gradients, which may prejudice the stability of that particular cap design, cannot be incorporated in the landfill development scheme.

Pollution control is the primary function of the combined capping and restoration system of a landfill. The potential to restore landfill sites to beneficial after-use, particularly where they have been developed in mineral workings or on despoiled sites, is an important part of this method of waste management but must not outweigh the need to prevent pollution. The necessary performance and design characteristics (e.g. slope gradients and heights) of the capping system must be determined before work begins on the restoration scheme. This will provide the landscape architects working on the restoration scheme with the correct design parameters.

Control of Infiltration

The designer should determine the target infiltration rate through the landfill's cap based upon the following considerations:

- leachate generation, treatment and handling;
- effect on waste degradation, landfill gas generation and settlement rates;
- the potential to limit leakage through basal lining systems;
- sustainability and financial provision.

Leachate generation

The treatment and disposal of leachate is costly. The designer should also be aware of any environmental and sustainability implications.

The designer should also be aware that the rate of infiltration may affect the design of the leachate drainage system within the landfill. The leachate drainage system should be designed with a clear understanding of the potential rate of infiltration through the cap. Alternatively, if the leachate drainage system is already installed, the cap designer should recognise that the capacity of the leachate drainage system to abstract leachate may be a major factor in achieving the required hydraulic performance of the cap necessary to keep leachate heads within permit or licence limits.

Rate of waste degradation

It might appear to be desirable to prevent leachate generation completely. However, this is neither practicable nor appropriate, as the waste mass would be contained in a 'dry tomb' in which waste degradation rates would be extremely slow. The landfill could then remain a hazard after many of the environmental control systems had degraded. In this context, the rate of degradation of geosynthetic components such as geomembranes and geosynthetic pipework may become relevant.

The rate of waste degradation is partly a function of the rate of infiltration through the capping system. This is because infiltration provides a flushing mechanism that gradually leaches mobile containments from the waste mass. A similar flushing action can be provided by leachate recirculation, coupled with appropriate leachate treatment.

If accelerated waste degradation is considered desirable, capping systems may need to incorporate sub-cap irrigation systems to allow efficient recirculation of leachate. The capacity of such leachate recirculation systems is often related primarily to the capacity of the basal leachate drainage systems. Recirculation should only be contemplated when there is sufficient capacity to prevent the build-up of leachate heads.

The cap designer should seek to identify the site – specific balance to be struck between preventing leachate generation (in accordance with the Regulations) and the length of time that the landfill is likely to pose an environmental hazard.

Control of landfill gas migration

The landfill cap is only part of the mechanism for controlling landfill gas emissions from the surface of a landfill. The fundamental control mechanism is an efficient gas extraction system either involving a ‘gas field’ comprising a network of boreholes installed into the waste or, for sites with relatively low gas generation rates , a drainage layer beneath the sealing layers in the landfill cap.

This means that, in contrast to the approach taken to hydraulic performance, it is generally unrealistic to prepare cap specifications from the point of view of gas permeability. However, the cap design should include specifications to ensure that there are no imperfections or discontinuities in the capping system.

Stability considerations

Having determined the appropriate hydraulic and gas control characteristics of the capping system, stability assessment should be carried out to determine the parameters (in terms of slope angle and slope height) within which the landscape and restoration scheme designer can work. Depending on the likely materials and slope angles, this assessment could initially be carried out on a qualitative basis by an experience geotechnical specialist.

The stability assessment and design process may involve several iterations, but should ensure that the fundamental parameters required for environmental protection are met in the final design. The final design should be subject to appropriate quantitative stability assessments.

4. Restoration of landfills

Designing the restoration scheme

The design of the restoration scheme should be considered as an integral part of the whole landfill site. The proposed after-use can affect the rate of evapotranspiration from the restored surface, which in turn affect the degree of infiltration of water into the landfill and thus the rate of leachate generation. Similarly, the choice of after-use is defined, at least partially, by the nature of the waste to be accepted by the landfill (which can affect its settlement characteristics) and the likely availability of restoration materials.

