EA - NCRAOA
Box 4

TRE FOR RISK ANALYSIS
& OPTIONS APPRAISAL

# Introducing Environmental Risk Assessment

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# Introduction

## Who should read this leaflet?

This leaflet is aimed at people encountering environmental risk assessment for the first time. It is possible that new legislation or internal procedures mean that you should consider risk in a more formal way. You may be asked to do a risk assessment, or asking others to do so to support a regulatory decision or to help decide how to manage risk. Typically, this will involve answering the following questions:

- What is at risk, and what is it at risk from?
- What, and how, might it happen?
- How large will the consequences be and how probable are they?
- What criteria will be used to judge their significance?
- How significant are the probabilities and consequences?
- How certain are you about the assessment of probability and consequence?

If you work in the environmental field, you are probably used to considering risks implicitly. This leaflet aims to help you structure your thinking about risk assessment in a more explicit way. It explains the principles of assessing and managing risk with a minimum of jargon. We cannot give you all the answers here, however, and further information is available from the sources listed at the end of this leaflet.

## What is environmental risk?

At the simplest level, a risk can be thought of as the chance of an event happening. It has two aspects: the chance, and the event that might happen. These are conventionally called the probability and the consequence. Some consequences have desirable benefits. Within the Environment Agency we are aiming to protect the environment and are usually concerned with the probability of undesirable consequences so that we can prevent, or manage them.

Just because something is hazardous, it doesn't mean it will cause harm. Petrol in a tanker is hazardous, but harm occurs only when the tanker accidentally spills fuel, perhaps into an adjacent river. We need to take into account the likelihood of the tanker accident occurring and the likelihood of the spill affecting the water quality of the river. An environmental risk then, is the probability of the environment (human health or the wider environment) suffering harm from a hazard. We are often also concerned about social, economic and political risks. These can be more difficult to assess and are not addressed here, but the principles explained in this leaflet can act as a useful first step.

## Definitions

**Hazard:** a situation or substance with the potential to cause harm.
**Harm:** the damage that results when a hazard is realised.
**Environmental risk:** the probability of the environment suffering harm from a hazard.

## When do I need a risk assessment?

You will usually need a risk assessment when you are concerned about a known hazard and there is a sensitive receptor likely to be affected, or nearby. Major chemical plants storing large quantities of hazardous bulk chemicals are an example of the former. Residential housing, or the presence of a unique habitat are examples of the latter.

Risk assessments are not always required, however. There may be an accepted way of managing a well-recognised risk such as bunding oil tanks or using wheel washes at landfill sites stations to avoid the release of mud or debris on approach roads. In these circumstances, you may only need a risk assessment if you intend to depart from the accepted solution.

## What will a risk assessment tell me?

A risk assessment will help determine how significant the probability of harm is and, usually, the options available to manage the harm. Before making your final decision on whether, and how, to manage the risk you will need to account for economic, social and political factors and issues of practicality.


*Environmental risk is a combination of the probability and the consequence.*



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# How to do a risk assessment

There is a structured way of doing an environmental risk assessment, which includes the following steps:

## Think about your audience

Having established that you need a risk assessment, think carefully about how you will use it, bearing in mind that people beyond those doing the assessment will also be interested in the results. Before undertaking any technical work, identify your audience and those who will be affected by the decision, and then plan how you will involve them and communicate the results.

## Define the problem

Be sure to get your logic sound from the start and ensure that the problem under study is properly described and understood by all the relevant parties. For example, have in mind the geographical area you are considering and the time period that the study will address. You will need a clear idea of what it is you are trying to protect (for example an ecosystem, human health, or an aquifer) and be able to break down the problem into its main parts. To help you, use the questions listed in the introduction, the source-pathway-receptor approach described below and the following risk assessment steps.

## Identify sources, pathways and receptors

For harm to occur, a hazard must in some way adversely affect what it is we are concerned about (river water quality in the petrol tanker example). The source-pathway-receptor approach is commonly used in risk assessment. It can be illustrated by imagining being on holiday in a caravan park on the banks of a river. Under normal river flow conditions, this might be an idyllic setting, but under extreme flood conditions, there is a risk that the caravan might be flooded or even washed away. The **source** of the hazard is unusually heavy rainfall. The **hazard** associated with this source is potential loss of life or property damage. The **pathway** is the passage of water through the catchment, resulting in a rise in river level and the overwhelming of the flood defences. The **receptor** is the caravan. If any of these is absent, then **harm**, that is actual damage, can't occur. For a risk to be present there must be a source of a hazard, a receptor and a pathway between the source and the receptor.

*Damage to caravan site due to flooding on the River Avon*

| Source | Pathway | Receptor | Harm |
|---|---|---|---|
| Rain | Flooding | Caravan | Material Damage |
| Stack emissions | Air Flow | Forests | Leaf Damage |
| Leachate | Leakage | Aquifer | Deterioration in the quality of a water supply |
| Drought | Loss of base flow | Wetland | Loss of aquatic life |

*Without a source-pathway-receptor linkage in place, harm cannot occur*

## Develop a conceptual model

Draw out the problem under study as a simple sketch of the environmental setting, including sources pathways and receptors. Decide what aspects the assessment will and will not cover. Using your diagram, write out possible source-pathway-receptor linkages; each linkage having only one source, pathway and receptor. Structure your thinking in a table like the one above. Then ask yourself whether they are linked or potentially linked. Screen out those for which the answer is "no".

