

---

**This publication was withdrawn on 21 April 2021**

It has been replaced by the updated [What to include in your hydrogeological risk assessment](#).

---

## **Environmental Permitting (England and Wales) Regulations Information in support of an application for a landfill permit**

### **Hydrogeological Risk Assessment Report**

#### **Notes to the Applicant – Please read before completing this Report**

- (a) This template should be completed in conjunction with the Conceptual Model, Environmental Setting and Installation Design (ESID) Report.
- (b) The hydrogeological risk assessment fulfils the ‘prior investigation’ requirement of the Groundwater Regulations, 2009. It is also a key process in the evaluation of future landfill developments and must:
- Assess whether the proposed installation will comply with the requirements of both the Landfill Directive 1999, and Groundwater Regulations 2009.
  - Consider the whole lifecycle of the landfill and not just the comparatively short operational phase.
  - Be used to set appropriate control and trigger levels for groundwater.
- (c) When completing this template, it is recommended that:
- All sections should be completed even if only to confirm that it may not be relevant and the reasons for this.
  - All tabulated information should be included within the text of the report at the appropriate point.
  - All numerical models that are relied upon must be supplied to the Environment Agency in an electronic format and must accompany this report.
  - The hydrogeological risk assessment should be accompanied by the drawings as set out within this template. One drawing can provide the information for more than one of the requirements as long as the drawing is clear. Identification numbers must be included for each monitoring point.
  - All drawings should be to recognised scales sufficient to show the following details as specified. Each drawing should have a label that includes:
    - title of drawing
    - installation name
    - name and address of the operator
    - date the drawing was made
    - drawing identification number (and revision number if appropriate)
    - scale of the drawing
    - Key
    - Grid lines and north point
    - Paper size of the original drawing
- (d) LandSim is the Environment Agency's preferred model for assessing the risks to groundwater from landfill sites (subject to the conceptual model being appropriate for the site being considered). If LandSim is appropriate, then the most up to date version should be used.

## **HYDROGEOLOGICAL RISK ASSESSMENT TABLE OF CONTENTS**

<b>1.0 INTRODUCTION.....</b>	<b>.....</b>
1.1 Report Context.....	.....
1.2 Conceptual Hydrogeological Site Model .....	.....
<b>2.0 HYDROGEOLOGICAL RISK ASSESSMENT .....</b>	<b>.....</b>
2.1 The Nature of the Hydrogeological Risk Assessment.....	.....
2.2 The Proposed Assessment Scenarios .....	.....
2.2.1 Lifecycle Phases .....	.....
2.3 The Priority Contaminants to be Modelled .....	.....
2.4 Review of Technical Precautions.....	.....
2.5 Numerical Modelling .....	.....
2.5.1 Justification for Modelling Approach and Software.....	.....
2.5.2 Model Parameterisation.....	.....
2.5.3 Sensitivity Analysis .....	.....
2.5.4 Model Validation .....	.....
2.5.5 Accidents and their consequences.....	.....
2.6 Emissions to Groundwater .....	.....
2.6.1 Hazardous Substances.....	.....
2.6.2 Non-hazardous pollutants.....	.....
2.6.2 Surface Water Management.....	.....
2.7 Hydrogeological Completion Criteria.....	.....
<b>3.0 REQUISITE SURVEILLANCE.....</b>	<b>.....</b>
3.1 The Risk Based Monitoring Scheme .....	.....
3.1.1 Leachate Monitoring .....	.....
3.1.2 Groundwater Monitoring .....	.....
3.1.3 Surface Water Monitoring .....	.....
<b>4.0 CONCLUSIONS.....</b>	<b>.....</b>
4.1 Compliance with the Landfill Directive .....	.....
4.2 Compliance with the Groundwater Regulations, 2009 .....	.....

## TABLES

Tables should be used whenever possible and included within the text to which they relate, as they can summarise large volumes of information/data into a manageable format. The numbering and content of the tables presented within this report will alter according to site-specific circumstances. However, typical examples of tables that could be included are presented below.

Table HRA1.	The prior investigations that have occurred at the site
Table HRA2.	The proposed conceptual site model for the detailed risk assessments required for the installation. This would include a summary of all of the relevant source, pathway and receptor terms
Table HRA3.	The proposed assessment scenarios, including the lifecycle phases and the possible accidents, and the conceptualisation of these scenarios (i.e. how certain inputs may change with time)
Table HRA4.	The justification for the priority contaminants to be modelled
Table HRA5.	The derivation and justification of the input parameters chosen
Table HRA6.	The results of any sensitivity analysis carried out for the site
Table HRA7.	The model validation exercise, which compares the output against observed conditions
Table HRA8.	The modelling results and the presentation of potential resultant concentrations of Hazardous substances and Non-hazardous pollutants at the relevant compliance points
Table HRA9.	The essential and technical precautions that must be used at the site in order to ensure compliance with the Landfill Directive and Groundwater Regulations
Table HRA10.	The hydrogeological completion criteria
Table HRA11.	The risk-based monitoring scheme, including proposals for the monitoring of leachate, groundwater and surface water
Table HRA12.	The proposals for control and trigger level concentrations for Hazardous substances and non-hazardous pollutants
Table HRA13.	Compliance with the Landfill Directive and Groundwater Regulations