The following elements of the restoration scheme should be considered as part of the design process:

- landform
- restoration profile
- soil suitability (e.g. for methane oxidation, afteruse)
- after-use
- detail design
- phasing
- interim landscape measures

Restoration profiles and materials

A thorough assessment of the available soil and soil-forming resources on site with which to form the restoration layers should be carried out before any design work.

It is appropriate to use compost as a soil additive, not a substitute, as it will enhance the soil properties which benefit plant growth in the top soil layer with prior approval from the Department. Expert assessment is necessary to demonstrate suitability of these materials for restoration and will require very careful investigation of variability and contaminants. Operators must demonstrate that the soil additive presents no risk of contamination of surface water and ground water. The Department will require the following information in order to carry out a site specific assessment on the suitability of the material:

- % dry matter,
- Ph
- "total" and "soluble" forms of nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), sulphur (S)
- Microbial respiration rate
- PTE concentrations i.e. Cu, Cd, Pb, Hg, Ni, Zn
- % physical contaminants

Although it is not necessary for the material to be PAS:100 accredited, the Department recommends operators to follow the parameters set out in the “PAS 100:2005 Specification for Composted Materials”. Appendix 1 outlines the parameters to be considered.

If there is insufficient subsoil onsite, consideration should be given to using soil forming materials such as surplus overburden or screened inert waste as a basal subsoil.

The nature and depth of the restoration profile (the soils and other materials that are placed on the top of the cap) will largely be conditioned by the available restoration materials and the desired after-use.

After-use

The main after-use options for landfills are agricultural use, ecological uses, recreational and amenity uses, and woodland. In many cases, it is possible – and desirable- for several to co-exist across a restored landfill.

The factors that influence the choice of after-use include:

- character and quantity of available soils;
- type of waste and associated operational constraints;
- size, location and access;
- the development plan or framework;
- the aspirations of local residents, interest groups, etc.;
- scheme economics;
- long-term management requirements.

5. Glossary

Aftercare	i) The steps necessary to bring the land to the required standard for the planned after-use. ii) The period after closure before the acceptance of surrender during which maintenance and monitoring work is needed to ensure that the restored that the restored landfill does not cause pollution of the environment, harm to human health or adverse effects on local amenities.
After-use	The ultimate use for the land after the landfill permit has been surrendered.
Capping	The covering of a landfill, usually with low permeability material. Permanent capping is part of the final restoration following completion of landfilling/tipping. Temporary capping is an intermediate cap, which may be removed on resumption of tipping.
Completion	The point at which a landfill has stabilised physically, chemically and biologically to such a degree that the undisturbed contents of the site are not likely to pose a pollution risk in the landfill's environmental setting.
CQA	Construction Quality Assurance: This is applicable specifically to construction activities and is an essential tool for the assurance of quality in landfill development. CQA should be certified by an independent quality engineer. CQA is required to ensure that the objective of producing a high quality, practically flaw-free liner is achieved, as even small variations in material and physical characteristics could prejudice the integrity of the liner and hence the design specification would not be met.
Emission	The direct or indirect release of substances, vibrations, heat or noise from the individual or diffuse sources in an instillation into the air, water or land.
Groundwater	As defined by the Groundwater Regulations 1998: all water that is below the surface of the ground in the saturation zone and in direct contact with the ground or subsoil. NB this differs from the definition of groundwater's used under 'controlled waters'.

Harm	The damage to a receptor that results when a hazard is realised. Harm to the health of living organisms or other interference with the ecological systems of which they form a part and in the case of man, includes offence to any of his senses or harm to his property.
Hazard	A property or situation that in particular circumstances could lead to harm.
Landfill gas	All the gases generated from the landfilled waste.
Landfill site	A waste disposal site for the deposit of the waste onto or into land.
Leachate	Any liquid percolating through the deposited waste and emitted from or contained within a landfill.
Monitoring	A continuous or regular periodic check to determine the on-going nature of a potential hazard, conditions along environmental pathways and the environmental impacts of landfill operations to ensure the landfill is performing according to design. The general definition of monitoring includes measurements undertaken for compliance purposes and those undertaken to assess landfill performance.
Permeability	A measure of the rate at which a fluid or gas will pass through a medium.