*A conceptual model of sources (landfills, petrol station, septic tank), pathways (groundwater flow) and receptors (public water supply).*

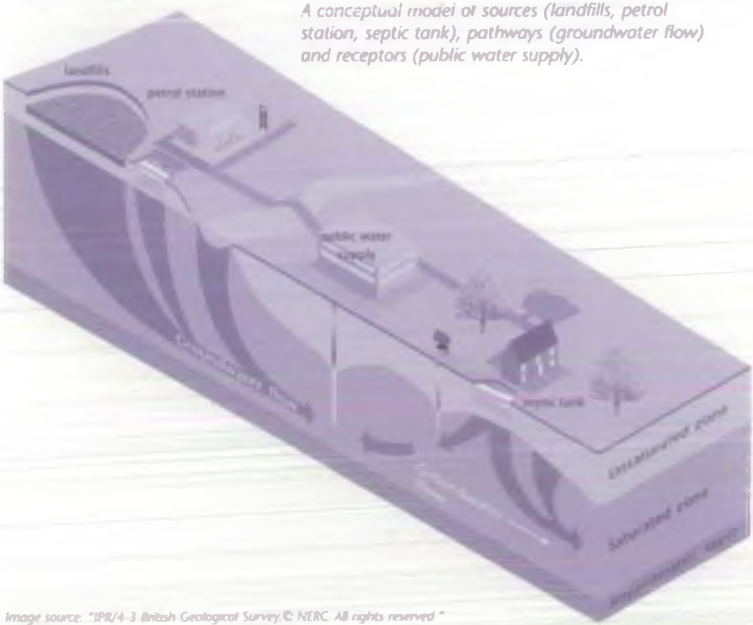
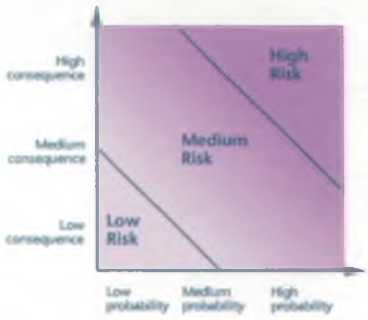



*Image source: "IPR/4-3 British Geological Survey.© NERC. All rights reserved "*

## *Assess the probabilities and consequences*

Assess separately the scale of the consequences (harm) and the probability of the harm being realised using a "high" "medium" or "low"scale that you define. In assessing the consequences, consider the nature of the source, the hazard and the sensitivity of the receptor. In assessing the probability, consider how likely the linkage is to be in place. Use your expert knowledge or that of others in making these assessments and then group together those linkages with high probabilities and high consequences. Record your reasoning throughout.

Work in a logical way and revisit your assumptions as you go. Start simply and build in complexity only as you need it. In general, resist the temptation to quantify the probabilities and consequences until you are sure you understand the problem and this becomes a necessity. Most risk assessments do not require quantitative risk estimates in order to prioritise issues.




*A qualitative risk assessment - address high priority risks (those with high probability and consequences) first.*

Use the best available information, and make reasonable assumptions, justifying them as you go. Remember to record your reasoning at each stage. You will find this helpful later in communicating risk and justifying your decisions.

Understanding risk in these terms is essential to any assessment on risk, and subsequently informs the process of risk management. Effort should concentrate on risks with high probabilities and high consequences. We manage risks by controlling the source-pathway-receptor linkage. To take flooding as an example, we may:

- remove receptors (steer development away from areas that flood, use flood warning and evacuation);
- block or alter pathways (install flood defences, alleviation channels, or set up sustainable drainage systems);
- address the source (difficult in this case for rainfall, but action to address climate change may reduce the future severity).

# Prioritising risk

## Key concepts

Understanding the following technical concepts will help you prioritise the risks you have identified:

- **exposure**;
- **potency**;
- the **number of receptors** at risk;
- their **vulnerability and sensitivity**.

## Exposure

Harm can only occur if the receptor is exposed to the hazard. What is important, is how much and how often the receptor is exposed to the hazard. In assessing risks from chemicals we call this overall amount of exposure the "dose". We are familiar with this concept in terms of the beneficial or harmful effects of taking paracetamol, for example. The concept of dose is also widely accepted in describing radiological risks to humans where the pathways of exposure are well understood. However, the magnitude, frequency and duration of exposure are also important in determining the extent of harm for hazardous situations. For example, the magnitude and duration of a drought will determine the extent of adverse affects on a wetland environment.