## **DRAWINGS**

The numbering and content of the drawings presented within this report will vary according to site-specific circumstances. Typical examples of drawings that could be included summarise the following:

### **Drawing HRA1. Conceptual Hydrogeological Site Model**

A plan accompanied with appropriate cross-sections, which identifies all the potential receptors of emissions to groundwater and relevant compliance points. These plans and cross sections should also identify all the potential pathways.

### **Drawing HRA2. Proposed Assessment Scenarios and Numerical Modelling**

Schematic cross-sections of each of the assessment or model scenarios to be considered, including the different phases of the landfill's lifecycle. This is to allow clear visualisation of how the geological cross sections and conceptual understanding of the site are to be translated into the generally simpler quantitative assessment. Relevant input parameters, and associated distributions, could be annotated onto these cross sections. If at all possible, each cross section should be no more than A3 in size.

### **Drawing HRA3. Emissions to Groundwater**

Annotated schematic cross sections and/ or plans of the different assessment or model scenarios to be considered showing the potential resultant concentrations of Hazardous substances and Non-hazardous pollutants at the relevant compliance points.

### **Drawing HRA4. Requisite Surveillance**

A plan of all monitoring points for leachate, groundwater and surface water. This should indicate all points where leachate and surface water assessment/compliance limits have been set as well as control and trigger levels for groundwater. Relevant limits could be annotated onto the plan.

## **APPENDICES**

The numbering and content of the appendices presented within this report will vary according to site-specific circumstances. However, typical examples of appendices that could be included are presented below.

Appendix HRA1	Electronic copies of all models relied upon within the assessment.
Appendix HRA2	Hard copies of the models and inputs used within the assessment
Appendix HRA3	Results of any sensitivity analysis carried out for the site (unless specified within the text).
Appendix HRA4	The derivation of hydrogeological completion criteria (unless specified within the text).
Appendix HRA5	The proposed risk-based monitoring scheme for the landfill (e.g. determinands, frequency, location, etc) (unless specified within the text).
Appendix HRA6	The derivation of all leachate and surface water assessment/ compliance limits and control and trigger levels for groundwater (unless specified within the text).

## **1.0 INTRODUCTION**

### **1.1 Report Context**

To include details relating to the following.

- The operator of the proposed installation.
- The agent who completed this report.
- An outline of the proposed installation and how it relates to historically operated areas of landfill.
- Cross reference to appropriate Conceptual Site Model (i.e. ESID report).

### **1.2 Conceptual Hydrogeological Site Model**

To include summary details, cross-referenced to the ESID report relating to the following.

#### **Sources**

- Summary of wastes including quantities, types, ratios of types and rates of filling.
- A summary of leachate quality (presence of Hazardous substances and Non-hazardous pollutants) and control (including external groundwater pressures – if appropriate).

#### **Pathways**

- A summary of all relevant pathways including their nature and characteristics (e.g. the purifying powers of soils and sub-soils).

#### **Receptors**

- For Hazardous substances, the receptor/ compliance point will be the point at which the substance will enter groundwater below or adjacent to the site.
- For Non-hazardous pollutants, the primary receptor/compliance point will normally be the downstream boundary of the site. Alternative compliance points down gradient may be applicable but this must be fully justified. However, secondary receptors could include existing or potential users of groundwater, river base-flows, springs within plausible range of impact.
- The specification of appropriate Environmentally Acceptable Levels (EALs).

## **2.0 HYDROGEOLOGICAL RISK ASSESSMENT**

### **2.1 The Nature of the Hydrogeological Risk Assessment**

To include details of:

- The full justification for the risk assessment methodology to be used (e.g. simple or complex). This requires a consideration of the potential risks presented by the site, the sensitivity of the surrounding environment, the degree of uncertainty and the likelihood of the risks being realised.

### **2.2 The Proposed Assessment Scenarios**

The hydrogeological risk assessment must be carried out for the whole lifecycle of the landfill, i.e. from the start of the operational phases until the point at which the landfill is no longer capable of posing an unacceptable environmental risk. This must include consideration of the proposed technical precautions in conjunction with any natural geological barriers. Different scenarios must be considered, to assess the hydrogeological risks at different stages of the landfill's lifecycle. Plausible external influences, failure scenarios and accidents must also be considered.