6. Key References

- SEPA Interim Technical Guidance Note Capping for Landfill Sites, January 2003.

- SEPA Composting Position, September 2004.

- Landfill Allowance Scheme (Scotland) Regulations 2005: SEPA Guidance on Operational Procedures.

- Environment Agency Guidance on Assessment of Risks from Landfill Sites, May 2004.

- Environmental Agency Technical Guidance on Capping and Restoration of Landfills.

- PAS 100 : 2005 Specification for compost materials: Wrap, The Composting Association, BSI

Appendix 1

PAS 100: 2005 Specification for composted materials

Table 3 Minimum compost quality for general use.

Parameter	Test Method	Unit	Upper Limit
Pathogens (human and animal indicator species)[b]			
Salmonella spp	ABPR 2003, Schedule 2, Part II or BSEN ISO 6579	25g fresh mass	Absent
Escherichia coli	BS ISO 11866-3	CFU g^{-1} fresh mass	1 000
Potentially toxic elements			
Cdmium (Cd)	BS EN 13650 (soluble in aqua regia)	mg kg^{-1} dry matter	1.5
Chromium (Cr)	BS EN 13650 (soluble in aqua regia)	mg kg^{-1} dry matter	100
Copper (Cu)	BS EN 13650 (soluble in aqua regia)	mg kg^{-1} dry matter	200
Lead (Pb)	BS EN 13650 (soluble in aqua regia)	mg kg^{-1} dry matter	200
Mercury (Hg)	BS ISO 16772	mg kg^{-1} dry matter	1.0
Nickel (Ni)	BS EN 13650 (soluble in aqua regia)	mg kg^{-1} dry matter	50
Zinc(Zn)	BS EN 13650 (soluble in aqua regia)	mg kg^{-1} dry matter	400
Stability / maturity [c]			
Microbial respiration rate	ORG 0020	Mg CO_2 / g organic matter/ day	16
Plant Response[d]			
Germination and Growth Test	BSI PAS 100: 2005, Annex D	Reduction in germination of plants in amended compost as % of germinated plants in peat control	20
		Reduction in Plant Mass above surface in amended compost as % of plant mass above surface in peat control	20
		Description of an abnormalities	No Abnormalities
Weed seeds and propagules			
Germinating weed seeds of propagule regrowth	BSI PAS 100: 2005, Annex D	Mean number per litre of compost	0

Parameter	Test Method	Unit	Upper Limit
Physical contaminants[e]			
Total glass, metal, plastic and any "other" non-stone fragments >2mm	BSI PAS 100: 2005, Annex E	% mass/mass of "air-dry" sample	0.5 (of which 0.25 is plastic)
Stones			
Stones > 4mm in grades other than "mulch" (N.B : see note on stones)	BSI PAS 100: 2005, Annex E	% mass/mass of "air-dry" sample	8
Stones > 4 mm in "mulch" grade			16

Notes to Table 3

a. Composts for some end uses may have requirements over and above those in Table 3. The composter is responsible for agreeing these with the compost specifier or user. An example is stones in compost supplied to growing media manufacturers and for turf dressing. See WRAP'S "Guidelines for the specification of composted green materials used as growing medium component"
b. Salmonella *spp* and Escherichia coli (E coli) are suitable and commonly used indicator species for human and animal pathogens.
c. See ORG 0020 for guideline values for the range of compost uses. If bagged, the compost uses.
d. The scope of this test is described at the start of Annex D of PAS 100: 2005 Specification for composted materials.
e. Physical contaminants that are "sharp" (such as glass fragments , nails and needles) are unacceptable in any compost that may be handled without protective gloves.