Some exposure pathways are more accessible, or direct, than others. Direct pathways involve exposure to the medium (air, water, soil) in which the source resides – the direct inhalation of hazardous vapours, for example. Indirect pathways usually involve transport of the source between media, such as the leaking of contaminants from a landfill site through permeable strata to an aquifer, and subsequently a public water supply. In any situation, risks may be dictated by direct or indirect exposure to the source of the hazard. An understanding of direct and indirect exposure helps in deciding the influence of different pathways and in assessing the probability of the hazard being realised at the receptor. Dispersion modelling is one approach to quantifying exposures in the wider environment from a point source.

## Potency

Some sources are more powerful, more potent, than others for the same amount of exposure - just like medicines. Potent sources pose more harm. The relationship between the "dose" and the harm, or the response, is an important characteristic of any hazardous situation. The concept has wide application. For example, equal depths of fresh, saline or polluted water in homes that become flooded will have different impacts because the potencies of these sources with respect to harm to human health or property, differ markedly. An assessment of consequences for any risk must take into account the potency of the source for the specific hazard.

## Number of receptors

One must also consider the number of receptors at risk. The consequences are generally thought to be more significant if a large population of receptors is at risk rather than a small population. This may not be universally applied, however, as we may attach substantial value to even a small number of receptors: single representative habitats, for example.

## Vulnerability / sensitivity

Some receptors are less resilient to hazards than others. This could be because of their sensitivity to a specific hazard or because they are more vulnerable by nature. For example, elderly people would be less able than the more mobile to evacuate in the event of a rapid flood (vulnerability); and acid deposition would have more impact on acid-sensitive moorland than on grassland (sensitivity). We are especially concerned in risk assessments about sensitive receptors, including children, special habitats and groundwater supplies of drinking water, for example.

*Children playing on wasteground near sewage works.*

# Uncertainty

## *Dealing with uncertainty*

Many risk assessments deal with complex issues, and there is often not enough data to be certain about all aspects of the source, pathway and receptor. Models may not be totally accurate or complete, and we may not know what changes will take place in the future. It is important to be aware of, and document, the uncertainties when carrying out a risk assessment. The following pointers can help with treating uncertainty:

- Concentrate on the "big picture" before getting into the detail, and avoid a complex analysis of an issue unless you are sure it is important.
- Concentrate on those parts of the assessment that have the greatest impacts on the outcome.
- Try to communicate where the greatest uncertainties lie. For example, you might be confident in the integrity of a landfill liner in good condition, but uncertain whether the liner is likely to be torn or damaged in the future.
- Be honest about uncertainties. Use "what if" questions to explore the importance of uncertainty to the final assessment of risk (sensitivity analysis).
- We often rely on the judgement of experts to inform the risk assessment process, especially where data are sparse. Be sure to review these judgements and the assumptions recorded.
- If necessary, compare or "benchmark" your assessment against similar studies.
- Finally, remember to consider how you will involve those with an interest in your assessment and communicate the issues raised by the output.

# Other methods

## *What about more sophisticated methods?*

Numerous tools, techniques and detailed numerical "models" are available to assist in undertaking risk assessments. They are usually specialist tools developed within a single discipline and require expert application. In the main, they deal with three different types of situation:

- An **initiating event** occurring. Something happens that results in a release to the environment or the loss of containment (for example, a storm causes a flood defence structure to breach; or a valve fails at a chemical plant);
- **Exposure** to a receptor. Releases to the wider environment follow initial release (for example, an oil plume impacts a surface water abstraction point);
- **Harm** occurring to a receptor following exposure. Here the focus is on the likelihood of harm actually occurring (for example, the effect of exposure to contaminated soil on human health).

These situations usually require quite distinct approaches. Some risk assessments involve all three types of situation. The National Centre for Risk Analysis and Options Appraisal (see page 11) can give more information.

*Assessing a potential hazard*

# More information

The Environment Agency's *National Centre for Risk Analysis and Options Appraisal* provides expert assistance on aspects of environmental risk assessment and management, and sets the Environment Agency's framework for risk assessment and options appraisal.

Steel House, 11 Tothill Street, London SW1H 9NF
Tel: 020 7664 6811
Fax: 020 7664 6911

*The National Centre for Ecotoxicology and Hazardous Substances* provides expert knowledge on chemical hazards and ecotoxicological effects and methods.

Evenlode House, Howbery Park, Wallingford, Oxon., OX10 8BD
Tel: 01491 828544
Fax: 01491 828427

*The National Groundwater and Contaminated Land Center* considers risk assessment and management in the context of groundwater resource management and contaminated land remediation.

Olton Court, 10 Warwick Road, Olton, Solihull, West Midlands, B92 7HX
Tel: 0121 711 5885
Fax: 0121 711 5925

If you would like to read more on the subject, you will find the following useful:


- European Environment Agency (1998) Environmental Risk Assessment, EEA, Copenhagen, ISBN 9291670804
- Department of the Environment (1995) Risk Assessment and Risk Management for Environmental Protection, HMSO, London (under revision), ISBN 0117530913
- Calow, P. (ed.) (1998) Handbook of Environmental Risk Assessment and Management, Blackwell Science, ISBN 0865427321
- ILGRA (1998) Risk Communication: A Guide to Regulatory Practice, HSE books, Suffolk.

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