#### **2.2.1 Lifecycle Phases**

To include details relating to the following.

- The proposed stages of the landfill's lifecycle that will be considered as separate scenarios within this assessment, along with the full justification for their choice.
- The conceptualisation of the different lifecycle stages and how certain inputs may change with time e.g. the potential for degradation of or change in the operation of the leachate drainage system and the integrity of the containment system, etc.
- Long term changes in the external groundwater situation, long term subsidence etc.
- The clear specification of the implications for further quantitative assessment (e.g. the nature of the degradation of the lining systems to be modelled etc.).

### **2.3 The Priority Contaminants to be Modelled**

The full justification for the priority contaminants to be modelled. To include details relating to the following:

- The actual or potential presence of Hazardous substances and Non-hazardous pollutants.
- The choice of representative substances to be modelled; either as representative of actual leachate or as surrogate substances that could be used as indicators, including an assessment of their chemical and physical characteristics.
- An assessment of the uncertainties associated with the choice of representative or surrogate substances.

### **2.4 Review of Technical Precautions**

In the context of a hydrogeological risk assessment, the necessary essential and technical precautions required by the Groundwater Regulations are likely to include limitations on the rates of input and concentrations of permitted waste types, waste acceptance ratios and methods of disposal, the engineering systems of the site associated with drainage, containment and leachate management. These should be reviewed to:

- provide confirmation of why the installation is considered to comply with the Groundwater Regulations, and the Landfill Directive, for its whole lifecycle from the active stage of landfilling through to closure and to reliance solely on natural geological barriers;
- consider the key technical precautions.

It should include a consideration of the following:

- capping;
- lining design and leakage detection;
- leachate drainage systems;
- leachate head control;
- groundwater and surface water management.

(Monitoring is also considered to be a technical precaution, however, it should be considered in more detail within Section 3.0, Requisite Surveillance).

The ability to control leachate should be assessed in a leachate head risk assessment, which should establish that the proposed leachate management measures are capable of providing sufficient control (e.g. the level of control as assumed by the hydrogeological risk assessment) for as long as the risk assessment predicts them to be necessary.

## **2.5 Numerical Modelling**

### ***2.5.1 Justification for Modelling Approach and Software***

To include details relating to the following.

- Model selection and suitability to represent all of the considered scenarios (i.e. the different modelled phases of the lifecycle, and potential impact of accidents) and hydrogeological conditions.
- Justification for the confidence levels used within any stochastic modelling.
- A full justification for the use of a particular computer models/ software, which includes relevance to the particular circumstance of the installation.
- Model verification and the suitability of model to identify and represent receptors and compliance criteria

### ***2.5.2 Model Parameterisation***

To include details relating to the following.

- The nature of the parameterisation process including all model inputs, probability density functions and model calibration where appropriate.
- The justification for using model defaults against providing field measurements.

### ***2.5.3 Sensitivity Analysis***

To include details relating to the following.

- The completion of a sufficient sensitivity analysis, which may include the use of multiple model runs to simulate different justifiable ranges of input parameter values.
- The consideration of assessment limitations, the assessment of uncertainties and the need for safety factors.



#### **2.5.4 Model Validation**

To include details relating to the following.

- The comparison of modelled output against what is observed in the field and represented within the conceptual hydrogeological site model (e.g. are the modelled heads above the liner compatible with those observed, are the hydraulic gradients compatible with permeability, etc.).
- Justification that the model provides a sufficiently adequate representation of reality.

#### **2.5.5 Accidents and their Consequences**

To include details relating to the following.

- A qualitative consideration of the impact of accidents and resulting damage to liner systems, leachate management and other engineering and management structures.
- The likelihood of the accidents occurring and the magnitude of the consequences of such accidents and failures.
- The justification for whether the specified accidents require quantitative assessment or not.
- The clear specification of additional scenarios that are to be given further quantitative analysis and the resultant implications for modelling.

### **2.6 Emissions to Groundwater**

The hydrogeological risk assessment must establish whether the predicted discharge from the landfill complies with the requirements of the Groundwater Regulations. This must be carried out for each of the considered scenarios (i.e. the different modelled phases of the lifecycle and the potential impact of accidents) and must include both Hazardous substances and Non-hazardous pollutants.

#### **2.6.1 Hazardous substances**

For each of the considered scenarios, the hydrogeological risk assessment must demonstrate that the technical precautions would “*prevent Hazardous substances from entering groundwater*”. Consequently, it must consider whether there is likely to be a discernible discharge of Hazardous substances to groundwater. The test shall be applied at the point at which leachate enters groundwater and shall not take account of the effect of dilution in that groundwater.

Consequently, this section should include the following (for all considered scenarios):

- The predicted concentrations of Hazardous substances at the point that they enter the groundwater.
- The determination of whether the concentrations are discernible (summarised in an explicit statement) and full justification for the conclusions.

#### **2.6.2 Non-hazardous pollutants**

For each of the considered scenarios, the hydrogeological risk assessment must demonstrate that the technical precautions would “*limit the introduction of Non-hazardous pollutants into groundwater so as to avoid pollution*”.

Consequently, it must consider whether the predicted concentrations of Non-hazardous pollutants are likely to exceed relevant use-base standards, other relevant environmental

quality criteria, or cause an unacceptable deterioration in water quality, in the groundwater following dilution.

This section should include the following (for all considered scenarios).

- The assessment of whether the predicted concentrations of Non-hazardous pollutants exceed the relevant Environmental Acceptable Levels at the downstream boundary of the landfill, i.e. after dilution in the groundwater. Alternative downstream compliance points may be applicable but must be fully justified (e.g. No viable potential use of groundwater exists at or nearer to the landfill boundary).
- The determination of whether the introduction of Non-hazardous pollutants to groundwater has been sufficiently limited so as to avoid pollution (summarised in an explicit statement) and full justification for the conclusions.

### **2.6.3 Surface Water Management**

The ability to control surface water to prevent ingress to the landfill or downstream flooding should be assessed in a surface water and water balance assessment.

## **2.7 Hydrogeological Completion Criteria**

Landfill completion requires a consideration of whether the site, as a result of the disposal of controlled wastes, is likely or unlikely to cause pollution of the environment or harm to human health. As the hydrogeological risk assessment must be undertaken for the whole lifecycle of the landfill, it follows that the process should result in the initial production of hydrogeological completion criteria.

Completion relating to hydrogeological risks will have been achieved when there is no unacceptable risk of pollution from the landfill i.e. when the site can comply with the requirements of the Groundwater Regulations, 2009, without the need for any active management.

Consequently, this section should provide details of the following.

- The determination of the levels of leachate quality and quantity at which the unmanaged landfill would not pose an unacceptable pollution risk.
- The estimated time take to reach these criteria and the assumptions behind this estimate.

## **3.0 REQUISITE SURVEILLANCE**

### **3.1 The Risk Based Monitoring Scheme**

Under the Groundwater Regulations, 2009, the Agency must ensure that “*requisite surveillance*” is undertaken, which takes the form of leachate, groundwater and surface water monitoring. In addition, environmental monitoring plays a central role in environmental risk assessment and management.

The hydrogeological risk assessment should be used to develop a risk-based monitoring plan containing both objectives and a sampling plan. This section must provide the Technical rationalisation for the design of a monitoring programme, to focus monitoring effort on actual risks.

Appropriate assessment and compliance criteria, as well as control and trigger levels for groundwater quality, must be specified within each of the appropriate sections. Full justification and a clear audit trail must be provided for each proposed criterion/level.

### **3.1.1 Leachate Monitoring**

To include details relating to the following:

- The risk-based rationale for the proposals.
- The monitoring objectives.
- The number and location of monitoring points.
- Monitoring measurements.
- Monitoring schedules.
- Design of monitoring points.
- Appropriate assessment and compliance criteria (with full justification).

### **3.1.2 Groundwater Monitoring**

To include details relating to the following.

- The risk-based rationale for the proposals on a cell by cell basis.
- The monitoring objectives.
- The number and location of monitoring points.
- Monitoring measurements.
- Monitoring schedules.
- Design of monitoring points.
- Appropriate control and trigger levels for groundwater quality (for both Hazardous substances and Non-hazardous pollutants with full justification).

### **3.1.3 Surface Water Monitoring**

To include details relating to the following:

- The risk-based rationale for the proposals.
- The monitoring objectives.
- The number and location of monitoring points.
- Monitoring measurements.
- Monitoring schedules.
- Design of monitoring points.
- Appropriate assessment and compliance criteria (with full justification).

## **4.0 CONCLUSIONS**

### **4.1 Compliance with the Landfill Directive**

This section must include specific conclusions identifying how the landfill complies with the following requirements of the Landfill Directive.

- The need to collect contaminated water and leachate (on a cell by cell basis)
- The compliance of the installation with the specified engineering standards (on a cell by cell basis).
- The derivation of control and trigger levels for groundwater quality (on a cell by cell basis).

### **4.2 Compliance with the Groundwater Regulations, 2009**

This section must include specific conclusions identifying how the landfill complies with the requirements of the Groundwater Regulations, 2009. These must relate to the following.

- The applicability of the Groundwater Regulations, 2009 (on a cell by cell basis).
- The need for prior investigation.
- The prevention of Hazardous substances from entering the groundwater.
- The limitation of the introduction of Non-hazardous pollutants Substances into groundwater so as to avoid pollution.
- Essential and technical precautions.
- Requisite surveillance.